RAPPORT D'ACTIVITÉ

LABORATOIRE DE L'INFORMATIQUE DU PARALLÉLISME

UMR 5668 CNRS - ENS Lyon - UCB Lyon 1, Inria
Université de Lyon

RAPPORT D'ACTIVITÉ 2009 - 2014

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Préambule

Le LIP, Laboratoire de l'Informatique du Parallélisme, a vingt-six ans. À sa création par Michel Cosnard en 1988 en tant que laboratoire d'informatique de l'École Normale Supérieure de Lyon il réunissait 26 membres. Œuvrant au départ sur le domaine unique du parallélisme, le LIP a rapidement fait évoluer l'étendue de ses recherches, son panel thématique riche couvre des tendances les plus fondamentales de l'informatique jusqu'à des travaux en prise directe sur le transfert et les applications. Jeune équipe puis URA CNRS-ENS en 1989, le LIP devient Unité Mixte de Recherche (UMR 5668) associée à Inria en 1999. Le laboratoire est dirigé par Yves Robert de 1997 à 2001. En 2001, le laboratoire regroupe 70 membres, Jean-Michel Muller prend la direction jusqu'en juin 2006. L'Université Claude Bernard Lyon 1 (UCBL) devient partenaire de l'UMR en 2003. Frédéric Desprez assure ensuite la direction à partir de 2006 – le laboratoire approche alors une taille d'une centaine de membres – puis passe le relais à Gilles Villard fin 2008. Guillaume Hanrot, directeur adjoint depuis début 2013, a pris la majeure partie des responsabilités au LIP en avril 2014, avec près de 130 collaboratrices et collaborateurs il porte le projet présenté dans ce document.

La jeunesse de l'informatique et les bouleversements qu'elle amène avec les sciences et technologies de l'information, la placent dans une position unique. Les chercheuses et les chercheurs du domaine participent à l'invention des infrastructures numériques et à celle de nouveaux modèles, langages, algorithmes et logiciels qui sont mis en œuvre en collaborant avec les autres sciences, ou pour étudier les objets que la discipline elle-même a créés. Le défi d'une fertilisation croisée étonnamment riche entre de nouvelles abstractions fondamentales et une diffusion des inventions partout dans la société est relevé. Le LIP présente ici un bilan qui démontre son rôle fort autour de nombreux aspects de ce défi. La qualité des équipes, leur complémentarité et la vitalité du laboratoire permettent d'aborder sereinement les évolutions rapides et complexes de la société numérique, dans laquelle les masses d'information produites tiennent une place aussi capitale que les infrastructures qui les produisent et les manipulent. L'invention de *modèles* est une des clés au cœur de notre projet qui doit nous permettre de dompter cette complexité.

Le présent document résume les activités du LIP sur la période janvier 2009 - juin 2014. La partie 1 comporte le bilan scientifique et administratif du laboratoire, ainsi que le projet scientifique pour les cinq prochaines années. Dans les parties 2 à 9, bilan et projet se déclinent selon les sept équipes de recherche et le service des moyens informatiques. Les listes exhaustives des collaborations, contrats et productions seront trouvées en annexe 6 (par équipe de A6.1 à A6.7).

Nous tenons à adresser un très vif merci à l'ensemble des membres du laboratoire. Chacune et chacun peut avoir la conviction que son investissement et sa confiance jouent un rôle primordial grâce auquel diriger le LIP est une fierté et un plaisir.

Finissons par un merci particulier à toutes celles et ceux qui par leur implication forte, dévouée et constante, assurent le fonctionnement quotidien administratif et scientifique du LIP, et qui permettent à la direction de se concentrer sur ses missions et sa réflexion stratégique. Nous pensons en particulier (mais pas seulement) au service des assistant(e)s, aux chefs d'équipe et aux ingénieurs du laboratoire.

Le 30 septembre 2014,

Gilles Villard	Guillaume Hanrot
Directeur du LIP	Porteur du projet

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1 Rapport et projet scientifique du LIP

1.1 Introduction

Le Laboratoire de l'Informatique du Parallélisme (LIP) a été créé à l'École Normale Supérieure de Lyon (ENS de Lyon) en 1988. C'est une unité mixte de recherche (UMR 5668) de l'ENS et du Centre National de la Recherche Scientifique (CNRS) depuis 1989, et de l'Université Claude Bernard Lyon 1 (UCBL) depuis 2003. Le LIP est associé à Inria depuis 1999.

Le laboratoire rassemble de l'ordre de 130 membres, dont 68 permanents scientifiques et personnels administratifs et techniques à la rentrée 2014. Ces membres permanents se répartissent en : 17 chercheurs et 4 ITA CNRS ; 13 chercheurs et 4 ITA Inria ; 17 enseignants-chercheurs et 3 ITA ENS ; 10 enseignants-chercheurs de l'UCBL. Cette répartition des affiliations – dont la diversité est un atout – reflète l'investissement équilibré de nos partenaires. Les arrivées de 25 scientifiques permanents[1] depuis 2009 illustre notre attractivité. Le laboratoire accueille chaque année plus de 40 nouveaux collaborateurs, doctorants ou chercheurs et ingénieurs contractuels. Plus de 140 chercheurs étrangers ont séjourné au LIP en 5 ans, dont près de 70 pour au moins deux semaines.

Sur un large spectre de thématiques en informatique et sciences de l'information, le LIP est organisé en sept équipes de recherche.

Aric : *Arithmétique et calcul*.

Avalon : *Algorithmes et architectures logicielles pour les plates-formes distribuées et à haute performance*.

Compsys : *Compilation, systèmes embarqués et calcul intensif*.

Dante : *Réseaux dynamiques*.

MC2 : *Modèles de calcul, complexité et combinatoire*.

Plume : *Théorie de la preuve et sémantique formelle*.

Roma : *Optimisation des ressources : modèles, algorithmes et ordonnancement*.

À ces équipes de recherche, il convient d'ajouter le *service des moyens informatiques*, dont l'action liée aux équipements et plates-formes est essentielle.

La géométrie des équipes a largement évolué depuis 2009, avec le renforcement d'orientations et l'apparition de nouvelles thématiques dont par exemple : l'optimisation multi-critères pour le calcul haute performance et le déploiement ; les réseaux euclidiens en cryptographie ; les réseaux dynamiques ; la résilience ; l'extension des méthodes polyédriques ; la sémantique pour la vérification ; les graphes et la combinatoire et leur application en calcul scientifique ; l'analyse de données sociales. Les équipes de recherche sont communes au CNRS, à l'ENS et à l'UCBL. Aric, Avalon, Compsys, Dante et Roma sont également équipes-projets communes (EPC) Inria[2] et représentent de l'ordre de 70% du laboratoire. Les relations et le fonctionnement avec la tutelle Inria sont de nature voisine de ce qui est en place avec les trois tutelles. L'équilibre que le LIP a pu atteindre avec quatre partenaires est une force.

Cette première partie du rapport synthétise l'ensemble des aspects scientifiques, présente l'organisation, les activités et les projets du laboratoire. Les équipes sont décrites plus en détail dans les parties 2 à 8 et les annexes. On pourra en particulier se reporter à l'annexe 6 pour la production complète, les collaborations et les contrats équipe par équipe. Le service des moyens informatiques est spécifiquement abordé en partie 9.

Une des forces principales du LIP est sa « mixité théorique-pratique » qui s'illustre par plus de 1000 publications (toutes catégories confondues), une production logicielle très diversifiée et des activités de transfert soutenues (5 start-ups créées). Le budget opérationnel annuel moyen de 2.4M€ s'établit à partir de nombreuses collaborations académiques et industrielles. Les membres du LIP publient avec des chercheurs de près de 70 institutions à l'étranger. En fondant le LabEx MILYON avec les laboratoires de mathématiques de Lyon et au travers d'une forte implication au sein du GDR IM, le LIP a conforté ses échanges avec les mathématiques. Les investissements pour Grid'5000-Héméra ou pour l'EquipEx FIT ainsi que les liens avec l'IN2P3 ou au sein du GDR ASR illustrent des recherches résolument orientées sur les infractutures numériques. La santé, les sciences du vivant, la physique, la sociologie et le calcul scientifique donnent lieu à la fois à des synergies marquées entre les équipes du laboratoire et à des avancées pluri-disciplinaires, particulièrement au sein de l'Université de Lyon et à l'échelle régionale (implication dans l'IXXI, LabEx PRIMES, projet Décrypthon, etc.).

Les enseignants-chercheurs naturellement, mais aussi la plupart des chercheurs du LIP, sont très impliqués dans les actions de formation, avec des prises de responsabilités fortes au niveau des départements d'enseignement des différentes structures à l'ENS et à l'UCBL. Cette implication participe beaucoup à la politique d'attractivité du laboratoire.

[1] Dont 3 prises de fonctions à l'automne 2014.
[2] Ou « équipes centre » en cours de création EPC.

Géographiquement parlant, les équipes du laboratoire sont partagées entre trois sites depuis 2008 (voir §1.3.6). La situation a vocation à se résorber grâce au plan Campus à un horizon actuellement annoncé fin 2017-mi 2018, des étapes intermédiaires avant regroupement complet sont discutées avec nos établissements hébergeurs l'ENS et l'UCBL.

1.2 Présentation scientifique du laboratoire

L'informatique est une des sciences centrales pour les évolutions et les enjeux de la société. Le calcul, l'échange et le traitement de l'information ont un impact majeur et sont omniprésents. Au-delà du progrès technologique et du monde numérique, la discipline possède l'expérience d'un « mode de pensée algorithmique » qui révolutionne également toutes les sciences et produit des résultats fondamentaux majeurs. Tirant parti de compétences solides et reconnues à la fois théoriques, appliquées et expérimentales, l'objectif du laboratoire est de participer à ce double défi technologique et fondamental.

Le LIP s'inscrit dans l'étude et l'anticipation du monde numérique futur, de ses fondements et de ses modèles, dans l'optique d'inventer de nouveaux concepts et méthodes informatiques et de devancer leurs répercussions sur les autres sciences. Une spécificité du laboratoire consiste en la mixité et la collaboration entre les avancées théoriques et l'innovation en développement logiciel et matériel. Ce fil rouge « de la théorie à la pratique » et « du langage à l'architecture » est à la fois une base solide pour les projets et une source majeure d'invention. L'évolution technologique engendre chaque jour de nouveaux défis pour la communauté scientifique qui doit assurer tant au niveau fondamental qu'appliqué la maîtrise et la qualité des environnements numériques de demain.

Sur la période 2009-2014, l'accent a été mis sur l'utilisation efficace, fiable et sûre des ressources de calcul et de communication. La machine (ordinateur, infrastructure), aussi bien entité abstraite qu'objet physique (localisé ou distribué et distant), est le centre des études.

Un premier élément de stratégie a été de mettre en œuvre deux grands axes de synergie, complémentaires et transverses aux équipes :

- défis des futures architectures de calcul et de communication ;
- modèles, méthodes et algorithmes en informatique mathématique.

La plupart des équipes et de leurs membres conduisent des recherches sur ces deux axes, ce qui a permis d'encourager la « mixité théorique-pratique » à l'échelle de l'ensemble du laboratoire. Bâtir sur cette mixité et la préserver est un des aspects déterminants de la politique scientifique du LIP.

Les forces du laboratoire sont celles de ses équipes qui sont la clef des dynamiques, projets, avancées et collaborations. Soutenir les équipes dans leurs objectifs et promouvoir leurs activités, leur permettre une meilleure prise en compte du contexte global, favoriser l'émergence de nouveaux thèmes et l'accession à l'indépendance des jeunes chercheuses/chercheurs, accompagner les changements de géométrie et favoriser l'obtention des effectifs et moyens nécessaires sont des aspects qui constituent un deuxième élément stratégique essentiel.

Un troisième élément de stratégie est un investissement appuyé à l'interface avec de nombreuses autres sciences. Outre des liens traditionnellement étroits avec les mathématiques, les ouvertures pluri-disciplinaires fortes concernent le calcul numérique et haute performance en modélisation et simulation (par exemple en sciences du vivant), la micro-électronique, le traitement du signal (en lien avec la physique) et la science des réseaux (en lien notamment avec les sciences sociales).

Sur la période à venir, un des principaux défis posés au laboratoire semblent être d'améliorer son insertion dans le paysage lyonnais, au moyen d'échanges plus solides avec les autres acteurs des sciences de l'information lyonnais, en occupant pleinement sa place d'acteur incontournable du calcul sur le site et en s'appuyant sur ce rôle pour continuer à développer les relations avec les autres disciplines. Reconstituer un socle « technologique » d'idées et de personnes éprouvé par les départs en promotion ou pour création de start-ups sera aussi un objectif important.

1.2.1 Faits marquants

Publications. On totalise près de 320 articles dans des revues, 550 dans des actes de conférences et presque 100 travaux d'éditions, livres et chapitres dans des livres ; 8 articles récompensés lors de conférences ; 2 prix de meilleure thèse pour A.-C. Orgerie (*Research in System / ASF*) et pour M. Noual (EADS).

Logiciels. Des projets à large impact et diffusion tels que : DIET (`http://graal.ens-lyon.fr/DIET`) en calcul et services distribués ; MUMPS (`http://mumps-solver.org`) et son consortium en algèbre linéaire creuse ; GNU MPFR (`http://www.mpfr.org`) en calcul flottant. Une quinzaine d'ensembles logiciels diffusés et une quarantaine de prototypes, logiciels expérimentaux et outils spécifiques.

Collaborations et projets. Portages de 14 projets ANR et participation à 25 autres projets ANR ; projet *ERC Starting Grant* de D. Stehlé ; des co-auteurs dans près de 70 institutions à l'étranger ; une vingtaine de collaborations formalisées dans le cadre de programmes exploratoires et de programmes bilatéraux « légers » (PICS CNRS, Équipes

Associées Inria, partenariats Hubert Curien, France-Japon, etc.), avec 7 thèses en co-tutelle ; les financements européens représentent 24% des ressources propres des équipes avec la participation à 25 projets et consortiums et deux actions Marie Curie. Y. Robert (Roma) est représentant d'Inria au sein du *Joint Laboratory for Petascale Computing* (Inria, U. Illinois Urbana-Champaign, Argonne National Laboratory, Barcelona Supercomputing Center).

Événements scientifiques. De nombreux temps forts se produisent à Lyon, organisés par des membres du LIP. Ont par exemple eu lieu récemment les conférences ICPP *42nd International Conference on Parallel Processing* 2013 (co-*chair* L. Lefèvre), STACS *31st Symposium on Theoretical Aspects of Computer Science* 2014 (*chair* N. Portier) et les mois/trimestres thématiques MILYON : *Compilation* 2013, *Mathematical Structures of Computation* 2014 et *Resource optimization for Exascale systems : Models and algorithms* 2014[3].

Les Journées Turing de 2012[4] ont donné lieu en particulier à la remise du premier doctorat *honoris causa* en informatique de l'ENS de Lyon à L. Valiant (U. Harvard).

Depuis 2011 se tiennent les rencontres mensuelles « Curry-Howard : Calcul et Logique » qui jouent un rôle fort dans l'animation de la communauté nationale de logique informatique (`http://chocola.ens-lyon.fr`, D. Hirschkoff, O. Laurent). La conférence GRESTSI 2015, principale conférence francophone en traitement du signal et images (400-500 participants), est organisée avec le laboratoire de physique de l'ENS (co-*chair* P. Gonçalves). Au total, une grande variété d'événements.

Création des équipes Avalon, Dante et Roma. Ces changements de géométrie ont concerné presque la moitié des membres permanents du laboratoire et se sont échelonnés en plusieurs étapes, de 2009 à 2012.

Dans un contexte d'évolution des thématiques de calcul parallèle, l'équipe Graal (algorithmique et ordonnancement pour les plates-formes distribuées), qui datait d'une dizaine d'années, a évolué en deux équipes, Avalon et Roma.

- Avec Avalon, l'évolution s'est faite vers les modèles de programmation, l'efficacité énergétique, et le déploiement d'applications et de services sur un spectre très varié d'architectures.
- Roma s'est spécialisée en optimisation de ressources et ordonnancement pour les clusters et les super-calculateurs, avec une focalisation particulière sur l'algèbre linéaire.

Le conseil de laboratoire a donné son accord en mars 2010 pour que ces deux équipes soient formées en interne au LIP et entrent dans le processus de création des équipes-projets communes Inria. Ce sont des équipes centre Inria depuis début 2012[5].

Dans le même temps, avec la montée en puissance de la thématique « modélisation des systèmes complexes », l'équipe temporaire D-Net a émergé en 2010 de l'équipe Reso (protocoles et logiciels pour les réseaux haute performance). Les évolutions se sont poursuivies courant 2011 et le projet Reso est arrivé à son terme. La composante « modélisation et évaluation de performance » de cette équipe s'est regroupée avec D-Net pour donner lieu (après un passage en conseil de laboratoire début 2012) à l'équipe Dante sur les réseaux dynamiques. La composante tournée vers les protocoles et les grilles s'est naturellement adjointe au groupe Avalon qui avait émané de Graal.

Si l'équipe Roma, créée depuis 2010, a donc maintenant eu 4 ans pour trouver sa géométrie et son fonctionnement, on peut considérer que Dante et Avalon, ayant intégré chacune une partie des thématiques issues de Reso, sont encore dans une phase de construction, ou de consolidation, de leur unité scientifique.

Distinctions. P. Vicat-Blanc Primet, chevalière de la Légion d'honneur en 2010, Prix Irène Joliot-Curie 2011 et Prix Inria – Académie des sciences – Dassault Systèmes de l'innovation D. Stehlé, médaille de bronze CNRS 2012. J.-M. Muller, médaille d'argent CNRS 2013. Y. Robert, *IEEE TCSC Award for Excellence* 2014.

Initiatives d'excellence. Création du LabEx MILYON, « Mathématique et Informatique Fondamentale de Lyon » (2011-2019), sous la forme d'un projet commun et d'une structure fédérative couvrant les deux laboratoires ICJ et UMPA de mathématiques lyonnais et le LIP. Partenariat du LabEx PRIMES « Physique, Radiobiologie, Imagerie Médicale et Simulation » (2012-2020) (C. Perez, Avalon). Responsabilité de la plate forme IoT LAB (*Internet Of Things*)[6] au sein de l'équipex FIT, « *Future Internet of Things* » (2011-2019) (É. Fleury, Dante).

Cinq start-ups ont été créées par des membres du LIP (§1.6.3) : Sysfera, 2010 (sysfera.com) ; Cosmo, 2010 (thecosmocompany.com) ; CloudWeaver/Lyatiss, 2010 (lyatiss.com) ; HiKob, 2011 (hikob.com) ; XtremLogic, 2014 (xtremlogic.com).

[3] `http://labexcompilation.ens-lyon.fr`, A. Darte ; `http://smc2014.univ-lyon1.fr`, P. Baillot, N. Brisebarre, D. Hirschkoff, J.-M. Muller, D. Pous ; `http://scheduling2014.sciencesconf.org` - `http://www.siam.org/meetings/csc14`, Y. Robert, B. Uçar, F. Vivien.

[4] `http://www.turing2012.fr`, É. Fleury, G. Villard.

[5] L'équipe-projet Inria GRAAL ayant été arrêtée au 31 décembre 2011.

[6] `https://www.iot-lab.info`

1.2.2 Axes de synergie inter-équipes

Au-delà des objectifs propres aux équipes qui regroupent les près de 120 scientifiques du LIP (chercheurs, enseignants-chercheurs, doctorants et ingénieurs), la promotion des activités du laboratoire et les échanges internes sont stimulés grâce à des lignes de force communes. Ces synergies se placent en prolongement des deux axes transverses –défis des infrastructures et informatique mathématique – du projet de 2009.

Algorithmique et informatique fondamentale. Le LIP est un acteur important en conception, analyse et mise en œuvre d'algorithmes, au travers de tous ses membres. Une compétence forte se situe dans le domaine du distribué (algorithmique fondamentale, protocoles et communication de données, calcul scientifique, etc.) et ouvre un champ d'échanges sur une majorité des équipes. Cette recherche algorithmique se prolonge sur le versant fondamental en sémantique de la concurrence.

Les domaines des graphes et de la combinatoire, en nette montée en puissance, représentent un axe fédérateur marqué entre Dante (graphes dynamiques et signal), MC2 (graphes et hypergraphes, complexité paramétrée, combinatoire des mots, dynamique symbolique) et Roma (structures discrètes et parallélisme, matrices creuses). En particulier, un séminaire commun « Graphes et structures discrètes » est très dynamique depuis 2011 et rassemble, autour d'un noyau issu de MC2, des membres des trois équipes. Compsys échange également avec MC2 sur le thème de l'algorithmique des graphes.

La complexité est un autre thème transverse à l'activité du LIP en informatique mathématique, allant de questions de complexité des problèmes dans MC2 (complexité algébrique, analogues algébriques du problème « P=NP ? ») ou Aric (algèbre linéaire, techniques de réduction en sécurité prouvée) à des questions centrées sur la complexité des programmes et des langages dans Plume (complexité implicite, langages avec borne de complexité garantie). Les points de vue des trois équipes ont des connexions avec la sécurité, connexions qui seront le thème d'une demi-journée scientifique mi-octobre 2014.

Le LIP est impliqué dans des disciplines qui ont un double ancrage informatique et mathématique avec un fort impact international et pour la plupart clefs dans le domaine de l'informatique mathématique au sein du GDR du même nom : en logique et calcul, complexité et calcul algébrique, réseaux euclidiens et cryptologie, arithmétique des ordinateurs, interprétation abstraite et optimisation polyédrique.

Les équipes Aric, MC2 et Plume, et leurs communautés à l'échelle nationale, ont des échanges favorisés par leur rôle au sein du GDR (direction du GDR, animation de groupes de travail nationaux, organisation d'écoles, etc.).

Calcul scientifique, infrastructures de calcul et de communication. Dans le domaine du calcul intensif ou calcul haute performance, ainsi qu'autour de l'internet des objets, le LIP regroupe des acteurs solides du domaine. Afin de faire face à l'accroissement de la quantité d'informations à traiter et la complexité des architectures à concevoir, les recherches visant à intégrer les aspects matériels et logiciels sont une clef. L'évolution des architectures de calcul, faites d'un assemblage de processeurs spécialisés, d'accélérateurs matériels et de multi-processeurs fortement couplés (GPU, multi-cœurs), a créé un point de convergence des travaux de plusieurs équipes. Dans ces travaux les problématiques liées au calcul vont souvent de pair avec celles des réseaux et de la communication des données. Les modèles et la simulation d'applications et d'intergiciels, le profilage et l'analyse de performances, l'ordonnancement et la consommation énergétique, se retrouvent chez Avalon, Compsys, Dante et Roma. Des recherches en optimisation et transformation de code, noyaux de calcul et bibliothèques scientifiques, sont menées chez Aric, Compsys et Roma, avec des accents en calcul numérique et une composante forte en algèbre linéaire.

Le laboratoire investit dans cette direction avec un soutien fort aux actions autour des grilles et plus récemment en développant une cellule « calcul et expérimentation » (S. Delamare[7], IR CNRS) au sein du service des moyens informatiques, par exemple avec l'achat mutualisé d'équipements multi-cœurs. En collaboration avec les initiatives fédératrices de calcul à Lyon et au sein du LabEx MILYON, des événements scientifiques sont organisés. Outre les actions LabEX *Compilation* et *Resource optimization for Exascale systems*, une journée « Regards croisés sur le calcul à Lyon » a eu lieu en 2014, un trimestre thématique calcul haute performance co-organisé avec des mathématiciens de Lyon se tiendra en 2016. Le laboratoire soutient le positionnement d'ingénieurs autour de Grid'5000, du Décrypthon et du consortium MUMPS.

Vérification, certification, validation et analyse de programmes. Face à la complexité, d'un côté des algorithmes, de l'autre des architectures cibles, une convergence s'opère entre la preuve et la génération automatique de code. Au LIP, cette convergence se retrouve en analyse et vérification de programmes scientifiques entre Aric (calcul symbolique-numérique et certification), Compsys (analyse et optimisation) et Plume (analyse et développement du versant preuve formelle). Le processus commun d'automatisation permet d'accéder à de meilleures spécifications

[7]Récruté grâce à l'INS2I en remplacement d'Éric Boix (IR CNRS), mis en disponibilité 25-1 pour la création de l'entreprise Cosmo.

et davantage de sûreté pour les programmes générés et d'introduire des composantes de vérification formelle au sein même de la chaîne de génération. D'un point de vue calcul scientifique, cela concerne la détermination, puis la certification éventuellement formelle, de propriétés numériques (bornes d'erreur, invariants numériques, etc.) et comportementales (terminaison des programmes, complexité).

L'invitation conjointe par Compsys et Plume d'A. Ben-Amram (Tel Aviv) en 2010 a permis une demi-journée thématique *Terminaison de programmes* et des collaborations entre logique et analyse statique. Des cours de M2 entre preuve formelle et arithmétique des ordinateurs sont proposés par Aric et Plume depuis 2012 et des membres des deux équipes sont impliqués dans le projet ANR *Fastrelax* (B. Salvy). Le mois thématique « *Mathematical Structures of Computation* » a été co-organisé par P. Baillot et les laboratoires ICJ et PPS sur cinq semaines (janv.-fév. 2014), dont deux semaines mises en place par Aric et Plume avec une composante commune de preuve formelle.

Santé et sciences du vivant. Sur ces thématiques, le LIP s'insère en particulier au sein du contexte lyonnais qui promeut les approches pluri-disciplinaires en modélisation de la complexité du vivant et au plus près des sciences humaines et sociales. Le rôle de l'informatique en sciences biomédicales et en simulation exige une recherche poussée pour l'abstraction des ressources vis à vis des applications, pour l'analyse et le traitement des données. Avalon et Dante ont une implication marquée du point de vue de la conception de plates-formes de service à grande échelle basées sur la mutualisation (grilles EGI, Décrypthon, etc.), par exemple au sein du LabEx PRIMES ou concernant les capacités d'imagerie *in vivo* (projet CPER), et en infrastructure pour l'internet des objets (réseaux de capteurs, équipex FIT, etc.). En modélisation, le processus de propagation est un des objets d'étude de Dante qui a par exemple conduit à mettre en place de larges expérimentations en infectiologie au sein du réseau européen MOSAR. Chez Plume, les langages à base de réécriture de graphes sont une thématique récente qui touche à la modélisation des systèmes biologiques.

1.2.3 Les équipes : évolutions et réalisations majeures

Toutes les équipes ont eu de nettes évolutions dans leur composition depuis 2009. Les arrivées de 22 membres permanents chercheurs et enseignants-chercheurs ont induit des consolidations et progressions thématiques particulièrement riches.

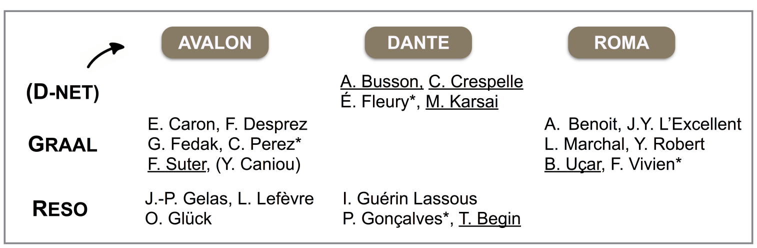

FIGURE 1.1 – *Créations de Avalon, Dante et Roma à partir de Graal, Reso et D-Net. Les arrivées 2009-2014 sont soulignées, les astérisques indiquent les responsables d'équipe.*

Nous avons vu au §1.2.1 comment à partir de Graal (resp. F. Vivien) et Reso (resp. P. Vicat-Blanc Primet puis P. Gonçalves), les trois nouvelles équipes Avalon (resp. C. Perez), Dante (resp. É. Fleury) et Roma (resp. F. Vivien) se sont constituées sur des thèmes complémentaires.

Aric (à partir de l'équipe Arénaire, resp. F. Dupont de Dinechin puis J.-M. Muller), Compsys (resp. A. Darte), MC2 (resp. P. Koiran) et Plume (resp. O. Laurent puis P. Baillot) sont les prolongements d'équipes qui existaient au 1er janvier 2009.

Aric - Arithmétique et calcul. Arrivées : G. Hanrot (PR ENS, 2009), F. Laguillaumie (PR UCBL, 2011), B. Salvy (DR Inria, 2012), D. Stehlé (PR ENS, 2012)[8]. Départ : F. Dupont de Dinechin (Mcf ENS/PR INSA). L'équipe AriC est la continuation de l'équipe Arénaire (Arénaire est devenue AriC en 2012).

Le but principal d'AriC est d'améliorer les primitives du calcul en termes de performance, efficacité et fiabilité. Nous travaillons sur les algorithmes arithmétiques eux-mêmes et leur implantation, les méthodes d'approximation, les réseaux euclidiens et la cryptographie, le calcul certifié et le calcul formel. En particulier, nous cherchons à implanter efficacement l'arithmétique virgule flottante sur processeurs embarqués, à construire des « briques de base » précises et efficaces pour le calcul numérique à partir des opérations spécifiées par le standard IEEE 754, et à rendre plus rigoureux les algorithmes et bornes d'erreur classiques. Nous cherchons à calculer des approximations certifiées en utilisant le calcul formel et en collaborant avec des spécialistes de preuve formelle, à étudier et développer des algorithmes de base du calcul « semi-numérique", à trouver des meilleures ou « presque meilleures » approximations sous des contraintes spécifiques, et

[8] D. Stehlé était auparavant CR CNRS dans la même équipe, revenu en juillet 2010 après une mise à disposition.

à développer des algorithmes efficaces pour l'algèbre linéaire exacte. Nous travaillons également à la standardisation de l'arithmétique d'intervalles. Enfin, le domaine bien établi de l'algorithmique des réseaux est revigoré par les constructions cryptographiques exploitant la difficulté des problèmes portant sur les réseaux. Nous souhaitons participer à une évolution technologique majeure, de la cryptographie « classique » vers celle basée sur les réseaux.

Réalisations majeures. Preuve de la sécurité du cryptosystème NTRU. Algorithme de réduction LLL en temps quasi-linéaire. Mise au point des techniques pour l'analyse fine d'erreurs d'arrondis de «briques de base» du calcul numérique (exemple de l'analyse de l'algorithme de Kahan pour des déterminants 2×2). Algorithme améliorant d'un ordre de grandeur la complexité du calcul de nombreuses intégrales. Dans le domaine des opérateurs arithmétiques spécialisés, N. Brunie, F. de Dinechin et B. de Dinechin (Kalray) ont déposé un brevet, *Mixed-Precision Merged Multiplication and Addition Operator*.

Avalon - Algorithmes et architectures logicielles pour les plates-formes distribuées et à haute performance. Recomposition à partir de Graal et Reso. Arrivée : F. Suter (CR CNRS, IN2P3-INS2I, 2012). Y. Caniou est parti 2 fois 2 ans en délégation CNRS au Japan-French Laboratory in Informatics (JFLI) au Japon (09/2009–09/2011 et 09/2012-09/2014).

L'objectif d'Avalon, ainsi que des équipes précédentes, est d'exécuter efficacement des applications parallèles et/ou distribuées sur des ressources parallèles et/ou distribuées telles que des supercalculateurs, des fédérations de *clouds*, ou des grilles de calcul. L'équipe Graal travaillait sur des algorithmes d'ordonnancement pour des plates-formes hétérogènes, ainsi que sur des environnements et des outils pour le déploiement d'applications. L'équipe Reso s'intéressait aux protocoles optimisés et aux logiciels pour des réseaux à haute performance ainsi qu'à l'efficacité énergétique des infrastructures à large échelle. L'équipe de recherche du centre de calcul de l'IN2P3 travaillait sur des algorithmes d'ordonnancement de workflows scientifiques et la simulation de systèmes et d'applications parallèles à large échelle. L'équipe Avalon s'attaque en particulier au profilage et à la modélisation de la consommation d'énergie et de l'accès aux données, de la gestion des données, de la simulation d'applications parallèle, de la description d'applications à base de modèles à composant, et du placement et de l'ordonnancement d'applications.

Réalisations majeures. Analyse de la consommation électrique de grappes de calcul ; développement d'un environnement logiciel de mesure de la consommation énergétique des centres de calcul ; développement d'un environnement complet pour la simulation et l'analyse d'applications parallèles MPI ; algorithmes de gestion des ressources pour réduire la consommation d'énergie ; modélisation de la sécurité pour le placement dans des *clouds* ; définition d'un modèle de composants génériques, hiérarchiques, à base de connecteurs ; standardisation de la gestion des données pour le GridRPC ; co-fondation de la société SysFera.

Compsys - Compilation, systèmes embarqués et calcul intensif.

Arrivées : C. Alias (CR Inria, 2009), L. Gonnord (Mcf UCBL, 2013), prolongation P. Feautrier (PR ENS, éméritat 2009, 2013), T. Yuki (CR Inria, 2014). Départ : F. Rastello (CR Inria, 2013).

Le but de Compsys est de développer des techniques d'analyse et d'optimisation de code, permettant d'aider à la programmation et à la conception de systèmes de calcul « embarqués » (par opposition au calcul à haute performance à grande échelle). L'équipe se concentre sur les optimisations de bas niveau (back-end) pour processeurs embarqués et les transformations de haut niveau (front-end, principalement source à source), en particulier pour la synthèse d'accélérateurs matériels (FPGA). Les activités récentes marquent une évolution vers la compilation pour les accélérateurs programmables (GPU, multi-cœurs), l'analyse de langages parallèles, les liens avec l'interprétation abstraite et la terminaison de programmes. Les caractéristiques de Compsys sont l'utilisation de méthodes formelles et algorithmiques (sur les graphes, de programmation linéaire, ou polyédriques) pour traiter de problèmes d'analyse et optimisation de codes (par ex. terminaison, allocation de registres, optimisations mémoire, ordonnancement, génération d'interfaces) et la validation de ces techniques par le développement d'outils de compilation.

Réalisations majeures. Analyses et optimisations de code (agressives et just-in-time) liées à SSA (Static Single Assignment) : sortie de SSA, analyse de vivacité rapide, propriétés structurelles, allocation de registres basée sur SSA. Analyses polyédriques pour le déport de noyau de calcul et compilation de réseaux de processus : application à la synthèse de circuits. Analyse polyédrique pour prouver la terminaison et estimer la complexité de programmes irréguliers. Analyse polyédrique de langages parallèles comme X10 (non-déterminisme) ou OpenStream (interblocages).

Dante - Réseaux dynamiques. Arrivées : M. Karsai MdC ENS de Lyon / Chaire Inria (2013), A. Busson Prof UCBL (2012), C. Crespelle MdC UCBL (2010), T. Begin MdC UCBL (2009). Départs : G. Chelius (CR1 Inria, 2011, start-up HiKoB), P. Vicat-Blanc Primet (DR Inria, 2010, start-up Lyatiss).

Les contours scientifiques de Dante sont le fruit d'une réflexion commune menée entre des membres de l'équipe D-Net et de l'EPI Reso. Bien qu'à l'origine portés par des motivations distinctes, les travaux des deux équipes se retrouvent sur la nature des objets étudiés et partagent le même besoin de mieux comprendre les mécanismes dynamiques qui les transforment. C'est cette convergence qui nous a amenés à associer nos efforts pour mettre au service de l'étude des « réseaux dynamiques », la complémentarité de nos approches et de nos compétences : théorie des graphes, traitement du signal, évaluation de performances et algorithmique distribuée.

Réalisations majeures. Nous avons contribué à des domaines tels que la qualité de service dans les protocoles de transport de l'Internet avec des travaux sur les protocoles de transport très haut débit, sur les processus de contrôle de congestion notamment en prenant en compte la notion de flux (et non plus uniquement de datagramme) et sur le partage de bande passante dans les réseaux radio. Nos contributions sont aussi dans le domaine de la métrologie avec des avancées majeures sur la caractérisation des longues dépendances dans les trafics Internet agrégés. Nous avons notamment caractérisé les grandes déviations des flux TCP de longue durée. Dans le domaine des réseaux de capteurs, nous avons contribué à la conception, production, programmation et déploiement des réseaux de capteurs sans fil large échelle avec des applications déployées in situ à très grande échelle (domaine médical) et des plates-formes expérimentales hautement innovantes (SensLAB et EquipEx FIT IoT LAB). Nos recherches se sont réorientées vers la modélisation des réseaux dynamiques et nous avons proposé des algorithmes de détection de communautés recouvrantes et dynamiques ; plus récemment nos travaux mettent en avant un domaine prometteur lié au traitement du signal sur graphes.

MC2 - Modèles de calcul, complexité et combinatoire. Arrivées : S. Thomassé (PR ENS, 2011), N. Aubrun (CR CNRS, 2012), M. Rao (CR CNRS, 2011), N. Trotignon (CR, CNRS, 2011), et spécifique P. Arrighi, Mcf UJF, dans l'équipe depuis septembre 2009 grâce à divers supports, départ en septembre 2014 pour un poste PR à Marseille. Départ : É. Rémila (Mcf IUT Roanne, 2012 PR Saint-Étienne).

Les principaux centres d'intérêt de l'équipe sont la complexité algorithmique, la conception d'algorithmes et la combinatoire. Un objectif important est de comprendre les possibilités et les limitations des algorithmes efficaces. Pour cela nous concevons et analysons des algorithmes, et nous établissons des résultats d'impossibilité (de complétude, ou même quand cela est possible des bornes inférieures inconditionnelles). Nous étudions également des objets combinatoires tels que les graphes, les mots et les pavages d'un point de vue algorithmique et structurel. L'étude de divers modèles de calcul permet de mettre l'accent sur différentes caractéristiques des algorithmes (séquentiels ou parallèles, synchrones ou asynchrones, déterministes, probabilistes ou quantiques...). Parmi les nombreux domaines des mathématiques qui peuvent contribuer à cette recherche, l'équipe s'intéresse particulièrement à l'algèbre et à la combinatoire. Ils sont tous les deux à la fois une source de problèmes d'une importance centrale en complexité (par exemple le calcul du permanent d'une matrice ou la coloration de graphes), et une source d'outils pour l'étude de la complexité des algorithmes.

Avec les recrutements récents, MC2 est devenue l'une des principales équipes françaises en combinatoire, et particulièrement en théorie et algorithmique des graphes. Pour cette raison, nous avons ajouté le mot-clé « combinatoire » au nom de l'équipe tout en conservant l'acronyme MC2.

Réalisations majeures. Nous avons contribué à des domaines tels que la théorie et l'algorithmique des graphes ; la théorie des nombres (conditions sur l'existence d'hypothétiques nombres premiers parfaits impairs) ; la combinatoire des mots et la dynamique symbolique ; l'algorithme $(\min, +)$ et ses applications aux systèmes embarqués ; la complexité du « compressed sensing" ; la réduction de profondeur pour les circuits arithmétiques ; l'étude des polynômes creux d'un point de vue algorithmique (factorisation), géométrique, et comme outil dans une approche du problème « VP=VNP ?". Pour plus de détails sur chacune de ces réalisations, on pourra consulter la section 6.3.1.

Plume - Théorie de la preuve et sémantique formelle. Arrivées : C. Riba (Mcf ENS, 2009), F. Bonchi (CR CNRS, 2010), P. Clairambault (CR CNRS, 2013), R. Harmer (CR CNRS, 2013), D. Pous (CR CNRS, 2012). Départs : J. Duprat (départ en retraite, Mcf ENS, 08/2011), A. Miquel (fin de détachement, 08/2013), éméritat P. Lescanne (PR ENS, 2012).

L'équipe étudie des méthodes pour l'analyse formelle de programmes et plus généralement de systèmes calculatoires, avec une approche basée sur la logique et la sémantique catégorique. Nous explorons les fondements de langages de programmation haut-niveau ainsi que l'analyse statique de programmes. Ces travaux sont menés notamment en utilisant la correspondance preuves-programmes dans le cadre du paradigme de programmation fonctionnelle, mais aussi dans des domaines comme la théorie de la concurrence et la vérification.

Dans la période écoulée Plume a évolué vers une configuration plus polarisée que par le passé, autour d'une part de la sémantique des jeux et d'autre part de la théorie de la concurrence. La formalisation au moyen de l'assistant à la preuve Coq est maintenant plus vue comme une facette de nos activités que comme une thématique en soi. Parmi les sujets émergents on peut noter l'analyse d'objets infinis au moyen de la coinduction et des coalgèbres ; la logique et les jeux pour la vérification ; et les langages à base de réécriture de graphes et leurs applications à la biologie systémique.

Réalisations majeures. Parmi les principales contributions apportées par Plume : en logique, de nouvelles applications de la notion de forcing, issue de la théorie des ensembles, à l'extraction de contenu calculatoire des preuves et à la logique monadique (MSO) ; en théorie de la concurrence, des progrès sur les systèmes de types pour garantir la terminaison et sur les notions d'équivalence pour les processus (méthodes *up to* et coinductives) ; ces dernières ont par ailleurs trouvé des applications à la théorie des automates.

Roma - Optimisation des ressources : modèles, algorithmes et ordonnancement. Arrivée : B. Uçar (CR CNRS, 2009). Départ B. Tourancheau, Graal, (PR UCBL, 2010, convention CITI puis PR UJF 2012).

L'équipe Roma s'intéresse à la définition de modèles, d'algorithmes et de stratégies d'ordonnancement qui permettent d'optimiser l'exécution des applications de calcul scientifique exécutées sur des plates-formes de calcul haute-performance. Plus spécifiquement, Roma cherche à obtenir la « meilleure » performance possible du point de vue de l'utilisateur (par exemple, le plus court temps d'exécution) tout en utilisant les ressources à disposition le plus efficacement possible (par exemple, en minimisant l'énergie consommée). Les travaux de Roma s'étendent des études théoriques au développement de logiciel utilisé quotidiennement dans l'industrie et dans le monde académique.

Au cours de la période écoulée, deux thèmes de recherche majeurs de l'équipe sont apparus : le calcul combinatoire scientifique, autour du recrutement de Bora Uçar, et la résilience des applications.

> *Réalisations majeures.* Stratégies optimales de *checkpoint* coordonné quand les pannes suivent une loi exponentielle et asymptotiquement optimales sinon ; algorithmes hiérarchiques de factorisation QR utilisant plusieurs tuiles d'élimination ; stratégies d'optimisation multi-critères pour le traitement de flots sur plates-formes distribuées ; complexité, inapproximabilité et premiers algorithmes parallèles pour l'ordonnancement d'arbres de tâches avec contraintes mémoires ; algorithmes de couplages maximaux pour graphes bipartis pour plates-formes multi- et *many*-cœurs.

1.2.4 Thèmes émergents

Convergence « systèmes embarqués » et calcul haute performance. La dissémination des multi-cœurs et accélérateurs matériels (FPGA, GPUs, etc.) met le calcul haute performance (HPC) à « petite échelle » (par opposition aux centres de calcul et à l'*exascale computing*) à la portée du plus grand nombre, bien qu'étant toujours difficile à exploiter. Cette convergence entre l'embarqué et le calcul parallèle/distribué opère un rapprochement entre les techniques et objectifs de ces communautés, en langages, compilation, systèmes d'exploitation et environnements de programmation. Les liens avec les utilisateurs du calcul scientifique sont à renforcer, de façon à garantir la pertinence des efforts de recherche au regard des besoins applicatifs. Les équipes du LIP participent à cet effort avec des acteurs lyonnais du calcul scientifique.

Extension des méthodes polyédriques et liens avec l'interprétation abstraite. Les méthodes d'analyse/optimisation polyédriques permettent de manipuler de façon symbolique (sans les « dérouler ») des structures régulières statiques multi-dimensionnelles (boucles d'itérations, tableaux, etc.). L'extension de leurs fondements et de leurs applications est un thème de recherche réactivé depuis le développement de bibliothèques et compilateurs plus robustes et accessibles. Un pont est attendu avec les techniques d'interprétation abstraite ou d'analyse par région de tableaux.

Consommation énergétique et multiplicité des critères d'optimisation en ordonnancement. Par le passé, la performance absolue (temps d'exécution des applications) était l'unique objectif, à l'exclusion de tout autre critère d'efficacité (consommation énergétique, mémoire, réseau, etc.). Les équipes Avalon et Roma conçoivent des algorithmes, des services et des stratégies d'ordonnancement qui optimisent, dans une approche multi-critères, l'utilisation des plates-formes.

Résilience des applications. Les plus puissants super-calculateurs mondiaux sont actuellement victimes de l'ordre d'une panne par jour. Les applications exécutées sur de telles plates-formes doivent obligatoirement mettre en œuvre des techniques de tolérance aux pannes. Roma a donc commencé à étudier la modélisation des mécanismes de tolérance aux pannes existants et l'optimisation de leur mise en œuvre.

Sémantique et vérification. Une évolution récente en sémantique et en théorie de la preuve consiste à revisiter certains concepts et méthodes standard, comme les sémantiques de jeux et les transformations de preuves, en vue de leur application à la vérification de programme, automatique ou interactive. Ceci conduit en particulier à étudier des logiques comme la logique monadique et le μ-calcul, et à rapprocher les méthodes sémantiques des automates et du *model-checking*. Cette direction se développe actuellement dans l'équipe Plume suite aux recrutements récents.

Calcul symbolique-numérique, certification, analyse de programmes et preuve. Les calculs numériques sont effectués de plus en plus efficacement, grâce aux progrès du calcul haute performance et des bibliothèques numériques. Cependant, dans la plupart des cas, la validité ou la qualité des approximations qui sont renvoyées est difficile à certifier, ce qui pose problème pour des applications critiques. L'approximation rapide et fiable est un défi de recherche à long terme traité par Aric avec la preuve assistée par ordinateur comme un des outils clef. L'équipe MC2 s'implique également en vérification automatique par exemple pour la preuve de conjectures et la recherche de contre-exemples en combinatoire et complexité.

Complexité de communication. L'équipe MC2 développe des algorithmes pour la coloration des graphes parfaits (algorithmes combinatoires et algorithmes basés sur des méthodes polyédrales et des formulations étendues du polytope des stables). Ces chercheurs ont remarqué que les outils structurels qu'ils utilisent s'appliquent aussi à la construction d'ensemble de coupes, ce qui rejoint des questions en complexité de communication (ex : coupes pour séparer les cliques et les stables). Le recrutement d'O. Fawzi amène le thème de la communication quantique, et tout récemment la complexité de communication se révèle un outil prometteur pour aborder des questions de pavages.

Réseaux euclidiens et cryptographie. Les primitives cryptographiques fondées sur les réseaux euclidiens jouent un rôle fondamental en cryptologie à clé publique depuis ces 5 dernières années ; elles permettent en particulier des constructions nouvelles, résistent à ce jour aux attaques quantiques et admettent des preuves de sécurité plus clairement fondées. Au sein du LIP, ce thème est porté dans l'équipe Aric (ERC LattAC, Package PALSE). L'objectif est de développer des primitives plus efficaces, aux fonctionnalités étendues, et dont les niveaux de sécurité en fonction des paramètres soient bien compris au prix d'une étude algorithmique approfondie des problèmes sur lesquels se fondent les preuves de sécurité.

Langages pour les systèmes complexes. Cette voie est ouverte par les travaux de Russ Harmer sur les langages à base de règles, en particulier le langage Kappa, inspiré de la réécriture de graphes. Ce langage est utilisé en biologie systémique, où il permet la représentation et la simulation d'une large classe de systèmes intra-cellulaires. Un projet DARPA (*Big Mechanism programme*) avec Harvard Medical School débute sur ce sujet.

Traitement du signal et science des réseaux. S'agissant de structures (réseaux représentés par des graphes), la dynamique temporelle des interactions peut sans doute être décrite par un ensemble de paramètres structurels (connectivité, poids des liens, longueur de chemins, etc.) dont on observerait l'évolution au cours du temps. Mais cette approche « naïve » masque en grande partie la nature même de l'objet étudié en n'exploitant pas la dimension topologique du réseau. Les outils du traitement du signal permettent, par exemple pour la vidéo, de dépasser cette vision étriquée. Nous souhaitons, dans le même esprit, définir des méthodes d'analyse adaptées aux interactions en réseaux et capables d'en caractériser fidèlement la dynamique.

Réseaux dynamiques et sciences sociales. Nous souhaitons arriver à conjuguer les efforts conjoints des sciences sociales et des sciences dites « dures » afin de développer les concepts et les formalismes théoriques adaptés pour mesurer, analyser et modéliser la dynamique des réseaux sociaux (au sens large). Le défi scientifique central, commun à la sociologie et à la science des réseaux, est de mieux comprendre les évolutions simultanées et les interactions mutuelles qui se déroulent à la fois entre les individus et au cœur des macrostructures.

1.2.5 Profil d'activités

Le profil d'activité est très homogène d'une équipe à l'autre. On obtient globalement : 50% du temps dédié à la recherche ; 23% à la formation par la recherche essentiellement pour les doctorants et l'animation scientifique autour des doctorants ; 20% à l'encadrement, l'administration et l'animation pour la recherche ; 7% aux interactions avec l'environnement social dont beaucoup de transfert et de vulgarisation.

1.3 Présentation du laboratoire : organisation et vie de l'unité

1.3.1 Composition

Sur la période début 2009 - juin 2014, le LIP a vu son effectif permanent augmenter d'un tiers. Avec 30 arrivées et 13 départs, le laboratoire est en effet passé de 49 à 66 membres statutaires. On compte d'une part 14 chercheurs et enseignants-chercheurs supplémentaires (22 arrivées et 8 départs) ce qui reflète un très bon niveau d'attractivité[9]. D'autre part, une politique appuyée pour stabiliser une équipe solide d'ITA et l'investissement de nos partenaires nous amènent à 3 membres ITA nouveaux (8 arrivées et 5 départs, voir §1.3.3). Cela conduit à une proportion au sein du LIP de 43% de scientifiques permanents, avec 22% de chercheurs et 21% d'enseignants-chercheurs (dont deux professeurs émérites), et de 9% pour le personnel administratif et technique (Figure 1.2).

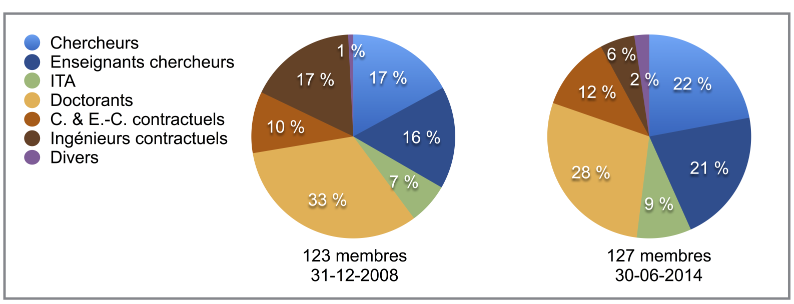

FIGURE 1.2 – *Effectif global du LIP : l'augmentation du nombre de permanents et la baisse du nombre des ingénieurs contractuels se compensent.*

Le nombre de doctorants s'établit en moyenne sur la période 2009-2014 au-dessus de 40, ce qui correspond à une proportion d'environ 1/3 des membres du laboratoire. Toutefois, nous le verrons un peu plus loin, ce nombre présente une grande variabilité. Le nombre de chercheurs temporairement au LIP (ex : délégations) et de chercheurs contractuels (ex : ATER et post-doctorats) est en augmentation et s'établit pour l'instant à 15 en 2014, soit une proportion de 12% de l'effectif total. Une évolution notable concerne l'effectif en ingénieurs contractuels qui est passé de 21 à 7. Une grande partie des embauches en début de période l'était sur des projets en lien avec les créations des start-ups.

[9] Ces décomptes ne prennent pas en compte les résultats de la campagne emplois 2014 et les prises de fonction d'un CR CNRS (Plume), d'un Mcf ENS (MC2) et d'un CR Inria (Compsys) au LIP en septembre-octobre 2014.

Les variations du nombre de doctorants et la nette diminution du nombre d'ingénieurs contractuels ont été équilibrées par l'augmentation du nombre des permanents. De ce fait, l'effectif du LIP a été globalement stable sur toute la période, avec entre 120 et 130 personnes[10]. Il découle que l'on anticipe une augmentation assez nette de l'effectif dès la fin 2014.

Recrutements. On détaille ici selon les 4 partenaires CNRS, Inria, ENS et UCBL, la figure 1.3 donne les cumuls de 2009 à juin 2014. Les équipes MC2 et Plume ont bénéficié d'une nette attractivité et du soutien du CNRS avec 3 recrutements CR (N. Aubrun, F. Bonchi, P. Clairambault)[11], 4 mutations CR (R. Harmer, D. Pous, N. Trotignon, M. Rao) et 2 promotions DR (P. Baillot, O. Laurent). Cette progression a permis de mener à bien la politique identifiée en 2009 pour renforcer MC2 et consolider Plume. L'arrivée CR de B. Uçar dans Roma a renforcé l'activité en algèbre linéaire creuse. La collaboration avec l'IN2P3 a conduit à la bi-localisation de F. Suter (CR CNRS) entre le centre de calcul de Lyon et le LIP en soutien pour Avalon, sur une interface production/recherche en calcul haute performance et traitement de données.

Au-delà d'un resserrement national pour les postes CR Inria, sans recrutement au LIP depuis celui de C. Alias (Compsys) en janvier 2009[12], Inria a eu un investissement marqué pour le laboratoire avec les promotions DR de C. Perez (Avalon), F. Vivien (Roma) et P. Gonçalves (Dante), ainsi qu'avec la mutation DR de B. Salvy chez Aric en appui en calcul algébrique et hybride symbolique-numérique.

En collaboration avec les départements informatiques de l'ENS de Lyon et de l'UCBL, le LIP a bénéficié des recrutements de 11 (+1 en 2014) enseignants-chercheurs. Le recrutement externe est une clef de la politique du LIP et pour 10 (+1) de ces postes, ce sont des scientifiques non-lyonnais qui ont été accueillis.

Sans profil thématique *a priori*, l'objectif, avec les 3 postes PR à l'ENS, était la valeur scientifique et la capacité à s'investir en encadrement de l'enseignement et de la recherche, ce qui a conduit aux recrutements de G. Hanrot, S. Thomassé et D. Stehlé. Le développement d'un pôle en réseaux euclidiens et cryptographie – qui se dessinait depuis quelques années – a été déterminant pour le choix de D. Stehlé qui était CR CNRS au LIP (dont 2 ans en détachement Macquarie U. & U. Sydney). Les 2 postes Mcf ENS[13] ont été des opérations spécifiques ciblées pour la solidité de Plume avec C. Riba (chaire ENS-CNRS) et en appui aux thématiques pluri-disciplinaires de Dante avec M. Karsai (chaire ENS-Inria). Le principe des chaires a été à plusieurs reprises discuté au sein du laboratoire et ne fait pas l'unanimité. L'intérêt des candidats et des établissements a cependant primé au final.

Une nette orientation politique du département informatique et les besoins en enseignement à l'UCBL (département informatique, IUT et ISFA – Institut de Science Financière et d'Assurances) ont conduit à des ouvertures de postes profilés en recherche y compris au niveau PR. Cela s'est traduit au LIP par une politique d'équilibrage volontariste entre les équipes qui rentraient dans les thèmes : T. Begin (Mcf, Reso puis Dante), A. Busson (PR, Dante), C. Crespelle (Mcf, D-Net puis Dante), L. Gonnord (Mcf, Compsys), F. Laguillaumie (PR, Aric).

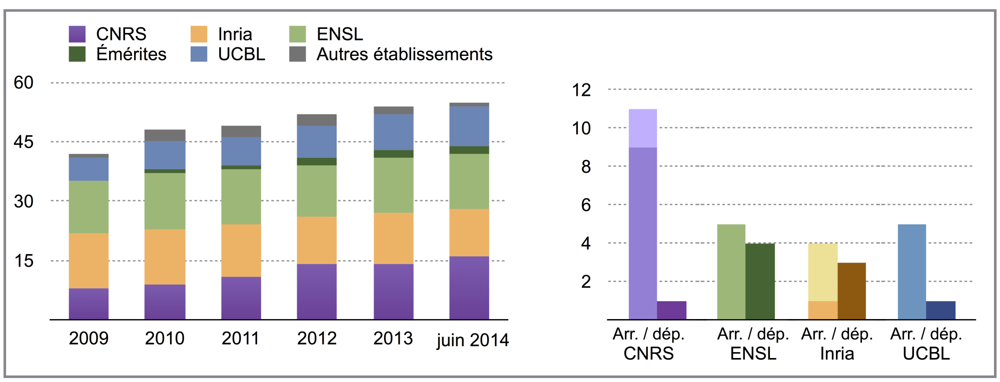

FIGURE 1.3 – *Évolution des nombres des chercheurs et EC permanents : +14 avec 22 arrivées[14] (+3 en oct. 2014) et 8 départs[14] (-1 en oct. 2014). À droite les parties claires des bâtonnets correspondent aux promotions DR.*

Les soutiens marqués de nos partenaires ont permis d'asseoir la politique d'une représentation relativement équilibrée des établissements et des organismes au sein du LIP puisqu'en effet les permanents sont à 30% CNRS, 30% ENS, 23% Inria et 17% UCBL à la rentrée 2014. Une vision globale des compositions des équipes est donnée à la figure 1.4. Les équipes-projets communes Inria représentent environ 70% des scientifiques du laboratoire.

[10]Ce concours de circonstances a en particulier permis d'éviter une situation excessivement tendue pour le taux d'occupation des locaux (voir §1.3.6).

[11]M. Mio prendra bientôt ses fonctions CR CNRS en vérification des systèmes probabilistes, dans l'équipe Plume.

[12]Tomofumi Yuki vient toutefois d'être recruté CR Inria pour la rentrée 2014 en compilation et calcul haute performance dans Compsys.

[13]Le poste 2014 qui n'était pas profilé va conduire à la prise de fonction à la rentrée d'O. Fawzi pour MC2 en complexité et informatique quantique.

[14]Les postes d'« autres établissements » correspondent à É. Rémila, Mcf IUT Roanne puis PR Université Jean Monnet en 2012 ; P. Arrighi, Mcf UJF sous convention LIP-LIG 2009-2014 puis PR Aix-Marseille Université rentrée 2014 ; A. Miquel, Mcf Paris 7 en détachement 2009-2013, puis PR U. de la República, Montevideo en 2013. P. Feautrier et P. Lescanne, PR ENS puis PR émérites, ainsi que D. Stehlé, CR CNRS puis PR ENS, apparaissent dans les bâtonnets à droite mais pas dans les 8 départs du laboratoire.

Concernant l'évolution générale, les recompositions et les recrutements ont permis à l'ensemble des équipes d'atteindre une taille assurant une certaine stabilité et un large potentiel d'évolution. La difficulté du recrutement sur les aspects mixtes informatique fondamentale/mise en œuvre du calcul nécessite néanmoins une attention particulière à long terme (voir l'analyse SWOT au §1.8). Cinq nouveaux professeurs portent le nombre de PR à 9 (et 2 émérites) et 6 nouveaux DR portent le nombre de DR à 10. La proportion des rangs A qui était de l'ordre d'un quart en 2009 va passer à un tiers fin 2014. Relativement aux incertitudes dans plusieurs équipes en 2009, c'est un aspect très positif qui facilite les projections sur plusieurs années et permet une meilleure répartition des responsabilités au sein du laboratoire.

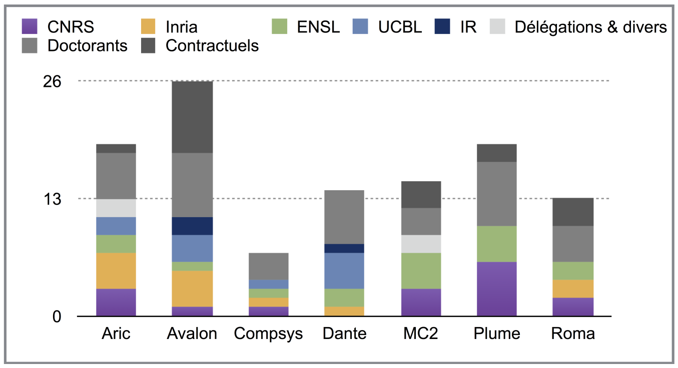

FIGURE 1.4 – *Répartition des personnels scientifiques selon les équipes, juin 2014.*

Doctorants. Un peu plus d'une centaine de doctorants ont été présents sur la période 2009-2014 ou sont présents au LIP et 56 thèses ont été soutenues. Le nombre de présents par année fluctue très sensiblement autour de 40-50. On voit toutefois à la figure 1.5 (en sommant les arrivées annuellement) que l'investissement en formation et encadrement peut être lissé, l'effectif des doctorants et celui des personnels contractuels notamment ingénieurs se complètent en un nombre d'arrivées stable de 40-45 collaborateurs chaque année.

La moyenne des durées des thèses soutenues depuis 2009 a été de 3 ans et 3-4 mois (seules 3 thèses ont duré plus de 4 ans). Les supports d'emploi sont à 80% des contrats doctoraux publics ou sur ressources propres (sur 94 thèses prises en compte). Les contrats spécifiques normaliens représentent un petit quart du total (37% sur la précédente période)[15]. Huit thèses ont été sous financement étranger et six thèses se sont déroulées directement avec l'industrie. De manière générale le LIP a su diversifier ses sources de financement.

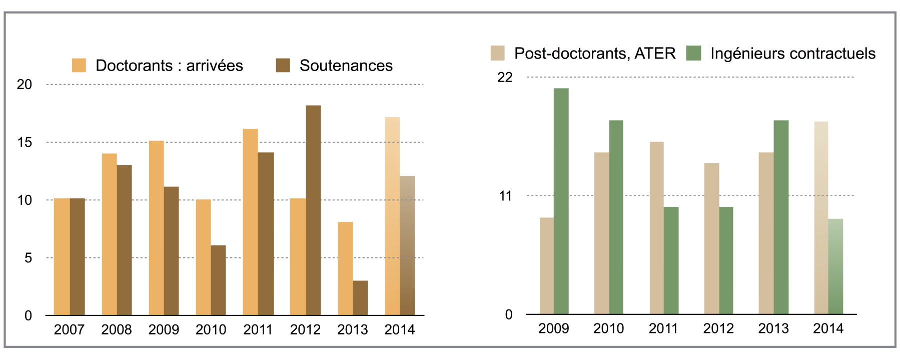

FIGURE 1.5 – *Arrivées et soutenances des doctorants, scientifiques contractuels (projection très probable pour 2014).*

Outre le contexte global national et international pour les doctorants, les incertitudes reliées à la recherche de financements et une nette tension pour ces derniers, par exemple à l'école doctorale ou à la région, sont des éléments qui concourent au fait que le nombre des doctorants au LIP n'ait pas suivi la progression du nombre de permanents. Dans ce contexte difficile le laboratoire a mis en place, avec le département d'informatique de l'ENS et le LabEx MILYON, une politique visant à dynamiser la mobilité entrante (soutien aux échanges internationaux, création de bourses de master DI-LIP en 2013, contrats doctoraux LabEx en 2014, etc.).

On compte 8 HDR soutenues sur la période, ce qui donne 26 membres habilités au sein du LIP, soit 47% des permanents. Sachant que 59% de ces derniers seront âgés de plus de 40 ans en 2014, la proportion d'habilités devrait encore augmenter. Le laboratoire garde une attitude incitative dans cette direction ce qui permet notamment à de nombreuses thèses d'être encadrées (via les systèmes d'accréditation de l'ENS et de l'UCBL) ou co-encadrées par des membres non HDR. Le taux d'encadrement, soit le nombre de doctorant par membre habilité, est de 1.4.

[15]Évolution probablement à rapprocher de la politique récente du département informatique de l'ENS, politique d'ouverture conduisant à limiter à 1/3 d'une promotion le nombre de contrats spécifiques financés sur le site lyonnais.

La qualité de notre formation doctorale se traduit par le fait que parmi 63 doctorants ayant soutenu de 2007 à août 2012[16], 19 ont été recrutés chargés de recherche ou maîtres de conférences en France, 5 au sein du système universitaire à l'étranger, 3 sont PRAG ou dans l'enseignement secondaire. Ces trois catégories représentent 43% du total (c'était 60% de 2000 à 2009). Un peu plus de 14% sont actuellement sur des postes académiques temporaires en France ou à l'étranger. Enfin, la proportion d'ingénieurs au sein de grands groupes comme Facebook, Google, Intel ou Orange, à l'ONERA et au sein de SS2I ou des start-ups issues du LIP est de 40%.

Chercheurs et ingénieurs contractuels. Avec les prévisions pour la fin 2014, on voit s'affirmer à la figure 1.5 l'augmentation du nombre de scientifiques contractuels (hors ingénieurs) après la thèse, avec un nombre annuel de 15-20. Le positionnement du LIP à l'interface de l'informatique fondamentale et de recherches davantage appliquées et orientées transfert se traduit également par presque 50 contrats d'ingénieur au total (80 hommes-années). En particulier, un gros investissement à été mis en œuvre sur la période 2009-2010 qui a conduit aux 4 premières start-ups. La période 2012-2013 fait également ressortir les actions reliées à l'internet des objets et à l'EquipEx FIT.

Ressources humaines. La période 2009-2014 a vu la mise en place de la LRU et a augmenté la diversité des sources de moyens avec en particulier les initiatives d'excellence ou localement l'Université de Lyon. La latitude budgétaire et les moyens de recrutement en CDD ont des facettes très positives par exemple pour l'attractivité à l'étranger, pour la politique scientifique et pour laisser plus de liberté sur les natures des emplois offerts (doctorats, chercheurs, ingénieurs).

Ces aspects croisent toutefois un contexte national tendu pour l'emploi permanent académique et plutôt générateur d'emplois à durée limitée. Sur la période 2009-2014, le laboratoire et les services ont dû être très rigoureux, et davantage créatifs et réactifs pour l'équilibrage des divers moyens financiers à court et plus long terme en RH (type d'emploi, niveaux de salaires, durées des contrats, etc.). Cela demande également de la solidité dans l'accompagnement des situations individuelles. Avec la création du contrat doctoral en 2009, nos établissements partenaires ont rapidement fait évoluer leurs règles dans le sens de l'amélioration du statut des doctorants. Tous les doctorants sont financés au moins jusqu'à la date de soutenance[17]. Pour les stagiaires étrangers, le LIP a adopté un cadrage interne qui suit un cadrage Inria de financement à hauteur de 1100€[18]. Les règlements administratifs rendent hélas souvent très difficile l'application de ce cadrage, hormis dans le contexte d'Inria qui travaille avec Campus France.

Attractivité internationale. De 2009 à 2014, le LIP a accueilli près de 140 visiteurs étrangers, dont 67 pour une durée d'au moins deux semaines, sur ressources propres ou sur les mois obtenus annuellement en « professeurs invités » de nos partenaires et du LabEx. De l'ordre de 60% des post-doctorants sont étrangers. La proportion est de 30% pour les doctorants, dont 2/3 de l'Union européenne ou du Maghreb. Sur la période 2009-2014, on peut compter un peu plus de 200 stagiaires au LIP, dont la moitié en fin d'études, M2 ou période doctorale (3 doctorants étrangers en visite longue). De l'ordre de 40% de ces étudiants sont étrangers, de 27 pays différents. Parmi ces étudiants, 26 roumains ont été accueillis, le département d'informatique de l'ENS et le LIP ayant notamment développé une collaboration avec l'Université Technique de Cluj-Napoca. On retrouve également 8 stagiaires de nationalité indienne et 7 de nationalité vietnamienne.

1.3.2 Gouvernance

Le laboratoire est organisé en 7 équipes, le service des assistant-e-s et des moyens informatiques. Le pilotage est assuré par le directeur et une direction adjointe. Le pilotage du laboratoire s'appuie sur l'*assemblée des responsables d'équipe* et le *conseil de laboratoire*. L'*assemblée des responsables d'équipe* (les 7 responsables et la direction) se réunit très fréquemment avec notamment des rôles d'éclairage et d'expertise scientifique auprès de la direction, d'aide à l'arbitrage pour les moyens humains et matériels, d'interaction rapide entre les équipes et la direction. Le *conseil de laboratoire* (10 membres élus, les responsables d'équipes sont nommés) qui se tient de l'ordre d'une fois par mois, formé une à deux fois par an en assemblée générale, est en particulier consulté pour les décisions stratégiques tant sur le plan de la vie interne que pour les enjeux liés au contexte de la recherche.

Le LIP est doté d'une *commission des habilités* (les membres HDR du laboratoire), coordonnée par J.-M. Muller et F. Vivien, puis F. Vivien et A. Busson après 2013. Cette commission et ses responsables ont en charge l'accompagnement, le suivi, les interactions avec l'école doctorale et plus généralement tous les sujets concernant les doctorants (voir §1.7). (Les liens du laboratoire avec les départements d'enseignement de l'ENS et de l'UCBL seront présentés au §1.4.) Pour les recrutements de personnels en CDD ou temporaires (ex : contrats doctoraux, post-doctorats, ATER conjointement avec les départements), des *commissions ad hoc* sont formées. La représentation des équipes est assurée en encourageant l'investissement de membres autres que les responsables. Ces instances se complètent de commissions traitant de sujets spécifiques : une *commission locaux* (6 membres du LIP et la direction), une commission des *correspondants in-*

[16] Choix de période pour identifier le devenir à deux ans.

[17] Si nécessaire avec une aide au moins partielle du laboratoire.

[18] Ce financement peut être multiforme : bourse perçue par ailleurs, prise en charge du billet d'avion, du logement, etc. en particulier pour pallier les difficultés administratives liées à ce niveau de rémunération.

formatiques (1 correspondant par équipe et MI-LIP) et une *correspondance bibliothèque* (P. Audebaud (Mcf ENS) puis N. Trotignon (CR CNRS)).

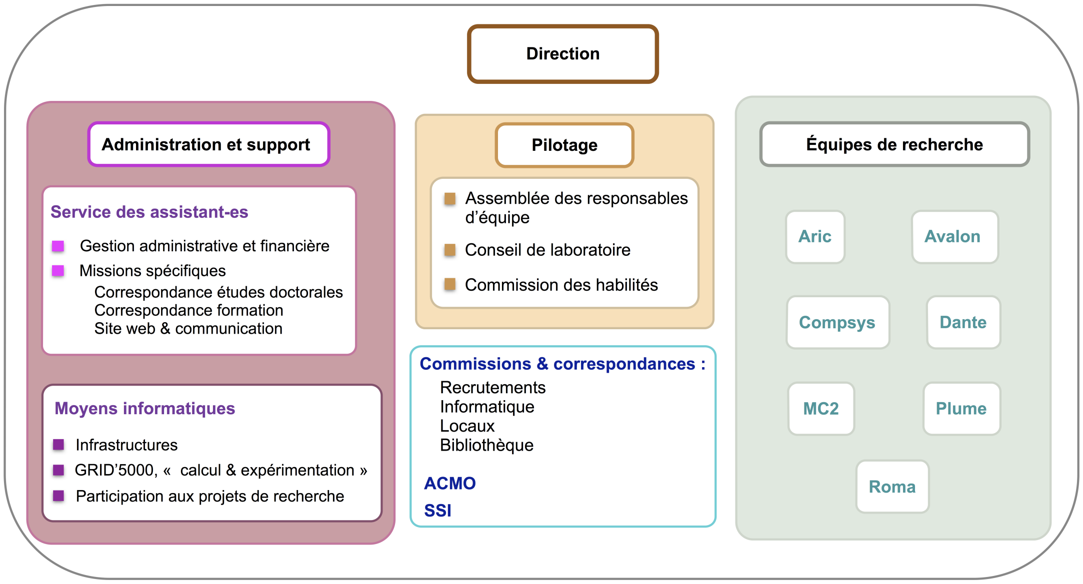

FIGURE 1.6 – *Organisation du laboratoire.*

G. Villard (DR CNRS) est directeur depuis novembre 2008. Le LIP reste dans la tradition d'un changement de direction au moment de la rédaction du nouveau projet du laboratoire. Après une campagne de changement de direction avec appel à candidature lancé en décembre 2012, un vote de confiance de l'AG du laboratoire en novembre 2013 et des échanges avec les tutelles, G. Hanrot (PR ENS) a pris la majeure partie des responsabilités au LIP en avril 2014. Il devrait être prochainement officiellement nommé directeur avec I. Guérin Lassous (PR UCBL) comme directrice adjointe. D. Hirschkoff (Mcf ENS) a été directeur adjoint de 2009 à 2012, dont une période de 9 mois en 2009 en binôme avec P. Vicat-Blanc Primet (DR Inria), suivi par G. Hanrot en 2013.

1.3.3 Administration et support à la recherche

L'administration et le support à la recherche sont organisés en deux services : le service des assistant-e-s pour l'administration, la gestion et le secrétariat des équipes et de l'unité, et le service des moyens informatiques dont les ingénieurs de recherche sont en partie en appui sur certains projets d'équipe. Le début de période en 2009-2010 au secrétariat a été assez instable et tendu. Un fort *turnover* – dans l'absolu positif puisque dû à trois promotions vers l'externe – a en effet conduit à un renouvellement complet du service. Aucune des 6 personnes présentes fin 2010 n'était présente au LIP à la mi-2009, et inversement. Même s'il a fallu ré-organiser à nouveau le service suite au départ de l'assistante de direction fin 2012 (promotion AI CNRS), le LIP connaît depuis 2011, grâce à l'investissement appuyé des tutelles, une période assez stable avec un support solide à la recherche avec 5,8 ETP (voir le récapitulatif de la figure 1.7)[19]. Ceci constitue la réalisation d'un des objectifs importants identifiés en 2009. Parmi les indicateurs de volume de travail, le budget opérationnel annuel de l'unité s'élève en moyenne à 2.4M€ et de l'ordre de 1200 missions sont gérées chaque année.

Gestionnaires d'équipe. Au fil des ré-organisations qui se sont imposées, l'unité a conservé un modèle où chaque équipe se voit affecter un-e gestionnaire d'équipe. Les assistant-e-s ont chacun-e un pourcentage de temps dédié à l'assistance et à la gestion complète pour une ou deux équipes (35-50% par équipe : budget, suivi de contrats, missions/achats, RH, indicateurs, accompagnement des arrivants, organisation d'événements scientifiques, etc.). Outre leur gestion d'équipe, les personnels se voient confier des missions mutualisées (voir ci-après). Cette organisation qui met une priorité sur le support aux équipes est également très favorable aux évolutions et aux promotions des ITA qui accèdent à des responsabilités diversifiées. La polyvalence des assistant-e-s, avec une expertise des procédures et outils sur les trois tutelles, plus éventuellement Inria, permet de minimiser les difficultés liées aux absences imprévues. Les investissements de l'ENS, du CNRS et d'Inria en personnel sont ici équilibrés. Le personnel CNRS ou ENS peut être affecté à une EPC Inria. Le personnel Inria s'investit sur des responsabilités mutualisées pour l'ensemble de l'unité.

Gestion du laboratoire et missions auprès de la direction. Suite au départ d'un agent fin 2012, l'assistance auprès de la direction et pour les suivis globaux du laboratoire (responsabilité administrative, finances, aspects inter-tutelles, etc.) est

[19] S. Boyer, IE Inria, est hébergée au LIP. Elle est responsable du service des assistantes des équipes Inria - Antenne de Lyon, et n'est pas positionnée au sein de l'organigramme du laboratoire.

		2009	2009/10	2010/11	2011/12	2012/13	2013/14
C. Desplanches	AJT puis T CNRS		•	•	•	•	•
C. Benamor	CDD CNRS					•	•
S. Morin	T CNRS		•	•	•		
M. Bozo	CDD, AJT, puis T ENS			•	•	•	•
J. Brajon	CDD ENS	•					
D. Séon	CDD puis T ENS			•	•	•	•
C. Iafrate	T ENS	•					
B. Martin-Sempore	CDD ENS		•				
L. Lécot	AJT ENS puis T Inria		•	•	•	•	•
E. Blesle	T Inria		•	•	•	•	•
M. Buillas	CDD Inria	•					
C. Suter	T Inria	•	•				

FIGURE 1.7 – *Personnel en gestion administrative au LIP de 2009 à 2014.*

assurée en binôme par M. Bozo (AJT ENS) et L. Lécot (T Inria) en attendant un recrutement AI CNRS (NOEMI hiver 2012, puis examen professionnel réservé 2013 puis mobilité interne NOEMI printemps 2014 infructueux).

Services mutualisés. Le laboratoire est doté de plusieurs services au sein desquels les personnels ITA exercent des missions transverses complémentaires à leur gestion d'équipe.

Cellule doctorants et correspondance études doctorales. Adossé à la gestion de la commission des habilités, un service géré par D. Séon (T ENS) centralise les questions d'accueil et d'accompagnement des doctorants et de suivi des dossiers avec l'école doctorale et les services correspondants des établissements.

Correspondance formation. C. Desplanches (T CNRS) est correspondante formation CNRS. À partir de la rédaction annuelle du PFU de l'unité et de son suivi, la responsabilité a été étendue depuis 2011 à un relais pour le recensement et la communication des offres et demandes de formations également avec l'ENS et l'UCBL.

Intranet et extranet & communication. La responsabilité du site du laboratoire est assurée par J.-C. Mignot (IR CNRS) en liaison avec l'ensemble des services et des personnels et plus particulièrement des chargées de l'intranet et de la communication, M. Bozo (AJT ENS) et E. Blesle (T Inria). Dans la période mouvante que nous avons connue au secrétariat, jointe à une complexification et professionnalisation des dossiers et procédures, nous devons dire que la communication actuelle du LIP n'a pas toujours été une priorité forte et qu'elle a une marge de progression au regard des services très actifs des différents partenaires.

C. Benamor assure le secrétariat du GDR Informatique Mathématique depuis la prise de fonction de directeur du GDR de J.-M. Muller début 2014.

La période a été globalement marquée par la complexification des dossiers et la multiplication des sources de financement, ce qui a rendu la gestion parfois difficile. Néanmoins, dans le contexte LRU les établissements ont su mettre en place des services compétents et réactifs sur lequel nous avons appris à nous appuyer : assistance au montage des contrats de recherche, aide appuyée sur le versant valorisation, aide à l'organisation et à la gestion d'événements scientifiques. À l'arrivée, grâce à l'aide des services mis en place il nous semble avoir réussi à gérer les difficultés et à accompagner les évolutions. Toutefois au niveau du LIP des progrès restent à faire : quant à la gestion et aux choix en amont, aux aiguillages, à l'établissement et la communication des procédures ; pour la préservation de l'information, tant sur les circuits et procédures que sur les données consolidées. Néanmoins, le fort taux de renouvellement du personnel ITA du laboratoire sur la période n'a pas permis de mettre en œuvre une vraie politique de gestion de ces flux d'information. C'est un dossier important pour la prochaine période.

Service des moyens informatiques. (Le service est abordé plus en détail en partie 9.) On comptabilise de l'ordre de 2.6 ETP dédiés aux moyens informatiques du LIP. Afin d'assurer la meilleure proximité scientifique et technique entre le service et les chercheurs, le laboratoire conduit la politique d'intégrer chacun des ingénieurs de recherche à une des 7 équipes et de permettre leur participation aux travaux scientifiques. Les 2.6 ETP correspondent aux temps spécifiquement service informatique de S. Delamare (IR CNRS), J.-C. Mignot (IR CNRS), D. Ponsard (IE CNRS) et S. Torres (IR ENS). Le service est crucial, son organisation stable et l'efficacité de ses membres permet une très bonne réalisation des missions physiquement dispersées sur trois sites géographiques en lien avec les services informatiques des différentes institutions. L'homologation du service comme CATI CNRS (Centre de Traitement Automatisé de l'Information) a été renouvelée en 2011. Sur les questions de serveurs et de réseau, pour une partie des postes de travail et pour la visio-conférence, le service administre, fournit le support aux utilisateurs, met en place et maintient les ressources et assure expertise et veille technologique. Les grands chantiers 2009-2014 ont concerné une refonte de l'organisation des services offerts aux membres du laboratoire et le début d'une globalisation concernant les évolutions du réseau et des moyens de stockage informatique, les installations des serveurs et la virtualisation, et la sécurité informatique. Faute de moyens humains adéquats, l'établissement et la mise en œuvre d'une politique de Sécurité des Systèmes d'Information du laboratoire

(PSSI) ne se sont pas développés à la vitesse que l'on aurait pu souhaiter. Le refonte 2009-2014 de notre organisation – qui était un prérequis – nous place maintenant en situation de pleinement accorder à la PSSI la priorité qui lui revient.

Plates-formes de calcul et Grid'5000. Le LIP est fortement impliqué dans des actions de plates-formes expérimentales gérées parallèlement aux infrastructures plus courantes (voir en annexe 3). Le service des moyens informatiques apporte également conseil et logistique sur ces aspects avec une cellule « calcul et expérimentation ».

1.3.4 Animation scientifique

Toutes les équipes ont un séminaire ou groupe de travail hebdomadaire annoncé et ouvert à l'ensemble du laboratoire (`http://www.ens-lyon.fr/LIP` onglet `LIP Seminars`) avec une forte proportion d'orateurs extérieurs. Ces très nombreux exposés sont une riche source d'échange entre les équipes.

Par ailleurs, au titre des initiatives inter-équipes, le séminaire « Graphes et structures discrètes » organisé en collaboration par Dante et MC2 est très actif depuis 2011. Le groupe de travail hebdomadaire de Dante est organisé en collaboration avec l'équipe Sisyphe du Laboratoire de physique de l'ENS et Dante s'implique dans le séminaire de l'IXXI (`www.ixxi.fr/?cat=8`). Un séminaire Coq a eu lieu en 2009/2010 entre Aric et Plume qui a nettement favorisé les liens des deux équipes en preuve formelle. Aric et Plume ont collaboré à la mise en place des semaines « *Mathematical Structures of Computation* » du LabEx MILYON et sont partenaires de l'ANR FastRelax (2014).

Le département informatique de l'ENS et le LIP ont pris en 2010 une initiative commune d'écoles de recherche. L'investissement des membres du LIP au sein du département conduit maintenant chaque année à des écoles très diversifiées ouvertes aussi bien aux étudiants qu'aux chercheurs (`www.ens-lyon.fr/DI/?page_id=2867`).

À l'échelle de l'ensemble du laboratoire, des journées au blanc du LIP se sont tenues en 2010, ainsi que des journées nouveaux arrivants (2011, 2011-2012, 2013). Une journée des doctorants a eu lieu en 2014 (à l'extérieur du laboratoire, sans membre permanent). D'autres occasions de rencontre importantes pour l'ensemble du laboratoire sont données par les exposés des candidats aux emplois du LIP. En particulier le LIP invite tous les candidats auditionnés sur les postes d'enseignants-chercheurs (12 postes sur 2009-2014) à exposer travaux et projets devant l'ensemble du laboratoire.

Enfin, les années sont ponctuées par les nombreux événements scientifiques locaux, nationaux et internationaux organisés à Lyon par les membres du laboratoire.

1.3.5 Moyens financiers

Le budget consolidé annuel de l'UMR est de l'ordre de 7.1M€ (évaluation hors coût de l'hébergement). En 2013 il se décompose en 4.7M€ pour le coût des fonctionnaires et personnels en CDD dont les salaires ne sont pas gérés par le laboratoire[20] et 2.4M€ de moyenne de dépenses sur ressources propres. Les évolutions qui donnent cette moyenne sont données à la figure 1.8. La figure indique également la façon dont se ventilent les dépenses en 2012 et 2013. Le poste le plus important est celui des salaires. Vient ensuite le poste des missions où on cumule l'activité des membres du LIP (déplacements pour les conférences et les projets) et les missions entrantes notamment pour les invitations, les visites de candidats, etc. Le poste équipement contient en 2013 les dépenses de l'EquipEx FIT. Outre les dépenses fixes du laboratoires, les bourses et les gratifications des stages apparaissent en fonctionnement.

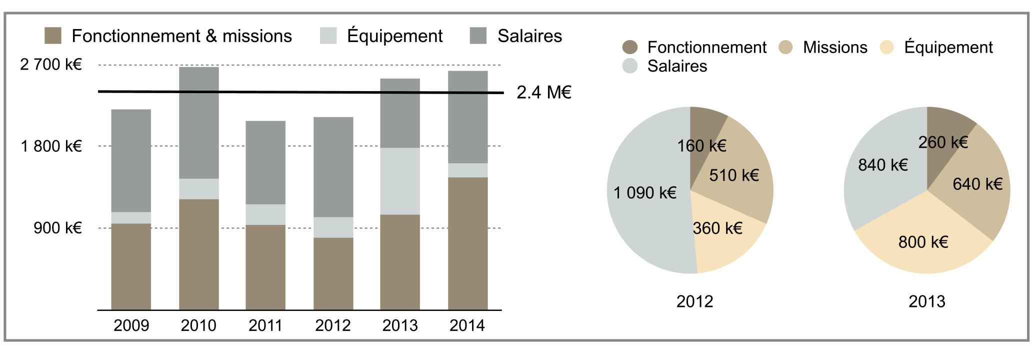

FIGURE 1.8 – *Budget opérationnel/dépenses (contrats gérés à l'avancement, au 30/06/14) du laboratoire.*

Le laboratoire n'a pas instauré de prélèvement type « impôt » sur les contrats des équipes, mais un prélèvement ENS de 15%, abondant un fonds recherche géré par l'établissement, est opéré sur les dotations CNRS, ENS et les contrats[21]. L'enveloppe moyenne de 2.4M€ consiste donc en une part gérée par la direction du laboratoire ou provenant – en partie

[20] Enseignants-chercheurs comptés à 50%. La masse chiffrée par le CNRS passe de 0.927M€ en 2009 à 1.547M€ en 2013.

[21] Le fonds étant abondé directement auprès de l'ENS par le préciput ANR, les contrats ANR sont sortis de l'assiette au niveau laboratoire, ainsi que par exemple les crédits d'intervention ou les subventions région. La quote-part Inria est reversée à l'ENS directement par le centre de recherche régional. Hors préciput ANR, les contrats du LIP abondent le fonds annuellement dans une fourchette de 100-200 k€.

sous arbitrage de la direction – du fonds recherche ou du LabEx (Figure 1.9) et d'une part gérée par les équipes. Au travers d'échanges budgétaires réguliers avec les responsables et les assistant-es des équipes, la direction conserve toute l'année une vue précise de l'ensemble des finances. Ce fonctionnement permet, d'une part d'arbitrer globalement et d'aider en prenant en compte les moyens individuels des équipes, d'autre part d'être efficace et réactif pour les crédits non utilisés et banalisés, pour réaliser des montages à partir de plusieurs sources tels que pour les CDD de chercheurs ou les investissements mutualisés.

Subventions directes et appels d'offres « locaux ». La somme des dotations du CNRS, de l'ENS et de l'UCBL est stable autour de 210k€ (avant prélèvement de 15%) depuis 2009. La dotation UCBL de 47k€ à partir de 2011 et le PPI jouvence ENS depuis 2012 ont compensé la baisse de la dotation ENS. La direction du laboratoire est impliquée de près dans les montages de projets et les arbitrages de moyens alloués sur les appels d'offres du fonds recherche ENS[22] et depuis 2011 du LabEx MILYON. Compte tenu de ces éléments d'arbitrage et en incluant les ressources propres au niveau de la direction telles que certains crédits banalisés ou des revenus d'exploitation, le budget opérationnel de la direction a été en progression du point de vue capacités de politique scientifique (Figure 1.9). Cependant, en écho à une gestion plus rigoureuse des ressources, avec en particulier la mise en œuvre de la LRU, et outre les nouvelles sources de recettes, on peut constater, sur la période, une complexité croissante de la gestion et une nette fragmentation des sources budgétaires.

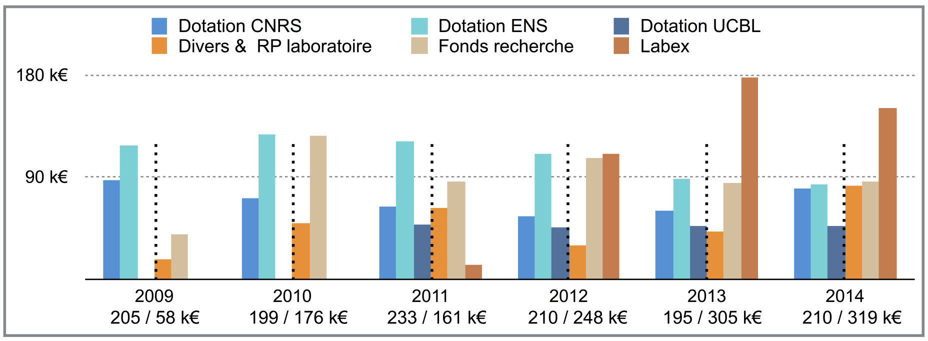

FIGURE 1.9 – *Dotations (gauche des pointillés) et budget opérationnel lié à la politique et aux arbitrages du LIP.*

Sur le budget de direction, un premier groupe de dépenses représente 60-70% du total avec les dépenses du laboratoire au jour le jour (fournitures, logistique, service informatique, déménagements, aménagements, cotisations, etc.). Cela se complète par un poste de 10-20% de reversements aux équipes au fil de l'eau (budgets de démarrage d'année, jurys de thèse, compléments de contrats, missions pour les candidats locaux à des concours extérieurs, etc.). Le troisième poste concerne pour 15-25% l'animation du laboratoire (journées du laboratoire, journées au blanc, journée des doctorants, séminaires, etc.), l'attractivité et la politique scientifique. Par exemple, tous les candidats auditionnés sur un poste sont invités à une visite du laboratoire et un « BQR » LIP sur deux ans a été instauré pour permettre l'installation des nouveaux arrivants dans de bonnes conditions. En partenariat avec le département informatique de l'ENS, le LabEx et Inria, le LIP finance des bourses de master ouvertes prioritairement aux candidats internationaux. Pour des projets co-montés avec le LabEx, le fonds recherche ou les partenaires, le laboratoire soutient les événements scientifiques et les séjours de visiteurs et a permis des financements de post-doctorats, d'ingénieurs CDD ou de type « délégation ENS ».

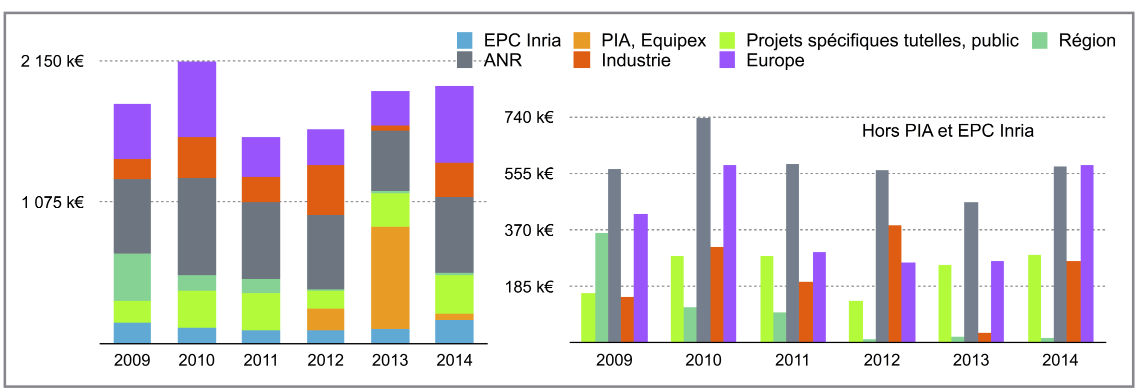

FIGURE 1.10 – *Ressources propres des équipes sur projets et contrats (à l'avancement au 30/06/14).*

Budgets des équipes. Les EPC communes avec Inria sont dotées par Inria[23] d'un budget ajusté annuellement qui a globalement fluctué sur la période entre 100 et 180k€/an. Les ressources sur projets et contrats des équipes (hors dotation

[22]Les professeurs ENS recrutés bénéficient au travers du fonds d'un budget « accueil » de 110-120k€ sur 3 ans.
[23]Équipe par équipe par le centre de recherche et indépendamment du laboratoire.

Inria), détaillées à la figure 1.10, représentent 70-75% du budget du laboratoire. La diversité des sources illustre la variété des activités et l'investissement marqué des chercheurs pour la recherche de financements.

La part et la hauteur des projets ANR sont relativement stables, cela représente un tiers du volume des contrats (faible retrait en % et augmentation en volume par rapport à la précédente période). Proprotionnellement au nombre de permanents du laboratoire le financement ANR est donc en baisse. Le pic ANR/Europe en 2010 est relié aux activités de transfert en lien avec les start-ups. L'ensemble des projets et subventions « spécifiques » nationaux et internationaux des tutelles, du public est un socle clef de plus de 22% en moyenne qui permet souvent la préparation de projets de plus grande envergure. Suite aux restructurations au niveau de la région en 2011/2012, les recherches fondamentales sont plus difficilement financées à ce niveau-là. Les subventions de l'Union européenne représentent presque un quart du total des contrats avec une reprise en 2013/2014 (ERC Stehlé et plusieurs projets). Depuis 2009, la part des contrats industriels s'établit aux alentours de 10%, c'est en légère progression par rapport à 2005-2008 et confirme l'intérêt des membres du laboratoire dans ce domaine.

1.3.6 Infrastructures

Géographiquement parlant, les équipes du laboratoire sont actuellement partagées entre trois sites :

- Le site principal, au troisième étage du bâtiment principal du site Monod (Sciences exactes et expérimentales) de l'ENS Lyon, au sein duquel se trouvent les locaux d'enseignement (amphithéâtres, salles de TD) de l'ENS, accueille 5 des 7 équipes ainsi que l'ensemble des services support et la direction.
- Un site situé dans un bâtiment recherche de l'UCBL, à 500m du premier, où les équipes hébergées changent environ tous les deux ans (à ce jour l'équipe Aric y est installée).
- L'équipe Dante est hébergée au sein de (et est l'acteur majeur de) l'IXXI, hôtel à projets pour les collaborations pluri-disciplinaires en modélisation des systèmes complexes, dans des locaux loués entre les deux bâtiments précédents. La fin du bail début 2015 devrait se traduire par un hébergement de l'IXXI au sein du site ENS.

La tri-localisation du laboratoire ne facilite pas les échanges scientifiques. Il s'agit d'une situation qui dure depuis 2008, ayant vocation à se résorber grâce au plan Campus, à un horizon actuellement annoncé fin 2017-mi 2018.

1.3.7 Hygiène et sécurité

Sous la responsabilité de Dominique Ponsard, agent de prévention (IE CNRS), en relation avec les services correspondants des trois tutelles et d'Inria, le document unique d'évaluation des risques et le plan d'action en découlant sont produits chaque année (voir en annexe 8). Le recensement, la priorisation et la mise en œuvre des chantiers et des procédures sont assurés voire inscrits annuellement au budget de l'unité. Durant la période couverte par la présente évaluation, grâce à l'aide de la direction du patrimoine et des moyens généraux (DPMG, ENS), une série d'améliorations a pu être apportée aux conditions de travail et à la sécurité dans le laboratoire (aménagement aire libre service, mise en conformité du système d'arrêt d'urgence et de câblage de la salle informatique, éclairage, insonorisation visio-conférence, travaux d'étanchéité, peinture des bureaux, etc.). Il reste une série de questions inscrites au DUER (infiltrations, distribution électrique dans les bureaux, gêne thermique) qui pourraient être traitées à court-moyen terme, notamment le cadre de l'opération Campus ENS Lyon.

1.4 Interaction avec l'environnement local, les tutelles et les structures académiques

Liens avec les départements d'enseignement et l'école doctorale. Le département Informatique de l'ENS est dirigé par des membres du LIP, qui constituent également l'essentiel des intervenants du cursus « Informatique fondamentale ». Cette correspondance département-laboratoire permet une collaboration fructueuse entre le directeur du département – É. Fleury jusqu'en 2013, puis D. Stehlé – et la direction du LIP et facilite la mise en place de projets mixtes enseignement-recherche (financement de bourses, écoles de recherche, etc. Voir §1.7). Les choix scientifiques et arbitrages pour les postes d'enseignants-chercheurs en informatique à l'ENS sont réalisés conjointement par le département et le laboratoire, en s'efforçant de maintenir la synergie entre profil enseignement et profil recherche des postes.

Les liens avec le département informatique de l'UCBL, auquel 4 laboratoires lyonnais sont rattachés, sont plus traditionnels. La politique du département conduit à échanger via des représentants UCBL des laboratoires plutôt qu'avec les directions respectives (campagnes emplois, professeur invités, soutiens aux conférences, etc.). Avec la commission recherche du département, les liens s'opèrent via I. Guérin Lassous (PR UCBL) qui est correspondante recherche pour le LIP. Le département est en particulier chargé de préparer l'arbitrage entre les demandes remontées par les différents laboratoires d'informatique de l'UCBL, et donc chargé de fait de la politique recherche de l'UCBL dans la discipline. La faible présence du LIP au sein de ce département rend parfois difficilement audible le discours du laboratoire.

La présence de Fabien Laguillaumie (recruté PR en 2012) au sein de l'ISFA[24] permet des échanges réactifs et de qualité avec cette structure d'enseignement. Les liens avec l'IUT (où un membre du laboratoire, Anthony Busson, est PR) sont peu formalisés et ils sont inexistants avec Polytech'Lyon (dont aucun enseignant-chercheur n'est membre du LIP).

Avec 6 autres laboratoires, le LIP est membre de l'École Doctorale 512 Informatique et Mathématiques de Lyon. Le responsable de la commission des habilités du LIP – J.-M. Muller (DR CNRS) puis F. Vivien (DR Inria) depuis 2013, en co-responsabilité avec A. Busson (PR UCBL) depuis 2014 – représente le LIP dans les instances de l'ED (conseil de l'ED, commission des thèses, jury d'attribution des contrats doctoraux).

Relations avec les tutelles et Inria. À l'ENS, le LIP s'inscrit au sein du pôle recherche en lien avec la vice-présidence à la recherche. La taille de l'établissement et l'hébergement permettent des liens étroits, y compris avec la présidence. Les membres du laboratoire s'investissent pleinement dans les instances de l'ENS[25]. À l'UCBL, le LIP est en liaison avec la vice-présidence du conseil scientifique et est affilié à la Faculté des Sciences et Technologies (FST), UFR créée en 2009 qui regroupe une quarantaine de laboratoires[26]. La FST dispose de moyens pour la recherche dont le LIP bénéficie (BQR, professeurs invités, soutiens aux conférences, etc.). Les réponses aux appels d'offre s'effectuent via la commission recherche du département d'enseignement (voir plus haut).

Au CNRS, le LIP est rattaché à l'INS2I. Depuis la création de l'institut en 2009, grâce aux rôles bien définis des directions adjointes scientifiques et grâce à la délégation régionale, les liens sont efficaces. Les membres du LIP sont également impliqués au sein des structures du CNRS : É. Rémila a été membre 2008-2012 du CS CNRS, S. Torres est membre 2010-2014 du CSI INS2I et I. Guérin Lassous est membre 2012-2016 du CoNRS 06. Nous avons vu que 70% des membres du LIP sont au sein d'équipes-projets communes avec Inria. Le laboratoire a grandement bénéficié de l'évolution des liens entre l'INS2I et Inria, par exemple du processus commun de création des EPC spécifié depuis 2011. Au plan de la politique scientifique, les difficultés liées au fait que le positionnement d'Inria par rapport aux laboratoires est différent de celui des autres partenaires[27] sont atténuées par une longue tradition de collaboration et grâce aux responsabilités des membres du LIP dans les instances du centre régional. Faisant suite à F. Desprez (DR Inria), É. Fleury (PR ENS) en est depuis 2013 vice-président du comité des projets et participe au bureau de direction. P. Gonçalves est correspondant scientifique pour les relations internationales. À l'échelle nationale G. Hanrot a été vice-président de la commission d'évaluation Inria de 2009 à 2011. F. Desprez est directeur scientifique adjoint à Inria, chargé du domaine Réseaux, Systèmes et services, calcul distribué, depuis 2012. Concernant les aspects de gestion administrative, le fonctionnement avec Inria est très proche de celui que le laboratoire a avec ses tutelles. Au-delà du niveau du laboratoire, la direction du LIP participe annuellement au comité de concertation ENS-Inria.

IXXI - Institut rhône-Alpin des systèmes complexes. Les membres de l'équipe Dante constituent le groupe résident le plus important de l'IXXI, É. Fleury est au comité de direction et C. Crespelle au comité de pilotage.

LabEx MILYON. Constitué de manière fédérative entre les laboratoires de mathématiques de Lyon, l'ICJ et l'UMPA, et le LIP, le LabEx a démarré ses activités en 2011. Ses objectifs sont de favoriser l'attractivité internationale des mathématiques et de l'informatique fondamentale, de développer les disciplines et leurs collaborations (voir aussi §1.5). Avec une représentation équilibrée des laboratoires au sein du comité exécutif et des commissions recherche, enseignement et diffusion, 9 membres du LIP sont impliqués dans la gouvernance de MILYON. Outre des moyens financiers, le LabEx place le LIP dans un contexte scientifique stimulant et contribue, par ses appels récurrents (bourses de master, post-doctorats, contrats doctoraux) mais aussi en encourageant l'animation scientifique (trimestres thématiques), à l'attractivité du laboratoire.

Université de Lyon. L'université et son programme PA-LSE – Programme Avenir Lyon Saint-Etienne – structure la recherche en s'appuyant sur les lauréats aux investissements d'avenir. En particulier, le programme gère et coordonne les LabEx. Dans sa politique d'attractivité, le PA-LSE émet des appels d'offre à l'échelle du site lyonnais pour des contrats doctoraux via les écoles doctorales : des post-doctorats, des bourses de mobilité internationale ou des *packages* d'accueil[28] sont arbitrés au niveau global des comités de pilotage et scientifiques du PA-LSE.

Région Rhône-Alpes. La stratégie régionale et en particulier la restructuration en « Communautés de Recherche Académique (ARC) » en 2011/2012 ont conduit à une nette baisse des budgets (moins orientés sur la recherche fondamentale) pour le LIP (Figure 1.10). Le laboratoire est rattaché à l'ARC 6, « Technologies de l'Information et de la Communication et Usages Informatiques Innovants » et a néanmoins bénéficié d'un contrat doctoral en 2014. É. Fleury et G. Villard ont participé sous l'égide de l'Université de Lyon aux groupes de travail pour la préparation du prochain CPER (2015-2020), volet recherche.

[24] Institut de science financière et d'assurances, une petite structure.

[25] Membres élus : P. Vicat-Blanc Primet a été membre du CA, J.-M. Muller membre du CS. N. Portier et F. Vivien sont membres du CS.

[26] O. Glück s'investit largement en siégeant au CEVU UCBL ; il a été responsable de la commission formation de la FST ; il siège au CS de la FST. L. Gonnord est, depuis peu, membre de la commission finances de la FST

[27] Le centre de recherche régional est d'abord en contact avec les responsables des équipes-projets plutôt qu'avec l'UMR.

[28] Moyens à hauteur de 500k€ sur deux ans pour une installation à Lyon et la structuration d'une équipe. B. Libert (Université catholique de Louvain, Crypto Group, puis Technicolor Research & Innovation) est lauréat 2014 au LIP.

1.5 Collaborations scientifiques

On pourra trouver en annexe 7 une liste des projets et contrats des équipes sur la période.

Informatique et sciences et technologies de l'information à Lyon. La période 2009-2014 a vu l'émergence de nouvelles collaborations avec le CITI (Insa de Lyon et Inria) autour de l'EquipEx FIT (internet du futur), de l'ANR MetaLibm (génération de code et arithmétique des ordinateurs) et de liens entre les équipes Compsys et Socrate. Le LabEx PRIMES – « Physique, Radiobiologie, Imagerie Médicale et Simulation » – permet à l'équipe Avalon de démarrer un partenariat fort en particulier avec CREATIS (UMR 5220). Il y a peu de collaborations directes avec le LIRIS (UMR 5205) dont les thèmes de recherche, proches et complémentaires de ceux du LIP, donnent toutefois lieu à des liens nets au sein des communautés nationales et internationales. Il y a donc un potentiel fort pour la collaboration des acteurs en STIC sur le site lyonnais. Les directions du CITI, du LIP et du LIRIS se sont fréquemment rencontrées ces dernières années dans une optique de concertation pour la discipline à Lyon, pour entreprendre des actions communes voire pour le montage d'une fédération. Même si aucun projet formel n'a pu aboutir jusqu'à présent la période à venir devrait donc être propice aux initiatives communes dans le contexte d'une COMUE Université de Lyon qui se construit pour coordonner la stratégie de recherche et de transfert sur le site.

LabEx MILYON. Les collaborations au sein du LabEx MILYON se concrétisent par l'organisation d'événements scientifiques avec les laboratoires partenaires. Début 2014 se sont tenues les cinq semaines *Mathematical Structures of Computation* organisées avec les laboratoires ICJ et PPS. Les ponts entre la recherche fondamentale de pointe en mathématiques appliquées et en informatique pour le calcul haute performance seront développés lors d'un demi-trimestre thématique au printemps 2016 avec, à Lyon, l'ICJ et le LMFA. Le LIP est partie prenante de ce trimestre (AriC, Avalon, Compsys et Roma).

À l'échelle régionale, outre les liens avec les mathématiques, le LIP s'investit sur deux aspects pluri-disciplinaires saillants des enjeux pour le numérique : à la convergence entre la simulation et le calcul intensif et autour de la mutation numérique notamment pour les infrastructures de communication et les sciences sociales. Ces ouvertures sont d'autant plus solides que les infrastructures de calcul et de communication et les sciences du vivant constituent deux des axes de synergie forte entre les équipes du LIP (§1.2.2).

Calcul intensif et simulation en sciences du vivant. Outre son implication dans le LabEx PRIMES évoquée ci-dessus, l'équipe Avalon participe à E-Biothon, une plateforme *cloud* expérimentale dédiée à la recherche en biologie, santé et environnement. Avalon collabore également avec l'Institut de Biologie et Chimie des Protéines (IBCP) sur l'utilisation et l'amélioration du squelette informatique *MapReduce* dans un contexte de production en bioinformatique au sein du projet ANR MapReduce [337]. Enfin, avec le centre de calcul de l'IN2P3 et CREATIS, Avalon travaille à l'amélioration de l'exécution des *workflows* soumis par le portail *Virtual Imaging Platform* (VIP) [259].

IXXI, sciences sociales, physique et traitement du signal. L'équipe Dante conduit au sein de l'IXXI des travaux avec des sociolinguistes (laboratoire ICAR) sur la variabilité linguistique sur Twitter. Le traitement automatique des langues et celui des données sociales par analyse des réseaux complexes se rejoignent. Dante a également des liens très étroits avec l'équipes SiSyPhe du laboratoire de physique de l'ENS en traitement du signal (ouvrages communs [751, 753], conduite de projets par exemple sur le rythme cardiaque, mise en place d'un séminaire sur le traitement de signal sur graphe).

Collaborations régionales. Il existe des liens et historiques entre le LIP et les laboratoires d'informatique de Grenoble qui se traduisent par des collaborations dans quasiment toutes les équipes.

Collaborations nationales. Les membres du LIP portent ou ont été porteurs de 14 *projets ANR*

CloudPower *Services cloud HPC*	CompA *Complexité algebrique*
COMPLICE *Complexité implicite, concurrence et extraction*	COOP *Gestion de ressources multi-niveaux*
EVA-Flo *Validation et automatisation en calcul flottant*	LEGO *Algorithmique et logiciel à large échelle*
PACE *Coinduction programmes et systèmes*	RÉCRÉ *Réalisabilité en logique, concurrence, références et ré-écriture*
RESCUE *Résilience et exascale*	SensLab *Réseaux de capteurs*
SPADES *Architectures petascale et services*	Stint *Structures interdites*
Stochagrid *Ordonnancement et modèles stochastiques*	TaMaDi *Arithmétique des ordinateurs et preuve formelle*

et participent par ailleurs ou ont participé à 25 projets. Ces collaborations impliquent de nombreux laboratoires, notamment le LAAS et le CERFACS, le LIG, le LIP6, le LIRMM, ou PPS. L'importance et le spectre de ces collaborations s'illustrent par un volume de 2.9M€ de ressources ANR sur 5 ans (1/3 des ressources propres des équipes). En calcul haute performance et autour des infrastructure de calcul et de communication, les projets PIA (EquipEx FIT, consortiums XLCloud et openCloudware), le cadre Inria des Actions d'Envergure Nationales/*Project Labs* – avec Grid'5000-Héméra (calcul distribué large échelle), C2S@Exa (calcul exascale) et Multicore – et des Actions de Développement Technologique (participation à 5 projets ADT au LIP), ont permis d'initier ou approfondir des collaborations avec un grand nombre d'équipes françaises et de projets Inria.

Projets et collaborations internationaux. Les membres du LIP publient avec des chercheurs de près 70 institutions à l'étrangers, dont une trentaine en Europe et une en Afrique, 29 en Amérique du Nord et du Sud et 9 en Asie-Pacifique. C'est une très nette progression sur toutes les zones mondiales par rapport aux 41 institutions de la période 2005-2009.

Une vingtaine de collaborations sont formalisées dans le cadre de programmes exploratoires et de programmes bilatéraux « légers » (PICS CNRS, Équipes Associées Inria, partenariats Hubert Curien, France-Japon, etc.) et on peut noter 7 thèses en co-tutelle sur la période.

L'ANR Petaflow autour des communications intercontinentales pour la simulation (Reso) était franco-japonaise. L'ANR PACE (Plume) est franco-chinoise sur la coinduction pour le raisonnement sur les programmes et les systèmes. L'équipe Plume entretient des liens étroits avec plusieurs équipes en Italie (Bologne, Pise, Turin..). Ces liens s'appuient sur des traditions scientifiques partagées en logique linéaire et théorie de la concurrence et donnent lieu à des projets communs variés (cotutelles, ANR, PICS, GDRE en préparation). Les équipes Roma et Avalon sont impliquées dans le *Joint Laboratory for Petascale Computing*, laboratoire commun à Inria, l'université d'Illinois à Urbana-Champaign (États-Unis), Argonne National Laboratory (États-Unis) et le Barcelona Supercomputing Center (Espagne). Depuis 2014, Yves Robert est le représentant d'Inria au sein de ce laboratoire.

Les financements européens représentent 24% des ressources propres des équipes avec la participation à 25 projets et consortiums et deux actions Marie Curie. Une grosse part de ces budgets se concentre en HPC, autour du déploiement sur les grilles et dans le *cloud*, et concernant l'efficacité énergétique chez Avalon avec notamment des collaborations dans le cadre des programmes FP7, COST et Celtic-Plus. Avalon est impliquée depuis 2010 dans le consortium GreenTouch qui fait interagir une cinquantaine de groupes industriels et académiques sur le domaine de l'efficacité énergétique dans les réseaux de communications. L. Lefèvre est le représentant d'Inria au sein de ce consortium, il est membre de l'*executive board* et a été *co-chair* du groupe de travail sur les réseaux filaires. Une forte activité européenne a également eu lieu dans le domaine des réseaux chez Reso puis D-Net dans le cadre des programmes FP6 et FP7.

Collaborations industrielles. L'intérêt et l'importance des collaborations industrielles au LIP s'établit au-delà de la proportion de 10% de budgets industriels sur les ressources propres des équipes. En effet, les partenaires industriels interviennent par exemple aussi dans les projets ANR et européen. En accompagnement de ces collaborations, 6 thèses se sont déroulées directement avec l'industrie (projets région, bourses cifre, contrats directs).

Inria a eu un rôle moteur de promotion, de cadrage et d'interface avec les grands industriels tels que STMicroelectronics et Alcatel-Lucent, et les pôles de compétitivité Minalogic et System@tic. Outre de nombreux contrats ponctuels, on peut citer par exemple l'axe de collaborations donné par l'embarqué avec l'arithmétique des ordinateurs (Aric), la compilation et la synthèse de circuits (Compsys). Avec l'importance des débouchés pour la conception des logiciels et des composants électroniques Aric et Compsys ont des collaborations sur plus de 10 ans avec STMicroelectronics (collaborations également avec Kalray, Alcatel-Lucent, Bosch, Orange labs, Intel). À un point de convergence entre les réseaux, les infrastructures de calcul et de service et le HPC Avalon a des collaborations actives avec BULL et EDF et un spectre large de contacts dans le cadre des divers consortiums de grilles. L'équipe Dante est nettement impliquée pour l'internet du futur notamment au sein du laboratoire Inria Alcatel-Lucent. Sur le long terme également, le logiciel et le consortium MUMPS (algèbre linéaire HPC) conduisent Roma à de riches contacts avec de nombreux industriels dont EDF, Total ou Samtech.

1.6 Réalisations

L'ensemble des réalisations est donné équipe par équipe en annexe 6 du §6.1 au §6.7.

1.6.1 Production scientifique : publications et logiciels

Publications. De 2009 à 2014, on totalise 322 articles dans des revues et 550 dans des actes de conférences avec évaluation. En partant sur une base moyenne de 50 scientifiques permanents sur la période et sur 5.5 années, cela donne un ordre de grandeur d'un peu plus de 3 publications par permanent et par an. Ce dernier chiffre est comparable à celui des années 2005-2009, la proportion des articles dans les revues a progressé de 30% à 37%[29]. Les livres[30], chapitres dans des livres[31] et travaux d'édition[32] constituent une petite centaine de publications additionnelles, auxquelles s'ajoutent les articles de vulgarisation et 65 mémoires de thèse et d'HDR.

On peut relever le prix de meilleure thèse *Research in System / ASF* décerné à A.-C. Orgerie [796] et celui d'EADS (et second prix Gilles Kahn) décerné à M. Noual [1034], les meilleurs papiers de conférence IEEE ASAP [84], ASONAM [688], CALCO [1115], CBMS [708], CGO [495], IWTAC [691], MFCS [990], HeteroPar [1235], ISPDC [1252] et le *Best demonstration award* ACM SIGMETRICS/PERFORMANCE [808].

[29]Ce point est relevé pour illustrer les ré-équilibrages thématiques du laboratoire, non pas comme indicateur qualitatif pour les publications.
[30]Ex : *Handbook of Floating-Point Arithmetic* [164], *A Guide to Algorithm Design : Paradigms, Methods, and Complexity Analysis* [1335].
[31]Ex : *Encyclopedia of Parallel Programming* [543, 544, 545, 546, 547].
[32]Ex : *Scaling, Fractals and Wavelets* [751], Réseaux de capteurs : théorie et modélisation [756], *Desktop Grid Computing Book* [424].

Logiciels. L'effort en développement logiciel au LIP est très conséquent. On pourra se reporter aux listes données dans les annexes par équipes. Il y a des projets au long cours à large impact et diffusion, parmi lesquel: DIET (`http://graal.ens-lyon.fr/DIET`) intergiciel pour le HPC en environnement hétérogène et distribué (qui est utilisé en production par exemple par la grille Décrypthon/E-Biothon et qui a été à la base de la création de la start-up SysFera) ; MUMPS (`http://mumps-solver.org`) en algèbre linéaire creuse, (bibliothèque téléchargée plus de 1000 fois par an) ; GNU MPFR (`http://www.mpfr.org`) pour le calcul flottant à précision arbitraire (bibliothèque utilisée régulièrement sur plus de la moitié des machines Debian). Les start-ups créées au LIP se sont appuyées sur des développements conduits au LIP. C'est un indicateur de qualité pour l'intense activité de prototypage, d'expérimentation et de développement que nous conduisons. À partir des listes des équipes on compte par ailleurs une quinzaine d'ensembles logiciels souvent expérimentaux au départ puis diffusés notamment dans le monde académique (calcul mathématique, HPC, gestion de ressources, réseaux, etc.) et une quarantaine de prototypes, logiciels expérimentaux et outils spécifiques (FPGA, compilation, coq, simulation, etc.). On compte également une dizaine de dépôts de brevets (Aric, Compsys, Reso-Dante) et des activités de standardisation en arithmétique d'intervalle (IEEE-1788 WG) et en gestion de données pour le Grid-RPC (OGF, GFD-R-P.186).

1.6.2 Rayonnement, animation et attractivité

Conférences et événements scientifiques. Les membres du LIP ont été impliqués à divers niveaux dans l'organisation de plus de 500 événements scientifiques de toutes natures. Pour la participation aux comités de pilotage ou de programme de conférences on a notamment: ARITH, ANTS, AofA, ISSAC, Crypto, Asiacrypt, ASAP, SCAN, PQ Crypto, ACM-IEEE LICS, FoSSaCS, ICALP, CSL, CC- Grid, Grid, IMPACT-HIPEAC, CPC, STACS, SC, IPDPS, ICCP, HiPC, etc.

De nombreux événements ont été organisés à Lyon ou dans la région tels que *International Conference on Parallel Computing* (Parco'2009), *Scientific Computing, Computer Arithmetic, and Validated Numerics* (SCAN 2010), *First International Workshop on Polyhedral Compilation Techniques* (IMPACT'11), GreenIT Workshop/Entretiens Jacques Cartier 2011-12, les Journées Turing 2012, les Journées du GDR IM 2013, L'École de Printemps d'Informatique Théorique 2013 (EPIT 2013), *The International Conference on Parallel Processing* (ICPP 2013), *The 31st Symposium on Theoretical Aspects of Computer Science* (STACS 2014), *The SIAM Workshop on Combinatorial Scientific Computing* (CSC'14), etc.

Comités éditoriaux. Les membres du LIP participent aux comités de 22 revues: ACM Transactions on Embedded Computing Systems ; IEEE Transactions on Computers ; Journal for Universal Computer Science ; Journal of Symbolic Computation ; Texts and Monographs in Symbolic Computation Springer ; Journal of Algebra ; Applicable Algebra in Engineering ; Communication and Computing ; Mathematical Logic Quarterly ; Mathématiques et Applications SMAI-Springer ; Computer Communications ; Cluster Computing Journal ; IEEE Transactions on Cloud Computing ; Parallel Computing ; International Journal of Parallel Programming ; Ad Hoc Networks ; Discrete Mathematics & Theoretical Computer Science ; Journal of Parallel and Distributed Computing ; Journal of Sustainable Computing: Informatics and Systems ; International Journal of High Performance Computing Applications ; International Journal of Grid and Utility Computing ; Journal of Computational Science.

Prix et distinctions.
- D. Stehlé medaille de bronze 2012, J.-M. Muller médaille d'argent du CNRS-INS2I.
- P. Feautrier, *Euro-Par Steering Committee Award "In recognition of his outstanding contributions to parallel processing"*, 2009.
- V. Lefèvre, N. Louvet, and J.-M. Muller, « Prix La Recherche pour les Sciences de l'Information » 2013.
- P. Vicat-Blanc Primet, chevalière de la Légion d'honneur en 2010, Prix Irène Joliot-Curie 2011 et Prix Inria – Académie des sciences – Dassault Systèmes de l'innovation 2013.
- Y. Robert, *IEEE TCSC Award for Excellence*, 2014.
- A. Benoît nommée IUF junior 2009, Y. Robert renouvelé IUF senior 2011.

Animation et administration de la recherche, expertises. Les membres du LIP sont très impliqués dans les différentes structures de la recherche. Les implications régionales ont été vues au paragraphe 1.4. On regroupe ici des éléments à une échelle plus générale. Au-delà du niveau local, des structures académiques nationales telles que les GDR sont importantes pour les communautés et en liaison avec les instances nationales.
- J.-M. Muller est co-directeur du GDR Informatique Mathématique (IM), N. Portier et G. Villard sont membres du comité de direction, B. Salvy est responsable du GT Calcul Formel, O. Laurent est responsable du GT Géométrie du calcul.
- É. Fleury est co-responsable du pôle RésCom du GDR Architecture, Systèmes, Réseaux (ASR).
- Le groupe Compilation commun aux GDRs ASR et GPL, a été créé et est animé par L. Gonnord et F. Rastello.
- F. Desprez est directeur du GIS (Groupement d'Intérêt Scientifique) Grid'5000, S. Delamare en est le vice-directeur technique, L. Lefèvre le coordinateur scientifique du site de Lyon et C. Perez est le coordinateur du *Project Lab* Inria Héméra.

- I. Guérin Lassous a été membre CNU 27 2010-2011.
- J.-M. Muller a été membre du conseil scientifique de Grenoble INP (2008-2011), il est membre de celui du CERFACS.
- Comités d'expert ANR: É. Fleury, président, ANR INFRA 2013, vice-président 2012 ; I. Guérin Lassous, vice-présidente 2012. J.-M. Muller vice-président du Comité d'évaluation scientifique mathématiques–informatique théorique.
- Présidence de comité de visite AERES: É. Fleury, laboratoire PRISM ; J.-M. Muller laboratoires LIMOS, LIAFA, PPS.
- Y. Robert est membre (seul non nord-américain) du *NSF/IEEE-TCPP Curriculum Initiative on Parallel and Distributed Computing - Core Topics for Undergraduates*.

1.6.3 Start-ups et valorisation

Le LIP a vu la création de cinq start-ups – toutes encore en activité – à partir de cinq équipes différentes.

- Sysfera (`sysfera.com`), avril 2010, fondateurs : E. Caron, F. Desprez (Avalon) et D. Loureiro. Solutions innovantes pour un accès simplifié aux ressources HPC et pour le passage en SaaS. La collaboration entre l'entreprise et l'équipe Avalon reste étroite.
- Cosmo (`thecosmocompany.com`), mai 2010, fondateurs : É. Boix et M. Morvan (MC2). Développement et services autour d'un logiciel de modélisation et de simulation en biologie à partir d'une approche système complexe.
- CloudWeaver/Lyatiss (`lyatiss.com`), juin 2010, fondateurs : P. Vicat-Blanc Primet (Reso) et S. Soudan. Logiciels et services pour la gestion d'infrastructures réseaux et *cloud* virtuelles.
- HiKob (`hikob.com`), juillet 2011, fondateurs : G. Chelius (D-Net), C. Braillon et A. Fraboulet. Systèmes d'instrumentation de nouvelle génération pour la capture d'informations et leur acheminement vers un système d'informations.
- XtremLogic (`xtremlogic.com`), mars 2014, fondateurs : C. Alias, A. Plesco. Synthèse de haut niveau pour applications multi-média et télécom à destination des FPGA.

Par ailleurs, G. Fedak est coordinateur du projet incubateur ANR Émergence CloudPower (`iexec.fr`) autour de solutions innovantes pour le calcul haute performance à la demande et à faible coût pour les PME.

1.6.4 Initiatives pour promouvoir et encourager le rôle des femmes en informatique

Les femmes constituent moins de 1 personne sur 5 en informatique ; au LIP, la proportion chez les scientifiques permanents est de 1 sur 9. Alors qu'il y a au bac scientifique à peu près autant de femmes que d'hommes, la proportion diminue au fur et à mesure des études et des carrières universitaires. Pour tenter d'obvier à ce phénomène, deux sortes d'actions globales sont menées auxquelles participent des membres du LIP.

La première sorte d'actions est en direction des élèves de l'enseignement secondaire qu'il s'agit d'encourager – plus particulièrement les filles – à envisager et choisir des filières et carrières scientifiques. Des femmes du LIP sont très impliquées et donnent des conférences dans des établissements scolaires et lors d'événements ponctuels comme la Semaine des Maths ou la Fête de la Science. Ces conférences présentent la recherche actuelle en informatique ou concernent la découverte du métier et des études, avec déconstruction des mythes d'austérité et d'inaccessibilité. La présence de femmes conférencières a pour but de présenter des modèles afin que les filles puissent s'identifier à ces femmes et se projeter scientifiques. En 2013-2014, une dizaine d'interventions ont été réalisées, avec un millier d'élèves rencontrés. L'autre type d'action est en direction des chercheuses et enseignantes-chercheuses, en particulier des plus jeunes: doctorantes, post-doctorantes et jeunes permanentes. Par exemple, le 13e Forum des Jeunes Mathématicien-ne-s a été organisé à Lyon en novembre 2013, avec 3 membres du LIP dans le comité d'organisation. Il a rassemblé une cinquantaine de participant-e-s pendant 3 jours. Ce Forum comporte une part scientifique et une part de réflexion sur notre métier (état des lieux, études sur le genre, conseils, atelier de mentorat, etc.) et sa féminisation. La partie scientifique est une opportunité pour les jeunes de présenter leurs travaux, d'assister à des exposés invités de femmes plus avancées dans leur carrière et de se créer un réseau professionnel.

1.6.5 Vulgarisation et diffusion scientifiques

Les membres du LIP s'impliquent beaucoup dans ce domaine à l'occasion des fêtes de la science, des semaines des mathématiques ou à l'occasion de conférences scientifiques grand public. On a aussi notamment:

- La participation à la mise en place de la MMI, *Maison des Mathématiques et de l'Informatique* (`http://math.univ-lyon1.fr/mmi`), comme structure du LabEx MILYON. La MMI a commencé ses activités en 2012 et organise des expositions, des conférences et diverses activités pour les écoliers et le grand public. N. Portier et N. Trotignon sont membres de son comité de pilotage.
- De nombreuses interventions dans les collèges et les lycées. N. Revol est particulièrement investie et a participée à une vingtaine d'actions, notamment autour du rôle des femmes. D. Hirschkoff s'implique pour « Math.en.Jeans » dans la région lyonnaise.

- Sous la houlette d'É. Fleury et du département informatique de l'ENS, la machine de Turing en lego construite par un projet d'étudiants encadré par K. Perrot a bénéficié d'une large couverture médiatique (`http://rubens.ens-lyon.fr`).
- É. Fleury a participé à l'exposition « Tous connectés » (CCSTI Grenoble – La Casemate / Universcience – Cité des sciences et de l'industrie), à des émissions radio et télé dans le cadre du projet NANOYOU (Nano for Youth).
- Des articles et interviews pour *La Recherche*, *Usine nouvelle*, *Interstices*, *Pour la Science*, France 2, France Info.
- G. Chelius (co-fondateur de la start-up Hikob) a eu de nombreuses interventions médiatiques (TV5 monde, France 5, RFI, France Inter, etc.) dans le cadre du projet XtremLog et de sa participation 25ème Marathon des Sables.

1.7 Implication de l'unité dans la formation par la recherche

Le LIP est membre de l'École Doctorale 512 Informatique et Mathématiques de Lyon. Il apporte une contribution significative à la formation par la recherche dans le cadre du cursus M1 et M2 spécialité « Informatique Fondamentale » du département informatique de l'ENS[33].

Le laboratoire est également fortement impliqué dans les filières de l'UCBL. Des membres du LIP interviennent et ont des responsabilités au sein du département informatique dans la licence et la spécialité « Réseaux » du M2 Informatique, ainsi que dans le master professionnel Compétences Complémentaires en Informatique. Plus récemment, le LIP s'est aussi impliqué dans les formations du département informatique de l'IUT Lyon 1 et de l'Institut de Science Financière et d'Assurances de l'UCBL, spécialité « Ingénierie des Risques » du master SAFIR.

Nous avons vu précédemment (Composition du laboratoire, §1.3.1) de nombreux éléments concernant les doctorants (une centaine d'accueil sur la période) et les stagiaires (de l'ordre 200 accueils dont 40% d'étrangers). L'attachement du LIP à la formation par la recherche se traduit par le rôle important joué par la commission des habilités et de la cellule administrative adossée (voir la figure 1.6) qui sont en charge de l'ensemble des sujets concernant les doctorants (inscriptions, accompagnement, suivi, etc.) et des interactions avec l'école doctorale (conseil de l'ED, commission des thèses, jury d'attribution des contrats doctoraux).

Le fait que les membres du LIP dirigent le département de l'ENS (É. Fleury puis D. Stehlé en 2013) et constituent l'essentiel des intervenants permet une correspondance département-laboratoire et une collaboration très fructueuse. Cette collaboration a lancé plusieurs opérations d'intérêt commun : financement de bourses de master avec obligation de stage au sein du laboratoire[34], utilisation des crédits compensant les chaires Inria de M. Karsai et É. Fleury pour financer la mise à disposition d'enseignants-chercheurs externes, organisation d'écoles de recherche[35], financement de visites d'établissements étrangers.

Grâce aux conventions entre les établissements partenaires et au soutien des directeurs des départements impliqués (notamment ENS et UCBL), tous les doctorants du LIP qui le désirent se sont vu proposer une activité complémentaire en enseignement (ACE) notamment à l'ENS où l'UCBL. Assurer cette possibilité à l'ensemble des doctorants concernés pour leur carrière est un aspect politique clef en informatique ; parvenir à implanter cette politique en pratique s'est néanmoins heurté à des difficultés croissantes ces dernières années à l'ENS.

Les collaborations pluri-disciplinaires au sein de l'IXXI servent de socle au cursus M2 « Systèmes Complexes », porté par Pablo Jensen (laboratoire de physique & IXXI). Ce cursus développe depuis 5 ans une voie originale centrée sur la pluri-disciplinarité et la modélisation des systèmes complexes – il s'agit d'un parcours commun entre plusieurs des masters scientifiques de l'ENS Lyon, dont la forte spécificité a permis, au cours des années, d'attirer nombre d'étudiants/étudiantes (notamment plusieurs de l'INSA chaque année) au sein de la formation d'informatique du département.

Le LIP s'implique également dans l'organisation d'écoles et de cours doctoraux ailleurs en France ou à l'étranger. N. Portier par exemple est co-responsable de l'École Jeunes Chercheurs du GDR IM qui est organisée chaque année, C. Crespelle développe des liens forts avec le Vietnam.

1.8 Auto-évaluation et analyse SWOT

1.8.1 Forces

Panel thématique. Le LIP offre sept équipes aux identités scientifiques bien dessinées, allant des tendances les plus fondamentales de l'informatique à des équipes en prise directe sur le transfert et les applications. Cette variété est une richesse, d'autant qu'elle se double d'une cohérence dans les préoccupations : l'ensemble des équipes se situe dans la

[33] Mention Informatique du master Sciences, Technologies, Santé cohabilité par l'Université Claude Bernard Lyon 1, l'INSA de Lyon, l'École Centrale de Lyon et l'École Normale Supérieure de Lyon.

[34] Cela s'inscrit dans une campagne de bourses de master ouvertes prioritairement aux candidats internationaux en partenariat avec le département informatique de l'ENS, le LabEx et Inria.

[35] Page des école de recherche: `www.ens-lyon.fr/DI/?page_id=2867`. Le département informatique organise également le séminaire SIESTE: `http://www.ens-lyon.fr/DI/?page_id=730`.

mouvance du calcul. Dans cette mouvance, à grand trait, le LIP a la chance de bénéficier de forces dans à peu près tous les maillons de la chaîne[36]: fondements des langages de programmation (Plume), modèles du calcul et complexité (MC2), algorithmique élémentaire et avancée (Aric), compilation (Compsys), calcul parallèle et distribué (Roma, Avalon), données (Dante).

Qualité scientifique et reconnaissance. Même s'il ne nous appartient pas d'en juger, nous sommes fiers de l'activité scientifique du LIP sur les principaux volets que sont production scientifique (logiciels inclus), reconnaissance, impact et investissement dans la formation. De nombreuses personnes / équipes du LIP ont un rôle de premier plan dans leurs communautés nationale et internationale. Enfin, le LIP contribue largement au fonctionnement de la communauté de recherche par l'implication de ses personnels dans des instances ou des opérations nationales et internationales, voir 1.6.2.

Attractivité. L'attractivité constatée lors des différents concours (post-doctorats, enseignants-chercheurs, CNRS) est très bonne, avec des recrutements de niveau clairement international et des concours à forte pression. Il convient néanmoins de relever un hiatus entre l'attractivité forte et internationale de deux équipes (MC2 et Plume) qui suscitent chaque année bon nombre de candidatures de haut niveau, et le reste du laboratoire pour lequel la compétition reste solide, mais peut-être légèrement moins internationale.

Aspects financiers. La solidité des équipes et leur bonne insertion dans leurs tissus scientifiques national et international permet de très bons taux de réussite, en particulier, aux appels ANR. À ce jour, les équipes vivent en quasi-autonomie financière, ce qui permet à la direction du laboratoire de jouir de bonnes marges de manœuvre budgétaires pour mettre en œuvre sa politique scientifique.

Renouvellement scientifique des équipes. Les équipes sont « à l'écoute » de leur communauté et savent généralement percevoir les évolutions scientifiques (voire en être actrices). Le renouvellement scientifique des thématiques au sein des équipes est élevé et il n'y a pas d'apparence d'activité obsolète ou de niche au sein du laboratoire. La recomposition des équipes a aussi été un moyen de rapprochements de thématiques qui a été un enrichissement au cours de la période – elle a par exemple permis le renforcement de l'expertise *cloud* et « énergie » dans Avalon ou le développement de la thématique « traitement du signal sur les graphes » dans Dante.

Réactivité du laboratoire. Sur la période, les tutelles et le laboratoire ont su accompagner, au travers des recrutements et mutations de permanents, le fort développement des équipes Dante, MC2 (surtout le versant « mathématiques discrètes / graphes ») et Plume. Développer ainsi trois équipes dans le laps de temps d'un quinquennal nous semble une réussite très significative à porter au crédit du laboratoire et de ses tutelles, d'autant que le même quinquennal a aussi vu l'émergence au sein d'Aric d'un groupe travaillant autour de la cryptographie fondée sur les réseaux euclidiens.

Start-ups. La période passée a vu l'incubation et la création de 5 start-ups, toutes encore en activité à ce jour, issues de 5 équipes différentes du LIP. Même s'il est difficile de projeter ce chiffre vers l'avenir, cela nous semble constituer un succès certain, que nous attribuons à la culture de mixité théorie/pratique en vigueur au sein du laboratoire. Cela nous semble néanmoins également refléter la « fin d'une époque » du LIP, avec la maturation et le départ d'un certain nombre d'idées et, en corollaire, l'affaiblissement net du « pôle » technologique du LIP.

Vivier de cadres. La période écoulée a permis de largement améliorer l'équilibre A/B au sein du laboratoire et de constituer un vivier de cadres scientifiques solides, par recrutement et par promotion. Cela permet à la direction du laboratoire de s'appuyer sur les compétences d'un plus grand nombre de collègues pour l'animation scientifique et pour les responsabilités collectives importantes ; cela permet également de préserver les personnels B des responsabilités les plus lourdes.

1.8.2 Faiblesses

Effectifs et rotation ITA. La cadence du renouvellement des personnels administratifs du laboratoire nous semble à un niveau trop élevé. C'est certes un indicateur de la qualité des personnels recrutés (qui sont souvent partis en promotion) mais cela induit des campagnes de recrutement récurrentes et un besoin de former aux usages internes les nouvelles personnes recrutées. Au-delà du coût en temps et énergie, cela rend également difficile la mise en place durable de procédures de recueil et de synthèse de l'information, et conduit à une gestion « au jour le jour ». La reconnaissance par le CNRS du fait que le laboratoire a besoin d'un personnel de catégorie A au service des assistant-e-s devrait permettre d'évoluer sur ce point, une fois les difficultés de recrutement dépassées (deux recrutements infructueux en mobilité interne en 2012 et 2014, examen professionnel réservé infructueux en 2013).

[36] Bien que le départ de F. de Dinechin nous prive, regrettablement, de notre ancienne expertise en architecture.

Effectifs et rotation permanents scientifiques de rang B *A contrario*, au niveau des permanents scientifiques « B », la mobilité est sans doute trop faible pour permettre au laboratoire une politique scientifique, ou un renouvellement thématique, plus fort. Ce fait s'explique par des perspectives de promotion sur la place lyonnaise très limitées (pour les enseignants-chercheurs)[37] et un engorgement sur les promotions DR au niveau national et au niveau du laboratoire (nombreux chercheurs CNRS et Inria dans la « tranche d'âge » promouvable), qui s'ajoute à la difficulté de la mobilité à cette tranche d'âge. Signalons qu'à notre sens les rangs B « expérimentés » du laboratoire nous semblent toutes et tous aptes à très bien figurer dans des concours PR. Cela induit une difficulté pour la direction du laboratoire à mettre en œuvre sa politique scientifique au niveau des recrutements de permanents – politique qui ne peut s'exercer sur les postes Inria et très à la marge sur les postes CNRS. Effet de bord de cette faiblesse, les chiffres du laboratoire concernant l'habilitation à diriger les recherches, très liée dans les esprits à la promotion PR/DR, nous semblent insuffisants.

Sciences de l'information lyonnaises. L'absence de structuration de l'informatique et des sciences de l'information au niveau lyonnais — il faut bien dire que chaque laboratoire, le LIP le premier, vit dans un relatif isolement — est probablement une notable faiblesse à laquelle la discipline, donc le laboratoire, fait face à court terme. Des contacts ont été pris au cours des dernières années avec le CITI et le LIRIS, plutôt constructifs dans le cadre d'une soumission de projet EquipEx. Les discussions en vue d'un LabEX puis d'une structure légère de concertation pouvant évoluer en structure de pilotage ont ensuite été peu fructueuses. Ce dossier est l'un des principaux défis pour le LIP dans l'avenir proche.

Équilibre théorie-pratique. Une spécificité maintes fois affirmée du LIP est de disposer de pôles forts à la fois sur le volet « théorie » et sur le volet « pratique ». La préservation de cette spécificité passe par une capacité à équilibrer effectifs et en particulier recrutement.

Au-delà de cette volonté d'équilibre global, un souhait fort du laboratoire est d'arriver à une forme d'équilibre tutelle par tutelle. Force est de constater un relatif échec sur ce plan au cours des quelques années passées. En particulier, le recrutement au CNRS sur la période 2009-2014 n'a concerné que l'axe « théorique » (et les seules équipes Plume et MC2) tandis que le recrutement à l'UCBL, fortement corrélé à des besoins d'enseignement, est marqué par un fort tropisme « pratique »[38].

Les postes publiés à l'ENS Lyon sont généralement de profil très large, avec une préférence indiquée, souvent, ces dernières années, de renforcer l'axe « pratique » sans renoncer à la volonté de recruter à un niveau clairement international. Les comités, composés après large consultation au sein du laboratoire, ont, hélas, estimé, de manière récurrente ces dernières années, difficile de recruter dans cet axe.

Relations scientifiques entre les équipes. Les actions de la direction lors de la période 2009-2014 n'ont eu qu'un impact limité dans ce domaine. Pour nuancer le constat, pointons que les restructurations d'équipe ont toutefois pu (ou pourront, une fois ces évolutions consolidées) permettre des ébauches de rapprochements entre thématiques.

Cette situation est peut-être à mettre en relation avec la croissance du fonctionnement en "projet" ; ainsi le rôle de l'ANR comme source significative de crédits, qui facilite une tendance naturelle à se replier sur son cœur disciplinaire et sa communauté établie, plutôt que d'investir dans des collaborations en interne au laboratoire. L'implication, forte et historique, d'Inria au sein du LIP nous semble également plutôt tendre à valoriser un modèle de petites équipes très focalisées et tendues vers leur objectif plus que la collaboration inter-équipes à l'échelle du laboratoire.

Dans l'absolu, un souhait du laboratoire est d'aller plus loin, que ce soit à l'échelle du LIP ou plus largement à l'échelle du site lyonnais.

Recrutement de doctorants. Comme pointé dans les données du bilan (Composition du laboratoire, §1.3.1), le nombre de doctorants par permanent est en nette baisse. Cela nous semble à la fois lié à des éléments de contexte (cf. la rubrique Menaces) et à un retard de prise de conscience au niveau du laboratoire du besoin d'être plus actif sur la recherche de candidats doctorants (même si des actions ont été entreprises depuis 3 ans à l'international) et de financements (où davantage de travail semble à faire).

1.8.3 Opportunités

Environnement lyonnais. Être un laboratoire sis au sein d'une école normale supérieure est probablement, en soi, une opportunité majeure. L'accès direct à des étudiants solides et bien formés, dont le financement des thèses est généralement plus aisé, est très clairement une grande chance. Signalons aussi que le lien avec une formation attractive permet, de manière fluctuante toutefois, d'attirer de très bons étudiants extérieurs au niveau M2, qui restent souvent en thèse au sein du LIP. Au-delà de cet aspect « étudiants », la présence à l'échelle locale de structures actives sur la thématique « calcul » (CBP, PSMN, personnes impliquées dans le sujet à l'ICJ, CC IN2P3), qui constitue l'étendard du LIP, est une opportunité forte à exploiter à l'avenir.

[37] Rappelons en particulier la position très réservée du laboratoire sur la promotion locale des enseignants-chercheurs.

[38] À l'exception peut-être du recrutement PR de F. Laguillaumie dans Aric.

Soutien des tutelles. Il faut relever l'investissement très fort des tutelles au LIP sur la dernière période:

- Soutien du CNRS à la montée en puissance continue de l'équipe Plume et au (re-)développement de MC2 ;
- Grande réactivité de l'ENS qui lui permet de mettre en place des moyens spécifiques (bourses Ampère de pré-recrutement des étudiants de master) et d'accompagner très rapidement les opérations fortes de politique scientifique[39].
- Montée en puissance de l'implication de la tutelle UCB ces dernières années qui a permis d'enrichir significativement le vivier de cadres du laboratoire (recrutement de 2 PR) et de compenser les réductions budgétaires côté CNRS et ENS.
- Aide importante et efficace d'Inria sur les contrats industriels et surtout sur les créations de start-ups, une des activités fortes de la période écoulée.

Enfin, la constitution de la COMUE lyonnaise agit comme une incitation très forte à entreprendre des actions visant au rapprochement des activités en informatique et sciences de l'information sur Lyon. La volonté forte affichée de la COMUE de développer une stratégie solide à l'international peut également devenir une opportunité de recrutement d'étudiants et de collaborations recherche.

LabEx MILYON. L'appartenance du LIP au LabEx MILYON, conjointement avec les deux laboratoires de mathématiques lyonnais (ICJ : CNRS, École centrale de Lyon, INSA Lyon, UCBL, Université Jean Monnet (St Étienne) et UMPA : CNRS, ENS Lyon) est une opportunité forte pour le LIP. Le LabEx constitue une forte incitation à mener des actions de visibilité d'ampleur (trimestres thématiques), ou plus habituelles (conférences, invitations) et d'attractivité (financement de post-doctorants[40], actions de diffusion et communication) ; le volant formation participe également de l'attractivité via le dispositif de bourses de master. Une montée en puissance des collaborations entre les UMR associées, pour l'heure encore assez ponctuelles, pourrait s'intensifier.

1.8.4 Menaces

Situation de l'informatique locale. À l'heure de l'unification de l'ensemble de la communauté universitaire lyonnaise et stéphanoise sous l'égide d'une COMUE, il paraît anachronique pour la communauté informatique lyonnaise d'avancer en ordre dispersé ; parmi les laboratoires se réclamant des STIC, on peut signaler au moins le LIRIS, le CITI, ERIC et CREATIS. Le danger est que la voix des STIC ne soit plus audible au niveau du pôle universitaire Lyon/Saint-Etienne. Au-delà de la question de la complémentarité scientifique, ou de structures, il importe que les différents acteurs parviennent à échanger et à trouver un mode de fonctionnement qui permette qu'une grande partie de cette communauté, au moins, parle d'une seule voix.

Fin du LabEx 2019. La fin de vie du LabEx MILYON, qui porte comme signalé *supra* un grand nombre d'activités, est d'ores et déjà programmée. Il faudra anticiper la fin de cette période et parvenir à identifier, parmi ces activités, celles qui sont finançables sur la durée et ont vocation à être pérennisées et abandonner les autres. Cette évolution doit être anticipée.

Réduction du nombre de doctorants. La réduction du nombre de doctorants, proportionnellement au nombre de permanents, constatée dans les données du présent document constitue un risque majeur pour le laboratoire. Il s'agit, selon notre analyse, d'un problème multiforme, pour partie conjoncturel (tendance lourde et nationale) et pour partie local.

La diminution des financements institutionnels tend à décourager une recherche active et dynamique de doctorants. Sur ce plan, citons en particulier la réduction des contrats doctoraux ENS à l'école doctorale InfoMaths de 3 à 2 pour l'ensemble LIP/UMPA, mais aussi la montée considérable en complexité des règles pour les financements de thèse par la région Rhône-Alpes. La baisse des financements de type « soutien technologique » obtenus, à la fois globale et liée aux évolutions internes du LIP déjà évoquées joue aussi un rôle fort dans cette situation.

Il importe de mettre en œuvre des actions pour contrebalancer cette évolution ; il nous semble plus urgent d'agir sur le terme « nombre de candidats » que « nombre de financements » même si les deux requièrent du travail.

- (à l'international) Collaborations internationales permettant d'attirer des étudiants (UT Cluj (Roumanie) sur la période 2005-2009 en perte de vitesse, embryon de collaboration avec Hanoi (Vietnam) en 2014, tentative vers São Paulo (Brésil) en 2015 ?): il est important dans ce cas de savoir mener de front plusieurs collaborations, pour ne pas être pris au dépourvu si un flux se tarit.

[39] Par exemple, création du poste de M. Karsai en 2013 avec chaire Inria.
[40] Et, exceptionnellement, en 2014 et 2015, d'un contrat doctoral

- Recherche de financement pour les étudiants internationaux, sur le modèle des bourses « Ampère » de l'ENS (1000 euros par mois). Le LabEx MILYON finance plusieurs bourses de ce type chaque année. En complément, le laboratoire a lui-même abondé deux bourses de ce type en 2012-2013, tandis que le département a obtenu le financement de plusieurs bourses de ce type par Inria (sous condition de stage dans une équipe-projet Inria hors LIP).
- Encourager les chercheurs du laboratoire à essayer d'intervenir dans d'autres masters (Paris, Grenoble) plutôt que de faire cours localement: une idée pourrait être de proposer à un master « proche » (comme Grenoble) un échange de *slots* de cours entre nos deux masters.

Structure de financement. Il est probable qu'il faille anticiper une baisse de régime des programmes ouverts de type « défi de tous les savoirs » de l'ANR, si ce n'est de l'ANR en général. La relative dépendance du budget du laboratoire de l'ANR, au travers en particulier de ses équipes de l'axe « fondamental » qui s'auto-financent presque par ce moyen, risque de faire de cette évolution une menace pour le laboratoire.

Recrutement. Le déséquilibre du recrutement récent vers les équipes « théoriques » constitue une menace pour la préservation de la ligne directrice du laboratoire, c'est-à-dire la capacité à étudier les problématiques du calcul, depuis ses fondements jusqu'au déploiement d'infrastructures logicielles et à la production.

Il faut relever les difficultés qu'il peut y avoir à recruter dans des domaines où l'appétence de l'industrie pour de bons scientifiques est forte: nous n'avons alors guère les moyens de lutter. Néanmoins, un effort d'attractivité significatif dans ces thématiques reste probablement à faire. Il serait souhaitable que la période 2014-2019 permette de progresser sur ce point, sans renoncer à notre exigence de recrutement au niveau international.

Pluri-disciplinarité. Sur le plan de la politique recherche de site, les STIC sont davantage vues au travers de leurs applications aux autres disciplines que comme une discipline stratégique dans laquelle il convient d'investir. Le positionnement actuel du LIP ne tire pas nécessairement toutes les leçons de cette situation et il serait probablement souhaitable de communiquer plus largement sur nos forces auprès des tutelles et des collectivités, mais aussi d'investir plus largement l'interdisciplinarité que cela n'a été fait jusqu'alors. En particulier, le potentiel d'applications aux sciences du vivant (qui, elles, sont à l'heure actuelle stratégiques dans les politiques de site lyonnaises) dans le laboratoire semble sous-exploité, même si des efforts ont été entamés sur la période passée, qui ont permis l'établissement de contacts et l'implication dans le LabEx PRIMES et la plate-forme E-Biothon.

Les compétences « calcul » et, dans une moindre mesure, « données » dont le développement au cours de la dernière période a permis des ouvertures récentes en direction des sciences sociales, devraient être valorisées sur ce point. Les contacts existants doivent s'intensifier et surtout s'élargir au sein du laboratoire.

1.9 Projet du LIP

Nous vivons un temps où notre discipline est en plein bouillonnement, voyant se succéder à grande vitesse idées et évolutions, énergiquement tirées vers l'avant par la naissance et la rapide croissance d'un monde numérique, par la demande sociétale mais aussi celle des autres disciplines scientifiques. Pour l'informaticien, l'évolution des matériels et des applications amènent de nouvelles problématiques, tandis que l'évolution des demandes montre de façon forte les limitations des solutions existantes. La rencontre de la complexité et du fort potentiel des nouveaux outils du calcul et du gisement d'information encore sous-exploité que constituent les données sont sans doute un élément-clé de ces défis.

Ces défis nous obligent à penser une stratégie de recherche à même de s'adapter à un environnement où il n'a jamais semblé aussi complexe d'anticiper nouvelles problématiques, nouveaux usages, nouveaux besoins et où il apparaît insuffisant se contenter de réagir aux changements. Dans cet environnement, la recherche de généricité — ne plus se contenter de traiter un problème ponctuel, mais savoir identifier la situation large dont il constitue un cas particulier — et de dynamicité — savoir s'adapter en temps réel à l'environnement — semblent être un trait commun à bon nombre de recherches menées au sein du laboratoire, dans la mesure où ces deux critères permettent de maximiser l'adaptabilité des solutions.

À une échelle plus modeste de laboratoire, nous avons aussi eu l'occasion de vivre ces évolutions : la création de plusieurs startups a marqué, dans le contexte favorable décrit plus haut, la maturation de plusieurs idées qui s'étaient construites sur la durée.

Ces évolutions concomitantes imposent au laboratoire de réaffirmer sa volonté d'être un lieu permettant la fertilisation croisée entre une recherche fondamentale, ancrée dans l'informatique théorique, de haut niveau, et des recherches plus directement en prise avec le versant applicatif. Les idées à fort potentiel d'innovation comme les réponses aux questions difficiles qui nous sont aujourd'hui posées ne peuvent venir que d'une réflexion fondamentale approfondie, jointe à une étude fine des problématiques appliquées et à un développement de solutions technologiques idoines – ces dernières seules permettent de détecter une idée prometteuse et de la mener à sa réalisation. La coexistence de ces expertises au sein des différentes équipes reste un fondement de la stratégie du LIP.

Parvenir à anticiper les questions soulevées par les évolutions impose de s'élever d'un niveau par rapport aux questions posées aujourd'hui, en particulier dans la quête d'une forme de généricité des solutions apportées. Dans cet esprit, la démarche de *modélisation* ou d'*abstraction* est au cœur du projet des équipes et du laboratoire pour la période à venir.

Souvent, la construction du modèle idoine est un défi en soi et ne se contente pas de précéder l'étude mais en est partie intégrante. Suivant le contexte, cela peut imposer une réflexion fondamentale pour se placer au bon niveau de généralité ; ainsi traiter d'un problème précis peut être trop restrictif ou, *a contrario*, trop difficile car trop général. Cela peut aussi imposer une démarche expérimentale détaillée pour construire un modèle adéquat, typiquement pour les problématiques proches du monde physique (mémoire, consommation énergétique, etc.), qui ne soit ni jouet ni artificiel. D'autres fois enfin le modèle est la question-clé, en particulier sur les questions liées aux données sur lesquelles l'expertise du laboratoire s'est développée sur la période passée, et on cherche alors, par exemple, à développer des outils génériques permettant de construire ce modèle. Ces outils seuls permettront de séparer le bruit de la régularité et d'identifier, ce faisant, les questions pertinentes que soulèvent lesdites données.

Si les modèles nous apparaissent comme le moyen-clé, le grand objectif des recherches menées au sein du laboratoire est de contribuer à construire des outils pour un calcul fiable, efficace, sûr et adaptable. Hormis l'architecture, les différents maillons de la chaîne du calcul sont étudiés au LIP, des langages et programmes aux outils pour le déploiement en passant par algorithmes et bibliothèques.

Le présent projet choisit de structurer les recherches du laboratoire selon ces axes de grands objectifs scientifiques au sein du calcul. Ce choix affirme le credo que les avancées les plus significatives doivent venir d'échanges entre équipes partageant le même objectif, mais d'équilibre théorie/pratique divers. Nous discuterons donc successivement les axes suivants :

- modèles pour les programmes et le calcul ;
- modèles et algorithmique mathématiques ;
- modèles, algorithmes et logiciels pour le calcul haute performance.

Le choix de considérer le modèle comme central dans les recherches du LIP présente un danger significatif, renforcé par les évolutions de la période 2009-2014 et la relative diminution des compétences « technologiques », à savoir celui de théoriser la recherche conduite au LIP, avec le risque de la déconnecter de ses utilisateurs. Pour conserver un niveau élevé de pertinence, il est alors stratégique de maintenir une source de dissémination dans l'attente de cette maturation: les liens pluri-disciplinaires du laboratoire mais aussi la forte production logicielle, présente dans la quasi-totalité des équipes, doivent en être garants et seront soutenus et encouragés.

1.9.1 Modèles pour les programmes et le calcul

L'étude des modèles de programmes et du calcul est centrale aux préoccupations des équipes MC2, Compsys et Plume ; ces questions sont également mobilisées par une partie de l'activité « cryptographie » d'Aric. Enfin, Avalon conçoit des langages de description permettant de modéliser les situations complexes que la mise en œuvre du calcul doit aujourd'hui prendre en compte (sécurité, description des architectures / des applications).

Modèles pour les programmes Au sein du LIP coexistent deux points de vue de modélisation des programmes ou de la programmation. La vision fondamentale incarnée dans Plume procède d'une démarche très générale centrée autour de la logique comme modèle des langages et du calcul/programme, modèle sur lequel on peut raisonner et dans lequel on peut donner un sens formel précis aux problèmes de sémantique ou de complexité auxquels l'équipe s'intéresse.

Comparativement, Compsys, dont l'objectif final est la compilation, choisit, notamment, de s'intéresser à un sous-ensemble concret mais restreint de programmes capturé par le modèle polyédrique, modèle qui permet une analyse purement statique et un large jeu d'optimisations et de parallélisations. L'un des objectifs est d'étendre ce modèle (programmes plus complexes ou programmes à sémantique non séquentielle) et son champ d'applications.

Dans cette direction, l'analyse statique apparaît comme un point d'évolution et de rencontre fort. Ces deux équipes ont par exemple développé des analyses de terminaison, pour des programmes impératifs (comportant typiquement des boucles *while*) côté Compsys, et pour des programmes fonctionnels ou concurrents côté Plume. Plume a commencé à étendre ses travaux fondamentaux en sémantique en direction de questions de vérification ; un objectif est de dépasser les limitations du *model-checking* en développant des méthodes modulaires d'une part et en s'intéressant aux programmes d'ordre supérieur d'autre part. Compsys intègre à présent des techniques d'analyse par interprétation abstraite, techniques d'approximation par nature, qui rejoignent les techniques de sur-approximations propres au modèle polyédrique. Comprendre la sémantique des programmes manipulés (notamment des programmes non séquentiels) est évidemment également la condition *sine qua non* pour la mise en œuvre de transformations de programmes préservant la sémantique.

Dans une même grande ligne de pensée, une activité de formalisation (dans l'assistant à la preuve Coq) a été poursuivie dans Plume et Aric et a permis le démarrage fin 2014 d'une ANR associant ces deux équipes autour du développement d'approximations numériques et de bibliothèques de calcul multi-précision formellement certifiées. De même, au-delà des méthodes de compilation dites « correctes par construction », le développement d'optimisations de codes certifiées, parfois rendues possibles par des formalismes plus simples comme SSA[41], est une tendance forte dans la communauté, point de convergence entre les groupes de recherche en compilation et en langages.

Enfin, le développement de langages de description est une activité importante d'Avalon. La nécessité de prendre en compte des contextes et besoins de plus en plus complexes et multiformes dessine en outre une convergence avec l'expertise fondamentale de Plume : il devient indispensable de pouvoir donner une sémantique formelle des langages ainsi développés pour en particulier prendre en compte des problématiques d'adaptabilité, c'est à dire d'évolution de la description d'applications en cours d'exécution.

Au-delà de ces modèles différents, les deux équipes Plume et Compsys ainsi qu'une partie de l'activité d'Aric et d'Avalon, se retrouvent donc dans leurs préoccupations de comprendre, contrôler, voire améliorer expressivité, fiabilité et efficacité des calculs.

Modèles du calcul et des systèmes, complexité Les travaux de MC2 sur le calcul sont principalement centrés sur la question de la complexité des problèmes, en particulier de la complexité algébrique et de la complexité dans les modèles à base de circuits.

En comparaison, Plume utilise là encore des techniques de logique et de théorie des catégories pour comprendre les problèmes liés à la concurrence et aux calculs de processus. Un accent particulier est mis récemment sur les méthodes de raisonnement sur les systèmes concurrents, comme la coinduction, et ces travaux s'orientent désormais vers une analyse des systèmes probabilistes ainsi que vers des formes de raisonnement quantitatif.

Sur ce plan enfin, la modélisation du calcul est centrale dans les activités de cryptographie menées dans l'équipe Aric : la sécurité prouvée et le développement de protocoles utilisent des techniques apparentées aux réductions de la théorie de la complexité. Dans ce cadre, la puissance de calcul de l'attaquant est clairement spécifiée et le but est de relier rigoureusement et quantitativement la capacité à attaquer le protocole spécifié et la capacité à attaquer un problème présumé difficile.

1.9.2 Modèles et algorithmique mathématique

Dans ce domaine, le LIP mène à la fois des travaux d'étude fondamentale de structures mathématiques *per se* se rattachant aux mathématiques discrètes et utilise de façon largement transverse les graphes comme outil de modélisation, avec l'idée que leurs invariants capturent une information pertinente sur la situation. En parallèle, le laboratoire s'implique fortement dans des travaux spécifiquement informatiques où le calcul sur les objets mathématiques est la question centrale, avec un point de vue fortement multi-critère, à cheval entre efficacité et qualité.

Graphes et structures combinatoires L'étude et l'utilisation de structures combinatoires, avec un fort focus sur les graphes et hypergraphes, s'est imposée et est appelée à rester une thématique fortement transverse au sein du laboratoire, en raison en particulier du rôle-clé que jouent les graphes dans une large catégorie de situations de modélisation.

Les graphes sont un objet d'étude de premier ordre au sein de MC2, qui les étudie avec un point de vue centré sur la compréhension des propriétés structurelles fondamentales. C'est aussi l'outil de modélisation des « données » dynamiques de type réseaux sociaux qui sont au cœur du projet de Dante ; dans ce cas, les graphes évoluent dans le temps. Au-delà de la conception de la démarche de modélisation, l'analyse des modèles construits peut, dans cette vision dynamique, amener à l'étude de fonctions à valeur graphes: comprendre les régularités et tendances lourdes de cette évolution dans le temps implique, dans ce cas, d'étendre les méthodologies de traitement du signal à ce cadre et implique l'utilisation de techniques délicates d'analyse fonctionnelle. Plus largement, Dante étudie la compréhension de la dynamique de connexions et d'utilisations dans les réseaux au sens large (réseaux sociaux et réseux de communication), les méthodes pour l'analyser et, le cas échéant, le développement de solutions pour la gérer.

Les travaux de Roma en algèbre linéaire et calcul haute performance les conduisent à développer le versant algorithmique de l'étude des structures combinatoires, dans le cadre du *combinatorial scientific computing*, comme le problème du partitionnement des hypergraphes. Plus largement, les graphes sont un outil de modélisation naturel pour nombre de recherches menées dans le laboratoire ; citons par exemple les résultats de Compsys sur la forme SSA, une représentation intermédiaire de code, reposant fortement sur les propriétés structurelles des graphes de contrôle, de dépendance, ou de conflits sous-jacents (graphes cordaux d'intervalle, de comparabilité, etc.).

[41] Static Single Assignment

Algorithmique symbolique et numérique haute performance En prolongement des travaux mentionnés sur l'algorithmique des graphes et structures combinatoires, il importe de relever que l'algorithmique du calcul mathématique — calcul formel, calcul numérique — et les interactions entre formel et numérique occupent une place scientifique importante au sein du LIP.

Le calcul formel est un point de rencontre de MC2 et Aric. L'approche de MC2, en lien avec la complexité, est davantage centrée sur les questions reliées à la représentation creuse et à l'algorithmique ou aux résultats de difficulté associés. L'expertise numérique et en particulier flottante forte d'Aric donne aux projets de calcul formel (allant de la géométrie des nombres à l'étude des fonctions D-finies) une couleur fortement centrée sur l'interaction symbolique-numérique. Cela peut être au travers de l'utilisation de méthodes numériques (ou modulaires) pour calculer avec des approximations, contrôlées, d'objets exacts débouchant *in fine* sur un résultat exact obtenu plus rapidement.

Dans ce paradigme général, les évolutions récentes portent *a contrario* plutôt sur l'utilisation plus forte du versant formel dans l'objectif de généralisation et d'automatisation pour des problèmes numériques : flottants symboliques (avec diverses retombées), hybridation entiers-flottants dans l'algorithmique virgule flottante, extension des travaux en approximation certifiée de fonctions.

L'algèbre linéaire, formelle et numérique, reste également un sujet important au sein du laboratoire, transverse au moins entre Aric et Roma. Pour les années à venir, au-delà du prolongement des activités passées, en particulier autour de l'algorithmique des réseaux euclidiens, on peut espérer des convergences entre le point de vue « matrices structurées » développé dans Aric et certains aspects du *combinatorial scientific computing* actif dans Roma.

1.9.3 Modèles, algorithmes et logiciels pour le calcul haute performance

Complémentaire des deux axes précédents, il s'agit de l'axe en prise la plus directe sur les applications et le calcul réel.

L'évolution des problématiques étudiées au LIP en lien direct avec le calcul haute performance vise à « coller » au plus près aux évolutions scientifiques et technologiques du domaine, avec un fort souci de pertinence. Les changements constants du calcul sur ces dernières années amènent à devoir gérer des situations où l'on doit être très générique au regard de l'application, de l'infrastructure de calcul, ou des deux ; à cette fin, il faut développer des modèles d'un niveau adapté de généralité.

Dans tous les cas, la situation du calcul aujourd'hui impose des approches et des solutions allant au-delà d'un passé où l'efficacité était la principale préoccupation ; par exemple, les coûts imposent d'être capable de capturer également les questions de consommation énergétique. D'autre part, les évolutions technologiques des architectures tendent à faire passer le comportement en mémoire des applications également au premier plan.

Ces deux évolutions (généricité et modélisation, multi-critères) sont centrales dans cet axe du projet du laboratoire.

Allocation et ordonnancement pour le calcul haute performance Il s'agit d'un sujet fortement transverse. Le problème de l'ordonnancement est fondamental en calcul haute performance et est traité avec des approches différentes suivant la spécificité des problématiques des équipes concernées – Avalon, Compsys, Roma. L'évolution du problème vers un aspect très multi-critère est également transverse : la prise en compte de l'ensemble des ressources (énergie, données, mémoire) est devenue indispensable.

Roma se positionne en particulier fortement sur ces aspects multi-critères dans la conception d'algorithmes d'ordonnancement, en étudiant le compromis efficacité / résilience / énergie dans des protocoles de tolérance aux pannes. Outre ce caractère multi-critère, Avalon veut notamment intégrer à ses travaux sur le HPC et le *cloud computing* une dimension fortement dynamique à la question de l'ordonnancement – cela impose de repenser également les questions de gestions de données. Des problèmes voisins sont partagés par Compsys à l'échelle du processeur ou d'un multi-cœur ; en particulier, le modèle polyédrique intègre difficilement les contraintes de ressources et de mémoire dans l'orchestration (ordonnancement) des calculs ; la localité reste un sujet majeur quels que soient le langage d'entrée et la plate-forme cible.

Modélisation, choix, généricité La question de la généricité ou de l'adaptation au contexte de chaque calcul (par rapport à l'infrastructure, par rapport à l'application, ou par rapport aux deux) est largement partagée au sein de l'axe. Les approches y sont diverses. Dans tous les cas, et largement au sein de l'axe, la nécessité de développer des modèles est centrale, pour parvenir à traiter un large ensemble d'applications ou d'infrastructures. Comprendre où mettre le curseur entre généricité et « optimalité » est, là encore, un point de vue partagé.

Roma prévoit d'étudier ces idées en lien avec les questions de résilience et de tolérances aux pannes. Avalon se spécialise sur le profilage énergétique d'applications HPC et le développement de modèles à base de composants logiciels, en se basant sur des études approfondies d'applications diverses d'un côté, et pour des infrastructures variées, sur les différents types de ressources (des supercalculateurs aux fédération de *clouds*). Compsys s'efforce de développer des techniques et concepts généraux, bien qu'adaptables aux différents scenarii de plate-forme cible.

Sécurité du calcul Au-delà des questions de ressources, la question de la sécurité des données se pose très fortement dans les environnements de type Cloud. Deux approches gagnent en puissance au sein du laboratoire : une approche orientée système (allocation de ressource en fonction de politiques de sécurité) dans Avalon, et une approche orientée cryptographie, visant à progresser sur les méthodes de chiffrement homomorphe, en terme d'efficacité (théorique et pratique) mais aussi de fonctionnalités, développée dans Aric – dans ce dernier cas, une réflexion qui s'apparente à la modélisation est en œuvre pour parvenir à comprendre quelles sont les primitives pertinentes à développer.

Outils logiciels pour le calcul Le développement logiciel (bibliothèques, intergiciels, logiciels) constitue une activité scientifique à part entière. Il est à la fois un terrain d'expérimentation et de validation des résultats, mais aussi un moyen privilégié de transférer les résultats et l'expertise acquise vers les mondes académiques et industriels, et d'obtenir un retour d'expérience en provenance de ces deux mondes.

Aric a une longue tradition de développement logiciel de bibliothèques d'arithmétique et d'outils d'algèbre linéaire. Sur la période à venir, le principal projet d'évolution est le développement d'une bibliothèque d'arithmétique en (petite) multiprécision dont les algorithmes seront formellement certifiés, pouvant servir de base à des calculs numériques fiables.

Roma est co-responsable du développement du solveur de systèmes linéaires creux MUMPS qui est utilisé quotidiennement dans l'industrie et le monde académique. L'objectif de la période à venir est d'adapter MUMPS aux spécificités architecturales des plates-formes actuelles et futures et de proposer un ensemble de compromis entre précision du résultat obtenu, temps d'exécution et consommation mémoire.

Les membres d'Avalon ont dévéloppé de nombreux logiciels dont certains ont donné lieu à des transferts indutriels. Sur la période à venir, l'objectif est de continuer à faire évoluer DIET, d'industrialiser SimGrid et de poursuivre la validation expérimentale de nos modèles à travers des prototypes.

Compsys continuera sa tradition de contribuer au développement d'outils d'analyse et d'optimisation, notamment polyédriques, qu'ils soient sous forme de prototypes internes ou destinés à la communauté. Une évolution est attendue vers les GPUs et les multi-cœurs, l'analyse de langages parallèles et les utilisateurs du calcul à haute performance.

1.9.4 Éléments sur l'interdisciplinarité

Le positionnement fortement orienté « calcul », de la théorie à la pratique, du LIP fait du laboratoire un interlocuteur naturel pour une large gamme d'applications, en particulier pour les utilisateurs du calcul venant d'autres disciplines. L'extension des compétences du LIP vers la modélisation des données, avec la création de Dante, a élargi la base correspondante.

Sur le site lyonnais, la force traditionnelle et stratégique réside dans les sciences du vivant ; il est donc naturel que s'intéresser à des questions issues de ces thématiques constitue un aspect important du projet. La relation avec les sciences humaines et sociales est facilitée par la localisation du laboratoire, depuis 2010, au sein d'une ENS réunissant à nouveau sciences et lettres.

L'échange avec les mathématiques est naturel : on a vu que l'outil mathématique est central pour les recherches conduites au sein du LIP, comme outil de modélisation et d'analyse des questions informatiques ; *a contrario*, le LIP doit se positionner comme interlocuteur sur les questions de calcul rencontrées par les mathématiciens appliqués et la simulation numérique.

Sciences du vivant Avalon vise les applications de bioinformatique d'un point de vue de calcul parallèle et distribuée. D'une part, elles offrent une problématique plus données que les applications scientifiques usuelles. D'autre part, il s'agit d'une grande opportunité de transfert de nos savoirs à cette discipline.

Au sein de Plume, les travaux sur les modèles à base de règles en biologie des systèmes doivent permettre d'augmenter le degré d'automatisation sur la génération de règles à partir des données connues. L'objectif de ces modèles est une meilleure compréhension des relations logiques (causalité) entre événements au niveau d'un système biologique donné.

Sciences humaines et sociales L'ouverture et l'utilisation massive des sciences du numérique au sein des sciences humaines et sociales sont relativement récentes. On peut y voir une réelle « rupture » comme a pu l'être la bio-informatique il y a plus de vingt ans. Tous les domaines des sciences sociales sont influencés par le numérique : linguistique, sociologie, géographie, économiste, arts.... Un des facteurs de cette (r)évolution est dû à l'omniprésence des systèmes numériques au cœur de l'activité humaine et des traces numériques qui sont générées et stockées de façon automatique et généralisée. Le défi est à l'heure actuelle la modélisation de ces grands monceaux de données, de leur structure, leur évolution et la dynamique des réseaux qui les sous-tend. Un des buts des travaux de Dante est de mieux comprendre, concevoir, exploiter et contrôler les réseaux sociaux à des niveaux de précision devant permettre de répondre aux questions pertinentes pour les autres disciplines, notamment la sociologie qui cherche à obtenir des modèles de comportements individuels et collectifs.

Physique Le lien avec la physique se fait actuellement au travers de la forte participation du LIP au sein de l'IXXI, point de rencontre pluridisciplinaire impliquant en particulier le laboratoire de physique de l'ENS. La principale thématique qui y est conjointement développée est la modélisation des systèmes complexes, avec un fort parfum traitement du signal, en particulier sur des données graphes. Le recrutement récent d'un spécialiste de calcul quantique dans l'équipe MC2 pourrait être l'occasion de créer de nouveaux liens.

Mathématiques Les liens avec les mathématiques existent au travers d'une large partie de l'activité du LIP, fortement en interaction, voire à la frontière avec cette discipline, comme l'atteste la forte implication du LIP dans le GDR Informatique Mathématique, aux côtés de nombreuses équipes de mathématiques. Des liens concrets existent au niveau de la logique, des travaux de calcul formel menés dans Aric et MC2, des travaux sur la combinatoire des graphes, etc.

Les possibilités latentes sur le site lyonnais semblent actuellement sous-exploitées et doivent progresser, en particulier dans le contexte du Labex. Une piste importante est le développement des relations initiés avec les collègues impliqués dans les questions de calcul, fédérés dans la structure « Lyon Calcul » (Violaine Louvet, Thierry Dumont). Prendre l'initiative de développer les relations avec les équipes locales orientées « simulation numérique » pour leur offrir notre expertise est également un projet important.

1.10 Mise en œuvre du projet

1.10.1 Gouvernance

Direction et structures de gouvernance La direction devrait être assumée à l'horizon 2015 par un binôme Guillaume Hanrot (directeur) – Isabelle Guérin-Lassous (directrice-adjointe). Il est en projet de s'adjoindre un(e) chargé(e) de mission pour assurer le lien avec les autres acteurs locaux de la thématique calcul et les utilisateurs potentiels, ainsi que de l'animation scientifique sur ces sujets.

La direction s'appuiera, pour ses prises de décision, sur le conseil de laboratoire pour la majorité des sujets, mais aussi sur l'assemblée consultative des chefs d'équipe (auquel s'adjoint la direction du département informatique de l'ENS) pour les sujets liés aux recrutements (thèses, post-doctorats, postes permanents, demande de postes et préparation des comités de sélection). La consultation de ces instances joue une part importante dans la construction de la position du laboratoire portée par la direction ou ses représentants auprès des instances (comité exécutif du LabEx, École doctorale, tutelles, comités de sélection), même si seule l'équipe de direction (dans son ensemble) reste décisionnelle.

Les aspects « formation » et les arbitrages enseignement/recherche (par ex. recrutement des enseignants-chercheurs ou structure du master) concernant l'ENS sont traités par échange direct entre direction du laboratoire et direction du département (ou, de manière élargie, avec l'ensemble de l'équipe de direction du département si nécessaire) ; ce lien fonctionne de manière très constructive, dans le respect mutuel des intérêts des deux parties.

Concernant l'UCBL, la situation est plus complexe, le département informatique souhaitant ne travailler qu'avec des représentants des laboratoires, ce qui conduit concrètement à un relais d'information qui peut être parfois inefficace entraînant souvent des pertes en ligne. Il sera important de progresser sur ce point, pour travailler de manière constructive sur l'ensemble des dossiers d'intérêt commun, et d'améliorer la représentation du LIP au sein des instances du département. Il serait également souhaitable d'établir un lien plus formel avec l'IUT et un lien tout court avec Polytech'Lyon.

La formation doctorale, est, quant à elle, gérée globalement par la commission des habilités, sous la supervision d'Anthony Busson et Frédéric Vivien.

Les rapports avec Inria prennent place davantage au niveau des équipes qu'au niveau du laboratoire, bien que des échanges fructueux s'effectuent, de manière informelle, avec Éric Fleury (vice-président du comité des projets). Notons la tenue annuelle d'un comité de coordination ENS-Inria pour discuter principalement des équipes Inria du LIP (mais également, à la marge, de l'UMPA qui héberge une équipe commune ENS Lyon-Inria).

Équipes de recherche La période 2009-2014 a vu d'importantes restructurations des équipes, autant au niveau de la géométrie du laboratoire (arrêt de Réso & Graal, création d'Avalon, Dante et Roma) qu'en interne aux équipes (important développement de Plume et de MC2, ou encore de Dante et d'Aric).

Il semble important que la période à venir consolide ces évolutions et peu de restructurations ou d'évolutions d'équipe semblent, à ce jour, à attendre, à la possible exception de l'équipe Aric qui conduit actuellement une réflexion interne sur des évolutions de structure.

Cette situation de relative stabilité, où beaucoup d'équipes ont été significativement renforcées au cours de la période passée, peut conduire à réfléchir à l'opportunité de la création d'une nouvelle équipe scientifique au LIP. Cette évolution ne sera possible qu'avec un soutien fort de la part des équipes du laboratoire et doit contribuer significativement à élargir l'expertise du LIP dans le cadre de son projet, soit en renforçant les compétences sur le versant des données et de leur traitement, soit en adjoignant une composante applicative. Cette évolution ne pourra se faire, aussi, qu'en prenant en compte les complémentarités avec l'environnement local et qu'avec un soutien significatif des tutelles (comme cela a été le cas pour le développement de Plume et MC2, ou de la thématique « Cryptographie » d'Aric) et, sans doute, avec des actions d'attractivité permettant des accueils de chercheurs en mutation.

Animation scientifique L'animation scientifique, dynamique dans les équipes, a progressé sur la période au sein du laboratoire. Elle reste néanmoins perfectible, principalement dans ce qui concerne les échanges inter-équipes. Sur ce dernier point, on peut relever des initiatives au cours de la période : quelques séances de séminaire commun Aric/Plume autour de la preuve formelle (avec comme lointain descendant l'obtention en 2014 d'un financement ANR commun) ou le séminaire « graphes » centré sur MC2 mais impliquant aussi des membres de Dante ou de Roma.

Au cours de la période 2012-2014, des efforts ont été faits pour financer des collaborations inter-équipes, voire inter-laboratoires du site lyonnais. Elles n'ont eu qu'un succès fort limité – les volants financiers qu'il est possible de dégager au niveau de la direction du laboratoire ne sont pas assez significatifs pour produire l'effet incitatif escompté. Il nous semble néanmoins important de continuer dans cette direction et de garder en tête cette priorité.

Il nous semble également important, dans une même direction, de parvenir à susciter à nouveau de l'intérêt dans le laboratoire pour les activités conduites au sein des diverses équipes. Une solution pour ce faire pourrait être la création d'une activité de type « colloquium », à périodicité réduite (mensuelle voire bimestrielle). Nous réfléchissons actuellement à financer une activité de ce type adressée aux (et organisée par les) doctorants, à notre sens les plus à même de pâtir des liens limités entre équipes.

La piste du colloquium d'audience large nous semble également intéressante à l'échelle lyonnaise, comme une première mesure visant à créer un lieu de rencontre et à améliorer la connaissance mutuelle entre les différents laboratoires du site — la distance géographique séparant les sites constitue néanmoins un frein à ne pas sous-estimer...

1.10.2 Personnel

Permanents scientifiques Comme lors de la période précédente, l'objectif du LIP reste d'arriver à une représentation de chacune des tutelles dans chacune des équipes ; du travail reste à faire sur ce point, à l'UCBL en développant les aspects « informatique mathématique » et au CNRS en développant les aspects plus appliqués. Les candidatures ayant des possibilités d'échange scientifique dans plusieurs équipes de recherche seront également considérées avec un intérêt particulier. À moyen terme, la poursuite du renforcement de l'équipe Compsys, de taille encore sous-critique, doit rester également présente à l'esprit. Pour ce qui est du CNRS (et d'Inria), les équipes sont vivement encouragées à réfléchir à des possibilités d'accueil en mutation, qui constituent une opportunité particulièrement intéressante d'élargir leur expertise – il nous semble que le laboratoire dispose d'arguments permettant de faire venir des chercheurs de qualité.

Le critère prioritaire s'agissant de personnels permanents reste avant tout de garantir la qualité scientifique du recrutement. En particulier, une définition de profil « forte » ne peut se concevoir qu'avec la certitude de l'existence d'un vivier suffisant pour permettre à un recrutement de niveau élevé. À niveau comparable, les priorités ci-dessus, ainsi bien sûr que le projet du laboratoire, serviront de guide à la position du laboratoire pour la définition des profils et pour le recrutement.

Malgré des évolutions récentes, l'équilibrage entre chercheurs seniors (rang A) et juniors (rang B) reste assez hétérogène selon les équipes. C'est un point important qui reste à surveiller de près, même si les moyens de la direction du laboratoire en la matière sont limités.

Doctorants Les évolutions constatées sur la période passée doivent amener à des actions fortes en matière de recrutement de doctorants. S'appuyer lourdement sur le vivier ENS Lyon ne doit plus être la seule solution pour le laboratoire. Il faut encourager les permanents du laboratoire à aller intervenir dans des masters extérieurs, à y proposer des sujets de stage.

Il faut aussi insister sur l'importance que chacun s'appuie sur ses collaborations internationales pour recruter des étudiants. L'ENS Lyon envoie chaque année bon nombre de ses étudiants en stage à l'étranger (M1, M2), les co-tutelles internationales de thèse sont fortement encouragées, il faut insister pour que ces bonnes pratiques se déroulent, autant que possible, dans un esprit de réciprocité.

De façon plus stratégique, le laboratoire soutient avec énergie le développement de collaborations internationales vers des établissements permettant des flux récurrents d'étudiants de qualité (UT Cluj (Roumanie) par le passé, plusieurs établissements de Hanoï (Vietnam) actuellement, intégration de l'informatique dans une collaboration existante ENS/ECNU (Shanghai)). Là encore, l'expérience montre que l'existence d'un flux d'étudiants durable ne peut s'appuyer que sur une collaboration recherche solide.

Enfin, on peut espérer que la politique internationale développée par l'université de Lyon aboutisse, dans un proche avenir, à des échanges dynamiques d'étudiants avec les sites stratégiques identifiés[42].

Personnel administratif Sur le plan du personnel administratif, nous avons la chance de vivre depuis 3 ans une période de relative stabilité avec un bon effectif de personnel de grande qualité et très impliqué dans la bonne marche du laboratoire. Mais le regret demeure de ne pas parvenir à pourvoir notre poste AI CNRS (en remplacement d'un poste TR parti en promotion AI, comme c'est arrivé à de nombreuses reprises au sein du LIP au cours des 10 dernières années).

La grande difficulté d'obtenir un poste au concours externe, les viviers limités en mobilité interne CNRS AI sur la région et très limités en examen professionnel réservé (loi Sauvadet), compliquent singulièrement les choses. La question de se résigner à demander un poste au concours externe TR est ouverte : elle conduirait, hélas, à pérenniser la situation très regrettable de fort turnover du personnel administratif du laboratoire, en particulier au poste d'assistante de direction.

[42] Les universités de Fudan, Tongji et Jiao Tong à Shanghai, East China Normal University, les universités de Tokyo et Tohoku, l'université d'Ottawa, l'université de Sao Paulo et les établissements de Genève, Neuchâtel, Lausanne, Turin et Milan.

Personnel technique Sur ce plan, la principale difficulté à anticiper est le départ probable à la retraite sur la période de Serge Torres, qui joue un rôle fort d'animation et de coordination de l'équipe (et qui accomplit également un certain nombre de tâches en support de la direction du laboratoire). Son remplacement est indispensable pour la bonne marche du support informatique du laboratoire et le maintien du fonctionnement actuel du service (part MI-LIP équilibrant une part recherche). Le recrutement de son remplaçant doit si possible être anticipé, pour permettre de comprendre comment faire jouer aux différents membres du service les fonctions qu'exerce actuellement Serge Torres.

1.10.3 Sciences du numérique à Lyon

En terme de politique à moyen terme, il s'agit probablement du dossier prioritaire de la période 2016-2021. Pour la visibilité de la discipline à l'échelle lyonnaise, il est indispensable de progresser sur ce point. À ce jour, des contacts ont été pris avec le CITI au long du précédent quinquennal, qui se sont intensifiés courant 2013. Ils ont conclu sur des synergies intéressantes et sur un intérêt réciproque certain des deux directions concernées à développer les liens, dans le respect des identités des laboratoires (le CITI est très attaché à son identité 27-61-63), mais n'ont pas, à ce stade, beaucoup avancé. Les discussions se sont étendues à l'automne 2013 pour inclure le LIRIS, mais les premiers échanges ont brutalement achoppé sur l'impossibilité de construire une position commune, même avec une ambition très limitée, sur la question des demandes de postes UCBL.

Les changements de direction à la tête des principaux laboratoires concernés donnent une occasion de reprendre le dossier au point de départ et doivent permettre de construire une confiance entre les différents interlocuteurs. Au-delà des discussions entre directions, il serait souhaitable que les membres des laboratoires explorent les liens scientifiques qui existent clairement, par exemple entre le LIP et le CITI (Compsys, la géométrie de l'ex-équipe Reso, certains aspects d'Aric), mais aussi par certains aspects entre le LIP et le LIRIS (Avalon, voire MC2 autour de questions de géométrie discrète et de dynamique symbolique).

1.10.4 Calcul à Lyon

Contexte local Le calcul revêt une importance particulière dans le contexte local lyonnais. D'une part, des besoins importants existent. Pointons, en particulier, le développement des problématiques de traitement de données du vivant, en rappelant que les sciences de la vie constituent une des priorités thématiques du site lyonnais.

Face à ces besoins existent un ensemble de structures et de ressources importantes, fédérées dans la Fédération lyonnaise de modélisation et sciences numériques : citons l'IXXI (institut des systèmes complexes), le CBP (centre d'expertise sur la modélisation numérique) et les structures de calcul proprement dites, dont le PSMN sis sur le site de Gerland. En parallèle de cette fédération, Lyon héberge également l'important centre de calcul de l'IN2P3 (avec lequel nous sommes en contact via Frédéric Suter, collaborateur proche de l'équipe Avalon). Enfin, une expertise forte et active existe également à l'ICJ, par exemple en les personnes de Thierry Dumont & Violaine Louvet (IR CNRS), très active au niveau local et national sur les aspects calcul.

Position du LIP Le contexte local concentre donc un important besoin d'expertise sur les divers aspects du calcul, au sein duquel le LIP a beaucoup à offrir. A contrario, ces structures sont les plus à même de nous mettre en lien avec les utilisateurs finaux et de fournir des problématiques nouvelles et pertinentes. Ledit contexte local est, également, encore en évolution ; l'ensemble de ces structures sont de création encore récente et leur articulation se cherche encore.

Il est important pour le LIP de saisir sa chance d'être un acteur important de cette articulation ; des premières actions ont eu lieu en 2013-2014 (journée Calcul au LIP, certains aspects du trimestre thématique « Compilation » organisé au sein du LabEx MILYON) ou sont en cours de montage (trimestre thématique « Calcul »).

Dans un contexte d'évolution de politiques nationales de recherche vers des politiques de site, la mise en avant probable des sciences de la vie à l'échelle lyonnaise impose au laboratoire de développer ses connexions vers les utilisateurs du calcul, pour sortir d'un simple positionnement de laboratoire d'excellence qui risque de devenir plus difficile à défendre.

1.10.5 Infrastructure

Grâce au travail de l'équipe MI-LIP, l'infrastructure de calcul du laboratoire est de qualité et permet largement aux équipes à la fois d'avoir accès à des plates-formes variées et d'actualité aux fins d'expérimentation, tout en offrant la possibilité de déployer en production des calculs d'envergure modérée, les calculs plus importants devant utiliser les grands outils mis à disposition au niveau national.

La question d'infrastructure centrale à ce jour est la question des locaux. Outre le fait que la croissance dynamique de la période écoulée pose un problème de place pour loger l'ensemble du laboratoire dans de bonnes conditions, le laboratoire est actuellement dispersé sur trois sites sur un diamètre de 500 mètres environ. Le bail des locaux de l'IXXI, au sein duquel est hébergée l'équipe Dante, prend fin début 2015.

Certaines des solutions proposées par les tutelles pour résoudre ces deux problèmes (croissance en taille et relogement de l'IXXI ou de Dante) ajoutent à la dispersion géographique existante ; dans une situation extrême, on peut imaginer le LIP dispersé entre 4 sites, des locaux UCB de Gerland au campus Descartes de l'ENS Lyon – pour un laboratoire constitué de 7 équipes, cela nous semble un réel éclatement – quand bien même cette situation n'a vocation qu'à être temporaire, avec, à l'horizon 2017 (?), le regroupement au sein du bâtiment ENS qui héberge déjà la principale partie des locaux, à la conclusion de la première tranche du plan Campus.

Ce regroupement sur un seul site à l'horizon le plus rapproché possible est la priorité absolue des 5 ans à venir en matière d'infrastructure. Au-delà de l'unité géographique du laboratoire, le regroupement est seul à même de permettre une meilleure interaction scientifique des équipes, il facilitera la mise en œuvre d'actions globales à l'échelle du laboratoire. Mais aussi, il doit permettre de mettre dans une proximité géographique forte le LIP, l'IXXI et le CBP, permettant de nourrir les échanges entre ces structures et le LIP, dont on espère qu'ils dynamiseront l'activité du LIP autour du calcul.

On peut souhaiter finalement que l'opération plan Campus soit l'opportunité de chercher des solutions au (très ancien...) problème de la température estivale dans les locaux, difficilement supportable dans l'aile sud 3 à 4 mois par an.

2 AriC team: Arithmetic and Computing

2.1 Scientific areas and activities

2.1.1 Goals and context

The overall objective of AriC is, through computer arithmetic, to improve computing at large, in terms of performance, efficiency, and reliability. We work on arithmetic algorithms (integer and floating-point arithmetic, complex arithmetic, multiple-precision arithmetic, finite-field arithmetic) and their implementation, approximation methods, Euclidean lattices and cryptology, certified computing and computer algebra. Note that the AriC team is the follow-up of the former Arenaire team (Arenaire became AriC in 2012).

2.1.2 Activity profile

There is much variation of the activity profile inside the team: some of us are full-time researchers, and others have teaching responsibilities. Also, three of us have had or have a strong involvement in the animation of the local or national scientific community. On average, for the whole AriC team, we estimate the activity profile as

- Academic research: 50 %;
- Interaction with socio-economic or cultural environment: 10%;
- Scientific animation: 20%;
- Formation: 20%.

2.1.3 Highlights

- Publication of the Handbook of Computer Arithmetic (Birkhauser, 2010; 572 pages - 9 authors, 8 of them being AriC members);
- CNRS silver medal awarded to Jean-Michel Muller and prize “La Recherche” awarded to Vincent Lefèvre, Nicolas Louvet, and Jean-Michel Muller;
- CNRS bronze medal awarded to Damien Stehlé;
- ERC Junior grant awarded to Damien Stehlé;
- IEEE Working Group P1788 for standardization of interval arithmetic, chaired by Nathalie Revol;
- Active collaborations with STMicroelectronics, Kalray, and Orange Labs; especially via regular technology transfer, joint publications, and two PhD CIFRE grants;
- Software: CRlibm, FLIP, FloPoCo, fplll, Sollya, etc.;
- Organization at ENS de Lyon of the international conference SCAN 2010 (Scientific Computing, Computer Arithmetic, and Validated Numerics), which gathered over 120 participants from 20 countries;
- Design of the first LLL-type algorithm whose running time is quasi-linear in the bit size of the matrix entries and polynomial in the matrix dimension;
- First complexity analysis of the BKZ algorithm, with the proposal of an execution model that fits with experimental data.

2.1.4 Research activities

2.2 Organisation and life of the team

2.2.1 Meetings

- **Scientific meetings:** Every week, there is a team seminar (on Thursday) and a team working group (on Tuesday)[1]. The seminars are "conventional", one-hour, seminars: a French or foreign colleague is invited and presents a recent research result. The working groups are more internal (although sometimes the speaker is not from the team) and more informal and are either devoted to discussion on ongoing research, or to an introduction to some domain that may be useful for the work of the team members.

- **Organizational meetings:** Twice a month, there is a meeting of the team for discussing administrative and organizational matters, and exchanging information. These rather informal "Café AriC" meetings are open to all members (including PhDs, postdocs and trainees) unless the agenda requires the discussion to be restricted to permanent members (e.g., for discussing recruitments).

2.2.2 Creating social bounding in the team

- every 5 years or so, we feel the need to work all together on a big common project, to create social bounding within the team, and to take benefit from the complementarities of expertise between members of the group. In 2009-2010, our big project was the publication of the Handbook on Floating-Point Arithmetic [164]. In 2015 it will be the organization in Lyon of the 22nd IEEE Symposium on Computer Arithmetic;

- almost everyday, the team members (including all PhD students and trainees who wish so) have lunch together.

2.3 Scientific outcomes, visibility, collaborations

2.3.1 Scientific outcomes

Lattices and cryptography

We have worked on lattice-reduction algorithms. Concerning **weak yet fast lattice reduction algorithms**, we have improved the bit-complexity of the best known algorithm producing bases of quality similar to those returned by LLL. This has involved a series of works, on the impact of approximating a reduced basis on its reducedness, the problem of reducing bases that are almost reduced, and using these building blocks to efficiently reduce arbitrary bases. As a result, we have obtained the first LLL-type algorithm whose bit-complexity bound is quasi-linear in the bit-size of the norms of the input vectors (and polynomial in the lattice dimension n). Concerning **strong yet slower lattice reduction algorithms**, we have been able to devise the first complexity upper bound for BKZ, which is the best currently known algorithm for lattice reduction in high dimension. Furthermore, BKZ relies on an oracle that finds shortest non-zero vectors in lattices of smaller dimensions. We have studied such algorithms, both from a theoretical viewpoint (at some stage, an algorithm we proposed had the best complexity upper bound), and from a practical perspective (with heuristics, parallelisation, and implementation on FPGA). Finally, BKZ has been implemented in C++ and incorporated in the fplll library. These works were done in collaboration with ANR Lareda, Xiao-Wen Chang (McGill University), and Jérémie Detrey (LORIA).

An important research direction of ours is the application of our expertise on lattice reduction to cryptography. In lattice-based cryptography, finding vectors that are not much longer than the shortest lattice vectors (say, within a factor that is polynomial in the lattice dimension) seems to be a hard problem to solve: BKZ is the best known algorithm, and its runtime is exponential for bases of such quality. As a result, lattices have attracted the attention of cryptographers, for constructing primitives based on the security assumption that this well-identified problem and variants of it are hard. Ajtai (in 1996) and Regev (in 2005) proposed two reductions from worst-case lattice problems to average-case problems that can be expressed in terms of linear algebra: SIS (Short Integer Solution) and LWE (Learning With Errors). These problems now serve as a foundation of lattice-based cryptography. Concerning **security foundations**, we partially dequantized Regev's hardness proof for LWE. LWE with parameters n and q consists in finding a hidden vector $\vec{s} \in (\mathbb{Z}/q\mathbb{Z})^n$ from arbitrarily many and independently sampled pairs $(\vec{a}, \langle \vec{a}, \vec{s} \rangle + e)$, where e is a small noise and $\vec{a} \in (\mathbb{Z}/q\mathbb{Z})^n$. We showed that standard worst-case problems in dimension $\sqrt{n}$ reduce to LWE in dimension n and modulus $q = n^{O(1)}$. We also proposed extensions of known reductions for lattices and lattices corresponding to ideals of the rings of integers of number fields, to lattices corresponding to finitely generated modules over such rings. Concerning **cryptographic design,** we showed that the NTRU encryption and signature schemes may be modified so that they become at least as secure as

[1] The list of recent seminars can be found at `http://www.ens-lyon.fr/LIP/AriC/reunions.html`.

finding shortest vectors in a certain family of lattices. Prior to this result, the security of the NTRU primitives was only heuristic. Finally, we also used these LWE and SIS problems as black-boxes to construct group signatures. These allow to anonymously but accountably sign for a group. On the way to that result, we devised zero-knowledge proofs of knowledge of solutions to the SIS and LWE problems.

Another example where lattice reduction is of interest is the Table-Maker's Dilemma; these applications are described below. Other examples are **i) finding integer relations between reals:** We adapted the LLL algorithm to produce an algorithm dealing with the algorithmic problem of finding a canonical representation of the set of all integer linear combinations of a finite set of possibly linearly dependent real-valued vectors. This question arises from the problem of finding integer relations between real numbers. Our algorithm may be seen as a generalization of the HJLS and PSLQ algorithms; and **ii) communications:** In a collaboration with Cong Ling (Imperial College), we have looked at several problems from the field of communications over noisy continuous channels (e.g., wifi and cell phone communications). Lattices are used in different contexts in that field, and we exploited our tools to suggest improvements.

Tools for function evaluation

When implementing functions in mathematical software libraries such as the popular C `libm`, the function f to be implemented is often replaced by an approximation polynomial p on a closed bounded interval $[a, b]$. In order to guarantee the correctness of the implementation, one has to compute a tight upper bound of the supremum norm of the approximation error, being it absolute $p - f$ or relative $p/f - 1$, on the interval. We proposed a novel algorithm for efficient and accurate computation of upper bounds of approximation errors. Key elements of this algorithm are the use of intermediate approximation polynomials with bounded truncation remainder and a non-negativity test based on a Sum-of-squares expression of polynomials. This algorithm is fully automated and the accuracy obtained for the result is controlled "a priori" by the user. It can deal uniformly with both absolute and relative errors. The algorithm focuses also on formally proving the numerical result and paves the way for formally certified supremum norms. It was implemented as a prototype using the scripting language of Sollya and is going to be integrated as a part of Sollya[2].

In collaboration with L. Rideau and L. Théry (INRIA Sophia Antipolis), we have worked on the problem of offering guaranteed error bounds for a specific kind of rigorous polynomial approximation called Taylor model. We carried out this work in the Coq proof assistant, with a special focus on genericity and efficiency for our implementation. We gave an abstract interface for rigorous polynomial approximations, parameterized by the type of coefficients and the implementation of polynomials, and we instantiated this interface to the case of Taylor models with interval coefficients, while providing all the machinery for computing them.

The use of Taylor series can be problematic numerically due to cancellations, for instance when the series are alternating. A typical example is the series expansion at the origin of the Airy function $\mathrm{Ai}(x)$ for $x > 0$. In a joint work with S. Chevillard (INRIA Sophia Antipolis), we showed how to find a nice decomposition $\mathrm{Ai}(x) = G(x)/F(x)$, where both factors are given by positive Taylor series. We then discussed how to evaluate these series efficiently and accurately, bounding all errors. The implementation allows for an arbitrary and certified accuracy, that can be used, e.g., for providing correct rounding in arbitrary precision.

In collaboration with A. Benoit (INRIA Rocquencourt), we also proposed a new tool for performing validated computations (global optimization or quadrature for instance). Following the Taylor model approach, we associate to a smooth function f a pair made of a Chebyshev interpolant or a truncated Chebyshev series P and an interval remainder which contains all the values of the difference $f - P$. Chebyshev interpolants and truncated Chebyshev series offer an almost optimal quality of approximation and polynomials expressed in the Chebyshev polynomial basis provide better numerical stability that in the monomial basis.

Another direction of research we are working on for the long term is the efficient numerical computation of (multiple) definite integrals depending on parameters. Numerically, these computations are often difficult (or expensive) even for moderate dimensions. We plan to investigate the benefit that can be gained from a symbolic-numeric approach, where a linear differential equation or a system of such is first computed symbolically for the integral and then symbolic-numeric methods for these differential equation (that we have been developing and will pursue further) can be applied. As a first step, in collaboration with A. Bostan and P. Lairez (INRIA Saclay), we considered the case of integrals of multivariate rational or algebraic functions over appropriate cycles. Using classical results of algebraic geometry and recent efficient linear algebra algorithms developed in the team, we obtained the first algorithm with a complexity that is singly exponential in the dimension.

Computer algebra

In collaboration with C. Pivoteau (Univ. Marne-la-Vallée) and M. Soria (Univ. Paris 6), we developed an algorithm based on a combinatorial Newton iteration for computing the numerical values required in a recent algorithm for random

[2] See Software section in the detailed report in appendix.

generation. With these techniques, random objects of sizes in the tens of thousands can be generated very efficiently, with a distribution of probability that is guaranteed to be uniform among all objects of the same size. The symbolic-numeric interplay is very nice: on the symbolic side, this approach produces the first quasi-optimal algorithms for the computation of the enumeration sequences (numbers of objects of size up to n) for a large class of combinatorial structures.

Gröbner bases form a central tool in symbolic computation with polynomial systems. Their complexity in the worst-case is infamously doubly exponential, but a recent trend of research stems from observing that these worst-cases are extremely rare (in a sense that can be made rigorous). Generic or structured systems of equations lead to algorithms with a much better complexity if one knows how to exploit the underlying structure. This approach has applications in cryptography, where understanding how to encode the secret key of a crypto-system as the solution of a polynomial system over a finite field is the basis of so-called algebraic attacks. These works were done in collaboration with M. Bardet (Univ. Rouen), J.-C. Faugère (INRIA Rocquencourt) and P.-J. Spaenlehauer (INRIA Nancy Grand-Est).

We designed new *faster exact algorithms* for a variety of problems on matrices, polynomial systems, and linear differential equations. Those include a quasi optimal algorithm for common left multiples of several linear differential operators with polynomial coefficients; an explicit division-free algorithm for the adjoint of a matrix over an arbitrary ring; the first algorithm whose practical cost drops below the $O(2^n)$ barrier for finding all the common zeros of n quadratic polynomials in n variables over the field with 2 elements; rank-sensitive and in-place algorithms for matrix echelon forms over a field; faster algorithms for structured matrix inversion, generalized Hermite-Padé approximation, and multivariate polynomial interpolation, leading to the best known complexity for list decoding à la Guruswami-Sudan.

New, highly efficient techniques for *verifying linear system solutions* were proposed, which given a floating-point solution $\widehat{x}$ to $Ax = b$ produce both a refined approximation $\widetilde{x}$ together with an interval vector e containing the error vector $x - \widetilde{x}$. Another thread of results deals with *interval matrix multiplication*, for which several algorithms were designed, offering various trade-offs between cost and accuracy. These algorithms come further with careful multi-core implementations and theoretical and practical rounding error analyses. Finally, *rigorous perturbation analyses* of numerical matrix factorizations were introduced, motivated by the design of faster LLL-type algorithms based on floating-point arithmetic.

Computer arithmetic

Algorithms and implementations have been developed to provide efficient and accurate floating-point support for targets like FPGAs or VLIW embedded cores. In both cases, it turned out to be worth developing *code generation tools* (like the FloPoCo and CGPE frameworks), as well as *custom operators* that are either specialized (e.g., multipliers by a constant or squarers), fused (e.g., fused multiply-add (FMA) and its extensions) or simultaneous (e.g., sincos). A third key ingredient was to base the design of higher-level operators like division, square root, and the elementary functions on *fast and accurate polynomial evaluation schemes*.

The latest revision of the IEEE 754 standard for floating-point arithmetic offers both a rigorous framework for the analysis of existing algorithms as well as new features like the *FMA operation*, *correctly-rounded elementary functions*, and *comparisons* and *conversions* between different formats. All these aspects have been covered during the period. Concerning elementary functions, the search for hard-to-round cases needed for their correct rounding was at the heart of the TaMaDi ANR project (see below). We also quantified the usefulness and impact of the FMA operation in various contexts (division, 2×2 determinants, complex arithmetic) and, on the other hand, proposed new algorithms for comparisons and conversions. Finally, we started a systematic exploration of the *"low-level" properties* of IEEE floating-point arithmetic, which already led to the improvement of various error bounds classically used in numerical analysis: summation, powers, complex products and quotients, etc.

We initiated and chair the IEEE 1788 working group for the standardization of *interval arithmetic*. The development of the standard relies on the set-based model. It now reaches its completion and the resulting document (about 100 pages) should be adopted by the end of 2014. Concerning *multiple-precision floating-point arithmetic*, we are strongly involved in the development of the GNU MPFR library. Five new releases have been produced over the period (for better portability and testing as well as for consistency with the IEEE 754-2008, ISO C, and POSIX standards).

The Table Maker's Dilemma (TMD) problem consists in evaluating with which intermediate accuracy a function must be approximated if one wishes to be able to always return the floating-point number closest to the exact value of the function, for all floating-point inputs. Members of the team coordinated and took an active part in the TaMaDi project of the ANR (years 2010–2013), which was devoted to this problem. This work was done in cooperation with members of the Pequan team of lab. LIP6 (Paris), and Laurent Théry and Laurence Rideau (Inria Sophia Antipolis). Stehlé's second algorithm for the TMD, based on Coppersmith's method has been implemented and experimented; new improvements have been included with moderate practical success. Experiments have been conducted and the limits of the method have been evaluated: despite the appealing fact that the method should have polynomial complexity when dealing with "very large" worst cases, ie. for $|f(x/2^p) - y/2^p| < 2^{-p'}$ with $p' = \Omega(p^2)$, where p is the precision of the floating-point system being used, the hidden constants make the method quite unpractical, even for moderate values of p (quadruple precision, ie. $p = 113$). However this method has proved to be interesting for a **certificate-based approach** in double precision: checking a certificate is an order of magnitude less expensive than computing it (we avoid the lattice basis reduction step). With this idea we were able to build a full certification chain in Coq and formally certify a full binade[3] for the exponential function in double precision, with $p' \simeq 150$, in roughly a week of computation and certification time. It was obvious from the beginning that heavy parallelization of the computations would yield advances in the resolution of the TMD. Nevertheless, it was not clear at early stages which parallel programming "styles" would be most adapted to our needs. A testbed was then setup to compare different approaches such as message passing (*à la* MPI"), shared memory multithreading ("à la OpenM") and mixed programming on the same hardware (a single "many cores" box). Members of the team also worked on Ziv's rounding test (a technique that allows one to decide if one has enough information to return a correctly rounded result) to formalize the problem and to find possibly optimal solutions (however impossible to prove so all situations). This work has practical implications for the efficiency of correctly rounded computations.

2.3.2 Visibility

Academic attractivity

The team was able to attract **new permanent members** either through professional transfer—Bruno Salvy, Directeur de Recherches (senior researcher) Inria, arrived in 2012—or through recruitment (Guillaume Hanrot, recruited professor at ENS Lyon in 2009; Fabien Laguillaumie, recruited professor at ISFA Lyon in 2012).

Several colleagues came for one year or more, either on a **"delegation" (partial secondment) position**—Laurent Stéphane Didier, then MCF (associate professor) at Paris Pierre & Marie Curie University, in 2012; Stef Graillat, MCF at Paris Pierre & Marie Curie University, in 2013; Micaela Mayero, MCF at Paris 13 University in 2009 and 2011; Clément Pernet, MCF at Grenoble UJF University, in 2013—, or, for younger ones, on a **postdoc position** (Rishiraj Bhattacharyya; Marc Mezzarobba; Andrew Novocin; Ioana Pasca; Alvaro Vazquez Alvarez), or an **"ATER"** (lecturer) position (Sylvain Collange in 2010; Nicolas Estibals in 2013; Eleonora Guerrini in 2012, Ioana Pasca again in 2012).

Concerning the **recruitment of PhD students,** we had a rather difficult period between 2010 and 2012, but the situation is improving: 4 new PhD students in 2009; 2 in 2010; 2 in 2011; 0 in 2012; 3 in 2013. As we are writing these lines we do not have all the information concerning the applications and grants, but we expect al least 5 applicants, and 4 of them are already funded (Maulat, Melczer, Plet, Popescu). A consequence of this is that the number of PhD students in the team, which attained its minimum (7) in 2013, should increase in 2014.

National and International visibility

The team organized in Lyon the SCAN'2010 (GAMM-IMACS International Symposium on Scientific Computing, Computer Arithmetic and Validated Numerics) conference, and will organize in Lyon the IEEE ARITH 2015 Conference.

During the period, members of the team have belonged to Program Committees and/or Steering Committees of IEEE ARITH, ANTS, ISSAC, Crypto, Africacrypt, Asiacrypt, ACM-CSS, ASAP, SCAN, PQ Crypto, . . .

Members of the team are associate editors of IEEE Transactions on Computers, Journal of Symbolic Computation, and Journal of Algebra.

A member of the team (N. Revol) chairs the IEEE-1788 working group for standardization of Interval arithmetic.

Members of the team got various awards during the period: ERC Junior Grant, CNRS Bronze Medal, CNRS Silver Medal, La Recherche Award for information Sciences, ASAP 2011 Best Paper Award.

2.3.3 Collaborations

Industrial collaborations with ST Microelectronics, Bosch, Kalray, Orange Labs. Donations to the team by Intel, Altera.

Long-term collaboration with Siegfried M. Rump (Hamburg, Germany); Éric Schost (London, Ontario, Canada); Peter Kornerup (Odense, Denmark); Milos Ercegovac (UCLA, California, USA); Ron Steinfeld (Monash, Australia); Xiao-Wen Chang (McGill, Canada); San Ling (NTU, Singapore); Cong Ling (Imperial College, UK).

In France, through ANR Grants, collaborations with the following labs/leams: LIG (Grenoble), LJK (Grenoble), Inria Polsys (Paris), Inria Marelle (Sophia Antipolis), Inria Tropics (Sophia Antipolis), LIP6 (Paris), LIRMM (Montpellier), DALI (Perpignan), Greyc (Caen).

[3] A binade is the interval between two consecutive integer powers of 2.

2.4 Training through research

2.4.1 PhD dissertations defended in the team, and doctoral studies

Since January 2009, 10 AriC students have defended their PhD: Sylvain Chevillard (July 2009); Guillaume Revy (December 2009); Hong-Diep Nguyen (January 2011); Bogdan Pasca (September 2011); Mioara Joldes (September 2011); Christophe Mouilleron (November 2011); Adrien Panhaleux (June 2012); Eric Martin-Dorel (September 2012); Jingyan Jourdan-Lu (November 2012); Nicolas Brunie (May 2014). As we are writing these lines, Adeline Langlois and Philippe Théveny are to defend their PhDs during the autumn of 2014.

Among the 6 students who defended their PhD before december 2011, 5 now have a permanent position: Sylvain Chevillard is now Inria researcher (CR) at Inria Sophia-Antipolis Méditerranée; Guillaume Revy is associate professor (MCF) at Université de Perpignan; Hong-Diep Nguyen is postdoctoral scholar at UC Berkeley; Bogdan Pasca is Engineer in the Altera European Technology Centre, UK; Mioara Joldes is CNRS researcher (CR) at LAAS Laboratory (Toulouse); Christophe Mouilleron is “professeur agrégé” in ENSIIE (Evry).

J.-M. Muller is a member of the council of the doctoral school InfoMaths.

2.4.2 Implications in MSc studies

The team members are strongly involved in the Master of ENS Lyon and the Master of ISFA (Uni. Lyon 1). For instance, during the academic year 2013-2014, the following M1 and M2 courses have been given by AriC members: Computer Arithmetic (14h, Univ. Lyon 1), Floating-Point Arithmetic and Formal Proof (8h + coordination of the 24h course, ENS de Lyon), Computer Algebra (24h, ENS de Lyon; and 12h, MPRI), Cryptography (24h, ENS de Lyon), Approximations: from symbolic to numerical computation, and applications (24h, ENS de Lyon).

2.5 Research project

2.5.1 Self-assessment and SWOT analysis

Strong points

We believe that the scientific quality of the team is good. Many AriC members have a strong international visibility. AriC is arguably the major center for computer arithmetic in the academic world. There is a strong cooperation between the members: AriC is not a mere concatenation of independent sub-teams. The thematic span of AriC is large, which makes AriC the right place for working on the symbolic-numeric interaction, and allows us to cooperate with people from different areas, such as formal proof. We believe that we have reached a good balance between theory and development.

Weak points

The cryptography theme is too small. We need to reinforce it. Also, since the departure of Florent de Dinechin, we have lost most of our competence in computer architecture.

Opportunities

The MI-Lyon Labex offers many possibilities, including the funding of events. For instance, in February 2014, we have organized a one-week workshop, “Formal Proof, Symbolic Computation and Computer Arithmetic”, with several top-rank participants (e.g., John Harrison, Warwick Tucker), funded by MI-Lyon.

The close presence of the students of Ecole Normale Supérieure de Lyon is also an interesting opportunity.

Risks

The age pyramid of the team becomes rather imbalanced: we need to recruit junior academics.

As we are writing these lines, we are in a building away from the main building of ENS Lyon, where the other teams and the students are located. For our junior researchers and our students, there is a risk of being isolated and not having enough contact with colleagues and students.

2.5.2 Research objectives

As written above, we believe that AriC is the right place for making progress on the symbolic-numeric interaction. We would like to work on the design of high-performance and reliable numeric and/or symbolic *kernels*. Also, to make progress in one of our traditional domains (function implementation), we need to focus more on efficient approximation methods (design of certified approximations, research of hardest-to-round cases, etc.). Also, the recent recruitments as professors of Damien Stehlé (who was already in the team as CNRS researcher) and Fabien Laguillaumie, as well as the possible recruitment–not fully certain as we are writing these lines–of Benoît Libert as Inria researcher constitute an interesting opportunity for launching a strong activity on lattice-based cryptography in the team.

Lattices: algorithms and cryptology

Lattice algorithms All known lattice reduction algorithms follow the same design principle: perform a sequence of small elementary steps transforming a current basis of the input lattice, where these steps are driven by the Gram-Schmidt orthogonalisation of the current basis.

In the short term, we will fully exploit this paradigm, and hopefully lower the cost of reduction algorithms with respect to the lattice dimension. We aim at asymptotically fast algorithms with complexity bounds closer to those of basic and normal form problems (matrix multiplication, Hermite normal form). In the same vein, we plan to investigate the parallelism potential of these algorithms.

Our long term goal is to go beyond the current design paradigm, to reach better trade-offs between run-time and shortness of the output bases. To reach this objective, we first plan to strengthen our understanding of the interplay between lattice reduction and numerical linear algebra (how far can we push the idea of working on approximations of a basis?), to assess the necessity of using the Gram-Schmidt orthogonalisation (e.g., to obtain a weakening of LLL-reduction that would work up to some stage, and save computations), and to determine whether working on generating sets can lead to more efficient algorithms than manipulating bases. We will also study algorithms for finding shortest non-zero vectors in lattices, and in particular look for quantum accelerations.

We will implement and distribute all algorithmic improvements, e.g., within the fplll library. We are interested in high performance lattice reduction computations (see application domains below), in particular in connection/continuation with the HPAC ANR project (algebraic computing and high performance consortium).

Lattice-based cryptography Our long term goal is to demonstrate the superiority of lattice-based cryptography over contemporary public-key cryptographic approaches. For this, we will 1- Strengthen its security foundations, 2- Drastically improve the performance of its primitives, and 3- Show that lattices allow to devise advanced and elaborate primitives.

The practical security foundations will be strengthened by the improved understanding of the limits of lattice reduction algorithms (see last section). On the theoretical side, we plan to attack two major open problems: Are ideal lattices (lattices corresponding to ideals in rings of integers of number fields) computationally as hard to handle as arbitrary lattices? What is the quantum hardness of lattice problems?

Lattice-based primitives involve two types of operations: sampling from discrete Gaussian distributions (with lattice supports), and arithmetic in polynomial rings such as $(\mathbb{Z}/q\mathbb{Z})[x]/(x^n + 1)$ with n a power of 2. When such polynomials are used (which is the case in all primitives that have the potential to be practical), then the underlying algorithmic problem that is assumed hard involves ideal lattices. This is why it is crucial to precisely understand the hardness of lattice problems for this family. We will work on improving both types of operations, both in software and in hardware, concentrating on values of q and n providing security. As these problems are very arithmetic in nature, this will naturally be a source of collaboration with the other Themes of the ARIC team.

Our main objective in terms of cryptographic functionality will be to determine the extent to which lattices can help securing cloud services. For example, is there a way for users to delegate computations on their outsourced dataset while minimizing what the server eventually learns about their data? Can servers compute on encrypted data in an efficiently verifiable manner? Can users retrieve their files and query remote databases anonymously provided they hold appropriate credentials? Lattice-based cryptography is the only approach so far that has allowed to make progress into those directions. We will investigate the practicality of the current constructions, the extension of their properties, and the design of more powerful primitives, such as functional encryption (allowing the recipient to learn only a function of the plaintext message). To achieve these goals, we will in particular focus on cryptographic multilinear maps.

This research axis of ARIC is gaining strength thanks to the recruitment of Benoit Libert. We will be particularly interested in the practical and operational impacts, and for this reason we envision a collaboration with an industrial partner.

Application domains

- Diophantine equations. Lattice reduction algorithms can be used to solve diophantine equations, and in particular to find simultaneous rational approximations to real numbers. We plan to investigate the interplay between this algorithmic task, the task of finding integer relations between real numbers, and lattice reduction. A related question is to devise LLL-reduction algorithms that exploit specific shapes of input bases. This will be done within the ANR DynA3S project.

- Communications. We will continue our collaboration with Cong Ling on the use of lattices in communications. We plan to work on the wiretap channel over a fading channel (modeling cell phone communications in a fast moving environment). The current approaches rely on ideal lattices, and we hope to be able to find new approaches thanks to our expertise on them due to their use in lattice-based cryptography. We will also tackle the problem of sampling vectors from Gaussian distributions with lattice support, for a very small standard deviation parameter. This would significantly improve current schemes for communication schemes based on lattices, as well as several cryptographic primitives.

- Cryptanalysis of variants of RSA. Lattices have been used extensively to break variants of the RSA encryption scheme, via Coppersmith's method to find small roots of polynomials. We plan to work with Nadia Heninger (U. of Pennsylvania) on improving these attacks, to make them more practical. This is an excellent test case for testing the practicality of LLL-type algorithm. Nadia Heninger has a strong experience in large scale cryptanalysis based on Coppersmith's method (`http://smartfacts.cr.yp.to/`)

Efficient approximation methods

Computer algebra generation of certified approximations. We plan to focus on the generation of certified and efficient approximations for solutions of linear differential equations. These functions cover many classical mathematical functions and many more can be built by combining them. One classical target area is the numerical evaluation of elementary or special functions. This is currently performed by code specifically handcrafted for each function. The computation of approximations and the error analysis are major steps of this process that we want to automate, in order to reduce the probability of errors, to allow one to implement "rare functions", to quickly adapt a function library to a new context: new processor, new requirements – either in terms of speed or accuracy.

In order to significantly extend the current range of functions under consideration, several methods originating from approximation theory have to be considered (divergent asymptotic expansions; Chebyshev or generalized Fourier expansions; Padé approximants; fixed point iterations for integral operators). We have done preliminary work on some of them. Our plan is to revisit them all from the points of view of effectivity, computational complexity (exploiting linear differential equations to obtain efficient algorithms), as well as in their ability to produce provable error bounds. This work is to constitute a major progress towards the automatic generation of code for moderate or arbitrary precision evaluation with good efficiency. Other useful, if not critical, applications are certified quadrature, the determination of certified trajectories of spatial objects and many more important questions in optimal control theory.

Digital Signal Processing. As computer arithmeticians, a wide and important target for us is the design of efficient and certified linear filters in digital signal processing (DSP). Actually, following the advent of Matlab as the major tool for filter design, the DSP experts now systematically delegate to Matlab all the part of the design related to numerical issues. And yet, various key Matlab routines are neither optimized, nor certified. Therefore, there is a lot of room for enhancing numerous DSP numerical implementations and there exist several promising approaches to do so.

The first important challenge that we want to address is the development and the implementation of optimal methods for rounding the coefficients involved in the design of the filter. If done in a naive way, this rounding may lead to a significant loss of performance. We will study in particular FIR and IIR filters.

Table Maker's Dilemma (TMD). There is a clear demand for hardest-to-round cases, and several computer manufacturers recently contacted us to obtain new cases. These hardest-to-tound cases are a precious help for building libraries of correctly rounded mathematical functions. The current code, based on Lefèvre algorithm, will be rewritten and formal proofs will be done. We plan to use uniform polynomial approximation and diophantine techniques in order to tackle the case of the IEEE quad precision and analytic number theory techniques (exponential sums estimates) for counting the hardest-to-round cases.

High-performance reliable kernels

The main theme here is the study of fundamental operations ("kernels") on a hierarchy of symbolic or numeric data types spanning integers, floating-point numbers, polynomials, power series, as well as matrices of all these. Fundamental operations include basic arithmetic (e.g., how to multiply or how to invert) common to all such data, as well as more specific ones (change of representation/conversions, GCDs, determinants, etc.). For such operations, which are ubiquitous and at the very core of computing (be it numerical, symbolic, or hybrid numeric-symbolic), our goal is to ensure both high-performance and reliability.

Algorithmic design and analysis of symbolic or numerical algorithms. On the symbolic side, we have so far obtained fast algorithms for basic operations on both polynomial matrices and structured matrices, but in a rather independent way. Both types turn out to have much in common, but this is sometimes not reflected by the complexities obtained, especially for applications in cryptology and coding theory. Our long term goal in this area is thus to explore these connections further, to provide a more unified treatment and bridge these complexity gaps, and to produce associated efficient implementations. A first step towards this goal will be the design and implementation of enhanced algorithms for various generalizations of Hermite-Padé approximation; in the context of list decoding, this should in particular make it possible to improve over the structured-matrix approach, which is so far the fastest known.

On the numerical side, we will continue to revisit and improve the classical error bounds of numerical analysis in the light of all the subtleties of IEEE floating-point arithmetic. These aspects will be developed jointly with the "symbolic floating-point" approach presented in the next paragraph. A complementary approach will also be studied, based on the estimation (possibly via automatic differentiation) of condition numbers in order to identify inputs leading to large backward errors. Finally, concerning interval arithmetic, a thorough analysis of the accuracy of several representations, such as mid-rad, is also to be done.

Symbolic floating-point arithmetic. Our work on the analysis of algorithms in floating-point arithmetic leads us to manipulate floating-point data in their greatest generality, that is, as symbolic expressions in the base and the precision. A long-term goal here is to develop theorems as well as efficient data structures and algorithms for handling such quantities by computer rather than by hand as we do now. This is a completely new direction, whose main outcome will be a "symbolic floating-point toolbox" distributed in computer algebra systems like Sage and or Maple. In particular, such a toolbox will provide a way to check automatically the certificates of optimality we have obtained on the error bounds of various numerical algorithms. A PhD student is to start on this subject in September 2014.

High-performance multiple precision arithmetic libraries. Many numerical problems require higher precision than the conventional floating-point (single, double) formats. One solution is to use multiple precision libraries such as GNU MPFR, which allow the manipulation of very high precision numbers, but their generality (they are able to handle numbers with millions of digits), is a quite heavy alternative when high performance is needed. Our objective is to design a multiple precision arithmetic library that would allow to tackle problems where a precision of a few hundred bits is sufficient, but which have strong performance requirements. Applications include the process of long-term iteration of chaotic dynamical systems ranging from the classical Henon map to calculations of planetary orbits. The designed algorithms will be formally proved. We are in close contact with Warwick Tucker (Uppsala University, Sweden) and Mioara Joldes (LAAS, Toulouse) on this topic. We will hire a PhD student on this topic in September 2014. The student will be funded by a Région Rhône-Alpes grant.

Interactions between arithmetics. We will work on the interplay between floating-point and integer arithmetics, and especially on how to make the best use of both integer and floating-point basic operations when designing floating-point numerical kernels for embedded devices. This will be done in the context of the Metalibm ANR project and of our collaboration with STMicroelectronics. In addition, our work on the IEEE 1788 standard leads naturally to the development of associated reference libraries for interval arithmetic. A first direction will be to implement IEEE 1788 interval arithmetic using the fixed-precision hardware available for IEEE 754-2008 floating-point arithmetic. Another one will be to provide efficient support for multiple-precision intervals, in mid-rad representation and by developing MPFR-based code-generation tools aimed at handling families of functions.

Adequation algorithms/architectures. So far, we have investigated how specific instructions like the fused multiply-add (FMA) impact the accuracy of computations, and have proposed several highly accurate FMA-based algorithms. The FMA being available on several recent architectures, we now want to understand its impact on such algorithms in terms of practical performances. This should be a medium term project, leading to FMA-based algorithms with best speed/accuracy/robustness tradeoff. On the other hand (and on the long term), a major issue is how to exploit the various levels of parallelism of recent and upcoming architectures to ensure simultaneously high performance and reliability. A first direction will be to focus on SIMD parallelism, offered by instruction sets via vector instructions. This kind of parallelism should be key for small numerical kernels like elementary functions, complex arithmetic, or low-dimensional matrix computations. A second direction will be at the multi-core processor level, especially for larger numerical or algebraic problems (and in conjunction with SIMD parallelism when handling sub-problems of small enough dimension). Finally, we will work on aspects of automatic adaptation (auto-tuning) to such architectural features, not only for speed, but also for accuracy. This could be done via the design and implementation of heuristics capable of inserting more accurate codes, based for example on error-free transforms, whenever needed.

3 Avalon team: Algorithms and Software Architectures for Distributed and HPC Platforms

The Avalon team has been created during the evaluation period. It is made of people coming from the GRAAL and RESO Inria teams and from the IN2P3 Computing Center (CC-IN2P3) at different moment in time. From a LIP point of view, the Avalon team has been created in July 2010 and was composed of about half of the GRAAL team (E. Caron, F. Desprez, G. Fedak, and C. Perez). F. Suter, from the IN2P3 Computing Center, joined the Avalon team in January 2012. About half of the RESO team (J.-P. Gelas, O. Gluck, and L. Lefevre) joined Avalon at 2013, January 1st, when the RESO team ended. At the end of the Inria GRAAL team (2011, December 31st), Avalon has started the process to become a join research team between Inria, CNRS, ENSL, and Univ. Lyon I. In June 2014, all the creation steps have been successfully done.

This section covers the work that has been done under the supervision of current permanent members of Avalon. Therefore, it also includes work that was done in GRAAL and RESO teams. As before being part of Avalon, F. Suter (CC IN2P3) was not evaluated by AERES, all his work of the current evaluation period is included as being part of Avalon even though he has joined Avalon in 2012.

3.1 Scientific areas and activities

3.1.1 Goals and context

The GRAAL team worked on algorithms and scheduling strategies for heterogeneous and distributed platforms, as well as on environments and tools for the deployment of applications over service oriented platforms. The research team of the IN2P3 Computing Center worked on scheduling algorithms for scientific workflows and on the simulation of large scale parallel and distributed systems and applications. The overall objective of the RESO team was concerning optimized protocols and software for high performance networking. Some aspects were focusing of dynamictiy of protocols and energy efficiency of large scale infrastructures.

The goal of the Avalon research team is to be able to execute parallel (HPC) and/or distributed applications on parallel and/or distributed resources (Grids, Clouds, etc.) while ensuring user and system objectives with respect to performance, cost, energy, security, etc. Avalon is contributing to the profiling and modeling of applications with respect to energy consumption and data management, to the description of applications based on software component models, and to algorithms to allocate and schedule applications on resources.

3.1.2 Activity profile

The AVALON team is composed of people with different profiles, including full time researchers, associate professors, permanent and temporay engineers, PhD students, and post-docs. Some people have strong involvement in the scientific community, in particular in the management of the GRID'5000 platform. The estimation activity profile has to be considered as a whole for the team.

1. Academic research: 50 %.
2. Interaction with socio-economic or cultural environment: 5%.
3. Scientific animation: 25%.
4. Formation: 20%.

3.1.3 Highlights

- Successful evaluation of the proposition of creation of the Inria-CNRS-ENSL-Lyon I Avalon team;
- Creation, leading, and strong involvement of the team in the GRID'5000 GIS (*Groupement d'Intérêt Scientifique*);
- Creation, leading, and strong involvement in the Inria large-scale initiative Hemera around GRID'5000 that had up to 24 French teams involved;
- Foundation of the SysFera startup in 2010 based on the success of the Décrypthon project and the maturity of the DIET middleware;

- Hiring of Frédéric Suter at Avalon to create a bridge with the IN2P3 Computing Center in Villeurbanne;
- Best Phd award for Research in System by ASF (Association ACM Sigops de France) for the PhD of Anne-Cécile Orgerie in Avalon team on "An Energy-Efficient Reservation Framework for Large Scale Distributed Systems" (co-advised by L. Lefevre and I. Guérin-Lassous);
- Organization at ENS de Lyon of the international conferences Parco'2009 (International Conference on Parallel Computing), SSS'2009 and ICPP'2013 (The 42nd Annual Conference International Conference on Parallel Processing);
- Active collaboration with BULL company through the FUI CompatibleOne and FSN XLCloud projects;
- Active collaboration with EDF company through the ANR Cosinus LEGO project and a CIFRE PhD Grant;
- Mature software, in particular DIET and SimGrid.
- We have obtained funding for 41 International, European, and French projects.

3.1.4 Research activities

As previously mentioned, research activities have evolved during this reporting period because of the structuring of research teams. The part of the GRAAL team covered here mainly focused on large scale distributed infrastructures, in particular grid computing, including desktop and hybrid computing. Results concerned middleware architecture, scheduling, and component models. The part of RESO reported in this section concerns activities in autonomic networking and energy awareness and efficiency in Grids and networks. The Avalon project focuses on algorithms and software architectures for distributed and high performance computing platforms. Its research activities can be divided into four complementary research axes: energy application profiling and modeling; data-intensive application profiling, modeling, and management; component models; and application mapping and scheduling. Detailed results are described in Section 3.3.1.

3.2 Organization and life of the team

Once per week, there is a team meeting. The content of this meeting can be either scientific presentations from team members or from invited people, or a tour de table. In this latter case, each member of the team gives an overview of what she has done recently, what she is doing, and what are the news she wants to share with the team. It proves to be a very efficient tool to gather and disseminate information in a large team. All meeting notes are accessible to team members through private pages of the GRAAL and then Avalon web sites.

Moreover, many of the members of the team are having lunch altogether. Daily coffee breaks are also a very living and useful place to integrate new members and to have open discussions.

3.3 Scientific outcomes, visibility, collaborations

3.3.1 Scientific outcomes

This section covers the work carried out during the reporting period, including results from a part of the GRAAL and RESO teams, and from the AVALON team.

High Performance Computing

Analyzing and understanding the performance behavior of parallel applications on parallel computing platforms is a long-standing concern in the High Performance Computing community. In the context of applications implemented with the Message Passing Interface, two simulation methods have been proposed: on-line simulation and off-line simulation. We proposed an off-line simulation framework, i.e., one that simulates the execution of an application based on event traces obtained from an actual execution [465]. The main novelty of this Time-Independent Trace Replay framework is that traces that drive the simulation can be acquired on large, distributed, heterogeneous, and non-dedicated platforms by enforcing that traces contain no time-related information. Moreover, our framework is based on the scalable, fast, and validated simulation kernel of the SimGrid toolkit.

Many scientific applications can be structured as Parallel Task Graphs (PTGs), that is, graphs of data-parallel tasks. Adding data-parallelism to a task-parallel application provides opportunities for higher performance and scalability, but poses additional scheduling challenges. We also proposed several scheduling algorithms specific to Parallel Task Graphs, i.e., applications represented by workflows of parallel components [237, 228, 292, 282, 294]. Part of this work was done under the umbrella of the COST Action IC805 on High Performance Computing on complex environments.

As resources become more powerful but heterogeneous, applications' structures are also becoming more complex, not only for harnessing the available power but also for more accurate modeling of physical phenomena. Efficient mapping and scheduling of applications to resources are thus becoming more challenging. However, this is not possible with existing resource management systems (RMS) that are assuming simple application models. With respect to moldable applications, we have proposed CooRM-m, an RMS architecture which delegates the mapping and scheduling responsibility to the applications themselves [459]. Simulations as well as a proof-of-concept implementation of CooRM-m show that the approach is feasible and performs well in terms of scalability and fairness. The support for CooRM-m has been integrated into the industrial SALOME platform. In the ANR Moebus project, we are studying the integration of CooRM-m in SLURM and OAR, respectively a RMS widely used in supercomputers, and the RMS used in GRID'5000.

We have extended CooRM-m to CooRM-e [459] to support non-predictably evolving applications. These applications change their resource requirements during execution. They exist, for example, as a result of using adaptive numeric methods, such as adaptive mesh refinement and adaptive particle methods. Simulations and a proof-of-concept show that the approach is feasible and leads to a more efficient resource usage while guaranteeing that resource allocations are always satisfied.

Grid Computing

Grid platform were built upon sets of machines managed by batch schedulers and connected through wide area networks (WAN). The management of the execution of jobs in such a distributed environment relies on the ability of the grid middleware to choose the appropriate resources, and to dynamically adapt to changes on the platform by modifying previous scheduling decisions. We proposed [456] a generic solution to dynamically adapt to errors on runtime estimates given to resource management systems. We studied the problem of reallocation in a multi-cluster environment with different kinds of jobs (rigid [287] and moldable [312] jobs).

A part of the architecture of CooRM-m have been specialized and applied to the DIET software to increase the fairness of the scheduling of optional computation in GridRPC middleware [365].

One of topic around the Grid Computing studied by the Avalon team during the last five years, was the deployment of distributed application. A computer application can be considered as a system of components that exchange information. Each component type has its specific constraints. The application, as a whole, has also its constraints. Deploying an application on a distributed system consists, among other things, in making a mapping between application components and system resources to meet each component constraints, the application constraints, and possibly those set by the user. Previous work on the deployment of middleware, including DIET, was done on homogeneous platform. We continue this work [457] to take into account heterogeneous platforms. However, few take into account the issue of redeployment in the event of variation (availability, load, number) of resources. We study this problem of self adaptive deployment of middleware. It consists of achieving an initial deployment, then scrutinizing some changes in the environment, and automatically adjust the deployment (if beneficial) in case of detecting a variation that degrades the performance expected. To do this, we have surveyed the fields of autonomic computing, self adaptive systems and we have defined the different problems that must be solved to achieve this goal. From this, we defined a resource model to represent the physical system, and a model of middleware-based software components. Then, we worked on the implementation of the resource model to achieve a simulator [367].

Running scientific workflows over production Grids is sometimes complicated due to the dynamicity of the platform the lack of estimation of its availability and characteristics. In collaboration with Tristan Glatard and Raphaël Silva, we designed a general self-healing process for autonomous detection and handling of operational incidents in scientific workflow executions on production grids [259, 375, 376, 377].

Cloud Computing

We had several activities around Cloud Computing platforms from low level resource management and simulation to the scheduling of workflows on top of IaaS infrastructures.

One of the scheduling algorithm designed for parallel task graphs has been extended to handle dynamic workflows, i.e. with conditional structures and loops, and target IaaS clouds [342].

In [416], we have shown the importance of auto-scaling, load balancing and monitoring for a Cloud client platform. We detailed each of the three topics and present details on their presence and implementation in the commercial, open-source and research worlds.

Validating a new application over a Cloud is not an easy task and it can be costly over public Clouds. Simulation is a good solution if the simulator is accurate enough and if it provides all the features of the target Cloud. We have proposed an extension of the SimGrid simulation toolkit to simulate the Amazon IaaS Cloud [452]. Based on an extensive study of the Amazon platform and previous evaluations, we have integrated models into the SimGrid Cloud Broker and exposed the same API as Amazon to the users. Our experimental results have shown that our simulator is able to simulate different parts of Amazon for different applications.

We have worked on scheduling algorithms for MapReduce applications in Grids and Clouds as we aim at providing resource-efficient and time-efficient scheduling algorithms [399]. This work is mainly done within the scope of the MapReduce ANR project [337].

The Cloud phenomenon brings along the cost-saving benefit of dynamic scaling. As a result, the question of efficient resource scaling arises. Prediction is necessary as the virtual resources that Cloud computing uses have a setup time that is not negligible. In [291] we proposed an approach to the problem of workload prediction based on identifying similar past occurrences of the current short-term workload history.

We have defined an economic model for Cloud infrastructure in [247]. We analyzed by simulations an economic approach to set resource prices and resolve when to scale resources depending on the users demand. The results show how the proposed system can successfully adapt the amount of allocated resources to the demand, while at the same time ensuring that resources are fairly shared among users. About the economic topics on the Cloud we also introduced solution for resource allocation with budget constraint for non-deterministic Workflows on an IaaS Cloud [342].

The cloud security challenge not only reflects on the secure running of software on one single machine, but rather on managing and guaranteeing security of a computer group or cluster seen as a single entity. Seed4C focus is to evolve from cloud security with an isolated point or centralized points of enforcement for security to cloud security with cooperative points of enforcement for security.

In this context, we have studied how to secure our platform at two levels: authenticated and secured interactions at the internal layer (between each software modules of the middleware) and at the external layer (between middleware and its users). By the way, we have added the SSL support into the DIET communication layer. We have worked to show how to securely use public cloud storage without taking the risk of losing confidentiality of data stored on them.

Based on this infrastructure, the SEED4C technology [428] will allow to securely deploy and execute a distributed business application in the cloud. For this purpose, we have developed the Sam4C model and tool [409] that can handle different security properties and contexts needed by an application as well as the related assurance properties. For example, it may be defined that a confidentiality property should be set between two components of this application which are running in two different Virtual Machines.

Desktop and Hybrid Computing

The Avalon team has a strong background in Desktop Grid Computing [448], whose principle is to harvest Desktop Computers distributed over the Internet during their idle time to execute very large parallel applications. During the last five years, the team has been involved strongly in two European FP7 projects aiming at establishing the first e-science infrastructure based on Desktop Grid technologies. We took the leadership of two work packages, which addressed respectively : $i)$ the issue of providing Grid $\leftrightarrow$ Desktop Grid interoperability [232] and $ii)$ the challenge of providing quality of service (QoS) to application executed on the European Desktop Grid Infrastructures (EDGI). To this end, we designed and developed the SpeQuloS middleware, which ensures a probabilistic guaranty that an application will complete according to a predicted completion time despite nodes volatility [257, 395, 422].

The second axes of research is large scale data and resource management in hybrid distributed computing infrastructures (Hybrid DCI). We call hybrid DCI, the assemblage of several computing infrastructures (e.g. Grids, Desktop Grids and Clouds) with very different characteristics in term of computing power, storage capacity, cost of usage, quality of service and energy footprint. We have developed BitDew [229], a middleware that provides large scale data management for such infrastructure based on user driven data scheduling. Based on this prototype, we investigated the ability to execute data-intense application on hybrid DCI by experimenting with the MapReduce programming model. To our knowledge, our MapReduce runtime environment based on BitDew was the first environment dedicated to Internet Desktop Grid, which lead us to propose several original contributions, such as for instance, securing a MapReduce computation on untrusted resources [251, 310, 354, 386, 388, 419, 424].

Energy Efficiency for Large Scale Distributed Systems

Energy consumption is one of the main limiting factor for designing and deploying large scale distributed systems (datacenters, clouds, networks). Avalon is involved in the design of new models, algorithms and software frameworks for proposing new energy efficient solutions. First, Avalon has a strong expertise on energy profiling and reporting of large scale systems. This expertise was exploited in the FUI CompatibleOne project and PrimeEnergyIT European project. The energy efficiency issues are addressed through 3 research directions. We first focus, during the RESO project, on energy profiling and efficiency in reservation based infrastructures. Through the PhD of Anne-Cécile Orgerie, we have have targeted our research activities on providing models and frameworks to improve energy efficiency of infrastructures based on reserved usage (ERIDIS framework)[242]. This work was done under the umbrella of the Green-Net ARC Inria initiative [293] and the COST Action IC804[369, 384]. This topic is currently under development and diffusion through a collaboration with BULL company within the FSN XLCloud project (Climate/Blazar project in OpenStack framework). Avalon has a strong focus on HPC services and protocols. Through the combined PhD of Mehdi Diouri and Ghislain Landry Tsafack, we have explored alternative solutions for designing energy efficient framework for large scale HPC services and applications [253]. We have designed the SESAMES framework focused on resilience and communication services for exascale platforms [370, 371] (in collaboration with the Inria-UIUC-NCSA Joint Laboratory for Petascale Computing). We also pursue some activities coming from networking on energy efficiency of traffic engineering protocols and virtualized services in last mile[350]. This topic is explored within the GreenTouch international project with a collaboration with Bell Labs and inside the CHIST-ERA STAR European project.

Software Component Model for Parallel and Distributed Applications

Our goal was to study whether and how software component models can be improved to efficiently and easily support parallel and distributed computing. A first direction of research has been to combine existing software components to offer a rich and coherent set of composition operators. For example, we defined ULCM, a component model providing data sharing, master-worker skeleton, and workflow operators [234]. Moreover, we extended STCM, a previous work that combines simple component models and workflows, with algorithmic skeletons. We validated the model by implementing a proof-of-concept based on SCA in cooperation with the University of Pisa (Italy) [269].

As a first generalization of this work, we have introduced genericity support into existing component models [272]. A more fundamental step has been to consider software model transformation: we have designed High Level Component Model (HLCM) [415], a software component model that supports the reuse of elements (component, partial assemblies, etc) thanks to the concepts of hierarchy, genericity and connectors – and in particular the novel concepts of open connection. An HLCM assembly is transformed into a low level deployable assembly, typically L2C. L2C (Low Level Component model) [338] supports directly native connectors for typical scenarios of high performance computing, such as MPI, shared memory and method invocation. Experiments with MapReduce [251], Jacobi [338], and 3D FFT applications are encouraging.

Our collaboration with EDF R&D around component models have led to two kinds of results [461]. First, we proposed and implemented several improvements, such as the cloning of components and ports, to the SALOME component model [461]. It was in particular useful to the coupling of several instances of Code_Aster, a thermomechanical calculation code from EDF R&D. Second, we initiated the study of recursive assemblies in ULCM and in SALOME that contributed to the definition of HLCM. In particular, we focused on adaptive mesh refinement applications (AMR) [306].

3.3.2 Attractivity, visibility, collaborations

Attractivity

This reporting period has mainly be concerned with the restructuring of research teams, and the creation of a new team. But of Frédéric Suter who was not part of the LIP, there has not been any new hiring of permanent researchers. However, the team has always been able to attract PhD students and post-docs from France (Paris, Bordeaux, Orléans, Toulouse, Bourges) and from abroad (Spain, Romania, Greece, China).

Through various collaborations, Avalon has attracted visiting PhD students to collaborate on energy efficiency topics and on cloud computing: in September 2009, A. Fernandez from University of Sevilla worked 6 weeks with us on energy efficient scheduling [248]; in January 2010 (6 weeks) Takayuki Imada from University of Tsukuba (Japan) worked with us on energy efficiency frameworks for virtualized servers; in July 2011 (2 weeks) Thomas Treutner from University of Vienna (Austria) came to collaborate on potential security risks associated with energy reporting [324]; Manuel F. Dolz from Jaume I University on energy monitoring and profiling in distributed systems [258, 369]. We attracted several foreign Ph.D student for long internship : Lu Lu, HUST University in Wuhan, China (6 months), Mircea Moca, University of Baves-Bolaj, Cluj Napoca, Romania (6 months) and Julio Anjos, Ph.D student from Federal University of Rio Grande do Sul, Brazil (12 months).

In the context of the GridRPC standardization, Hidemoto Nakada a researcher from AIST (Advanced Industrial Science and Technology, Japan) and co-chair with Eddy Caron of the GridRPC working group (OpenGrid Forum), has been visiting the Avalon team from December 2008 to the end of February 2009 (10 weeks).

In 2012, Matei Ripeanu from University of British Columbia, Vancouver (Canada) has been visiting the Avalon team as an *Invited Professor* ENS-Lyon for 6 weeks.

Visibility

The team is strongly involved in the management of the GRID'5000 research infrastructure (cf Section 6.2.8), and the associated Hemera project. Moreover, the team is involved in many program committees of international conferences and journals, and it has been involved in the organization of international conferences, and some members have acted as national and international experts 6.2.12. Moreover, we have been involved in 41 International, European, and French projects.

Collaborations

We have strengthen our involvement at the Lyon level with the participation to two laboratories of excellence (MILYON and PRIMES) as well as our participation to the *Fédération Lyonnaise de Modélisation et Sciences Numériques* and our particular relationship to the Lyon Computing Center of CNRS (IN2P3). At the French level, we have very strong relationships and usually collaborations with major French academic laboratories such as EMN, I3S, IRISA, IRIT, LabRI, LIFL, LIG, LIP6, and Loria.

At international level, we have established relationships with European and USA teams working on composition based programming models such as the University of Pisa (Italy) and the Common Component Architecture forum (USA) as well as some teams working on parallel languages such as the Barcelona Supercomputer Center (Spain), the University of Hawaiʻi at Manoa and the Parallel Programming Laboratory (UIUC, IL, USA). This latter collaboration takes place through our active participation to the UIUC-INRIA-NCSA Joint Laboratory for Petascale Computing, which also encompasses research dealing with energy efficiency. Avalon is also collaborating with University of Addis Abeba (Ethiopia) on the topic of energy efficiency issues in large scale networked services.

We collaborate with the Universidad Complutense of Madrid (UCM) around scheduling applications on multi-clouds. As a member of the International Desktop Grid Federation, we collaborate with the key players of desktop grid computing, in Europe as well as in the U.S. (Univ. Berkeley, Virginia Tech.) and Asia (HUST, China). We also collaborate with AIST (Japan) for the GridRPC topics and standardization effort [311, 411], and with the universities of Tokyo and of Tsukuba around distributed scheduling and grid deployment.

3.4 Training through research

3.4.1 PhD dissertations defended in the team, and doctoral studies

During this evaluation period, 10 students have defended their PhD: Benjamin Depardon (October 2010); Julien Bigot (December 2010); Ghislain Charrier (December 2010); Anne-Cécile Orgerie (September 2011); Vincent Pichon (November 2012); Cristian Klein (November 2012); Adrian Muresan (December 2012); Mohammed El Mehdi Diouri (September 2013); Ghislain Landry Tsafack Chetsa (December 2013); and Georgios Markomanolis (January 2014). As we are writing these lines, Sylvain Gault, and Anthony Simonet are finishing writing their PhD.

Among the seven students who defended their PhD before December 2012, four have now a permanent position: Benjamin Depardon is now CTO at the SysFera company; Julien Bigot is engineer-researcher at CEA (*Maison de la Simulation*); Anne-Cécile Orgerie is a CNRS researcher in the Myriads team (IRISA); Vincent Pichon is engineer at the CS group. From recent PhDs, Mohammed El Mehdi Diouri is associate professor at IGA (Casablanca, Morocco).

3.4.2 Implications in MSc studies

The team members are involved in the master of ENS Lyon (5 courses), of INSA Lyon (1 course), and in different Computer Science Masters of the University Claude Bernard Lyon 1 (9 courses).

3.5 Research project

3.5.1 Self-assessment and SWOT analysis

Strong points

- Balance of expertise including theory, simulation, and experimental platforms.
- Strong connections to infrastructures (platforms) and applications.
- Strong involvement and access to the GRID'5000 research platforms
- Privileged access to production platform through CC-IN2P3
- Strong national and international collaborations and project participations
- Solid knowledge in software development (DIET, SimGrid, etc.)

Weak points

We need to be careful to successfully interconnect the various research axes of the team. However, we are very confident as we have already stated join master supervisions, as well as join project participations.

Several permanents could leave the team for a professor position. Hiring young scientists seem to be a good solution to anticipate this.

Opportunities

We have established solid contact with the cosmological community thank to our close relationship with the IN2P3 Computing Center, and with bio-computer teams in particular thanks to the PRIMES Labex. They provide us opportunities to transfer our results to real use cases and to bring us new problems not handled by the state-of-the-art.

There is a close will of the computing community of Lyon to be more integrated, in particular thanks to MI-Lyon Labex and to our involvement in research platforms.

Risks

- No visibility in future funding.
- No visibility in the funding of the GRID'5000 experimental platform.

3.5.2 Research objectives

The goal of the Avalon team is to be able to execute parallel and/or distributed applications on parallel and/or distributed resources while ensuring user and system objectives with respect to performance, cost, energy, security, etc. Users are not interested in the resources used during the execution. Instead, they are interested in how their application is going to be executed: in which duration, at which cost, what is the environmental footprint involved, etc. This vision of utility computing has been strengthen by the cloud concepts and by the short lifespan of supercomputers (3 years) compared to application lifespan (tens of years). Therefore, a major issue is to design models, systems, and algorithms to execute applications on resources while ensuring user constraints (price, performance, etc.) as well as system administrator constraints (maximizing resource usage, minimizing energy usage, etc.).

The Avalon project aims at making progress to four complementary research axis: energy, data, component models, and application scheduling. Avalon will improve i) the profiling and modeling of scientific applications with respect to energy consumption, ii) the profiling, modeling, and management of scientific applications with respect to CPU and data intensive applications, iii) component models to capture the different facets of parallel and distributed applications, and iv) multi-criteria mapping and scheduling algorithms.

These four axis have strong inter-relationships. Obviously, application mapping and scheduling is highly impacted by information that can be extracted from application modeling and description. Application description has to be able to easily integrate information about energy consumption and/or data issues.

3.5.3 Project implementation

In June 2014, we have successfully gone through all the evaluation steps toward the creation of the Inria-CNRS-ENSL-Lyon I Avalon join team of research.

Our overall methodology is to solve use cases requiring advanced solutions along one research axis, or across several research axis. The actual path will depend on the difficulty of solving each issue, and of the importance of the problems from a use case point of view. Avalon will validate its theoretical research results through real use case experiments. Therefore, an expected outcome of Avalon is to produce software, that may be transferred to industry.

Application Fields

The Avalon team targets applications with large computing and/or data storage needs, which are still difficult to program, maintain, and deploy. Those applications can be parallel and/or distributed applications. It is the case for large simulation and/or code coupling applications typically making use of high performance computing. Applications can also be workflow based as commonly found in distributed systems such as grids or clouds.

The team aims at not being restricted to a particular application field, thus avoiding any spotlight. The team targets different HPC and distributed application fields, which bring use cases with different issues. This will be eased by our various collaborations: the team participates to the Inria-Illinois Joint Laboratory for Petascale Computing, the Physics, Radiobiology, Medical Imaging, and Simulation French laboratory of excellence, the E-Biothon project, the Inria large scale initiative Computer and Computational Sciences at Exascale (C2S@Exa), and to BioSyL, a federative research structure about Systems Biology of the University of Lyon. Moreover, the team members have a long tradition of co-operation with application developers such as CERFACS and EDF R&D. Last but not least, the team has a privileged connection with the Computing Center of IN2P3 that opens up collaborations, in particular in the astrophysics field.

Research Axis

This section presents in more detail the four research axis of Avalon: energy, data, component models, application mapping and scheduling.

Energy Application Profiling and Modeling International roadmaps schedule to build exascale systems by the 2018 time frame. According to the Top500 list published in June 2014, the most powerful supercomputer is the Tianhe-2 platform, a machine with more than 3,000,000 cores. It consumes more than 17 MW for a maximum performance of 33 PFlops while the Defense Advanced Research Projects Agency (DARPA) has set to 20 MW the maximum energy consumption of an exascale supercomputer.

Energy efficiency is therefore a major challenge for building next generation large scale platforms. The targeted platforms will gather hundreds of million cores, low power servers, or CPU. Besides being very important, their power consumption will be dynamic and irregular.

Thus, to consume energy more efficiently, we aim at investigating two research directions. Firstly, we need to improve the measure, the understanding, and the analysis of the large scale platform energy consumption. Unlike some approaches that mix the usage of internal and external wattmeters on a small set of resources, we target high frequency and precise internal and external energy measurements of each physical and virtual resources on large scale distributed systems.

Secondly, we need to find new mechanisms to consume less and better on such platforms. Combined with hardware optimizations, several works based on shutdown or slowdown approaches aim at reducing energy consumption of distributed platforms and applications. To consume less, we first plan to explore the provision of accurate estimation of the energy consumed by applications without pre-executing and knowing them while most of the works try to do it based on in-depth application knowledge (code instrumentation, phase detection for specific HPC applications, etc.). As a second step, we aim at designing a framework model that allows interactions, dialogs and decisions taken in cooperation between the user/application, the administrator, the resource manager, and the energy supplier. While smart grid is one of the last killer scenarios for networks, electrical provisioning of next generation large IT infrastructures remains a challenge.

Data-Intensive Application Profiling, Modeling, and Management Recently, the term “Big Data” has emerged to design data sets or collections so large they become intractable for classical tools. This term is most of the time implicitly linked to “analytics” to refer to issues such as curation, storage, search, sharing, analysis, and visualization. However, the Big Data challenge is not limited to data-analytics, a field that is well covered by programming languages and run-time systems such as Map-Reduce. It also encompasses data-intensive applications. These applications can be sorted into two categories. In High Performance Computing, data-intensive applications leverage post-petascale infrastructures to perform highly parallel computations on large amount of data, while in High Throughput Computing, a large amount of independent and sequential computations are performed on huge data collections.

These two types of data-intensive applications (HTC and HPC) raise challenges related to profiling and modeling that the Avalon team proposes to address. While the characteristics of data-intensive applications are very different, our work will remain coherent and focused. Indeed, a common goal will be to acquire a better understanding of both the applications and the underlying infrastructures running them to propose the best match between application requirements and infrastructure capacities. To achieve this objective, we will extensively rely on logging and profiling in order to design sound, accurate, and validated models. Then, the proposed models will be integrated and consolidated within a single simulation framework (SimGrid, cf Section 6.2.7). This will allow us to explore various potential “what-if?” scenarios and offer objective indicators to select interesting infrastructure configurations that match application specificities.

Another challenge is the ability to mix several heterogeneous infrastructure that scientists have at their disposal (e.g., Grids, Clouds and Desktop Grids) to execute data-intensive applications. Leveraging the aforementioned results, we will design strategies for efficient data management service for hybrid computing infrastructures.

Resource Agnostic Application Description Model When programming in parallel, users expect to obtain performance improvement, whatever the cost is. Parallel machines have for long been simple enough to let a user program them given a minimal abstraction of their hardware. However, machines and applications are getting more and more complex so that the cost of manually handling an application is becoming very high. Hence, even though an abstract enough parallel language (UPC, Fortress, X10, etc.) succeeds, it will still face the challenge of supporting distinct codes corresponding to different algorithms corresponding to distinct hardware capacities.

Therefore, the challenge we aim to address is to define a model, for describing the structure of parallel and distributed applications that enables code variations but also efficient executions on parallel and distributed infrastructures. Our approach is to consider component based models as they offer the ability to manipulate the software architecture of an application. To achieve our goal, we consider a "compilation" approach that transforms a resource agnostic application description into a resource specific description. The challenge is thus to determine a component based model that enables to efficiently compute application mapping while being tractable. In particular, it has to provide an efficient support with respect to energy and data concerns.

In 2010, we have proposed HLCM as an answer to the question of determining a candidate component based model for describing moldable HPC and cloud applications independently of resources. HLCM is a hierarchical generic connector based component model that supports multiple component and connector implementations. It aims at describing an abstract structure of an application that is transformed into a concrete structure at deployment. The model of the concrete structure is flexible: primitive components and connectors are user level specializable.

The next challenges are to define component models and algorithms to support dynamic adaptation in an large scale context (work started in the PhD of Vincent Lanore), and to combine component models and task-oriented runtime models (It will be the focus of the PhD of Jérôme Richard to start in November 2014).

Application Mapping and Scheduling This research axis is at the crossroad of the Avalon project. In particular, it gathers results of the three others research axis. We plan to consider application mapping and scheduling through three issues. First, two issues deal with the best possible utilization of resources: The first issue concerns the scheduling of applications onto resources, while the second issue is related to non-deterministic workflow scheduling. The third issue is to handle security management when scheduling and deploying applications in clouds.

First, application mapping and software deployment consist in the process of assigning distributed pieces of software to a set of resources. Resources can be selected according to different criteria such as performance, cost, energy consumption, security management, etc. A first issue is to select resources at application launch time. With the wide adoption of elastic platforms, i.e., platforms that let the number of resources allocated to an application to be increased or decreased during its execution, the issue is also to handle resource selection at runtime. The challenge in this context corresponds to the mapping of applications onto distributed resources. It will consist in designing algorithms that in particular take into consideration application profiling, modeling, and description.

Second, many scientific applications are described through workflow structures and several software environments have been designed to handle them over grid platforms. Due to the increasing level of parallelism offered by modern computing infrastructures, workflow applications now have to be composed not only of sequential programs, but also of parallel ones. In the past, we have worked on the scheduling of parallel task graphs over clusters and clusters of clusters. New applications are now built upon workflows with conditionals and loops (also called non-deterministic workflows). These workflows can not be scheduled beforehand. Moreover cloud platforms bring on-demand resource provisioning and pay-as-you-go billing model. Therefore, there is a problem of resource allocation for non-deterministic workflows under budget constraints and using such an elastic management of resources. Part of the solution consists in transforming the initial problem into sub-problems that can be semi-statically scheduled, taking into account granularity. This involves automatic workflow graphs analysis, graph partitioning techniques and workflow graph re-arrangement. Another important issue is data management. We need to schedule the data movements and replications while taking job scheduling into account. If possible, data management and job scheduling should be done at the same time in a closely coupled interaction.

Third, security has been proven to be sometimes difficult to obtain and several issues have been raised in Clouds. Several different kinds of attacks and security issues can be observed that may lower the impact of Clouds. In highly secured environments, strong security is done by using unshared resource environments for tasks with different security clearance. It is still the strongest defense against covert-channels (and other attacks). But this approach eliminates most of the current Clouds but also the way how virtualization is used. Indeed, nowadays virtualization is used as the sole mechanism to secure different users sharing resources on Clouds. But, due to improper virtualization of all the components of Clouds (such as micro-architectural components), data leak and modification can occur. Accordingly at the scale of a Cloud, there is no one fits all security mechanism. Our approach is to combine a set of existing and novel security mechanisms that are spread in the different layers and components of Clouds in order to provide an in-depth and end-to-end security on Clouds. To do it, our first challenge is to define a model to express security policies. Indeed, when combining heterogeneous security mechanisms, we have different way to express security. Our goal is to propose a generic model to express security policies that can be spread between the different security mechanisms and transformed these policies into mechanism specific policies. Our second challenge is to work on security-aware resource allocation algorithms. The goal of such algorithms is to find a good trade-off between security and unshared resources. Our third challenge is to design such algorithms tailored toward optimizing these trade-offs and their combination with SLA (Service Level Agreement) and objective function (e.g., minimize the total makespan, energy consumption, etc.).

Technological involvement

The members of Avalon have a long history of software development as illustrated in Section 6.2.7. Avalon aims at pursuing these developments in the objective of i) disseminating research results to the broadest audience by releasing open-source software, ii) conducting large and complex experiments which sometimes require robust software and specialized developments such as GRID'5000, iii) teaching our students good practices about software development and project management, and iv) transferring it to industry.

The Avalon team will continue to be strongly involved in the management of the experimental GRID'5000 platform. GRID'5000 is a scientific instrument designed to support experiment-driven research in all areas of computer science related to parallel, large-scale or distributed computing, and networking. GRID'5000 is a collection of clusters spread over 10 locations in France and in Luxembourg, and interconnected with a dedicated 10 Gbit/s backbone.

The team aims at transferring its research results to industry according to different paths. First, the team collaborates with SMEs and large companies. With respect to SMEs, we continue collaborating with SysFera, a spin-off company from the GRAAL project-team. Recently, we have started collaborating with New Generation SR and with CapRezo. With respect to large companies, the team members collaborate with EDF R&D around the Salome simulation platform, with Alcatel-Lucent Bell Labs France on security and green topics, with Bull on the topics of energy and batch schedulers, and with IBM and Orange around clouds. Through the GreenTouch initiative, Avalon also collaborates with Bells Labs (USA) on the energy efficient support of large scale services for last mile equipments. The team also supports the creation of new company by helping with the technology transfer. CloudPower is an ANR Emergence project, which aims at providing SME's with simple and low cost High Performance Computing solution based on desktop grid technologies developed by Avalon. Several economical demonstrators are being set-up to investigate the potential value of this technology as a product. These fruitful collaborations with industries enable us to transfer our research results as well as they help us to better understand and prioritize the actual challenges faced by companies.

4 Compsys team: Compilation and Embedded Computing Systems

4.1 Scientific areas and activities

4.1.1 Goals and context

Compsys develops compilation techniques, more precisely code analysis and optimization techniques, to help programming or designing "embedded computing systems". The team focuses on both low-level (back-end) optimizations for embedded processors and high-level (front-end, mainly source-to-source) transformations, in particular for the high-level synthesis of hardware accelerators (FPGA). Recent activities include a shift towards the compilation for programmable hardware accelerators (GPU, multicores), the analysis of parallel languages, and links with abstract interpretation and program termination. The main characteristic of Compsys is its use of algorithmic and formal methods (with graph algorithms, linear programming, polyhedral optimizations) to address code analysis and optimization problems (e.g., termination, register allocation, memory optimizations, scheduling, automatic generation of interfaces) and the validation of these techniques through the development of compilation tools.

Keywords: Embedded systems, DSP, VLIW, FPGA, hardware accelerators, compilation, code & memory optimization, program analysis, high-level synthesis, parallelism, scheduling, polyhedra, graphs, regular computations.

4.1.2 Activity profile

Laure Gonnord (from sep. 2013) is assistant professor thus has teaching duties. Christophe Alias is a full-time researcher but is also quite involved in teaching, at ENS-Lyon or elsewhere. The three other members, except for a small number of teaching hours at Master 2 level, are full-time researchers. There are variations among members but the average profile is:

- Academic research: 50 %.
- Administration: 15 %.
- Scientific animation: 15 %.
- Supervision of research students: 20 %.

4.1.3 Highlights

- Important and recognized results in SSA (Static Single Assignment) and register allocation: out-of-SSA conversion, fast liveness analysis in SSA, analysis of spilling models, proof of particular structures in SSA and SSI, etc. 3 PhD theses on these topics, strong collaboration with STMicroelectronics and Minas Gerais (Brazil), many joint papers. Organization of the first spring school on SSA[1], with almost all international experts.
- Important extensions (both in terms of techniques and applications) of polyhedral methods: termination of irregular programs (the Rank software suite), pipelined processes (for kernel offloading, through the CRP language, and the DCC software), data reuse and tiling, parametric tiling, analysis of races in parallel programs.
- Industrial contracts with STMicroelectronics (Mediacom and S2S4HLS) and Kalray (ManycoreLabs).
- Creation of Zettice startup (now named XtremLogic), initiated by Alexandru Plesco and Christophe Alias. XtremLogic won the "concours OSEO" 2013 grant.
- Departure of Fabrice Rastello (in Grenoble since jan. 2013), arrival of Laure Gonnord (since sep. 2013).
- Creation (by Laure Gonnord and Fabrice Rastello) of the french compilation community[2] (8 events since 2010), now a subgroup of the GDRs GPL and ASR. This initiative was an important boost for the community.
- Creation (by Christophe Alias, with Cédric Bastoul) of the first international workshop on polyhedral techniques (IMPACT)[3], now an annual event, satellite workshop of the HIPEAC conference. This effort helped to create the polyhedral community, which is now better identified and more visible.
- Organization (by Alain Darte) of a thematic quarter on compilation[4], including the french compilation days and 3 international events: a) the first spring school on polyhedral code analysis and optimizations[5], b) a unique 4-days set of keynotes on HPC languages[6], c) the 17th international workshop on compilers for parallel computers (CPC'13)[7].
- Five chapters [543, 544, 545, 546, 547] of the Encyclopedia of Parallel Programming[8] edited by David Padua.

[1] Static Single-Assignment Form Seminar: `http://www.cdl.uni-saarland.de/ssasem`
[2] Communauté Française de Compilation: `http://compilation.gforge.inria.fr`
[3] IMPACT workshop series: `http://impact.gforge.inria.fr`
[4] Labex MILYON thematic quarter on compilation: `http://labexcompilation.ens-lyon.fr`
[5] Polyhedral school: `http://labexcompilation.ens-lyon.fr/polyhedral-school`
[6] Keynotes on HPC languages: `http://labexcompilation.ens-lyon.fr/hpc-languages`
[7] Workshop CPC'13: `http://labexcompilation.ens-lyon.fr/cpc2013`
[8] Encyclopedia of Parallel Programming: `http://www.springer.com/computer/swe/book/978-0-387-09765-7`

4.1.4 Research activities

Context and overall goal of the team

Before its creation in 2002, all members of Compsys have been working, more or less, in the field of automatic parallelization and high-level program transformations. Paul Feautrier was the initiator of the polytope model for program transformations. Before coming to Lyon, he started to be more interested in programming models and optimizations for embedded applications, in particular through collaborations with Philips. Alain Darte worked on mathematical tools and algorithmic issues for parallelism extraction in programs. He became interested in the automatic generation of hardware accelerators, thanks to his stay at HP Labs in the PiCo project in 2001. Fabrice Rastello, after a PhD on tiling transformations for parallel machines and before joining Compsys, worked at STMicroelectronics on back-end code optimizations for embedded processors, which became an important research topic of Compsys. Finally, Christophe Alias, who joined Compsys in 2009, brought his expertise on source-to-source program analysis and optimizations as well as software development. (Tanguy Risset and Antoine Fraboulet, who left Compsys to Insa-Lyon in 2007, had worked on the synthesis of systolic arrays with the HLS tool MMAlpha and on code and memory optimizations for embedded applications.)

Around 2000, many researchers working on high-performance computing (HPC) – parallelization, scheduling, operating systems, networks – moved to grid computing, while we made a shift towards the "small HPC", i.e., embedded platforms, motivated by the applications, industrial needs, and research problems of this field. Also, we were convinced that our expertise on high-level and back-end code optimizations could be more useful in this field. We fully shared and still share the vision of compilation and architecture given by Bob Rau and his colleagues (IEEE Computer, sept. 2002):

"Engineering disciplines tend to go through fairly predictable phases: ad hoc, formal and rigorous, and automation When the discipline is in its infancy and designers do not yet fully understand its potential problems and solutions, a rich diversity of poorly understood design techniques tends to flourish. As understanding grows, designers sacrifice the flexibility of wild and woolly design for more stylized and restrictive methodologies that have underpinnings in formalism and rigorous theory. Once the formalism and theory mature, the designers can automate the design process. [...] We believe that the computer architecture discipline is ready to enter the automation phase. Although the gratification of inventing brave new architectures will always tempt us, for the most part the focus will shift to the automatic and speedy design of highly customized computer systems using well-understood architecture and compiler technologies."

With this view on automation (for us, of code optimization) in mind, we were convinced of two complementary facts:

- The mathematical tools developed in the past for manipulating programs in automatic parallelization were lacking in HLS and embedded computing optimizations. Even more, they started to be rediscovered frequently under less mature forms. They also needed to be extended to become more robust and to address new challenges. Similarly, back-end code optimizations needed to be revisited in the light of embedded processors features and objectives.
- Before being able to really use these techniques in HLS and embedded program optimizations, we needed to learn from the application, the electrical engineering, and the embedded architecture sides, which we did in the previous evaluation period of Compsys (2002-2009) with work on HLS, traffic generators, SoC simulation, power issues.

The departure of Tanguy Risset and Antoine Fraboulet, who were the main SoC experts in Compsys, pushed us to a stronger focus again on compiler optimizations and "theoretical" research. The recent hiring of Laure Gonnord (sep. 2013), combined with the departure of Fabrice Rastello, now shifts Compsys more towards code analysis. Concerning the evolution of architectures, the development of not-so-general platforms such as domain-specific boards, GPUs, or multicores, now brings, into the embedded world, the "medium-size HPC" (compared to clusters and exascale computing), a topic where the hiring of Tomofumi Yuki (sep. 2014) will provide new forces. Despite these changes, Compsys activities remain at the frontier between languages and architectures, trying to identify the concepts and techniques that make the automation, from codes to machines, possible by compilation techniques. These activities are supported by a marked investment in mathematical and algorithmic studies, in addition to industrial collaborations when possible, with the aim of constructing operational software tools, not just theoretical results; hence the 3rd research theme, centered on the development of these tools. Our three objectives during the 2009-2014 period were:

- back-end code optimization for both aggressive and just-in-time (JIT) compilation;
- program analysis and transformations, in particular for high-level synthesis (HLS);
- development of polyhedral tools.

Objective 1: Aggressive and JIT back-end code optimizations

Compilation for embedded processors can be aggressive or just in time (JIT). Aggressive compilation consists in allowing more time to implement possibly-costly techniques. This is acceptable when the application is cross-compiled, i.e., compiled on a powerful platform distinct from the target processor, and the executable code is loaded in permanent memory. JIT compilation, on the other hand, corresponds to compiling bytecode on demand on the target processor, at load time or even dynamically during execution. The heuristics, constrained by time and limited resources, must then be fast enough. In this context, our goal was to contribute to the understanding of combinatorial problems that arise in compilation for embedded processors (e.g., code analysis, opcode selection, register allocation, code placement) to derive both aggressive heuristics and JIT techniques. This was done by both developing theoretical results (e.g., using graph theory, NP-completeness) even for problems that can appear "old" (such as register allocation) and by implementing and testing our techniques directly within an industrial compiler (STMicroelectronics, and more recently Kalray). The strategy was, after clarifying, debunking, understanding the key issues that make the addressed problem hard, to first develop potentially-costly solutions (e.g., using integer linear programing) for aggressive compilation. This process allowed us to confront the theory with the practice and to provide a basis for designing and evaluating JIT solutions.

SSA (static single assignment) is an intermediate code representation or property where each scalar variable is defined, textually, only once. It is quite popular in retargetable compilers as it leads to simpler analysis and optimization algorithms, easier to design and maintain (a feature increasingly important in compilers), and more suitable for JIT compilation. After 2002, exploiting the fact that interference graph of variables in SSA is chordal, we started to advocate a decoupled register allocator that first spills (assignment to memory, optimizing load/stores), then colors (allocation to registers, reducing register-to-register copies), and finally repairs (lowering using available instructions). After 2009, our efforts were devoted to a deeper understanding of such a register allocation strategy and, more generally, of the properties of SSA (and of the related SSI) linked to dominance, out-of-SSA conversion, liveness & interval analysis, memory optimizations, etc., and how they can be useful for the combination of aggressive and just-in-time compilation (a.k.a. split compilation).

Objective 2: Program analysis and transformations, in particular for HLS

With the advent of parallelism in supercomputers, the bulk of research in code transformation resulted in (semi-)automatic parallelization, with many techniques (analysis, scheduling, code generation, etc.) based on the description and manipulation of nested loops with polyhedra. Compsys has always taken an active part in the development of these so-called "polyhedral techniques". Embedded systems generated new problems in high-level code optimization, especially for loops, both for optimizing embedded applications and for transforming programs for HLS (where loop unrolling and basic block scheduling of the loop body have been, for a long time, the only loop optimizations). Everything that has to do with data storage is of prime importance as it impacts power consumption, performance, and chip area.

On the application side, multimedia applications often make intensive use of multi-dimensional arrays, in sequences of (nested) loops, which make them good targets for multi-dimensional static program analysis. In practice, applications are rewritten several times, by the compiler or developer, to go from a high-level algorithmic description down to an optimized and customized version. But for memory optimizations, the high-level description is where the largest gain can be obtained thanks to global program analysis and transformations: analyzing multimedia applications at the source level is thus important. On the architecture side, the hardware, in particular memories, can be customized. When designing/optimizing a programmable embedded system, adequate parameters can be selected for cache and scratch-pad memories to achieve the smallest cost for the right performance for a given application or set of applications. In HLS, memories (size, topology, connections with processing parts) can even be fully customized for a given application.

Embedded systems are thus good targets for memory optimizations. But powerful compile-time program and memory analysis are needed to (semi-)automatically generate a fully-customized and optimized circuit from a high-level C-like description. Also, new specification languages or compilation directives are needed to express communicating processes and their communication media: processes communicating through FIFOs or shared memories are a good target. Our objective in this topic was to adapt and extend high-level transformations, previously developed for automatic parallelization, for HLS and embedded computing optimizations. Such techniques started to be rediscovered under various forms and we thought our previous expertise could be useful both for the dissemination of already-known techniques and the development of new ones. Actually, it turned out that the polyhedral techniques we developed found some unexpected applications, which we also explored, linked to the termination of irregular programs and the analysis of parallel programs.

Objective 3: Development of polyhedral tools

Since the times of Pip and of the Polylib, Compsys has been active in the implementation of basic mathematical tools for program analysis and synthesis. Pip is still developed by Paul Feautrier and Cédric Bastoul, while the Polylib is now taken care of by the Inria Camus project, which introduced Ehrhart polynomials. These tools are still in use world-wide and they also have been reimplemented many times with (sometimes slight) improvements, e.g., as part of the Parma Polylib, Sven Verdoolaege's Isl and Barvinok libraries, or the Jollylib of Reservoir Labs. Other groups also made a lot of efforts towards the democratization of the use of polyhedral techniques, in particular the Alchemy Inria project, with Cloog and the development of Graphite in GCC, and Sadayappan's group in the USA, with the development of Pluto.

After 2009, Compsys continued to focus on the introduction of concepts and techniques to extend the polytope model, with a shift toward tools that may prepare the future. For instance, PoCo and C2fsm are able to parse general programs, not just SCoPs (static control programs), while the efficient handling of Boolean affine formulas is a prerequisite for the construction of non-convex approximations. Cl@k is the first step towards memory optimization in stream languages and may be useful in other situations. Our work on Chuba introduced a new element-wise array reuse analysis and the possibility of handling approximations. Finally, our work on the analysis of while loops is both an extension of the polytope model itself (i.e., beyond SCoPs) and of its applications (links with program termination and WCET tools).

4.2 Organization and life of the team

Not all members were full-time in Compsys during the evaluation period. Laure Gonnord was, until sep. 2013, only an external collaborator, once a week in the team. Christophe Alias, since the end of 2010, is very involved (> 50%) in the Zettice/XtremLogic start-up. Fabrice Rastello was in sabbatical for a year in 2010-2011, then moved to Grenoble in fall 2012, to start building a new group, on new research directions (he officially left the group one year later).

Information circulates in the group mainly on a daily basis, through mails, lunches, or dedicated meetings, when needed. Paul Feautrier manages a regular meeting group, with discussions or work-in-progress presentations, sometimes with external speakers, sometimes joint with Tanguy Risset's group at Insa-Lyon, as well as Yann Orlarey (Grame). All members take responsibilities to represent the team outside (contracts, industrial meetings, networks, teaching) and to work on the animation of its research communities (organization of community life, of schools, workshops, etc.).

4.3 Scientific outcomes, visibility, collaborations

4.3.1 Scientific achievements

Objective 1: Aggressive and JIT back-end code optimizations

Going out of SSA In SSA, ϕ functions (conceptual multiplexers) merge values at "join" points of the control flow graph (CFG). To generate machine code, these functions have to be replaced by register-to-register copies, but this cannot be done naively. We addressed three issues: correctness, code quality (elimination of useless copies), algorithm efficiency (speed & memory footprint). Our method, best paper at CGO'09 [495], separates the issues of correctness and optimization, which makes it conceptually simpler and more robust than previous approaches, which were either incorrect or based on "patches". This correctness issue was, for a long time, a slowing factor in the development of SSA (e.g., bugs in GCC and Jikes). By exploiting SSA properties (e.g., with a dedicated liveness check method), our algorithm is 2x faster than the best algorithm so far (Sreedhar) and 10x better in terms of memory footprint, making it more suitable for JIT compilation.

Structure of interferences in SSA & SSI and liveness analysis In SSA, the corresponding interference graph is chordal. What first attracted our curiosity to SSI (static single information, a variant of SSA with bi-directional properties) was the claim (true but with a wrong proof) that the interference graph in SSI is an interval graph. In [477], we clarified a number of mistakes on SSI and provided a proof (much harder than the initial wrong one) of this property. We also revisited SSI for its theoretical ability to perform both forward and backward data flow analysis. This work was then continued in [532] to organize the zoo of existing program representations (SSA, SSI, e-SSA, etc.) that enforce static single information properties (i.e., valid on a whole live-range). Also, by exploiting the dominance property of (strict) SSA and Ramalingam's loop-nesting forests, we were able to design a two-phase (thus non-iterative) data-flow algorithm for computing liveness sets. Compared to traditional iterative data-flow approaches, which perform updates until a fixed point is reached, our algorithm, presented at APLAS'11 [508], is 2x faster on average than the fastest algorithm (Cooper).

Spilling In a decoupled register allocator, the decoupling between the spilling (lowering register pressure) and the coloring (register assignment) phases makes possible new spilling strategies. For split compilation, we developed an ahead-of-time "spill-everywhere" (i.e., each live-range is considered as a whole) algorithm [505], which drives, through portable bytecode annotations, the decisions of a light online target-dependent JIT algorithm. We designed a purely JIT approach of same nature [523] too. Also, to better understand spilling in its generality (i.e., with live-range splitting), we developed an integer linear programming formulation [510], more accurate and expressive than previous approaches. The experimental comparison, in the STMicroelectronics compiler, of various heuristics w.r.t. this "optimal" showed some expected facts (significant savings in static spill costs, cache misses, and dynamic instruction counts can still be obtained; "rematerialization", i.e., reinitialization/recomputation, is very important and SSA can pay off here) but also that interactions with the post-pass scheduler can be very high (e.g., less freedom if spilling is too aggressive, wrong dynamic cost if load latencies are then hidden), making existing cost models completely inadequate. A lot remains to be done on this topic.

Coping with compiler and processor constraints With the democratization of SIMD instruction set architectures, handling register aliasing becomes critical even though compilers are not mature enough to fully expose it. The effectiveness of a decoupled approach depends on the ability to cope efficiently, during the coloring phase, with such register constraints. We first generalized Pereira-Palsberg "puzzle" into a "semi-elementary form" [516] to cope with hierarchical aliasing. We then designed a practical SSA-based "coloring" algorithm – tree scan, generalization of linear scan – to efficiently handle register constraints [509], by post-repairing violated register constraints, whose costs are encapsulated in the coloring objective function. Finally, codes were optimized even further thanks to a new back-end optimization called "parallel copy motion". This technique was first applied to register-allocated codes [502], then extended to "register-allocated data dependence graphs" [519, 479] so as to eliminate useless copies and reorder instructions, while preserving a valid register assignment. This last approach is a possible first step towards the design of register-pressure aware schedulers.

Objective 2: Program analysis and transformations, in particular for HLS

Program analysis and communication optimization for HLS Today, HLS tools are more mature for generating hardware accelerators with an optimized internal structure, thanks to efficient instruction scheduling techniques, resource sharing, and finite-state machines generation. However, interfacing them with the outside world, i.e., integrating the automatically-generated hardware accelerators within the complete design, with optimized communications, so that they achieve the best throughput, remains a hard task, reserved to expert designers. We made several studies and attempts to solve this issue. Finally, using the C2H HLS tool from Altera, which can synthesize hardware accelerators communicating to an external DDR-SDRAM memory, we showed that it is possible to restructure the application code, to generate adequate communication processes entirely in C, and to compile all of them with C2H, so that the resulting application makes full usage of the memory bandwidth [501]. These transformations and optimizations combine, in an interleaved manner, techniques such as double buffering, array contraction, loop tiling, software pipelining, among others. We showed how to perform the required analysis and optimizations automatically using polyhedral techniques [517, 522]. These techniques were incorporated in an automatic source-to-source transformation tool, called Chuba, core of Alexandru Plesco PhD [562]. This study showed that HLS tools can indeed be used as back-end optimizers for front-end optimizations, as in standard compilation where high-level transformations can be developed on top of assembly-code optimizers.

HLS with pipelined arithmetic In HLS, the target circuit must not only be efficient, but also produce quality results, thanks to specific arithmetic operators. Such operators are produced by FLOPOCO, an open-source FPGA-specific generator, developed by the Aric team, that converts functional descriptions into pipelined floating-point arithmetic operators. These pipelined operators need a fine optimization of the data and control paths to deliver performances. As current HLS tools usually provide an abstraction that hides the back-end details, a purely source-to-source approach was not enough in this case. We developed an algorithm to generate, from a C program, an hardware accelerator that efficiently uses these pipelined operators, rescheduling the initial program execution to keep the operator's pipeline as busy as possible, while minimizing the memory accesses. This new schedule is then used to generate the VHDL code of finite state machines (FSM) controlling the data-flow through the arithmetic operator [507]. We also addressed the problem of generating control FSMs of multiple parallel computing cores accelerating the same application [476]. The Zettice/XtremLogic start-up is based on these technologies, those developed in Chuba (as we just explained), and those presented in the patent [559].

Kernel offloading with inter-tile data reuse Actually, the techniques we developed for Chuba turned out to be more general than our initial intent, i.e., optimizing communications for FPGA. Indeed, the mechanisms we used were a form of kernel offloading (outlining of a computation kernel to a distant platform), thanks to loop tiling, and is related to some optimizations for scratch-pad memories and GPUs. A unique feature of our method is that we can pipeline tiles, exploit inter-tile data reuse (not just intra-tile reuse as previous approaches), and cope with approximations, an increasingly important topic for polyhedral optimizations [489]. We then developed the theory showing that these optimizations can be parameterized by the tile sizes and approximated [526], including the lifetime analysis necessary to perform array contraction (following our previous work on the tool Cl@k). The fact that the tile sizes can be kept parametric in the optimization was an unexpected result, as loop tiling usually generates quadratic constraints, thus goes out of the standard polyhedral model. Another way of dealing with parametric tiling (in a more general context but with one parameter) was developed in [529], in collaboration with Sanjay Rajopadhye (CSU). This approach can represent the sets obtained after parametric tiling as unions of polyhedral sets, on which any standard polyhedral analysis can then possibly be applied.

Analysis of while loops: towards irregular programs Initially exploring techniques to transform kernels with while loops into kernels with static loop bounds (to make them acceptable for HLS tools), we ended up on the problem of how to evaluate the number of iterations of while loops and thus also their termination. Establishing a link (see the surveys [488, 543]) between seminal work (in the 60s) on recurrence equations, our past work (in the 90s) on multi-dimensional loop scheduling, and ranking functions (used for program termination), we were able to bring to the termination community many results developed for the detection of parallel loops. Our technique for generating multi-dimensional affine ranking functions [500] subsumes several algorithms proposed by this community. In addition, coupled with counting methods in polytopes, it can provide upper bounds on the number of iterations, which can be of interest for the WCET (worst-case execution time) community. A complete software suite was developed, whose stages were presented at TAPAS'10 [506] and CSTVA'13 [521]. First, C2fsm converts the C source into an interpreted automaton. Then Aspic, previously developed by Laure Gonnord and whose abstract interpretation techniques were extended in [481, 514], computes invariants as polyhedral approximations. Finally, Rank builds a ranking (if any) using Pip and computes upper bounds on the number of iterations using Ehrhart polynomials with Polylib. This work was then extended to deal with larger programs [518] and scalability concerns were at the origin of the practical study described in [530]. Finally, using classical static analysis techniques, we also developed a method to statically detect memory overflows of full-C programs [531].

Analysis of parallel/streaming languages While, historically, Compsys has applied polyhedral analysis to sequential programs, it was recently realized it also applies to parallel programs, with the aim of checking their correctness or improving their performance. The prospect of having to program exascale architectures, with their millions of cores, has led to the development of new programming languages, whose objective is to increase the programmer productivity. Compsys has applied polyhedral techniques to synchronous languages, to IBM's high-productivity language X10, and to a streaming language, OpenStream, developed by Albert Cohen's group in the context of the ManycoreLabs project.

Synchronous languages are used to program reactive control systems when the context dictates very high safety and reliability. Most program operations consist in taking decisions according to boolean manipulations. However, when connected to the physical world, they also have to deal with sensors and actuators whose outputs and inputs are continuous variables. While existing compilers can optimize the boolean part of a program, they do not try to take advantage of the semantics of continuous signals. We have built an analysis tool suite [478, 513], which first uses abstract interpretation methods to extract a representation of the target program as a system of boolean-affine relations, then constructs all valid models of these relations, finally analyzes the models to extract interesting properties, like never-active signals and redundant clocks. The tool can also build a clock tree, to be used by the compiler to optimize the target program.

X10 is based on the creation of independent *activities* (light-weight threads), which can synchronize either by a generalization of the fork/join scheme, or with *clocks*, an improved version of the familiar barriers. X10 is deadlock-free by construction but it is the programmer responsibility to insure determinism by a proper use of synchronizations. Non-determinism bugs may have a very low occurrence probability thus be very difficult to detect by testing, hence the interest for detecting races at compile time. In collaboration with CSU (S. Rajopadhye, T. Yuki) and IBM (V. Saraswat), we extended array dataflow analysis to polyhedral clock-free X10 programs [525]. We are now working on clocked programs [527]: race detection becomes undecidable [558], but realistic problems may still be solved by heuristics.

In contrast to X10, OpenStream is deterministic by construction, but may have deadlocks. A usual way of disproving deadlocks is by exhibiting a schedule for the program operations, a well-known problem for polyhedral programs, where dependences can be described by affine constraints. In the case of OpenStream, communications use one-dimensional channels and, in a form of linearization, give rise to polynomial dependences for polyhedral OpenStream codes. In a ManycoreLabs project deliverable, we have formalized the problem and proved that deadlock detection is undecidable in general. However, we hope to be able to construct a semi-algorithm, using recent results on the so-called Positivstellensatz.

Objective 3: Development of polyhedral tools

We just give here a quick description of the most recent developments of polyhedral tools (see Section 6.3.7 for more details on all tools). The work on back-end optimizations also implied important developments with implementations in the STMicroelectronics compiler, speed/memory and performance evaluation of the algorithms, bug tracking.

Bee Source-to-source optimizer [567], with lifetime analysis of array elements and lattice-based array contraction, thanks to Cl@k. Roughly 2500 lines of C++. Binary used by the Cairn HLS toolbox Gecos, through the S2S4HLS project (see the online tool demo at `http://compsys-tools.ens-lyon.fr/bee/index.html`).

Chuba Source-level optimizer [568] that offloads a C kernel onto FPGA, with optimized communications to an external DDR memory [562, 522]. Roughly 1000 lines of C++. At the heart of the Zettice/XtremLogic start-up initiative.

C2fsm Extractor [570], from a C program, of an interpreted automaton. Used to interface C programs with the abstract interpretation tool Aspic (see details on Aspic at `http://laure.gonnord.org/pro/aspic`).

Dcc DPN ("data-aware process network") C compiler [569], front-end of the HLS tool transferred to Zettice/XtremLogic. Takes as input a C program annotated with pragmas and produces an optimized DPN, i.e., a regular process network that makes explicit the I/O transfers and the synchronizations, as exposed in [559]. Complemented by its back-end IceGEN (Integrated Circuit Generator), which outputs both SystemC and VHDL. More than 3000 lines of C++.

PoCo Polyhedral compilation framework [565], used by Bee, Chuba, and Rank. Provides many features to quickly prototype polyhedral analysis & optimizations. Front-end based on EDG (via Rose). Roughly 20000 lines of C++.

RanK Analysis tool [566] to decide (when possible) the termination of an interpreted automaton. Connected to C2fsm and Aspic to handle C while loops and to give an upper bound on their number of iterations (kind of WCET) [500]. Roughly 3000 lines of C++. See `http://www.ens-lyon.fr/LIP/COMPSYS/Tools/Ranking/`.

Simple Simplifier of affine Boolean expressions [555], in particular Quasts (quasi affine selection trees) extensively used in the polyhedral community. See `http://www.ens-lyon.fr//LIP/COMPSYS/Tools/Simple/`.

Stop Extension of Rank based on the scalable technique of [518]. Conservatively checks the termination of a C program, by generating smaller programs whose termination implies the termination of the larger. Roughly 2000 lines of C++.

Termite LLVM implementation (in progress) of a termination algorithm that aims to scale better than Rank. Collaborative development with D. Monniaux and G. Radanne. Roughly 2000 lines of OCaml.

4.3.2 Visibility and collaborations

Compsys is very visible both in back-end code optimizations and polyhedral optimizations, and has been very active in organizing these two communities. One can cite the organization of two spring schools, one on SSA (followed by a book [548]), one on polyhedral optimizations, and the creation of the IMPACT workshop series as well as the french compilation community. An effort is also made to bring closer the communities of polyhedral optimizations, abstract interpretation, and program termination. The participation to the Encyclopedia of Parallel Programming, to the upcoming IEEE videos on parallel programming, and to numerous program committees, attests the visibility of Compsys. See more details in the executive summary and detailed reports in the appendix, Sections 1.6 and 6.3. Compsys has collaborations with Christophe Guillon and Benoit Dupont de Dinechin (STMicroelectronics and Kalray), Albert Cohen (ENS Paris), David Monniaux (Grenoble), Alain Ketterlin and Eric Violard (Strasbourg), Sanjay Rajopadhye (Colorado State), P. Sadayappan (Ohio State), J. Ramanujam (Louisiana State), Fernando Pereira (Minas Gerais, Brazil), etc.

4.4 Training through research

Fabrice Rastello defended his "HDR" in 2012. Since 2009, 4 PhD students graduated: Florent Bouchez [560] is now assistant professor in Grenoble, Benoit Boissinot [561] R&D engineer at Google Zürich, Alexandru Plesco [562] CEO/CTO of XtremLogic, Quentin Colombet [563] R&D engineer at Apple Cupertino. Guillaume Iooss will finish next year (joint PhD with CSU), Alexandre Isoard has still two years of funding, and Maroua Maleej will start in sep. 2014.

Teaching at master level is done through the M1 compilation course (Christophe Alias) and M2 code optimization course (shared among Compsys members). Christophe Alias and Laure Gonnord organized 4 one-week "Master schools" for ENS-Lyon students: "Beyond the PC. Application-specific systems: design and implementation" (2010), "Verification and certification of software" (2012), "Programming embedded systems with synchronous languages" (2014), "Static analyses in the state-of-the-art compilers" (to come in 2015). The team members also regularly advise research interns.

4.5 Research project

4.5.1 Self-assessment and SWOT analysis

Strong points

Our activities on back-end optimizations with STMicroelectronics (2002-2012) were a huge success for us, not only for the contracts, funding, and joint papers with our industrial colleagues. Being able to work within a complete industrial compiler made our studies more relevant and fully evaluated. Through this activity, Compsys succeeded to attract young researchers: 2 PhD students from ENS-Lyon (F. Bouchez and B. Boissinot), and 1 PhD student and 1 post-doc directly from this link with STMicro (Q. Colombet was engineer there before joining Compsys, F. Brandner entered in contact with us through STMicro). Thanks to our scientific results, our team was recognized as one of the most advanced group on SSA and decoupled register allocation, which we introduced.

In program analysis and transformations for HLS, we first made slow[9] but strong progress with new polyhedral problems and solutions. The automation of optimized communications with inter-tile reuse, automated "double-buffering"-like execution, then pipelined operators, offered interesting perspectives, beyond HLS, and was the starting point for initiating the XtremLogic start-up. The work on while loops and on data races in X10 opened wide perspectives, in unexpected directions, for the development of new polyhedral optimizations: program termination and WCET, approximations and abstract interpretation, analysis of parallel programs. These directions motivated our future research project.

Finally, we believe that our effort to convert abstract theorems and algorithms into practical software was worthwhile and on the whole successful. This also helped other groups to compare their results to ours, thanks to our tools web page with some demonstrators[10]. A crucial point is that while abstract complexity results are important, they should not deter us to attack NP-complete problems, which may have feasible solutions in practical cases. The recent success of SAT and SMT solvers (or ISL in the polyhedral community), due to improved algorithms and processors, is a case in point.

Weak points

Being strongly connected with an industrial partner (STMicro) was a strength but also made us more dependent: in dec. 2010, the government nationally froze all Nano2012 projects (including our two main funding sources Mediacom and S2S4HLS). At the same period, STMicro changed its strategy, allocating almost all its manpower to the Platform2012 project (towards a multicore machine), and less on back-end optimizations. This made our compiler development more difficult, and some topics were not completed as we wished. Today, this collaboration has stopped. We may nevertheless find again common topics of interest with STMicro in the future, in particular on code analysis and parallel optimizations.

Concerning HLS, except for A. Plesco, we did not succeed to hire collaborators with a strong architecture/synthesis background and with skills in both mathematics and computer science. We had difficulties to find our place within the HLS community too, either through ANR projects (ANR COACH rejected) or industrial collaborations (fruitless S2S4HLS project with STMicro). Also, SoC-SiP and ArtistDesign NoE are still a bit far from our activities.

Concerning tools and prototypes, they are not always developed in a common software toolchain, although this simplifies maintenance and evolution. Also, the dissemination of the tools is not uniform (due to different strategic policies), but the online tool demo web page gives a good access to our software development activities.

[9] This is mostly due to the interaction with HLS tools and FPGA platforms, with tough developments and use, and our lack of expertise.
[10] Compsys tools: http://compsys-tools.ens-lyon.fr/

Opportunities

Our research project, detailed hereafter, will focus on: a) extending (i.e., developing new methods) and expanding (i.e., applying them to new applications) polyhedral optimizations; b) combining static analysis and compilation, trading accuracy for speed and applicability, at both front-end and back-end levels; c) establishing more connections with GPU and multicore programming, language design (e.g., X10, OpenStream), and scientific computing users. This is motivated by the opportunities we see with respect to current research challenges, our forces, and our environment.

The main strength of Compsys, result of an experience of more than twenty years, is indeed to master the polyhedral analysis and optimization (including parallelization) techniques applied to compilation. Polyhedra and their sub-classes (intervals, pentagons, octagons, etc.) are one of the few systems that represent infinite or non-bounded objects, which, with an acceptable complexity, do not immediately face undecidability problems, as polynomials and formal languages do. It is thus not surprising to see them resurface periodically in program analysis, verification, termination, parallelization, and synthesis. In return of this strength, polyhedral techniques have a restricted application scope, in short, they are for program analysis what linear differential equations are in functional analysis. But while mathematicians and physicists have built an arsenal of approximation methods, this work is at its start for polyhedral methods. From this point of view, a reconciliation with abstract interpretation is expected, and the hiring of Laure Gonnord is a step in this direction. Polyhedral techniques are actually the symbolic front-end counterpart, for structured loops, of back-end analysis and optimizations of unstructured programs (through control-flow graphs), such as scheduling, lifetime analysis, register allocation, etc. A strength of Compsys so far was to juggle with both aspects, one more on graph theory with SSA-type optimizations, the other with polyhedra representing loops, and to exploit the correspondence between both. This has still to be exploited, for applying polyhedral techniques to more irregular programs.

As for the environment, the last Inria evaluation of our theme pointed out the importance of pushing the french research on polyhedral optimizations, and our strengths on this topic, while our regional Inria center marked as a priority the research on software/hardware interface (our topic). This is also attested by the recent hiring of Tomofumi Yuki. The creation of the IMPACT workshop and of the spring school on polyhedral techniques (with the invitation of A. Miné et B. Creusillet, experts in abstract interpretation and approximation-based fixed-point analysis), as well as our last scientific results, show our role in the revival of this community and its extension. Finally, the support of Labex MILYON (through its thematic quarters) and the activities of the Lyon-Calcul initiative[11] are means to get closer to users of scientific computing (also a goal of T. Yuki's objectives), even if it is too early to know if we can indeed be directly helpful to them.

Risks

The first risk of our research directions is the hiring of our PhD students. This is particularly true at CNRS where profiles between theory and practice seem less attractive. Our activities are at the intersection of sections 06 and 07, but both sections sometimes think we belong to the other one. So far, past Compsys PhD students usually go to industry. Our theme lies between three GDRs (SoC-SiP, GPL, and ASR), but it was not really represented until L. Gonnord and F. Rastello created the compilation group[12]. This may help increase the visibility of our activities.

The second risk is more a difficulty that we do not succeed to overcome. Working on HLS, between computer science and electrical engineering, is hard: this topic is marginal in the lab (in particular no engineer expertise) and industrial collaborations and funding are difficult (as shown by the S2S4HLS and COACH projects). This is also one of the reasons why A. Plesco and C. Alias created the Zettice start-up.

The last risk is due to possible difficulties due to external decisions, with a stronger impact due to our size (a manpower reduction in a large team has fewer consequences). The departure of F. Rastello was not simple and mainly motivated by Inria. The Zettice/XtremLogics initiative is of course an opportunity but can also be a risk if, in addition to the confidentiality and conflict-of-interest problems it creates, it consumes too much manpower without feeding back the team with research problems, applications, and industrial trends.

4.5.2 Research objectives

Compsys has always focused on the development of fundamental concepts or techniques whose applicability go beyond a particular architectural or language trend. Our work on back-end, resp. front-end, optimizations was based on the development of the mathematical properties of the SSA form, resp. the polyhedral model. We will continue this type of research, pushing the theory beyond current knowledge, as independently as possible of technological trends (but aware of them), complemented by small stand-alone tools – proofs of concepts or basic blocks for larger tools/compilers developed by others – and our own experimental prototypes. Our main focus will be to push static polyhedral compilation beyond its present limits, both in terms of techniques (extension of the model) and applications (expansion of the model).

The polyhedral model is neither a programming language nor an execution model, rather an intermediate representation, As such, it can be generated from imperative sequential languages like C or Fortran, streaming languages like CRP, or equational languages like Alpha. While the structure of the model is the same in all three cases, it may enjoy different

[11] Lyon Calcul federation: `http://lyoncalcul.univ-lyon1.fr`

[12] Communauté française de compilation: `http://compilation.gforge.inria.fr/`

properties, e.g., a schedule always exists in the first case, not in the two others. The import of the polyhedral model is that many questions relative to the analysis of a program and the applicability of transformations can be answered precisely and efficiently by applying well-known mathematical results to the model. The price to pay is that the expressive power of polyhedral programs is severely limited: they cannot handle either dynamic data structures or dynamic control.

Meanwhile, the evolution of the technology landscape has led to the introduction of (possibly massively) parallel architectures, with multi-level memories, from embedded appliances to high-performance computers. Processor counts of a thousand up to a billion are now contemplated. Parallel applications, compilers, and new parallel languages must scale up to these figures. Several research groups are attempting to trade predictability for expressiveness, in the form of parallel libraries whose behavior is data dependent and cannot be analyzed at compile time, e.g., the Galois system (K. Pingali) or the Concurrent Collections (Intel, K. Knobe). One should note, however, that these groups are wondering how to detect and take advantage of regular (i.e., polyhedral) program parts in order to improve the performance of their systems. Our feeling is that there is a continuum of approaches for parallel programming, with the (static) polyhedral model at one of the extremities, and purely dynamical low-level approaches at the other one. Most research teams start from one of these extremities and try to move, step by step, in the other direction. The work on parallel libraries is an attempt to alleviate the well-known difficulties of thread programming. The objective of Compsys will be to move in the opposite direction, i.e., to enlarge the applicability of the polyhedral model in a controlled and manageable way. But, instead of being driven by architecture issues or by languages features, we want to be driven by compiler issues, i.e., by what we know can be automated. The emergence of non-linear problems (as seen for example in the analysis of the OpenStream language) is an important issue. All these extensions stress the polyhedral model and require new objective functions, new optimizations techniques, and a better control of complexity and scalability.

4.5.3 Project implementation

Communications and hierarchical memories So far, our solution to deal with different levels of memory (in particular the external memory) consists in maximizing data reuse in the most local memory. This approach may need too much local memory. This can be alleviated either by spilling to an external memory (live-range splitting), by exploiting only partial data reuse, by multi-level tiling, or by slowing down the schedule. The adaptation to GPUs and more general multicore architectures remains to be done. The fact that our tiling techniques can be parameterized by the tile size should help defining cost models, both for performance and memory consumption. Going further, data reuse with live-range splitting can be exploited even for sequences of kernels, adapting CFG-like spilling techniques to polyhedral regions.

Scheduling and mapping When scheduling communicating processes, the obvious solution is firstly to compute local schedules for each process, then to compute inter-process schedules. As the CRP experience has shown, this can be used to prove the absence of deadlocks but this is not the best way to simplify communications. Also, taking resource and memory constraints into account is difficult with polyhedral techniques, for instance pipelined schedules, except in an ad hoc and restricted way, are difficult to express. Much progress is needed in this direction, in particular in the light of streaming specification or execution. Also, the recent use of polyhedral techniques for analyzing parallel languages and/or to derive parallel execution has shown the need for more advanced lifetime analysis and memory allocation mechanisms, possibly piece-wise affine. The exploitation of memory banks is also crucial, both for partitioning the data sets and to adapt the schedule to the limited parallelism allowed by the number of available memory banks.

Dealing with approximations The basic idea is to construct a polyhedral over-approximation of an irregular program, i.e., a program which has more operations, a larger memory footprint, and more dependences than the original. One can then parallelize the approximated program using polyhedral tools, and then return to the original, either by introducing guards, or by insuring that approximations are harmless. This technique is the standard way of dealing with approximated dependences. We already started to study the impact of approximations in our kernel offloading technique, for optimizing remote communications. It is clear however that this method will apply only to mildly non-polyhedral programs. The restriction to arrays as the only data structure is still present. Its advantage is that it subsumes in a coherent framework many disparate tricks: the extraction of SCoPs, induction variable detection, the omission of non-affine subscripts, or the conversion of control dependences into data dependences. The link with the techniques developed in the PIPS compiler (based on array region analysis) is strong and will have to be explored.

Semantic optimizations Program optimizations usually modify the execution order of the original program and/or the data layout while preserving the equivalence of the underlying calculus. Relaxing this program equivalence by taking into account the equational properties of the arithmetic operators (associativity/commutativity, etc) opens a large field of possible optimizations. An example is *semantic tiling* [524], a loop transformation that increases the granularity of the operators (scalar $\rightarrow$ matrix) by playing on the associativity/commutativity of + and *. As a first step, an heuristic has been designed to check the equivalence of two programs modulo associativity/commutativity [528]. Surprisingly, it seems that both the original and semantically-tiled programs can be normalized to systems of recurrence equations with the same structure. This property has still to be proved and explained. We also plan to investigate how semantic tiling can be applied to improve the precision of a program involving floating-point operators, which is also a semantic optimization.

Non-regular process networks In the context of the XtremLogic start-up, we have developed a HLS-specific process network model. Communications with the central memory and the parallel access to channels are explicit, and the model is close enough to the hardware constraints to be translated directly into a circuit. Currently, our model is bounded to *regular* programs (`for` loops, affine tests and array indices), whose behavior can be predicated statically. We plan to study how to extend our translation rules to irregular programs (`while` loops, non-affine tests and array indices) into process networks. Our previous work on program termination and on approximations could be applied here. We also plan to extend our process network model with modularity (as in Alpha or in CRP), i.e., the possibility to view a process network as a process in a bigger network, while keeping the efficiency of the global system. Such a feature would dramatically enlarge the class of programs currently handled, allowing bigger kernels and irregular constructions.

Enhancing the interactions between programmer and compiler for performance & productivity Current techniques for automatic parallelization are based on two tenets:

- all knowledge about the computation comes from the source program text;
- the target program must reproduce the source results up to the last bit.

This limits the applicability of automatic parallelization to a relatively small subset of programs. Application specific knowledge that can guide compiler decisions may be hidden in various forms, such as comments, documentation, proof of correctness, or not even written down yet. It is impossible for a compiler alone to fully exploit such pieces of information. A possible approach to better utilize such knowledge is to put the programmers "in the loop".

Expert parallel programmers often have a good idea about coarse-grain parallelism and locality that they want to use for an application. On the other hand, fine-grain parallelism (e.g., ILP, SIMD) is tedious and specific to each underlying architecture, and is best left to the compiler. Furthermore, approximations will have opportunities to be refined using programmer knowledge. The key challenge is to create a programming environment where compiler techniques and programmer knowledge can be combined effectively. One of the difficulties is to design a usable interface between the compiler and the programmer. Early attempts, like the pragmas of the Cray Fortran Translator or N. Vasilache's WrapIt tool have met with limited success. A promising solution is the tool Clint by C. Bastoul.

Program termination, while loops, and fast approximated static analysis Using approximations is also a way to simplify and make algorithms faster. This is true for both polyhedral optimizations and back-end optimizations. Static analyzes by abstract interpretation have proved their ability to handle large programs, but with a focus more on precision than cost. Our work on program termination and the handling of while loops through interpreted automata, analyzed by abstract interpretation, connects the work on back-end CFG-like and front-end polyhedral-like optimizations. We first plan to extend the applicability of our termination analysis on larger C programs. This work should also give connections with WCET (worst-case execution time) analysis. In addition, following our work on range analysis of numerical variables and on the memory footprint on real-world C programs [531], we plan to explore how we can design cheaper analyzes that scale well, mainly based on compact representations derived from variants of SSA.

5 Dante team: Dynamic Networks

5.1 Scientific areas and activities

5.1.1 Goals and context

The scientific lines of the DANTE team stem from a joint reflexion between a part of RESO (T. Begin, P. Gonçalves and I. Guérin Lassous) and D-Net (E. Fleury and C. Crespelle). The RESO team was focusing on resource management and communication protocols in the context of high speed networks and virtualized infrastructures (clouds) and applied their results to the domain of high demanding applications and Future Internet. The main goal of the D-NET team was to lay foundations to the characterization of dynamic networks, and to the field of dynamic processes occurring on large scale interaction networks. In order to develop tools of practical relevance in real-world settings, DNET proposed to ground its methodological studies on real data sets obtained through large scale in situ experiments. Although the two had distinct motivations at their origin, we meet on the systems we analyse and their nature, and we both endeavour at understanding the complex mechanisms that cause their transformations. It is this convergence that led us to pool our efforts and to combine our competences in Graph Theory, Signal Processing, Performance Evaluation and Distributed Algorithms to tackle the study of “Dynamic networks”. Our main objective is thus to work out, based on a multi-disciplinary foundation, a theoretical and methodological framework devoted to time-space networks, able to connect structural features (viz. vertices / entities or edges / links) with dynamic properties.

5.1.2 Activity profile

The DANTE team is not uniform in term of activity profile since some of the permanent staff are full-time researcher, other have teaching duties and other have strong involvements either at the local or global scientific community. On average, for the whole DANTE we can propose an estimation of the activity profile as: **Academic research:**50 %; **Interaction with socio-economic or cultural environment:** 10%; **Scientific animation:** 20%; **Formation:** 20%.

5.1.3 Highlights

On the Academic research axe:

- During this period we have attracted 3 assistant professors and 1 full professor.
- Books: *"Scaling, Fractals and Wavelets"* by P. Abry, P. Gonçalves, and J. Lévy Véhel; *"Cluster and Computing Networks."* by P. Primet; *"Réseaux de calcul - Des grappes aux nuages de calcul"* by P. Primet, S. Soudan, R. Guillier, and B. Goglin and *"Réseaux de capteurs : théorie et modélisation"* by E. Fleury and D. Simplot-Ryl.
- Pascale Vicat-Blanc : Prix Inria – Académie des sciences – Dassault Systèmes de l’innovation 2013
- Best paper award: *Classification of Content and Users in BitTorrent by Semi-supervised Learning Methods* at the 3rd International Workshop on Traffic Analysis and Classification; *Hurst Exponent IntraPartum Fetal Heart Rate: Impact of Decelerations* in the 26th IEEE International Symposium on Computer-Based Medical Systems; *Community detection with fuzzy community structure* at ASONAM 2011 and *Automated Traffic measurements and analysis in Grid’5000* at ACM SIGMETRICS/PERFORMANCE.
- Journals: 52; Conferences: 96; Patents: 5

On the scientific animation part:

- Inria RESO team was evaluated successfully: *The evaluation committee congratulates RESO for its excellent evaluation. RESO has been a very successful project with important academic and industrial results including the foundation of the start-up Lyattis on cloud network control.*
- Members of the DANTE are deeply involved at the national level: president/vice-president of the ANR call INFRA, Blanc/JCJC (SIMI2), member of CNU, member of the CNRS CN, member of the International Relation of Inria, Vice-Chairman of the Inria Grenoble Rhône Alpes projects committee.
- We have obtain funding for 1 EQUIPEX FIT, 8 ANR projects, 8 European projects and Inria funding for ADT, ARC and an Inria International Associated team with Japan.

On Interaction with socio-economic or cultural environment:

- 2 start-ups were founded: Lyattis by P. Primet and HiKoB by G. Chelius.

- Organisation of the conference Alan Turing's heritage that was the occasion to program public lectures (computer science, philosophy and epistemology) intended for a broad audience. It was also a great opportunity to award a doctorate honoris causa to Leslie Valiant (a first for CS at ENS de Lyon). At this occasion, a movie "The Turing Machine Comes True" was released[1].
- Chair of the workshop "Social networks, from structures to politics" in conjunction with IXXI. What are we learning about the social world? With which tools? What kind of world are we making with this digital frenzy? Invited speakers were Bruno Latour, Alain Barrat, Vincent Blondel, Gianluca Manzo and Pierre Mercklé.
- Participation to the "Premier Forum des Usages et des Images des nanotechnologies dans la ville" in conjunction with CCSTI Grenoble, CASAMATE, NANOYOU FP7 project and Cité des Sciences et de l'industrie.
- Within MOSAR project[2] we developed and deployed a large scale in situ wireless sensor networks to record all contacts between staff and patient of an hospital: 600 people recorded every 30sec during 6 months. The MOSAR project was also the occasion to disseminate the context and the result towards a broader audience (news in national news paper like "Le Quotidien du Médecin", movie at cité des sciences et de l'industrie, Radio on RFI/MICROMEGA and short interview on TF1 news.)
- We are the prime investigator for FIT-IoT LAB[3]. IoT-LAB features over 2700 wireless sensor nodes spread across six different sites in France. IoT-LAB is part of the Equipex FIT experimental platform, a set of complementary components that enable experimentation on innovative services for academic and industrial users. FIT is one of 52 winning projects in the Equipex research grant program. FIT benefits from 5.8€ million grant from the French government.

On the Formation side:

- Scientific organisation of 4 research winter schools at ENS de Lyon (Optimisation and convexity; Stochastic Geometry for Wireless Networks; Compressive Sensing; Game theory for networks) and one summer school for the GDR ASR/ResCom (Network Science)
- Members of the DANTE team were strongly involved in the management of the departments and formations cursus: head of the master at ENS de Lyon, head of the CS dept. at ENS de Lyon, co-direction of the cursus "modelling complexe science" in link with 3 masters of ENS de lyon (Mathematics, Physique and Computer Science) and IXXI (Rhone Alpes complex science institute), head of a cursus on networking at Lyon 1.

5.1.4 Research activities

In order to give a global view of the activities that come from 2 initial teams, we present first the research activities of RESO (2009/2012), then DNET (2009/2012) and finally the activities of the DANTE team created on novembre, 1st, 2012.

Reso - 2009/2012

Axis 1: Advanced protocol implementation and networking equipment.
Main researchers involved: P. Gonçalves, I. Guérin-Lassous, P. Vicat-Blanc (on leave on June 2010).

Since several years, virtualization of the operating system is used in end system to improve security, isolation, reliability and flexibility of the environments. These mechanisms becoming incontrovertible in large scale distributed systems, we explore how the same can also be adapted and used in data transport networks and specifically in switching and routing equipments. In this direction, RESO addressed the following main questions: *(i)* Where and how do we need to integrate the required autonomy to manage and to control high speed networks at large scale? *(ii)* How can we obtain both high performance and efficient communications along with controlled energy consumption and reliability in virtualized infrastructures context?

Major scientific achievements.

− **Performance and sharing in virtualized networks.** As a groundwork towards routers virtualization, we analyzed and evaluated the impact of virtualization mechanisms on communication performance. Our conclusion is that software optimization is a promising approach for experimentation but dedicated hardware is required for production networks. This research yields to the conception of VxSwitch[4], a virtualized switching fabric.

− **Virtual Infrastructure Description Language (VXDL).** We designed this descriptive and declarative language to allow users and systems to exhaustively describe the components of a virtual infrastructure, including virtual resources,

[1] more that 107 000 views on `http://www.dailymotion.com/video/xrmfie_the-turing-machine-comes-true_tech`
[2] IP supported for 5 years by the European Commission under the Life Science Health Priority of the Sixth Framework
[3] `https://www.iot-lab.info`
[4] VXSwitch Patent - INPI: No 10/00368, 2010. LYaTiss, INRIA, ENS Lyon

network topology, and organization of the internal timeline. We used this language to develop a mechanism that translates workflows of a distributed application into VI specifications[5][6].

Axis 2: End-to-end Quality of Service and Transport layer.

Main researchers involved: T. Begin, P. Gonçalves, I. Guérin-Lassous, P. Vicat-Blanc (on leave on June 2010).

The goal of this axis is to guarantee quality of service in machine/user to machine/user communication while using efficiently the resources of the future networks around the following main concepts: *i) dynamic bandwidth sharing and congestion control in the Future Internet and ii) control and flow management in semantic networks.* RESO addressed the following main questions: *(i)* Which congestion control and which transport protocol for high speed networks in large scale contexts? *(ii)* How to efficiently share and to dynamically provision a network bandwidth dedicated to computing tasks? *(iii)*Is the "flow-aware" approach a reliable solution to solve end to end quality of service issues raised by the very high speed Future Internet?

Major scientific achievements.

– **High-speed transport protocol.** We carried out an exhaustive and fair comparative evaluation of transport protocols in large-scale high-speed networks. To this end, an operational and strict procedure NXE[7] has been set up – along with corresponding tools[8]. – to highlight the characteristic behavior of transport solutions in a real and utility context.

– **Dynamic bandwidth sharing and congestion control.** We consolidated the algorithmic development and strengthened the effectiveness of our BDTS[9] and FLOC[10] solutions. We formalized the corresponding provisioning optimisation problem in a tiered architecture implying the client, the service provider and the network provider.

– **Flow-based networks.** We proposed a scalable Flow-Scheduler architecture that improve the completion time of small flows (with negligible performance degradation for larger flows). We moreover studied the robustness of size-based scheduling systems when user-behavior fails because large flows have an incentive to behave like the small ones.

– **Bandwidth sharing in wireless networks.** The use of IEEE 802.11, and specifically in multihop networks, raises issues, like efficiency and/or fairness issues. We have proposed a distributed and dynamic rate allocation solution that is based on a simple sharing model. Our protocole, called *Profiterole* provides a fair bandwidth sharing between end-to-end flows while maintaining an efficient overall throughput in the network.

Axis 3: High-Speed Network's traffic metrology, analysis and modeling.

Main researchers involved: T. Begin, P. Gonçalves, I. Guérin-Lassous, P. Vicat-Blanc (on leave on June 2010).

This activity consists in measuring along time, the nature and the amount of exchanged information between the constituents of a system. It is then a matter of using the collected data to forecast the network load evolution, so as to anticipate congestion, and more widely, to guarantee a certain (probabilistic) Quality of Service, rationalizing the resources usage. This research axis is the most recent, and it is the one that was at the heart of the reflexion between DNET and RESO since it deals with measure of dynamic process on a possible evolving infrastructure. RESO addressed the two following generic questions: *(i)* How do the traffic statistical properties really impact the Quality of Service? *(ii)* How to identify and to classify, in real time, transiting flows, according to a sensible typology?

Major scientific achievements.

– **Metrology.** We design packet capture probes so that we can now monitor a 10Gbps link capacity and checked that capture is loss free and bidirectional, time stamping precision is close to the μs and storage capacity permits several hours of capture at full speed.

– **Heavy Tailed Distribution and Long Range Dependence.** Thanks to our large scale testbed, we experimentally validated the functional bond that theoretically exists between the heavy tailed distribution of flow size and the long range dependence property of aggregated traffic. For the first time, we were able to demonstrate that this theoretical relation holds true on real traffic traces and over a wide range of experimental conditions. Considering the case of TCP protocol, we showed that the impact is far more intricate than what was claimed in the literature, and more surprisingly, that sometimes it can even increase the network performance. We also proposed a maximum likelihood estimator of the heavy-tail exponent of a random variable from a doubly censured dataset realization.

– **Traffic and Large Deviations.** Focusing on long-lived TCP flows we extended the scope of the famous Padhye's relation and demonstrated that deviations of a long TCP flow's throughput from its almost-sure mean value are rigorously quantifiable. This result relies on an ergodic large deviations principle proved to hold on almost every single realization of a large class of stochastic processes.

– **Probabilistic Resource Management.** We reused the same Large Deviation principle mentioned above, to characterize the workload volatility of a content delivery server when the users' behavior can reliably be described by a Markovian based epidemiological model.

[5]VXAlloc Patent - INPI: 10/01626, 2010, LYaTiss, INRIA, ENS Lyon

[6]VXCap Patent - INPI: 10/01624, 2010, LYaTiss, INRIA, ENS Lyon.

[7]NXE: APP No IDDN.FR.001.030005.000.S.P.2009.000.10800.

[8]PATHNIF: APP IDDN.FR.001.260002.000.S.P.2009.000.10800

[9]BDTS: APP IDDN.FR.001.220025.000.S.P.2008.000.10700.

[10]FLOC: APP IDDN.FR.001.290009.000.S.P.2009.000.10200.

D-Net - 2009/2012

Axis 1: Sensor network, distributed measure and distributed processing

Main researchers involved: Guillaume Chelius (On leave on July 2011), Eric Fleury).

Sensors networks offer an efficient way to measure physical phenomena at various space and time scales. Given a target application, the goal is to design adequate sensor nodes and to set up the way they communicate, cooperate and collect their data in order to fulfill the application constraints. Fulfilling this goal requires the development of theoretical and practical techniques to help the dimensioning and deployment of such distributed sensing tools, to manage the distributed measures and to perform efficient and reliable distributed computing on top of the network.

Major scientific achievements.

− **Cross-Layer Optimization for Software Layer to Physical Device layer Mapping.** We develop a generic method for mapping software state machines used in protocol stacks and communication layers directly to hardware communication devices using their specifications. The proposed method can handle power modes and timing constraints imposed by hardware devices in order to optimise the software code running on top of the device. This property allows the use of the hardware device in its lowest power consumption mode while making sure that real time constraints are met.

−**Reconstructing the social interactions using Wireless Sensor Network.** We addressed the challenges of capturing physical proximity and social interaction by means of a wireless network. In particular, as a concrete case study, we exhibit the deployment of a wireless sensor network applied to the measurement of Health Care Workers' exposure to tuberculosis infected patients in a service unit of the Bichat-Claude Bernard hospital in Paris, France. We also address the challenge of recording contact interactions in an hospital within the MOSAR project dedicated to nosocomial infections where we analyzed Staphylococcus aureus carriage and Close proximity interactions recorded simultaneously in a long-term care hospital for 4 months in 329 patients and 261 healthcare workers with a snapshot every 30sec. We highlight the bias introduced by the measurement system reliability and provide a reconstruction method which not only leads to a significantly more coherent and realistic dataset but also evidences phenomena a priori hidden in the raw data. By this analysis, we suggested that a processing step is required prior to any adequate exploitation of data gathered thanks to a non-fully reliable measurement architecture.

−**Developing and deploying large scale research infrastructure.** We are leading the SensLAB project. SensLAB's main and most important goal is to offer an accurate and efficient scientific tool to help in the design, development, tuning, and experimentation of real large-scale sensor network applications. SensLAB was also supported by several Inria ADTs (SensTOOLS, SensSAS) in order to foster the development and the diffusion of the technology developed an deployed.

Axis 2: Theory and Structural Dynamic Properties of dynamic Networks

Main researchers involved: Guillaume Chelius (On leave on July 2011), Christophe Crespelle (hired on sept 2010), Eric Fleury).

Major scientific achievements.

− **Dynamic network model.** We proposed a framework for the study of dynamic mobility networks. We address the characterization of dynamics by proposing an in-depth description and analysis of two real-world data sets. We show in particular that edges creation and deletion processes are independent of other graph properties and that such networks exhibit a large number of possible configurations, from sparse to dense. From those observations, we propose simple yet very accurate models that allow to generate random mobility graphs with similar temporal behavior as the one observed in experimental data.

− **Community detection: dynamic and overlapping.** We conduct two main approaches in community detection suitable for dynamic network. The first one is related to overlapping detection and the second one is to be able to detect dynamic communities. We present a new framework to uncover community structure in series os temporal graph. We also introduce an approach to identify overlapping community structure based on an efficient partition algorithm. In our method, communities are formed by merging peripheral clusters with cores. We also take an orthogonal approach by introducing a novel point of view to the problem of overlapping communities. Instead of quantifying the quality of a set of communities, we choose to focus on the intrinsic community-ness of one given set of nodes. To do so, we propose a general metric on graphs, the cohesion, based on counting triangles and inspired by well established sociological considerations. The model has been validated through a large-scale online experiment called Fellows in which users were able to compute their social groups on Facebook and rate the quality of the obtained groups.

Dante - 2012/2014

First axis: Graph-based signal processing

Main researchers involved: Eric Fleury, Paulo Gonçalves, Marton Karsai.

Major scientific achievements.

– **Semi-Supervised Learning for Graph to Signal Mapping.** We investigate a graph to signal mapping with the objective of analysing intricate structural properties of graphs with tools borrowed from signal processing. We successfully use a graph-based semi-supervised learning approach to map nodes of a graph to signal amplitudes such that the resulting time series is smooth and the procedure efficient and scalable. Theoretical analysis of this method reveals that it essentially amounts to a linear graph-shift-invariant filter with the a priori knowledge put into the training set as input and we show that we can interpret this filter as a Wiener filter on graphs.

– **Function analysis through wavelets on dynamic contact graphs.** The MOSAR dataset can be seen as a huge dynamic graph where nodes are the support of several carriage functions (one per bacteria strain). The aim is then to explain the temporal evolution of these functions through the spatio-temporal evolution of the contact graph. Our recent work focuses on comparing the diffusion of some selected strains to the results obtained with wavelets on the aggregated contact graph, the selection being made such as the strains show a clear diffusion over time. We study the correlation between the spatial diffusion of the wavelets and the spatio-temporal diffusion of those strains. We aim at identifying the factors of diffusion in order to be able to leverage this knowledge to design new care protocols reducing the impact of nosocomial infection by highly resistant Staphylococcus Aureus that are becoming a major concern in hospitals.

– **Large deviations estimates for the multiscale analysis of heart rate variability.** In the realm of multi-scale signal analysis, multi-fractal analysis provides with a natural and rich framework to measure the roughness of time series. Notwithstanding of considerable progresses, multi-fractal analysis almost exclusively developed around the concept of Legendre singularity spectrum which are structurally blind to subtle features like non-concavity or, to a certain extent, non scaling of the distributions. Large deviations theory allows bypassing these limitations. We illustrate the relevance of this approach and verify that large deviation principles reveal significant information that otherwise remains hidden with classical approaches, and which can be reminiscent of some physiological characteristics. In particular we quantify the presence/absence of scale invariance of RR signals.

Second axis: Dynamic graph theory

Main researchers involved: Anthony Busson, Christophe Crespelle, Éric Fleury, Márton Karsai.

Major scientific achievements.

– **Structure of Changes in Dynamic Contact Networks.** We present a methodology to investigate the structure of dynamic networks in terms of concentration of changes in the network. We handle dynamic networks as series of graphs on a set of nodes and consider the changes occurring between two consecutive graphs in the series. We also consider the problem of aggregating temporal contact series into a series of graph, i.e., choose the length of aggregation windows without loosing too much causality information on the dynamic. Finally, we propose a novel model for representing finite discrete Time-Varying Graphs (TVGs). We also analyse the data structures used for the representation of dynamic networks built following our proposed model and demonstrate that, for most practical cases, the asymptotic memory complexity of our TVG representation model is determined by the cardinality of the set of edges.

– **Community detection.** Social Network Analysis has often focused on the structure of the network without taking into account the characteristics of the individual involved. In our work, we aim at identifying how individual differences in psychological traits affect the community structure of social networks. Using psychological data from the myPersonality application and social data from Facebook, we confront the personality traits of the subjects to metrics obtained after applying the C3 community detection algorithm to the social neighborhood of the subjects. We observe that introverts tend to have less communities and hide into large communities, whereas extroverts tend to act as bridges between more communities, which are on average smaller and of varying cohesion.

Third axis: Distributed Algorithms for dynamic networks: regulation, adaptation and interaction

Main researchers involved: Thomas Begin, Anthony Busson, Paulo Gonçalves, Isabelle Guérin Lassous).

Major scientific achievements.

–**Dynamic Resource Management, Admission Control & characterisation of wireless network.**

We suggest a probabilistic resource provisioning approach that can be exploited as the input of a dynamic resource management scheme. Using a Video on Demand use case to justify our claims, we propose an analytical model inspired from standard models developed for epidemiology spreading, to represent sudden and intense workload variations. We show that the resulting model verifies a Large Deviation Principle that statistically characterizes extreme rare events, such as the ones produced by "buzz/flash crowd effects" that may cause workload overflow in the VoD context. We exploit the information obtained using the Large Deviation Principle for the proposed Video on Demand use-case for defining policies (Service Level Agreements). We introduce a novel data-driven method based on a time varying model that we refer to as Knowledge-Based Admission Control solution (KBAC). Our KBAC solution provides a probabilistic guarantee whose admission threshold is either expressed, as a bounded delay or as a bounded loss rate. We study the performance of the IEEE 802.11 Mac layer through 2-Dimensional stochastic models that describe the spatial locations of the transmitters. These models allow us to characterize the link between the spatial usage of the wireless medium and the performances in terms of wireless link quality and network capacity.

5.2 Organisation and life of the team

As already mentioned, the DANTE team was officially created on november 2012 and it is issue of the merge of researcher coming from RESO and from DNET. This makes the DANTE team a relatively new team, with, within the same period several changes and new arrivals: 4 people over the 7 permeant staff.

To foster the collaboration and discussion, we set up a team seminar that is usually heme on Friday morning. The topic of the seminar oscillate between signal over graph sessions and network science session. The goal is to have a real "working session" on ongoing work, so most of the times, speakers are inter to ENS de lyon. This DANTE seminar is jointly organised with the SISYPHE (SIgnaux, SYstèmes et PHysiquE) team of the physic lab at ENS de Lyon. The seminar is hosted by IXXI and thus open to all IXXI residents. Note that Paulo Gonçalves also initiate at the beginning of the DANTE team a series of short tutorials on signal processing so that every member may get a common vocabulary and notions on the subject. We also organise jointly with the MC2 team, a seminar on graphs and discrete structures[11]. It is usually held on Tuesday afternoons. Most talks are given by visitors. In addition to members of the two organizing teams, this seminar regularly attracts some audience from Université Lyon I.

5.3 Scientific outcomes, visibility, collaborations

The outcomes of the research activities in the DANTE team has been mainly exposed and detailed in section 5.1.4. We would like to highlight here specific facts for the difference research axes detailed above.

- Concerning results relating to Virtualization (VxSwitch and VXDL notably) and also Dynamic bandwidth sharing and congestion control, they gave rise to patents licensing. It is this outstanding break-through that partly motivated the creation in 2010 of the Lyatiss start-up by P. Vicat-Blanc (CEO) and S. Soudan (CTO). An important part of RESO's outcomes stands at the core of Lyatiss activity and development. This technological transfer was awarded several national and international prizes to Lyatiss and we believe this is the striking sign of a high quality upstream research.
- Regarding the works on bandwidth sharing in multihop wireless networks, we have significantly improved the existing solutions in terms of performance, feasibility and evaluation. Our works have been published in highly selective conferences and journals (e.g., IEEE TMC, ACM MSWiM).
- Regarding the characterization of statistical properties of network traffic and the identification of certain of their generating mechanisms, we believe that we have significantly contributed to a better comprehension of these complex systems. Our work has been reckoned in some of the best conferences (ACM sigmetrics, IFIP performance) and transactions (IEEE TON, Stochastic Models) of the domain and it is something we are quite proud of. We believe that this work holds ground in a deep knowledge in statistical signal processing and in a strong expertise with experimental data analysis and modeling, two assets of RESO that we wish to reinforce in the future. The design and the deployment of our packet capture system based on the GtrcNet technology, provided us with a flexible and high performance metrology tool. This achievement represents a tremendous effort during the last four years, and notwithstanding its success (all our experimental studies relied on MetroFlux), we found very difficult to valorize its outcome in the network community. By inexperience also, we considerably underestimated the time spent on technological pitfalls, which drastically hampered the progression of our scientific advances.
- Concerning results relating to wireless sensor network as an easy to deploy accurate data acquisition system, they gave rise to patents licensing, to large scale in situ deployment in terms of node and/or duration of the experiment monitored (ANR SensLAB, Equipex FIT, European MOSAR project, Xtremlog[12]). It is this outstanding break-through that partly motivated the creation in 2011 of the HiKoB start-up by G. Chelius (CEO). This technological transfer was awarded several national prizes to HiKoB and we believe this is the striking sign of a high quality upstream research. Researches was also published in highly selective conferences and journals (e.g., PLoS ONE, Computer Communications, IEEE/ASME Transactions on Mechatronics, PIMRC, Networking, WoWMoM). This researches also lead to strong collaborations and specialization of our pluri-disciplinary culture with medical teams, namely the ones with Pr Didier Guillemot Epidemiologist, MD specializing in Internal Medicine, PhD, HDR, Professor of Public Health and Epidemiology, at the UVSQ Medical School and also Pr Jean-Christophe Lucet, Head, Infection Control Unit, Bichat –Claude Bernard Hospital University Hospital.
- Concerning the works on signal processing, and more specifically on graph, this activity is more recent but yet has led to first promising results published in the top conference of the domain, ICASSP. This activity is at the heart of the working group jointly organized with the Sisyphe team from the physic lab of ENS de Lyon. The research

[11] `http://www.ens-lyon.fr/LIP/MC2/groupe-de-travail-graphes-et-structures-discretes/`
[12] `http://www.inrialpes.fr/Xtremlog/`

theme of signal processing on graph is also granted by a new ANR project. The GRAPHSIP, project[13] aims at developing a set of advanced methods and algorithms for the processing of graph signals: in particular multi-scale transforms and solutions of variational problems on graphs. The major outcomes of this project are expected to lead to significant breakthroughs for graph data processing.

- Regarding the works on community detection, we succeed to propose a new metric, test it and validated it through on line experiments with Facebook. Moreover, this metric was used with a collaboration with The Psychometrics Centre at the University of Cambridge to identifying how individual differences in psychological traits affect the community structure of social networks. Instead of choosing to study only either structural or psychological properties of an individual, our aim is to exhibit in which way the psychological attributes of interacting individuals impacts the social network topology. Other researches on community detection leads also to powerful results in terms of overlapping detection and a framework to follow communities behavior when the network structure is evolving. Researches was also published in highly selective conferences like IEEE SocialCom, two book chapters in Springer and selective conferences like IEEE ASONAM. The theme of community detection is also a strong vector of collaboration with other disciplinary teams. We already mentioned the psychological center of cambridge, one can also note collaboration with Sara Franceschelli (Institut d'Histoire de la Pensée Classique UMR 5037 - IHPC) for the work one *Complex Systems Science: Dreams of Universality, Reality of Interdisciplinarity* published in the Journal of the American Society for Information Science and Technology.

5.4 Training through research

- Paulo Goncalves defended his HdR in 2010;
- 13 PhD students were graduated;
- Several master courses at the M1 or M2 level were done;
- 4 winter research schools at ENS de Lyon and one summer school with the GDR ASR/ResCom were organized;
- Strong involvement of the DANTE team in the master of complex science, clearly with a strong plury-disciplinary goal, which evolve even more toward a "network science" cursus. This master is in in link with 3 masters of ENS de lyon (Mathematics, Physique and Computer Science) and IXXI (Rhone Alpes complex science institute).
- Isabelle Guerin Lassous is the head of the Networking Speciality of the Master of Computer Science at University of Lyon 1
- Eric Fleury was the head of the Computer Science department of ENS de Lyon from Sept. 2009 to 2013. Before he was the head of the master in fundamental computer science at ENS de Lyon and from 2007 to 2013 he was in charge of the option in modeling complex systems for the Computer Science department.

5.5 Research project

5.5.1 Self-assessment and SWOT analysis

Strong points. We found that the scientific expertise and quality of the team is good. The research themes of the DANTE team are well-positioned on timely challenges in Network Science. DANTE members have a strong visibility and the collaboration between members is one of the strength for the challenge we want to address: to lay solid foundations to the characterization of dynamic networks, and to the field of dynamic processes occurring on large scale dynamic networks. The team gathers a good balance of expertise including theory, simulation and in situ experimental skills with also a real capacity of development. We have also the capacity to handle strong collaboration with industry and especially to promote a data oriented researches on "real data" in order to address to tackle socially relevant questions.

Weak points. The DANTE team will greatly benefit from hiring a full time researcher. Currently there is only one full time researcher within the team and it will be desirable to reinforce the effort we made to promote signal processing on graphs. One may think that it will be desirable to hire a CNRS researcher on this theme.

Opportunities. 2010 was the beginning of a new ENS: the Ecole Normale Supérieure de Lyon brings together the Ecole Normale Supérieure Lettres et Sciences Humaines and the former Ecole Normale Supérieure de Lyon, which was devoted to the exact sciences. We believe that the deliberate choice of internationally promoting the fact that ENS de Lyon is resolutely engaged in research and innovation in the exact sciences, social and human sciences and interdisciplinarity is a opportunity for the domaine of Network Science. ENS de Lyon is a pluri-disciplinary higher education establishment. The fact that the DANTE team is hosted by IXXI (Rhone Alpes complex system institute) is also a great opportunity.

[13]partners are: GREYC research laboratory, Laboratoire d'Informatique Gaspard Monge, Laboratoire Grenoble Image Signal Parole and ENS de Lyon

Finally, within this context, the interaction between research and teaching should be encourage, especially in the pluri disciplinary domains. ENS de Lyon have and should play a proactive role in this area, locally and at the international level. The help of Inria and more specifically the offer of Inria chair with ENS de Lyon is a great opportunity to hire first class researchers and should be encourage.

Risks. DANTE could hire junior researchers in order to balance the ratio senior/junior. A inherent risk is also that junior are looking for other positions since they are all supervising PhDs, waiting to defend their HdR and eventually eligible for professor positions.

5.5.2 Research objectives

The goal of DANTE is to develop **novel models, algorithms and methods to analyse the dynamics of large-scale networks**, (*e.g., social networks, email exchanges, bacteria propagation in human networks...*). Large datasets describing such networks are nowadays more "accessible" due to the emergence of online activities and new techniques of data collection. These advantages provide us an unprecedent avalanche of large data sets, recording the digital footprints of millions of entities and their temporal interactions.[14] Such large amount of information allows an easier and more precise traceability of social activities, better observation of the structural and temporal evolution of social/technological/economical networks, the emergence of their localised and cascading failures, and provides information about the general roles of self-organization in an interdisciplinary sense. All these questions represent a major scientific, economic, and social challenge, which has the potential to revolutionise our understanding of the arising socio-technical world of our age. Our main challenge is to propose **generic methodologies and concepts to develop relevant formal tools to model, analyse the dynamics and evolution of such networks, that is, to formalise the dynamic properties of both structural and temporal interactions of network entities/relations**:

- **Ask** application domains relevant questions, to learn something new about such domains instead of merely playing with powerful computers on huge data sets.
- **Access** and collect data with adapted and efficient tools. This includes a reflexive step on the biases of the data collected and their relations to real activities/application domain.
- **Model** the dynamics of networks by analysing their structural and temporal properties jointly, inventing original approaches combining graph theory with signal processing. A key point is to capture temporal features in the data, which may reveal meaningful insights on the evolution of thenetworks. Subsequently the aim is to infer the observed structural and temporal features from the model processes, and match the emerging statistical properties (probability densities, dependencies, conditionals) to characterise the dynamical behaviour of the targeted systems (*e.g.*, non-stationarity, scaling laws, burstiness...).
- **Interpret** the results, make the knowledge robust and useful in order to be able to control, optimise and (re)-act on the network structure itself and on the protocols exchange/interactions in order to tune the performance of the global system.

The challenge is to solve a major scientific puzzle, common to several application domains (*e.g.*, sociology, information technology, epidemiology) and central in network science: how to understand the causality between the evolution of macro-structures and individuals, at local and global scales?

Applications

The research targeted by DANTE can be applied to a large spectrum of domains. Indeed, the study of networks has become extremely popular recently, mainly because they offer a unifying framework to represent a broad range of social, biological and technological systems. At the core of network science theory, there is the underlying idea that the behaviour of complex systems is shaped by the topology and the dynamics of the interactions between their constituents. Network science should provide the means to identify generic organisation principles behind the structural and temporal architecture of "*complex networks and/or systems*" and should provide key mathematical tools for cross-disciplinary research. **Our researches are mainly focused on the complementarity between network structure and dynamics. We wish to root them in the analysis of empirical systems to get a feedback on theoretical consideration. The ultimate goal is to develop algorithmic and numerical methods for uncovering meaningful representations that can help us to understand and predict the behaviour of complex systems.**

[14] YouTube claims to receive 48 hours of video every minute, Google and Facebook represent major world companies that generate millions of traces on our activities every second. Every day, hundreds of millions of posts are added to the blogosphere, from which information on citizen opinions and their evolutions can be collected.

5.5.3 Project implementation

First axis: Graph-based signal processing

Analysing, modelling, and even defining adapted concepts for dynamic graphs is at the heart of DANTE. This is a largely open question that has to be answered by keeping a balance between specificity (solutions triggered by specific data sets) and generality (universal approaches disconnected from social realities). We will tackle this challenge from a graph-based signal processing perspective involving signal analysts and computer scientists, together with experts of the data domain application. One can distinguish two different issues in this challenge, one related to the graph-based organisation of the data and the other to the time dependency that naturally exits in the dynamic graph object. In both cases, a number of contributions can be found in the literature, albeit in different contexts. In our application domain, high-dimensional data "naturally reside" on the vertices of weighted graphs. The emerging field of signal processing on graphs merges algebraic and spectral graph theoretic concepts with computational harmonic analysis to process such signals on graphs.

As for the first point, adapting well-founded signal processing techniques to data represented as graphs is an emerging, yet quickly developing field that has already received key contributions. Some of them are very general and delineate ambitious programs aimed at defining universal, generally unsupervised methods for exploring high-dimensional data sets and processing them. This is the case for instance of the "diffusion wavelets" and "diffusion maps". Others are more traditionally connected with standard signal processing concepts, in the spirit of elaborating new methodologies via some bridging between networks and time series. Other viewpoints can be found as well, including multi-resolution Markov models, Bayesian networks, or distributed processing over sensor networks. Such approaches can be particularly successful for handling static graphs and unveiling aspects of their organisation in terms of dependencies between nodes, grouping, etc. Incorporating possible time dependencies within the whole picture calls however for the addition of an extra dimension to the problem "as it would be the case when switching from one image to a video sequence", a situation for which one can imagine to take advantage of the whole body of knowledge attached to non-stationary signal processing.

During the last decade, a variety of methods aimed at analyzing and interpreting graph structured data emerged under the common denomination of *Network Science*, which often strived hard to reveal the (universal) principles that govern the networks' organisations. Stemming from graph theory or from statistical physics, the concepts of *Network Science* offer a vast potential that nonetheless, did not bring yet clear answers about global or individual behaviors. Notwithstanding their own interest, the reason for this limitation certainly lies in the lack of certified methods to analyse and to model the dynamical features of the data. In this direction though, a recent work investigated the influence of the burstiness of a contact graphs on the dynamics of a diffusion process, by means of random walks in continuous time. But despite this progress and others, there is still no global consensus on analytical tools to characterise non-stationary dynamics of graphs. This research axis aims at conceiving signal processing tools able to take into account the time varying structure of graphs and to explain the nature of the phenomena (processes) that can be observed on networks :

- Granularity scale of the observations. Sampling a graph time series is an issue that needs to be the better formalized, yet difficult problem of detecting stationarity ruptures in a sequence, whereas for standard time processes, stationarity can either be strict or with respect to a particular observation time scale. Then, there are two possible approaches:

  1. We can focus on the representation space of (dynamic) graph and try to design analyzing tools of the graph structure, which integrate the time variable.
  2. We can strive to establish mapping rules between dynamic graphs and standard stochastic processes, in order to study the (non-)stationarity properties of the graph time series in this dual domain, for which a rich toolkit already exists.

  Both directions raise theoretical and algorithmic challenges that we elaborate below, along with some concrete lines of thought.

- Evolutionary spectrum of a dynamic graph. If one chooses to retain the concept of wavelet decomposition on a graph, which as we mentioned, allows the spatial dynamics of a function defined on a graph to be characterized, it is necessary to incorporate the time dimension into the analysis framework so as to account for the structural and/or the functional evolutions. We work at defining adjacency structures that take into account the variability of contacts with time. As a preliminary starting point, we are presently considering a sequence of two static graphs and making explicit in the adjacency matrix the nodes instances at the two dates t_1 and t_2.

  At this stage, we could only focus on the *evolutionary spectral analysis of graphs*. However, we believe that it is also a compulsory gateway towards the construction of a time-space wavelet decomposition on graphs. We will address this more difficult point in a further step.

- Duality between dynamic graphs and (non-)stationary processes. To explore this second approach, we foresee to adapt well-grounded signal processing techniques to the graphical representation of data. This is quite a recent area of investigation in a constant growth and which already received some major contributions. Among those, some are very general and delineate an ambitious program targeting an universal method, often non-supervised, to explore and to treat big datasets or high dimensional sets. In the context of dynamic graphs where the statistical distribution of links and nodes vary with time, adaptability of semi-supervised machine learning can be of interest for the duality principle: The structural changes of the graph would transpose to the variability of the corresponding Markov process. Then, **characterising the graph dynamics** amounts to analysing a non-stationary process, taking advantage of the rich toolkit of methods available to identify mode changes, pseudo-periodicity, scaling laws or more generally, all kinds of alterations in data organisation.

Second axis: Dynamic graph theory

Through the systematic analysis and characterisation of static network representations of many different systems, researchers of several disciplines have unveiled complex topologies and heterogeneous structures, with connectivity patterns statistically characterised by heavy-tails and large fluctuations, scale-free properties and non trivial correlations such as high clustering and hierarchical ordering. A large amount of work has been devoted to the development of new tools for statistical characterisation and modelling of networks, in order to identify their most relevant properties, and to understand which growth mechanisms could lead to these properties. Most of those contributions have focused on static graphs or on dynamic processes (*e.g.*, diffusion) occurring on static graphs. This has called forth a major effort in developing the methodology to characterise the topology and temporal behaviour of complex networks, to describe the observed structural and temporal heterogeneities, to detect and measure emerging community structures, to see how the functionality of networks determines their evolving structure, and to determine what kinds of correlations play a role in their dynamics. The highly challenging issue is to fully taking into account the dynamics of the links into a network and to extend this kind of statistical characterisation to dynamical graphs.

It should be stressed that discrete graph theory will interact profitably with the methods derived from graph-based signal processing. The first idea is to carefully compare how both approaches describe small scales or large scales in networks. Related to the notion of structural scale, an important issue concerns the existence of community structures. Combining time and space descriptions will give us a key for giving sense to notions such as "evolving communities" or "small scale / large scale co-evolutions". Such tools requires suitable algorithms but these tools which connect the local and global scales will detect which micro changes have led to the detected macro-restructurings and which micro changes have been absorbed without large transformations. In dynamic networks, an issue is to detect nodes that play a key role in information propagation. We have started designing new notions of exposure, based either on direct connection, temporal paths or temporal flows in a dynamic network.

The temporal scale of the dynamic of the network structure can be different from the time-scale of the evolution of the ongoing processes. We can talk about three typical cases. First when the network evolves in a very slow time scale and could be considered as static from the point of the co-evolving process. This case was typically assumed in most of the earlier studies. On the other hand, it is possible that the contact patterns are evolving much faster than the ongoing process (this is called the annealed case or the mean-field case). Finally, we can speak about a case when the network and the ongoing process are evolving on the same time-scale. Here the influence can spread between two entities only at the time of their interactions, not always (quenched case) and not between anyone (mean-field case). Following this picture we plan to study the network-process co-evolution in each case.

We could highlight several research directions to encompass both the dynamic and the structural aspects of dynamic graphs. Our effort will be dedicated to taking into account the dynamics of links in the network since it appears as a crucial and highly challenging issue:

1. To design metrics that measure the exposure of a node to a diffusion process in a dynamic network, and to use it to predict and model such diffusions;

2. To compute the community structure of a dynamic network and to design models of diffusion in a dynamic network that take into account its community structure;

3. To derive data-driven representations of temporal networks and their co-evolution with contagion processes.

Third axis: Distributed Algorithms for dynamic networks: regulation, adaptation and interaction

An instantiation of dynamic networks are communication networks which are known to potentially undergo high dynamicity. The dynamicity exhibited by these networks results from several factors including, for instance, changes in the topology and varying workload conditions. Although most implemented protocols and existing solutions in the literature can cope with a dynamic behaviour, the evolution of their behaviour operates identically whatever the actual properties of the dynamicity. For instance, parameters of the routing protocols (*e.g.*, hello packets transmission frequency) or routing methods (*e.g.*, reactive / proactive) are commonly held constant regardless of the nodes mobility. Similarly, MAC layer algorithms ruling CSMA/CA (*e.g.*, size of the contention window) are tuned identically and they do not change according to the actual workload and observed topology.

Dynamicity in computer networks tends to affect a large number of performance parameters (if not all) coming from various layers (viz. physical, link, routing and transport). To find out which ones matters the most for our intended purpose, we will rely on the tools developed by the two former axes. These quantities should capture and characterise the actual network dynamicity. Our goal is to take advantage of this latter information in order to refine the existing protocols, or even to propose new solutions. More precisely, we will attempt to associate "fundamental" changes occurring in the underlying graph of a network (reported through graph-based signal tools) to a quantitative performance that is a matter of interest for networking applications and the end-users. We will also use available testbeds such as Senslab and Equipex FIT to experiment our solutions and ultimately validate our approach.

The main directions of researches are:

- How to tackle mobility of nodes? When evaluating the performance of a network protocol in presence of dynamicity, generally the method consists in simulating this protocol under different mobility scenarios. However, realistic mobility models are complex, leading to results restricted to the considered mobility models and radio environments. We propose to study the network dynamics from a topology point of view. We will focus on wireless networks, where node locations are directly linked to the network topology. The idea consists in characterising the dynamicity when the network is seen as a graph, and to propose algorithms/generation tools that mimic the graph dynamic. Basically, the dynamicity will be modelled at the graph level and not through mobility models.

- How to deal with the workload dynamic? In the case of a wireless network, the activity of the nodes, and hence their workload, is likely to vary a lot over time. Therefore, the interactions between nodes (not necessarily restricted to neighbour nodes) exhibit complex patterns that may deeply affect the communications. Our idea consists in developing a framework that enables each node to infer not only the "quality" of its neighbourhood, but also the factors that badly impact its communications as well as those from its neighbours. One may imagine a portfolio of known solutions and the choice of the more appropriate one will be based on learning and optimisation technics in order to accurately identify the troubling factors, analytical models issued from the queueing theory to better understand the key parameters and their impact on the node performance, as well as distributed algorithms to come up with efficient and adapted protocols.

6 MC2 team: Models of Computation, Complexity, Combinatorics

6.1 Scientific areas and activities

6.1.1 Goals and context

Our main research topics are computational complexity theory, algorithm design, and combinatorics. One important goal is to understand the power and limitations of efficient algorithms. To this end we design and analyse algorithms, and we set impossibility results (completeness results or, when possible, unconditional lower bounds). We also study the relevant combinatorial structures.

Various models of computation can be considered to allow different features in the algorithms (e.g., sequential versus parallel, synchronous versus asynchronous, deterministic versus probabilistic or quantum). Various complexity measures can be considered to quantify efficiency, such as time, space, communication.

Among the several fields of mathematics at the heart of this research, our team focuses on algebra and combinatorics. Both of these areas are a source of algorithmic problems which play key roles in the architecture of complexity theory (e.g., the complexity of computing matrix permanents or graph colourings). Both areas also provide mathematical tools which are essential to proving theorems in complexity theory.

6.1.2 Activity profile

Our team is deeply involved in teaching at ENS Lyon since we have two full professors and three associate professors in our ranks. This is not fully reflected in the following breakdown since, as per the AERES guidelines, the teaching activities of professors (and ATER staff) is not taken into account. We are also active in popularization of mathematics and computer science (in particular at the *Maison des Mathématiques et de l'Informatique*). For the same reason, this is also not fully reflected in the breakdown since these activities are included in the teaching loads of our professors.

1. Research: 45 %.
2. Popularization of science: 5%.
3. Administation: 20%.
4. Teaching and supervision of research students: 30%.

6.1.3 Highlights

- We succeded in hiring several permanent members: Stéphan Thomassé was hired as ENS Lyon professor, Michael Rao and Nicolas Trotignon moved from previous CNRS positions and Nathalie Aubrun was hired as a new CNRS researcher (in Mathematics). Omar Fawzi will start as associate professor at ENS Lyon in September 2014.

  We could attract two long-term visitors on *delegation* from their home universities: Pablo Arrighi (MCF Univ. Joseph Fourier, Grenoble) and Mathieu Sablik (MCF Univ. de Provence).

  We have also been able to attract several bright post-docs from abroad including Zhentao Li (from McGill, now associate professor at ENS Paris) and Irena Penev (from Columbia), both funded by Labex MiLyon. Four new postdocs will join our group in Fall 2014.

- We have obtained funding for two ANR "white" projects in 2013 (out of 12 such projects in computer science for the whole country). Project Stint ("Structures Interdites", or "forbidden structures") is coordinated by Nicolas Trotignon, and project CompA (algebraic complexity) is coordinated by Pascal Koiran. They got started in January and February 2014.

- Two of our PhD students obtained scientific awards. Mathilde Noual obtained the EADS thesis prize and the second Gilles Kahn prize for the year 2012 (this thesis prize is awarded by SIF, the Société Informatique de France). Sébastien Tavenas obtained a best paper award and a best student paper award at MFCS 2013.

- We have organized several national and international conferences, including STACS 2014 (a complete list can be found in Appendix 6). We helped organize a conference on Alan Turing's heritage (ENS Lyon, July 2012, http://www.turing2012.fr) and the award of a doctorate honoris causa to Leslie Valiant (a first for computer science at ENS Lyon).

- Numerous invited talks, for instance: ISSAC 2012 tutorial (Pascal Koiran) and STACS 2013 invited talk (Stéphan Thomassé). The complete list can be found in Appendix 6.

6.1.4 Research activities

The research carried out by current team members is summarized in Section 6.3.1. We note that one area of expertise of Eric Remila (game theory) was lost for the team when he left for a professor position in Saint-Etienne. Another area (tilings) lives on in the team thanks to the hiring of Nathalie Aubrun.

6.2 Organisation and life of the team

There was considerable change in the team's composition: among current team members, only Pascal Koiran, Natacha Portier and Eric Thierry were present at the beginning of the evaluation period (January 2009). Thanks to our recent hires, combinatorics has become a new strength of the team. To reflect this, the team's name was changed from *Modèles de Calcul and Complexité* to *Modèles de calcul, Complexité, Combinatoire* while keeping the acronym MC2.

The team's seminar is usually held on Wednesday morning. A few talks are given by team members, but most talks are given by visitors (see www.ens-lyon.fr/LIP/MC2/groupe-de-travail/).

We also organize jointly with the Dante team a seminar on graphs and discrete structures. It is usually held on Tuesday afternoons, and again most talks are given by visitors. In addition to members of the two organizing teams, this seminar regularly attracts some audience from Université Lyon I. The seminar's web page is at www.ens-lyon.fr/LIP/MC2/groupe-de-travail-graphes-et-structures-discretes/.

6.3 Scientific outcomes, visibility, collaborations

6.3.1 Scientific outcomes

We highlight below some of the results obtained since 2009, focusing on the work done by current team members.

Graph Theory and Algorithms:

We have proposed a new approach for coloring perfect graphs [865]. We have also proved Scott's conjecture for maximal triangle-free graphs [847]. According to this conjecture, for any fixed graph G the class C of gaphs which do not contain G as an induced subgraph is χ-bounded (i.e., its chromatic number can be bounded as a function of its clique number).

In [993], we use a recent characterization of the so-called bull-free graphs to provide an FPT-algorithm for the stable set problem in the class. Our algorithm relies on the notion of polynomial Turing kernel. This notion was defined by Lokshtanov, and our work is the first example of a polynomial Turing kernel not arising from an artificial construction.

In [890], we prove a conjecture of Morris and Spiga about bipartite graphs that do not have a cycle of length 0 modulo 6. Our proof relies on a promising tool, the so-called extreme decomposition. These are decompositions of graphs such that one part of the decomposition is "basic" (that is in a sense simple).

In [878], we describe a polynomial algorithm that decides whether an input graph contains a chordless cycle with three non-incident pendant edges. This is the only algorithm of that kind that does rely on the only generic tool solving this kinds of problem, the so-called "3-in-a-tree" algorithm due to Chudnovsky and Seymour.

In collaboration with C. Crespelle from Dante team, we have started investigating the computational complexity of the factorisation for classical products of graphs (cartesian, direct, strong). Though several algorithms are already compiled in the Handbook of Product Graphs by R. Hammack, W. Wilfried, S. Klavzar, some cases are missing and some complexities seem improvable. As a first result, we managed to provide the first linear algorithm factorizing digraphs for the cartesian product [989].

Perfect numbers:

An integer is said to be perfect if it is equal to the sum of its divisors. Even perfect numbers are well characterized (they are in bijection with Mersenne primes), but the existence of an odd perfect number has been an open problem for centuries. We only know some necessary conditions that an hypothetical perfect odd number should respect. For instance, the first such condition, due to Euler, states that $N = p^q * m^2$ where p is prime and $q = 1$ mod 4. In collaboration with Pascal Ochem (LIRMM), Michael Rao wrote a computer program to find new conditions that any odd perfect number must satisfy. This work has led so far to 2 publications in Mathematics of Computation [864, 907].

Combinatorics on words:

It is commonly admitted that the origin of combinatorics on words goes back to the work of Axel Thue in the beginning of the 20th century, with his works on repetition-free words.

A word is a (possibly infinite) sequence of letters, taken in a finite alphabet. A factor of a word is a sub-sequence of consecutive letters in the word. A square is a factor of the form uu, where u is a non-empty word. Similarly, a cube is a factor uuu, with u non-empty. An overlap is a factor of the form uux, where u is a non-empty word and x is the first letter of u. A word is square-free (resp. cube-free, overlap-free) if it does not contain a square as factor (resp. cube, overlap).

Thue showed that there exist ternary square-free words of arbitrary length, and binary cube-free words of arbitrary length. Since then, the study of repetitions is a central focus in the domain combinatorics on words. One famous example is the conjecture of Françoise Dejean (1972), solved in 2009 by M.Rao [837], that characterizes the avoidable repetitions depending on the alphabet size. Since then, M. Rao obtained results on stronger versions of Dejean's conjecture [835, 1029, 893].

In 1957, Paul Erdös asked whether abelian squares can be avoided by an infinite word on an alphabet of 4 letters (uv is an abelian square if u is a permutation of the letters of v). Keränen gave a positive answer to Erdös's question in 1992, with an intensive use of the computer. Erdös also raised the question whether arbitrarily long squares can be avoided in binary words. Some conjectures are still open on the size the smallest alphabet required to avoid arbitrarily long abelian squares (resp. cubes).

Recently Karhumäki et al. introduced a new notion of word equivalence, the k-*abelian equivalence*, which is a generalization of both Abelian and standard equivalence.Michaël Rao proved in 2013 that 2-abelian-cubes are avoidable over a binary alphabet and that 3-abelian-squares are avoidable over a ternary alphabet, answering positively two questions of Karhumäki et al. [1019].

Multidimensional Symbolic Dynamics:

Multidimensional subshifts of finite type (SFT) and sofic subshifts, that are closed and shift-invariant subsets of colourings of $\mathbb{Z}^d$ for $d \geq 2$ given by local rules, have strong computational properties. A brilliant result by Hochman (Inventiones Mathematicae, 2009) states that up to an increase of the dimension by 2, effective subshifts are very close to sofic subshifts. We managed to improve Hochman's construction and proved that any effective subshift of dimension d can be found as the projective subaction of a sofic subshift of dimension $d+1$, making the increase of the dimension optimal. Our strategy was to replace the extra dimension with an extra hierarchy of communication between nested objects in the plane.

This result leads to numerous applications, for instance concerning subshifts defined by a sequence of substitution (S-adic subshifts). In higher dimension, we proved that computability of the defining sequence implies soficness of the S-adic subshift. We thus generalize a result by Mozes, which shows soficness for constant sequences. The proof we presented consists in a direct application of our previous result, together with a clever encoding for the sequence of substitutions.

These results were obtained in collaboration with Mathieu Sablik [871, 892].

Symbolic Dynamics on groups and monoids:

The following results were obtained by Nathalie Aubrun in collaboration with Marie-Pierre Béal [891], Jarkko Kari [986] and Mathieu Sablik [1023].

- Algebraic characterization of finite type and almost of finite type tree-shifts: The case of tree-shifts – susbhifts defined on the free monoid with two generators – has been proven to be quite close to the one-dimensional and one-sided case at least for the decidability of two problems – domino problem and conjugacy problem. We adapt algebraic concepts introduced for $\mathbb{N}$-subshifts and we give effective syntactic characterizations of two classes of regular tree-shift languages: the finite type tree languages and the tree languages which are almost of finite type. Each class corresponds to a class of subshifts of trees which is invariant by conjugacy.

- Undecidability of the Domino problem on Baumslag-Solitar groups: There exists no complete characterization for the class of finitely presented groups having decidable domino problem – even if it is known that all virtually free groups possess this property. We investigate the case of Baumslag-Solitar groups – two generators and one relator groups that are non virtually free – and prove that the domino problem is undecidable on these groups. From the proof we also conclude that there exist arecursive tile sets on the Baumslag-Solitar groups, that is, tile sets that admit valid tilings but all valid tilings are non-recursive.

- Effectiveness and soficness for subshifts on the hyperbolic plane: Effectiveness and soficness for subshifts on the hyperbolic plane: a natural question is to determine whether results similar to Hochman's can be proved on other structures than $\mathbb{Z}^d$. Our intuition is that we can obtain an even stronger results than Hochman's if the structure is well-chosen, and we conjecture that effective subshifts are sofic in the hyperbolic plane. We prove a preliminary result, weaker than the previous conjecture since we need the additional row-constrained property to prove that effectiveness implies soficness in the hyperbolic plane.

Network Calculus: This is an abstract framework formalizing communication networks as (min,+)-filtering operators, yielding bounds on worst case performances through combinations of performance curves with tropical operations such as the (min,+) convolution. As part of our work in ANR project PEGASE, we designed and analyzed network calculus algorithms, and they were implemented in the PEGASE software (http://www.realtimeatwork.com/software/rtaw-pegase/) by the INRIA startup "Real-Time at Work". This tool can validate the architecture of avionics embedded systems.

Experimental work led by the ONERA members on real data improved by 20 percent the performance bounds that the Thales partners had obtained with their own methods.

The Restricted Isometry Property: Compressed sensing can be viewed as a technique for finding sparse solutions to underdetermined linear systems. This technique relies on properties of the sensing matrix such as the *restricted isometry property*. Sensing matrices that satisfy this property with optimal parameters are mainly obtained via probabilistic arguments. Deciding whether a given matrix satisfies the restricted isometry property is a non-trivial computational problem. Indeed, we showed in [862] that restricted isometry parameters cannot be approximated in polynomial time within any constant factor under the assumption that the hidden clique problem is hard. Moreover, on the positive side we proposed an improvement on the brute-force enumeration algorithm for checking the restricted isometry property.

Algebraic complexity: Our work in this area is motivated by the problem "VP=VNP?" an algebraic version of "P=NP?" proposed by Leslie Valiant. We have proposed an approach to this problem based on the properties of "sparse like" polynomials. More precisely, we have shown [973] that a polynomial (or slightly superpolynomial) bound on the number of real roots of sums of products of sparse univariate polynomials implies that VP is different from VNP. We have obtained partial results [970, 861, 1013] toward this "real τ-conjecture" and have also proposed a similar approach based on the Newton polygons of bivariate polygons instead of the real roots of univariate polynomials [885].

We note that these two approaches rely on a depth reduction result: following the pioneering work of Agrawal and Vinay, we have obtained improved [860] (and essentially optimal [990]) bounds showing that an arbitrary arithmetic circuit can be transformed into a depth 4 circuit with a "reasonable" (slightly superpolynomial) blow-up in size. Our depth reduction results play an important role in a very different approach to VP=VNP proposed by Neeraj Kayal. The idea is to obtain lower bounds on the size of depth 4 circuits using "shifted partial derivatives" (this is a generalization of Nisan and Wigderson's method partial derivatives).

Algebraic algorithms: We have continued our work on the computation of low-degree factors of sparse polynomials [988, 1011]. A main goal is to avoid the advanced number-theoretic techniques used in our previous work with Erich Kaltofen. A common tool, the Wronskian determinant, turns out to be very useful for the the factorisation of sparse polynomials as well as in our work in algebraic complexity (for bounding the number of real roots). We note that a complete solution was provided very recently (ISSAC 2014) by our former PhD student Bruno Grenet.

6.3.2 Academic Attractivity

1. We have obtained funding for two ANR "white" projects in 2013 (out of 12 such projects in computer science for the whole country). Project Stint ("Structures Interdites", or "forbidden structures") is coordinated by Nicolas Trotignon, and project CompA (algebraic complexity) is coordinated by Pascal Koiran. They got started in January and February 2014.
2. Two of our PhD students obtained scientific awards. Mathilde Noual obtained the EADS thesis prize and the second Gilles Kahn prize for the year 2012 (this thesis prize is awarded by SIF, the Société Informatique de France). Sébastien Tavenas obtained a best paper award and a best student paper award at MFCS 2013.
3. We have organized several national and international conferences, including STACS 2014 (a complete list can be found in Appendix 6). We helped organize a conference on Alan Turing's heritage (ENS Lyon, July 2012, http://www.turing2012.fr) and the award of a doctorate honoris causa to Leslie Valiant (a first for computer science at ENS Lyon).
4. We have been able to attract several bright post-docs from abroad, including Zhentao Li (from McGill, now associate professor at ENS Paris) and Irena Penev (from Columbia). Four new postdocs will join our group in Fall 2014.
5. Numerous invited talks, for instance: ISSAC 2012 tutorial (Pascal Koiran) and STACS 2013 invited talk (Stéphan Thomassé). The complete list is in appendix.

6.4 Training through research

We are heavily involved in the CS curriculum of ENS Lyon since 4 of our members (Pascal Koiran, Natacha Portier, Stéphan Thomassé and Eric Thierry) have a professor or an associate professor position in this institution. Our CNRS researchers contribute to M2 classes (Nicolas Trotignon, 2013-2014 and 2014-2015; Nathalie Aubrun, 2014-2015). Eric Thierry is in charge of the L3 year and Stéphan Thomassé of the M2 year.

We have supervised 11 PhD students (Pierre Aboulker, Florent Becker, Irénée Briquel, Bruno Grenet, Laurent Jouhet, Mathilde Noual, Kévin Perrot, Damien Régnault, Julien Robert, Jean-Baptiste Rouquier, Sébastien Tavenas) and are currently (July 2014) supervising two PhD students: Théophile Trunck (defense set for September 2014) and Aurélie Lagoutte. Two additional students (Sebastian Barbieri and Matthieu Rosenfeld) will start a PhD in September 2014.

6.5 Research project

6.5.1 Self-assessment and SWOT analysis

Strong points

We have a good research record and a good national and international visibility, as shown in particular by our publications, the conferences organized, our invited talks, the numerous visitors and numerous applications to our team for all kinds of job openings (ATER, postdocs, CNRS, assistant professors,...). This has helped us hire permanent and non-permanent resarchers. A downside is that we spend a considerable amount of time on this hiring process.

Weak points

Our team is pursuing a fairly large number of different research topics. We stress that this is a deliberate policy, and this research model is rather commonplace internationally (in many theory groups, only a handful of researchers will work on the same topic). One benefit is that team members are exposed to a number of different tools and approaches. Still, this means that we must continue to work hard at understanding each other.

It would be desirable to hire a CNRS researcher in complexity theory since this is our only research area for which we have no full-time researcher.

Opportunities

ENS Lyon plays an important role in the nationwide development of theoretical computer science and more generally of mathematical computer science (which could be defined as the study of computer science problems with mathematical techniques). Indeed, theoretical / mathematical computer science are fields with a high level of international competition where a taste and a talent in both mathematics and computer science are a must. In the French higher education system, ENS Lyon is one of the very few institutions with the ability to train such students in any significant number. Their training must of course rely on research at the highest possible level. In return, MC2 and other research teams benefit from this environment by hiring some of the graduates of ENS Lyon as PhD students. We hope and expect that this positive interaction between research and teaching will continue in the future.

Risks

Our research is supported to a large extent by two ANR projects which began in January and February 2014. We will have to look for new sources of funding (from ANR or elsewhere) before the end of these two projects.

There is some concern with future job opportunities for young scientists in France. We could be impacted by worse employment prospects for our PhD students, and reduced hiring opportunities for our team.

6.5.2 Research objectives

A large part of the team's work in the next 4 years will be devoted to the two ANR projects that began in 2014. Project Stint (Structures interdites) focuses on graphs with (or should we say *without*) forbidden structures. The permanent team members that are involved in this project are Nicolas Trotignon (coordinator), Michael Rao and Stéphan Thomassé. Two other teams are members of this project (COATI in Nice, G-SCOP in Grenoble).

In the last few years, there has been a renewed interest for algebraic complexity in the international research community. This especially true in India, Israel, the U.S.A (e.g. at Caltech, Stanford, the University of Chicago, Princeton, Rutgers) and Germany (Berlin, Saarbrücken). The two most prominent open problem in this area are the complexity of matrix multiplication and the complexity of computing the permanent polynomial. We are interested in the latter problem, and are coordinating a research project (ANR CompA) which gathers most (if not all) of the French researchers working in this area. The permanent team members that are involved in this project are Pascal Koiran (coordinator), Natacha Portier and Stéphan Thomassé. The other partner is Paris 7; three individual researchers from Grenoble, Lyon 1 and Versailles also participate.

We wil also work on a few topics that do not fit within these two projects, e.g., symbolic dynamics. We note that this subject is relatively close in spirit to the Stint project: in both subjects, there is an emphasis on locally forbidden configurations (be they induced subgraphs or "tiling errors"). The same is also true of combinatorics on words, with its emphasis on forbidden patterns (e.g., forbidden squares or forbidden cubes). There will also be a renewed emphasis on quantum information and computation with the arrival of Omar Fawzi as associate professor. This research topic is currently represented by Pablo Arrighi, who is leaving us in September for a full professor position in Marseille.

Finally, there is some potential for collaborations with the DANTE team that go beyond the shared organisation of the graph theory seminar. They could range from theorical studies like the joint work about factorization of directed graphs for the cartesian product in linear time [989], to more applied projects where the work of the DANTE team on large graphs from real world applications might benefit from our expertise in graph theory.

6.5.3 Project implementation

Algebraic complexity

We plan to continue our work on the real τ-conjecture and its analogue for Newton polygons. Alternatively, as proposed by Pavel Hrubes, one can try to bound the multiplicities of complex roots of sums of products of sparse polynomials. Regarding Newton polygons, the case of polynomials with coefficients in $\mathbb{Z}/2\mathbb{Z}$ is especially attractive since there is a simple combinatorial interpretation of cancellations between monomials (namely, a given monomial does not appear in the final result if it occurs an even of times after expanding the products in a sum of products). We plan to start this investigation with polynomials of a very simple form, for instance, of the form $fg + 1$ where f and g have at most t monomials each.

There has been a flurry of recent papers on lower founds for depth 4 circuits using the method of shifted drivatives (including by our CompA collaborators from Paris 7). We are tantalizingly close to a separation of VP from VNP with this method, but completing the last step is likely to require some truly new ideas. There are also more approachable open questions in this area, for instance on lower bounds for circuits of constant depth higher than 4, or on homogeneous versus general arithmetic circuits. We have begun to investigate the role of the Wronskian determinant as a tool for proving lower bounds (we have already used this tool successfully for factoring sparse polynomials and bounding the number of real roots). It would be especially interesting to understand how this tool compares to the method of shifted derivatives.

Dearandomization of polynomial identity testing (PIT) is another central open problem in algebraic complexity: given a polynomial P succintly described by an arithmetic circuit, decide if P is identically equal to 0. There is a simple randomized algorithm for this problem, based on evaluation of P at random points. Hardness versus randomness tradeoffs (Impagliazzo and Kabanets) show that derandomization of PIT is essentially equivalent to proving arithmetic circuit lower bounds. There are similar results for bounded depth circuits (Dvir, Shpilka and Yehudayoff). We haven't been able yet to obtain the "ultimate" arithmetic circuit lower bounds (such as a separation of VP from VNP), but still, it is a natural question whether the lower bounds that have been achieved so far imply any non-trivial derandomization result.

Algebraic algorithms

The factorization of sparse polynomials is far from being a solved problem. A natural next step beyond the determination of low-degree factors is the determination of factors with few monomials (the so-called "sparse factors"). This seems to require some truly new ideas.

A problem of somewhat different nature is the computation of the sign of a sparse polynomial at a rational point. We treated the case of integer points in a 1997 paper. Sign evaluation at a rational point is especially interesting after the recent work on the approximation of real roots of sparse polynomials (by Kurth Melhorn, Michael Sagraloff and Pengim Wang at ISSAC 2014). Indeed, this problem is a basic building blocks in the recent approximation algorithms.

Forbidden subgraphs

Induced subgraphs play a central role in both structural and algorithmic graph theory. A graph H is an *induced subgraph* of a graph G if one can delete vertices of G to obtain H. This is the strongest notion of subgraph, hence being *H-free* (that is not containing H as an induced subgraph) is not a very restrictive requirement. Weaker notions of containment, like for instance minors, are now well understood, and the next achievement in Graph Theory should certainly be the understanding of forbidden induced structures. We will therefore focus on the following very general question:

Given a (possibly infinite) family ψ of graphs, what properties does a ψ-free graph have?

This is the key question of many important and longstanding problems, because many crucial graph classes are defined in terms of forbidden induced subgraphs. This field is now quickly growing, and new techniques and tools have been recently developed.

Our first goal is to establish bounds on some classical graph parameters for ψ-free graphs, such as the clique number, the stability number and the chromatic number. A second goal is to design efficient algorithms to recognize ψ-free graphs and to determine or approximate some parameters for those graphs.

For this purpose, we plan to use and develop various proof techniques, some of these being recently discovered, such as the structural description of graph classes, the regularity lemma, graph limits, flag algebras, VC-dimension, discharging method as well as computer-assisted proofs.

Symbolic dynamics

Historically symbolic dynamics, *i.e.* the study of sets of colorings defined by local rules, were first defined for two-sided sequences of colors as a model for discrete dynamical systems. When they respect constraints given by local rules, sets of such sequences are called $\mathbb{Z}$-subshifts of finite type (SFT) and enjoy a lot of nice properties due to the existence of a finite graph canonical representation. Unfortunately this simple representation cannot be generalized to higher dimensional SFT, and even worst most problems concerning 2D-SFT become undecidable.

$\mathbb{Z}^2$-subshifts of finite type, similar to tilings by Wang tiles, can also be defined on structures more general than $\mathbb{Z}^d$. Nevertheless, there exists for now no unifying formalism to define tilings on general graphs, hence we consider particular cases such as Cayley graphs of finitely presented groups or monoids, or fractal structures given by a substitution for instance.

The motivation for studying generalized symbolic dynamics is to understand which property makes SFT on a structure easy to deal with or not. More precisely, we aim at finding characterizations for classes of structures enjoying some specific property, for instance : for which finitely generated groups can one decide emptyness of SFT, or what are the possible entropies of SFT defined on fractal structures ?

To this aim we plan to combine various techniques, such as embedding computational models inside SFT, using the geometry of the structure – for instance amenability – from a combinatorial point of view or tools from combinatorial group theory.

The main person involved is Nathalie Aubrun. We note that other members of the team have been and will be working on tilings and related problems, in particular, Michael Rao, Mathieu Sablik, Svetlana Puzynina (a postdoc in our group starting in September 2014).

Combinatorics on words

Some conjectures are still open on repetition avoidability in infinite words. In 1957, Paul Erdös asked whether abelian squares can be avoided by an infinite word on an alphabet of 4 letters. Keränen answered positively to this question in 1992. Erdös also raised the question whether arbitrarily long squares can be avoided in binary words. It was also answered positively by Entringer, Jackson and Schatz in 1974. Following theses questions, Mäkelä conjectured in 2003 that one can avoid long abelian squares (resp. cubes) on ternary (resp. binary) infinite words. Michael Rao and Matthieu Rosenfeld (who will start a PhD thesis in MC2 in September 2014) started, more generally, to work on avoidability of long k-abelian repetitions.

7 Plume team: Programs and Proofs

7.1 Scientific areas and activities

7.1.1 Goals and context

We study methods for the formal analysis of computer programs and more generally of computing systems, with an approach rooted in logic and categorical semantics. We explore the foundations of high-level programming languages and the static analysis of programs. These investigations are carried out in particular using the proofs-as-programs correspondence in the setting of functional computation, but also in areas like those of concurrency theory and verification. Our work sometimes leads to formalizations developed by means of the Coq proof-assistant.

7.1.2 Activity profile

The activity profile of individual members of the team varies considerably. On average, we estimate it as follows:

- Academic research: 45 %;
- Interaction with socio-economic or cultural environment: 5 %;
- Scientific animation: 20%;
- Teaching and training: 30%.

7.1.3 Highlights

- We have attracted during this period 4 CNRS researchers: Bonchi (2010) and Clairambault (2013) by recruitment, Pous (2012) and Harmer (2013) by *mutation*.

  The arrival of Clairambault and Harmer in 2013 in particular has given to the team a critical size and an international visibility in the area of game semantics.

  We have also hired bright young researchers from abroad for postdoc positions: Federico Aschieri (from Torino) (funded by Labex MILYON), Alexander Kreuzer (from Darmstadt) (ANR Récré), Daniela Petrisan (from Leicester) (ANR Picoq).

- We have obtained 3 ANR projects: PACE (bilateral France-China ANR project, coordinated by D. Hirschkoff) (2013-2016); RÉCRÉ (ANR blanc project, coordinated by A. Miquel and then C. Riba) (2012-2015); COMPLICE (ANR blanc project, coordinated by P. Baillot) (2009-2013). Through these projects Plume plays a pivotal rôle in the community of proof theory and semantics in France.

- The monthly *ChoCoLa* seminar gathers participants coming from various French universities (Paris, Marseille, Chambéry . . .) for a one-day-long meeting. There are about 30 participants each time, including a large proportion of PhD students. This seminar was initially organized as part of the Choco ANR project (2007-2010).

- Several invited speakers to international conferences: Damien Pous at RAMICS 13 and CALCO'13, and Alexandre Miquel at TLCA'11.

- Co-organisation of a thematic session "Mathematical Structures of Computation" in 2014, involving members of the AriC and Plume teams, and of Institut Camille Jordan (Univ. Lyon 1), with the support of the Labex MILYON. Around 170 participants altogether, over a total period of 5 weeks.

- The joint paper [1114] by Bonchi and Pous at the leading international conference POPL 2013 (*ACM Symposium on Principles of Programming Languages*) will appear in the Communications of the ACM Research Highlights (publication scheduled for nov. 2014) and illustrates a fruitful collaboration by two recently-hired members of the team. This work has been widely appreciated and considered a "proof of concept" of how the coinductive techniques developed in concurrency and coalgebra theory can be exploited in different areas of computer science.

7.1.4 Research activities

At the international level our team participates in the communities of logic in computer science and of foundations of programming languages, as illustrated respectively by the conferences ACM-IEEE LICS and FoSSaCS. In France we participate in the GEOCAL and LAC working groups of the GdR *Informatique Mathématique*.

The description of our research activities is split into three themes: Logical foundations of programming languages, Semantic tools and new behavioural properties of programs, and Formalization. As appears below, there are several interactions between themes.

Theme 1: Logical foundations of programming languages

Computational contents of classical proofs and games

List of participants.

F. Aschieri, V. Blot, A. Kreuzer, M. Lasson, O. Laurent, A. Miquel, C. Riba, A. Tsouanas

Scientific issues, goals, and positioning of the team.

We address various approaches to the analysis of the computational contents of classical proofs. Games semantics, classical realizability and forcing appear as strong converging tools for that purpose, with a leading role of the team at the international level.

Major results.

In the area of game semantics, Tsouanas in his PhD thesis has proposed a game semantics of a logic programming language extended with the connectives of disjunction and negation [1064]. Laurent has studied with Dal Lago the notion of total strategy in game semantics and has used for that a categorical notion inspired by realizability, the double-glueing construction.

Several contributions of the team deal with the technique of classical realizability, introduced by Krivine. Riba and Blot proposed a classical realizability model based on game semantics, which they exploited to prove an extraction of witness result in a classical arithmetic setting, namely higher-type Peano arithmetic with countable choice [1112]. Miquel also showed how to use classical realizability to extract existential witnesses from classical proofs in second-order arithmetic and studied the links of this approach to a classical one by Friedman [1048].

Aschieri developped a new "game semantical" intuitionistic realizability [1127], which is a very minor modification of Kreisel's modified realizability, but realizes a classical logic principle, Markov's principle, in Arithmetic. He also proposed two new classical lambda calculi which give computational interpretations to the excluded middle principle EM1 in Arithmetic [1109, 1140] as well as to the full excluded middle principle EM in first-order logic [1060]. In this way he obtained a new proof of Herbrand's theorem in the setting of natural deduction, while previously it could only be derived in a simple way in sequent calculus.

In the general setting of pure type systems, Lasson has defined in his PhD thesis a method to build from a programming language L a logic to reason about the programs of L. In this context he has analysed the relationship between the methods of parametricity, a technique introduced by Reynolds to analyse the behaviour of programs, and that of realizability [1091]. With Keller [1107] he has proposed a definition of parametricity in the calculus of constructions, the logic underlying the Coq proof assistant; this result has opened new perspectives on the use of parametricity methods to reason on programs in Coq.

Forcing is a technique initially introduced in set theory in the 1960s by Cohen in order to prove independence results. Several contributions in the team have developed new applications of forcing in proof theory. Miquel has introduced a new viewpoint on the forcing transformation by analysing it as a program transformation in the setting of the proofs-as-programs correspondence [1098]. Rieg has then extended this analysis and exploited it to extract a witness from the proof of an existential statement in classical higher-order arithmetic, which turns forcing into a programming feature [1166]. Aschieri developed a new constructive version of forcing to interpret the classical axiom of choice [1060, 1140]. Finally forcing has also been used by Riba in the setting of monadic second-order logic (see the paragraph *Logic and automata* below).

Self-assessment.

Games, realizability and forcing have proved to be powerful tools to analyse proofs and programs. In view of the differences between these settings, it would be important to go towards a unified framework

λ-calculus, linear logic and applications

List of participants.

P. Baillot, O. Laurent, P. Lescanne, M. Perrinel

Scientific issues, goals, and positioning of the team.

λ-calculus and linear logic are core tools used in almost all the works of the team and are also the object of fundamental studies.

Major results.

Laurent has studied proof-nets, a graphical syntax for linear logic proofs, and devised a new proof for transforming proof-nets into sequent calculus proofs. He has also defined a Coq library based on a shallow embedding of intuitionistic linear logic, l2coq, which allows one to use Coq as a certified proof assistant for linear logic.

Moreover, we have studied the application of linear logic to type systems. Baillot has explored with Hofmann (LMU, Munich) the use of intuitionistic linear logic as a type system for λ-calculus and devised an efficient type inference algorithm [1081]. Laurent has analysed the subtyping theory of intersection type systems by means of a sequent calculus inspired by non-commutative intuitionistic linear logic [1057]. With collaborators from Novi Sad (Serbia), Lescanne has explored the addition of resource control in the λ-calculus, by exploiting techniques based on intersection types [1096]. In collaboration with the Jagiellonian University (Krakow, Poland) he has also investigated the counting of λ-calculus terms, as well as their random generation [1062, 1061].

Finally Perrinel in his PhD thesis has investigated interaction nets, a graph rewriting system inspired from linear logic, and has introduced a denotational semantics for those [1138].

Self-assessment.

Our contributions to the theory of λ-calculus and linear logic are of a general purpose with potential use by people using these tools outside our team.

Theme 2: Semantic tools and new behavioural properties of programs

Implicit computational complexity

List of participants.

P. Baillot, E. De Benedetti, M. Lasson, O. Laurent, M. Perrinel

Scientific issues, goals, and positioning of the team.

We explore various approaches to define programming languages with intrinsic complexity properties, for instance in which all programs run in polynomial time (PTIME), as well as static criteria on general programming languages ensuring similar properties.

Major results.

We have employed several techniques: semantic methods, linear logic, type systems, proof systems. Concerning the semantic approach, several results were known in the literature about interpretation-based criteria for first-order term rewriting systems ensuring complexity bounds. Baillot and Dal Lago [1102] have generalized this approach to typed higher-order rewriting systems and devised in this setting a criterion ensuring a PTIME complexity bound on programs.

In the setting of linear logic, Perrinel [1070] has analysed several variants of this logic for PTIME complexity and defined a general PTIME complexity criterion that subsumes them and is more expressive algorithmically. This criterion is defined thanks to a semantics based on the notion of path. Moreover concerning the particular system of elementary linear logic, Baillot [1090] has shown that beside elementary complexity it can also characterize the family of complexity classes k-EXPTIME, for $k \geq 0$.

Concerning type systems, several systems for PTIME derived from linear logic had been previously defined for the λ-calculus. Baillot, Gaboardi and Mogbil [1080] extended this approach to a functional language including recursive definitions with pattern-matching. As to proof systems, Lasson [1095] has introduced an intuitionistic second order logic inspired by a variant of linear logic, light linear logic, which makes it possible to extract PTIME bounded programs.

Self-assessment.

We have an expertise on linear logic methods for implicit computational complexity. In order to be more useful for practical programs, these techniques should however be combined with first-order methods based on the analysis of the size of values, either with types or with interpretations.

Concurrency

List of participants.F. Bonchi, P. Clairambault, R. Demangeon, R. Harmer, D. Hirschkoff, O. Laurent, J.-M. Madiot, D. Pous

Scientific issues, goals, and positioning of the team.

We study formal models of concurrent activities, and techniques to reason about these.

An important subject of study is process calculi, such as CCS, or the π-calculus, and their variants. We work on coinduction-based proof techniques to establish behavioural equivalence results for processes. We also study type systems for concurrent processes, drawing in some cases inspiration from existing approaches in the sequential case.

In addition to process calculi, researchers in Plume also use game semantics and graph rewriting to represent and analyse concurrent behaviours.

Major results.

Demangeon has studied in his PhD (2007-2010) type systems for termination of mobile processes. A type system combining techniques from functional programming (logical relations) and rewriting (multiset orders) has been introduced, and adapted to handle also a λ-calculus with references [1084, 1093]. In his PhD thesis (2011-), Madiot has introduced a π-calculus with name preorders [1165]. This calculus overcomes difficulties of fusion calculi in relation to typing and subtyping, and benefits from a well understood behavioural theory (joint work with Xu, Shanghai [1167]). (The PhD theses of Demangeon and Madiot are under the co-supervision of D. Hirschkoff (LIP) and D. Sangiorgi (Univ. Bologna and INRIA).)

Pous has proposed an encoding of the λ-calculus into HOcore, a very small fragment of the Higher-order π-calculus, [1139]. This is work in collaboration with A. Schmitt (INRIA Rennes).

Laurent has worked on a refinement of the correspondence between the asynchronous pi-calculus and linear logic proof nets to represent session types. This line of work establishes links between concurrency theory and proof theory.

Hirschkoff and Pous study axiomatisations of bisimilarity in process calculi that lack the sum operator; [1085] presents such a result in a subset of CCS with replication. Behavioural equivalences for processes (axiomatisations, labelled transition systems characterisations, proof techniques) are an important subject of study in the team, notably in connection with coinduction (see below).

The recent arrival of Clairambault and Harmer (fall 2013, both CNRS researchers) has brought new expertise for the modelisation of concurrent behaviours, both from a technical point of view and regarding domains of application. Harmer studies the rule-based approach to modeling, which exploits *graph rewriting* techniques [1118]. *Game semantics* can also be used to analyse concurrent computation. In collaboration with S. Castellan and G. Winskel in Cambridge (UK), Clairambault has studied a notion of concurrent games with symmetry allowing replication of resources [1134].

Self-assessment.

Concurrency belongs to the topics studied in the Plume team since a decade (1999). Beyond the “traditional” view, based on process calculi, different other approaches have emerged since 2009: coalgebras, game semantics, and applications to modeling of complex systems.

Coalgebras and coinduction

List of participants. F. Bonchi, P. Lescanne, J.-M. Madiot, D. Petrisan, D. Pous, F. Zanasi

Scientific issues, goals, and positioning of the team.

Category theory can be used to study behavioural equivalences of systems. Notions such as labelled transition systems and bisimilarity can be formulated using the theory of coalgebras. Adopting such an abstract approach makes it possible to unify and generalise existing theory of (possibly concurrent) systems, and to obtain a better understanding of associated reasoning techniques. In turn, the general framework can be specialised in order to discover new techniques.

Major results.

In the setting of coalgebras, one can study bisimulation-related equivalences for automata, as explored in various works by Bonchi and coauthors [1052, 1099].

One essential objective of such an abstract approach is to promote compositionality in the models of computation. Bonchi and Zanasi have analysed, with coauthors, general criteria to give compositional and coinductive semantics to different sorts of formal languages (like process calculi, logic and concurrent constraint programming, software connectors and signal-flow graphs) [1090, 1131, 1129].

Pous and Bonchi defined a new algorithm for testing the equivalence of finite automata, using so-called "coinductive up-to techniques". This lead to a paper published at POPL [1114], that was later nominated for the CACM Research Highlights [1068]. This contribution renewed the interested in such techniques, and lead to their generalisation, first at a categorical level [1113, 1071], and then, thanks to the arrival of Petrisan in the team, at the fibrational level [1130].

Lescanne works on applications of coinduction to reason about infinite sequential economic games, with applications to analyse escalation behaviours [1156, 1157, 1150, 1164, 1058].

Self-assessment.

The research activity in the Plume team about category theory for concurrency, coalgebras and coinduction has bloomed in recent years. The team has very active international connections on these topics, particularly with CWI (NL) and Southampton (UK).

Logic and automata

List of participants.P. Brunet, P. Clairambault, D. Pous, C. Riba, F. Zanasi

Scientific issues, goals, and positioning of the team.

We investigate how algebraic and semantical approaches can help in defining techniques for the automated analysis of systems.

Major results.

Pous developped a new library for relation algebra in Coq, including a decision procedure for Kleene algebra with tests (KAT) [1123]. Brunet started his PhD under supervision of Pous on a related topic: understanding extensions of Kleene algebras. He simplified an existing algorithm for Kleene algebra with converse [1132], which allowed him to prove that the corresponding theory is PSPACE (while it was only known to be PSPACE-hard).

The work mentioned above (paragraph *Coalgebras and coinduction*), by Bonchi and Pous, about an algorithm to check NFA equivalence [1114] is also relevant in this section.

In joint work with Murawski [1117], Clairambault described an extension of higher-order model-checking to infinite normal forms of higher-order programs, which include binders.

Zanasi has studied the expressiveness of monadic second-order logic (MSO) and the modal mu-calculus, in joint work with F. Carreiro, A. Facchini and Y. Venema on characterising fragments of these two logics by means of automata [1133, 1126]. Riba worked on the axiomatization of MSO [1108] using model-theoretic and algebraic tools. He also proposed an interpretation of MSO in Weak MSO using Cohen's forcing method [1124] (see also the paragraph *Computational contents of classical proofs and games* above), and provided a new perspective on the determinization theorem of automata on infinite words, a central result in automata interpretation of MSO.

Self-assessment.

The study of automated methods, and connection with verification, has appeared rather recently in Plume. These contributions build on techniques which are also studied at a theoretical level in the team.

Theme 3: Formalization

List of participants. Ph. Audebaud, P. Brunet, O. Laurent, J.-M. Madiot, D. Pous, L. Rieg

Scientific issues, goals, and positioning of the team.

Several members of Plume are users of the Coq proof assistant, and develop mechanised proofs of (some of) their results. Moreover, some of our research efforts are intended to ease the construction of computer formalised proofs.

Major results.

Audebaud has proposed with Ch. Paulin [1039] a method for proving properties of randomized algorithms in the Coq proof assistant. It is based on the monadic interpretation of randomized programs as probabilistic distributions.

Pous develops a library about relation algebra, which includes a reflexive decision procedure for Kleene algebra with tests (KAT). He plans to integrate new results about other extensions of Kleene algebras into this library.

Pous also worked on two distinct projects, developped by two teams in Grenoble, where he brought his Coq expertise to formalise reconfiguration algorithms for dynamic components (with F. Boyer and O. Gruber [1116]), and logics for programs with effects (with D. Duval and J.G. Dumas [1135])

Rieg carried out a complete formalization of second-order classical realizability, with the proofs of the main standard results.

One goal of the work by Laurent on l2coq is to use the Coq system as a framework in which to build linear logic proofs.

Finally, some papers published by members of Plume feature formalised proofs of some results presented in the paper. This is the case for Bonchi and Pous' work on automata [1114], and Hirschkoff, Madiot and Xu's work on a π-calculus with preorders [1167].

Self-assessment.

Regarding formalization, the angle has changed with respect to the previous evaluation of the LIP, in terms of what kind of theories are formalised. Nevertheless, the Coq system still plays an important role in the activity of Plume members, both in research and in teaching.

In conclusion to this part, let us stress the fact that though the scope of the team is large, several techniques are used in a transverse way in many of the topics described above:

- formalized proofs, as already explained above,
- type systems, which are used in λ-calculus, games, implicit computational complexity, concurrency,
- category theory, which is employed in games, coalgebras, concurrency (in particular for rule-based languages).

7.2 Organisation and life of the team

We have weekly scientific meetings (*groupe de travail*) (see the webpage) gathering all team members.

We also organise meetings on a monthly basis, to gather researchers of the French community working on proof theory, semantics, and related topics. These meetings are called CHoCoLa (Curry-Howard, Logic and Computation) and are the follow-up of the former meetings of the ANR project "Choco". Beside the CHoCoLa meetings we also have some team seminars.

From 11/2011 to 2/2013 Plume was located in another building (UCBL building) than the main building of ENS Lyon and this has been a delicate period for the everyday life of the team, since we had fewer contacts with the rest of the lab.

7.3 Scientific outcomes, visibility, collaborations

The outcomes of the research in the Plume team are exposed in Section 7.1. We would like to highlight the following facts, regarding both our results and the visibility of the team.

- The paper *"Checking NFA equivalence with bisimulations up to congruence"* by F. Bonchi and D. Pous has been invited for publication in CACM [1068].
- F. Zanasi has won the AILA Thesis Award for the Best Master Thesis in Logic by an Italian student. AILA is the Italian Association for Logic and its Applications. F. Bonchi and F. Zanasi received the best paper award at the international conference CALCO 2013 (5th Conference on Algebra and Coalgebra in Computer Science) for their paper [1115].
- Participation to Programme Committees of conferences:

  Members of the team have served on the PCs of many international conferences, like ACM-IEEE LICS, FoSSaCS, ICALP, CSL, APLAS, TLCA . . . and workshops. For instance in the FoSSaCS PC there has been a Plume member in 2010-2011-2012 and at ACM-IEEE LICS in 2011-2012.
- Members of the Plume team regularly publish at the leading international conferences of our area, like ACM-IEEE LICS and FoSSaCS. As an example at LICS 2013, 3 papers were co-authored by Plume members (while there were 3 for Cambridge, 2 for Oxford and 1 for the PPS lab); there were 4 at LICS 2014.
- The team organises the CHoCoLa meetings (formerly Choco, active since 2007), which play an important rôle in gathering researchers working in the areas covered by Plume, at a national level.
- Organisation of events:

  Baillot co-organized with Guiraud and Malbos in 2014 the thematic session *Mathematical Structures of Computation* in Lyon, which consisted in 5 weeks of workshops and was supported by the Labex MILYON. It attracted altogether around 170 participants.

  As part of this session, one workshop, entitled *Concurrency, Logic and Types* was organized by Baillot, Hirschkoff and Pous. Another one, *Formal Proof, Symbolic Computation and Computer Arithmetic* was organized by members of the AriC team, Brisebarre and Muller.

  As part of the thematic session *Logic and Interactions* 2012 at the CIRM in Marseille, Laurent co-organized two workshops, *Logic and interaction* and *Proofs and programs*, and Baillot co-organized one workshop, *Complexity*.

  Creation of the DICE (*Developments in Implicit Computational complExity*) annual workshop series (Baillot) in 2010.

  Harmer co-organized the workshops LSB 2014 (*5th Workshop on Logic and Systems Biology*, Vienna, July 2014) and DCM 2014 (*10th Workshop on Developments in Computational Models*, Vienna, July 2014).
- O. Laurent is responsible for the *Groupe de Travail* "Géométrie du Calcul" (GEOCAL) in the GDR Informatique-Mathématique at CNRS since 2012.
- O. Laurent is coordinator of the LLWiki web site, a collaborative site about linear logic.

Collaborations.
At a national level, we have collaborations with researchers from ENS Paris, Paris 7, Paris 13, Rennes, and Grenoble.
We also have several active collaborations outside France, leading to co-publications. In Italy: Bologna, Pisa and Torino; in the Netherlands: Nijmegen and Amsterdam; in the US: Harvard Medical School; in China: Shanghai; in the UK: Cambridge, Southampton, Edinburgh, Dundee; in Poland: Warsaw and Cracow; in Serbia: Novi Sad; in Germany: Munich.

7.4 Training through research

Habilitations.
Since 2009, three *habilitations à diriger les recherches* have been defended by members of the team, at Univ. Paris 7 (A. Miquel [1170], O. Laurent [1172]) and ENS Lyon (D. Hirschkoff [1169]).

PhD defended in the team.

Since 2009, 5 PhD thesis have been defended in the Plume team: Romain Demangeon (11/2010); Barbara Petit (7/2011); Marc Lasson (11/2012); Lionel Rieg (6/2014); Athanasios Tsouanas (7/2014). Moreover 3 PhD thesis by students in other universities have also been co-directed by members of the team: Severine Maingaud (Univ. Paris 7, 2011); Antoine Madet (Univ. Paris 7, 12/2012); Guilhem Jaber (Ecole des Mines de Nantes, 7/2014). Finally 4 students should defend their PhD by the winter 2014-2015: Valentin Blot; Erika De Benedetti; Jean-Marie Madiot; Matthieu Perrinel. Let us also stress that among the PhD theses mentioned above, defended or on-going, three are in *cotutelle* (2 with Univ. of Bologna, and 1 with Univ. of Torino, in Italy).

Among the 5 students who have defended their PhD, 1 has a permanents position at University (R. Demangeon, MdC at Univ. Paris 6), 1 in a private company (B. Petit), and 2 have non-permanent positions (M. Lasson postdoc at INRIA-Paris, L. Rieg ATER at Univ. Evry).

Organization of research schools

- Members of Plume have organized 5 research schools as part of the local Master (these research schools last for one week and are mainly directed towards Master students):

  2014: *Logic of dynamical systems* (organized by Bonchi); 2013: *Semantics and tools for low-level concurrent programming* (Bonchi); 2011: *Separation logic and applications* (Hirschkoff); 2011: *Rule-based modeling and application to biomolecular networks* (Laurent); 2010: *Game semantics and linear logic* (Baillot).

- O. Laurent has taken part to the organization committee of the *School on Linear Logic* in Torino (Italy), in August 2014.

7.5 Research project

7.5.1 Self-assessment and SWOT analysis

Strong points

- Since 2008, an important renewal of staff has taken place in the Plume group: among the 9 current permanent members of the team, 5 have joined the team since 2009 (and 7 in total since 2008). All but one of the new members are CNRS researchers: F. Bonchi (2010) and P. Clairambault (2013) have been hired on CR2 positions, while D. Pous (2012) and R. Harmer (2013) have moved to Plume (as did P. Baillot and O. Laurent in 2008).
- The team has become more stable. It is also more visible at national and international levels. This is testified, for instance, through the increased quality of applications in the team (for permanent and postdoc positions), participation in the Programme Committee of important international conferences, and the strengthening of international collaborations (illustrated by joint publications and international visitors).
- An important proportion of very good young French researchers in the research areas covered by the Plume team are former students of ENS Lyon, which can be seen as a consequence of the rôle played by Plume in teaching.

Weak points

- Foreseeing the evolution of the Plume team is a rather delicate task, because of a strong dependency w.r.t. the CNRS. In particular, when P. Lescanne retired from his Professor position and obtained his Emeritus position (in 2012), the newly recruited Professor was not hired in Plume. Additionally, A. Miquel left in 2013, which had consequences on the equilibrium of research domains in the team. We believe that for its stability, both at the level of research and teaching, Plume would benefit from hiring a Professor.
- The current rank A members of the team (O. Laurent, and P. Baillot from Oct. 2014) do not cover the current thematic spectrum of the team, and in particular the recent emergent topics of coalgebraic and coinductive methods in concurrency, and logics and semantics for verification.

Opportunities

- The recent hiring of bright young researchers working in game semantics and concurrency theory provides the opportunity of having Plume play a key role at an international level. Recruiting a senior researcher would help in this direction.
- Recent evolutions in the research topics covered in Plume open new directions for interactions, both within the LIP lab (in particular on questions related to compilers, or to formal proofs for computer arithmetic) and outside (notably on verification, and on the modelling of complex systems).

Risks

- The MPRI (Master Parisien de Recherche en Informatique) plays a prominent role, at a national level, in the scientific curricula addressing the research themes of Plume. We believe that it should be profitable not to have the MPRI as the only Master in this area in France, despite its size and visibility.

- The number (and proportion) of permanent members holding teaching positions in Plume has shrunk, which has negative consequences both in terms of future prospects (management of resources) and in terms of visibility of our research topics w.r.t. the local students.

- Currently all members of the team are employed by CNRS or ENS Lyon, which is a limitation for future recruitments as well as for resources (e.g. PhD grants, Postdoc grants, *délégations* ...) in comparison with INRIA teams or teams which have Univ. Lyon I members.

7.5.2 Research objectives

We believe that a strength of our team is the overall combined expertise it has gathered in logic, semantics of concurrency and formal proofs. Our goal is to develop sound mathematical understandings of computing systems based on logic and categorical semantics, which can then be employed for the purposes of analysis. In the previous period such analysis has been carried out mainly using type systems and formal proofs. In the forthcoming period we additionally want to establish connections with other approaches such as model-checking and semantics-based program verification. Our conviction is that proof theory and game semantics in particular have strong potential for these areas, which has until now been little explored. We moreover want to extend our methods to more general programming paradigms, bringing together concurrency, higher-order and imperative features, a task which raises non-trivial issues in terms of complexity and scalability.

We will put particular emphasis on the following emerging topics, which benefit from a strong synergy in the team as well as from vivid international collaborations:

- coalgebraic and coinductive methods in concurrency,

- logics, games and automata for verification.

In the *Project implementation* below these topics actually lie at the intersection of several themes, ranging from foundational investigations (e.g. game models) to verification-motivated algorithmic techniques (e.g. higher-order model checking).

Another recently emerged topic is that of rule-based languages for stochastic modeling of complex systems, and in particular of biological systems. This line of work has been originally inspired by concurrency theory and graph rewriting, and has led to the Kappa language, currently used in systems biology.

More generally we anticipate that, in a transversal manner, probabilistic aspects will gain importance in our themes, as this is a trend we can observe in our community, e.g. in concurrency and in semantics. We also expect that some of our research directions might benefit from stimulating interaction with the area of computational security, like for instance implicit complexity and behavioural equivalences on concurrent processes.

Finally we will collaborate with the AriC team concerning the formalization in Coq of computer arithmetic and of approximation methods in symbolic and numeric computation.

7.5.3 Project implementation

Our research plan is organized in two main themes, which however have strong ties and intersections. The first theme revolves around logic, and more specifically proof theory, seen as a guideline for the investigation of the foundation of programming languages and of their semantics. The second theme focuses on computing systems as an object of study which we analyze by borrowing tools coming from categorical semantics and logic again.

Theme 1: Logical foundations of programming languages

Logics and types. We will explore the use of logic for the study of computation, notably through the design of type systems. This involves in particular the investigation of λ-calculus and linear logic, which are fundamental tools used throughout our project.

- **Implicit computational complexity**. In the last period we have mainly explored implicit complexity criteria for ensuring polynomial time complexity on functional programs. In the next period we will more generally investigate logical methods for static complexity analysis for a wider range of programming paradigms and with the goal of extracting concrete time bounds. This will be developed as part of the starting ANR project ELICA[1]. We are in particular interested on the one hand by probabilistic languages, and on the other by concurrent systems. Probabilistic languages will be useful to explore possible applications to computational security, in particular to analyze the complexity of adversaries in reduction proofs. Concerning concurrent systems we aim at designing type systems for processes making it possible to ensure time and space complexity bounds. In this setting we are interested for instance by complexity bounds on the reactivity of processes, that is to say on the time needed to answer a request.

- **Linear logic**. We will on the one hand work on improving the theory of linear logic proof-nets, and on the other develop the proof-assistant l2coq and interface it with automatic provers.

- **λ-calculus**. We will study the counting of the number of λ-calculus terms of a given size according to various size models. We will use this analysis for automatic generation of random λ-calculus terms, and explore applications to the generation of random Haskell programs for testing.

Games. The team has now gathered an important expertise in this area. We plan to work both on the foundations of game semantics and on its applications.

- **Foundations of game semantics and interpretation of logic**. We will investigate the relationships between several variants of game semantics, which differ by the way in which the reuse of an argument by a function is represented. An important motivation for that is the exploration of *finitary* versions of game semantics, which have promising applications in program verification (see *Logics, games and automata for verification* below). An example of game semantics which is well-suited for these finite presentations is that of *sequential algorithms* and we thus want to clarify its relationships with the more mainstream models.

  We will also use game semantics to investigate the computational nature of the proof theory of first-order classical logic with a focus on the call-by-name / call-by-value duality.

- **Games on event structures**. Historically, games models of programming languages have almost exclusively been formulated in sequential structures such as trees, where an execution consists in a total ordering of its computational events. Accordingly games models of concurrent programming languages are based on interleavings, and therefore are subject to a combinatorial explosion problem hindering applications to verification. Moreover, even for sequential, purely functional programs, the tree-based composition mechanism at the heart of standard game semantics produces overly sequential execution witnesses that have to be decomposed further using additional notions of 'views'. In contrast, games based on truly concurrent frameworks – such as event structures – solve these issues by providing a direct handle on causality in models of programming languages, yielding more precise and concise structures. Relying on recent progress on game semantics based on such partially ordered structures, we want to design partial order models of rich higher-order effectful programming languages, with a focus on concurrency; and to pave the way for applications to program verification.

Theme 2: Semantic tools and analysis of computing systems

Concurrency.

Concurrent systems are an object of study from several points of views in the Plume team. In addition to the aforementioned recent developments related to these aspects (implicit complexity, game semantics), we have an important activity on more traditional areas of concurrency theory, and on their applications for the modeling of various kinds of systems. The development of both proof theory-based and concurrency theory-based techniques for concurrency is a source of interactions within the team.

- **Coinduction** plays a crucial rôle in the study of process calculi and behavioural equivalences for concurrent systems. In recent years, the focus on coinductive-based reasoning has grown within the team, turning coinduction from being a useful tool to being an object of study *per se*. The understanding and promotion of coinduction represents an important angle for research in the next years.

  We will work on enhancing the **abstract presentations of coinduction (based mostly on coalgebras)** to take into account rich forms of behaviours and equivalences. We are in particular interested in coinductive techniques for languages featuring higher-order computation, as well as probabilistic computation (a theme which is also mentioned in the presentation of implicit computational complexity above). We also plan to study coinductive metrics, in order to support "quantitative reasoning" on systems.

[1] *Expanding Logical Ideas for Complexity Analysis*

We have a long standing interest in **up-to techniques for bisimulation**, which can be used to ease coinductive proofs about the behaviours of systems. We would like to develop and adapt these techniques, in order to establish new connections with other approaches used in computer science (examples include algorithms for algebraic structures, proof systems for the modal μ-calculus).

We promote the use of coinductive reasoning in an emerging **collaboration with economists** (work by Lescanne and Perrinel), focusing on the concept of escalation.

- **Mechanisation of reasonings about behaviours of concurrent systems.** We want to develop the theory of operational accounts of process calculi, with the long term goal of providing techniques to reason about concurrent behaviours in a theorem prover. This involves developing appropriate presentations of the objects being manipulated (processes, transitions, equivalences), and coming up with unified presentation of existing theories. Connections with techniques used in functional languages (logical relations, types, control operators) are also relevant in this perspective.

- **Rule-based modeling** is a programming paradigm for the representation and analysis of complex systems, in particular for modeling intra-cellular signaling networks. It is based on techniques of fundamental computer science—in particular from graph rewriting, concurrency theory and extensions of the notions of causality found in event structures—and has led to the language Kappa which is used in systems biology. Our efforts in this research line will principally focus on enhancing the model development process as part of a starting DARPA project with Harvard Medical School. The intent is to provide tools to automate the generation and analysis of rules from existing data in order to formulate, and subsequently test, hypotheses about the causality underlying the structure of the signaling networks implicated in disease states (typically cancers).

Logics, games and automata for verification. In this particularly active topic we apply in an innovative way to verification problems various concepts and tools coming from logic and semantics: game semantics, λ-calculus, proof theory, formal proofs... Several works described in the previous paragraphs will be put to use here.

- **Kleene algebras**. Kleene algebras and related structures like Kleene algebras with tests (KAT) are algebraic systems with applications to verification (see, e.g., the work by D. Kozen). D. Pous mechanised the theory of KAT into a Coq library, thus providing tools for verification of imperative programs in Coq, as well as automation tactics for proofs about binary relations. To further enhance these tools, we plan to explore various extensions of Kleene algebras, from the point of view of decidability and axiomatisability. The decidability of several such extensions is still open, and we plan to use techniques coming from automata theory as a starting point. If decidability holds, we will implement the resulting algorithm as a Coq tactic, be it reflexive or certified *a posteriori*. Building on these results, we plan to formalise the general theory of bisimulations and up to techniques in a streamlined way.

- **Verification of higher-order programs**. Model-checking is an automated verification approach that has been initially developed for finite-state systems. It has recently been extended to the setting of higher-order programs, mainly by Ong and Kobayashi. However this methodology currently follows a global approach and verifies a program as a whole. We propose to develop instead a *compositional* approach to higher-order model-checking, by bridging it with tools coming from semantics (type systems). The main advantage is that compositionality allows to restrain the automated part to smaller problem instances, and thus would lead to greater efficiency.

  In another direction we also want to develop semantic approaches to program verification. Our goal is to define effective models of higher-order programming languages allowing to observe non-functional properties of programs, such as the order of evaluation. This is necessary for instance in situations where we want to check properties of programs interacting with a stateful environment, and where standard denotational models used for functional programs are blind. Our idea is to develop finitary game semantics models, inspired by concepts coming from sequential algorithms.

- **Proof-theoretic investigation of logics for verification**. We will explore the application to the field of Monadic Second Order logic (MSO) and modal μ-calculus of concepts coming from proof theory and semantics: Gödel's Dialectica interpretation, the forcing construction. We will first focus on MSO on infinite trees and then on logics for data, in particular considering dependent type systems for fragments of XPath and the Curry-Howard interpretation of MSO on finite structures.

8 Roma team: Resource Optimization : Models, Algorithms and Scheduling

This section covers the work that has been done during the whole reporting period under the supervision of current permanent members of Roma. Therefore, it also includes work that was done in the former GRAAL team. See Section 8.2 for details.

8.1 Scientific areas and activities

8.1.1 Goals and context

The ROMA team aims at designing models, algorithms, and scheduling strategies to optimize the execution of scientific applications on High-Performance Computing platforms. More specifically, ROMA is interested in obtaining the "best" possible performance from the point of view of the user (e.g., application execution time) while using ressources as efficiently as possible (e.g., low energy consumption). The work performed by ROMA ranges from theoretical studies to the development of software used daily in the academic and industrial world.

8.1.2 Activity profile

There is much variation in the activity profile inside the team as some members are full-time researchers while others have teaching responsibilities. However, all permanent members are involved in student advising and most researchers are involved in teaching at master level. Several permanent members are significantly involved in the animation of the scientific community at an international level.

- Academic research: 60 %;
- Interaction with socio-economic or cultural environment: 5%;
- Scientific animation: 15%;
- Teaching and supervision of research students: 20%.

8.1.3 Highlights

Awards and visibility

- Yves Robert was awarded the 2014 *IEEE Technical Committee on Scalable Computing* (TCSC) Award for Excellence. [IEEE TCSC award]
- Members of Roma were awarded the best paper award at ISPDC'2010 and HeteroPar'2009, a best poster award at the PhD Forum of IPDPS 2011, and ranked second in the 10th DIMACS Implementation Challenge.
- Anne Benoit was appointed junior member of the Institut Universitaire de France (IUF) in 2009, and Yves Robert was renewed as a senior member in 2011.
- Yves Robert is a member of the "NSF/TCPP Curriculum Initiative on Parallel and Distributed Computing" that defined the "core topics in parallel and distributed computing that a student graduating with a Bachelors degree in Computer Science or Computer Engineering is expected to have covered". Out of the twenty members of this committee, Yves Robert is the only one not coming from North America.
- The ROMA team co-organized (with the AVALON team) the ICPP'2013 conference (the 42nd Annual Conference International Conference on Parallel Processing).
- The ROMA team organized at ENS Lyon a thematic quarter of the MILYON Labex in 2014 "Resource optimization for Exascale systems: Models and algorithms". This thematic quarter included the *Sixth SIAM Workshop on Combinatorial Scientific Computing* and an edition of the invitation-only workshop on *Scheduling for Large Scale Systems* the team has been organizing each year (around 40 participants, most of them from foreign institutions).
- Team members were involved in many program committees. Most notably, three different team members were vice-program chairs for the *Algorithms* tracks of HiPC 2010, HiPC 2012, HiPC 2014, IPDPS'13, IPDPS'14, and SC'14, and another was vice-program chair for the *Applications* track of ICPP 2011.

Publications

- Anne Benoit, Yves Robert, and Frédéric Vivien authored the textbook "A Guide to Algorithm Design: Paradigms, Methods, and Complexity Analysis" published by Chapman & Hall/CRC in August 2013. [webpage]
- Yves Robert and Frédéric Vivien edited the textbook "Introduction to scheduling" published by Chapman & Hall/CRC in December 2009. [webpage]

- During the reporting period, the ROMA team published 48 articles in international peer-reviewed journals, 89 articles in international peer-reviewed conference proceedings, 15 books or book chapters, and edited 7 books, special issues, or conference proceedings. Also, 6 PhD and 2 habilitation theses were defended.

Software development

- The ROMA team is co-leading the work around the software package MUMPS. This software remains an international reference among solvers for sparse linear systems. [webpage]

New research themes

- Bora Uçar was hired as a CNRS junior research scientist in the team in January 2009, which added Combinatorial Scientific Computing to the research topics covered by the team.
- During the reporting period the ROMA team started working on the resilience of applications executed on failure-prone platforms. The ROMA team quickly made significant contributions to this research field with, for instance, a publication to the Supercomputing 2011 (SC'11) conference. The ROMA team was also awarded (as leader) a "White project" from ANR (the RESCUE project) on this topic. Among the three PhD theses that will be defended in 2014 in the team, one is devoted to the study of resilience, while half of a second is also devoted to that subject.

8.2 Organisation and life of the team

The ROMA team was created during the evaluation period, on April 1, 2010. During the last evaluation of the laboratory, in December 2009, the splitting of the GRAAL team was presented and approved. One half of GRAAL lead to the creation of the ROMA team, and the other to the creation of the AVALON team (see Section 3).

The creation of ROMA gave us the opportunity of having a far more tightly knit group, far more focused scientifically. Furthermore, there is a strong will among the ROMA team members to collaborate. Consequently, most of the PhD students in the team are co-advised by team members (even when both advisors have the Habilitation). This also leads to joint research work between permanent team members not involving any student. Therefore, there are strong interactions, on a daily basis, between permanent team members. In turn, this leads to strong interactions between students (in PhD or in PostDoc) and joint work between students. The strong interactions between permanent team members is illustrated by the graph of their co-publications, which is almost complete (see Figure 8.1). The team has several strong, long-term international collaborations. Most of our PhD students are involved in these collaborations. Furthermore, every year the team organizes an invitation-only workshop. Almost all team members, including students, take part in this workshop. This gives us the opportunity to gather our main international collaborators along with representatives of other closely-related teams. This enables us to present and discuss our recent advances, and to foster new collaborations.

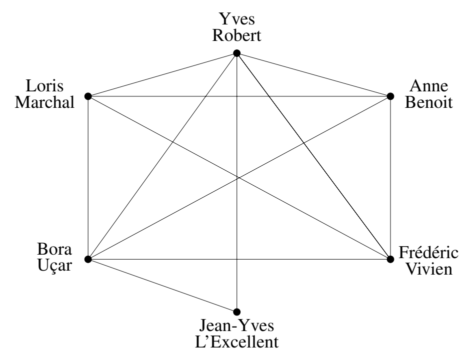

Figure 8.1: Graph of co-publications between ROMA permanent team members.

8.3 Scientific outcomes, visibility, collaborations

8.3.1 Scientific outcomes

Application resilience

We have studied the optimization of the execution of applications in failure-prone environments in very different settings.

In a first series of work, we have considered the execution of a divisible load on a set of remote processors subject to unrecoverable failures of known probabilities. The goal was to maximize the expectation of the amount of work successfully completed. Initially, we considered that failures followed a linear model. From the theoretical results obtained in this context, we designed and validated scheduling policies for any failure distribution. This work was done in the context of homogeneous platforms [1211] and then extended to heterogeneous platforms [1193].

Most of our work targeted the execution of distributed applications on HPC platforms that use some coordinated checkpointing mechanism. In this context, we first formally proved a result from the folklore that claimed that the optimal checkpointing policy was periodic when failures follow an exponential distribution [1271]. We also proposed asymptotically optimal checkpointing policies for any distribution [1271]. We then studied the use of coordinated checkpointing with a set of other fault-tolerance approaches. We studied when replication could be a beneficial addition to coordinated checkpointing [1221]. Because many fault predictors have been proposed in the literature, we have assessed what benefits could be obtained by using an (imperfect) fault predictor in addition to coordinated checkpointing, and have defined how the checkpointing policy should be adapted with respect to the characteristics of the fault predictor [1219, 1300]. One striking conclusion of this study is that the recall of a predictor (the percentage of actual faults it predicts) is far more important than its precision (the percentage of predictions corresponding to actual faults); many authors of fault predictors were focusing, on the contrary, on improving the precision. We also compared the benefits of using either preventive checkpointing or migration when a fault is predicted [1195].

Because faults are not always detected at the time they occur (e.g., silent errors), we studied the impact of the detection latency. When the distribution of the failures and of the detection latencies both follow an exponential law, the detection latency has no impact on the optimal checkpointing period! This surprising result assumes that an infinite number of checkpoints can be stored [1297]. When, more realistically, this is not the case, we designed checkpointing policies for any failure distribution.

In order to compare coordinated and non-coordinated hierarchical checkpointing protocols, we designed and analyzed a model to study most of these protocols. Knowing the application and platform parameters, this study enables us to determine which protocol will minimize the expectation of the execution time [1212].

We have studied the reliability of task graph schedules with transient and fail-stop failures. While computing the reliability of a given schedule is easy in the absence of task replication, the problem becomes much more difficult when task replication is used. We have filled a complexity gap of the scheduling literature: our main result is that this reliability problem is #P-complete (hence at least as hard as NP-complete problems), both for transient and for fail-stop processor failures. We have also studied the evaluation of a restricted class of schedules, where a task cannot be scheduled before all replicas of all its predecessors have completed their execution. Although the complexity in this case with fail-stop failures remains open, we provided an algorithm to estimate the reliability while limiting the evaluation cost, and we validated this approach through simulations [1201].

Streaming applications

A streaming application operates on a collection of data sets that are processed in a pipeline fashion. These applications are described by a task graph, which may be linear. The scheduling of streaming applications, sometimes called pipelined workflow scheduling, has been widely studied in the last decade; multiple models and algorithms have flourished, many various programming paradigms, constraints, machine behaviors, and optimization goals have been considered. We proposed a survey of this field by summing up and structuring known results and approaches [1207].

Filtering applications are streaming applications where each task modifies the size of its input data by a fixed ratio, increasing or decreasing the size of data. With filtering applications, the schedule has the additional freedom to decide the order of execution of tasks. We studied the complexity of scheduling filtering applications when optimizing either the latency, the period, or both, when the platform is homogeneous or heterogeneous, when there are communication costs or not, and when the mapping is either one-to-one (each task is assigned to a different processor) or general. Whatever the objective function, the problem is of polynomial complexity when the platform is homogeneous, the mapping is one-to-one, and when there are no communication costs. Almost all other cases are NP-complete [1199]. Sometimes, even when the mapping is given, computing the best execution dates is difficult. We also considered this problem when mappings can be general but when the platform is a chain of processors [1238].

We studied the scheduling of linear streaming applications on platforms subject to failures. We used replication to increase the reliability of computation: several processors may execute the same computation. We studied the complexity of the problem and proposed practical solutions when the mapping is an interval mapping, i.e., when the application is partitioned into intervals of consecutive stages and each processor is allocated a single interval. The considered objective functions were either the period, the latency, and the reliability in mono- and multi-criteria approaches [1188, 1209]. When mappings are general, computing the period of a given mapping is an NP-complete problem [1188].

We have also considered the scheduling of streaming applications where computation and communication times are not fixed constants but described by random variables. We then investigated how to compute the throughput of a replicated linear streaming application whose one-to-one mapping is given. The problem is easy when application stages are not replicated: the throughput is dictated by the critical hardware resource. When stages are replicated, the problem becomes surprisingly complicated: even in the deterministic case, the optimal throughput may be lower than the smallest internal resource throughput. We provided a general method to compute the throughput when mapping parameters are constant or follow I.I.D. exponential laws. We provided bounds for the throughput when computation and communication times form associated random sequences, and are N.B.U.E. (New Better than Used in Expectation) variables: the throughput is bounded from below by the exponential case and bounded from above by the deterministic case [1220].

In a slightly different setting, we investigated the operator mapping problem for in-network stream-processing applications: one or more trees of operators are applied in steady-state to multiple data objects that are continuously updated at different locations in the network. Different operator trees may share common subtrees, and it may be possible to reuse some intermediate results. We provided complexity results for different instances of the basic problem, as well as integer linear program formulations of various problem variants. Also, we designed several polynomial-time heuristics, demonstrating the importance of choosing appropriate processors for operator mapping [1189, 1190].

We have studied the problem of optimizing the throughput of coarse-grain workflow applications, where tasks have types and are subject to failures. Each processor can be specialized to process a single type of tasks. We have studied the complexity of this mapping problem: the throughput can be maximized in polynomial time if there is exactly one task per processor, otherwise the problem is NP-hard. We have designed several polynomial-time heuristics, and the evaluation showed that they provide good performance [1191]. We have also studied this problem on heterogeneous systems [1208].

Energy-aware scheduling

We have considered the minimization of the energy consumption of applications in many different settings.

We considered the problem of scheduling a set of independent tasks on a fully heterogeneous master–worker platform with communication costs. We aimed at maximizing the throughput while minimizing the energy consumed. Assuming arbitrary super-linear power consumption laws, we investigated different models with memory constraints. Building upon closed-form expressions for the uni-processor case, we derived asymptotically optimal solutions for all models [1198].

In the scope of streaming applications, we considered the concurrent execution of a set of linear applications on the same homogeneous or heterogeneous platform. The optimization criteria were the energy consumption, the period, and the latency. The mappings were either one-to-one, by intervals, or general. We performed an exhaustive complexity study of all mono-criterion, bi-criteria, and tri-criteria problems: we exhibited polynomial algorithms for the simpler instances and NP-completeness proofs for the more intricate ones. We designed several heuristics for the most general problem [1192]. We then considered series-parallel graphs and the minimization of the energy consumption given a bound on the period. We studied the complexity of the problem and designed practical heuristics [1210].

We have investigated the execution of a task graph when its mapping is given. We minimized energy consumption given a bound on the execution time, knowing that one can change the execution speed of each task. We studied the impact of several speed variation models on the problem complexity. For continuous speeds, we gave a closed-form formula for trees and series–parallel graphs, and we cast the problem into a geometric programming problem for general directed acyclic graphs. We showed that the classical dynamic voltage and frequency scaling (DVFS) model with discrete modes leads to an NP-complete problem, even if the modes are regularly distributed (the incremental model). On the contrary, the Vdd-hopping model –that allows to change voltages while executing a task– leads to a polynomial-time solution. We also provided an approximation algorithm for the incremental model, which we extended for the general DVFS model [1206].

In a slightly different context, there is a set of clients who submit streams of requests that must be answered by servers in a tree-shaped network. Given a set of existing servers, and dynamically evolving streams of requests, the problem is to find which server to replicate, and where to locate servers, so as to minimize the energy consumption without exceeding a bound on the cost of server creation and migration [1218, 1270].

We have investigated the routing of communications in chip multiprocessors (CMPs) from the point of view of energy consumption. We quantified the benefits that can be gained by using a Manhattan routing rather than an XY routing [1286].

For applications using non-blocking periodic coordinated checkpointing to enforce resilience, we provided a model and detailed formulas for the total execution time and the consumed energy. We characterized the optimal period for both objectives, and we assessed the range of time/energy trade-offs to be made by instantiating the model with a set of realistic scenarios for Exascale systems. We gave a particular emphasis to the cost of I/O transfers [1296].

Memory-aware algorithms

In these studies, we focused on the complexity of traversing tree-shaped workflows whose tasks require large I/O data. Such workflows arise in the multifrontal method for sparse matrix factorization. The large memory footprint of some input matrices requires a careful schedule of the workflow in order to complete the factorization with a limited memory. A task in the workflow can be processed if all its predecessors have been processed, and if its input and output data currently fit in the memory. The amount of memory used at a given time depends on the ordering in which the tasks are executed.

In a first study [1277], we focused on finding the minimum amount of memory necessary to process the whole workflow, and on schedules that achieve this minimum. We proposed a new, polynomial time, exact algorithm that runs faster than a reference algorithm. We also compared the performance of such a memory-optimal traversal with postorder traversals, which are used in practice. We showed that although the best postorder can be arbitrarily bad compared to the optimal traversal, it has a behavior close to the optimal on task trees corresponding to the factorization of actual matrices. We also considered the out-of-core processing of such workflows. Then, the question is: what is the minimum amount of I/O required by the computation? We showed that this problem is NP-hard, and proposed efficient heuristics.

In a second work [1312], we pursued our investigation, this time considering multiple processors. In this setting, one also has to minimize the tree execution time (the makespan). Not surprisingly, this bi-objective problem (makespan and memory minimization) has proven to be much harder. We studied its computational complexity and provided inapproximability results even for unit weight trees. Several heuristics were proposed, each with a different optimization focus. We also proposed heuristics for the more realistic case where the amount of available memory is fixed. As in the previous study, we have tested and analyzed all proposed heuristics on trees arising in the context of sparse matrix factorizations.

Numerical kernels for dense linear algebra

The usual matrix factorization algorithms need to be redesigned on massively parallel systems. We have introduced HQR, a flexible QR factorization algorithm that introduces many eliminator tiles per panel, several levels of reduction trees, and outperforms all current competitors [1214]. We have also proposed a hybrid LU/QR algorithm that alternates between LU and QR steps; LU steps use local pivoting within domains and reach over 90% of platform peek performance; QR steps are taken only when required to guarantee numerical stability. Several criteria to switch between LU and QR steps are compared, thereby providing a wide range of trade-offs between speed and stability [1318].

Direct solvers for sparse linear systems

Sparse linear algebra is at the heart of many applicative fields related to numerical modeling, and sparse linear solvers are often a key component for the efficiency of large scale simulation on high performance computers. For methods involving direct factorization of the matrix (so called direct solvers) our numerical algorithms have been revisited from two complementary perspectives.

Scalability on multicores and distributed architectures. We have worked on new approaches to efficiently handle multiple threads within a node and showed that the OpenMP paradigm combined with multithreaded BLAS could be very efficient, and that NUMA architectures could be handled with adapted memory allocation policies [1224]. On large numbers of processors, we have also exposed our algorithms to finer grained parallelism in order to control reliably the memory consumption of parallel methods with memory-aware algorithms [1359]. Both in a limited-memory context and in case of huge numbers of nodes, the management of asynchronism and of immediate collective communications has shown to be critical. In this starting work, specific asynchronous broadcast algorithms were modeled [1314].

Low-rank compression. A new approach dedicated to PDE based applications relying on low-rank approximations has been designed. We have shown that low-rank approximation methods can be effectively used in multifrontal solvers through a novel approach called Block Low-Rank [1355, 1361, 1363, 1357] which delivers more than one order of magnitude reduction in the complexity on some PDE based applications. Recent work based on hierarchical formats used at the Purdue University and the Lawrence Berkeley National Laboratory (LBNL) are an alternative to our work. We have shown, in tight collaboration with LBNL, that our BLR approach has comparable complexity while providing a better potential for preserving other numerical features (such as robust partial pivoting needed, for example, for applications in structural mechanics) and for preserving computational efficiency (fast kernels and flexibility for exposing parallelism), opening new interesting perspectives for research and industrial collaborations.

Combinatorial scientific computing

We have three main research direction on Combinatorial scientific computing (CSC): graph and hypergraph partitioning and clustering; matching in graphs and hypergraphs; and task mapping and scheduling.

Our interest in the graph and hypergraph partitioning arises from the parallelization requirements of sparse matrix computations: often, achieving load balance while reducing the communication cost for efficient parallelization can be cast as a graph/hypergraph partitioning problem. Our recent work includes parallelizing sparse matrix scaling algorithms on multi-threaded systems with the most common OpenMP programming principles [1288]; investigating the communication aspects of the sparse matrix vector multiply operations [1362] and tuning partitioning methods for those [1336]. Some other work investigates special partitioning instances arising in important applications [1200, 1265, 1290]. More fundamental work includes algorithms for two dimensional partitioning of sparse matrices [1184, 1187], which became more popular in large scale graph analysis applications. We also used our know-how to design effective clustering algorithms for large data sets [1337].

In the sparse direct solvers context, algorithms for the maximum cardinality matching problem in bipartite graphs are used to detect the reducibility of the linear systems (if so tangible reductions in the running time and memory requirements are achievable). We implemented almost all practical algorithms for this matching problem [1196, 1215]. This helped us identify the most efficient ones. Once acquainted with the most effective techniques, we adapted them for the current multi-core [1287] and many-core [1307, 1308] computing systems. We also conducted more theoretical studies on the matching problem, in particular its implication for symmetric matrices lacking a perfect matching [1185].

We investigated task graphs that arise in sparse direct solvers, and addressed problems related to their mapping and scheduling. We investigated constructing such graphs for recent solvers and designed an algorithm with the best known asymptotic time complexity [1216]. We also investigated the peak memory requirements of some well-known solvers when executing the associated task graphs sequentially [1277] (see also Section 8.3.1). We have worked on matchings in hypergraphs as a tool for the task mapping problem in parallel systems with processors having different capabilities [1303].

8.3.2 Visibility

The team visibility is best exemplified by our involvement in numerous program committees and, especially, by the numerous program committees where we were vice-program chairs (Cluster 2012, HiPC 2010, HiPC 2012, HiPC 2014, ICPP 2011, ICPP 2013, ICPP 2014, IPDPS 2013, IPDPS 2014, SC'14) or program chairs (HCW 2010, ICPP 2013).

8.3.3 Collaborations

The team had international collaborations leading to joint publications with: Arnold Rosenberg from Northeastern University, USA; Aurélien Bouteiller, George Bosilca, Jack Dongarra, Thomas Hérault, Jakub Kurzak and Piotr Luszczek from the University of Tennessee, Knoxville, USA; Cleve Ashcraft from LSTC (Livermore Software Technology Corporation), USA; Cevdet Aykanat from Bilkent University, Turkey; Erik Saule from University of North-Carolina Charlotte, USA; Franck Cappello, Sheng Di, and Marc Snir from Argonne National Laboratory; Henri Casanova and Lipyeow Lim from University of Hawai'i at Mānoa, USA; Iain S. Duff from Rutherford Appleton Laboratory, Didcot, UK; Julien Langou from the University of Colorado, Denver, USA; Kamer Kaya from Sabanci University, Turkey; Kunal Agrawal from the Washington University in St. Louis, USA; Xiaoye S. Li, from the Lawrence Berkeley Laboratory, USA; Cristian Pozza and Michele Forzan from Padova University, Italy; Oliver Sinnen from the University of Auckland, New Zealand; Philip A. Knight from the University of Strathclyde, UK; Qishi Wu from the University of Memphis, USA; Rami Melhem from the University of Pittsburgh, USA; Ümit V. Çatalyürek from the Ohio State University, USA.

The team had national collaborations with joint publications and/or research projects with the following teams (labs): Grand-Large (LRI), HiePACS (LaBRI), Cepage (LaBRI), Runtime (LaBRI), Moais (LIG), PopArt (LIG), Mescal (LIG), Bamboo (LBBE), APO (IRIT), CERFACS and CEA/CESTA.

The team had industrial collaborations with EDF R&D, ESI Group, EADS-IW, CEDRAT, SAMTECH, TOTAL, and EMGS.

8.4 Training through research

Two permanents members of ROMA defended their Habilitation thesis (HDR) at ENS Lyon since 2009: Anne Benoit in July 2009, and Jean-Yves L'Excellent in October 2012.

Since January 2009, six ROMA students have defended their PhDs: Fanny Dufossé (September 2011), Matthieu Gallet (October 2009), Mathias Jacquelin (July 2011), Veronika Rehn-Sonigo (July 2009), Paul Renaud-Goud (July 2012), Clément Rezvoy (September 2011). Three additional PhD students should defend their PhD before the end of 2014: Guillaume Aupy, Mohammed Wissam Sid-Lakhdar, and Dounia Zaidouni. Among the five students who defended their PhDs before december 2011, 4 have a permanent position: Veronika Rehn-Sonigo is associate professor at IUT Besançon-Vesoul; Fanny Dufossé is an INRIA junior research scientist at Lille; Matthieu Gallet is a research engineer at the French Department of Defense; and Clément Rezvoy is an engineer in a start-up company. Mathias Jacquelin is a post-doctoral student at Lawrence Berkeley National Laboratory, USA.

Anne Benoit, Yves Robert, and Frédéric Vivien co-authored the textbook "A Guide to Algorithm Design: Paradigms, Methods, and Complexity Analysis" [1335]. Yves Robert and Frédéric Vivien co-edited the textbook "Introduction to scheduling" [1340]. Roma organized a "research school" on application resilience in Dec. 2012. Since 2013, Frédéric Vivien is head of the LIP PhD committee and is the laboratory correspondent for the doctoral school Infomaths (previously, he was the committee vice-head).

8.5 Research project

8.5.1 Self-assessment and SWOT analysis

Strong points

We believe that the team has a very good worldwide visibility and recognition, and a strong publication track. We chair or are members of numerous program committees, and stand on the editorial board of several journals. We have some strong and long-term international collaborations. There are strong collaborations (and many co-publications) between permanent team members. The team expertise covers the full range from theoretical work to software development and industrial applications. The team is renewing its main focus at a dynamic (but reasonable) pace. In the last five years, we have started investigating new topics (e.g., resilience, combinatorial scientific computing), and got acquainted with new mathematical and algorithmic techniques (e.g., probabilistic optimization and multi-criteria optimization).

Weak points

The team has not hired any new permanent member since January 2009. During the reporting period the team failed to secure external recurrent fundings to hire engineers for the development of the MUMPS software platform.

Opportunities

The close presence of the students of ENS Lyon enables us to hire high-quality PhD students. The MI-Lyon Labex offers many funding opportunities. The software agreement signed in 2012 and the consortium agreement that should be signed in 2014 around MUMPS should give the opportunity to set-up recurrent fundings for the development of MUMPS.

Risks

Apart from the risks shared nowadays by most, if not all, research teams (uncertainties on fundings, lack of hiring positions, etc.), the main risk for the team is the obsolescence of MUMPS if software development is insufficient.

8.5.2 Research objectives

Among all the problems that will have to be solved to enable the efficient utilization of modern and future computing platforms, the ROMA team is devoted to the study of the fault tolerance, the energy consumption, and the memory usage of scientific computing applications executed on clusters and on supercomputers, with a special interest in direct solvers for sparse linear systems. The work of the ROMA team is organized along the three following research themes.

1. **Resilience.** We focus on the efficient execution of applications on failure-prone platforms. Here, we typically address questions such as: Given a platform and an application, which fault-tolerance protocols should be used, when, and with which parameters?
2. **Multi-criteria scheduling strategies.** We focus on the design of scheduling strategies that finely take into account some platform characteristics beyond the most classical ones, namely the computing speed of processors and accelerators, and the communication bandwidth of network links. In the scope of this theme, when designing scheduling strategies, we focus either on the energy consumption of applications or on their memory behavior. All optimization problems under study are multi-criteria.
3. **Solvers for sparse linear algebra and related optimization problems.** We work on most aspects of direct multifrontal solvers for linear systems, usually in the scope of the MUMPS solver we co-develop. We also work on combinatorial scientific computing, that is, on the design of combinatorial algorithms and tools to solve combinatorial problems, such as those encountered in the preprocessing phases of solvers of sparse linear systems.

Resilience

An application is resilient if it can successfully produce a correct result in spite of potential faults in the underlying system. Application resilience can involve a broad range of techniques, including fault prediction, error detection, error containment, error correction, checkpointing, replication, migration, recovery, etc. Faults are quite frequent in the most powerful existing supercomputers (on the order of a fault per day). Furthermore, it is feared that the progresses in reliability will far from compensate the steady projected increase of the number of components in the largest supercomputers. In such a context, any application using a significant fraction of a supercomputer and running for a significant amount of time will have to use some fault-tolerance solution. Our research on resilience will follow two different directions. On the one hand we will design new resilience solutions. On the other hand we will model and theoretically analyze the performance of existing and future solutions, in order to tune their usage and help determine which solution to use in which context.

Algorithm-based fault tolerance. Whenever possible, rather than resorting to generic solutions, one should use application-specific approaches. This is in particular the case for dense linear algebra kernels. Currently, the solution of choice for the resilience of dense numerical kernels is called *Algorithm-based fault tolerance* or *ABFT*. In dense linear-algebra kernels, the regular layout of the data along a 2D-grid, together with a pipelined execution flow across that grid, is the key to enabling ABFT: extra rows and extra columns are dedicated to provide fault-tolerance by maintaining error-correcting codes. The question on the potential limit of the scalability of ABFT techniques at very-large scale is open. The trade-off between the numerical benefit and the extra cost on computing resources must be examined and evaluated when varying the number of computing elements and the rate of faults. In addition, the hierarchical nature of exascale architectures calls for the design of hierarchical ABFT approaches, with several levels of fault tolerance.

Analysis of fault-tolerance protocols. Many fault-tolerance approaches and protocols have recently been proposed. A few studies experimentally compare several fault-tolerance protocols. Most of the time, however, new solutions are only validated through proofs of concept, because the amount of computing time needed to perform a "true" experimentation campaign would be prohibitive. It is therefore necessary to theoretically model and study fault-tolerance protocols in order to determine the best set of parameters for each protocol, and which protocol to use in which context. We plan to perform this type of theoretical studies: modeling platforms, applications, and fault-tolerance protocols, and determining either exactly or through some first-order approximation the optimal performance of the studied system. Analytical findings will be verified through extensive simulation campaigns using discrete-event simulators.

Multi-criteria scheduling strategies

In this theme, we study and design scheduling strategies, focusing either on energy consumption or on memory behavior. In most existing studies, a single optimization objective is considered, and the target is some sort of absolute performance (e.g., the minimization of the application execution time). Such an approach can lead to a significant waste of resources, because it does not take into account any notion of efficiency nor of yield. In all our work, we plan to look only for algorithmic solutions that make a "clever" usage of resources. However, looking for the solution that optimizes a metric such as efficiency, energy consumption, or peak of memory usage, is doomed for the applications we consider: in most cases, any optimal solution for such a metric is sequential, and sequential solutions have prohibitive execution times. We thus have to consider multi-criteria approaches where one looks for trade-offs between some user-oriented metrics that are typically related to notions of Quality of Service—execution time, response time, stretch, throughput, latency, reliability, etc.—and some system-oriented metrics that guarantee that resources are not wasted. In general, we will look for solutions that minimize some given objective while satisfying some bounds, or "budgets", on all the other objectives.

Energy-aware algorithms: Fault tolerance and energy minimization. Energy issues are now also important for traditional computer systems: the design specifications of any new computing platform now always include an upper bound on energy consumption. We plan to focus on energy-consumption issues in the scope of failure-prone platforms. Until now, fault-tolerance protocols have been mostly studied from the point of view of the execution time of applications. These protocols should instead be optimized to decrease energy consumption (e.g., what is the optimal checkpointing period for energy minimization?). A good starting point would be the study of multilevel checkpointing algorithms. Furthermore, powering parts of a computing platform below nominal values could lead to aggressive energy savings. However, this would greatly raise the probability of error occurrence (e.g., data corruption). The idea would be to execute in such a context naturally fault-tolerant applications. The question is then whether such an approach could lead to (significant) energy savings. In multi- and many-core platforms, one could go even further and power some cores below their nominal values and some others above that threshold. An application could then run on a mix of reliable and unreliable cores.

Memory-aware algorithms. For years, the computing power of processors has been increasing more rapidly than the bandwidth between memory and processors, and the memory latency has been improved at an even slower pace. Thus, in the time needed for a processor to perform a floating point operation, the amount of data transferred between the memory and the processor has been decreasing with each passing year. The risk is for an application to reach a point where the time needed to solve a problem is no longer dictated by the processor computing power but by the memory characteristics. Because of these trends, one must take memory constraints into account when designing algorithms.

We will focus on the memory-aware scheduling of task graphs. There, the processing of each task requires the presence of some input data in memory, uses some temporary memory, and produces some output that may have to remain in memory because of some later reuse. The order in which tasks are processed can have a significant impact on the maximum amount of memory needed for the processing of the whole task graph. We plan to design algorithms to process tree-shaped task graphs in parallel, and algorithms to process general graphs or, some classes of graphs such as series-parallel graphs. We also plan to investigate how to process tree-shaped task graphs on hybrid platforms, consisting of CPU cores and accelerators. We will consider these problems both in very general settings, and in the particular context of direct solvers for sparse linear systems for which memory usage is especially important.

Solvers for sparse linear algebra and related optimization problems

Our work in this theme is organized along two research directions. The first direction is devoted to direct solvers of sparse linear systems, where we aim at solving very large problems on large numbers of cores (current target: 1 billion equations on thousands of cores). The second direction is devoted to combinatorial scientific computing, that is, the design of combinatorial algorithms and tools that solve problems encountered in some of the other research themes, including the problems faced in the preprocessing phases of sparse solvers.

Direct solvers for sparse linear systems. The solution of sparse systems of linear equations is at the heart of many scientific applications arising in domains such as geophysics, structural mechanics, chemistry, electromagnetism, numerical optimization, or computational fluid dynamics, etc. Therefore, any significant progress on solvers will impact many application domains. Research on sparse direct solvers is very active because: 1) many applications fields require large-scale simulations that are still too big or too complicated for existing methods; 2) the current evolution of architectures with massive, hierarchical, multicore parallelism imposes to overhaul all existing solutions; 3) the evolution of numerical needs and types of simulations increase the importance of certain classes of matrices, which may benefit from a specialized processing. In this context, we aim at designing parallel sparse direct methods that will scale to large modern platforms, and that are able to answer new challenges arising from applications, both efficiently and accurately. For that, and even with increasing parallelism, we do not want to sacrifice in any manner numerical stability, based on threshold partial pivoting, one of the main originalities of our approach in the context of distributed-memory computers. Although this makes the parallelization more complicated, applying the same pivoting strategy as in the serial case ensures the numerical robustness of our approach. Among direct methods, we rely on the multifrontal method. Our work is organized along two research directions: 1) we aim at efficiently addressing new architectures with massive, hierarchical parallelism; 2) we aim at reducing the running time complexity and memory requirements of direct solvers, while controlling accuracy.

Addressing massive, hierarchical, parallelism. This concerns the necessary adaptation of our approaches to modern high performance computers, in particular large clusters of multicore nodes. In this context, it is necessary to move from a pure distributed-memory parallelism paradigm based on message passing towards a hybrid parallelism paradigm using both message-passing and multithreading. There are two main approaches to achieve this goal. One is to employ complementary technologies such as MPI and OpenMP — an approach that, despite its complexity, has the merit of being robust and reliable. The other is to use the so-called "runtime systems" such as StarPU or PaRSEC. These runtime systems correspond to a novel programming paradigm that may be better suited to modern architectures and, specifically, to large multicores and to systems equipped with accelerators such as GPUs or MIC devices. We will investigate both approaches.

Exploitation of low-rank representations. Low-rank approximations are commonly used to compress the representation of data structures. The loss of information induced is often negligible and can be controlled. We want to exploit low-rank properties in order to reduce the demand of sparse direct solvers in terms of floating-point operations and memory usage. Although the dense internal data structures involved in a multifrontal method (the frontal matrices) are full-rank, their off-diagonal blocks can often be represented by a set of products between low-rank matrices. We will study the capacity of this representation to reduce the complexity of both the factorization and solve phases, according to different possible ways of grouping the system unknowns. We plan to study both how the execution time and the memory usage can be reduced by employing the Block Low-Rank (BLR) format. Our goal is to carefully analyze both the numerical and structural properties that are required to exploit low-rank properties so that we can understand how to design a robust and general sparse solver that will accommodate features such as numerical pivoting and out-of-core solution.

Combinatorial scientific computing. Combinatorial scientific computing (CSC) is an interdisciplinary research field at the intersection of discrete mathematics, computer science, and scientific computing. It refers to the development, application, and analysis of combinatorial algorithms to enable scientific computing applications. CSC's deepest roots are in the realm of direct methods for solving sparse linear systems of equations where graph theoretical models are central to the exploitation of sparsity. The general approach is to identify performance issues in a scientific computing problem, such as memory use, parallel speed up, and/or the rate of convergence, and to develop combinatorial algorithms and models to tackle those issues. Our target scientific computing applications are (i) the preprocessing phases of direct, iterative, and hybrid methods for solving linear systems of equations; and (ii) the mapping of tasks. We have two focus areas in CSC. The first one is the development and the use of graph and hypergraph models, and related tools such as hypergraph partitioning algorithms, to solve problems of load balancing and task mapping. The second one is bipartite graph matching and vertex ordering methods for reducing the memory overhead and computational requirements of solvers. Although we work on these problems through the lens of linear system solvers, our solutions are general enough to be applied to some other resource optimization problems. We describe our upcoming research in these two focus areas.

Hypergraph partitioning. A hypergraph is a set of vertices and a set of hyperedges each of which is a subset of vertices. The standard hypergraph partitioning problem asks for a partitioning of the vertices into a given number of parts. The partitioning objective is to minimize a cut function associated with the hyperedges that straddle the cut; and the partitioning constraint is to maintain a notion of balance among vertex parts. The hypergraph partitioning problem is NP-complete, hence heuristic algorithms are used. All of the heuristics used in the state-of-the-art partitioners are based on the multilevel hypergraph partitioning paradigm. The algorithms that adopt this paradigm consist of three phases: (i) an incremental coarsening of the original hypergraph into a smaller hypergraph; (ii) an initial partitioning of the coarsest hypergraph; and (iii) a projection of the partition found in the second phase to the original hypergraph by refining the partition at each intermediate hypergraph. These methods have no performance guarantee. Currently, we do not have any generic means to measure the success of the state-of-the-art tools on instances. Therefore, we need to investigate the success/performance of those tools and develop alternatives. Alternative methods specialized for particular classes of hypergraphs are especially required. Recently, we have investigated two different classes of hypergraphs, and have presented fast algorithms that deliver better results than the state-of-the-art partitioning tools on those classes. Assuming that a hypergraph can be gradually transformed into one with a special structure, one can combine specialized partitioning algorithms with ideas similar to those used in the multilevel paradigm in an attempt to obtain general partitioning algorithms. In the forthcoming years, we plan to identify classes of hypergraphs that arise in important applications, and investigate the associated partitioning problems theoretically and algorithmically.

Bipartite matching. Given a bipartite graph, the maximum cardinality bipartite matching problem asks for a set of edges with maximum cardinality where no two edges in the set share a vertex. The problem is polynomial time solvable, and there are well-known algorithms. The algorithms with the best asymptotical worst-case time complexity have a running time of $\mathcal{O}(\sqrt{n}\tau)$, where n is the number of vertices and τ is the number of edges in the given bipartite graph. We find $\mathcal{O}(\sqrt{n}\tau)$ high, as evidence suggests that $\mathcal{O}(n \log n)$ could be possible for a certain class of matching algorithms. This discrepancy between the possibility and existing solutions forms the basis of our long term research. We ask the following questions: Is there a non-trivial lower bound for the running time complexity of a maximum cardinality matching algorithm? Does there exist an algorithm that attains that running time bound? Answering the questions above is a formidable task; it entails finding computational models for possible algorithms. Therefore, we ask more practical questions as short term goals, such as, how can we adapt matching algorithms to run efficiently on the modern computers?

9 Progress report and perspectives: IT Support Team MI-LIP

9.1 Organisation of the team

Current team members

Permanent and Fixed Term Engineers				
Name	First name	Function % of time (if other than 100%)	Institution	Arrival date
DELAMARE	Simon	Research Engineer (IR), 50 %	CNRS	2012
MIGNOT	Jean-Christophe	Research Engineer (IR), 50 %	CNRS	1996
PONSARD	Dominique	Study Engineer (IE)	CNRS	1999
TORRES	Serge	Research Engineer (IR), 60 %	ENS de Lyon	2001

9.2 Executive summary

Keywords
IT infrastructure management, scientific research support, scientific instruments operation.

Research area
The MI-LIP does not have *per se* a research area: its activity comes in support of scientific investigations on behalf of the laboratory research teams and, partly, of external scientists.

Main goals

- build and manage an IT environment for the laboratory activities (research, dissemination, administration. . .);
- provide support and expertise to research teams for their specific projects;
- participate to the global operation of the experimental distributed platform Grid'5000 and manage its Lyon local node.

Methodology
In its IT management activity, the team strives to follow the "rules of the trade" of the field. It progressively adopts, as they appear, more formal standards (e.g. ISO 2700x on security). Team's proficiency about these methods and tools is maintained through regular training.

Highlights

- a sound and convenient to work with IT infrastructure for the laboratory day to day duties;
- several specific and customized services to suit particular research needs;
- operation of Grid'5000 as a global instrument (partial reponsability), local Lyon evolution and upgrade (full responsability).

The MI-LIP team does not have an independent research activity. It operates in support of the research teams and activities of the laboratory and offers services to external users.

9.3 Main evolution in organization and activity

9.3.1 Staff

The single most important evolution has been the hiring of Simon Delamare as a permanent Research Engineer. This long waited arrival helps, on the one hand, to mitigate risks and weak points pointed out in our previous report (insufficient work force, instability caused by temporary hired engineers departures). On the other hand integration of "young blood" to the team has also helped to reinvigorate its activity and dynamics.

9.3.2 Directions in activity

A shift has been taken, from a rather user-support centric activity to a more infrastructure-oriented effort.

Usage and expectations of the users have evolved over the time span covered by this report. Less emphasis is nowadays necessary on installation and support of individual workstations that are largely replaced by laptops, from different brands and models (PCs, Apple Mac, netbooks. . .) directly managed by their users. This change in format also induces an evolution in the operating model that becomes closer to the BYOD ("Bring Your Own Device") practice, even if equipment is generally funded by the laboratory affiliated to institutions and remains their property. Mobile devices are user-managed, they house personal and professional data and applications, they become the entry point to a full range of IT services not (at all) limited to institutional environment that becomes only a part of it.

Another trend is the increasing availability of external resources, notably in the (high-performance) computing field. In this context, the team's point is less that of building a local computing infrastructure: due to scarcity of resources home-brewed solutions will less and less be able to compete with the tools offered at different levels (from the local to the international level). In this field, duplication of efforts is not only futile but it can also be harmful (resource waste, orienting local scientists to dead-ends).

Hence, at the lower end of the needs spectrum, the team's activity has focused on the provision of services that can not be efficiently arranged at the individual level and where pooling makes sense (storage, backup, printing. . .), specialized shared equipment (professional video conferencing equipment. . .), computing resources specific to the research being conducted in the lab, that have to seen more as test beds than production environments.

At the higher end, work has continued (and will continue) on Grid'5000 to actively participate in the operation of a significant scientific instrument (more on this in Appendix 3. Equipment list) or a new activity is starting in order to help the lab's scientists to use external computing resources. As it has been noted, despite of the communication efforts of the service providers, the lack of mediation may curb their wide-scale adoption.

9.3.3 Evolution in methods

Another evolution is not only about what is done but also in how things are getting done.

This has two aspects:

- the methods;
- pooling and/or outsourcing.

Shifting methods

Over the last years methods have changed from that of the craftsmen to more industrial ones. Advances in technology and the wide scale availability of new tools allow for the centralization of very fine-grained configurations management (for the installation and maintenance of equipment and services) and the automatic surveillance of the infrastructure (supervision tools). An large effort has been undertaken to deploy these tools, to use them for new services, and to retrofit older ones with the new features.

Pooling and/or outsourcing

The basic ideas are not to duplicate the work that is done else where and when outsourcing is not possible, share the burden with others. It has been applied in several realms (authentication, storage, backup, forge. . .). Nowadays, available tools offer a comfortable level of customization that allow resources or infrastructures to be operated in pool and yet make every stakeholder feel at home. The advantages are, of course, a better resource usage optimization but also a better service quality (better support).

9.4 Self-assessment and SWOT analysis

Some progress has been made on the mitigation of the weak points and risks since our previous report. The quickly changing local and global environment in the realm of research and higher education opens new opportunities but also creates new risks.

Strong points

- experienced and mostly stable workforce: most engineers are with the LIP for several years and are well integrated within the laboratory and the ENS de Lyon; from this perspective, the arrival of a new member can not be considered, all of the contrary, as a weakening of the team as quicky integrated his work environement; this fosters a capacity for autonomous work of the members;

- the well engaged process of organizational strengthening and strategic refocusing: this will help to have, on one hand, a more robust infrastructure and, on the other hand, allow for a more optimal use of resources; the team has rather clear directions for its activity in the forthcoming years;
- a wide and rather coherent base of services and platforms: along the years, the team has built a suite of elements that provide a comfortable to work with environment for the laboratory. Future efforts will enable to capitalize over the existing base to extend and upgrade it;
- fruitful partnership with other bodies at ENS: good collaboration and sometimes service sharing have been established with ENS IT department and, for instance, "Centre Blaise Pascal" and PSMN;
- direct participation to research work of team members ; almost all of them have a split workload: one part with the MI-LIP team, another with a research team; this has two benefits: an insider's view of researchers needs, the mitigation the lassitude that may arise from the mere repetition of IT administration work.
- revamped basic elements of infrastructure (e.g. local data center and network equipment) that allow to cope with the current and medium-term needs of the laboratory;
- the team has been acknowledged twice (and currently is) as a CTAI (Automatic Data Processing Center) by the CNRS, in view of its activity.

Weak points

- a too loose articulation between the MI-LIP team and the laboratory as a whole; all attempts to revive some kind of "users committee" have failed; this is mitigated by other elements described elsewhere in this section but is nonetheless worrisome;
- limited workforce that delays the implementation of the new projects: the long time spans between decisions and actual deployment make it difficult to keep the focus and require some self-discipline to get the projects completed; that has to do with weaknesses in project management as well;
- lack of focus on the security issues which will get a larger share in the forthcoming years activity;
- lack of proper documentation either internally (corrected to some extent by the centralized configuration system) or externally, for the lab's users; this has to be taken more seriously since it can jeopardize the return on investment (in our case, in terms of money/effort invested over of actual user usage and satisfaction) of some operations;

Opportunities

- the successful participation of the lab or it's teams in several calls for projects allows for a comfortable (if not extravagant) IT budget;
- within the so-called "Plan Campus", the renovation and long-waited extension of the lab's premises will be realized; this will include network revamping and also a relocation of other entities inside the Ens ; beyond the direct benefits for the laboratory and IT operations, this will allow to envision new collaborations or even further reshuffle in activities with, for instance, the "Centre Blaise Pascal";
- new offers from research or higher education institutions in the field of IT resources will widen the spectrum of available options for services and functions ; this may allow to alleviate the burden of some tasks that are done internally and also open new opportunities in the area of technical mediation to empower the scientist with these new tools;

Risks

- the speed in changes in the environment that may make it hard for the team to keep the pace; current planning may have to adapt quickly under new constraints;
- consequently, the risk of being torn between alternatives (new services / traditional ones, research / IT administration, divergent options for new activities);
- team's workforce reduction and/or leave(s) (even if balanced by new input, itself uncertain); one leave (for retirement), at least, can be taken as granted in the next years.

9.5 Perspectives

The perspectives are organized around three directions:

- consolidate the betterment of the previous period;
- correct the weak points;
- develop new services and/or new perspectives.

These mainlines will, with variable intensity, traverse the more specific items listed in the project implementation section. The overall objective is to create a state-of-the-art compliant set of tools and an environment that makes the laboratory activity more efficient.

9.6 Project implementation

We will detail here, in more operational term, how we mean to reach our goals.

9.6.1 Multi-annual investments planning

As stated before, the financial situation of the laboratory and the commitment of its management allow for a multi-annual investments planning. This gives visibility to both the laboratory head and the IT team on economical issues and allows the latter to focus on operation and services.

9.6.2 Security policy

The recent simplification of the CNRS procedures for the elaboration of Information System security policies make it possible (and at the same time absolutely mandatory) to design an action plan in this field. Nevertheless this remains a big challenge and the laboratory will seek for help (e.g. momentary staff reinforcement for the elaboration action plan and launch).

Even if it was in an informal way, security issues have always received a very serious consideration in the design of the laboratory IT services. The team intends to take a step further by taking into account the impact of the projects on the improvement the overall security level as criteria for their selection and scheduling. The security action plan and the general planing will have to work hand in hand.

9.6.3 Infrastructure consolidation, platform evolution

There are still some systems and services that live out from the realm of the centralized configuration management and operational supervision. They will be eventually integrated. However, in some fields such as data storage, what is planed is more a change of scale than a mere consolidation. As for computing services, raw power will remain within its current somehow modest (by today standards) level. Focus will be kept on the diversity of approaches and on making emerging architectures available and easily exploitable for researchers. In the intensive computing area a stronger accent will be put on outsourcing (see below).

9.6.4 Traditional services in new clothes + new services

The general evolution in computing services and usage (cloud computing, Saas, ubiquitous and multi-platform access to data, among others) can only have a strong impact the form under which traditional services are delivered. This is not a matter of "fashion victimization" of academic IT services but is only acknowledgement of real-world reality. The challenge is to uphold the relevance of the internal offer and, as a consequence, "customer" loyalty to it. At the same time, the extensive recourse we observe to external consumer-market oriented operators for vital services, such as professional data storage, raises a lot security issues that have been heavily illustrated in the recent years. Our affiliation institutions have shown a serious concern on the incurred risks.

On the other hand the tight coupling of individual professional data and specialized computing tools nowadays offered in the laboratory still has a lot of appeal to our researchers audience. But what is necessary now is an accessibility that matches the new usages:

- multiple terminals and systems;
- ubiquitous access.

Tackling these issues will be an important work direction for the coming years. Their fixing will also involve interaction with our hosting institution (Éns de Lyon) and its own IT infrastructure.

The generalization of personal devices also raises new needs. Backup is the first thing that springs to mind. It is not only a matter of user data protection : what is needed here is the ability to backup and restore full systems, a big leap in storage capacity. This is presently done for the laboratory staff laptops and that kind of services will be extended to other users. While this by no means a new service, the unprecedented scale of data volume and the very behavior of the users deeply transform the conditions of its operation.

At the same time, to make them acceptable to users, the latter must be shielded from the intricacies involved with these revamped and new services. All this is another substantial work direction: making sophisticated tools look simple is always a challenge.

9.6.5 Accompaniment of change

The previously expressed concerns have also been taken into account by different bodies (RENATER, CNRS, INRIA, GENCI, Universities and schools. . .) operating in the academic field and we witness a proliferation of initiatives and services coming from different sources, all aimed to the research community. If not all are relevant and if some simply will never happen at all, an important part of the team activity will directed to help our audience in leveraging these new tools. This is perfectly clear in the realm of production computing where team main role, as already stated, is to empower the users with the existing medium to high performance computing resources rather than trying to duplicate them in-house. This will require, but is not limited to, specific training for the IT team and a strong communication/documentation effort directed to the laboratory community (see below). A personalized, hands-on accompaniment of the researchers will also needed to put them one foot on the stirrup.

9.6.6 Information and documentation

Performing systems and service have no impact on the laboratory activity if they are not known to the community. They are merely IT staff toys. As pointed out previously information and communication are fields where there is much room for improvement. The task of building a good (possibly all-inclusive but over all up-to-date) documentation is inescapable and a good starting point. But this will not be enough in our information saturated environment: advertising, quick presentations, hands-on sessions and other initiatives based on direct contact will also be called in to spread the word about existing and new services and help for their adoption by users. Eye-to-eye contact with them in this context will also play as a feedback channel about their needs and their satisfaction (or lack of it).

A particular focus will also be put on IT security information. The perspective will not be that of moral blame and exhortation alone but will try to be as solution-oriented as possible and linked to team global service policy.

Internal documentation will also be consolidated. Some kind of project management tool (not necessarily a full fledged planning application) will be used to cope with the already mentioned problem caused by the long time spans taken by projects.

9.6.7 IT Training

The notice of the the quick path of evolution in the realm of IT is to much of a truism to be shamelessly recalled here. So much for the permanent need for training for IT team members. This endogenous technological catch up necessity, with the constant support of the laboratory head, has been coped with in the last years in a rather satisfactory way. But we have to look beyond, to less obvious training fields will have to be covered in the coming years. In this regard, gathering expertise with the operation of tools and services made available to our community by other bodies or institutions is instrumental in being able to efficiently play a bridging role between the former and the latter.

Annexe 1 / Appendix 1. Présentations synthétiques / Executive summaries

1.1 Présentation synthétique : équipe Aric

Nom du responsable de l'équipe pour le contrat en cours: F. de Dinechin (01/10–07/13), J.-M. Muller (07/13–).

Nom du responsable de l'équipe pour le futur contrat: Bruno Salvy et Gilles Villard

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Effectifs de l'équipe (au début du contrat en cours)

2 enseignants-chercheurs: Florent de Dinechin (MCF ENS Lyon) et Nicolas Louvet (MCF Université Claude Bernard) ; 4 chercheurs: Nicolas Brisebarre (CR CNRS), Claude-Pierre Jeannerod (CR Inria), Vincent Lefèvre (CR Inria), Jean-Michel Muller (DR CNRS), Nathalie Revol (CR Inria), Gilles Villard (DR CNRS) ; 2 techniciens, ingénieurs et autres personnels: Serge Torres (IR ENS Lyon) et Damien Séon (assistant, ENS Lyon) ; 1 post-docs et 9 doctorants.

Personnels ayant quitté l'équipe

1 statutaires, Florent de Dinechin (36 mois) ; 2 délégations/sabbatiques, Laurent-Stéphane Didier et Micaela Mayero (18 mois) ; 10 doctorants (220 mois) ; 8 post-docs (124 mois).

Recrutements

4 permanents: Guillaume Hanrot (PR, ENS Lyon, auparavant DR2 Inria au centre de Nancy Grand Est), Fabien Laguillaumie (PR, Université Claude Bernard, auparavant MCF à l'Université de Caen), Damien Stehlé (revenu comme CR CNRS en 2010, puis PR ENS Lyon en 2012), Bruno Salvy (DR, INRIA, venu en mutation depuis le Centre de Recherche de Rocquencourt).

5 doctorants: Sylviu Filip (ENS Lyon), Adeline Langlois (ENS Cachan), Vincent Neiger (ENS Lyon), Marie Paindavoine (CIFRE Orange Labs), Philippe Théveny (ENS Lyon).

Réalisations et produits de la recherche

1. preuve de sécurité du cryptosystème NTRU (publiée dans D. Stehlé et R. Steinfeld, *Making NTRUencrypt as secure as worst-case problems over ideal lattices*, Eurocrypt'11)
2. Réduction LLL en temps quasi-linéaire (publié dans A. Novocin, D. Stehlé, G. Villard, *An LLL-reduction algorithm with quasi-linear time complexity*, STOC, San Jose, California, 2011)
3. Mise au point de techniques pour l'analyse fine d'erreurs d'arrondis de «briques de base» du calcul numérique, illustrées par exemple par l'article C.-P. Jeannerod, N. Louvet, J.-M. Muller, *Further analysis of Kahan's algorithm for the accurate computation of* 2×2 *determinants*, Mathematics of Computation, 82:2245-2264, 2013
4. L'article d'A. Bostan, P. Lairez et B. Salvy *Creative telescoping for rational functions using the Griffiths-Dwork method*, Issac'13: proceedings of the 38th international symposium on symbolic and algebraic computation, Ed. Manuel Kauers. ACM Press, pages 93-100, 2013 a reçu le *Distinguished Student Award* de la conférence ;
5. Opérateurs arithmétiques spécialisés : Brevet N. Brunie, F. de Dinechin et B. de Dinechin, *Mixed-Precision Merged Multiplication and Addition Operator*, Patent WO/2012/175828, décembre 2012.

Bilan quantitatif des publications de l'équipe

41 articles dans des journaux internationaux avec comité de lecture, 7 conférences invitées, 84 articles dans des actes de conférences internationales avec comité de lecture, 7 livres ou chapitres de livres.

Publications majeures

1. J.-M. Muller (coordonateur), N. Brisebarre, F. de Dinechin, C.-P. Jeannerod, V. Lefèvre, G. Melquiond, N. Revol, D. Stehlé, S. Torres, Handbook of Floating-Point Arithmetic, Birkhauser, 2010.
2. A. Novocin, D. Stehlé, G. Villard. An LLL-reduction algorithm with quasi-linear time complexity, STOC, San Jose, USA, 2011.
3. C.-P. Jeannerod, N. Louvet, J.-M. Muller. Further analysis of Kahan's algorithm for the accurate computation of 2 x 2 determinants. Mathematics of Computation, 82:2245-2264, 2013.
4. G. Hanrot, D. Stehlé, X. Pujol, Analyzing Blockwise Lattice Reduction Algorithms using Dynamical Systems, Crypto'2011, Santa Barbara, USA, 2011.
5. N. Brisebarre et M. Joldes, Chebyshev interpolation polynomial-based tools for rigorous computing, Proc. 35th Int. Symp. on Symbolic and Algebraic Computation (ISSAC 2010), pages 147-154. Munich, Allemagne, Juillet 2010.

Documents majeurs

1. CRlibm: bibliothèque de fonctions élémentaires avec arrondi correct
2. FloPoCo: générateur d'opérateurs pour FPGAs
3. FLIP: bibliothèque virgule flottante pour processeurs entiers
4. FPLLL: bibliothèque de réduction de réseaux euclidiens
5. nous contribuons à la bibliothèque GNU MPFR (basée au Loria, à Nancy)

Rayonnement et attractivité de l'équipe

1. D. Stehlé Médaille de Bronze du CNRS en 2012 et J.-M. Muller Médaille d'argent du CNRS en 2013 ;
2. D. Stehlé a obtenu une ERC Starting Grant en 2013 pour son projet LattAC (lattices: algorithms and cryptography) ;
3. N. Revol préside le groupe de travail IEEE 1788 pour la normalisation de l'arithmétique d'intervalles ;
4. L'équipe a organisé la conférence SCAN 2010, et a été choisie pour organiser le 22nd IEEE Symposium on Computer Arithmetic en 2015, la principale conférence consacrée à l'arithmétique des ordinateurs ;
5. V. Lefèvre, N. Louvet, J.-M. Muller et leur collègue P. Kornerup ont obtenu le prix La Recherche 2013 pour les sci. de l'Information pour l'article *On the computation of correctly-rounded sums* (IEEE Trans. Comp., mars 2012).

Interactions de l'équipe avec son environnement

1. Collaboration très active avec le Compilation Expertise Center de STMicroelectronics (Grenoble), autour du logiciel FLIP (calcul flottant IEEE sur des processeurs n'ayant que des unités entières), dont certaines versions sont intégrées dans les compilateurs de production des processeurs embarqués ST200. Collaboration à travers un contrat CIFRE, un projet Région, etc. ;
2. Collaborations avec Kalray (une CIFRE), INTEL (donation), début de collaboration avec Bosch (conseil), une CIFRE avec Orange Labs ;
3. Participation au Conseil Scientifique du CERFACS (`www.cerfacs.fr`) ;
4. Vulgarisation: interventions en collèges et lycées (action "Ingénieur-e et Technicien-ne Demain" ; et Semaine des Mathématiques) ; jury de la finale de "Faites de la Science" 2010 ; participation au comité de sélection de l'International Summer School of Mathematics for Young Students en 2012 et 2014 et au comité de pilotage de la Maison des Maths et de l'Informatique ; Organisation du Forum des Jeunes Mathématicien-ne-s 2013 ; organisation de conférences scientifiques grand public à la Maison du Livre, de l'Image et du Son (Villeurbanne).

Actions de formation

- G. Hanrot a été responsable du master d'informatique (2009-2013) et directeur adjoint du Département d'informatique de l'ENS Lyon (2009-2012). Il a été vice-président du concours d'entrée à l'ENS Lyon (2010-2013) ;
- D. Stehlé a été directeur adjoint (2013) puis directeur (2013-) du département d'informatique de l'ENS Lyon ;
- G. Hanrot et D. Stehlé ont organisé l'Ecole de Printemps d'Informatique Théorique (EPIT) de 2013 à Autrans ;
- N. Brisebarre et J.-M. Muller ont organisé à l'ENS Lyon les écoles de recherche d'hiver "algorithmes pour l'approximation géométrique" (janvier 2010) et "vision et apprentissage" (janvier 2011) ;
- F. Laguillaumie est responsable de la 2ème année de la spécialité "Ingénierie des Risques" du master SAFIR à l'ISFA (Lyon) ;
- J.-M. Muller a participé au conseil et à la commission des thèses de l'Ecole Doctorale Infomaths (Lyon), ainsi qu'au conseil scientifique de Grenoble INP (2008-2011) et au conseil scientifique de l'ENS Lyon (2010-2014) ;
- Implication significative dans les enseignements au dept d'informatique de l'ENS Lyon et à l'ISFA. En particulier, montage du cours de de M2 Pro «Algorithmique numérique et fiabilité des calculs en arithmétique flottante,» (ISFA) ; et des cours de M2R «Algorithms for verified linear algebra,» (ENS Lyon) ; «Floating-Point Arithmetic and Formal Proof» (ENS Lyon) ; «Approximations: from symbolic to numerical computation, and applications» (ENS Lyon).

Le responsable de l'équipe peut indiquer ici brièvement 3 points précis sur lesquels il souhaite obtenir l'expertise du comité.

1.2 Executive summary: Aric team

Name of the head of the team for the present contract: F. de Dinechin (01/10–07/13), J.-M. Muller (07/13–).

Name of the head of the team for the upcoming contract: Bruno Salvy and Gilles Villard

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Team composition 2 lecturers and professors: Florent de Dinechin (MCF ENS Lyon) and Nicolas Louvet (MCF Université Claude Bernard) ; 4 researchers: Nicolas Brisebarre (CR CNRS), Claude-Pierre Jeannerod (CR Inria), Vincent Lefèvre (CR Inria), Jean-Michel Muller (DR CNRS), Nathalie Revol (CR Inria), Gilles Villard (DR CNRS) ; 2 technical staff, engineers and others: 2 techniciens, ingénieurs et autres personnels: Serge Torres (IR ENS Lyon) and Damien Séon (assistant, ENS Lyon); 1 post-docs and 9 PhD students.

Persons who left the team

1 staff Florent de Dinechin (36 months) ; 2 "délégations"/sabbaticals, Laurent-Stéphane Didier and Micaela Mayero (18 months); 10 PhD students (220 months) ; 8 post-docs (124 months).

New members

4 permanent staff: Guillaume Hanrot (PR, ENS Lyon, formerly DR in the Nancy Grand Est Inria research center), Fabien Laguillaumie (PR, Université Claude Bernard, formerly assistant prof. at Caen University), Damien Stehlé (PR, ENS Lyon, formerly CR, CNRS), Bruno Salvy (Directeur de Recherches, INRIA, formerly DR in the Rocquencourt Inria research center).

5 PHD students: Silviu Filip (ENS Lyon), Adeline Langlois (ENS Cachan), Vincent Neiger (ENS Lyon), Marie Paindavoine (CIFRE Orange Labs), Philippe Théveny (ENS Lyon).

Scientific outcomes

1. proof of security of the NTRU cryptosystem (published in D. Stehlé and R. Steinfeld, *Making NTRUencrypt as secure as worst-case problems over ideal lattices*, Eurocrypt'11)
2. Quasi-linear time LLL reduction (published in A. Novocin, D. Stehlé, G. Villard, *An LLL-reduction algorithm with quasi-linear time complexity*, STOC, San Jose, California, 2011)
3. Conception of techniques for analyzing the rounding errors of basic building blocks of numerical algorithms, illustrated for instance by the paper C.-P. Jeannerod, N. Louvet, J.-M. Muller, *Further analysis of Kahan's algorithm for the accurate computation of* 2×2 *determinants*, Mathematics of Computation, 82:2245-2264, 2013
4. the paper by A. Bostan, P. Lairez and B. Salvy *Creative telescoping for rational functions using the Griffiths-Dwork method*, Issac'13: proceedings of the 38th international symposium on symbolic and algebraic computation, Ed. Manuel Kauers. ACM Press, pages 93-100, 2013 won the *Distinguished Student Award* of the conference;
5. Special-purpose arithmetic operators: Patent by N. Brunie, F. de Dinechin and B. de Dinechin, *Mixed-Precision Merged Multiplication and Addition Operator*, Patent WO/2012/175828, december 2012.

Quantitative assessment of team's publications

41 articles in international peer-reviewed journals, 7 invited conferences, 84 articles in international peer-reviewed conference proceedings, 7 books or book chapters.

Major publications

1. J.-M. Muller (coordonateur), N. Brisebarre, F. de Dinechin, C.-P. Jeannerod, V. Lefèvre, G. Melquiond, N. Revol, D. Stehlé, S. Torres, Handbook of Floating-Point Arithmetic, Birkhauser, 2010.
2. A. Novocin, D. Stehlé, G. Villard. An LLL-reduction algorithm with quasi-linear time complexity, STOC, San Jose, USA, 2011.
3. C.-P. Jeannerod, N. Louvet, J.-M. Muller. Further analysis of Kahan's algorithm for the accurate computation of 2×2 determinants. Mathematics of Computation, 82:2245-2264, 2013.
4. G. Hanrot, D. Stehlé, X. Pujol, Analyzing Blockwise Lattice Reduction Algorithms using Dynamical Systems, Crypto'2011, Santa Barbara, USA, 2011.
5. N. Brisebarre and M. Joldes, Chebyshev interpolation polynomial-based tools for rigorous computing, Proc. 35th Int. Symp. on Symbolic and Algebraic Computation (ISSAC 2010), pp. 147-154. Munich, Germany, July 2010.

Major documents

1. CRlibm: a Library of Elementary Functions with Correct Rounding
2. FloPoCo: a generator of operators for FPGAs
3. FLIP: a Floating-point Library for Integer Processors
4. FPLLL: a Lattice Reduction Library
5. we contribute to GNU MPFR (the head of the projet is in Loria, Nancy)

Influence and attractiveness of the team

1. D. Stehlé: CNRS Bronze Medal in 2012, and J.-M. Muller: CNRS Silver Medal in 2013;
2. D. Stehlé was awarded an ERC Starting Grant in 2013 for his LattAC (lattices: algorithms and cryptography) project;
3. N. Revol chairs the IEEE 1788 Working Group for the standardization of Interval Arithmetic;
4. the team organized the SCAN 2010 conference and was selected for running the 22nd IEEE Symposium on Computer Arithmetic in 2015, which is the major conference devoted to computer arithmetic;
5. V. Lefèvre, N. Louvet, J.-M. Muller, and their danish colleague P. Kornerup got the *La Recherche 2013* award for information sci. for their paper *On the computation of correctly-rounded sums* (IEEE Trans. Comp., march 2012).

Interaction of the team with its environment

1. Very active collaboration with the Compilation Expertise Center of STMicroelectronics (Grenoble) on the FLIP software (floating-point arithmetic on processors without native floating-point support). Some versions of FLIP are integrated in the compilers for the embedded ST200 processors. Collaboration through a CIFFRE PhD Grant, a Region Rhône-Alpes project, etc.;
2. Collaborations with Kalray (a CIFRE PhD grant), INTEL (donation), starting collaboration with Bosch (advices), CIFRE PhD grant with Orange Labs;
3. Participation to the Scientific Council of CERFACS (`www.cerfacs.fr`);
4. Popular Science dissemination: presentations in High Schools ("Ingénieur-e et Technicien-ne Demain" program, and "Semaine des Mathématiques" program); Participation to the jury of the "Faites de la Science" award in 2010; participation to the selection committee of the International Summer School of Mathematics for Young Students in 2012 and 2014, and to the steering committee of "Maison des Maths et de l'Informatique"; organization of the "Forum des Jeunes Mathématicien-ne-s" in 2013; organization of scientific conferences targeted for general public in the Maison du Livre, de l'Image et du Son (Villeurbanne).

Training initiatives

- G. Hanrot was head of the MSc in Computer Sci. specialty (2009-2013) and vice-chair (2009-2012) of the Computer Sci. Department of ENS Lyon. He was vice-chair of the ENS Lyon entrance examination (2010-2013);
- D. Stehlé was vice chair (2013), then chair (2013-) of the Computer Science Department of ENS Lyon, ;
- G. Hanrot and D. Stehlé ran the 2013 "Ecole de Printemps d'Informatique Theorique" (Theoretical computer science spring school, EPIT) in Autrans;
- N. Brisebarre and J.-M. Muller organized in ENS Lyon the one-week winter schools "algorithms for geometric approximation " (Jan. 2010) and "vision and machine learning" (Jan. 2011);
- F. Laguillaumie is head of the 2nd year of the specially "Risk Management" of the SAFIR Master in ISFA (Lyon);
- J.-M. Muller participated to the Council and the PhD committee of the doctoral school Infomaths (Lyon), to the scientific council of Grenoble INP (2008-2011) and to the scientific council of ENS Lyon (2010-2014);
- Significant implication in the computer science dept of ENS Lyon and in the teachings at ISFA. Especially, conception of the M2 Pro « Numerical algorithms and reliable computing in floating-point arithmetic, » course (ISFA); and of the M2R courses «Algorithms for verified linear algebra,» (ENS Lyon); «Floating-Point Arithmetic and Formal Proof» (ENS Lyon) ; « Approximations: from symbolic to numerical computation, and applications » (ENS Lyon).

The head of the team can briefly state 3 precise points on which he would like to know the evaluation of the committee.

1.3 Présentation synthétique : équipe Avalon

Nom du responsable de l'équipe pour le contrat en cours: Frédéric Desprez (7/2010-8/11), Christian Perez (9/11-)

Nom du responsable de l'équipe pour le futur contrat: Christian Perez

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Effectifs de l'équipe

L'équipe Avalon a été créée en tant qu'équipe LIP au 1er juillet 2010. Ses membres provenaient de l'équipe Graal. 1 enseignant-chercheur: E. Caron (MdC ENS Lyon) ; 3 chercheurs: F. Desprez (DR Inria), G. Fedak (CR Inria), C. Perez (CR puis DR Inria) ; 2 techniciens, ingénieurs et autres personnels permanents: Evelyne Blesle (assistante, Inria), Matthieu Imbert (IR Inria, 40%) ; 8 ingénieurs non permanents ; 12 post-docs et doctorants.

Personnels ayant quitté l'équipe (depuis 1er janvier 2009)

1 statutaires: Yves Caniou (MdC Lyon I, 12 mois) était membre de GRAAL mais pas d'Avalon ; 11 doctorants (314 mois) ; 8 post-docs (116 mois) ; 17 ingénieurs (291).

Recrutements (depuis le 1er janvier 2009)

Frédéric Suter (CR CNRS, CC-IN2P3) a été rattaché au LIP et à Avalon au 1er janvier 2012.

Environ la moitié de l'équipe RESO du LIP a rejoint Avalon à la fin de RESO: 2 enseignants-chercheurs: Jean-Patrick Gelas (MdC Univ. Lyon I), Olivier Glück (MdC Univ. Lyon I) ; 1 chercheur: Laurent Lefevre (CR INRIA)

Simon Delamare (IR CNRS) a été recruté et partiellement affecté à Avalon. Jean-Christophe Mignot (IR CNRS) a été partiellement affecté à Avalon (20%).

6 doctorants: Daniel Balouek (NewGeneration SR), Maurice-Djibril Faye (Univ. Gaston Berger, St Louis, Sénégal/ENSL), Sylvain Gault (Inria), Vincent Lanore (ENS Lyon), Arnaud Lefray (ENSI de Bourges), Anthony Simonet (Inria), Violaine Villebonnet (Inria)

Réalisations et produits de la recherche

1. Définition et implémentation de HLCM, un modèle de composant logiciels pour les applications à haute performance statiques (publication numéro 5 ci-dessous).
2. Extension du logiciel de simulation SimGrid pour la gestion d'infrastructures Cloud et HPC (publication numéro 4 et logiciel 3 ci-dessous)
3. Conception, implémentation et déploiement d'une infrastructure de gestion de l'énergie pour des infrastructures de type Clouds, intégrée à OpenStack, supportant des capteurs d'énergie hétérogènes, et fournie avec une interface de visualisation.
4. Conception et implémentation d'une plateforme de virtualisation haute densité pour l'hébergement de passerelles résidentielles virtualisées (vHGW: virtual Home Gateway).
5. Conception et développement de SpeQuloS, un intergiciel permettant de fournir de la qualité de service aux applications s'exécutant sur des infrastructures distribuées hybrides (publication numéro 2)

Bilan quantitatif des publications de l'équipe

International peer-reviewed journals [ACL]	36
National peer-reviewed journals [ACL]	1
Invited conferences [INV], seminars, and tutorials	6
International peer-reviewed conference proceedings [ACT]	120
National peer-reviewed conference proceedings [ACT]	12
Short communications [COM] and posters [AFF] in conferences and workshops	9
Scientific books and book chapters [OS]	22
Scientific popularization [OV]	13
Book or Proceedings editing [DO]	5
Other Publications [AP]	4
Doctoral Dissertations and Habilitation Theses [TH]	12

Publications majeures

1. Eddy Caron, Frédéric Desprez, and Adrian Muresan. Forecasting for Cloud Computing On-Demand Resources Based on Pattern Matching. Journal of Grid Computing, 9(1):49-64, March 2011.
2. Simon Delamare, Gilles Fedak, Derrick Kondo, Oleg Lodygensky, SpeQuloS: A QoS Service for BoT Applications Using Best Effort Distributed Computing Infrastructures. Proceedings of the 21st ACM International Symposium on High Performance Distributed Computing (HPDC'12), June 2012, Delft, Netherlands. ACM, pp. 173-186
3. Anne-Cécile Orgerie, and Laurent Lefèvre. ERIDIS: Energy-efficient Reservation Infrastructure for large-scale DIstributed Systems, Parallel Processing Letters, Volume 21, Issue 2, pages 133-154, June 2011
4. Pierre-Nicolas Clauss, Mark Stillwell, Stéphane Genaud, Frédéric Suter, Henri Casanova and Martin Quinson Single Node On-Line Simulation of MPI Applications with SMPI. In 25th IEEE International Parallel and Distributed Processing Symposium (IPDPS), Anchorage, Alaska, May 2011.
5. Julien Bigot, and Christian Pérez. – High Performance Computing: From Grids and Clouds to Exascale, chap. On High Performance Composition Operators in Component Models. – Advances in Parallel Computing, vol 20, pp 182-201, IOS Press, 2011.

Documents majeurs

1. Logiciel DIET v2.8.1 sortie en 2012.
2. Logiciel Bitdew, v1.2.0, sortie en 2012.
3. Logiciel SimGrid, v3.10, sortie en novembre 2013
4. Participation de C. Pérez à la rédaction d'un rapport d'expertise pour le ministère des affaires étrangères français sur le cloud computing en Chine.
5. Participation de F. Desprez à un groupe d'experts à l'Europe dans le cadre de l'appel H2020 (A Roadmap for Advanced Cloud Technologies under H2020, European Commission, Recommandations by the Cloud Expert Group, Digital Agenda for Europe, Dec. 2012)

Rayonnement et attractivité de l'équipe

1. Le projet Green-Net a été nominé comme une des meilleures innovations dans le Green IT lors du concours "Prix de la Croissance Verte Numérique", France, Novembre 2011
2. Co-organisation avec l'équipe ROMA de la conférence ICPP2013: the 42nd International Conference on Parallel Processing, 1-4 Octobre 2013, Lyon.
3. Organisation des SimGrid Users Days (2010, 2012, 2013, 2014) et des Green Days (2011, 2012, 2013, 2014)
4. Invitation à intervenir à l'atelier "Cloud computing : plates-formes d'applications et de services distribués" organisé par le Club des Adhérents de l'AFNOR, 25 mars 2011. (C. Perez)
5. Invitation à donner un exposé invité lors de la conférence Closer 2012 (F. Desprez, Experimental Computer Science, Approaches and instruments)

Interactions de l'équipe avec son environnement

1. Deux membres de l'équipe (E. Caron et F. Desprez) sont co-fondateurs et consultants scientifiques pour la start'up SysFera issue elle-même de l'équipe.
2. L'équipe a eu une relation suivie avec le département SINETICS d'EDF R&D, notamment via une bourse CIFRE (2009-2012) et le projet ANR Cosinus COOP (2009-2013).
3. Participation au projet du Fonds de Solidarité Numérique "XLCLOUD : Calcul en nuage pour des applications hautes performances" (2012-2014).
4. Coordination du projet ANR CloudPower, visant à transférer une technologie du CNRS et de l'INRIA vers l'industrie (création de start'up).
5. Participation en 2013-14 de F. Desprez au groupe de travail "Nouvelle France Industrielle" autour des Clouds du Ministère de l'Economie, de l'Industrie et du Numérique.

Actions de formation

1. Co-organisation et intervention aux écoles GRID'5000 (2011, 2012, et 2014)
2. Gestion de la formation M2 CCI (Compétence Complémentaire en Informatique) du département informatique de Lyon 1.
3. Gestion des UE Nouvelles Technologies, Administration et sécurité des systèmes, Services et Protocoles Applicatifs d'Internet, Administration Systèmes et Réseaux du M2 Informatique de l'Université Lyon 1.
4. Organisation de 4 cours en M2 à l'ENS de Lyon sur le calcul distribué (grille, cloud, etc.) et de 9 cours à l'université Lyon I sur les réseaux et le parallélisme.

Le responsable de l'équipe peut indiquer ici brièvement 3 points précis sur lesquels il souhaite obtenir l'expertise du comité.

1.4 Executive summary: Avalon team

Name of the head of the team for the present contract: Frédéric Desprez (7/2010-8/11), Christian Perez (9/11-)

Name of the head of the team for the upcoming contract: Christian Perez

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Team composition

The Avalon team has been created as a LIP team 2010, July 1st. Its members were coming from the GRAAL team. 1 lecturer: E. Caron (MdC ENS Lyon); 3 researchers: F. Desprez (DR Inria), G. Fedak (CR Inria), C. Perez (CR then DR Inria); 2 technical staff, engineers and others: Evelyne Blesle (assistant, Inria), Matthieu Imbert (IR Inria, 40%); 8 non permanent engineers; 12 post-docs and PhD students.

Persons who left the team

1 staff: Yves Caniou (MdC Lyon I, 12 months) was a member of GRAAL but not of Avalon (he left for a CNRS delegation at Japan) 11 PhD students (314 months) ; 8 post-docs (116 months); 17 engineers (291).

New members

Frédéric Suter (CR CNRS, CC-IN2P3) has been attached at LIP and at Avalon since 2012, January 1st.

About half of the RESO team from LIP joint Avalon at the end of RESO: 2 lecturers: Jean-Patrick Gelas (MdC Univ. Lyon I), Olivier Glück (MdC Univ. Lyon I); 1 researcher: Laurent Lefevre (CR INRIA)

Simon Delamare (IR CNRS) has been hired and partially (50%) attached to Avalon. Jean-Christophe Mignot (IR CNRS) has been partially attached to Avalon (20%).

6 PhD students: Daniel Balouek (NewGeneration SR), Maurice-Djibril Faye (Univ. Gaston Berger, St Louis, Sénégal/ENSL), Sylvain Gault (Inria), Vincent Lanore (ENS Lyon), Arnaud Lefray (ENSI de Bourges), Anthony Simonet (Inria), Violaine Villebonnet (Inria)

Scientific outcomes

1. Definition and implementation of HLCM, a software component based model for HPC static applications (Publication 5 hereafter).
2. Extension of the SimGrid simulation software for Cloud and HPC infrastructure management (Publication 4 and Software 3 hereafter).
3. Design, implementation and deployment of an energy management infrastructure for Cloud-like infrastructure, integrated to OpenStack, supporting heterogeneous energy sensors, and providing a visualization interface.
4. Design and implementation of an high density virtualization platform for virtualized home gateway hosting (vHGW).
5. Design and development of SpeQuloS, a middleware for providing quality of service to applications running on hybrid distributed computing infrastructures (Publication 2 hereafter)

Quantitative assessment of team's publications

International peer-reviewed journals [ACL]	36
National peer-reviewed journals [ACL]	1
Invited conferences [INV], seminars, and tutorials	6
International peer-reviewed conference proceedings [ACT]	120
National peer-reviewed conference proceedings [ACT]	12
Short communications [COM] and posters [AFF] in conferences and workshops	9
Scientific books and book chapters [OS]	22
Scientific popularization [OV]	13
Book or Proceedings editing [DO]	5
Other Publications [AP]	4
Doctoral Dissertations and Habilitation Theses [TH]	12

Major publications

1. Eddy Caron, Frédéric Desprez, and Adrian Muresan. Forecasting for Cloud Computing On-Demand Resources Based on Pattern Matching. Journal of Grid Computing, 9(1):49-64, March 2011.
2. Simon Delamare, Gilles Fedak, Derrick Kondo, Oleg Lodygensky, SpeQuloS: A QoS Service for BoT Applications Using Best Effort Distributed Computing Infrastructures. Proceedings of the 21st ACM International Symposium on High Performance Distributed Computing (HPDC'12), June 2012, Delft, Netherlands. ACM, pp. 173-186

3. Anne-Cécile Orgerie, and Laurent Lefèvre. ERIDIS: Energy-efficient Reservation Infrastructure for large-scale Distributed Systems, Parallel Processing Letters, Volume 21, Issue 2, pages 133-154, June 2011
4. Pierre-Nicolas Clauss, Mark Stillwell, Stéphane Genaud, Frédéric Suter, Henri Casanova and Martin Quinson Single Node On-Line Simulation of MPI Applications with SMPI. In 25th IEEE International Parallel and Distributed Processing Symposium (IPDPS), Anchorage, Alaska, May 2011.
5. Julien Bigot, and Christian Pérez. – High Performance Computing: From Grids and Clouds to Exascale, chap. On High Performance Composition Operators in Component Models. – Advances in Parallel Computing, vol 20, pp 182-201, IOS Press, 2011.

Major documents

1. Software DIET v2.8.1 released in 2012.
2. Software Bitdew, v1.2.0, released in 2012.
3. Software SimGrid, v3.10, released in 2013.
4. Participation of C. Pérez to an expertise report for the French Ministry of Foreign Affairs on the Cloud Computing in China.
5. Participation of F. Desprez to an European expert group in the framework of the H2020 call (A Roadmap for Advanced Cloud Technologies under H2020, European Commission, Recommendations by the Cloud Expert Group, Digital Agenda for Europe, Dec. 2012)

Influence and attractiveness of the team

1. The Green-Net project has been nominated as one the best innovation in GreenIT at the “Prix de la Croissance Verte Numérique” contest, France, November 2011
2. Co-organization with the ROMA team of the 42nd International Conference on Parallel Processing (ICPP2013), 2013 October 1-4, Lyon.
3. Organization of SimGrid Users Days (2010, 2012, 2013, 2014) and of Green Days (2011, 2012, 2013, 2014)
4. Invitation to a panel of the workshop ”Cloud computing : plates-formes d’applications et de services distribués” organized by the Club des Adhérents de l’AFNOR, 2011, march 25. (C. Perez)
5. Invitation to give an invited talk to the Closer conference 2012 (F. Desprez, Experimental Computer Science, Approaches and instruments)

Interaction of the team with its environment

1. Two members (E. Caron and F. Desprez) are co-founders and scientific consultant for the SysFera spin-off of the GRAAL team.
2. The team has a strong relationship with the SINETICS department of EDF R&D, in particular through a CIFRE grant (2009-2012) and the ANR Cosinus COOP project (2009-2013).
3. Participation to the XLCLOUD project “Calcul en nuage pour des applications hautes performances” (2012-2014) of the French “Fonds de Solidarité Numérique”.
4. Coordination of the French ANR CloudPower project, targeting to transfer a CNRS and Inria technology to industry (spin-off creation).
5. Participation in of F. Desprez 2013-14 to the “Nouvelle France Industrielle” working group around Clouds of the french Ministère de l’Economie, de l’Industrie et du Numérique.

Training initiatives

1. Co-organization and intervention at the GRID’5000 schools (2011, 2012, and 2014)
2. Management of the M2 CCI formation (Compétence Complémentaire en Informatique) of the computer science department of the University of Lyon I.
3. Management of UE Nouvelles Technologies, Administration et sécurité des systèmes, Services et Protocoles Applicatifs d’Internet, Administration Systèmes et Réseaux of the computer science Master2 of the University of Lyon 1.
4. Organisation of 4 M2 lectures at ENS of Lyon on distributed computing (grids, cloud, etc.) and of 9 lectures at the University Lyon I on networks and parallelism.

The head of the team can briefly state 3 precise points on which he would like to know the evaluation of the committee.

1.5 Présentation synthétique : équipe Compsys

Nom du responsable de l'équipe pour le contrat en cours: Alain Darte

Nom du responsable de l'équipe pour le futur contrat: Alain Darte

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Effectifs de l'équipe (au début du contrat en cours)

- 4 permanents: Christophe Alias (CR Inria), Alain Darte (DR CNRS), Paul Feautrier (Prof. ENS-Lyon, émérite), Fabrice Rastello (CR Inria).
- 1 ingénieur et 1 post-doctorant: Quentin Colombet (Ing. projet Sceptre), Laure Gonnord (ATER Lyon 1).
- 2 doctorants: Benoit Boissinot (bourse ENS-Lyon), Alexandru Plesco (bourse MESR).

Personnels ayant quitté l'équipe (pendant le contrat en cours et nombre de mois cumulés dans l'entité)

- 1 permanent (48 mois): Fabrice Rastello (changement d'affectation en déc. 2013).
- 3 doctorants: (90 mois): Benoit Boissinot (jusqu'en sep. 2010, voir [561]), Quentin Colombet (jusqu'en sep. 2012, voir [563]), Alexandru Plesco (jusqu'en déc. 2010, voir [562], puis à Zettice comme collaborateur extérieur.
- 2 post-doctorants (29 mois): Laure Gonnord (ATER, jusqu'à juin 2009, puis collaboratrice extérieure), Florian Brandner (projet Mediacom, de déc. 2009 jusqu'à oct. 2011).

Recrutements (réalisés au cours de la période considérée et origine des personnels)

- 2 permanents: Laure Gonnord (Maître de Conférences Lille 1), mutée à Lyon 1 en sep. 2013, Tomofumi Yuki (doctorant Colorado State University puis post-doctorant Irisa) rejoindra Compsys en oct. 2014 comme CR2 INRIA.
- 1 post-doctorant: Florian Brandner (doctorant Vienna University), de déc. 2009 à oct. 2011.
- 4 doctorants: Quentin Colombet (projet Mediacom, de jan. 2010 à sep. 2012, auparavant ingénieur Compsys), Guillaume Iooss (bourse ENS-Lyon, thèse en cotutelle avec CSU, depuis sep. 2011), Alexandre Isoard (bourse ENS-Lyon, depuis sep. 2012), Maroua Maleej (bourse Labex MILYON, débutera en oct. 2014).

Note: cette liste ne comprend pas les recrutements à Grenoble en lien avec le changement d'affectation de F. Rastello.

Réalisations et produits de la recherche (5 résultats majeurs au cours de la période 1er janvier 2009 – 30 juin 2014)

1. Analyses de code liées à SSA (Static Single Assignment), en particulier sortie de SSA, analyse de vivacité rapide sans calcul de point fixe, et propriétés structurelles de SSA et de sa variante SSI (Static Single Information).
2. Allocation de registres basée sur SSA, en collaboration avec STMicroelectronics, dans le cadre du projet Mediacom. Contexte: optimisation agressive et compilation à la volée (just-in-time compilation).
3. Analyse et optimisation polyédriques pour le déport d'un noyau de calcul sur un circuit FPGA. Optimisation des communications, compilation de réseaux de processus, exploitation d'opérateurs pipelinés. Certains de ces résultats (par exemple [501, 476, 522]) ont conduit à la création de la start-up Zettice/XtremLogic.
4. Analyse polyédrique pour prouver la terminaison et estimer la complexité de programmes irréguliers.
5. Analyse polyédrique de langages parallèles comme X10 (non-déterminisme) ou OpenStream (interblocages).

Bilan quantitatif des publications de l'équipe

8 articles dans des journaux internationaux avec comité de lecture, 13 conférences invitées ou tutoriaux, 38 articles de conférences internationales avec comité de lecture, 5 chapitres de livres, 1 livre édité, 5 thèses de doctorat ou d'habilitation.

Publications majeures (Max 5, avec titre et en soulignant le nom du ou des membre(s) de l'entité)

1. Benoit Boissinot, Philip Brisk, Alain Darte, and Fabrice Rastello. SSI properties revisited. *ACM Transactions on Embedded Computing Systems*, 11S(1), June 2012. Article 21, 23 pages.
2. Christophe Alias, Alain Darte, Paul Feautrier, and Laure Gonnord. Multi-dimensional rankings, program termination, and complexity bounds of flowchart programs. In *17th International Static Analysis Symposium (SAS'10)*, pages 117–133, Perpignan, France, September 2010. ACM press.
3. Quentin Colombet, Florian Brandner, and Alain Darte. Studying optimal spilling in the light of SSA. In *International Conference on Compilers, Architectures, and Synthesis of Embedded Systems (CASES'11)*, pages 25–34, Taipei, Taiwan, October 2011. IEEE Computer Society.
4. Christophe Alias, Alain Darte, and Alexandru Plesco. Optimizing remote accesses for offloaded kernels: Application to high-level synthesis for FPGA. In *Design, Automation & Test in Europe (DATE'13)*, pages 575–580, Grenoble, France, March 2013.
5. Tomofumi Yuki, Paul Feautrier, Sanjay V. Rajopadhye, and Vijay Saraswat. Array dataflow analysis for polyhedral X10 programs. In *18th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (PPoPP'13)*, pages 23–34, Shenzhen, China, February 2013. ACM.

Documents majeurs (Max 5, autres que publications, produits par l'entité, ici logiciels et brevet)

1. Florian Brandner, Quentin Colombet, Fabrice Rastello. Analyses basées sur la forme SSA (optimisation de code et allocation de registres) pour le compilateur de STMicroelectronics.
2. Paul Feautrier. C2fsm: outil de génération d'automates à états finis à partir de programmes C. Front-end de plusieurs logiciels de recherche de l'équipe.
3. Christophe Alias. Rank: outil pour vérifier la terminaison d'un programme et calculer sa complexité. En liaison avec les outils C2fsm et Aspic.
4. Christophe Alias, Alain Darte, and Alexandru Plesco. Chuba: optimiseur source-à-source des accès mémoire en lien avec C2H, outil de synthèse de circuits d'Altera.
5. Christophe Alias and Alexandru Plesco. Procédé de synthèse de circuits, dispositif et programme d'ordinateur associés. Brevet FR1453308, avr. 2014.

Rayonnement et attractivité de l'équipe (au plus 5 faits montrant le rayonnement de l'équipe)

1. Création (par L. Gonnord et F. Rastello) de la communauté française de compilation[1] (8 colloques depuis 2010), à présent reconnue comme sous-groupe des GDR GPL et ASR.
2. Création (par C. Alias, avec C. Bastoul) du premier colloque international sur les techniques polyédriques (IMPACT)[2], devenu colloque annuel, satellite de la conférence HIPEAC.
3. Organisation (par A. Darte) d'un trimestre thématique en compilation[3] comprenant, outre les journées françaises de compilation, 3 événements internationaux: la première école sur les analyses et optimisations polyédriques, 4 jours de "keynotes" sur les langages pour le calcul à hautes performance, et le colloque international sur les compilateurs pour le calcul parallèle (CPC'13).
4. Cinq chapitres [543, 544, 545, 546, 547] de l'Encyclopedia of Parallel Programming[4], editée par D. Padua.
5. Paul Feautrier a reçu du "steering committee" d'Euro-Par une distinction "pour reconnaître ses contributions exceptionnelles au calcul parallèle" (2009). Il a été honoré d'une soirée spéciale durant la conférence CGO'11. Son article "Array Expansion" de 1988 a été sélectionné pour le volume anniversaire d'ICS (Int. Conference on Supercomputing), avec 34 autres articles parmi les 1800 publiés entre 1987 et 2011. En sep. 2014, il enregistrera une leçon sur le modèle polyédrique, partie d'un cours sur la parallélisation automatique organisé par l'institut IEEE.

Interactions de l'équipe avec son environnement (au plus 5 faits en lien avec le milieu socio-économique ou culturel)

1. Projet Mediacom (2009-2012) avec STMicro sur les optimisations de code agressives et à la volée, basées sur SSA.
2. Projet S2S4HLS (2009-2011) avec STMicro sur les transformations source-à-source en synthèse de haut niveau.
3. Projet ManycoreLabs (2012-2015) avec Kalray, sur l'analyse et la compilation des langages de "streams".
4. Jeune entreprise Zettice/XtremLogic, pour exploiter les résultats de la thèse d'Alexandru Plesco [562] ainsi que de ses extensions [476, 559]). Christophe Alias en est co-fondateur et conseiller scientifique.

Actions de formation

(principales contributions, ex: conception/coordination de modules de formation en master & doctorat, accueil/suivi des doctorants, conception d'outils à vocation pédagogique, action de formation continue, ...)

- Christophe Alias (CR Inria) est chargé du cours de compilation du Master 1 de l'ENS-Lyon depuis 2010.
- L'équipe Compsys organise le cours avancé d'optimisation de programmes du Master 2 de l'ENS-Lyon.
- Alain Darte a été jusqu'en 2010 vice-président du concours d'entrée de l'ENS-Lyon, resp. de l'informatique.
- Christophe Alias et Laure Gonnord ont organisé quatre "Master classes" pour les étudiants de l'ENS-Lyon: "Beyond the PC. Application-specific systems, design and implementation" (en 2010), "Verification and certification of software" (en 2012), "Programming embedded systems with synchronous languages" (en 2014), "Static analyses in the state-of-the-art compilers" (prévue en 2015).
- 4 doctorants ont soutenus depuis 2009. Florent Bouchez [560] est maintenant maître de conférence à Grenoble, Benoit Boissinot [561] est ingénieur de recherche chez Google (Zürich), Alexandru Plesco [562] est directeur (CEA/CTO) d'XtremLogic, Quentin Colombet [563] est ingénieur de recherche chez Apple (Cupertino).

Le responsable de l'équipe peut indiquer ici brièvement 3 points précis sur lesquels il souhaite obtenir l'expertise du comité.

[1] http://compilation.gforge.inria.fr
[2] http://impact.gforge.inria.fr
[3] http://labexcompilation.ens-lyon.fr
[4] http://www.springer.com/computer/swe/book/978-0-387-09765-7

1.6 Executive summary: Compsys team

Name of the head of the team for the present contract: Alain Darte.

Name of the head of the team for the upcoming contract: Alain Darte.

Team composition (at the beginning of the present contract)

- 4 permanent staff: Christophe Alias (CR Inria), Alain Darte (DR CNRS), Paul Feautrier (Prof. ENS-Lyon, emeritus), Fabrice Rastello (CR Inria).
- 1 engineer and 1 post-doc: Quentin Colombet (Eng. Sceptre project), Laure Gonnord (ATER Lyon 1).
- 2 PhD students: Benoit Boissinot (PhD ENS-Lyon grant), Alexandru Plesco (PhD MESR grant).

Persons who left the team (during the present contract, with cumulative number of months during this period)

- 1 permanent staff (48 months): Fabrice Rastello (administrative departure dec. 2013).
- 3 PhD students (90 months): Benoit Boissinot (until sep. 2010, see also [561]), Quentin Colombet (until sep. 2012, see also [563]), Alexandru Plesco (until dec. 2010, see also [562], then in Zettice as external collaborator).
- 2 post-docs (29 months): Laure Gonnord (ATER, departure jun. 2009, then external collaborator), Florian Brandner (Mediacom project, from dec. 2009 to oct. 2011).

New members (people hired during the considered period)

- 2 permanent staff: Laure Gonnord (previously Lille 1) moved as assistant professor Lyon 1 in sep. 2013, Tomofumi Yuki (previously PhD Colorado State University, post-doc Irisa) will join Compsys in sep. 2014 as CR Inria.
- 1 post-doc: Florian Brandner (previously PhD Vienna University), from dec. 2009 to oct. 2011.
- 4 PhD students: Quentin Colombet (Mediacom project, from jan. 2010 to sep. 2012, previously engineer in the team), Guillaume Iooss (ENS-Lyon grant, joint PhD with CSU, since sep. 2011), Alexandre Isoard (ENS-Lyon grant, since sep. 2012), Maroua Maleej (Labex MILYON grant, will start in oct. 2014).

Note: this list does not mention the people hired in Grenoble since 2013 and linked to the move of Fabrice Rastello there.

Scientific outcomes (5 major results during the past period, January 1st 2009 - June 30 2014)

1. Code analysis results linked to SSA (Static Single Assignment), in particular out-of-SSA conversion, fast non-iterative liveness analysis, and structural properties for SSA and its variant SSI (Static Single Information).
2. SSA-based register allocation, in collaboration with STMicroelectronics, through the Mediacom project, in the context of both aggressive and just-in-time compilation.
3. Polyhedral-based analysis and optimization for automatic kernel offloading towards FPGA with optimized communications, compilation of process networks, and transformations for exploiting pipelined operators. Some of these results (e.g., [501, 476, 522]) have led to the XtremLogic (formerly Zettice) start-up.
4. Polyhedral-based analysis for proving the termination of irregular programs and estimating their number of steps.
5. Polyhedral-based analysis of parallel languages, such as X10 (e.g., for races) and OpenStream (e.g., for deadlocks).

Quantitative assessment of team's publications

8 papers in international peer-reviewed journals, 13 invited conferences or tutorials, 38 articles at international peer-reviewed conferences, 5 book chapters, 1 edited book, 5 PhD or HDR theses.

Major publications (Max 5, with title and underlining the name of the team member(s))

1. Benoit Boissinot, Philip Brisk, Alain Darte, and Fabrice Rastello. SSI properties revisited. *ACM Transactions on Embedded Computing Systems*, 11S(1), June 2012. Article 21, 23 pages.
2. Christophe Alias, Alain Darte, Paul Feautrier, and Laure Gonnord. Multi-dimensional rankings, program termination, and complexity bounds of flowchart programs. In *17th International Static Analysis Symposium (SAS'10)*, pages 117–133, Perpignan, France, September 2010. ACM press.
3. Quentin Colombet, Florian Brandner, and Alain Darte. Studying optimal spilling in the light of SSA. In *International Conference on Compilers, Architectures, and Synthesis of Embedded Systems (CASES'11)*, pages 25–34, Taipei, Taiwan, October 2011. IEEE Computer Society.
4. Christophe Alias, Alain Darte, and Alexandru Plesco. Optimizing remote accesses for offloaded kernels: Application to high-level synthesis for FPGA. In *Design, Automation & Test in Europe (DATE'13)*, pages 575–580, Grenoble, France, March 2013.
5. Tomofumi Yuki, Paul Feautrier, Sanjay V. Rajopadhye, and Vijay Saraswat. Array dataflow analysis for polyhedral X10 programs. In *18th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (PPoPP'13)*, pages 23–34, Shenzhen, China, February 2013. ACM.

Major documents (Max 5, other than publications, produced by the team, here software tools and patent)

1. Florian Brandner, Quentin Colombet, Fabrice Rastello. SSA-based analyses and code optimizations (including register allocation) within the STMicroelectronics compiler.
2. Paul Feautrier. C2fsm: A tool to generate finite state machines from C code. Front-end for several team prototypes.
3. Christophe Alias. Rank: A tool to check program termination and computational complexity. In connection with the C2fsm and Aspic tools.
4. Christophe Alias, Alain Darte, and Alexandru Plesco. Chuba: A source-level optimizer of remote memory accesses for the HLS tool C2H of Altera.
5. Christophe Alias and Alexandru Plesco. Procédé de synthèse de circuits, dispositif et programme d'ordinateur associés. Patent number FR1453308, apr. 2014.

Influence and attractiveness of the team (at most 5 facts showing the influence or academic attractiveness of the team)

1. Creation (by L. Gonnord and F. Rastello) of the french compilation community[5] (8 events since 2010), now a subgroup of the GDRs GPL and ASR.
2. Creation (by C. Alias, with C. Bastoul) of the first international workshop on polyhedral techniques (IMPACT)[6], now an annual event, satellite workshop of the HIPEAC conference.
3. Organization (by A. Darte) of a thematic quarter on compilation[7] with, in addition to the compilation days, 3 international events: a) the first spring school on polyhedral code analysis and optimizations, b) a unique 4-days set of keynotes on HPC languages, c) the international workshop on compilers for parallel computers (CPC'13).
4. Five chapters [543, 544, 545, 546, 547] of the Encyclopedia of Parallel Programming[8], edited by D. Padua.
5. Paul Feautrier received, from the Euro-Par steering committee, an award "in recognition of his outstanding contributions to parallel processing" (2009). He was also honored in a special "P. Feautrier evening" during CGO'11. His 1988 "Array Expansion" seminal paper has been selected for the upcoming 25th anniversary retrospective of ICS (Int. Conf. on Supercomputing) with 34 other papers, among 1800 from 1987 to 2011. In sep. 2014, together with ten other specialists in automatic parallelization, he will record for the IEEE a lecture on the "polyhedral model".

Interaction of the team with its environment (at most 5 facts, interaction with social, economic or cultural environment)

1. Mediacom project (2009-2012) with STMicro on aggressive and just-in-time SSA-based code optimizations.
2. S2S4HLS project (2009-2011) with STMicro on source-to-source transformations for high-level synthesis.
3. ManycoreLabs project (2012-2015) with Kalray, on analysis and compilation for streaming-like languages.
4. Zettice/XtremLogic start-up, as a follow-up to Alexandru Plesco PhD thesis [562] and several additional results (e.g., [476, 559]). Christophe Alias is taking an active part in this effort as co-founder and chief scientific advisor.

Training initiatives

(main contributions such as: conception and coordination of training modules in master and PhD programs, PhD student monitoring, conception of education tools, lifelong learning initiatives, . . .)

- Christophe Alias (CR Inria) is in charge of the Master 1 compilation course at ENS-Lyon, since 2010.
- The team runs the Master 2 course on advanced code optimizations at ENS-Lyon.
- Alain Darte was vice-chair of the ENS-Lyon entrance examination (responsible for computer science), until 2010.
- Christophe Alias and Laure Gonnord organized four "Master schools" for ENS-Lyon students: "Beyond the PC. Application-specific systems: design and implementation" (in 2010), "Verification and certification of software" (in 2012), "Programming embedded systems with synchronous languages" (in 2014), "Static analyses in the state-of-the-art compilers" (to come in 2015).
- 4 PhD students graduated in Compsys since 2009. Florent Bouchez [560] is now assistant professor in Grenoble, Benoit Boissinot [561] is R&D engineer at Google Zürich, Alexandru Plesco [562] is CEO/CTO of XtremLogic, Quentin Colombet [563] is R&D engineer at Apple Cupertino.

The head of the team can briefly state 3 precise points on which he would like to know the evaluation of the committee.

[5] http://compilation.gforge.inria.fr
[6] http://impact.gforge.inria.fr
[7] http://labexcompilation.ens-lyon.fr
[8] http://www.springer.com/computer/swe/book/978-0-387-09765-7

1.7 Présentation synthétique : équipe Dante

Nom du responsable de l'équipe pour le contrat en cours: Éric FLEURY depuis novembre 2012. L'équipe DANTE a été créé en novembre 2012. L'équipe DANTE est née d'une réflexion commune avec RESO et D-NET. Paulo GONÇALVES était le responsable de RESO et Éric FLEURY le responsable de D-Net.
Nom du responsable de l'équipe pour le futur contrat: Éric FLEURY

Effectifs de l'équipe

6 enseignants chercheurs (T. Begin, A. Busson, C. Crespelle, E. Fleury, I. Guérin-Lassous, M. Karsai) 1 chercheur (P. Gonçalves) ; 1 personnel administratif (L. Lecot) et 7 étudiants en thèse.

Personnels ayant quitté l'équipe 2 chercheurs (G Chelius 36 months and P. Primet 24 months) ; 16 thésards (396 months) ; 14 post-docs (168 months).

Recrutements : 4

Thomas Begin (Univ. Lyon I, MdC (depuis septembre 2009), était en thèse à l'UPMC).
Anthony Busson (Univ. Lyon I, Professeur (depuis septembre 2012), était MdC à Orsay).
Christophe Crespelle (Univ. Lyon I, MdC (depuis septembre 2010), était postdoc à l'UPMC).
Márton Karsai (ENS de Lyon / Inria, Mdc / Chaire Inria, depuis Sep 2013, était postdoc au MIT/Boston).

Réalisations et produits de la recherche

1. Caractérisation et estimation des différentes propriétés de loi d'échelle pour les traffics de longue durée. Nous avons formalisé et quantifié l'influence de diverses caractéristiques statistiques du traffic sur les performances du réseau [611, 683, 645, 647, 668, 590]. Nous avons exploité ces propriétés pour définir une approche probabiliste pour de l'allocation de ressources dans le "cloud" [609, 720, 721, 695].
2. Contrôle d'admission basé sur la connaissance : nous avons proposé une méthode orientée données basée sur un modèle temporel. Notre proposition offre une garantie probabiliste sur le seuil qui s'exprime soit comme un délai borné soit comme un taux de pertes borné [690, 673, 805].
3. Détection de communauté. Nous avons poursuivi deux approches dans ce domaine : l'une sur la détection de communautés recouvrantes et l'autre traitant des communautés dynamiques [615, 577, 699, 698, 680, 682, 688, 679, 681, 599].
4. Développement, conception et déploiement d'infrastructure pout l'IoT (Internet of Things) [598, 678, 676, 677, 640]. Nous avons construit la plate-forme SensLAB et sommes en charge de la plate-forme IoT-LAB au sein de l'Equipex FIT. Nous avons également effectué des déploiements massifs de capteurs au sein du projet MOSAR [619, 612, 603]. Une partie de notre expertise fut à la base du transfert vers la startup HiKoB.
5. Traitement de signal sur graphe. Ce nouvel axe de recherche, poussé par DANTE se révèle prometteur. Nous avons déjà pu avancer sur la correspondance entre graphe et signal avec comme objectif d'analyser la structure inhérente aux graphes avec des outils empruntés au traitement du signal [724, 715, 716].

Bilan quantitatif des publications de l'équipe

Journaux [ACL]	52
Conférences invitées	5
Conférences [ACT]	96
Workshop / communications courtes	24
Livres / chapitres de livre [OS]	15
Médiation scientifique [OV]	10
Autres / Brevets / Logiciels [AP]	15
Thèse et HDR [TH]	14

Publications majeures

1. [590] P. Loiseau, P. Gonçalves G. Dewaele, P. Borgnat, P. Abry, and P. Primet. Investigating self-similarity and heavy-tailed distributions on a large scale experimental facility. *IIEEE/ACM Transactions on Networking*, (99):1, 2010.
2. [597] Christophe Crespelle and Fabien Tarissan. Evaluation of a New Method for Measuring the Internet Degree Distribution: Simulation Results. *Computer Communications*, 34(5):635–648, 2011.

3. [621] A. Busson, B. Jabbari, B. Alireza, and V. Vèque. Interference and Throughput in Spectrum Sensing Cognitive Radio Networks using Point Processes. *Journal of Communications and Networks*, 16(1):67–80, 2014.
4. [608] A. Brandwajn and T. Begin. A recurrent solution of Ph/M/c/N-like and Ph/M/c-like queues. *Journal of Applied Probability*, 49(1):84–99, 2012.
5. [612] J.-C. Lucet, C. Laouenan, G. Chelius, N. Veziris, D. Lepelletier, A. Friggeri, D. Abiteboul, E. Bouvet, F. Mentré, and Eric Fleury. Electronic Sensors for Assessing Interactions between Healthcare Workers and Patients under Airborne Precautions. *PLoS ONE*, 7(5), May 2012.

Documents majeurs

1. 5 brevets (3 autours de la virtualisation, 1 sur un protocole pour les réseaux de capteurs et 1 pour la détection d'applications maligne).
2. Nous avons développer de nombreux de logiciels (OS, drivers, bibliothèques de communication) pour les plate-formes SensLAB et FIT IoT-LAB[9]
3. Outil pour la résolution numérique de files d'attente classiques. Cette application web[10] facilite l'usage de nos algorithmes permettant la résolution de files d'attente. [608]. Depuis 2012, le site reçoit une quinzaine de visiteurs par jour.
4. Metroflux: nous avons conçu une sonde pour capturer le trafic d'un lien à 10Gbps. La capture est garantie sans perte, full-duplex avec une précision temporelle de l'ordre de la μs et une capacité de stockage permettant des captures de plusieurs heures à plein débit. (Prix de la meilleure démonstration à ACM SIGMETRICS/PERFORMANCE [808])

Rayonnement et attractivité de l'équipe

1. Pascale Vicat-Blanc : Prix Inria – Académie des sciences – Dassault Systèmes de l'innovation 2013 ; Prix Irène Joliot-Curie 2011 ; chevalière de la Légion d'honneur en 2010
2. Responsable de la plate-forme IoT-LAB[11] au sein de l'Equipes FIT. FIT-IoT LAB. IoT-LAB offre plus de 2700 capteurs sans fil sur différents sites en France.
3. Paulo Gonçalves a été conférencier invité à CLOSER 2014[12].
4. Nous avons bénéficié d'un financement Equipex lors de la première vague (Equipex FIT) ; de 8 projets ANR, 8 projets européens. Nous avons également obtenu via Inria 2 ADT, 2 ARC et une équipe associée internationale.
5. Márton Karsai a été conférencier invité à ThetSphys'14 (NetSci'14 Symposium)
6. Isabelle Guérin Lassous a été Chair de ACM PE-WASUN

Interactions de l'équipe avec son environnement

1. 2 start-ups ont été fondées : Lyatis sur le contrôle des "cloud" par P. Primet et HiKob sur le développement et déploiement d'infrastructure de réseaux de capteurs par G. Chelius.
2. Nous avons organisé la conférence "L'héritage d'Alan Turing, où comment la machine universelle a bouleversé notre société". Ce fut l'occasion de remettre le premier diplôme honoris causa en informatique de l'ENS de Lyon à Leslie Valiant. Pour cette occasion un film sur la machine de turing réalisée en LEGO a été produit[13].
3. Dialogue entre science et société au travers de films[14] , émission de radian (RFI), Interview Télé. Participation au projet NANOYOU (Nano for Youth). Participation au concours vidéo NANOYOU où des jeunes ont réalisé de courtes vidéos sur le thème "Vivre la ville 2.0".
4. Les membres de DANTE assurent des responsabilités importantes au sein des GDR ASR et ISIS, du Labex MI-LYON, des appels ANR INFRA (présidence).

Actions de formation

Nous avons été en charge de l'organisation scientifique de 4 écoles de recherche à l'ENS de Lyon (Optimisation and convexity ; Stochastic Geometry for Wireless Networks ; Compressive Sensing ; Game theory for networks) et de l'école d'été du GDR ASR ResCOM (Network Science).
Les membres de DANTE sont très impliqués dans la gestion des structures administratives et pédagogiques : direction du département informatique de l'ENS de Lyon ; responsable du master d'informatique à l'ENS de Lyon ; co direction du parcours "modélisation des systèmes complexes" à cheval sur 3 masters (Informatique, Mathématique & Physique) ; responsable de la spécialité "réseaux" au sein de Lyon 1. Nous intervenons aussi dans plusieurs cours de M2 à l'ENS de Lyon et à l'UCBL.

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[9] https://www.iot-lab.info/dev-center/
[10] http://queueing-systems.ens-lyon.fr
[11] https://www.iot- lab.info
[12] http://closer.scitevents.org/Home.aspx
[13] plus de 108 000 vues sur http://www.dailymotion.com/video/xrmfie_the-turing-machine-comes-true_tech
[14] http://www.universcience.tv/video-i-bird-comprendre-les-infections-nosocomiales-621.html

1.8 Executive summary: Dante team

Name of the head of the team for the present contract: Éric FLEURY since november 2012. The DANTE team was created in November 2012. The scientific lines of the DANTE team stem from a joint reflexion between a part of RESO and D-Net. Paulo GONÇALVES was the head of RESO and Éric FLEURY the head of D-Net.
Name of the head of the team for the upcoming contract: Éric FLEURY

Team composition

6 lecturers and professors (T. Begin, A. Busson, C. Crespelle, E. Fleury, I. Guérin-Lassous, M. Karsai) 1 researchers (P. Gonçalves) ; 1 technical staff (L. Lecot) ; 7 PhD students.

Persons who left the team 2 researchers (G. Chelius 36 months and P. Primet 24 months); 16 PhD students (396 months); 14 post-docs (168 months).

New members : 4

Thomas Begin (Univ. Lyon I, Associate Professor (arrived in September 2009), was previously PhD at UPMC).
Anthony Busson (Univ. Lyon I, Professor (arrived in September 2012), was previously Associated Professor at Orsay).
Christophe Crespelle (Univ. Lyon I, Associate Professor (arrived in September 2010), was previously postdoc at UPMC).
Márton Karsai (ENS de Lyon / Inria, Associate Professor / Inria Chair, from Sep 2013).

Scientific outcomes

1. Characterization and estimation of different scaling law properties in traffic flows. We formalize and quantify the impact of diverse statistical traffic features on network performance [611, 683, 645, 647, 668, 590]. We exploit this properties to derive a probabilistic approach for resource provisioning in cloud environment [609, 720, 721, 695].
2. Knowledge-Based Admission Control: we introduce a novel data-driven method based on a timevarying model that we refer to as Knowledge-Based Admission Control solution (KBAC). Our KBAC solution provides a probabilistic guarantee whose admission threshold is either expressed, as a bounded delay or as a bounded loss rate [690, 673, 805].
3. Community detection. We conduct two main approaches in community detection suitable for large scale network. The first one is related to overlapping detection and the second one is to be able to detect dynamic communities [615, 577, 699, 698, 680, 682, 688, 679, 681, 599]
4. Developping and deploying large scale research infrastructure for IoT researches [598, 678, 676, 677, 640]. We are leading the SensLAB tool, the Iot-LAB tool within the equipped FIT and we perform very large scale deployment in the Heath/medical domain (MOSAR FP6) [619, 612, 603]. Our knowledge was transfered to the startup HiKoB.
5. Graph-based signal processing. The novel research direction pushed by DANTE reveals promising. We investigate a graph to signal mapping with the objective of analyzing intricate structural properties of graphs with tools borrowed from signal processing [724, 715, 716]

Quantitative assessment of team's publications

International and national peer-reviewed journals [ACL]	52
Invited conferences [INV], seminars, and tutorials	5
International and national peer-reviewed conference proceedings [ACT]	96
Short communications [COM] and posters [AFF] in conferences and workshops	24
Scientific books and book chapters [OS]	15
Scientific popularization [OV]	10
Other Publications [AP]	15
Doctoral Dissertations and Habilitation Theses [TH]	14

Major publications

1. [590] P. Loiseau, P. Gonçalves G. Dewaele, P. Borgnat, P. Abry, and P. Primet. Investigating self-similarity and heavy-tailed distributions on a large scale experimental facility. *IIEEE/ACM TON*, (99):1, 2010.
2. [597] Christophe Crespelle and Fabien Tarissan. Evaluation of a New Method for Measuring the Internet Degree Distribution: Simulation Results. *Computer Communications*, 34(5):635–648, 2011.
3. [621] A. Busson, B. Jabbari, B. Alireza, and V. Vèque. Interference and Throughput in Spectrum Sensing Cognitive Radio Networks using Point Processes. *Journal of Communications and Networks*, 16(1):67–80, 2014.

4. [608] A. Brandwajn and T. Begin. A recurrent solution of Ph/M/c/N-like and Ph/M/c-like queues. *Journal of Applied Probability*, 49(1):84–99, 2012.
5. [612] J.-C. Lucet, C. Laouenan, G. Chelius, N. Veziris, D. Lepelletier, A. Friggeri, D. Abiteboul, E. Bouvet, F. Mentré, and Eric Fleury. Electronic Sensors for Assessing Interactions between Healthcare Workers and Patients under Airborne Precautions. *PLoS ONE*, 7(5), May 2012.

Major documents

1. 5 patents (3 f on Virtualization, 1 for wireless sensor network and 1 for detecting cheating applications
2. Within SensLAB and FIT IoT-LAB[15] we offers full support for embedded software development, ranging from direct access to node hardware to OS-level features. Developers can leverage the different APIs to build applications.
3. Classical queueing systems solver: This tool provides a simple web application[16] to promote the use of our algorithms for solving classical queueing systems. [608]. As of beginning of 2012, this site is averaging over 15 unique visits per day.
4. Metroflux: We design packet capture probe so that we can now monitor a 10Gbps link capacity. As for the 1Gbps version, we checked that capture is loss free and bidirectional, time stamping precision is close to the μs and storage capacity permits several hours of capture at full speed (Best Demonstration award at ACM SIGMETRICS/PERFORMANCE [808])

Influence and attractiveness of the team

1. Pascale Vicat-Blanc : Prix Inria – Académie des sciences – Dassault Systèmes de l'innovation 2013 ; Prix Irène Joliot-Curie 2011; chevalière de la Légion d'honneur en 2010
2. We are the prime investigator for the Equipex FIT-IoT LAB[17]. IoT-LAB features over 2700 wireless sensor nodes spread across six different sites in France.
3. Paulo Gonçalves keynote speaker at CLOSER 2014[18]
4. We have obtained funding for for 1 EQUIPEX, 8 ANR projects, 8 European projects. We also have obtain Inria funding for 2 ADT, 2 ARC and an International Associated team with Japan.
5. Marton Karsai, invited speaker at ThetSphys'14 (NetSci'14 Symposium)
6. Isabelle Guérin Lassous was Chair of ACM PE-WASUN

Interaction of the team with its environment

1. 2 start-ups were founded: namely Lyatis on cloud networking control by Pascal Primet-Blanc in 2010 and HiKoB on the development of wireless autonomous multi-points data acquisition system by Guillaume Chelius.
2. Organisation of the conference Alan Turing's heritage that was the occasion to program 6 public lectures intended for a broad audience. It was also a great opportunity to award an honorary degree from ENS de Lyon, doctorate honoris causa to Leslie Valiant (a first for Computer Science at ENS de Lyon). At this occasion, a short movie "The Turing Machine Comes True"[19] was released on the "Real Turing Machine".
3. Dialogue between science and society through movies[20] , Radio and TV on MOSAR, or within the context of the NANOYOU (Nano for Youth) project, funded by the EC's 7th Framework Program that aims to increase young people's basic understanding of nanotechnologies and to engage in the dialogue about its ethical, legal and social aspects. Movies are presented at "La Cité des sciences et de l'industrie".
4. Members of DANTE are engaged in the scientific community and assure administrative responsibilities: GDR ASR and ISIS, Labex MILYON, presidence of ANR expert committee for INFRA.

Training initiatives

Scientific organisation of 4 research winter schools at ENS de Lyon (Optimisation and convexity; Stochastic Geometry for Wireless Networks; Compressive Sensing; Game theory for networks) and one summer school for the GDR ASR/ResCom (Network Science).
Members of the DANTE team were strongly involved in the management of the departments and formations cursus: head of the master at ENS de Lyon, head of the ENS de Lyon computer science department, co-direction of the cursus "modelling complexe science" in link with 3 masters of ENS de lyon (Mathematics, Physique and Computer Science) and IXXI (Rhone Alpes complex systems institute), head of a cursus on networking at Lyon 1 and we teach several Master 2 research courses at ENS de Lyon and Lyon 1.
20 Phd and 1 HDR were defended.

[15] `https://www.iot-lab.info/dev-center/`
[16] `http://queueing-systems.ens-lyon.fr`
[17] https://www.iot- lab.info
[18] `http://closer.scitevents.org/Home.aspx`
[19] more that 108 000 views on `http://www.dailymotion.com/video/xrmfie_the-turing-machine-comes-true_tech`
[20] `http://www.universcience.tv/video-i-bird-comprendre-les-infections-nosocomiales-621.html`

1.9 Présentation synthétique : équipe MC2

Nom du responsable de l'équipe pour le contrat en cours: Pascal Koiran (conjointement avec Eric Thierry entre septembre 2009 et septembre 2011)
Nom du responsable de l'équipe pour le futur contrat: Nicolas Trotignon

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Effectifs de l'équipe en janvier 2009

Enseignants-chercheurs : Pascal Koiran, Natacha Portier, Eric Rémila, Eric Thierry. Ingénieurs : Eric Boix, Gina Chiquillo Mojica, Ricardo Uribe-Lobello. Personnel administratif : Soline Beaud (for Morphex project). Doctorants : Florent Becker, Irénée Briquel, Laurent Jouhet, Julien Robert.

Personnels ayant quitté l'équipe

MCF: Eric Rémila (44 mois passés dans l'équipe). Ingénieurs: Eric Boix (36 mois), Jorge Bertran Salazar (12 mois), Gina Chiquillo Mojica (24 mois), Arnaud Grignard (20 mois), Mathieu Malaterre (18 mois), Ricardo Uribe-Lobello (12 mois), Vincent Hobeika (11 mois), Yves Quemener (9 mois), Personnel administratif: Soline Beaud (11 mois). Doctorants: Florent Becker (8 mois), Irénée Briquel (48 mois), Bruno Grenet (48 mois), Laurent Jouhet (24 mois), Mathilde Noual (12 mois), Damien Régnault (8 mois), Julien Robert (8 mois), Jean-Baptiste Rouquier (8 mois), Kevin Perrot (36 mois), Pierre Aboulker (19 mois), ATER et post-docs: Jonathan Grattage (28 mois), Emilie Diot (12 mois), Zhentao Li (12 mois).

Recrutements *(les membres qui ont quitté l'équipe avant 2014 ne sont pas indiqués)*

5 membres permanents: Nathalie Aubrun (chercheur CNRS, section mathématiques, auparavant post-doc à Turku) ; Omar Fawzi (maître de conférences, rejoint l'équipe en septembre 2014 après un post-doc à l'ETH Zürich) ; Michael Rao (chercheur CNRS, poste CNRS précédent à Moscou) ; Stéphan Thomassé (professeur ENS Lyon, auparavant professeur à Montpellier) ; Nicolas Trotignon (chercheur CNRS, poste CNRS précédent au LIAFA).

Pablo Arrighi et Mathieu Sablik, maîtres de conférences à l'Université Joseph Fourier et à l'Université de Provence (quittent le LIP tous les deux en septembre).

Irena Penev, postdoc (labex MiLyon, auparavant doctorante à Columbia).

2 ATER: Maxime Senot (auparavant doctorant à Orléans) et Petru Valicov (auparavant ATER à Paris 11). Ils quittent le LIP en septembre.

3 doctorants: Aurélie Lagoutte, Sébastien Tavenas, Théophile Trunck. 2 doctorants, 4 postdocs et un ATER rejoignent l'équipe en septembre.

Réalisations et produits de la recherche

1. **Coloration de graphes:** Nous avons proposé une nouvelle approche pour la coloration des graphes marfait (voir la publication majeure numéro 5). Nous avons également démontré la conjecture de Scott pour les graphes sans triangle maximaux (publication majeure numéro 3). D'après cette conjecture, pour tout graphe fixé G, la classe des graphes qui ne contiennent pas G comme sous-graphe induit est χ-bornée (c'est à dire que son nombre chromatique est borné par une fonction de la taille de sa plus grande clique).

2. **Graphes dynamiques:** Nous avons proposé un formalisme général pour la description des graphes dynamiques évoluants grâce à des interactions entre sommets voisins (publication majeure 1).

3. **Nombres parfaits impairs:** Nous avons montré [864] avec une preuve assistée par ordinateur que tout nombre parfait impair (s'il en existe) doit être plus grand que 10^{500}.

4. **Dynamique symbolique:** Nous avons montré que tout sous-shift effectif (appelé aussi “décalage effectif”) en dimension d peut être obtenu comme sous-action d'un sous-shift sofique de dimension $d + 1$ (publication majeure numéro 2). Ce résultat améliore la construction d'Hochmann, qui nécessitait 2 dimensions supplémentaires.

5. **Réduction de profondeur pour les circuits arithmétiques:** Nous avons montré que tout circuit arithmétique peut être transformé en un circuit équivalent de profondeur 4 de taille “raisonnable.” La borne obtenue est optimale sous une condition technique assez faible (l'homogénéité du circuit de profondeur 4). Voir la publication majeure 4 ainsi que [860].

Bilan quantitatif des publications de l'équipe

Publications majeures

1. Pablo Arrighi and Gilles Dowek. Causal graph dynamics, ICALP 2012, Warwick, July 2012. LNCS 7392, 54-66, (2012).
2. Nathalie Aubrun and Mathieu Sablik: Simulation of effective subshifts by two-dimensional subshifts of finite type. Acta Applicandae Mathematicae, Volume 128, issue 1, p.35-63, 2013.
3. Nicolas Bousquet and Stéphan Thomassé: Scott's Induced Subdivision Conjecture for Maximal Triangle-Free Graphs. Combinatorics, Probability and Computing 21(4): 512-514 (2012)
4. Sébastien Tavenas. Improved bounds for reduction to depth 4 and depth 3. MFCS 2013. Best paper and best student paper.
5. Nicolas Trotignon and Kristina Vuskovic. Combinatorial optimization with 2-joins. Journal of Combinatorial Theory, Series B, 102:153–185, 2012.

Documents majeurs

En collaboration avec Pascal Ochem (LIRMM), Michael Rao a écrit un programme montrant que tout nombre parfait impair (s'il en existe) doit être plus grand que 10^500. Ce travail a donné lieu à 2 publications dans Mathematics of Computation [864, 907].

Rayonnement et attractivité de l'équipe

1. Nous avons obtenu en 2013 le financement de deux projets ANR blancs (sur 12 en informatique pour la France entière). Le projet Stint (structures interdites) est coordonné par Nicolas Trotignon, et le projet CompA (complexité algébrique) est coordonné par by Pascal Koiran. Ils ont démarré en janvier et février 2014.
2. Deux de nos doctorants ont obtenu des prix scientifiques. Mathilde Noual a obtenu le prix de thèse EADS et le second prix de thèse Gilles Kahn pour l'année 2012 (ce prix de thèse est décerné par la SIF, la Société Informatique de France). Sébastien Tavenas a obtenu le prix du meilleur article et le prix du meilleur article étudiant à MFCS 2013.
3. Nous avons organisé plusieurs conférences nationales et internationales, dont STACS 2014 (une liste complète se trouve en appendice 6). Nous avons participé à l'organisation d'une conférence sue l'héritage d'Alan Turing (ENS Lyon, juillet 2012, http://www.turing2012.fr) et à la remise d'un doctorat honoris causa à Leslie Valiant (une première pour l'informatique à l'ENS Lyon).
4. Nous sommes parvenus à attirer plusieurs post-docts brillants de l'étranger, dont Zhentao Li (de McGill, actuellement MCF à l'ENS Paris) et Irena Penev (de Columbia). Quatre nouveaux postdocs et un MCF rejoignent l"équipe à l'automne 2014.
5. Les membres de l'équipe ont donné de nombreux exposés invités, par exemple à STACS 2013 (Stéphan Thomassé) ou ISSAC 2012 (Pascal Koiran, pour le tutoriel). Une liste complète se trouve en appendice.

Interactions de l'équipe avec son environnement

1. La MMI (Maison des Mathématiques et de l'Informatique) organise des expositions, des conférences et diverses activités pour les écoliers et le grand public. Elle est financée par le labex MiLyon et a commencé ses activités en 2012. Natacha Portier et Nicolas Trotignon sont membres de son comité de pilotage et participatent à ses activités de diffusion (comme par exemple la programmation de robots Lego robots pour des lycéens).
2. L'un de nos doctorants, Kevin Perrot, a supervisé un project étudiant qui a débouché sur la construction d'une machine de Turing en Légo entièrement mécanique, une première mondiale. Ce projet a reçu une importante couverture médiatique (voir http://rubens.ens-lyon.fr).
3. Pablo Arrighi a été interviewé par Marie-Odile Monchicourt sur France Info le 12 septembre 2012. Sujets abordés: physique quantique, information et calcul quantique. Il est coauteur avec Jonathan Grattage d'un article dans le numéro de septembre 2012 de La Recherche: "Le monde est un ordinateur quantique".
4. Pascal Koiran a été inteviewé par le journal du CNRS pour son numéro spécial consacré à Alan Turing. Il a également été interviewé par le journaliste scientifique David Larousserie pour son article "Alan Turing, l'héritage d'un géant" (Le Monde, cahier "sciences et technologies", 23 juin 2012).
5. Dans le cadre du projet ANR Pegase (2009-2012), Eric Thierry a travaillé sur les algorithmes $(\min, +)$ pour l'évaluation de performance dans le formalisme du "network calculus". Les partenaires du projet étaient Thales Alenia Space, Thales Avionics, ONERA (leader), ENS Cachan - Bretagne, LIP, Real-Time at Work, INRIA Rhône-Alpes.

Actions de formation

Nous sommes fortement impliqués dans le cursus d'informatique à l'ENS Lyon puisque 4 de nos membres (Pascal Koiran, Natacha Portier, Stéphan Thomassé et Eric Thierry) y sont maîtres de conférences ou professeurs. Un nouveau maître de conférences (Omar Fawzi) nous rejoindra en septembre 2014. Nos chercheurs CNRS contribuent à des cours de M2 (Nicolas Trotignon, 2013-2014 and 2014-2015 ; Nathalie Aubrun, 2014-2015). Eric Thierry est repsonsable de l'année de L3 et Stéphan Thomassé est directeur adjoint du département et responsable du M2. Pascal Koiran est responsable du séminaire des élèves, de la semaine sport-études et des écoles de recherche du mois de janvier.

1.10 Executive summary: MC2 team

Name of the head of the team for the present contract: Pascal Koiran (with Eric Thierry as joint head between September 2009 and September 2011)
Name of the head of the team for the upcoming contract: Nicolas Trotignon

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Team composition in January 2009

Lecturers and professors: Pascal Koiran, Natacha Portier, Eric Rémila, Eric Thierry. Engineers: Eric Boix, Gina Chiquillo Mojica, Ricardo Uribe-Lobello. Administrative staff: Soline Beaud (for Morphex project). PhD students: Florent Becker, Irénée Briquel, Laurent Jouhet, Julien Robert.

Persons who left the team

Lecturer: Eric Rémila (44 months in the team). Engineers: Eric Boix (36 months), Jorge Bertran Salazar (12 months), Gina Chiquillo Mojica (24 months), Arnaud Grignard (20 months), Mathieu Malaterre (18 months), Ricardo Uribe-Lobello (12 months), Vincent Hobeika (11 months), Yves Quemener (9 months), Administrative staff: Soline Beaud (11 months). PhD students: Florent Becker (8 months), Irénée Briquel (48 months), Bruno Grenet (48 months), Laurent Jouhet (24 months), Mathilde Noual (12 months), Damien Régnault (8 months), Julien Robert (8 months), Jean-Baptiste Rouquier (8 months), Kevin Perrot (36 months), Pierre Aboulker (19 months), ATER and Post-docs: Jonathan Grattage (28 months), Emilie Diot (12 months), Zhentao Li (12 months).

New members (*Does not include new members who left the team before 2014*)

5 permanent members: Nathalie Aubrun (CNRS researcher, math section, formerly post-doc in Turku); Omar Fawzi (associate professor, will leave a post-doc position at ETH Zürich to join the group in September); Michael Rao (CNRS researcher, previous CNRS position in Moscow); Stéphan Thomassé (professor at ENS Lyon, formerly professor in Montpellier); Nicolas Trotignon (CNRS researcher, previous CNRS position at LIAFA).

Pablo Arrighi and Mathieu Sablik, associate professors on leave from Université Joseph Fourier and Université de Provence (will leave LIP in September).

Irena Penev, postdoc (labex MiLyon, formerly PhD student at Columbia).

2 ATER: Maxime Senot (formerly PhD student in Orléans) and Petru Valicov (formerly ATER at Paris 11). They will leave LIP in September.

3 PhD students: Aurélie Lagoutte, Sébastien Tavenas, Théophile Trunck. 2 doctorants, 4 postdocs et un ATER rejoignent l'équipe en septembre.

Scientific outcomes

5 major results during the past period (January 1st 2009 - June 30 2014)

1. **Graph coloring:** We have proposed a new approach for coloring perfect graphs (see major publication number 5). We have also proved Scott's conjecture for maximal triangle-free graphs (major publication number 3). According to this conjecture, for any fixed graph G the class C of gaphs which do not contain G as an induced subgraph is χ-bounded (i.e., its chromatic number can be bounded as a function of its clique number).

2. **Dynamic Graphs:** We have proposed a general formalism for the description of dynamic graphs evolving through interactions between neighbouring vertices (major publication 1).

3. **Odd perfect numbers:** We have shown [864] with a computer-assisted proof that any odd perfect number (if there are any) must be larger than 10^{500}.

4. **Symbolic Dynamics:** We proved that any effective subshift of dimension d can be found as the projective subaction of a sofic subshift of dimension $d+1$ (major publication 2). This result improves Hochman's construction, which needed two extra dimensions.

5. **Depth reduction for arithmetic circuits:** We have shown that any arithmetic circuit can be tranformed into an equivalent circuit of depth 4 without blowing up the circuit size too much. Our bound is provably optimal under a mild technical condition (homogeneity of the depth 4 circuit). See major publication 4 and [860].

Quantitative assessment of team's publications

Major publications

Max 5 (With their title and underlining, in case of common publications, the name of the team member(s)).

1. Pablo Arrighi and Gilles Dowek. Causal graph dynamics, ICALP 2012, Warwick, July 2012. LNCS 7392, 54-66, (2012).
2. Nathalie Aubrun and Mathieu Sablik: Simulation of effective subshifts by two-dimensional subshifts of finite type. Acta Applicandae Mathematicae, Volume 128, issue 1, p.35-63, 2013.
3. Nicolas Bousquet and Stéphan Thomassé: Scott's Induced Subdivision Conjecture for Maximal Triangle-Free Graphs. Combinatorics, Probability and Computing 21(4): 512-514 (2012)
4. Sébastien Tavenas. Improved bounds for reduction to depth 4 and depth 3. MFCS 2013. Best paper and best student paper.
5. Nicolas Trotignon and Kristina Vuskovic. Combinatorial optimization with 2-joins. Journal of Combinatorial Theory, Series B, 102:153–185, 2012.

Major documents

In collaboration with Pascal Ochem (LIRMM), Michael Rao wrote a computer program showing that any odd perfect number (if there exists any) must be greater than 10^{500}. This work has led so far to two publications in Mathematics of Computation [864, 907].

Influence and attractiveness of the team

1. We have obtained funding for two ANR "white" projects in 2013 (out of 12 such projects in computer science for the whole country). Project Stint ("Structures Interdites", or "forbidden structures") is coordinated by Nicolas Trotignon, and project CompA (algebraic complexity) is coordinated by Pascal Koiran. They got started in January and February 2014.
2. Two of our PhD students obtained scientific awards. Mathilde Noual obtained the EADS thesis prize and the second Gilles Kahn prize for the year 2012 (this thesis prize is awarded by SIF, the Société Informatique de France). Sébastien Tavenas obtained a best paper award and a best student paper award at MFCS 2013.
3. We have organized several national and international conferences, including STACS 2014 (a complete list can be found in Appendix 6). We helped organize a conference on Alan Turing's heritage (ENS Lyon, July 2012, http://www.turing2012.fr) and the award of a doctorate honoris causa to Leslie Valiant (a first for computer science at ENS Lyon).
4. We have been able to attract several bright post-docs from abroad, including Zhentao Li (from McGill, now associate professor at ENS Paris) and Irena Penev (from Columbia). Four new postdocs and an associate professor are joining our group in Fall 2014.
5. Numerous invited talks, for instance: ISSAC 2012 tutorial (Pascal Koiran) and STACS 2013 invited talk (Stéphan Thomassé). The complete list is in appendix.

Interaction of the team with its environment

1. The MMI (Maison des Mathématiques et de l'Informatique) organizes exhibits, conferences, and various activities for schoolchildren and for the general public. It is funded by labex MiLyon and began its operations in 2012. Natacha Portier and Nicolas Trotignon are members of its steering committee and participate in its outreach activities (e.g., programming of Lego robots for high-school students).
2. One of our PhD students, Kevin Perrot, supervised a student project which resulted in the construction of the world's first entirely mechanical Lego Turing machine. This project has received a substantial media coverage (see http://rubens.ens-lyon.fr).
3. Pablo Arrighi was interviewed by Marie-Odile Monchicourt on France Info (September 12, 2012). Topics covered: quantum physics, quantum information, quantum computing. He is the coauthor with Jonathan Grattage of an article in the September 2012 issue of La Recherche: "Le monde est un ordinateur quantique".
4. Pascal Koiran was interviewed by the CNRS journal for its special issue on Alan Turing. He was interviewed by science journalist David Larousserie for his article "Alan Turing, l'héritage d'un géant" (Le Monde, cahier "sciences et technologies", June 23, 2012).
5. Within ANR project Pegase (2009-2012), Eric Thierry worked on $(\min, +)$ algorithms for performance evaluation using the network calculus formalism. The project partners were Thales Alenia Space, Thales Avionics, ONERA (leader), ENS Cachan - Bretagne, LIP, Real-Time at Work, INRIA Rhône-Alpes.

Training initiatives

We are heavily involved in the CS curriculum of ENS Lyon since 4 of our members (Pascal Koiran, Natacha Portier, Stéphan Thomassé and Eric Thierry) have a professor or an associate professor position in this institution. A new associate professor (Omar Fawzi) will join the team in september 2014. Our CNRS researchers contribute to M2 classes (Nicolas Trotignon, 2013-2014 and 2014-2015; Nathalie Aubrun, 2014-2015). Eric Thierry is in charge of the L3 year and Stéphan Thomassé of the M2 year. Pascal Koiran is in charge of the student seminar, of the sports-study week and of the winter research schools.

1.11 Présentation synthétique : équipe Plume

Nom du responsable de l'équipe pour le contrat en cours: O. Laurent (01/09-09/12), P. Baillot (09/12–).

Nom du responsable de l'équipe pour le futur contrat: P. Baillot.

Effectifs de l'équipe

5 enseignants-chercheurs: Ph. Audebaud, J. Duprat, D. Hirschkoff, P. Lescanne, A. Miquel (*délégation*). 2 chercheurs: P. Baillot, O. Laurent. 1 techniciens, ingénieurs et autres personnels: J. Brajon (assistant). 4 post-docs et doctorants: R. Demangeon, A. Pardon, B. Petit (doctorants), C. Riba (ATER).

Personnels ayant quitté l'équipe

2 statutaires (88 mois): J. Duprat (départ retraite 8/2011), A. Miquel (8/2013) (de plus P. Lescanne est devenu Prof. émérite en 2012). puisqu'émérite 5 doctorants (148 mois): R. Demangeon (8/2010), A. Pardon (12/2010), M. Lasson (8/2012), B. Petit (8/2011), L. Rieg (8/2013). (seulement en juillet 2014) 2 post-docs (40 mois): P. Tranquilli (8/2011), A. Kreuzer (2/2014).

Recrutements (n'inclut pas les nouveaux membres qui ont quitté l'équipe avant juin 2014)

5 nouveaux membres permanents : C. Riba (MdC ENSL, auparavant Postdoc Sophia-Antipolis puis ATER ENSL), F. Bonchi (CR2 CNRS recruté, auparavant Postdoc CWI Amsterdam), D. Pous (CR2 CNRS, mutation depuis LIG, Grenoble), R. Harmer (CR1 CNRS, mutation depuis PPS, Paris), P. Clairambault (CR2 CNRS recruté, auparavant Postdoc Univ. de Cambridge).

2 postdocs: F. Aschieri (Labex Milyon, auparavant postdoc PPS Paris) ; D. Petrisan (ANR Picoq, auparavant postdoc Leicester, UK).

7 doctorants: V. Blot (ENS Lyon), P. Brunet (Paris MPRI), E. De Benedetti (Torino), J.-M. Madiot (ENS Lyon), M. Perrinel (ENS Lyon), A. Tsouanas (Athens), F. Zanasi (Amsterdam).

Réalisations et produits de la recherche

1. Bonchi et Pous ont développé de nouvelles techniques pour montrer l'équivalence d'automates finis non-déterministes, fondées sur des méthodes venant de techniques de bisimulation en concurrence, et permettant d'optimiser des algorithmes classiques (article POPL 2013, [1] ci-dessous).

2. Riba a montré comment utiliser des méthodes de forcing de théorie des ensembles (issues des travaux de P. Cohen) afin de montrer par des arguments de théorie des modèles des résultats en vérification sur les logiques monadiques (article LICS 2013, [2] ci-dessous).

3. Miquel a apporté un nouveau point de vue sur la transformation de forcing, introduite en théorie des ensembles, en l'analysant comme une transformation de programmes, dans le cadre de la correspondance preuves-programmes (article LICS 2011, [5] ci-dessous).

4. Hirschkoff et Madiot ont exploré avec Sangiorgi les liens entre différents langages pour représenter les systèmes concurrents: le pi-calcul et le calcul des fusions. Ils en ont déduit des manières de transférer des propriétés de systèmes de types et d'équivalences de programmes de l'un à l'autre de ces calculs (article LICS 2013, [3]).

5. Pous a développé pour l'assistant à la preuve Coq une librairie permettant de construire des preuves formelles pour les raisonnements en algèbre relationnelle, utilisés par exemple pour certifier des optimisations de compilateurs (cf documents majeurs, entrée [1], ci-dessous).

Bilan quantitatif des publications de l'équipe

34 articles dans des journaux internationaux avec comité de lecture, 3 conférences invitées, 65 articles dans des actes de conférences internationales avec comité de lecture, 2 livres ou chapitres de livres.

Publications majeures

1. Filippo Bonchi, Damien Pous: Checking NFA equivalence with bisimulations up to congruence. Proceedings of ACM Symposium on Principles of Programming Languages, (POPL 2013): p. 457-468, ACM, 2013.
2. Colin Riba. Forcing MSO on Infinite Words in Weak MSO. Proceedings of Sympoisum on Logic In Computer Science LICS 2013, IEEE Computer Science, 2013.

3. Daniel Hirschkoff, Jean-Marie Madiot, Davide Sangiorgi. Name-passing calculi: from fusions to preorders and types. Proceedings of Symposium on Logic in Computer Science (LICS 2013), IEEE Computer Science.
4. Patrick Baillot, Ugo Dal Lago: Higher-Order Interpretations and Program Complexity. Proceedings of Conference on Computer Science Logic (CSL 2012): p. 62-76, LIPICS 16 Schloss Dagstuhl, 2012.
5. Alexandre Miquel. Forcing as a Program Transformation. Proceedings of Symposium on Logic in Computer Science (LICS 2011), pp. 197-206, IEEE Computer Press, 2011.

Documents majeurs

1. Damien Pous. contribution logicielle: librairie pour l'assistant de preuves Coq: "Relation Algebra and KAT in Coq" `http://perso.ens-lyon.fr/damien.pous/ra/`
2. Site web: *linear logic wiki*, `http://llwiki.ens-lyon.fr/` . Ce site web présente une introduction et un état de l'art des résultats en logique linéaire. Coordonné par Olivier Laurent.
3. Olivier Laurent. contribution logicielle: module pour l'assistant de preuves Coq: construction de preuves de logique linéaire. `http://perso.ens-lyon.fr/olivier.laurent/l2coq.tgz` , 2013.

Rayonnement et attractivité de l'équipe

1. Séminaire mensuel CHoCoLa, réunissant à la journée des participants de toute la France (Paris, Marseille, Chambéry...). Environ une trentaine de participants, dont une large part de doctorants.
2. Coordination de plusieurs projets ANR, qui donne à l'équipe un rôle pivot: Récré (Miquel/Riba), PACE (Projet ANR Franco-Chinois) (Hirschkoff), COMPLICE (Baillot)
3. Orateurs invités à des conférences internationales: D. Pous orateur invité à 13th International Conference on Relational and Algebraic Methods in Computer Science (RAMiCS 13) Cambridge, 2012, et à 5th Conference on Algebra and Coalgebra in Computer Science (CALCO) 2013 (Varsovie) ; A. Miquel, orateur invité à la conférence TLCA 2011 (Novi Sad, Serbie).
4. Comités de programmes de conférences: l'équipe a été représentée dans de nombreux PC de conférences importantes durant cette période: LICS, FoSSaCS, TLCA...
5. Co-organisation d'une session thématique "Mathematical Structures of Computation" en 2014, impliquant des membres des équipes AriC et Plume, et de l'ICJ Lyon1, dans le cadre du Labex MILYON. Environ 170 participants sur 5 semaines.

Interactions de l'équipe avec son environnement

1. Articles de vulgarisation scientifique: P. Lescanne a écrit plusieurs articles de vulgarisation, dont 4 dans *Images des Mathématiques* (CNRS) et 1 dans *Pour la Science* (No 74 - Janvier - Mars 2012).
2. Diffusion des connaissances: D. Hirschkoff participe à l'association "Maths en Jeans" et a coorganisé des activités de recherche dans des collèges à Villeurbanne et Rillieux la Pape (2011-2014) ; O. Laurent a donné un exposé dans le cadre de la semaine de la science 2014 à la Cité Scolaire Internationale de Lyon. D. Pous a donné un exposé au Puy-en-Velay, dans le cadre des "cordées de la réussite", pour un public de lycéens (avril 2014).

Actions de formation

1. Mise en place de plusieurs cours M2 recherche à l'ENSL, dont certains avec des co-intervenants extérieurs pour compléter notre expertise (par ex. *Recognizability and Model-Checking, from Automata to λ-Calculus* en 2013).
2. 5 thèses de doctorat soutenues durant cette période, et 4 autres à venir en 2014-2015. Dont plusieurs cotutelles avec l'Italie: R. Demangeon, J.-M. Madiot (en cours) avec Bologne, E. De Benedetti (en cours) avec Turin.
3. Participation au réseau de formation (Initial Training Network) européen MALOA (From Mathematical Logic to Application), 2009-2013 (thèse d'A. Tsouanas).
4. Organisation de 5 écoles de recherche d'hiver dans le cadre du Master à l'ENS Lyon entre 2010 et 2014.
5. Participation de membres de l'équipe à des cours de l'école thématique Proof theory, à Paraty (Rio de Janeiro State, Brésil), septembre 2012.
6. D. Hirschkoff a été responsable de la 1ère année de Master à l'ENS Lyon, Ph. Audebaud de la préparation à l'option D (informatique) de l'agrégation de mathématiques et C. Riba des stages de L3.

Le responsable de l'équipe peut indiquer ici brièvement 3 points précis sur lesquels il souhaite obtenir l'expertise du comité.

1.12 Executive summary: Plume team

Name of the head of the team for the present contract: O. Laurent (01/09-09/12), P. Baillot (09/12–).

Name of the head of the team for the upcoming contract: P. Baillot.

Team composition

5 lecturers and professors: Ph. Audebaud, J. Duprat, D. Hirschkoff, P. Lescanne, A. Miquel (*délégation*). 2 researchers: P. Baillot, O. Laurent. 1 technical staff, engineers and others: J. Brajon (assistant). 4 post-docs and PhD students: R. Demangeon, A. Pardon, B. Petit (PhD students), C. Riba (ATER).

Persons who left the team

2 staff (88 months): J. Duprat (8/2011), A. Miquel (8/2013) (additionally P. Lescanne became Emeritus Prof. in 2012). 5 PhD students (148 months): R. Demangeon (8/2010), A. Pardon (12/2010), M. Lasson (8/2012), B. Petit (8/2011), L. Rieg (8/2013). 2 post-docs (40 months): P. Tranquilli (8/2011), A. Kreuzer (2/2014).

New members

5 new permanent members: C. Riba (MdC ENSL; previously: Postdoc Sophia-Antipolis and then ATER ENSL), F. Bonchi (CR2 CNRS hired; previously: Postdoc CWI Amsterdam), D. Pous (CR2 CNRS, *mutation* from LIG, Grenoble), R. Harmer (CR1 CNRS, *mutation* from PPS, Paris), P. Clairambault (CR2 CNRS hired; previously Postdoc Cambridge Univ.).

2 postdocs: F. Aschieri (Labex Milyon; previously postdoc PPS Paris); D. Petrisan (ANR Picoq; previously postdoc Leicester, UK).

7 PhD students: V. Blot (ENS Lyon), P. Brunet (Paris MPRI), E. De Benedetti (Torino), J.-M. Madiot (ENS Lyon), M. Perrinel (ENS Lyon), A. Tsouanas (Athens), F. Zanasi (Amsterdam).

Scientific outcomes

1. Bonchi and Pous have developed new techniques for proving the equivalence of non-deterministic finite automata, based on methods coming from bisimulation techniques in concurrency, and improving the classical algorithms (article at POPL 2013, [1] below).

2. Riba has shown how to use *forcing* methods inspired from set theory (originally due to P. Cohen) in order to prove by means of model theory arguments some results on monadic logic, which is relevant for verification (article at LICS 2013, [2] below).

3. Miquel has brought a new point of view on the forcing transformation, coming from set theory, by analyzing it as a program transformation, in the setting of the proofs-as-programs correspondence (article at LICS 2011, [5] below).

4. Hirschkoff and Madiot have explored with Sangiorgi the relationships between several languages used to represent concurrent systems: pi-calculus and fusion calculus. They have derived from that some new ways to transfer properties on type systems and on program equivalence between these two calculi (article at LICS 2013, [3] below).

5. Pous has developed for the Coq proof assistant a library to build formal proofs for reasoning in algebras of relations, used for instance to certify some compiler optimizations (see Major documents below, item [1]).

Quantitative assessment of team's publications

34 articles in international peer-reviewed journals, 3 invited conferences, 65 articles in international peer-reviewed conference proceedings, 2 books or book chapters.

Major publications

1. Filippo Bonchi, Damien Pous: Checking NFA equivalence with bisimulations up to congruence. Proceedings of ACM SIGPLANSIGACT Symposium on Principles of Programming Languages, (POPL 2013): p. 457-468, ACM, 2013.
2. Colin Riba. Forcing MSO on Infinite Words in Weak MSO. Proceedings of Symposium on Logic In Computer Science LICS 2013, IEEE Computer Science, 2013.
3. Daniel Hirschkoff, Jean-Marie Madiot, Davide Sangiorgi. Name-passing calculi: from fusions to preorders and types. Proceedings of Symposium on Logic in Computer Science (LICS 2013), IEEE Computer Science.

4. Patrick Baillot, Ugo Dal Lago: Higher-Order Interpretations and Program Complexity. Proceedings of Conference on Computer Science Logic (CSL 2012): p. 62-76, LIPICS 16 Schloss Dagstuhl, 2012.
5. Alexandre Miquel. Forcing as a Program Transformation. Proceedings of Symposium on Logic in Computer Science (LICS 2011), pp. 197-206, IEEE Computer Press, 2011.

Major documents

1. Damien Pous. software: library for the Coq proof assistant: "Relation Algebra and KAT in Coq" `http://perso.ens-lyon.fr/damien.pous/ra/`
2. Web site : *linear logic wiki*, `http://llwiki.ens-lyon.fr/` . This site contains an introduction and a survey of results in linear logic. Coordinated by Olivier Laurent.
3. Olivier Laurent. software: library for the Coq proof assistant: construction of proofs in linear logic. `http://perso.ens-lyon.fr/olivier.laurent/l2coq.tgz` , 2013.

Influence and attractiveness of the team

1. The *Chocola* seminar, held about once a month, gathers for a one-day-long meeting participants coming from various French universities (Paris, Marseille, Chambéry . . .). There are about 30 participants each time, including a large proportion of PhD students.
2. Coordination of several ANR projects which have given to the Plume team a pivotal rôle: Récré (Miquel/Riba), PACE (bilateral ANR project France-China) (Hirschkoff), COMPLICE (Baillot).
3. Invited speakers to international conferences: Damien Pous invited speaker at 13th International Conference on Relational and Algebraic Methods in Computer Science (RAMiCS 13) Cambridge, 2012, and at 5th Conference on Algebra and Coalgebra in Computer Science (CALCO) 2013 (Warsaw); Alexandre Miquel, invited speaker at the conference Typed Lambda Calculi and Applications 2011 (Novi Sad, Serbia).
4. Participation to Programme Committees of international conferences: Plume team members have taken part to PCs of important conferences during this period: LICS, FoSSaCS, TLCA . . .
5. Co-organisation of a thematic session "Mathematical Structures of Computation" in 2014, involving members of the AriC and Plume teams, and of Institut Camille Jordan (Univ. Lyon 1), with the support of the Labex MILYON. Around 170 participants altogether, over a total period of 5 weeks.

Interaction of the team with its environment

1. P. Lescanne wrote several articles of scientific popularization: 4 articles for *Images des Mathématiques* (CNRS) and one article for *Pour la Science* (No 74 - Janvier - Mars 2012).
2. Popular science, for secondary school pupils: D. Hirschkoff is involved in the “Maths en Jeans” activity; he has co-organised some “research activities” with schools in Villeurbanne and Rillieux la Pape (2011-2014); O. Laurent gave a talk at the Cité Scolaire Internationale de Lyon as part of the “2014 science week”. D. Pous gave a talk in a high school at Puy-en-Velay (april 2014), as part of the "cordées de la réussite".

Training initiatives

1. Several Master 2 research courses at ENSL, some of them involving some external lecturers, to complement our expertise (e.g. *Recognizability and Model-Checking, from Automata to Lambda-Calculus* in 2013).
2. 5 PhD theses defended in the team, and 4 others to be defended in 2014-2015. Among those several theses in *cotutelle* with Italy: R. Demangeon, J.-M. Madiot (ongoing) with Bologna, E. De Benedetti (ongoing) with Torino.
3. Participation to the European *Initial Training Network* MALOA (From Mathematical Logic to Application), 2009-2013 (PhD thesis by A. Tsouanas).
4. Organisation of 5 research winter schools as part of the Master at ENS Lyon, between 2010 and 2014.
5. Participation of some team members to lectures at the thematic research school Proof theory at Paraty (Rio de Janeiro State, Brazil), september 2012.
6. D. Hirschkoff has been in charge of the Master1 year at ENS Lyon, Ph. Audebaud of the *préparation à l’option D (informatique) de l’agrégation de mathématiques* and C. Riba of the L3 research internships.

The head of the team can briefly state 3 precise points on which he would like to know the evaluation of the committee.

1.13 Présentation synthétique : équipe Roma

Nom du responsable de l'équipe pour le contrat en cours: Frédéric Vivien

Nom du responsable de l'équipe pour le futur contrat: Frédéric Vivien

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Effectifs de l'équipe (au début du contrat en cours)

L'équipe a été créée le 1er avril 2010.
2 enseignants-chercheurs ; 4 chercheurs ; 2 techniciens, ingénieurs et autres personnels ; 6 post-docs et doctorants.

Personnels ayant quitté l'équipe (pendant le contrat en cours et nombre de mois cumulés passés dans l'équipe)

0 statutaires (0 mois) ; 6 doctorants (176 mois) ; 6 post-docs (70 mois).

Recrutements (réalisés au cours de la période considérée et origine des personnels)

1 ingénieure: Chiara Puglisi (ingénieure, Toulouse) ; 8 post-docs: Marin Bougeret (doctorant, Grenoble), Hinde Bouziane (doctorant, Rennes), Indranil Chowdhury (ingénieur, California, États-Unis), Amina Guermouche (doctorant, LRI, Paris), Enver Kayaaslan (doctorant, Bilkent University, Turquie), Johannes Langguth (doctorant, Bergen, Norvège), Mark Stillwell (doctorant, Univ. of Hawaii, États-Unis), Hongyang Sun (post-doctorant, Toulouse) ; 4 doctorants: Guillaume Aupy (ENS Lyon), Julien Herrmann (ENS Lyon), Mohamed Wissam Sid-Lakhdar (ENSEEIHT, Toulouse), Dounia Zaidouni (UCB Lyon 1).

Réalisations et produits de la recherche

1. Stratégies optimales de prises coordonnées de points de sauvegarde quand les pannes suivent une loi de distribution exponentielle, et politiques asymptotiquement optimales pour des distributions quelconques [1271, 1212].
2. Algorithmes hiérarchiques de factorisation QR, utilisant plusieurs tuiles d'élimination, pour des *clusters* de nœuds multicœurs [1272, 1214].
3. Stratégies d'optimisation multi-critères (débit, latence, consommation énergétique, fiabilité) pour l'exécution d'applications de traitement de flots sur plates-formes distribuées [1207, 1199].
4. Étude de complexité, résultats d'inapproximabilité, et premiers algorithmes parallèles prenant en compte les contraintes mémoires, pour l'ordonnancement d'arbres de tâches [1312, 1277, 1222].
5. Algorithmes de construction de couplages maximaux pour graphes bipartis et leur adaptation aux plates-formes de calcul multi- et *many*-cœurs [1196, 1215, 1287, 1307, 1308].

Bilan quantitatif des publications de l'équipe

48 articles dans des journaux internationaux avec comité de lecture, 6 conférences invitées, 89 articles dans des actes de conférences internationales avec comité de lecture, 15 livres ou chapitres de livres, 7 livres, numéros spéciaux de journaux ou actes de conférence édités.

Publications majeures

1. Patrick R. Amestoy, Iain S. Duff, Jean-Yves L'Excellent, Yves Robert, François-Henry Rouet, and Bora Uçar. On computing inverse entries of a sparse matrix in an out-of-core environment. *SIAM Journal on Scientific Computing*, 34(4):A1975–A1999, juillet 2012.
2. Anne Benoit, Ümit V. Çatalyürek, Yves Robert, and Erik Saule. A survey of pipelined workflow scheduling: models and algorithms. *ACM Computing Surveys*, 45(4), 2013.
3. Anne Benoit, Loris Marchal, Jean-François Pineau, Yves Robert, and Frédéric Vivien. Scheduling concurrent bag-of-tasks applications on heterogeneous platforms. *IEEE Transactions on Computers*, 59(2):202–2017, 2010.
4. Anne Benoit, Yves Robert, and Frédéric Vivien. *A Guide to Algorithm Design: Paradigms, Methods, and Complexity Analysis*. Applied Algorithms and Data Structures series. Chapman & Hall/CRC, août 2013.
5. Iain S. Duff, Kamer Kaya, and Bora Uçar. Design, implementation, and analysis of maximum transversal algorithms. *ACM Transactions on Mathematical Software*, 38:13:1–13:31, 2011.

Documents majeurs

1. Solveur direct de systèmes linéaires creux MUMPS: version 4.10.0, mai 2011.

2. ProDom est une base de données de familles de domains protéiques construite automatiquement (`http://prodom.prabi.fr/prodom/current/html/home.php`). ProDom 2010.1 a été construite avec un algorithme élaboré par l'équipe et utilisant les données produites par l'équipe (en coordination avec Daniel Kahn du laboratoire LBBE de Lyon 1).
3. Une famille d'algorithmes de construction de couplages maximaux pour graphes bipartis: matchmaker et matchmaker2 (`http://bmi.osu.edu/hpc/software/matchmaker2/index.html`).

Rayonnement et attractivité de l'équipe

1. Yves Robert a reçu le prix *2014 IEEE TCSC Award for Excellence*. "*The IEEE TCSC Award for Excellence in Scalable Computing is awarded for significant and sustained contributions to the scalable computing community through the IEEE Technical Committee on Scalable Computing (TCSC), coupled with an outstanding record of high quality and high impact research*" (`https://www.ieeetcsc.org/awards/award_for_excellence`).
2. L'équipe ROMA a co-organisé avec l'équipe AVALON la conférence ICPP'2013 (*International Conference on Parallel Processing*), du 1er au 4 octobre 2013 à Lyon.
3. Bora Uçar a organisé le workshop CSC14 (*Sixth SIAM Workshop on Combinatorial Scientific Computing*) à Lyon en juillet 2014.
4. Yves Robert a été responsable du comité de programme de la conférence HiPC'13, Frédéric Vivien a été vice-responsable du comité de programme pour le thème *Algorithms* de la conférence HiPC'14, et Anne Benoit (en 2014) et Frédéric Vivien (en 2013) ont été vices-responsables du comité de programme pour le thème *Algorithms* de la conférence IPDPS.
5. L'équipe organise chaque année un *workshop* sur invitation intitulé *Scheduling for Large Scale Systems* (`http://scheduling2014.sciencesconf.org/`).

Interactions de l'équipe avec son environnement

1. L'équipe a de très fortes interactions avec les utilisateurs de MUMPS. Certains des utilisateurs de MUMPS ont supporté le projet financièrement, en fournissant de nouveaux thèmes de recherche (par exemple, la conception de solveurs dont la précision est contrôlée), ou en soumettant de véritables défis: gros problèmes de géophysiques (EMGS, consortium SEISCOPE) et problèmes numériquement difficiles (EDF, ESI Group et Total). En 2010 et en 2013 l'équipe a co-organisé des journées d'utilisateurs (*MUMPS User Group Meetings*). La dernière édition a été hébergée par EDF, et a rassemblé des experts et des utilisateurs de solveurs directs de systèmes linéaires creux, industriels et académiques.
2. Depuis 2014 Frédéric Vivien est membre du Conseil Scientifique de l'ENS Lyon.
3. Collaboration avec le laboratoire LBBE de l'Université Lyon 1 autour de la construction automatique de familles de domaines protéiques ProDom (co-direction de la thèse de Clément Rezvoy avec Daniel Kahn).

Actions de formation

- Yves Robert est membre du comité de l'IEEE et de la NSF intitulé *NSF/TCPP Curriculum Initiative on Parallel and Distributed Computing*. Ce comité a défini les connaissances en calcul parallèle et distribué que les étudiants en licence d'informatique devraient acquérir lors de leur formation. Parmi les vingt membres de ce comité, Yves Robert est le seul qui ne travaille pas en Amérique du nord.
- Anne Benoit, Yves Robert, et Frédéric Vivien ont co-écrit le livre *A Guide to Algorithm Design: Paradigms, Methods, and Complexity Analysis* publié par Chapman & Hall/CRC en août 2013 (`http://www.crcpress.com/product/isbn/9781439825648`).
- Yves Robert et Frédéric Vivien ont co-édité le livre *Introduction to scheduling* publié par CRC Press en novembre 2009. Ce livre couvre les fondements de l'ordonnancement et des récentes avancées dans ce domaine.
- Frédéric Vivien est responsable de la *commission des habilités* du laboratoire depuis 2013 (il en était précédemment le responsable adjoint). Cette commission est en charge de l'accompagnement et du suivi des doctorants et des interactions avec l'école doctorale.

Le responsable de l'équipe peut indiquer ici brièvement 3 points précis sur lesquels il souhaite obtenir l'expertise du comité.

1.14 Executive summary: Roma team

Name of the head of the team for the present contract: Frédéric Vivien

Name of the head of the team for the upcoming contract: Frédéric Vivien

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Team composition (at the beginning of the present contract)

The team was created on April 1, 2010.
2 lecturers and professors ; 4 researchers ; 1 technical staff, engineers and others ; 6 post-docs and PhD students.

Persons who left the team (during the present contract, with cumulative number of months spent in the team)

0 staff (0 months) ; 1 technical staff (24 months); 6 PhD students (176 months) ; 6 post-docs (70 months).

New members (people hired during the considered period and their origin)

1 engineer: Chiara Puglisi (engineer, Toulouse); 8 post-docs: Marin Bougeret (PhD student, Grenoble), Hinde Bouziane (PhD student, Rennes), Indranil Chowdhury (Engineer, California, USA), Amina Guermouche (PhD student, LRI, Paris), Enver Kayaaslan (PhD Student, Bilkent University, Turkey), Johannes Langguth (PhD student, Bergen, Norway), Mark Stillwell (PhD student, Univ. of Hawaii, USA), Hongyang Sun (post-doc, Toulouse); 4 PhD students: Guillaume Aupy (ENS Lyon), Julien Herrmann (ENS Lyon), Mohamed Wissam Sid-Lakhdar (ENSEEIHT, Toulouse), Dounia Zaidouni (UCB Lyon 1).

Scientific outcomes

1. Optimal checkpointing strategies for coordinated checkpointing protocols when failures follow an exponential distribution, and asymptotically optimal policies for any distribution [1271, 1212].
2. Hierarchical QR-factorization algorithms for clusters of multicore nodes using multiple eliminator tiles [1272, 1214].
3. Multicriteria (throughput, latency, energy consumption, reliability) optimization strategies for the execution of streaming applications on distributed platforms [1207, 1199].
4. Complexity study, inapproximability results, and first parallel memory-aware algorithms for the scheduling of tree-shaped task graphs [1312, 1277, 1222].
5. Cardinality matching algorithms for bipartite graphs and their adaptations to multi-core and many-core computing systems [1196, 1215, 1287, 1307, 1308]

Quantitative assessment of team's publications

48 articles in international peer-reviewed journals, 6 invited conferences, 89 articles in international peer-reviewed conference proceedings, 15 books or book chapters, and 7 books, special issues, or conference proceedings edited .

Major publications

1. Patrick R. Amestoy, Iain S. Duff, Jean-Yves L'Excellent, Yves Robert, François-Henry Rouet, and Bora Uçar. On computing inverse entries of a sparse matrix in an out-of-core environment. *SIAM Journal on Scientific Computing*, 34(4):A1975–A1999, July 2012.
2. Anne Benoit, Ümit V. Çatalyürek, Yves Robert, and Erik Saule. A survey of pipelined workflow scheduling: models and algorithms. *ACM Computing Surveys*, 45(4), 2013.
3. Anne Benoit, Loris Marchal, Jean-François Pineau, Yves Robert, and Frédéric Vivien. Scheduling concurrent bag-of-tasks applications on heterogeneous platforms. *IEEE Transactions on Computers*, 59(2):202–2017, 2010.
4. Anne Benoit, Yves Robert, and Frédéric Vivien. *A Guide to Algorithm Design: Paradigms, Methods, and Complexity Analysis*. Applied Algorithms and Data Structures series. Chapman & Hall/CRC, August 2013.
5. Iain S. Duff, Kamer Kaya, and Bora Uçar. Design, implementation, and analysis of maximum transversal algorithms. *ACM Transactions on Mathematical Software*, 38:13:1–13:31, 2011.

Major documents

1. Parallel Sparse Direct Solver MUMPS: release 4.10.0, May 2011.

2. ProDom is a protein domain family database that is constructed automatically (http://prodom.prabi.fr/prodom/current/html/home.php). ProDom 2010.1 was built using algorithms designed by the team and using the data processing performed by the team (in coordination with Daniel Kahn from the LBBE laboratory of Lyon 1).
3. A family of cardinality matching algorithms for bipartite graphs: matchmaker and matchmaker2 (http://bmi.osu.edu/hpc/software/matchmaker2/index.html).

Influence and attractiveness of the team

1. Yves Robert was awarded the 2014 IEEE TCSC Award for Excellence. "The IEEE TCSC Award for Excellence in Scalable Computing is awarded for significant and sustained contributions to the scalable computing community through the IEEE Technical Committee on Scalable Computing (TCSC), coupled with an outstanding record of high quality and high impact research" (https://www.ieeetcsc.org/awards/award_for_excellence).
2. The ROMA team co-organized with the AVALON team ICPP'2013, the 2013 International Conference on Parallel Processing, October 1-4, 2013, Lyon.
3. Bora Uçar organized the CSC14 workshop, the *Sixth SIAM Workshop on Combinatorial Scientific Computing*, July 2014, Lyon.
4. Yves Robert was program chair for HiPC'13, Frédéric Vivien was program vice-chair for the Algorithms track of HiPC'14, and Anne Benoit (2014) and Frédéric Vivien (2013) were program vice-chairs for the Algorithms track for IPDPS.
5. The team organizes each year an invitation-only workshop on *Scheduling for Large Scale Systems* (http://scheduling2014.sciencesconf.org/).

Interaction of the team with its environment

1. The team has a strong interaction with MUMPS users. Some MUMPS users have been very supportive both by backing the project financially and by providing new themes of research (for instance, solvers with controlled accuracy) and challenging objectives: huge problems in geophysics (EMGS, SEISCOPE consortium) and numerically difficult problems (EDF, ESI Group, and Total). In 2010 and 2013 the team co-organized "MUMPS User Group Meetings", the last one located at EDF, bringing together experts and users of sparse direct solvers from both academia and industry.
2. Since 2014 Frédéric Vivien is a member of the Scientific Council of ENS Lyon.
3. Collaboration with the LBBE laboratory of Lyon 1 University on the automatic construction of protein domain family database ProDom (co-advising of the PhD thesis of Clément Rezvoy with Daniel Kahn)

Training initiatives

- Yves Robert is a member of the "NSF/TCPP Curriculum Initiative on Parallel and Distributed Computing" that defined the "core topics in parallel and distributed computing that a student graduating with a Bachelors degree in Computer Science or Computer Engineering is expected to have covered". Out of the twenty members of this committee, Yves Robert is the only one not coming from North America.
- Anne Benoit, Yves Robert, and Frédéric Vivien co-authored a textbook titled "A Guide to Algorithm Design: Paradigms, Methods, and Complexity Analysis", published by Chapman & Hall/CRC in August 2013 (http://www.crcpress.com/product/isbn/9781439825648).
- Yves Robert and Frédéric Vivien co-edited a textbook titled "Introduction to scheduling", published by CRC Press in November 2009. This textbook covers both the foundations in scheduling and modern developments.
- Frédéric Vivien is head of the LIP PhD committee that is monitoring all the laboratory PhD students since 2013 (previously, he was vice-head of this committee).

The head of the team can briefly state 3 precise points on which he would like to know the evaluation of the committee.

Annexe 2. Néant (pas de lettre de mission)

Appendix 3. Equipment list

3.1 Laboratory Equipment

Two broad categories of equipment are hosted in LIP: categories of equipment:

1. the first one is related to platforms that offer services beyond the lab limits (Grid'5000 most notably).
2. the second one gathers the equipment needed for internal LIP operation.

The MI-LIP team is involved in the management and operation of these resources.

3.1.1 Grid'5000

Grid'5000 is a scientific instrument dedicated to experimentation in all area of distributed computing, including distributed systems, peer-to-peer systems, high performance computing, parallel processing, cloud computing, operating systems, networks,). The platform is distributed over 10 sites over France and Luxembourg, including Lyon.

Grid'5000 is a unique platform as it offers to computer science research community a large number of hardware resources (CPU, GPU, fast network, storage,) and a complete software stack to ease large scale experiment setup, understanding, and reproducibility. Since its creation in 2005, Grid'5000 has be cited in more than 1000 scientific publications, and about 500 active users from all over the world are reported each year.

Grid'5000 is driven by a Groupement d'Intérêt Scientifique (GIS). Among GIS members are represented Inria, CNRS and Renater. Thanks to GIS organization, scientists lead Grid'5000 development to ensure the platform fulfill theirs research interests. The Grid'5000 technical team is in charge of the platform evolution and maintenance, according to researchers' needs.

The LIP hosts the Grid'5000 site of Lyon. Simon Delamare, one of the MI-LIP team member is in charge of equipment administration, along with Marc Pinhède, Inria's junior engineer (Ingénieur Jeune Diplomé). As such, they participate in Grid'5000 at a local and national level, involving the whole platform. This includes contribution to new developments, meetings participation, assistance to users.

Since summer 2013, Simon Delamare is the operational manager of the technical team. He is in charge of ensuring the proper functioning of the platform and coordinates the technical team. This involves advising of technical team members (8 people), especially junior engineers, and taking day-to-day technical decisions. This work is done in close collaboration with David Margery, the Grid'5000 technical director.

The Lyon platform is efficiently operational for several years. It provides several clusters (including 450 compute cores) to Grid'5000 users and features closely related to local research, such as fine grained energy monitoring devices for green computing related experimentation. However, the aging of some of the hardware will require a significant funding in the forthcoming years to upgrade decaying equipment. Anyway, the constant evolution of Grid'5000 suggests that the platform administration needs will not decrease in the coming years.

As an important part of the technical team has temporary contracts, a continuous training activity is needed, and it is difficult to keep expertise and experienced people over the long term. Yet, this is part of the culture of the Grid'5000 project: it is well known for the training of highly skilled engineers for both industry and academia. Furthermore, an apprentice engineer, part-time housed at LIP, will join the team in beginning of September.

3.1.2 LIP local platform

MI-LIP team provides some computing resources to LIP members. Different kind of resources, in terms of characteristics and targeted usage, are available. Here is an overview of those resources:

- *Computing servers*: They are dedicated to "heavy" workload execution. All LIP members can use them through an interactive shell provided by SSH. Seven computing servers are available for a total amount of 192 cores.
- *Remote workstations*: They are dedicated to remote application execution of users programs. Usage of remote workstations is similar to computing servers. About ten remote workstations are available, comprising variety of hardware aged from 1 to 5 years.
- *Experimentation*: The "Crunch" experimentation servers are dedicated to multicore related research. These servers require subscription to be used by LIP members. The characteristics of crunch servers are: 2 quad-CPU nodes, connected by an Infiniband QDR network, for an amount of 64 cores and 769GB of RAM in total.

- *Batch jobs management* A batch scheduler, running Sun Grid Engine, is also available to LIP members for submitting non interactive programs. Execution of these jobs are scheduled among remote workstations and computing servers.

Selecting computing resources that fits research needs is quite a complex task. A survey of current needs among LIP members is underway. The variety of research done at LIP leads to diverse needs and the technical characteristics of future computing resources, whereas it should include GPU, Intel Xeon Phy or ARM CPUs for example, is still unknown.

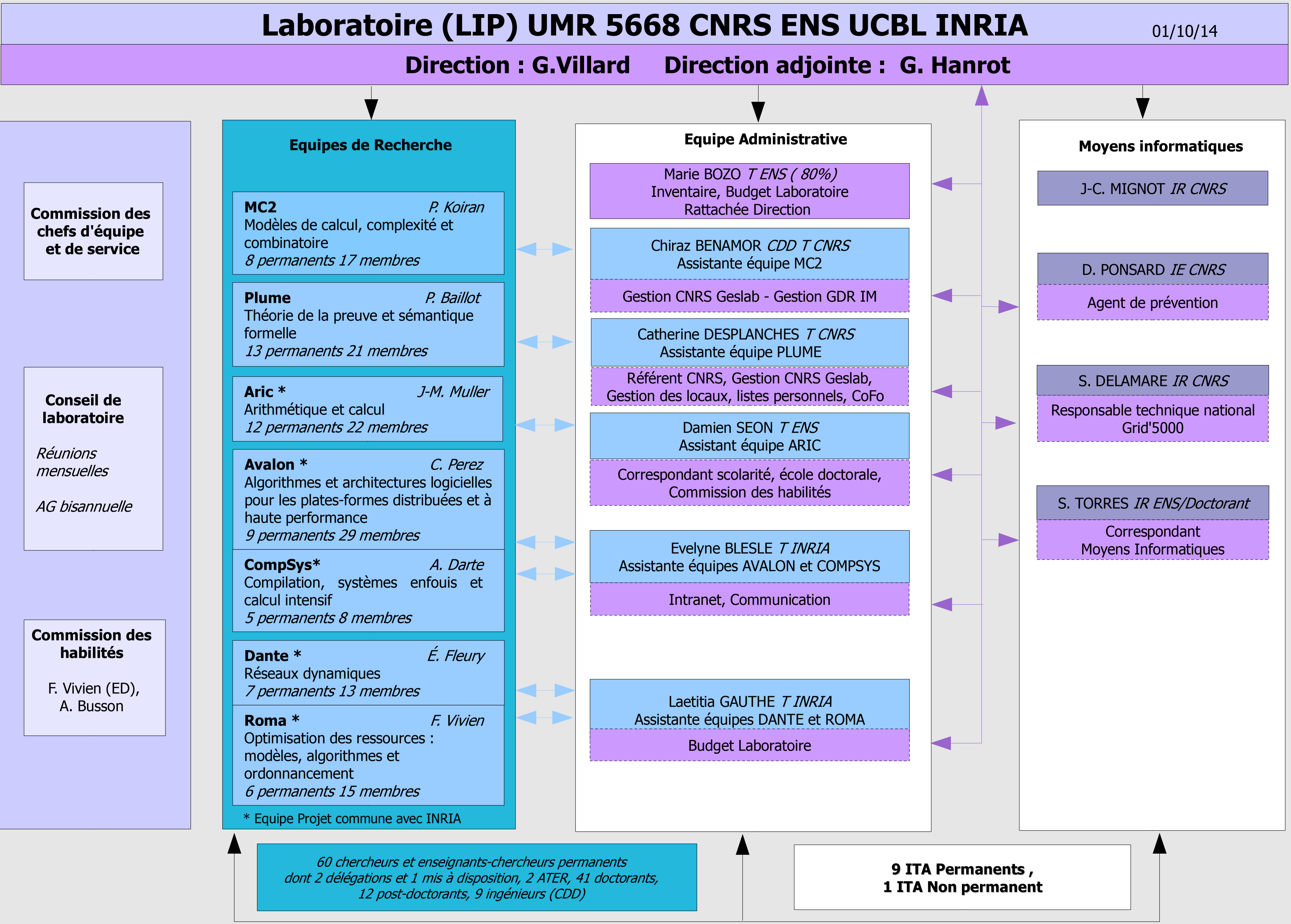
3.2 External Equipments

In addition to global-wide Grid'5000 plateform described earlier, various external resources are regulary used by LIP members. Most of these resources are high performance computing plateforms, whose size is too large to be available locally.

Most signaficant usages are spread among:

- Pôle Scientifique de Modélisation Numérique (PSMN), which is the regional sized computing center, hosted at Ens Lyon.
- Grand Equipement National de Calcul Intensif (GENCI) resources, which provides national-scaled computing clusters.

Annexe 4. Organigramme



Laboratoire (LIP) UMR 5668 CNRS ENS UCBL INRIA
01/10/14
Direction : G.Villard
Direction adjointe : G. Hanrot
Commission des chefs d'équipe et de service
Conseil de laboratoire
Réunions mensuelles
AG bisannuelle
Commission des habilités
F. Vivien (ED), A. Busson
Equipes de Recherche
MC2 *P. Koiran*
Modèles de calcul, complexité et combinatoire
8 permanents 17 membres
Plume *P. Baillot*
Théorie de la preuve et sémantique formelle
13 permanents 21 membres
Aric * *J-M. Muller*
Arithmétique et calcul
12 permanents 22 membres
Avalon * *C. Perez*
Algorithmes et architectures logicielles pour les plates-formes distribuées et à haute performance
9 permanents 29 membres
CompSys* *A. Darte*
Compilation, systèmes enfouis et calcul intensif
5 permanents 8 membres
Dante * *É. Fleury*
Réseaux dynamiques
7 permanents 13 membres
Roma * *F. Vivien*
Optimisation des ressources : modèles, algorithmes et ordonnancement
6 permanents 15 membres
* Equipe Projet commune avec INRIA
Equipe Administrative
Marie BOZO *T ENS (80%)*
Inventaire, Budget Laboratoire
Rattachée Direction
Chiraz BENAMOR *CDD T CNRS*
Assistante équipe MC2
Gestion CNRS Geslab - Gestion GDR IM
Catherine DESPLANCHES *T CNRS*
Assistante équipe PLUME
Référent CNRS, Gestion CNRS Geslab,
Gestion des locaux, listes personnels, CoFo
Damien SEON *T ENS*
Assistant équipe ARIC
Correspondant scolarité, école doctorale,
Commission des habilités
Evelyne BLESLE *T INRIA*
Assistante équipes AVALON et COMPSYS
Intranet, Communication
Laetitia GAUTHE *T INRIA*
Assistante équipes DANTE et ROMA
Budget Laboratoire
Moyens informatiques
J-C. MIGNOT *IR CNRS*
D. PONSARD *IE CNRS*
Agent de prévention
S. DELAMARE *IR CNRS*
Responsable technique national
Grid'5000
S. TORRES *IR ENS/Doctorant*
Correspondant
Moyens Informatiques
60 chercheurs et enseignants-chercheurs permanents
dont 2 délégations et 1 mis à disposition, 2 ATER, 41 doctorants,
12 post-doctorants, 9 ingénieurs (CDD)
9 ITA Permanents ,
1 ITA Non permanent

Annexe 5. Règlement intérieur

À ce jour, le LIP est toujours régi par un règlement intérieur de 2005. La remise à jour de ce règlement avec notamment la prise en compte des (nombreuses) évolutions des structures a été reportée lors de la période 2009-2014 en particulier dans l'attente de la signature d'une convention d'UMR, qui pouvait trancher une partie des points en suspens.

Le dossier a été remis à l'ordre du jour du conseil du laboratoire courant 2014 ; sa complexité et la nécessité de prendre en compte des dossiers lourds évoluant rapidement comme la PSSI et l'éventualité d'un classement en ZRR n'ont pas permis de converger vers un nouveau règlement intérieur à la date de remise du présent document. Nous espérons traiter cette question au cours du dernier trimestre 2014.

Appendix 6. Detailed reports, and research outcomes by team

6.1 ARIC: Arithmetic and Computing

6.1.1 Team composition

Current members

Permanent members

Nicolas Brisebarre (CNRS, Researcher).
Guillaume Hanrot (ENS de Lyon, Professor).
Claude-Pierre Jeannerod (Inria, Researcher).
Fabien Laguillaumie (Univ. Lyon I, Professor).
Vincent Lefèvre (Inria, Researcher).
Nicolas Louvet (Univ. Lyon I, Associate Professor).
Jean-Michel Muller (CNRS, Senior Researcher).
Nathalie Revol (Inria, Researcher).
Bruno Salvy (Inria, Senior Researcher).
Damien Stehlé (ENS de Lyon, Professor).
Serge Torres (ENS de Lyon, Engineer).
Gilles Villard (CNRS, Senior Researcher).

Nonpermanent members

Stef Graillat (Univ. Paris 6, Associate Professor; CNRS partial secondment from Sep 2013 to Sep 2014).
Clément Pernet (Univ. Grenoble I, Associate Professor; CNRS partial secondment since Sep 2013).
Nicolas Brunie (PhD student, CIFRE grant Kalray).
Silviu Filip (PhD student, ENS de Lyon).
Adeline Langlois (PhD student, ENS de Lyon).
Vincent Neiger (PhD student, ENS de Lyon; Western University, London, Canada (international co-direction)).
Marie Paindavoine (PhD student, Orange Labs).
Philippe Théveny (PhD student, ENS de Lyon).

Assistant

Damien Séon (Assistant, ENS de Lyon).

Former members

Professors

Florent De Dinechin (INSA Lyon, Professor).
Laurent-Stéphane Didier (Univ. Paris 6, Associate Professor, sabbatical, September 2011–February 2012).
Micaela Mayero (Univ. Paris Nord, Associate Professor; Inria partial secondment September 2009–August 2010, September 2011–August 2012).

PostDocs

Rishiraj Bhattacharyya (Inria, June 2012–April 2014).
Jingwei Chen (joint fellowship from CNRS and Chinese Academy of Sciences, January 2012–December 2012).
Sylvain Collange (ENS de Lyon, October 2010–September 2011).
Nicolas Estibals (ENS de Lyon, September 2012–August 2013).
Eleonora Guerrini (ENS de Lyon, September 2011–August 2012).
Marc Mezzarobba (ANR TaMaDi, December 2011–April 2013).
Andrew Novocin (ENS de Lyon, September 2009–August 2011).
Ioana Pasca (ANR TaMaDi, December 2010–August 2012).
Álvaro Vázquez Álvarez (Inria, October 2009–March 2011).

PhD students

Sylvain Chevillard (PhD student, ENS de Lyon, until July 2009).
Mioara Joldeş (PhD student, Région Rhône-Alpes grant, until September 2011).
Jingyan Jourdan-Lu (PhD student, CIFRE grant STMicroelectronics, until November 2012).
Érik Martin-Dorel (PhD student, MESR grant, until September 2012).
Ivan Morel (PhD student, ENS de Lyon, cotutelle with the University of Sydney, until August 2011).
Christophe Mouilleron (PhD student, ENS de Lyon, until November 2011).
Hong Diep Nguyen (PhD student, Inria grant, until January 2011).
Adrien Panhaleux (PhD student, ENS grant, until August 2012).
Bogdan Pasca (PhD student, MESR grant, until September 2011).
David Pfannholzer (PhD student, MEFI grant, until 2012).
Xavier Pujol (PhD student, ENS grant, until August 2012).
Guillaume Revy (PhD student, MESR grant, until December 2009).

Engineers

Andrea Cameli (Engineer, ANR TaMaDi, September 2013–December 2013).
Christman Fagbohoun (Inria, Technical Staff, since April 2009).
Matei Istoan (Engineer, ANR TaMaDi project, September 2012–June 2013).
Honoré Takeugming (Engineer, ANR TCHATER, until January 2011).

Visitors

The team receives numerous visitors, speakers or attendees of its seminar, as well as collaborators. We list some of them below.

Jean-Luc Beuchat (Tsukuba University, Japan), INRIA invited researcher: April 14 – May 18, 2010.

Xiao-Wen Chang (McGill U., Canada): June 23–July 23, 2011; and April 14–June 14, 2013, under the invited professor scheme from ENS de Lyon.

Daniel Dadush (New York University): March 06–March 23, 2013.

John Harrison (Intel): September 29–October 1, 2010, and February 3 – February 7, 2014.

Peter Kornerup (U. of Southern Denmark): September 5–September 19, 2012; and September 13–September 29, 2013.

Benoît Libert (U. de Louvain-la-Neuve, Belgium), INRIA invited researcher: May 29–July 13, 2012.

San Ling (Nanyang Technological University, Singapore), ENS Lyon invited professor: August 20–October 11, 2012.

Takeshi Ogita (Tokyo Woman's Christian University, Japan), March 06–March 10, 2011.

Dave Saunders (University of Delaware, U.S.A.), ENS Lyon invited professor: April 15–July 31, 2012.

Ron Steinfeld (Monash University, Australia), January 13–January 24, 2013; and December 7–December 22, 2013.

Arne Storjohann (Univ. of Waterloo, Canada), October 11–October 25, 2011.

Warwick Tucker (Uppsala U., Sweden): May 22–May 25, 2012; February 15–March 31, 2013 (invited professor scheme from ENS de Lyon).

6.1.2 Life of the team

- **Scientific meetings:** Every week, there is a team seminar (on Thursday) and a team working group (on Tuesday)[1]. The seminars are "conventional", one-hour, seminars: a French or foreign colleague is invited and presents a recent research result. The working groups are more internal (although sometimes the speaker is not from the team) and more informal and are either devoted to discussion on ongoing research, or to an introduction to some domain that may be useful for the work of the team members.

- **Organizational meetings:** Twice a month, there is a meeting of the team for discussing administrative and organizational matters, and exchanging information. These rather informal "Café AriC" meetings are open to all members (including PhDs, postdocs and trainees) unless the agenda requires the discussion to be restricted to permanent members (e.g., for discussing recruitments).

Budget: a typical year (2013) of the period the budget of AriC was as follows:

- 26 k euro of regular funding from Inria;

- 3 k euro of regular funding from LIP (part of the CNRS and ENS dotation);

[1]The list of recent seminars can be found at `http://www.ens-lyon.fr/LIP/AriC/reunions.html`.

- 87.7 k euro of ANR funding (76.5 through Inria for the TAMADI project and 11.2 through CNRS for the HPAC project);
- 35.7 k euro of ENS funding for accompanying the arrival as PR of Damien Stehlé;
- 6.6 k euro of UCBL funding for accompanying the arrival as PR of Fabien Laguillaumie;
- 22.6 k euro from Kalray for accompanying the CIFRE PhD of Nicolas Brunie;
- 3 k euro of donation from Intel (part of a $10k\$$ donation).

These figures will drastically change in the forthcoming years with the ERC Grant of Damien Stehlé (1.4 M euro for 5 years from Jan. 2014) and the PALSE grant of Benoît Libert (500 k euro from July 2014 to November 2016).

6.1.3 International collaborations resulting in joint publications

We have close contacts and long-term collaborations with many people, notably, during the period: Siegfried M. Rump (Hamburg, Germany); Éric Schost (London, Ontario, Canada); Peter Kornerup (Odense, Denmark); Milos Ercegovac (UCLA, California, USA); Ron Steinfeld (Monash, Australia); Xiao-Wen Chang (McGill, Canada); San Ling (NTU, Singapore); Cong Ling (Imperial College, UK).

6.1.4 Management of research projects and contracts

TaMaDi ANR Project. The TaMaDi project (Table Maker's Dilemma, 2010-2013) was funded by the ANR and headed by Jean-Michel Muller. It started in October 2010 and finished in October 2013. The other French teams involved in the project were the MARELLE team-project of INRIA Sophia Antipolis-Méditerranée, and the PEQUAN team of LIP6 lab., Paris.

The aim of the project was to find "hardest to round" (HR) cases for the most common functions and floating-point formats. In floating-point (FP) arithmetic having fully-specified "atomic" operations is a key-requirement for portable, predictable and provable numerical software. Since 1985, the four arithmetic operations and the square root are IEEE specified (it is required that they should be correctly rounded: the system must always return the floating-point number nearest the exact result of the operation). This is not fully the case for the basic mathematical functions (sine, cosine, exponential, etc.). Indeed, the same function, on the same argument value, with the same format, may return significantly different results depending on the environment. As a consequence, numerical programs using these functions suffer from various problems. The lack of specification is due to a problem called the Table Maker's Dilemma (TMD). To compute $f(x)$ in a given format, where x is a FP number, we must first compute an approximation to $f(x)$ with a given precision, which we round to the nearest FP number in the considered format. The problem is the following: finding what the accuracy of the approximation must be to ensure that the obtained result is always equal to the "exact" $f(x)$ rounded to the nearest FP number. In the last years, our team-project and the CACAO team-project of INRIA Nancy-Grand Est designed algorithms for finding hardest-to-round cases. These algorithms do not allow to tackle with large formats. The TaMaDi project mainly focused on three aspects:

- big precisions: we must get new algorithms for dealing with precisions larger than double precision. Such precisions will become more and more important (even if double precision may be thought as more than enough for a final result, it may not be sufficient for the intermediate results of long or critical calculations);
- formal proof: we must provide formal proofs of the critical parts of our methods. Another possibility is to have our programs generating certificates that show the validity of their results. We should then focus on proving the certificates;
- aggressive computing: the methods we have designed for generating HR points in double precision require weeks of computation on hundreds of PCs. Even if we design faster algorithms, we must massively parallelize our methods, and study various ways of doing that.

ANR EVA-Flo Project. The EVA-Flo project (Évaluation et Validation Automatiques de calculs Flottants, 2006-2010) was headed by N. Revol (Arénaire). The other teams participating in this project were DALI (Eliaus, U. Perpignan), Measi (LIST, CEA Saclay) and Tropics (INRIA Sophia-Antipolis).

This project focused on the way a mathematical formula is evaluated in floating-point arithmetic. The approach was threefold: study of algorithms for approximating and evaluating mathematical formulae, validation of such algorithms, and automation of the process.

Grant from Minalogic/EMSOC. This project was headed by C.-P. Jeannerod and J.-M. Muller. From October 2006 to September 2009, we have been involved in Sceptre, a project of the EMSOC cluster of the Minalogic Competitivity Centre. This project, led by STMicroelectronics, aims at providing new techniques for implementing software on system-on-chips. Within Arénaire, we were focusing on the generation of optimized code for accurate evaluation of mathematical functions; our partner at STMicroelectronics is the Compiler Expertise Center (Grenoble).

PHC Sakura - INRIA Ayame junior program (France-Japan). The project "Software and Hardware Components for Pairing-Based Cryptography", (2008-2009), was headed by G. Hanrot (CACAO/LORIA then Arénaire/LIP) and E. Okamoto (LCIS, Univ. of Tsukuba).

The participants belonged to the Arénaire (LIP, ENS Lyon) and CACAO (LORIA, Nancy) teams for the French part and to the LCIS (Univ. of Tsukuba, Japan) and the Future Univ. of Hakodate (Japan). The goal of this project was the enhancement of software and hardware implementations of pairings defined over algebraic curves. We worked on the development of a more efficient arithmetic over Jacobian of (hyper)elliptic curves, implementing genus 2 curve based pairings and designing algorithms and implementations resistant to side channel attacks.

6.1.5 Participation in research projects and contracts

ANR HPAC Project. "High-performance Algebraic Computing" (HPAC) is a four year ANR project that started in January 2012. HPAC is headed by Jean-Guillaume Dumas (CASYS team, LJK laboratory, Grenoble); it involves AriC as well as the INRIA project-team MOAIS (LIG, Grenoble), the INRIA project-team PolSys (LIP6 lab., Paris), the ARITH group (LIRMM laboratory, Montpellier), and the HPC Project company.

The overall ambition of HPAC is to provide international reference high-performance libraries for exact linear algebra and algebraic systems on multi-processor architecture and to influence parallel programming approaches for algebraic computing. The central goal is to extend the efficiency of the LinBox and FGb libraries to new trend parallel architectures such as clusters of multi-processor systems and graphics processing units in order to tackle a broader class of problems in lattice-based cryptography and algebraic cryptanalysis. HPAC conducts researches along three axes:

- A domain specific parallel language (DSL) adapted to high-performance algebraic computations;
- Parallel linear algebra kernels and higher-level mathematical algorithms and library modules;
- Library composition, their integration into state-of-the-art software, and innovative high performance solutions for cryptology challenges.

ANR TCHATER Project. The TCHATER project (Terminal Cohérent Hétérodyne Adaptatif TEmps Réel, 2008-2011) was a collaboration between Alcatel-Lucent France, E2V Semiconductors, GET-ENST and the INRIA Arénaire and ASPI project/teams. Its purpose was to demonstrate a coherent terminal operating at 40Gb/s using real-time digital signal processing and efficient polarization division multiplexing. In Lyon, we studied the FPGA implementation of specific algorithms for polarization demultiplexing and forward error correction with soft decoding.

ANR LaRedA Project. The LaRedA project (Lattice Reduction Algorithms, 2008-2011) was funded by the ANR and headed by Brigitte Vallée (CNRS/GREYC) and Valérie Berthé (CNRS/LIRMM). The aim of the project was to finely analyze lattice reduction algorithms such as LLL, by using experiments, probabilistic tools and dynamic analysis. Among the major goals were the average-case analysis of LLL and its output distribution. In Lyon, we have concentrated on the experimental side of the project (by using fpLLL and MAGMA) and the applications of lattice reduction algorithms to cryptography.

6.1.6 Industrial contracts and collaborations

Contracts with STMicroelectronics. We have been involved in Mediacom in 2009-2013. Mediacom was a 40-month joint project with the Compiler Expertise Center (STMicroelectronics Grenoble) and INRIA project-teams Alchemy, Alf, AriC, and Compsys, and a Nano 2012 partner project. For us, in particular, it has funded the 3-year MEFI PhD grant of David Pfannholzer.

A contract between STMicroelectronics and Inria supported our work on floating-point arithmetic code generation and specialization for embedded processors (duration: 36 months; amount: 36,000 euros; signature: fall 2010). This contract, which was done jointly with the Compilation Expertise Center of STMicroelectronics Grenoble, was also supporting the PhD CIFRE grant of Jingyan Jourdan-Lu.

Collaboration with Bosch. Bosch (Stuttgart) ordered us a study on the choice of an adequate representation of numbers (fixed-point or floating-point) for some embedded systems. The study was conducted by Florent de Dinechin and Jean-Michel Muller.

Contracts with Kalray. A 2.5 month contract covered the development of synthesizable register-transfer level description of a floating-point unit for the Kalray processor, as well as compatible C models, for evaluation purposes. Details are confidential at this point.

Nicolas Brunie has been supported by a CIFRE PhD grant (from 15/04/2011 to 14/04/2014) from Kalray. The purpose was the study of a tightly coupled reconfigurable accelerator to be embedded in the Kalray multicore processor. Advisors: Florent de Dinechin and, within Kalray, Benoît de Dinechin.

Orange Labs PhD Grant. Marie Paindavoine is supported by an Orange Labs PhD Grant (from October 2013 to November 2016). She works on privacy-preserving encryption mechanisms.

Collaboration with Intel. INTEL made a $20000 donation in recognition of our work on the correct rounding of functions.

Altera hardware donation. Altera donated to the team an FPGA-based acceleration card (Altera DK-DEV-4SGX530N) for the Table-Maker's Dilemma acceleration project.

Adacsys contract. Adacsys granted Arénaire free access to their RAVA remote hardware validation tool to help develop the FloPoCo project.

6.1.7 Software production and contribution to research infrastructures

The AriC software and hardware realizations are accessible from the web page
`http://www.ens-lyon.fr/LIP/AriC/ware.html`.

Large-scale projects led by the team

- CRlibm: a Library of Elementary Functions with Correct Rounding

  The CRlibm project has consisted in developing a mathematical library (`libm`) which provides implementations of the double precision C99 standard elementary functions, with the following properties: *(i)* correct rounding in the four IEEE-754 rounding modes; *(ii)* a comprehensive proof of both the algorithms used and their implementation; *(iii)* sufficient efficiency in average time, worst-case time, and memory consumption to replace existing `libms` transparently.

  Version 1.0beta4 was released in 2010. Then, the development focus has turned to automated libm development with the Metalibm project described below.

  `http://lipforge.ens-lyon.fr/www/crlibm/`

- FloPoCo: a generator of operators for FPGAs

  This project explores the many ways in which the flexibility of the FPGA target can be exploited in the arithmetic realm. FloPoCo is a generator of operators written in C++ and outputting synthesizable VHDL automatically pipelined to an arbitrary frequency. It has both academic and industrial users. `http://flopoco.gforge.inria.fr/`

- FLIP: a Floating-point Library for Integer Processors

  FLIP is a C library for the efficient software support of binary32 IEEE 754-2008 floating-point arithmetic on processors without floating-point hardware units, such as VLIW or DSP processors for embedded applications. The current target architecture is the VLIW ST200 family from STMicroelectronics (especially the ST231 cores).

  `http://flip.gforge.inria.fr/`

- FPLLL: a Lattice Reduction Library

  fplll contains several algorithms on lattices that rely on floating-point computations. This includes implementations of the floating-point LLL reduction algorithm, offering different speed/guarantees ratios. It contains a "wrapper" choosing the estimated best sequence of variants in order to provide a guaranteed output as fast as possible. In the case of the wrapper, the succession of variants is oblivious to the user. It also includes a rigorous floating-point implementation of the Kannan-Fincke-Pohst algorithm that finds a shortest non-zero lattice vector, and the BKZ reduction algorithm.

  The fplll library is used or has been adapted to be integrated within several mathematical computation systems such as Magma, Sage, and PariGP. It is also used for cryptanalytic purposes, to test the resistance of cryptographic primitives.

  `http://perso.ens-lyon.fr/damien.stehle/fplll/`

Intermediate libraries and on-going developments

- CGPE: Code Generation for Polynomial Evaluation

  The CGPE project, developed with Guillaume Revy (DALI research team, Université de Perpignan and LIRMM laboratory), aims at generating C codes for fast and certified polynomial evaluation, given various accuracy and architectural constraints. Several improvements for this tool, based on the addition of constraints in the first step of the generation process, were proposed in the PhD thesis of Ch. Mouilleron. These improvements have been implemented, thus allowing us to reduce the whole generation time by about 50% on average.

  `http://cgpe.gforge.inria.fr/`

- Sollya: a toolbox of numerical algorithms for the development of safe numerical codes

  Sollya aims at providing a safe, user-friendly, all-in-one environment for manipulating numerical functions. Its distinguishing feature is that the focus is on safety: numerical results are certified, or a warning is produced. Functionalities include plotting, infinite norm, polynomial approximation (including an original minimax approximation among polynomials with floating-point coefficients), zero finding, etc., and an interpreter for the Sollya scripting language.

  `http://sollya.gforge.inria.fr/`

- EFT: Exhaustive Tests for the Correct Rounding of Mathematical Functions

  The search for the worst cases for the correct rounding (hardest-to-round cases) of mathematical functions ($\exp$, $\log$, $\sin$, $\cos$, etc.) in a fixed precision (mainly double precision) using Lefèvre's algorithm is implemented by a set of utilities written in Perl, with calls to Maple/intpakX for computations on intervals and with C code generation for fast computations. It also includes a client-server system for the distribution of intervals to be tested and for tracking the status of intervals (fully tested, being tested, aborted).

- Metalibm: a code generator for elementary functions

  The Metalibm project provides a tool for the automatic implementation of mathematical (libm) functions. A function f is automatically transformed into Gappa-certified C code implementing an approximation polynomial in a given domain with given accuracy. Metalibm is based on the Sollya tool and has been used to produce large parts of CRlibm.

  `http://lipforge.ens-lyon.fr/www/metalibm/`

- Sipe:

  A mini-library in the form of a C header file, to perform radix-2 floating-point computations in very low precisions with correct rounding, either to nearest or toward zero. The goal of such a tool is to do proofs of algorithms/properties or computations of tight error bounds in these precisions by exhaustive tests, in order to try to generalize them to higher precisions. The currently supported operations are addition, subtraction, multiplication (possibly with the error term), fused multiply-add/subtract (FMA/FMS), and miscellaneous comparisons and conversions. Sipe provides two implementations of these operations, with the same API and the same behavior: one based on integer arithmetic, and a new one based on floating-point arithmetic.

  `https://www.vinc17.net/research/sipe/`

- GNU MPFR:

  An efficient multiple-precision floating-point library with well-defined semantics (copying the good ideas from the IEEE-754 standard), in particular correct rounding in 5 rounding modes. GNU MPFR provides about 80 mathematical functions, in addition to utility functions (assignments, conversions…). Special data (*Not a Number*, infinities, signed zeros) are handled like in the IEEE-754 standard.

  MPFR was one of the main pieces of software developed by the old SPACES team at Loria. Since late 2006, with the departure of Vincent Lefèvre to Lyon, it has become a joint project between the Caramel (formerly SPACES then CACAO) and the AriC (formerly Arénaire) project-teams.

  `http://www.mpfr.org/`

- MPFI:

  A library in C for interval arithmetic using arbitrary precision (arithmetic and algebraic operations, elementary functions, operations on sets). It is based on MPFR and maintained on par with MPFR: it offers the interval counterpart of most mathematical functions provided by MPFR.

  `http://mpfi.gforge.inria.fr/`

- NumGfun: Symbolic-numeric Computations with Linear ODEs

  A Maple package for performing numerical and "analytic" computations with the solutions of linear ordinary differential equations with polynomial coefficients. Its main features include the numerical evaluation of these functions with rigorous error bounds and the computation of symbolic bounds on solutions of certain recurrences. NumGfun is distributed as part of gfun, itself part of the Algolib bundle. It is used by the Dynamic Dictionary of Mathematical Functions to provide its numerical evaluation features.

  `http://marc.mezzarobba.net/#code-NumGfun`

6.1.8 Prizes and awards

- Jean-Michel Muller received the CNRS-INS2I silver medal in 2013;
- Damien Stehlé received the CNRS-INS2I bronze medal in 2012;
- Damien Stehlé was awarded a "starting" ERC grant for his project "Euclidean lattices: algorithms and cryptography" (LattAC) in 2013;
- Vincent Lefèvre, Nicolas Louvet, and Jean-Michel Muller received the "Prix La Recherche pour les Sciences de l'Information" in 2013;
- The article "An FPGA architecture for solving the Table Maker's Dilemma" [84] received the best paper award at IEEE ASAP 2011.

6.1.9 Contribution to the scientific community and administrative responsibilities

- Florent de Dinechin has been head of the Arenaire and then AriC teams during most of the period.
- Guillaume Hanrot has been deputy director of the LIP since 01/01/13. He has also been in charge of the computer science master at ENS de Lyon for the academic year 2012-2013. He has been a member of hiring committees for an assistant professor position at Caen IUT (2013), for an assistant professor position at Saint-Étienne IUT (2013), for a professor position at ENSIIE Strasbourg (2013), Caen (2012), Toulon (2012), UCB Lyon 1 (2012), and of the Inria national committee for "Prime d'excellence scientifique" (2013). He was vice-president of INRIA's Evaluation Committee till 2010. He is a member of the scientific council of ENSIIE (Évry). He chairs a working group in charge of making recommendations concerning general teaching and training policy at ENS de Lyon.
- Jean-Michel Muller is co-director of GDR IM (`http://www.gdr-im.fr`) and head of the AriC team (since June 2013). He was a member of the Scientific Council of Grenoble INP from 2008 to 2011, and "Chargé de Mission", ST2I dept. of CNRS, until September 2009. He has been a member of the Scientific Council of CERFACS since 2012. He chaired the Aeres evaluation committees of laboratories LIMOS (Clermont-Ferrand, 2011), LIAFA (Paris, 2012), PPS (Paris, 2012), and was a member of the evaluation committees of laboratories GREYC (Caen, 2010) and LIRMM (Montpellier, 2013). In 2014, he is vice-chair of the "Comité d'évaluation scientifique mathématiques–informatique théorique" of the ANR (the French national research agency).
- Fabien Laguillaumie is responsible for the second year "Ingénierie des Risques" of the Master SAFIR. He was a member of the hiring committee for an assistant professor position at Université Lyon 1 (2013).
- Nathalie Revol was in the hiring committee for junior researchers (CR) of INRIA Grenoble - Rhône-Alpes in 2014 and 2009 and for an associate professor position at Orsay-Paris Sud (2014). She is a member of the CES (Commission des Emplois Scientifiques), the hiring committee for postdocs at INRIA Grenoble - Rhône-Alpes. She is a member of the "comité de diffusion" of the MILyon labex. She belongs to the steering committee for the MMI (Maison des Mathématiques et de l'Informatique). She is a member of the selecting committee of CapMaths.
- Bruno Salvy is organizing the working group Computer Algebra of the CNRS GDR IM. In 2012, he has also been a member of several committees: PES at Inria; hiring junior researchers (CR) at Inria; hiring professors in Caen and Grenoble; visiting committee of the laboratory Liafa (Paris 7) for the Aeres.
- Damien Stehlé was deputy director and Erasmus coordinator of the ENS de Lyon Computer Science department from 01/01/13 to 30/06/13. He has been the director of the Computer Science department since 01/07/13. He is a member of the steering committee of the working group Cryptography and Coding of the CNRS GDR IM. He was in the hiring committees for lecturers at the universities of Grenoble and Montpellier (2012), and at ENS de Lyon (2014).
- Gilles Villard has chaired the LIP laboratory since January 2009.

6.1.10 Editorial duties

- Florent de Dinechin is an associate editor of the journal *IEEE Transactions on Computers*.
- Jean-Michel Muller is a member of the editorial board of the *IEEE Transactions on Computers*. He is a member of the board of foundation editors of the *Journal for Universal Computer Science*.
- Bruno Salvy is a member of the editorial boards of the *Journal of Symbolic Computation*, of the *Journal of Algebra* (section Computational Algebra) and of the collections *Texts and Monographs in Symbolic Computation* (Springer) and *Mathématiques et Applications* (SMAI-Springer).
- Gilles Villard is a member of the editorial board of the *Journal of Symbolic Computation*.

6.1.11 Organisation and committees of scientific conferences

- F. de Dinechin, C.-P. Jeannerod, V. Lefèvre, N. Louvet, and N. Revol organized the *3es Rencontres "Arithmétique de l'Informatique Mathématique" (RAIM'09)* at ENS-Lyon (3 days, over 70 participants).
- Florent de Dinechin, Claude-Pierre Jeannerod, Vincent Lefèvre, Nicolas Louvet, Sèverine Morin, Hong Diep Nguyen, and Nathalie Revol (chair) organized the SCAN 2010 conference (Scientific Computing, Computer Arithmetic and Validated Numerics), held in Lyon, 27-30 September 2010, which gathered 123 participants from 20 countries. They were in charge of the scientific program and of the local organization.
- Florent de Dinechin is a member of the Steering Committee of the *Symposium en Architectures de Machines*. He was a member of the Program Committees of the conferences CompAs (Grenoble, January 2013), ARC (Applied Reconfigurable Computing) in 2013, 2012 and 2011, HEART (Highly Efficient Accelerators and Reconfigurable Technologies) in 2013, 2012 and 2011, FPL (Field-Programmable Logic) in 2013, 2012, 2011 and 2009, FPT (Field-Programmable Technology) in 2013, 2012, 2011 and 2009, ReConfig 2013. He also organized a tutorial half-day on arithmetic core generation using the FloPoCo framework at HiPEAC 2013 (Berlin, January 2013).
- Guillaume Hanrot was program committee co-chair of the 9th Algorithmic Number Theory Symposium (ANTS IX, Nancy, July 2010).
- Fabien Laguillaumie was in the program committees of ProvSec 2013, ACISP 2012 (17th Australasian Conference on Information Security and Privacy), Africacrypt 2014, WCC 2015.
- Claude-Pierre Jeannerod is a member of the scientific committee of *Journées Nationales de Calcul Formel*. He was in the software exhibits committee of ISSAC 2012 and in the program committee of SNC 2011 (Fourth International Workshop on Symbolic-NumericComputation).
- Vincent Lefèvre and Nicolas Louvet were in the scientific committee of the CNRS thematic school *Précision et reproductibilité en calcul numérique* (Fréjus, France, March, 2013).
- Benoit Libert is a member of the program committees of ACM-CCS 2014 and PKC 2015.
- Jean-Michel Muller has been a member of the steering committee of the RNC series of conferences. He was a member of the Program Committees of the conferences IEEE ARITH (Symposium on Computer Arithmetic) in 2013, 2011 and 2009, IEEE ASAP (Application-Specific Systems, Architectures and Processors) in 2013, 2012, 2011, 2010 and 2009.
- Nathalie Revol was the chair of the organization committee and took charge of the "gender aspects" of the Forum 2013 des Jeunes Mathématicien-ne-s, 13-15 November, Lyon. She was in the steering and scientific committees of SCAN 2012, Novosibirsk, in the program committee of NSV (Numerical Software Verification) in 2011 and 2010, MACIS 2011 (Mathematical Aspects of Computer and Information Sciences), PASCO 2010, ICMS 2010.
- Bruno Salvy was in the program committees of the conferences ISSAC 2013, Analco 2013, AofA 2014. He is a co-organizer of a workshop *Challenges in 21st Century Experimental Mathematical Computation* in Providence, Rhode Island, in 2014
- Damien Stehlé is a member of the steering committee of the PQCrypto conference series. He served in the program committees of the conferences PQCrypto (Post-Quantum Cryptography) in 2011, 2013 and 2014, Latincrypt in 2014, Asiacrypt in 2013, Indocrypt in 2011 and 2012, CRYPTO'12, ISSAC'12, ACISP (Australasian Conference on Information Security and Privacy) in 2010, 2011 and 2014, CANS 2011 (Cryptography and Network Security).

6.1.12 National and international boards and expertise, consulting activities

- Nathalie Revol has chaired the IEEE P1788 working group on the standardization of interval arithmetic since November 2008.

6.1.13 Patents, startups, and technology transfer

- Mixed-precision merged multiplication and addition operator. N. Brunie and F. de Dinechin and B. Dupont de Dinechin. Patent WO/2012/175828. December 2012.
- Improving Execution Efficiency in a Single-Program, Multiple-Data Processor. S. Collange and N. Brunie. Patent application US 13/707 301. December 2012.

6.1.14 Training and teaching activities

PhD students

Since January 2009, 10 AriC students have defended their PhD: Sylvain Chevillard (July 2009); Guillaume Revy (December 2009); Hong-Diep Nguyen (January 2011); Bogdan Pasca (September 2011); Mioara Joldes (September 2011); Christophe Mouilleron (November 2011); Adrien Panhaleux (June 2012); Eric Martin-Dorel (September 2012); Jingyan Jourdan-Lu (November 2012); Nicolas Brunie (May 2014). As we are writing these lines, Adeline Langlois and Philippe Théveny are to defend their PhDs during the autumn of 2014.

Among the 6 students who defended their PhD before december 2011, 5 now have a permanent position: Sylvain Chevillard is now Inria researcher (CR) at Inria Sophia-Antipolis Méditerranée; Guillaume Revy is associate professor (MCF) at Université de Perpignan; Hong-Diep Nguyen is postdoctoral scholar at UC Berkeley; Bogdan Pasca is Engineer in the Altera European Technology Centre, UK; Mioara Joldes is CNRS researcher (CR) at LAAS Laboratory (Toulouse); Christophe Mouilleron is “professeur agrégé” in ENSIIE (Evry).

National or International Courses and Tutorials

- Lattices in computer arithmetic (N. Brisebarre) at the *École de Printemps d’Informatique Théorique*, Autrans, 2013.
- Introduction to lattices (D. Stehlé), same *École*.
- Introduction to lattice algorithms (G. Hanrot), same *École*.
- Lattice-based cryptography, (D. Stehlé) at ENS in Casablanca and ENSA in SAFI (Morocco) .
- Cryptography and Euclidean lattices (F. Laguillaumie) at the *École de Printemps Codage et Cryptographie*, Grenoble, 2014.
- Advanced cryptography with the problem Learning with Errors (F. Laguillaumie) at the *École jeunes chercheurs en Informatique Mathématique*, Caen, 2014.
- Arithmétique flottante (F. de Dinechin) at the *École CNRS Précision et reproductibilité en calcul numérique*, Fréjus, 2013.
- Arithmétique flottante en précision arbitraire (V. Lefèvre), same *École*.
- Arithmétique flottante (J.-M. Muller), same *École* and also *École HPC*, Lyon.
- Arithmétique flottante et intervalles (N. Revol and P. Théveny), same *École*.
- Introductory talk on Floating-Point Arithmetic (J.-M. Muller) at the *Journées nationales de l’association des professeurs de Mathématiques de l’enseignement Public*, Grenoble, 2011.
- Floating-Point Arithmetic (F. de Dinechin), Nizhniy Novgorod State University, 2011.
- Précision et arithmétique flottante : outils, bibliothèques (N. Revol and P. Théveny), *Journées du Développement Logiciel*, École Polytechnique, 2013.
- Introduction à l’arithmétique par intervalles (N. Revol and P. Théveny), professional training entitled “Contrôler et améliorer la qualité numérique d’un code de calcul industriel”, Collège de l’X, Paris, 2013.
- Introduction to informatics for high school teachers (G. Hanrot), 2012.

Master level courses

- Computer Algebra: G. Hanrot, C.-P. Jeannerod, J.-M Muller at ENS de Lyon in 2012–2014 and B. Salvy at MPRI since 2005.
- Multiple-Precision Arithmetic: G. Hanrot, V. Lefèvre, J.-M. Muller, ENS de Lyon, 2009.
- Algorithms for Verified Linear Algebra: C.-P. Jeannerod, N. Louvet, N. Revol, ENS de Lyon, 2009–2012.
- Approximations: from symbolic to numerical computation, and applications: N. Brisebarre and B. Salvy, ENS de Lyon, 2012–2014.
- Numerical Algorithms: C.-P. Jeannerod, N. Louvet, N. Revol, Univ. Lyon 1, 2009–2013.
- Computer Arithmetic: V. Lefèvre, Univ. Lyon 1, 2009–2014 and F. de Dinechin at ENS de Lyon in 2009.
- Arithmetic Algorithms: E. Guerrini, G. Hanrot, C.-P. Jeannerod, J.-M. Muller, ENS de Lyon, 2009–2012.
- Floating-Point Arithmetic and Formal Proof: J.-M. Muller, ENS de Lyon, 2011–2013.
- Cryptography: Damien Stehlé, ENS de Lyon, 2012.
- Cryptography, Error Correcting Codes: F. Laguillaumie, Univ. Lyon 1, since 2012.
- Cryptology: new primitives and applications: G. Hanrot and D. Stehlé, ENS de Lyon, 2010–2012.
- Cryptographic Algorithms: N. Brisebarre, ENSIAS of Rabat (Morocco), 2009–2011.
- Lattice basis reduction and applications: G. Hanrot, ENS de Lyon, 2009.
- Reconfigurable Computing: F. de Dinechin, ENS de Lyon, 2009–2012.

License level courses

- Numerous courses at Univ. Lyon 1 by N. Louvet, on Computer Architecture, Algorithms and Data Structures, Operating Systems, Introduction to Functional Programming.
- Introduction to computer science, ENS de Lyon / classe passerelle pour l'enseignement supérieur, taught by G. Hanrot (2012–2014).
- Courses on computer architecture, networks and systems at ENS de Lyon by F. de Dinechin.

6.1.15 Interaction with the social and cultural environment

- Nathalie Revol gives talks for pupils at collèges and lycées, as an incentive to choose scientific careers (about 20 such interventions took place in the period). She also gave talks to conferences for high-school pupils and Science Fairs, to a meetings of "inspecteurs d'académie" and talks around Women's day. When the French Ministry of Education launched the first week of mathematics, N. Revol took part in the preparation of a television report for France 2
- Damien Stehlé was interviewed for an article in *La Recherche*, published in September 2013.

6.1.16 Publications and productions

International peer-reviewed journals [ACL]

2009

[1] Stef Graillat, Philippe Langlois, and Nicolas Louvet. Algorithms for Accurate, Validated and Fast Polynomial Evaluation. *Japan Journal of Industrial and Applied Mathematics*, (26):121–124, 2009.

[2] Peter Kornerup, Paolo Montuschi, Jean-Michel Muller, and Eric Schwarz. Guest Editors' Introduction: Special Section on Computer Arithmetic. *IEEE Transactions on Computers*, 58(2):145–147, February 2009.

[3] Christoph Quirin Lauter and Vincent Lefèvre. An efficient rounding boundary test for pow(x,y) in double precision. *IEEE Transactions on Computers*, 58(2):197–207, February 2009.

[4] Phong Q. Nguyen and Damien Stehlé. An LLL Algorithm with Quadratic Complexity. *SIAM Journal on Computing*, pages 874–903, 2009.

2010

[5] Xiao-Wen Chang and Damien Stehlé. Rigorous Perturbation Bounds of Some Matrix Factorizations. *SIAM Journal on Matrix Analysis and Applications*, 31(5):2841–2859, November 2010.

[6] Milos Ercegovac and Jean-Michel Muller. An Efficient Method for Evaluating Complex Polynomials. *Journal of Signal Processing Systems*, 58(1):17–27, January 2010.

[7] Kaveh Ghazi, R., Vincent Lefèvre, Philippe Théveny, and Paul Zimmermann. Why and How to Use Arbitrary Precision. *Computing in Science and Engineering*, 12(3):62–65, 2010.

[8] Peter Kornerup, Christoph Lauter, Vincent Lefèvre, Nicolas Louvet, and Jean-Michel Muller. Computing Correctly Rounded Integer Powers in Floating-Point Arithmetic. *ACM Transactions on Mathematical Software*, 37(1):4:1–4:23, January 2010.

[9] Alvaro Vazquez, Elisardo Antelo, and Paolo Montuschi. Improved Design of High-Performance Parallel Decimal Multipliers. *IEEE Transactions on Computers*, 59(5):679–693, May 2010.

2011

[10] Sylvie Boldo and Jean-Michel Muller. Exact and Approximated error of the FMA. *IEEE Transactions on Computers*, 60(2):157–164, February 2011.

[11] Sylvain Chevillard, John Harrison, Mioara Joldes, and Christoph Lauter. Efficient and accurate computation of upper bounds of approximation errors. *Journal of Theoretical Computer Science*, 412(16):1523–1543, 2011.

[12] Pieter Collins, Milad Niqui, and Nathalie Revol. A validated real function calculus. *Mathematics in Computer Science*, 5(4):437–467, December 2011.

[13] Florent de Dinechin, Christoph Lauter, and Guillaume Melquiond. Certifying the floating-point implementation of an elementary function using Gappa. *IEEE Transactions on Computers*, 60(2):242–253, February 2011.

[14] Florent De Dinechin and Bogdan Pasca. Designing Custom Arithmetic Data Paths with FloPoCo. *IEEE Design and Test of Computers*, 28:18–27, July 2011.

[15] Claude-Pierre Jeannerod, Hervé Knochel, Christophe Monat, and Guillaume Revy. Computing floating-point square roots via bivariate polynomial evaluation. *IEEE Transactions on Computers*, 60(2):214–227, February 2011.

[16] Claude-Pierre Jeannerod, Nicolas Louvet, Jean-Michel Muller, and Adrien Panhaleux. Midpoints and exact points of some algebraic functions in floating-point arithmetic. *IEEE Transactions on Computers*, 60(2):228–241, February 2011. Recherche en partie supportée par le "Pole de competitivite mondial" Minalogic et le projet ANR EVA-Flo.

[17] Peter Kornerup, Jean-Michel Muller, and Adrien Panhaleux. Performing Arithmetic Operations on Round-to-Nearest Representations. *IEEE Transactions on Computers*, 60(2):282–291, February 2011.

[18] Cong Ling, Shuiyin Liu, and Damien Stehlé. Decoding by Sampling: A Randomized Lattice Algorithm for Bounded Distance Decoding. *IEEE Transactions on Information Theory*, pages 5933–5945, 2011.

[19] Hong Diep Nguyen and Nathalie Revol. Solving and Certifying the Solution of a Linear System. *Reliable Computing*, 15(2):120–131, 2011. The Reliable Computing journal has no more paper publication, only free, electronic publication.

[20] Gilles Villard. Kaltofen's division-free determinant algorithm differentiated for matrix adjoint computation. *Journal of Symbolic Computation*, 46(7):773–790, 2011.

2012

[21] Christophe Alias, Bogdan Pasca, and Alexandru Plesco. FPGA-Specific Synthesis of Loop Nests with Pipelined Computational Cores. *Microprocessors and Microsystems - Embedded Hardware Design*, 36(8):606–619, 2012.

[22] Nuttapong Attrapadung, Javier Herranz, Fabien Laguillaumie, Benoît Libert, Elie De Panafieu, and Carla Ràfols. Attribute-Based Encryption Schemes with Constant-Size Ciphertexts. *Theoretical Computer Science*, 422:15–38, 2012.

[23] Xiao-Wen Chang, Damien Stehlé, and Gilles Villard. Perturbation Analysis of the QR Factor R in the Context of LLL Lattice Basis Reduction. *Mathematics of Computation*, 81(279):1487–1511, 2012.

[24] Florent De Dinechin. Multiplication by rational constants. *IEEE Transactions on Circuits and Systems. Part II, Express Briefs*, page 00, 2012.

[25] Peter Kornerup, Vincent Lefèvre, Nicolas Louvet, and Jean-Michel Muller. On the computation of correctly-rounded sums. *IEEE Transactions on Computers*, 61(3):pages 289–298, March 2012. 10 pages.

[26] Carine Pivoteau, Bruno Salvy, and Michele Soria. Algorithms for combinatorial structures: Well-founded systems and Newton iterations. *Journal of Combinatorial Theory, Series A*, 119(8):1711–1773, November 2012.

2013

[27] Magali Bardet, Jean-Charles Faugère, Bruno Salvy, and Pierre-Jean Spaenlehauer. On the Complexity of Solving Quadratic Boolean Systems. *Journal of Complexity*, 29(1):53–75, February 2013.

[28] Sylvie Boldo, François Clément, Jean-Christophe Filliâtre, Micaela Mayero, Guillaume Melquiond, and Pierre Weis. Wave Equation Numerical Resolution: a Comprehensive Mechanized Proof of a C Program. *Journal of Automated Reasoning*, 50(4):423–456, April 2013.

[29] Florent De Dinechin, Pedro Echeverria, Marisa Lopez-Vallejo, and Bogdan Pasca. Floating-Point Exponentiation Units for Reconfigurable Computing. *ACM Transactions on Reconfigurable Technology and Systems*, 6(1):4:1–4:15, May 2013.

[30] Florent De Dinechin, Christoph Lauter, Jean-Michel Muller, and Serge Torres. On Ziv's rounding test. *ACM Transactions on Mathematical Software*, 39(4):26, 2013.

[31] Claude-Pierre Jeannerod, Nicolas Louvet, and Jean-Michel Muller. Further analysis of Kahan's algorithm for the accurate computation of 2 x 2 determinants. *Mathematics of Computation*, 82(284):2245–2264, 2013.

[32] Claude-Pierre Jeannerod, Clément Pernet, and Arne Storjohann. Rank-profile revealing Gaussian elimination and the CUP matrix decomposition. *Journal of Symbolic Computation*, 56:46–68, 2013.

[33] Claude-Pierre Jeannerod and Siegfried M. Rump. Improved error bounds for inner products in floating-point arithmetic. *SIAM Journal on Matrix Analysis and Applications*, 34(2):338–344, April 2013.

[34] Cong Ling, Laura Luzzi, and Damien Stehlé. Decoding by Embedding: Correct Decoding Radius and DMT Optimality. *IEEE Transactions on Information Theory*, 59(5):2960–2973, 2013.

[35] Érik Martin-Dorel, Guillaume Melquiond, and Jean-Michel Muller. Some issues related to double roundings. *BIT Numerical Mathematics*, 53(4):897–924, December 2013.

[36] Nathalie Revol and Philippe Théveny. Parallel Implementation of Interval Matrix Multiplication. *Reliable Computing*, 19(1):91–106, 2013.

2014

[37] Magali Bardet, Jean-Charles Faugere, and Bruno Salvy. On the Complexity of the F5 Gröbner basis Algorithm. *Journal of Symbolic Computation*, pages 1–24, September 2014.

[38] Alin Bostan, Kilian Raschel, and Bruno Salvy. Non-D-finite excursions in the quarter plane. *Journal of Combinatorial Theory, Series A*, 121:45–63, January 2014.

[39] Jean-Michel Muller. On the error of Computing ab + cd using Cornea, Harrison and Tang's method. *ACM Transactions on Mathematical Software*, (à paraître):8, 2014. Submitted to ACM TOMS.

[40] Nathalie Revol and Philippe Théveny. Numerical Reproducibility and Parallel Computations: Issues for Interval Algorithms. *IEEE Transactions on Computers*, 63(8):1915–1924, 2014. (to appear).

[41] Siegfried M. Rump and Claude-Pierre Jeannerod. Improved backward error bounds for LU and Cholesky factorizations. *SIAM Journal on Matrix Analysis and Applications*, 35(2):684–698, 2014.

National peer-reviewed journals [ACL]

2010

[42] Ivan Morel, Damien Stehlé, and Gilles Villard. Analyse numérique et réduction de réseaux. *Technique et Science Informatiques (TSI)*, 29(1):115–144, 2010. 29 pages.

2013

[43] Nicolas Brunie and Sylvain Collange. Reconvergence de contrôle implicite pour les architectures SIMT. *Technique et Science Informatiques (TSI)*, 32(2):153–178, February 2013.

Invited conferences [INV], seminars, and tutorials

2011

[44] Damien Stehlé. Algorithms for the shortest and closest vectors problems, 2011. Invited talk, June, International Workshop on Coding and Cryptology, Qingdao, China.

[45] Gilles Villard. Recent progress in linear algebra and lattice basis reduction (invited). In *ISSAC'11 - International symposium on Symbolic and algebraic computation*, ACM proceedings, pages 3–4, San Jose, United States, 2011.

2012

[46] Nathalie Revol. IEEE-1788 standardization of interval arithmetic: work in progress (a personal view). In *IFIP Working Group 2.5 on Numerical Software*, Santander, Spain, July 2012. Invited talk.

[47] Damien Stehlé. Lattice reduction and cryptanalysis of lattice-based cryptosystems, 2012. Plenary invited talk, July 12, Third international conference on Symbolic Computation and Cryptography, Castro Urdiales, Spain.

2013

[48] Damien Stehlé. Making ntruencrypt and ntrusign as secure as worst-case problems over ideal lattices, 2013. Plenary Invited talk, November 27, 16th Annual International Conference on Information Security and Cryptology, South Korea.

[49] Damien Stehlé. Speeding up lattice reduction with numerical linear algebra techniques, 2013. Plenary Invited talk, August 4, SIAM Conference on applied algebraic geometry, Fort Collins, CO, USA.

2014

[50] Damien Stehlé. Secure lattice codes for the gaussian wiretap channel, 2014. Invited talk, June 17, Algebra, Codes and Networks symposium, Bordeaux, France.

International peer-reviewed conference proceedings [ACT]

2009

[51] Florent De Dinechin, Cristian Klein, and Bogdan Pasca. Generating high-performance custom floating-point pipelines. In *Field Programmable Logic and Applications*, Prague, Czech Republic, August 2009. IEEE.

[52] Florent De Dinechin and Bogdan Pasca. Large multipliers with less DSP blocks. In *Field Programmable Logic and Applications*, Czech Republic, August 2009. IEEE.

[53] Pouya Dormiani, Milos Ercegovac, and Jean-Michel Muller. Design and Implementation of a Radix-4 Complex Division Unit with Prescaling. In *20th IEEE International Conference on Application-specific Systems, Architectures and Processors (ASAP'09)*, Boston, United States, 2009. IEEE Computer Society.

[54] Claude-Pierre Jeannerod, Hervé Knochel, Christophe Monat, Guillaume Revy, and Gilles Villard. A new binary floating-point division algorithm and its software implementation on the ST231 processor. In *19th IEEE Symposium on Computer Arithmetic (ARITH 19)*, pages 95–103, Portland, Oregon, United States, June 2009. IEEE.

[55] Claude-Pierre Jeannerod and Guillaume Revy. Optimizing correctly-rounded reciprocal square roots for embedded VLIW cores. In *Asilomar Conference on Signals, Systems, and Computers*, United States, 2009. IEEE Signal Processing Society.

[56] Peter Kornerup, Vincent Lefèvre, Nicolas Louvet, and Jean-Michel Muller. On the Computation of Correctly-Rounded Sums. In *19th IEEE Symposium on Computer Arithmetic - Arith'19*, Portland, Oregon, United States, 2009.

[57] Ivan Morel, Damien Stehlé, and Gilles Villard. H-LLL: Using Householder inside LLL. In *ISSAC 2009*, pages 271–278, Korea, Republic Of, 2009.

[58] Damien Stehlé, Ron Steinfeld, Keisuke Tanaka, and Keita Xagawa. Efficient Public-Key Encryption Based on Ideal Lattices (Extended Abstract). In *Asiacrypt 2009*, pages 617–635, Japan, 2009.

2010

[59] Sebastian Banescu, Florent De Dinechin, Bogdan Pasca, and Radu Tudoran. Multipliers for Floating-Point Double Precision and Beyond on FPGAs. In *Highly Efficient Accelerators and Reconfigurable Technologies*, Tsukuba, Japan, June 2010. EIC.

[60] Christian Bertin, Claude-Pierre Jeannerod, Jingyan Jourdan-Lu, Hervé Knochel, Christophe Monat, Christophe Mouilleron, Jean-Michel Muller, and Guillaume Revy. Techniques and tools for implementing IEEE 754 floating-point arithmetic on VLIW integer processors. In *4th International Workshop on Parallel and Symbolic Computation (PASCO'10)*, pages 1–9, Grenoble, France, 2010. ACM.

[61] Sylvie Boldo, François Clément, Jean-Christophe Filliâtre, Micaela Mayero, Guillaume Melquiond, and Pierre Weis. Formal Proof of a Wave Equation Resolution Scheme: the Method Error. In Matt Kaufmann and Lawrence C. Paulson, editors, *ITP'10 - Interactive Theorem Proving*, volume 6172 of *Lecture Notes in Computer Science*, pages 147–162, Edinburgh, United Kingdom, July 2010. Springer.

[62] Nicolas Brisebarre, Milos Ercegovac, Nicolas Louvet, Erik Martin-Dorel, Jean-Michel Muller, and Adrien Panhaleux. Implementing decimal floating-point arithmetic through binary: some suggestions. In *21st IEEE International Conference on Application-specific Systems, Architectures and Processors (ASAP'2010)*, pages 317–320, Rennes, France, 2010. IEEE.

[63] Nicolas Brisebarre and Mioara Joldes. Chebyshev Interpolation Polynomial-based Tools for Rigorous Computing. In *ISSAC '10, 2010 International Symposium on Symbolic and Algebraic Computation*, pages 147–154, Münich, Germany, July 2010. ACM New York, NY, USA. 17 pages.

[64] Franck Butelle, Florent Hivert, Micaela Mayero, and Frédéric Toumazet. Formal Proof of SCHUR Conjugate Function. In *CALCULEMUS 2010*, volume 6167 of *LNAI*, pages 158–171, Paris, France, 2010. Springer.

[65] Sylvain Chevillard, Mioara Joldes, and Christoph Lauter. Sollya: an environment for the development of numerical codes. In Michael Joswig Nobuki Takayama Komei Fukuda, Joris van der Hoeven, editor, *Third International Congress on Mathematical Software - ICMS 2010*, volume 6327 of *Lecture Notes in Computer Science*, pages 28 – 31, Kobe, Japan, September 2010. Springer.

[66] Florent De Dinechin, Mioara Joldes, and Bogdan Pasca. Automatic generation of polynomial-based hardware architectures for function evaluation. In *Application-specific Systems, Architectures and Processors*, Rennes, France, July 2010. IEEE.

[67] Florent De Dinechin, Mioara Joldes, Bogdan Pasca, and Guillaume Revy. Multiplicative square root algorithms for FPGAs. In *International Conference on Field Programmable Logic and Applications*, page 14, Milano, Italy, 2010. IEEE.

[68] Florent De Dinechin, Hong Diep Nguyen, and Bogdan Pasca. Pipelined FPGA Adders. In *International Conference on Field Programmable Logic and Applications*, pages 422–427, Milano, Italy, 2010. IEEE.

[69] Florent De Dinechin and Bogdan Pasca. Floating-point exponential functions for DSP-enabled FPGAs. In *International Conference on Field-Programmable Technology*, pages 110–117, Beijing, China, December 2010. IEEE.

[70] Florent De Dinechin, Honoré Takeugming, and Jean-Marc Tanguy. A 128-Tap Complex FIR Filter Processing 20 Giga-Samples/s in a Single FPGA. In *44th Conference on signals, systems and computers*, United States, November 2010. IEEE.

[71] Jérémie Detrey, Guillaume Hanrot, Xavier Pujol, and Damien Stehlé. Accelerating lattice reduction with FPGAs. In Michel Abdalla and Paulo S. L. M. Barreto, editors, *First International Conference on Cryptology and Information Security in Latin America (LATINCRYPT'10)*, volume 6212 of *Lecture Notes in Computer Science*, pages 124–143, Puebla, Mexico, August 2010.

[72] Claus Fieker and Damien Stehlé. Short bases of lattices over number fields. In *ANTS-IX*, volume LNCS 6197, pages 157–173, France, 2010.

[73] Claude-Pierre Jeannerod and Christophe Mouilleron. Computing specified generators of structured matrix inverses. In *35th International Symposium on Symbolic and Algebraic Computation (ISSAC 2010)*, Münich, Germany, 2010. ACM.

[74] Vincent Lefèvre, Philippe Théveny, Florent De Dinechin, Claude-Pierre Jeannerod, Christophe Mouilleron, David Pfannholzer, and Nathalie Revol. LEMA: Towards a Language for Reliable Arithmetic. In *International Workshop on Programming Languages for Mechanized Mathematics Systems (PLMMS 2010)*, volume 44 of *ACM Communications in Computer Algebra*, pages 41–52, Paris, France, June 2010. ACM.

[75] Nicolas Louvet, Jean-Michel Muller, and Adrien Panhaleux. Newton-Raphson Algorithms for Floating-Point Division Using an FMA. In *21st IEEE International Conference on Application-specific Systems Architectures and Processors (ASAP), 2010*, pages 200–207, Rennes, France, 2010. IEEE.

[76] Nathalie Revol. Standardized Interval Arithmetic and Interval Arithmetic Used in Libraries. In *ICMS 2010 - Third International Congress on Mathematical Software*, volume 6327, pages 337–341, Kobe, Japan, 2010. Takayama, Nobuki and Fukuda, Komei and van der Hoeven, Joris and Joswig, Michael and Noro, Masayuki, Springer.

[77] Damien Stehlé and Ron Steinfeld. Faster Fully Homomorphic Encryption. In *Proceedings of ASIACRYPT 2010*, pages 377–394, Singapore, 2010.

[78] Damien Stehlé and Mark Watkins. On the Extremality of an 80-Dimensional Lattice. In *ANTS-IX*, volume LNCS 6197, pages 340–356, France, 2010.

[79] Mark Van Hoeij and Andrew Novocin. Gradual sub-lattice reduction and a new complexity for factoring polynomials. In *LATIN 2010*, Oaxaca, Mexico, April 2010. LLNCS.

[80] Alvaro Vazquez and Elisardo Antelo. Multi-Operand Decimal Addition by Efficient Reuse of a Binary Carry-Save Adder Tree. In *44th ASILOMAR Conference on Signals, Systems and Computers*, Pacific Grove, CA, United States, November 2010.

[81] Alvaro Vazquez and Florent de Dinechin. Efficient implementation of Parallel BCD Multiplication in LUT-6 FPGAs. In *2010 International Conference on Field-Programmable Technology*, Beijing, China, December 2010.

2011

[82] Nicolas Brisebarre, Mioara Joldes, Peter Kornerup, Érik Martin-Dorel, and Jean-Michel Muller. Augmented precision square roots, 2-D norms, and discussion on correctly rounding x^2+y^2. In *20th IEEE Symposium on Computer Arithmetic (ARITH-20)*, pages 23–30, Tübingen, Germany, July 2011. IEEE Computer Society.

[83] Florent De Dinechin. The arithmetic operators you will never see in a microprocessor. In *20th IEEE Symposium of Computer Arithmetic*, pages 189–190, Germany, July 2011. IEEE.

[84] Florent de Dinechin, Jean-Michel Muller, Bogdan Pasca, and Alexandru Plesco. An FPGA architecture for solving the Table Maker's Dilemma. In *Application-Specific Systems, Architectures and Processors (ASAP), 2011 IEEE International Conference on*, pages 187–194, Santa Monica, United States, 2011. IEEE Computer Society. Cet article a obtenu le "best paper award" de la conférence.

[85] Guillaume Hanrot, Xavier Pujol, and Damien Stehlé. Algorithms for the Shortest and Closest Lattice Vector Problems. In *IWCC 2011*, pages 159–190, China, 2011.

[86] Guillaume Hanrot, Xavier Pujol, and Damien Stehlé. Analyzing Blockwise Lattice Algorithms using Dynamical Systems. In *CRYPTO 2011*, pages 447–464, United States, 2011.

[87] William Hart, Mark Van Hoeij, and Andrew Novocin. Practical polynomial factoring in polynomial time. In *Proceedings of ISSAC 2011*, pages 163–170, United States, 2011.

[88] William Hart and Andrew Novocin. Practical Divide-and-Conquer Algorithms for Polynomial Arithmetic. In *Proceedings of CASC 2011*, pages 200–214, Germany, 2011.

[89] Mark Van Hoeij, Jürgen Klüners, and Andrew Novocin. Generating subfields. In *Proceedings of ISSAC 2011*, pages 345–352, United States, 2011.

[90] Claude-Pierre Jeannerod, Jingyan Jourdan-Lu, Christophe Monat, and Guillaume Revy. How to Square Floats Accurately and Efficiently on the ST231 Integer Processor. In *20th IEEE Symposium on Computer Arithmetic (ARITH)*, pages 77–81, Tübingen, Germany, August 2011.

[91] Cong Ling, Shuiyin Liu, Laura Luzzi, and Damien Stehlé. Decoding by Embedding: Correct Decoding Radius and DMT Optimality. In *Proceedings of ISIT 2011*, pages 1106 – 1110, Russian Federation, 2011.

[92] Christophe Mouilleron and Guillaume Revy. Automatic Generation of Fast and Certified Code for Polynomial Evaluation. In *20th IEEE Symposium on Computer Arithmetic (ARITH)*, pages 233–242, Tübingen, Germany, August 2011.

[93] Hong Diep Nguyen, Bogdan Pasca, Thomas Preusser, and B. FPGA-Specific Arithmetic Optimizations of Short-Latency Adders. In *2011 International Conference on Field Programmable Logic and Applications (FPL)*, 2011, pages 232 – 237, Chania, Greece, September 2011.

[94] Andrew Novocin, Damien Stehlé, and Gilles Villard. An LLL-reduction algorithm with quasi-linear time complexity. In *STOC'11 - 43rd annual ACM symposium on Theory of computing*, pages 403–412, San Jose, United States, 2011. ACM New York, NY, USA.

[95] Damien Stehlé and Ron Steinfeld. Making NTRU as secure as worst-case problems over ideal lattices. In *Proceedings of EUROCRYPT 2011*, pages 27–47, Estonia, 2011.

2012

[96] Alin Bostan, Muhammad F. I. Chowdhury, Romain Lebreton, Bruno Salvy, and Éric Schost. Power Series Solutions of Singular (q)-Differential Equations. In Mark van Hoeij and Joris van der Hoeven, editors, *ISSAC '12: 37th International Symposium on Symbolic and Algebraic Computation*, pages 107–114, Grenoble, France, July 2012.

[97] Alin Bostan, Frédéric Chyzak, Ziming Li, and Bruno Salvy. Fast Computation of Common Left Multiples of Linear Ordinary Differential Operators. In Mark van Hoeij and Joris van der Hoeven, editors, *ISSAC 2012 - 37th International Symposium on Symbolic and Algebraic Computation*, pages 99–106, Grenoble, France, July 2012.

[98] Nicolas Brisebarre, Milos Ercegovac, and Jean-Michel Muller. (M,p,k)-friendly points: a table-based method for trigonometric function evaluation. In *2012 IEEE 23rd International Conference on Application-Specific Systems, Architectures and Processors*, pages pages 46–52, ISBN: 978–1–4673–2243–0, Delft, Netherlands, July 2012. IEEE Computer Society.

[99] Nicolas Brisebarre, Mioara Joldes, Érik Martin-Dorel, Micaela Mayero, Jean-Michel Muller, Ioana Pasca, Laurence Rideau, and Laurent Théry. Rigorous Polynomial Approximation using Taylor Models in Coq. In Alwyn Goodloe and Suzette Person, editors, *Fourth NASA Formal Methods Symposium*, Lecture Notes in Computer Science, page 15, Norfolk, Virginia, United States, April 2012. Springer.

[100] Nicolas Brunie, Sylvain Collange, and Gregory Diamos. Simultaneous Branch and Warp Interweaving for Sustained GPU Performance. In *39th Annual International Symposium on Computer Architecture (ISCA)*, pages 49 – 60, Portland, OR, United States, June 2012.

[101] Nicolas Brunie, Florent De Dinechin, and Benoît De Dinechin. Mixed-precision Fused Multiply and Add. In *45th Asilomar Conference on Signals, Systems & Computers*, pages 165–169, United States, March 2012.

[102] Sébastien Canard, Georg Fuchsbauer, Aline Gouget, and Fabien Laguillaumie. Plaintext-Checkable Encryption. In Orr Dunkelman, editor, *CT-RSA 2012*, volume 7178 of *Lecture Notes in Computer Science*, pages 332–348, San Francisco, United States, 2012.

[103] Florent De Dinechin and Laurent-Stéphane Didier. Table-based division by small integer constants. In *Applied Reconfigurable Computing*, pages 53–63, Hong Kong, Hong Kong, March 2012.

[104] Eric Dutisseuil, Jean-Marc Tanguy, Adrian Voicila, Rémi Laube, Francois Bore, Honore Takeugming, Florent De Dinechin, Frederic Cerou, and And Gabriel Charlet. 34 Gb/s PDM-QPSK coherent receiver using SiGe ADCs and a single FPGA for digital signal processing. In *Optical Fiber Communication Conference*, page OM3H.7, United States, March 2012.

[105] Javier Herranz, Fabien Laguillaumie, Benoît Libert, and Carla Ràfols. Short Attribute-Based Signatures for Threshold Predicates. In *RSA Conference 2012*, volume 7178 of *Lecture Notes in Computer Science*, pages 51–67, San Francisco, United States, 2012. Springer.

[106] Claude-Pierre Jeannerod and Jingyan Jourdan-Lu. Simultaneous floating-point sine and cosine for VLIW integer processors. In *23rd IEEE International Conference on Application-specific Systems, Architectures and Processors (ASAP 2012)*, pages 69–76, Delft, Netherlands, February 2012.

[107] Claude-Pierre Jeannerod, Jingyan Jourdan-Lu, and Christophe Monat. Non-generic floating-point software support for embedded media processing. In *7th IEEE International Symposium on Industrial Embedded Systems (SIES'12)*, Karlsruhe, Germany, 2012.

[108] Fabien Laguillaumie and Guilhem Castagnos. Homomorphic Encryption for Multiplications and Pairing Evaluation. In Ivan Visconti and Roberto De Prisco, editors, *Security and Cryptography for Networks - 8th International Conference, SCN 2012*, Amalfi, Italy, 2012.

[109] Marc Mezzarobba. A Note on the Space Complexity of Fast D-Finite Function Evaluation. In V.P. Gerdt, W. Koepf, E.W. Mayr, and E.V. Vorozhtsov, editors, *CASC - Computer Algebra in Scientific Computing*, volume 7442 of *Lecture Notes in Computer Science*, pages 212–223, Maribor, Slovenia, 2012. Springer.

2013

[110] Rishiraj Bhattacharyya and Arnab Roy. Secure Message Authentication against Related Key Attack. In *Fast Software Encryption*, pages 245–262, Singapore, 2013.

[111] Alin Bostan, Pierre Lairez, and Bruno Salvy. Creative telescoping for rational functions using the Griffiths-Dwork method. In *ISSAC'13 - 38th International Symposium on Symbolic and Algebraic Computation*, pages 93–100, Boston, United States, 2013. Northeastern University, Boston, Massachusetts, USA.

[112] Zvika Brakerski, Adeline Langlois, Chris Peikert, Oded Regev, and Damien Stehlé. Classical Hardness of Learning with Errors. In *Proceedings of STOC*, pages 575–584, United States, 2013.

[113] Nicolas Brisebarre, Marc Mezzarobba, Jean-Michel Muller, and Christoph Lauter. Comparison between binary64 and decimal64 floating-point numbers. In Alberto Nannarelli, Peter-Michael Seidel, and Ping Tak Peter Tang, editors, *21st IEEE Symposium on Computer Arithmetic*, page 8, Austin, TX, United States, April 2013. IEEE Computer Society.

[114] Nicolas Brunie, Florent De Dinechin, Matei Istoan, Guillaume Sergent, Kinga Illyes, and Bogdan Popa. Arithmetic core generation using bit heaps. In *23rd International Conference on Field Programmable Logic and Applications*, pages 1–8, Porto, Portugal, September 2013.

[115] Jingwei Chen, Damien Stehlé, and Gilles Villard. A New View on HJLS and PSLQ: Sums and Projections of Lattices. In *Proceedings of ISSAC*, pages 149–156, United States, 2013.

[116] Sylvain Chevillard and Marc Mezzarobba. Multiple precision evaluation of the Airy Ai function with reduced cancellation. In Alberto Nannarelli, Peter-Michael Seidel, and Ping Tak Peter Tang, editors, *21st IEEE Symposium on Computer Arithmetic*, pages 175–182, Austin, TX, United States, 2013.

[117] Florent De Dinechin, Matei Istoan, and Guillaume Sergent. Fixed-Point Trigonometric Functions on FPGAs. In *Fourth International Symposium on Highly-Efficient Accelerators and Reconfigurable Technologies*, pages 1–6, Edimburgh, United Kingdom, June 2013.

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6.2 AVALON: Algorithms and Software Architectures for Distributed and HPC Platforms

6.2.1 Team composition

Current members – 2014, July 1st

Permanent members

Christian Perez (Team leader, Inria, Senior Researcher) [Habilite]
Frédéric Desprez (Inria, Senior Researcher) [Habilite]
Gilles Fedak (Inria, Researcher)
Laurent Lefèvre (Inria, Researcher) [Habilite]
Frédéric Suter (CNRS, Researcher)
Eddy Caron (ENS Lyon, Associate Professor) [Habilite]
Jean-Patrick Gelas (Univ. Lyon I, Associate Professor)
Olivier Glück (Univ. Lyon I, Associate Professor)
Simon Delamare (CNRS)
Matthieu Imbert (Inria)
Jean-Christophe Mignot (CNRS)
Evelyne Blesle (Inria)

PostDocs / Temporary Researcher / ATER

Marcos Dias de Asuncao (Inria)
Gael LeMahec (Univ. Lyon I)
Jonathan Rouzaud-Cornabas (Inria)
Ghislain Landry Tsafack Chetsa (Univ. Lyon I)

PhD Students

Daniel Balouek (NewGeneration SR)
Maurice-Djibril Faye (Univ. Gaston Berger, St Louis, Sénégal/ENSL)
Sylvain Gault (Inria)
Vincent Lanore (ENS Lyon)
Arnaud Lefray (ENSI de Bourges)
Anthony Simonet (Inria)
Violaine Villebonnet (Inria)

Engineers

Sylvain Bernard (ENS Lyon, granted by ANR CloudPower)
François Rossigneux (Inria, granted by XLcloud project)
Guillaume Verger (Inria, granted by SEED4C project)
Huaxi Zhang (Inria, granted by SEED4C project)
Abderhaman Cheniour (CNRS, supported by E-Biothon)
Marc Pinhède (Inria, supported by Grid'5000)
Laurent Pouilloux (Inria, supported by Hemera Large Scale Initiative)

Former members

Professor

Yves Caniou (Univ. Lyon I, Associate Professor)

PostDocs

Julien Bigot (Inria, granted by ANR MapReduce)
Laurent Bobelin (Post-doc at INSA CVL)
Simon Delamare (Inria, granted by EDGI project)
Marcos Dias de Asuncao (Postdoc on Inria ARC Green-Net and IEEE PrimeEnergyIT european project)
Zhengxiong Hou (Inria, granted by PRACE 2IP project)
Luis Rodero-Merino (Inria)
Bing Tang (Inria, granted by Cloud@Home project)

Lamiel Toch (Inria, granted by SEED4C project)

ATER

Hinde Bouziane (ENSL)

PhD Students

Julien Bigot (Inria)
Raphaël Bolze (ENS-AFM)
Ghislain Charrier (Inria)
Benjamin Depardon (MENRT)
Mohammed El Mehdi Diouri (MENRT)
Jean-Sébastien Gay (Regional grant)
Cristian Klein (INRIA)
Georgios Markomanolis (Inria)
Adrian Muresan (MENRT)
Anne-Cécile Orgerie (MENRT)
Vincent Pichon (CIFRE EDF R&D)

Engineers

Nicolas Bard (CNRS, granted by E-Biothon project)
Laurent Bobelin (Inria, granted by ANR USS-SimGrid)
Amine Bsila (SysFera, provisional assignment)
Julien Carpentier (Inria, granted by XLcloud project)
Florent Chuffart (Inria, granted by ANR SPADES)
José Francisco Saray Villamizar (Inria)
Haiwu He (ENS Lyon, granted by ANR CloudPower)
Benjamin Isnard (Inria, granted by ANR Gwendia)
David Loureiro (Inria Transfer and inovation Engineer. Inria)
Noua Toukourou (Inria, granted by PRACE 2IP)
Daouda Traore (Inria, granted by ANR SPADES)
Gael LeMahec (Inria)
Vincent Pichon (Inria)
Benjamin Depardon (Inria, granted by EDF collaboration)
Daniel Balouek (Inria, granted by Hemera)
Abderhaman Cheniour (Inria, granted by Autonomic Internet)
Maxime Morel (Inria)

Visitors

Jose Luis Lucas (Univ. Computense of Madrid)
Julio Anjos (Universidade Federal do Rio Grande do Sul (Brazil))
Lu Lu (Huazong University of Science and Technology (China))
Mircea Moca (Babeş-Bolyai University of Cluj-Napoca)
Matei Ripeanu Associate Professor (University of British Columbia (Canada))
Hidemoto Nakada (AIST Japan)
Franck Petit (University of Picardie Jules Verne, Amiens)
Manuel F. Dolz (Depto. de Ingeniería y Ciencia de Computadores, Universitat Jaume I, (Spain))
Alejandro Fernandez (University of Sevilla (Spain))
Takayuki Imada (University of Tsukuba (Japan))
Thomas Treutner (University of Vienna (Austria))

6.2.2 Life of the team

Scientific meetings

Once per week, there is a team meeting. The content of this meeting can be either scientific presentations from team members or from invited people, or a tour de table. In this latter case, each member of the team gives an overview of what she has done recently, what she is doing, and what are the news she wants to share with the team. It proves to be a very efficient tool to gather and disseminate information in a large team.

All meeting notes are accessible to team members through private pages of the Graal and then Avalon web sites.

Moreover, many of the members of the team are having lunch altogether. Daily coffee breaks are also a very living and useful place to integrate new members and to have open discussions.

Budget Analysis

From 2009 to 2014, we globally had a significant budget from our participation to projects (cf Section 7.2). Contacts are handled mainly by Inria, CNRS, and ENSL. Most of this budget enables us to hire PhD students, post-docs, and engineers. Second, it also enables us to participate to conferences that is very valuable for PhD students.

Moreover, as we are very involved in GRID'5000, some years the team hosted exceptional budget for buying clusters for GRID'5000, in Lyon, and in Nantes. We are also hosting some engineers for national initiative such as GRID'5000 and Hemera.

The main drawback of this budget made of projects is that it is quite time consuming to answer to project calls and then to manage projects.

Engineer Involvement

Many engineers have been part of the team during the evaluation period. They have mainly been funded though contracts. Engineers work usually in close relationship with researchers, as they have mainly contribute to software coming from research (DIET, BitDew, SBAM, etc.) or to support users in making experiments with complex platform (GRID'5000, E-Biothon, etc.). The contribution of engineers to maturing software help us a lot in creating the SysFera spin-off. Moreover, thanks to engineers, we are investigating the possibility of creating a new one in the ANR CloudPower project.

6.2.3 International collaborations resulting in joint publications

During the past years, we developed the following collaboration on Desktop Grid and large scale data management topics : with UBC (Vancouver, Canada) on large scale storage and data management, with HUST (Wuhan, China) on MapReduce for Desktop Grid Computing, with ANL and UC (Chicago, US) on data surveillance, with Univ. Coimbra (Portugal) on error detection with Desktop Grid, with SZTAKI (Budapest, Hungary) on Grid $\leftrightarrow$ Desktop Grid bridge, with Cardiff University (UK) on data distribution network.

We developed some international collaborations linked with our research activities on energy efficiency with : University of Vienna (Austria) on potential security risks associated with energy reporting [324], University Jaume1 (Spain) on demystifying energy monitoring and profiling in distributed systems [258, 369], University of Sevilla of Energy efficient scheduling [248] and on new architectures for statefull firewalls [246], University of Tsukuba on energy efficient virtualized servers, Addis Abeba University (Ethiopia) on clustering virtual home gateways for large scale energy reduction [350], University of Illinois at Urbana-Champaign on energy consumption of fault-tolerence protocols [349, 372, 371].

We also have tight links with the University of Hawai'i at Manoa on parallel task graph scheduling [228, 237, 292] and simulation of MPI application [319, 368, 255, 256].

6.2.4 Management of research projects and contracts

The team has managed 12 projects: 1 regional project, 1 CNRS PICS, 1 Inria ARC, 2 Inria ADT, 1 Inria large scale initiative, 4 French ANR, 1 French GIS, and 1 ERCIM working group.

Regional Projet "Calcul Hautes Performances et Informatique Distribuée", 2008-2011. E. Caron leads (with C. Prudhomme from LJK, Grenoble) the "Calcul Hautes Performances et Informatique Distribuée" project of the cluster "Informatique, Signal, Logiciels Embarqués". Together with several research laboratories from the Rhône-Alpes region, we initiate collaborations between application researchers and distributed computing experts

PICS CNRS DimSim: Dimensioning Through Simulation, 2010-2012. More and more sciences rely on computing infrastructures to produce scientific results from large amounts of data. Then Data- and Computing-Centers constantly have to upgrade their resources to keep pace with the increasing demands. The common practice is to rely on the expertise of system administrators and/or users to take empirical decisions about what should be the next upgrade. A sound alternative is to resort to simulation to obtain objective indicators on candidate solutions. In this collaborative project with the University of Hawai'i at Manoa, we focus on parallel MPI applications as a representative workload. We aim at evaluating, comparing, solidying, and integrating within a single framework two complementary approaches: Off-line simulation, in which a trace of an instrumented execution is then replayed in a simulation context. We proposed and developed a Time-Independent Trace Replay Framework that follows this approach; and On-line simulation, in which the actual execution is executed while parts of it are intercepted and simulated. We proposed and develop the SMPI simulator that allows the user to simulate the execution of unmodified MPI applications on a single node. Both developments have been integrated with the SimGrid toolkit. This project is led by Frédéric Suter.

Inria ARC Green-Net, 2008-2010 The ARC (Action de Recherche Cooperative Inria) "GREEN-NET : Power aware software frameworks for high performance data transport and computing in large scale distributed systems" explored the design of energy-aware software frameworks dedicated to large scale distributed systems. These frameworks collect energy usage information and provide them to resources managers and schedulers. Large scale experimental deployment on Grid5000 and DSLLAB platforms have been validated. The project was leaded by Laurent Lefevre and included Inria Mescal team (Grenoble), IRIT Lab. (Toulouse) and Virginia Tech. (USA).

Inria ADT BitDew, 2010-2012. ADT BitDew is an INRIA support action of technological development for the BitDew middleware. Objectives are several fold : i/ provide documentation and education material for end-users, ii/ improve software quality and support, iii/ develop new features allowing the management of Cloud and Grid resources. The ADT BitDew, leaded by G. Fedak, allows to recruit a young engineer for 24 months.

Inria ADT Aladdin, 6 years, 2008-2014. ADT ALADDIN is an Inria support action of technological development which supports the GRID'5000 instrument. Frédéric Desprez is leading this action (with David Margery from Rennes as the Technical Director).

GIS GRID'5000, 4 years, 2012-2016. GRID'5000 is now managed through a GIS [2] leaded by F. Desprez and signed in May 2012. Its role is to allow GRID'5000 to handle new issues of large distributed systems and platforms and to ensure the persistency of the infrastructure.

Its partners are CDEFI (Conférence des Directeurs des Ecoles Françaises d'Ingénieurs), Commissariat à l'énergie atomique et aux énergies alternatives (CEA), Centre national de la recherche scientifique (CNRS), Conférence des Présidents d'Université (CPU), Inria, institut Mines-Telecom, and Renater.

Inria Large Scale Initiative HEMERA, 2010-2014. The goal of HEMERA[3] is to demonstrate ambitious up-scaling techniques for large scale distributed computing by carrying out several dimensioning experiments on the GRID'5000 infrastructure, to animate the scientific community around GRID'5000, and to enlarge the GRID'5000 community by helping newcomers to make use of GRID'5000. It aims at making progress in the understanding and management of large scale infrastructure by leveraging competences distributed in various French teams. Hemera addresses several scientific challenges and supports some working groups. The project involves around 24 teams located in all around France.

Christian Pérez is leading the project. Avalon participates to various challenges that cover almost all the research topics addressed by Avalon.

ANR EMERGENCE CloudPower: a Cloud Service Providing High Performance Computing to SMEs. HPC is a key factor in knowledge and innovation in many fields of industry and service, with high economic and social issues: aerospace, finance and business intelligence, energy and environment, chemicals and materials, medicine and biology , digital art and games, Web and social networks, ... Today, acquiring HPC supercomputer is very expensive, making HPC unreachable to SMIs / SMEs for their research and development. The CloudPower project The goal of CloudPower is to offer a low cost Cloud HPC service for small and medium-sized innovative companies. With CloudPower, companies and scientists will run their simulations to design and develop new products on a powerful, scalable, economical, reliable and secure infrastructure.

The project[4] will lead the creation of a new and innovative company operating the platform implemented in the framework of the ANR Emergence. CloudPower will leverage on the open-source software XtremWeb-HEP previously developed by the CNRS and INRIA.

Avalon is the leader of the project. Building on the network of SMIs from the competitiveness clusters System@tic and LyonBiopole, Avalon will implement scenarios and/or demonstrators which illustrate the ability of CloudPower to increase competitiveness, research and marketing of innovative SMEs.

ANR LEGO: League for Efficient Grid Operation, CICG-05-11, 2006-2009. The aim of this project is to provide algorithmic and software solutions for large scale architectures; our focus is on performance issues. The software component provides a flexible programming model where resource management issues and performance optimizations are handled by the implementation. On the other hand, current component technology does not provide adequate data management facilities, needed for large data in widely distributed platforms, and does not deal efficiently with dynamic behaviors. We choose three applications: ocean-atmosphere numerical simulation, cosmological simulation, and sparse matrix solver. We propose to study the following topics: Parallel software component programming; Data sharing model; Network-based data migration solution; Co-scheduling of CPU, data movement and I/O bandwidth; High- perf. network support. The GRID'5000 platform provides the ideal environment for testing and validation of our approaches. E. Caron is leading the project, which comprises six teams: GRAAL/LIP (Lyon), PARIS/IRISA (Rennes), RUNTIME/LaBRI (Bordeaux), ENSEEIHT/IRIT (Toulouse), CERFACS (Toulouse) and CRAL/ENS-Lyon (Lyon). The project has ended in June 2009.

[2] Groupement d'Intérêt Scientifique
[3] `https://grid5000.fr/Hemera`
[4] `http://www.iexec.fr`

ANR COSINUS COOP: Multi Level Cooperative Resource Management, ANR-09-COSI-001-01, 2009-2013. The main goals of COOP[5] are to set up such a cooperation as general as possible with respect to programming models and resource management systems and to develop algorithms for efficient resource selection. In particular, the project targets the SALOME platform and GRID-TLSE expert-site (http://gridtlse. org/) as an example of programming models, and Marcel/PadicoTM, DIET and XtreemOS as examples of multithread scheduler/communication manager, grid middleware and distributed operating systems. The project is led by Christian Pérez.

ANR ARPEGE SPADES: Servicing Petascale Architectures and DistributEd System, 2009-2012. Today's emergence of Petascale architectures and evolutions of both research grids and computational grids increase a lot the number of potential resources. However, existing infrastructures and access rules do not allow to fully take advantage of these resources. One key idea of the SPADES project[6] is to propose a non-intrusive but highly dynamic environment able to take advantage of the available resources without disturbing their native use. In other words, the SPADES vision is to adapt the desktop grid paradigm by replacing users at the edge of the Internet by volatile resources. These volatile resources are in fact submitted via batch schedulers to reservation mechanisms which are limited in time or susceptible to preemption (best-effort mode). One of the priorities of SPADES is to support platforms at a very large scale. Petascale environments are therefore particularly considered. Nevertheless, these next-generation architectures still suffer from a lack of expertise for an accurate and relevant use. One of the SPADES goal is to show how to take advantage of the power of such architectures. Another challenge of SPADES is to provide a software solution for a service discovery system able to face a highly dynamic platform. This system will be deployed over volatile nodes and thus must tolerate failures. SPADES will propose solutions for the management of distributed schedulers in Desktop Computing environments, coping with a co-scheduling framework. The project is led by Eddy Caron.

ERCIM Working Group CoreGrid, 2009-2012. Following the success of the network of excellence CoreGRID, an ERCIM WG was started in 2009, leaded by F. Desprez. This working group gathers 31 research teams from all over Europe working on Grids, service oriented architectures and Clouds.

6.2.5 Participation in research projects and contracts

We have participated to 29 projects: 5 international collaborations, 1 international industrial project, 8 European projects, 1 CHIST-ERA, 3 COST, 1 CETIC+, 1 FUI, 1 FSN, 6 ANR, 1 Inria large scale initiative, and 1 CNRS/Inria project.

OGF-Europe European Project (SSA), 2008-2010. We have participated in the OGF-Europe to reinforce the french participation to OGF standardization activities. We mainly concentrate our contribution on Telco interaction and Energy-efficiency in Grid context.

CNRS-USA grant SchedLife, University of Hawai'i (2007-2009). We have been awarded a CNRS grant in the framework of the CNRS/USA funding scheme, which runs for three years starting in 2007. The collaboration is done with the Concurrency Research Group (CoRG) of Henri Casanova, and the Bioinformatics Laboratory (BiL) of Guylaine Poisson of the Information and Computer Sciences Department, of the University of Hawai'i at Mano'a, USA.

Japanese-French REDIMPS: Research and Development of International Matrix Prediction System, 2007-2009. REDIMPS[7] (Research and Development of International Matrix Prediction System) is a project funded by the Strategic Japanese-French Cooperative Program on "Information and Communications Technology including Computer Science" with the CNRS and the JST. The goal of this international collaboration is building an international sparse linear equation solver expert site. Among the objectives of the project, one resides in the cooperation of the TLSE partners and the JAEA in the testing, the validation and the promotion of the TLSE system that is currently released. JAEA, who is one of the leading institute and organization of Japanese HPC, is studying high-performance numerical simulation methods on novel supercomputers, and is expecting to find the best linear solver within this collaboration. By integrating knowledge and technology of JAEA and TLSE partners, it is expected that we will achieve the construction

Inria-UIUC-NCSA Joint Laboratory for Petascale Computing. The Joint Laboratory for Petascale Computing[8] focuses on software challenges found in complex high-performance computers. The Joint Laboratory is based at the University of Illinois at Urbana-Champaign and it includes researchers from Inria, Illinois' Center for Extreme-Scale Computation, and the National Center for Supercomputing Applications. Much of the Joint Laboratory's work will focus on algorithms and software that will run on Blue Waters and other petascale computers.

Avalon is working on energy consumption of fault tolerant algorithms, large scale data management, and parallel programming models.

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[5] urlhttp://coop.gforge.inria.fr/
[6] `http://graal.ens-lyon.fr/SPADES`
[7] `http://redimps.org/`
[8] `http://jointlab.ncsa.illinois.edu`

GreenTouch, 2012-2015. GreenTouch[9] is a consortium of leading Information and Communications Technology (ICT) industry, academic and non-governmental research experts dedicated to fundamentally transforming communications and data networks, including the Internet, and significantly reducing the carbon footprint of ICT devices, platforms and networks.

Avalon is involved in this consortium and participates in several projects concerning the consolidation of services in virtualized environments in order to reduce energy consumption of networked equipments at large scale. As an example, Avalon collaborates with Bells Labs on the scalability issues of large scale virtualization of virtual home gateways services.

Intelligent Energy Europe PrimeEnergyIT project: Efficient DataCenters, 2010-2012. The fast development of IT services and IT performance in many areas of the public and private service sector (e.g. administration, health services, entertainment etc.). has led to a rapid increase of energy consumption and energy costs for central IT equipment. A broad implementation of energy efficient technology in the EU however would allow a reduction of energy demand of about 60% compared to the business as usual scenario. Energy efficient technology is available but needs to be broadly implemented in the demand side market. To exploit the enormous saving potentials concerted action is needed across the EU member states. The PrimeEnergyIT[10] project deals with the development and implementation of hardware and service based energy efficiency criteria as major tools to support IT and infrastructure managers in the selection and management of IT hardware and cooling equipment; the demonstration and evaluation of energy efficient IT solutions in best practice; Education and training of IT managers and experts to support energy efficient procurement and management and Implementation of energy efficiency criteria for central IT equipment and cooling in public procurement. Inria has been mainly involved in energy efficiency criteria in the context of storage for small and medium datacenters.

FP7 AuToI: Autonomic Internet, 2008-2010. Autonomic Internet[11] (AutoI - FP7.ICT.2007.Call1-216404 - 2008-2010) project suggests a transition from a service agnostic Internet to service-aware network, managing resources by applying autonomic principles. In order to achieve the objective of service-aware resources and to overcome the ossification of the current Internet AutoI will develop a self-managing virtual resource overlay that can span across heterogeneous networks that can support service mobility, security, quality of service and reliability. In this overlay network, multiple virtual networks co-exist on top of a shared substrate with uniform control. The overlay will be self-managed based on the system's business goals, which drive the service specifications, the subsequent changes in these goals (service context) and changes in the resource environment (resource context). This will be realized by the successful co-operation of the following activities: autonomic control principles, resource virtualization, enhanced control algorithms, information modeling, policy based management and programmability. Wa have been mainly involved in the programmability of the AUTOI overlay by proposing an Autonomic Network Programming Interface which will support large scale service deployment. Laurent Lefèvre was leader of of the workpackage 5 on "Service Deployment".

FP7 EDGeS: Enabling Desktop Grids for e-Science, 2008-2010. This project is lead by P. Kacsuk, and involves the following partners : SZTAKI, INRIA, CIEMAT, Fundecyt, University of Westminster, Cardiff University, University of Coimbra. Grid systems are currently being used and adopted by a growing number of user groups and diverse application domains. However, there still exist many scientific communities whose applications require much more computing resources than existing Grids like EGEE can provide. The main objective of this project is to interconnect the existing EGEE Grid infrastructure with existing Desktop Grid (DG) systems like BOINC or X TREM W EB in a strong partnership with EGEE. The interconnection of these two types of Grid systems will enable more advanced applications and provide extended compute capabilities to more researchers. In this collaboration G. Fedak represents the GRAAL team and is responsible for JRA1: Service Grids-Desktop Grids Bridges Technologies and is involved in JRA3 : Data Management, as well as NA3 : Standardization within the OGF group.

FP7 EDGI: European Desktop Grid Initiative, 2010-2012. The project EDGI[12] will develop middleware that consolidates the results achieved in the EDGeS project concerning the extension of Service Grids with Desktop Grids in order to support EGI and NGI user communities that are heavy users of DCIs and require extremely large number of CPUs and cores. EDGI will go beyond existing DCIs that are typically cluster Grids and supercomputer Grids, and will extend them with public and institutional Desktop Grids and Clouds. EDGI will integrate software components of ARC, gLite, Unicore, BOINC, XWHEP, 3G Bridge, and Cloud middleware such as OpenNebula and Eucalyptus into SG=>DG=>Cloud platforms for service provision and as a result EDGI will extend ARC, gLite and Unicore Grids with volunteer and institutional DG systems. Our partners in EDGI are : SZTAKI, INRIA, CIEMAT, Fundecyt, University of Westminster, Cardiff University, University of Coimbra. In this project, G. Fedak is the INRIA representative and lead the JRA2 work package which is responsible for providing QoS to Desktop Grids.

[9] http://greentouch.org
[10] http://www.efficient-datacenter.eu/
[11] http://ist-autoi.eu
[12] http://edgi-project.eu/

FP7 IP BonFire: Building service testbeds on FIRE BonFIRE, 2010-2013. BonFIRE[13] will design, build and operate a multi-site Cloud prototype FIRE facility to sup- port research across applications, services and systems at all stages of the R&D lifecycle, targeting the services research community on Future Internet. The BonFIRE vision is to give researchers in these areas access to a facility that supports large scale multi- disciplinary experimentation of their systems and applications addressing all aspects of research across all layers. We will develop and support a framework which allows service-based computing practitioners to experiment with their latest ideas in service orientation and distributed computing. We have elaborated 3 usage scenarios. Our overall goal is to encourage new communities of experimenters to take advantage of the opportunities offered by the FIRE infrastructure to guide the development of the Future Internet from a service-based applications standpoint. The facility will be demand-driven, open, standards-based and dynamic. It will provide additional functionality to that currently available. It will adopt the principle of "open coordinated federation of testbeds" and will provide innovative usage scenarios. We will stimulate research through 2 open calls to establish a methodology of experimentally driven research. The facility shall be open not only to the researchers selected and funded by BonFIRE through the open calls but also to a wider researcher community in order to encourage the usage and involvement of a significant number of end users.

FP7 PRACE: Second Implementation Phase Project, 2011-2014. The purpose of the PRACE RI[14] is to provide a sustainable high-quality infrastructure for Europe that can meet the most demanding needs of European HPC user communities through the provision of user access to the most powerful HPC systems available worldwide at any given time. In tandem with access to Tier-0 systems, the PRACE-2IP project will foster the coordination between national HPC resources (Tier-1 systems) to best meet the needs of the European HPC user community. To ensure that European scientific and engineering communities have access to leading edge supercomputers in the future, the PRACE-2IP project evaluates novel architectures, technologies, systems, and software. Optimizing and scaling of application for Tier-0 and Tier-1 systems is a core service of PRACE.

Avalon participates to Work Package 12 which is about novel programming techniques. Avalon validates its component models (L2C, HLCM) for HPC applications on supercomputers such as Curie.

FP7 PaaSage: Model-based Cloud Platform Upperware, 2012-2016. PaaSage[15] will deliver an open and integrated platform, to support both deployment and design of cloud applications, together with an accompanying methodology that allows model-based development, configuration, optimization, and deployment of existing and new applications independently of the existing underlying cloud infrastructures. Specifically it will deliver an IDE (Integrated Development Environment) incorporating modules for design time and execution time optimizations of applications specified in the CLOUD Modeling Language (CloudML), execution-level mappers and interfaces, and a metadata database.

Avalon aims at proposing mapping algorithms for deploying (and adapting) an application on multi cloud systems with respect to user constraints. Avalon is using in particular SimGrid to validate solutions.

EuroNF JRA.S.1.44 project SPEC, 2010-2012. We have participated to the SPEC on "Security and Privacy Concerns in Energy Efficient Computing". To design highly energy efficient systems is one of the most important design goals which are under investigation currently. The underlying motifs to design such systems are economical as well as environmental in nature. However, it has been identified that while focusing solely on energy efficiency mechanisms, the other design parameters must also be considered to achieve a well balanced system. Security and privacy aspects are among those very important parameters. This SJRP focuses on the security and privacy aspects involved in the application of modern energy efficiency mechanisms. We focus on two of the key technologies including virtualization for energy efficiency and smart metering. In first part of the project, we investigate the security issues within virtualized environments for energy efficiency while the second part focus on the end user privacy concerns when monitoring physical resources in clouds.

CHIST-ERA STAR: SwiTching And tRansmission project, 2013-2015. The Internet power consumption has continued to increase over the last decade as a result of a bandwidth growth of at least 50 to 100 times. Further bandwidth growth between 40% and 300% is predicted in the next 3 years as a result of the growing popularity of bandwidth intensive applications. Energy efficiency is therefore increasingly becoming a key priority for ICT organizations given the obvious ecological and economic drivers. In this project we adopt the GreenTouch energy saving target of a factor of a 100 for Core Switching and Routing and believe this ambitious target is achievable should the research in this proposal prove successful. A key observation in core networks is that most of the power is consumed in the IP layer while optical transmission and optical switching are power efficient in comparison, hence the inspiration for this project. Initial studies by the applicants show that physical topology choices in networks have the potential to significantly reduce the power consumption, however network optimization and the consideration of traffic and the opportunities afforded by large, low

[13]`http://www.bonfire-project.eu`
[14]`http://prace-ri.eu`
[15]`http://paasage.eu`

power photonic switch architectures will lead to further power savings. Networks are typically over provisioned at present to maintain quality of service. We will study optimum resource allocation to reduce the over-provisioning factor while maintaining the quality of service. Protection is currently provided in networks through the allocation of redundant paths and resources, and for full protection there is a protection route for every working route.

Avalon is contributing to STAR[16] in terms of software network protocols and services optimizations which will be combined with more efficient photonic switches in order to obtain a factor of 100 power saving in core networks can be realized through this project with significant potential for resulting impact on how core photonic networks are designed and implemented.

European COST IC804: Energy efficiency in Large Scale Distributed Systems, 2009-2013. The COST Action IC0804[17] proposes realistic energy-efficient alternate solutions to share IT distributed resources. As large scale distributed systems gather and share more and more computing nodes and Storage resources, their energy consumption is exponentially increasing. While much effort is nowadays put into hardware specific solutions to lower energy consumptions, the need for a complementary approach is necessary at the distributed system level, i.e. middleware, network and applications. This Action characterizes the energy consumption and energy efficiencies of distributed applications. Then based on the current hardware adaptation possibilities and innovative algorithms it proposes adaptive and alternative approaches taking into account the energy saving dimension of the problem. This Action also characterizes the trade-off between energy savings and functional and non-functional parameters, including the economic dimension. Deliverables includes workshop proceedings, books, good practice leaflets fostering consciousness rise at ICT researchers, scientists, managers and users levels. Finally, benefits addresses scientific and societal needs.

European COST IC805: Open Network for High Performance Computing onComplex Environments, 2009-2013. In different fields of science and engineering it is necessary to solve complex and challenging problems with high computational cost. For this purpose, scientists and engineers normally use homogeneous high performance computers. Nowadays, the emergence of heterogeneous computing allows research groups, enterprise and educational institutions to use networks of processors which are already available. On the other hand, high performance computers have become more and more hierarchical and heterogeneous (e.g., a cluster of multiprocessor nodes using multicore processors). These modern hierarchical and heterogeneous computing infrastructures are hard to program and use efficiently, particularly for extreme-scale computing. Consequently, none of the state-of-the-art solutions are able to efficiently use such environments. The The COST Action IC0805[18] established a European research network focused on high performance heterogeneous computing in order to address the whole range of challenges posed by these new platforms including models, algorithms, programming tools and applications.

European COST IC1305: Network for Sustainable Ultrascale Computing, 2014-2018. In the COST Action IC1305[19], Ultrascale systems are envisioned as large-scale complex systems joining parallel and distributed computing systems that will be two to three orders of magnitude larger that today's systems. The goal of the NESUS Action is to establish an open European research network targeting sustainable solutions for ultrascale computing aiming at cross fertilization among HPC, large scale distributed systems, and big data management. The network will contribute to glue disparate researchers working across different areas and provide a meeting ground for researchers in these separate areas to exchange ideas, to identify synergies, and to pursue common activities in research topics such as sustainable software solutions (applications and system software stack), data management, energy efficiency, and resilience. Avalon is involved in Energy profiling and efficiency networking of such ultrascale scenario. Laurent Lefevre is Management Committee Substitute and co chair of the Nesus working group on energy efficiency.

SEED4C: Security Embedded Element and Data privacy for the Cloud, 2012-2015. SEED4C[20] is a Celtic-Plus project: an industry-driven European research initiative to define, perform and finance through public and private funding common research projects in the area of telecommunications, new media, future Internet, and applications and services focusing on a new "Smart Connected World" paradigm. Celtic-Plus is a EUREKA ICT cluster and is part of the intergovernmental EUREKA network.

The cloud security challenge not only reflects on the secure running of software on one single machine, but rather on managing and guaranteeing security of a computer group or cluster seen as a single entity. Seed4C focus is to evolve from a cloud security with an isolated point or centralized points of enforcement for security to a cloud security with cooperative points of enforcement for security.

Avalon contributes to design a generic security policy model and associated scheduling algorithms.

[16] `http://www.chistera.eu/projects/star`
[17] `http://www.cost804.org/`
[18] `http://complexhpc.org/`
[19] `http://www.nesus.eu/`
[20] `http://www.celticplus-seed4c.org`

FUI CompatibleOne Project, 2010-2012. The CompatibleOne project[21] (Nov 2010-Nov 2012) funded by the Fonds Unique Interministériel (FUI) is dealing with the building of a cloud architecture open software stack.

CompatibleOne is an open source project with the aim of providing interoperable middleware for the description and federation of heterogeneous clouds comprising resources provisioned by different cloud providers. Services provided by Inria participation (module COEES) should allow to act on the system's core by offering a scenario for the broker using energy constraints. These constraints should allow virtual machines placement and displacement using energy profile. Collected data must be available for CO and other systems for future researches. We took part in the analysis of the specification of the system. Mainly, we are in charge of the energy efficiency module. We also had participation in several modules like COMONS (monitoring module), ACCORDS (brokering module), EZVM (virtualization module) and CONETS (networking module). To make energy measurement, we used hardware probes and we studied software probes too. We evaluated several probes providers like Eaton and Schleifenbauer which provide smart PDU (Power Distribution Unit). We also evaluated IPMI board provided by DELL, our computers manufacturer, and OmegaWatt, a small company which provides custom hardware for energy measurement.

In this project, our work is focused on the design and provisioning of energy aware and energy efficient components in order to include energy aspects in QoS, SLAs and billing in clouds architectures. We lead the task T3.4 on energy management and will participate in activities on virtual machines design and migration.

FSN XLcloud, 2012-2014. Focused on High-Performance Computing, the XLcloud[22] collaborative project sets out to define and demonstrate a cloud platform based on *HPC-as-a-Service*. This is designed for computational intensive workloads, with interactive remote visualization capabilities, thus allowing different users to work on a common platform. XLcloud project's members design, develop and integrate the software elements of a High Performance cloud Computing (HPCC) System.

Expected results of the projects include: Functional and technical specification of the XLcloud platform architecture, open source API of the XLcloud platform, implementation of algorithms for 3D and video streaming display, prototype of the XLcloud platform including the support of on-demand virtual clusters and remote visualization service, use cases for validation, illustrating the performance and suggesting future improvements.

XLcloud aims at overcoming some of the most important challenges of implementing operationally high performance applications in the cloud. The goal is to allow partners of the project to take leadership position in the market, as cloud service providers, or as technology providers. XLcloud relies on a consortium of various partners (BULL (project leader), TSP, Silkan, EISTI, Ateme, Inria, CEA List, OW2, AMG.Lab).

Avalon investigates the issue of energy awareness and energy efficiency in OpenStack cloud based platforms.

ANR MDCA Gwendia: Grid Workflow Efficient Enactment for Data Intensive Applications), ANR-06-MDCA-009, 2007-2010. The objective of the Gwendia project is to design and develop workflow management systems for applications involving large amounts of data. It is a multidisciplinary project involving researchers in computer science (including GRAAL) and in life science (medical imaging and drug discovery). Our work consists in designing algorithms for the management of several workflows in distributed and heterogeneous platforms and to validate them within DIET over the GRID'5000 platform.

ANR ARPEGE USS SimGrid: Ultra Scalable Simulation with SimGrid, 2009-2012. Unlike other sciences such as biology or physics, where experimental protocols are carefully described using standard tools and methodology, in computer science such information are generally poorly described and overlooked. Many works involving distributed application study merely describe the workload and analysis and usually rely on *ad hoc* tools that are not made publicly available. This prevents the reproduction of presented experiments as well as the comparison of new results with those available in the literature. Only widely available and accepted tools and methodology can fill this gap.

The USS-SimGrid[23] project aims at providing such an environment for the simulation of distributed applications and systems. We rely on SimGrid, one of the main grid infrastructure simulator, and extend it so that it fits the needs of the large scale distributed system community. We aim at having a deep methodological reflection allowing users to easily conduct "good" experiments thanks to realistic and scalable simulations as well as associated tools helping to manage simulation campaigns and analysis.

ANR JCJC Clouds@Home: Cloud Computing over Unreliable, Shared Resources, ANR-09-JCJC-0056-01, 2009-2012. Recently, a new vision of cloud computing has emerged where the complexity of an IT infrastructure is completely hidden from its users. At the same time, cloud computing platforms provide massive scalability, 99.999% reliability, and speedy performance at relatively low costs for complex applications and services. This project[24], lead by D. Kondo from INRIA MESCAL investigates the use of cloud computing for large-scale and demanding applications and services over unreliable resources. In particular, we target volunteered resources distributed over the Internet. In this project, G. Fedak leads the Data management task (WP3).

[21] `http://compatibleone.org`
[22] `http://xlcloud.org`
[23] `http://uss-simgrid.gforge.inria.fr`
[24] `http://clouds.gforge.inria.fr/`

ANR ARPEGE MapReduce: Scalable data management for Map-Reduce-based data-intensive applications on cloud and hybrid infrastructures, 2010-2014. MapReduce is a parallel programming paradigm successfully used by large Internet service providers to perform computations on massive amounts of data. After being strongly promoted by Google, it has also been implemented by the open source community through the Hadoop project, maintained by the Apache Foundation and supported by Yahoo! and even by Google itself. This model is currently getting more and more popular as a solution for rapid implementation of distributed data-intensive applications. The key strength of the MapReduce model is its inherently high degree of potential parallelism.

Avalon participates to several work packages of this project[25] which address key issues such as efficient scheduling of several MapReduce applications, integration using components on large infrastructures, security and dependability, and MapReduce for desktop grids.

ANR INFRA SONGS: Simulation Of Next Generation Systems, 2012-2015. The last decade has brought tremendous changes to the characteristics of large scale distributed computing platforms. Large grids processing terabytes of information a day and the peer-to-peer technology have become common even though understanding how to efficiently such platforms still raises many challenges. As demonstrated by the USS SimGrid project, simulation has proved to be a very effective approach for studying such platforms. Although even more challenging, we think the issues raised by petaflop/exaflop computers and emerging cloud infrastructures can be addressed using similar simulation methodology.

The goal of the SONGS[26] project is to extend the applicability of the SimGrid simulation framework from grids and peer-to-peer systems to clouds and HPC systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

Avalon extends SimGrid with respect to cloud and hierarchical data-storage system concerns.

ANR INFRA MOEBUS: Multi-objective scheduling for large scale parallel systems, 2013-2016. The MOEBUS[27] project focuses on the efficient execution of parallel applications submitted by various users and sharing resources in large-scale high-performance computing environments.

We propose to investigate new functionalities to add at low cost in actual large scale schedulers and programming standards, for a better use of the resources according to various objectives and criteria. We also propose to revisit the principles of existing schedulers after studying the main factors impacted by job submissions. Then, we will propose novel efficient algorithms for optimizing the schedule for unconventional objectives like energy consumption and to design provable approximation multi-objective optimization algorithms for some relevant combinations of objectives (performance, fairness, energy consumption, etc.). An important characteristic of the project is its right balance between theoretical analysis and practical implementation. The most promising ideas will lead to integration in reference systems such as SLURM and OAR as well as new features in programming standards implementations such as MPI or OpenMP. We expect MOEBUS results to impact further use of very large scale parallel platforms.

Avalon brings its expertise about resource management systems, workflow scheduling algorithms, and energy profiles of applications and systems.

Inria Large Scale Initiative C2S@Exa, 2013-2017. Computer and Computational Sciences at Exascale[28] (C2S@Exa) is concerned with the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society.

At the current state of the art in technologies and methodologies, a multidisciplinary approach is required to overcome the challenges raised by the development of highly scalable numerical simulation software that can exploit computing platforms offering several hundreds of thousands of cores. Hence, the main objective of the C2S@Exa Inria large-scale initiative is the establishment of a continuum of expertise in the computer science and numerical mathematics domains, by gathering researchers from Inria project-teams whose research and development activities are tightly linked to high performance computing issues in these domains.

Avalon is a core-team member, co-leading Pole 4 on Programming models. Avalon is collaborating with GYSELA[29] developers to improve the application with concepts coming from the component approach.

Action Interfaces Recherche en grille – Grilles de production. Institut des Grilles du CNRS – Action Aladdin INRIA. This action addresses economical issues concerning greenness in scientific and production grids. Different issues are addressed like the confrontation of energy models in place in experimental grids versus the operational realities in production grids, the study of new energy prediction models related to real measures of energy consumption in production grids, and the design of energy aware scheduling heuristics.

[25] `http://mapreduce.inria.fr`
[26] `http://infra-songs.gforge.inria.fr`
[27] `http://moebus.gforge.inria.fr/`
[28] `http://www-sop.inria.fr/c2s_at_exa/`
[29] A code Gyrokinetic Semi-Lagrangian in 5D. `http://gyseladoc.gforge.inria.fr/`

6.2.6 Industrial contracts and collaborations

Collaboration with CapRézo. One goal of the CapRézo company is to provide an original tool to make 2D/3D animation films. This tool is an innovative and distributed numerical platform. This platform is built on software developed by Avalon like DIET. Technologies developed in collaboration between CapRézo and Inria are based on Cloud federation environment. The collaboration, started in 2014, is scheduled for the next 5 years. Two M2 internships and one engineer (G. Verger) are working in relationship of this collaboration.

Collaboration with EDF. Vincent Pichon was supported by an EDF R&D PhD Grant (From April 2009 to November 2012). He worked on improving component models for parallel scientific applications in general, and for SALOME in particular.

FastExpand: Regional Grant. The FastExpand startup asked to take benefit of the knowledge of the GRAAL research team on distributed and middleware systems. The aim of this company is to create games of new generation using a new distributed architecture. E. Caron and F. Desprez participated to this action. In 2011, a distributed prototype that works on burst requests from the MMORPG (Massively Multiplayer Online Role Playing Games) was successfully designed. The required performance has been reached.

Collaboration with NewGeneration-SR. We have a collaboration with the company NewGeneration-SR. The aim of this company is to reduce the energy impact through solutions on each layer of the energy consumption (from the data-center design and the production to usage). NewGeneration-SR improve the life cycle (design, production, recycling) in order to reduce the environmental impact of it. NewGeneration-SR was member of the Nu@ge consortium: one of five national Cloud Computing projects with “emprunts d’avenir” funding. With a CIFRE PhD student (Daniel Balouek), we are developing models to reduce the energy consumption for the benefit of data-center

6.2.7 Software production and contribution to research infrastructures

Software production

The members of Avalon have a long history of software development: DIET is a toolbox for computting on multiple and heterogeneous distributed infrastructures; SimGrid[30] is a versatile simulation toolkit for distributed systems and applications; BITDEW is a software for data management on hybrid infrastructure; KwAPI is a toolbox for energy usage measurements of large scale distributed systems; HLCM is a development framework for component-based programming.

Our objective with these developments are to i) disseminate our research results to the broadest audience by releasing open-source software, ii) conduct large and complex experiments which sometimes require specialized developments and robust software, iii) teach our students good practices about software development and project management, and iv) transfer it to industry.

Mature Software

DIET (Distributed Interactive Engineering Toolbox, `http:///graal.ens-lyon.fr/DIET`) is a middleware designed for high-performance computing in an heterogeneous and distributed environment (workstations, clusters, grids, clouds). By using GridRPC, it eases the usage and composition of services over Internet. The DIET project is focused on the development of a scalable middleware with initial efforts focused on distributing the scheduling problem across a hierarchy of agents.

DIET was started in 2000 and is still actively improved and updated by an open-source community led by the Avalon team and the SysFera company[31]. Current hot topics for DIET are cloud support, data management, workflow management, energy, and security.

DIET is declared at the Agency for the Protection of Programs (APP). DIET is available in many distributions as Debian or Fedora. DIET is an open source software under CeCILL free software license. DIET has been used and is used by academics as research laboratories, Supelec, ENSEEIHT, etc. and some companies as SysFera, IBM, EDF R&D, etc. DIET is composed of more than 200 000 lines in C++ (mainly).

DIET will be used to integrate and validate many results around energy, data management, and mapping and scheduling heuristics.

[30] In collaboration with Algorille and Mescal Inria teams and the University of Hawaiʻi at Manoa (USA).
[31] SysFera (`http://www.sysfera.com`) is a spin off of the GRAAL Inria project team.

SimGrid (`http://simgrid.gforge.inria.fr`) is a toolkit for the simulation of distributed applications in heterogeneous distributed environments. The specific goal of the project is to facilitate research in the area of parallel and distributed large scale systems, such as grids, P2P and HPC systems, and clouds. Its use cases encompass heuristic evaluation, application prototyping or even real application development and tuning. SimGrid has an active user community of more than one hundred members, and is available under a GPLv3 license.

This research and software development project is a joint effort with members of the MESCAL and Algorille project-teams, and the University of Hawai'i at Manoa (USA). It started in 1999, and it has been since supported by the ANR through the USS SimGrid and SONGS projects, and Inria though ODT and ADT funded supports.

SimGrid will be used to integrate application models about energy and data concerns. It will be used to validate mapping and scheduling algorithms.

BitDew (`http://www.bitdew.net`) is an open source middleware implementing a set of distributed services for large scale data management on grids, desktop grids and clouds. BITDEW has the following features: i) data scheduling guided according to user's preference (*e.g.*, data affinity, fault resilience etc.); ii) multi-protocol file transfer including cloud (S3, dropbox) and grid through the SAGA API; iii) MapReduce runtime on large scale network of loosely connected and volatile devices; iv) hybrid storage with configurable storage strategies (*e.g.*, reliability, durability, privacy). Programmers define for every data items distribution and storage criteria, and let the BITDEW runtime environment manage operations of data creation, deletion, movement, replication, and fault-tolerance operation.

BITDEW is open source and it is distributed under the GPLv3 or Cecill license at the user's choice. Ten releases were produced in the last two years, and it has been downloaded approximately 6000 times on the Inria forge. Known users are Université Paris-XI, Université Paris-XIII, University of Florida, Cardiff University and University of Sfax. In terms of support, the development of BitDew is partly funded by the Inria ADT BitDew and by the ANR MapReduce projects. Thanks to this support, we have developed and released the first prototype of the MapReduce programming model for desktop grids on top of BitDew.

BITDEW will be used to perform experimentation and to validate our results around data management such as hybrid storage and large-scale MapReduce processing.

Research Prototypes

ActiveData Active Data is an programming environment to develop *Data Life Cycle* management applications. Description of the Data Life Cycle, i.e the different steps a data pass through such as creation, transfer, archival, deletion, is based on a formalism inspired by Petri Nets. The Active Data programming model allows the programmer to write code that will be executed whenever the new step is reached in the Data Life Cycle. The runtime environment allows to manipulate Data Life Cycle, even when the data sets are distributed over heterogeneous sets of software and infrastructures.

CooRM-m & CooRM-e CooRM (Cooperative Resource Management) is an architecture, a protocol and a prototype implementation of a resource management system for multi-cluster HPC platforms. Its main purpose is to improve resource selection for moldable applications, malleable and evolving applications. It comes in two flavors:

CooRM-m deals with moldable applications. A high-level description of it can be found here. A more detailed description which includes the pseudo-code of the prototype implementation can be found here.

CooRM-e deals with malleable and evolving applications. It is backwards compatible with CooRMv1, save for a few implementation details. A details description of it, including pseudo-code can be found here.

Software is available at `http://coorm.gforge.inria.fr`.

Sam4C Security-Aware Models for Clouds

The Sam4C software is used to model the different security properties and contexts needed for this application as well as the related assurance properties. For example, it may be defined that a confidentiality property should be set between two components of this application which are running in two different Virtual Machines.

Our framework Security Aware Models for Clouds (Sam4C) has two purposes.

- The first one is, for a client, to model an IaaS application composed of virtual machines, applications, datas and communications and specify the associated security requirements. The whole modelization is contained into a XML file.

- The second one is the scheduling. It takes as inputs application models (XML) and the infrastructure of the cloud (currently in XML) i.e. a hierarchical set of physical machines. The scheduler encapsulates applications into virtual machines when needed and then maps virtual machines onto physical machines. The result of this scheduling is a file with the mapping i.e. a list of (VM, PM) couples.

The scheduler, as a standalone engine, can be used as simulator. But it can be interfaced with a Cloud stack (e.g. OpenStack, OpenNebula) to act as a production scheduler. This inferfacing is achieved by dynamically inferring the infrastructure model from the Cloud database and applying the decision i.e the output mapping list. Furthermore, the security policies (as input) are splitted for local security enforcement on each physical machine.

Software is available at `https://gforge.inria.fr/projects/sam4c/`

Participants: Eddy Caron, Arnaud Lefray, Yulin Zhang

SBAM SBAM initiates a non-intrusive, but highly dynamic environment able to take advantages of available resources without disturbing their native mechanism. SBAM federates multisite resources in order to schedule, submit and compute users' tasks in a transparent way.

SBAM is, firstly, a decentralized grid middleware. It relies on a P2P approach, i.e., a set of agents able to discover resources and schedule computing tasks over a federation of heterogeneous computing platforms (petascale computers, data centers, clouds. . .). SBAM dynamically acquires and releases resources of computing sites according to users' needs and conditions, to federate them into a global constantly growing or shrinking logical platform, referred to as the overlay.

SBAM is the Java implementation of the DLPT (Distributed Lexicographic Placement Table). SBAM proposes 2-abstraction layers in order to support the distributed data structure: the peer-layer and the agent-layer. The peer-layer is the closest to the hardware layer. It relies on the Ibis Portability Layer (IPL) that enables the P2P communication. We instantiate one JVM per machine, also called peer. JVM communicate all together as a P2P fashion using the IPL communication bus. The agent-layer supports the data structure. Each node of the DLPT is instantiated as a SBAM agent. Agents are uniformly distributed over peers and communicate together in a transparent way using a proxy interface. Since we want to guarantee truthfulness of information exchanged between SBAM-agents, the implementation of an efficient mechanism ensuring quality of large scale service discovery is quite challenging. In SBAM, the feature is implemented using synchronous message exchange between agents. Indeed, when a node has to read its neighbor states, it sends a message to each and wait all responses.

Software is available at `http://graal.ens-lyon.fr/SBAM`.

Participants: Eddy Caron, Florent Chuffart and Haiwu He,

ULCMi is an implementation of the ULCM component model defined in the ANR COSINUS LEGO project. It aims at increasing component model abstraction level for high performance computing by combining component, workflow, data sharing and skeletton concepts.

ULCMi embeds an ULCM interpreter and the adequate runtime systems. It currently supports primitive components written in Java, C++, and also OMG CORBA component. With respect to deployment, Java and C++ components are deployed locally and supports multithreading, while CCM components can be deployed remotely thanks to the use of ADAGE. It has been superseded by HLCM.

Participants: Julien Bigot, Hinde Bouziane, Christian Pérez, Vincent Pichon

L2C (`http://hlcm.gforge.inria.fr/l2c:start`) is a Low Level Component model implementation targeting at use-cases where overhead matters such as High-Performance Computing. L2C does not offer network transparency neither language transparency. Instead, L2C lets the user choose between various kinds of interactions between components, some with ultra low overhead and others that support network transport. L2C is extensible as additional interaction kinds can be added quite easily. L2C currently supports C++, FORTRAN 2013, MPI and CORBA interactions. Gluon++(http://hlcm.gforge.inria.fr) is a thin component model layer added on top of Charm++ (`http://charm.cs.uiuc.edu/`). It defines chare components as a Charm++ chare with minimal metadata, C++ components as a C++ class with minimal metadata, (asynchronous) entry method calls between components, and plain C++ method calls between components. L2C and Gluon++ are implemented in the LLCMc++ framework. It is distributed under a LGPL licence and represents 6400 lines of C++.

Participants: Julien Bigot, Christian Pérez.

HLCM (`http://hlcm.gforge.inria.fr/hlcm:start`) is an implementation of the HLCM component model. HLCM is a generic extensible component model with respect to component implementations and interaction concerns. Moreover, HLCM is abstract; it is its specialization—such as HLCM/L2C – that defines the primitive elements of the model, such as the primitive components and the primitive interactions. HLCM is making use of

Model-driven Engineering (MDE) methodology to generate a concrete assembly from an high level description. It is based on the Eclipse Modeling Framework (EMF). HLCM contains around 700 Emfatic lines to describe its models and around 7000 JAVA lines for utility and model transformation purposes. HLCM is a general framework that may support several HLCM specializations such HLCM/CCM, HLCM/JAVA, HLCM/L2C and HLCM/Charm++ (known as Gluon++).

Participants: Julien Bigot, Christian Pérez

SESAMES is a Smart-Grid Based Framework for Consuming Less and Better in Extreme-Scale Infrastructures. This framework proposes some solutions to optimize the energy consumption of the services running on an exascale system. It relies on a smart grid that establishes a permanent communication flow between the energy provider, the platform administrator and the users. Through a bidirectional negotiation with the energy provider, SESAMES schedules the reservations in a multi-criteria way by taking into consideration the energy consumption, the power capping, the financial cost and the pollution factor.

Participants: Mohammed El Mehdi Diouri, Olivier Glück, Laurent Lefevre

KwAPI (`http://greencloud.ens-lyon.fr/kwapi/`) KwAPI is a framework designed for acquiring energy consumption metrics. It allows to upload metrics from various wattmeters to Openstack Ceilometer (among other). Its architecture is based on a layer of drivers, which retrieve measurements from wattmeters, and a layer of plugins that collect and process them. The communication between these two layers goes through a bus. In the case of a distributed architecture, a plugin can listen to several drivers at remote locations. Drivers and plugins are easily extensible to support other types of wattmeters, and provide other services. Kwapi could be used to do: Energy monitoring of data centers ; Usage-based billing ; Efficient scheduling. It aims at supporting various wattmeters, being scalable and easily extensible.

Participants: Laurent Lefevre, Francois Rossigneux, Laurent Pouilloux, Jean-Patrick Gelas.

6.2.8 Research infrastructures

The Avalon team is strongly involved in the management of the experimental GRID'5000 platform. GRID'5000 is a scientific instrument designed to support experiment-driven research in all areas of computer science related to parallel, large-scale or distributed computing, and networking. GRID'5000 is a collection of clusters spread over 10 locations in France and in Luxembourg, and interconnected with a dedicated 10 Gbit/s backbone.

F. Desprez is Director of the Grille 5k GIS[32], the consortium that operates the GRID'5000 platform, S. Delamare is Vice Technical Director, and L. Lefèvre is the Scientific Coordinator of the site of Lyon. C. Perez is a member of the consortium board. He also acts as the leader of the Inria project lab Hemera that manages scientific activities around GRID'5000, and thus has a strong link with this consortium.

6.2.9 Prizes and awards

Anne-Cécile Orgerie has been awarded by the 1st Price for Research in System by ASF (Association ACM Sigops de France) for her PhD in Avalon team on "An Energy-Efficient Reservation Framework for Large Scale Distributed Systems" (co-advised by L. Lefevre and I. Guérin-Lassous).

6.2.10 Contribution to the scientific community and administrative responsibilities

- Christian Perez is leading the Avalon team from July 2011. He is a member of the GRID'5000 executive committee since 2010. He has been a member of hiring committees for associate professor positions at Univ. Rennes I (2009), Univ. Lyon I (2013), INP Grenoble (2011), Univ. Bordeaux (2011).

  He served as an expert for evaluating proposals to two ANR calls (Cosinus 2009, blanc 2010), and for evaluating a Thalès PhD CIFRE candidate (2009).

- Frédéric Desprez has leaded the Avalon team before July 2011. He is the scientific director of the GRID'5000 GIS and member of the executive committee. He is Deputy Scientific Director of Inria since October 2012. He was member of the board of INRIA Grenoble Rhône-Alpes between July 2006 and Oct. 2012. He has been member of hiring committees for associate professor positions at Univ. Rennes 1 (2009), INPG (2009), Univ. Saclay (2010), professor at INSA Lyon (2009), Univ. Nice (2010), junior (2009, 2010) and senior researcher at Inria.

  He served as an expert for evaluating proposals in France (ANR, ACI Grid, RNTL, INRIA) and Europe (Science Foundation Ireland Science Foundation Ireland, European commission (NEST, FP6 IST “Grid research",

[32] More information on https://www.grid5000.fr. GIS: Groupement d'Intérêt Scientifique

IST-Information Society Technologies, Future and emerging technologies, FET), Austrian Science Fund (FWF), Belgium Technological attractions poles, Belgian Information society support programme, “Interuniversity Attraction Poles" (IAP)).

6.2.11 Editorial duties

- F. Desprez is associate editor of Scalable Computing: Practice and Experience, Scientific International Journal for Parallel and Distributed Computing. He was co-editor with Ottmar Krämer-Fuhrmann and Ramin Yahyapour of the ERCIM News Special Theme on Cloud Computing. He has co-edited with B. Chapman, G.-R. Joubert, A. Lichnewsky, F. Peters and T. Priol the Proceedings of Parco 2009, with M. Danelutto, V. Getov and W. Ziegler the Proceedings of the CoreGRID/ERCIM workshop on grids, clouds and P2P computing within Euro-Par'11, with D. Talia and R. Yahyapour of the Proceedings of the CoreGRID/ERCIM workshop on grids, clouds and P2P computing within Euro-Par'12, with D. Ferguson, E. Hadar, F. Leymann, M. Jarke and M. Helfert of the Proceedings of the 3rd International Conference on Cloud Computing and Services Science (Closer'13), with A. Costan of the Proceedings of the Big Data Cloud workshop of EuroPAR'13 and with M. Helfert, D. Ferguson, F. Leymann and V. Méndez Muñoz of the Proceedings of the 4th International Conference on Cloud Computing and Services Science (Closer'14).
- G. Fedak was co-editor with Christophe Cérin of the *Desktop Grid Computing Book* published by Chapman and All, CRC Press, 2012. He is a member of the editorial board of the Cluster Computing Journal published by Elsevier, 2014. He has co-edited with Keqiu Li and Kai Lin the Special Issue: Combined Special Issue of MapReduce and its Applications & Advanced Topics on Wireless Sensor Networks of Journal on Concurrency and Computation. John Wiley & Sons, Ltd, 2013. He has co-edited with Shantenu Jha, Nils Gentschen Felde, and Rajkumar Buyya the Proceedings of 12th IEEE/ACM International Conference on Grid Computing (Grid), 2011
- Laurent Lefevre is Associate editor of IEEE Transactions on Cloud Computing (TCC) and Co-Editor of the Future Internet Assembly (FIA) Book 2013 : "Validated Results and New Horizons". He was co-editor with Jean-Marc Pierson of the ERCIM News Special Theme on "Towards Green ICT" (oct. 2009) and co-edited with Z. Huang, Z. Xu, H. Shen, J. Hine, and Y. Pan a special Issue on Emerging Research in Parallel and Distributed Computing, Journal of Supercomputing (March 2010).

6.2.12 Organisation and committees of scientific conferences

- Eddy Caron was local chair for SSS'09 (The 11th International Symposium on Stabilization, Safety, and Security of Distributed Systems), co-local chair for ICPP2013 (42nd International Conference on Parallel Processing) From 2009 to 2013 he co-organized the Inria's booth at SuperComputing.

  Eddy Caron was program committee member of the following scientific conferences : CLOSER (2012-2014), CloudCom (2010, 2013), Cloud&Grid (2012) FedICI (2013), CGCIC (2013) GridPeer (2009), HCW (2009-2014), HotP2P (2009), IPDPS (2013-2014), ISPA (2009-2010), MapRed (2010), MGC (2009), ParCo (2009), PDP (2009-2010), RenPar (2009-2011), SC'12 Tutorial (2012), SSS (2009),

  Eddy Caron was involved in the review process of the following journals and conferences: Journal of Grid Computing, Parallel Computing, FGCS, IPDPS, HPCC, EuroPVM, Super Computing, TSI, JPDC.
- Frédéric Desprez was chair of the Algorithms track for the poster session of Supercomputing'09, organizing chair of Parco'09, chair of the CoreGRID workshop on Grids, P2P and Service computing (co-located with EuroPAR'09, vice-chair of the Scheduling topic at EuroPar'10, program chair of VTDC'10 in conjunction with HPDC'10, vice-chair of the "Tools/Software/Middleware" topic of Grid'10, local organizer of SSS-11, and program co-chair of Closer'2013.

  Frédéric Desprez was program committe member of DEPEND'09'10, CCGRID'09'10'11'12'13'14, HPDC'09 PCGrid'09, CLADE'09, Grid track of SSS'09, CloudCom'09, EuroMPI'09'10'11, ICSOC'09 co-located with ServiceWave'09, Grid'09'11'12, Cloud and Grid Computing track of the 2010 ACS/IEEE Int. Conf. on Computer Systems and Applications, AACEC'10, in conjunction with IEEE Cluster 2010, CloudComp'10'11, HeteroPar'10'11, CloudCom'10, Grid, Cluster and Cloud Computing Track of ICPADS'10, CCGrid-Health'10 in conjunction with CCGrid'10, VECPAR'10'14, Grids meet Autonomic Computing workshop (in conjunction with ICAC'10), InterCloud'10 in conjunction with IWCMC 2010, LaSCoG'10'12, Track of Cluster, Grid and Cloud of ICPADS'11, HPGC-11, Cloud track at ServiceWave'11, VTDC'11'12'13 within HPDC'11'12'13, CLOSER'11'12'13,14, ParCo'11, ISPA'11, Grid, P2P and Scalable Computing track of AINA'11, SPCLOUD'11 as part of HPCS'11, Cloud for High Performance Computing Workshop at ICCSA'11, Services and Applications track of IEEE CloudCom'11'12, BDMC'12 in conjunction with EuroPar'12, Federatedclouds Workshop on Cloud Services and the 8th Open Cirrus

Summit 2012, CGWS'2012 within EuroPAR'12. ICA CON'12, HPGC'12, 3PGCIC'12, ICPADS'12, CFSE'12, IPDPS'13'14, CGC'13, NPC'13, BigData'13'14, BDSE'13, BigDataCloud'13'14 within EuroPAR'13'14 Workshop Committee Member of Supercomputing'14, ComPAS'14, HotCloud'14, and Cluster'14.

- Gilles Fedak was Publicity Chair of SBAC-PAD'2014 (26th International Symposium on Computer Architecture and High Performance Computing) and Grid'2012 (13th IEEE/ACM International Conference on Grid Computing). He was Poster and Workshop Chair of Grid'11 (12th IEEE/ACM International Conference on Grid Computing Grid'11) and track co-chair of ICCCN 2010 (19th IEEE International Conference on Computer Communications and Networks). He co-organized as General Chair with G. Fox the International Workshop on the MapReduce Programing Model and its Application (MAPREDUCE) with HPDC in 2012, 2011 and 2010. He co-organized as General Chair with D. Kondo the Workshop on Large-Scale and Volatile Desktop Grids (PCGrid) associated with IPDPS and CCGRID in 2010, 2009 and 2008.

  Gilles Fedak was program committee member of the following scientific conferences: HPDC'14, '13, '12, '11 CloudCom '14, '13, '12, '11, '10, Europar '14, AINA '14, e-Science '13, '12, SBAC-PAD '13, BDDS '13, NPC '13, HPCC '13, CCGRID '13, '11, '09 Grid '12, ICCCN '12, ScalCom '12, '11 EuromicroPDP '12, DCTAP'11,

- Laurent Lefevre, as General Chair, has co-organized ICPP2013 (42nd International Conference on Parallel Processing) and HPCC09 (11th IEEE International Conference on High Performance Computing and Communications). As Program chair, he co-organized CGC 2013 (Third International Conference on Cloud and Green Computing), GreenCom 2012 and 2010 (The IEEE International Conference on Green Computing and Communications), HPCC2012 (14th IEEE International Conference on High Performance Computing and Communications) and Grid 2010 (11th IEEE / ACM International Conference on Grid Computing). He is steering committee member of CCGrid conferences (since 2004), Grid2011, CGC2013 and ICPS (2007-2009). Laurent Lefevre has co-organized the TASUS2014 workshop on "Techniques and Applications for Sustainable Ultrascale Computing Systems" (during Europar2014), the ExtremeGreen'13 &'14 workshop on "Extreme Green & Energy Efficiency in Large Scale Distributed Systems " (during CCGrid conferences) and SUNSET2011 workshop on "Sustainable Networking" (during Networking 2011 conference). He is the initiator and co-organizer of the GreenDays series ('11, '12, '13, '14) for french research community of energy efficiency. He was co-organizer of a colloquium on GreenIT during "Entretiens Jacques Cartier" in '11 and '12.

  Laurent Lefevre was program committee member of the following scientific conferences : SuperComputing'09 & '11, IEEE CCGrid'09,'10,'11 & '12, ICA3PP'10,'11,'12 & '13, , HPC'09, NSS'09,'10,11 & '12, ACM Grid'12, HPDC'09, e-Energy '11 & '12, CLOSER 2013, SMART- GREENS'12 & '13, CNSM'11 & '12, ICCS'09 & '10) and international workshops : HP- PAC'09,'10,'11,'12 & '13, ICT-GLOW'11 & '12.

- Olivier Glück was program committee member of the following scientific conferences: PDP/SMEEPAP 2015, ExtremeGreen 2014, ExtremeGreen 2013, International Conference on Cloud and Green Computing 2013, CCGrid2012 and was involved in the review process of Cluster Computing, Euro-Par.

- Christian Perez co-organized the 9th Workshop of the Inria-Illinois Joint Laboratory on Petascale Computing, and the GRID'5000 Spring School (2010, 2011, 2012, 2014). He was a local chair of Euro-Par (2011), publicity co-chair of HPCS (2009).

  He was a member of the Steering Committee of CBHPC (2009-2010).

  He was member of the program committee of the following conferences and workshops: AINA (2009), CBHPC (2009, 2010), CCGRID (2009), Cluster (2011), ICPADS (2011), HipHaC (2011), HPCC (2009, 2010), HPCS (2012), MapReduce (2010, 2011), ParCO (2009, 2010, 2011, 2013), ICSOC (2011, 2012, 2013), RenPar'20 (2011), VecPar (2010)

- Frédéric Suter was local chair of the Grid'11 and EuroPar'11 conferences. He also served in the program committee of the following conferences and workshops: CLADE (2009), HPeCC (2010), LasCog-Scodis (2010-2012), MapReduce (2010-2012), VDTC (2010-2014), Closer (2010-2013), CCGrid (2011), Grid (2011), EuroPar (2011, 2014), Cloud& Grid (2012), IPDPS (2013), SYNASC (2013), VECPAR (2012-2014), EuroMPI (2013-2014).

6.2.13 National and international boards and expertise, consulting activities

- Christian Perez served as expert for a research project of the Innovational Research Incentives Scheme of the Division for Physical Sciences of the Netherlands Organisation for Scientific Research (2010). He was a member of the French embassy delegation visiting China about cloud computing in China (2012).

- G. Fedak has been invited as an expert by the following funding agencies : Danish Council for Independent Research - 2014, Netherlands Organisation for Scientific Research (NWO) - 2011, 2012 and Agence National de la Recherche (ANR) 2010, 2011 2013. He has participated to the following selection jury for associate professor position at University of Cluj Napoca - 2014 and Université Paris XIII - 2011.

- Frédéric Suter served as member of the ANR Evaluation committee SIMI2 in 2013 and has been invited as an expert by the following funding agencies : Netherlands Organisation for Scientific Research (2011), Israel Science Foundation (2013), Fonds National pour la Recherche Scientifique (2014).

- Frédéric Desprez served as an expert for evaluating proposals in France (ANR, ACI Grid, RNTL, INRIA) and Europe (Science Foundation Ireland Science Foundation Ireland, European commission (NEST, FP6 IST "Grid research", IST-Information Society Technologies, Future and emerging technologies, FET), Austrian Science Fund (FWF), Belgium Technological attractions poles, Belgian Information society support programme, "Interuniversity Attraction Poles" (IAP)). He participated in 2013-14 to the "Nouvelle France Industrielle" working group around Clouds of the french Ministère de l'Economie, de l'Industrie et du Numérique. He also participated to an European expert group in the framework of the H2020 call (A Roadmap for Advanced Cloud Technologies under H2020, European Commission, Recommendations by the Cloud Expert Group, Digital Agenda for Europe, Dec. 2012)

6.2.14 Patents, startups, and technology transfer

SysFera

Frédéric Desprez and Eddy Caron - who are still part of the Avalon research team and David Loureiro (CEO of SysFera) co-founded SysFera in March 2010. The technology and concepts developed by SysFera originated at Avalon, which continues to perform advanced research on scheduling, Clouds and Big Data.

SysFera-DS is an intuitive web interface that enables engineers and researchers to more easily run their applications on complex HPC environments from their own browser. Since visualization is increasingly used to explore results and present Big Data, the web interface includes built-in capability to do this remotely.

SysFera's web portal makes it simple and fast to run both non-interactive and interactive graphical HPC applications on traditional servers, hybrid, and/or cloud environments – all via a simple web browser. The product is unique in that it requires no modification by application vendors, no changes to the HPC system security by IT managers, and no local software installation by the user.

This ease of use translates directly into productivity savings:

1. Engineers and researchers who are not computer scientists become productive more quickly (don't have to learn multiple HPC tools and interfaces), and are able to focus more on their core expertise - resulting in increased productivity and less wastage due to repeat jobs
2. Project managers spend less time administering applications and project/user account admin and resource quotas
3. IT departments and computing centers have more control over applications and resources - enabling optimal usage of their HPC infrastructure as well as the ability to bill customers more accurately and with less effort.
4. Users benefit from a single interface to manage their simulation data on remote distributed storage resources. This streamlines the entire processing workflow, from pre-processing to post-processing and data visualization

Two collaborations between the research team and the SysFera company exist to provide a distributed computing platform using SysFera-DS for the interface and DIET for the core.

Deeply rooted in innovation, SysFera continues to invest in the development of High Performance Computing. The company takes part in both European (FP7 PaaSage) and French national (ANR SOP, BioDataCloud) research projects.

SysFera is backed by investors who support the company's strategy of becoming an international player in hybrid cloud HPC solutions. The company was founded with initial support from IT-Translation, an incubator and investment fund for government funded ICT research. SysFera also is backed by two regional investment funds, Rhône-Alpes Création and Edelweiss Participations, and several French Business Angels with strong industry backgrounds.

6.2.15 Training and teaching activities

PhD students

During this evaluation period, 10 students have defended their PhD: Benjamin Depardon (October 2010); Julien Bigot (December 2010); Ghislain Charrier (December 2010); Anne-Cécile Orgerie (September 2011); Vincent Pichon (November 2012); Cristian Klein (November 2012); Adrian Muresan (December 2012); Mohammed El Mehdi Diouri (September 2013); Ghislain Landry Tsafack Chetsa (December 2013); and Georgios Markomanolis (January 2014). As we are writing these lines, Sylvain Gault, and Anthony Simonet are finishing writing their PhD.

Among the seven students who defended their PhD before December 2012, four have now a permanent position: Benjamin Depardon is now CTO at the SysFera company; Julien Bigot is engineer-researcher at CEA (*Maison de la Simulation*); Anne-Cécile Orgerie is a CNRS researcher in the Myriads team (IRISA); Vincent Pichon is engineer at the CS group. From recent PhDs, Mohammed El Mehdi Diouri is associate professor at IGA (Casablanca, Morocco).

National or International Courses and Tutorials

- Gilles Fedak proposes a course on *MapReduce Environments: Design, Performance, Optimizations*, which covers the basic design of the runtime environments to implement the MapReduce programming model. This mini course has been presented at Université Paris XIII - Formation doctorale de l'Institut Galilé, 2014, Ecole Normale Supérieure de Lyon, 2013, Il Escola Regional de Alto Desempenho - Região Nordeste, Savaldor de Bahia, Brazil, 2013, Seminar Datenverarbeitung mit Map-Reduce, Univ. of Heidelberg, Germany, 2012.

- Laurent Lefevre gave a course on "Advanced networks" in Addis Abeba University (Ethiopia) (40h, 2010)

- Olivier Glück gave a course on "Networks" in Ho Chi Minh City International University (Vietnam) (60h, 2012)

Master level courses

- E. Caron, G. Fedak, C. Perez, J. Rouzaud-Cornabas: "Grid and Cloud", M2 ENS de Lyon (22h, 2009-2014)
- E. Caron: "Distributed System", M1 ENS de Lyon (36h, 2009-2014)
- E. Caron: "Software engineering and project management", M1 ENS de Lyon (36h, 2009-2014)
- L. Lefevre: "Green Networking", M2 ENS Lyon (12h, 2012)
- L. Lefevre: "Advanced networks" , M2 ENS Lyon (8h, 2011)
- E. Caron: "Grid Computing", M2 INSA de Lyon (8h, 2013-2014)
- L. Lefevre: "Operating systems and networks", M2 (CCI), Université Lyon 1 (50h, 2012)
- JP. Gelas: "Computer Networks", M2 (CCI), Université Lyon 1, France (48h, 2006-2014)
- JP. Gelas: "Operating system", M2 (CCI), Université Lyon 1, France (30h, 2006-2014)
- F. Desprez: "Parallel Computing" M1 Université Lyon I (30h, 2012-14)
- JP. Gelas: "Router architecture", M2, Université Lyon 1, France (6h, 2010-2014)
- JP. Gelas: "Embedded technologies", M2, Université Lyon 1, France (85h, 2009-2014)
- JP. Gelas: "Internet Routing and IPv6", M2, Université Lyon 1, France (45h, 2010-2014)
- O. Glück: "Applications and Protocols of Internet", M2, Université Lyon 1, France (30h, 2009-2014)
- O. Glück: "Networks and Systems Administration", M2, Université Lyon 1, France (30h, 2009-2014)

License level courses

- E. Caron "ASR1: Architecture, Système et Réseaux", L3, ENS de Lyon (36h, 2013-2014)
- O. Glück "LIF4 : Introduction to DataBase and Networks", L2 Informatique, Université Lyon 1 (2×6h, 2009-2014)
- O. Glück "LIF8 : Networks", L3 Informatique, Université Lyon 1 (2×60h, 2009-2014)

6.2.16 Interaction with the social and cultural environment

- Eddy Caron was a speaker of the public round table "La recherche scientifique est-elle un métier comme les autres? Du public au privé, les dessous du métier..." organized by students of the University of Lyon 2.

- In September 2009, Frédéric Suter was a speaker during "la Nuit des Chercheurs à Villeurbanne (with videoconference with Henri Casanova from the Hawai'i University to talk about the research job). `http://www.universite-lyon.fr/science-societe/nuit-des-chercheurs-2009-128682.kjsp`

- For his activities on energy efficiency and Green IT, Laurent Lefevre was interviewed and contributed to various articles (Okapi Magazine (Apr. 2011), La recherche (Sep. 2010), 01 Informatique Business et Technologies (Sep. 2010), Pour la Science (Mar. 2010), Les Echos (Apr. 2012), Liberation (Apr. 2013), La Vie (Jun. 2013)) and made some radio interventions (RCF Isere, Radio Méditerranée Internationale). Laurent Lefevre was invited speaker in the event : "Technologies vertes de l'information : une réponse aux défis environnementaux - Green IT Technologies : an answer to environmental challenges" (organized by Enviscope and ITADVICE (Jun. 2010). Laurent Lefevre was invited speaker to the round table on Green Computing organized by GDR - GPL - CIEL AFADL (Nancy, April 2013), in the panel of HPCS2010 conference on "Energy-aware, Power-aware, and Green Computing for Large Distributed Systems and Applications" (Caen, Jun. 2010) and in the panel of IEEE Globecom 2013 Workshop on Cloud Computing Systems, Networks, and Applications (Atlanta, USA, Dec. 2013).

- Mohammed El Mehdi Diouri, Olivier Glück and Laurent Lefevre have published an article [443] on energy efficiency and Green IT in ERCIM News, the magazine of European Community in Information Technology for the wider scientific community. Laurent Lefèvre has co-edited (with Jean-Marc Pierson - IRIT Lab. Toulouse) a special theme of ERCIM News on " Towards Green ICT" (Oct. 2009).

6.2.17 Publications and productions

International peer-reviewed journals [ACL]

2009

[226] V. Bertis, R. Bolze, F. Desprez, and K. Reed. From Dedicated Grid to Volunteer Grid: Large Scale Execution of a Bioinformatics Application. *Journal of Grid Computing*, 7(4):463–478, December 2009.

[227] Fatiha Bouabache, Thomas Herault, Gilles Fedak, and Franck Cappello. Hierarchical Replication Techniques to Ensure Checkpoint Storage Reliability in Grid Environment. *Journal of Interconnection Networks*, 10(4):345–364, 2009.

[228] Pierre-François Dutot, Tchimou N'Takpé, Frédéric Suter, and Henri Casanova. Scheduling Parallel Task Graphs on (Almost) Homogeneous Multi-cluster Platforms. *IEEE Transactions on Parallel and Distributed Systems*, 20(7):940–952, July 2009.

[229] Gilles Fedak, Haiwu He, and Franck Cappello. BitDew: A Data Management and Distribution Service with Multi-Protocol and Reliable File Transfer. *Journal of Network and Computer Applications*, 32(5):961–975, September 2009.

[230] Laurent Lefèvre and Anne-Cécile Orgerie. Towards energy aware reservation infrastructure for large-scale experimental distributed systems. *Parallel Processing Letters - Special Issue on Clusters and Computational Grids for Scientific Computing*, 19(3):419–433, September 2009.

[231] Pablo Neira Ayuso, Rafael M. Gasca, and Laurent Lefèvre. Demystifying cluster-based fault-tolerant firewalls. *IEEE Internet Computing : Special Issue on Unwanted Traffic*, 13(6):30–37, November 2009.

[232] E. Urbah, P. Kacsuk, Z. Farkas, G. Fedak, G. Kecskemeti, O. Lodygensky, A. Marosi, Z. Balaton, G. Caillat, G. Gombas, A. Kornafeld, J. Kovacs, H. He, and R. Lovas. EDGeS: Bridging EGEE to BOINC and XtremWeb. *Journal of Grid Computing*, 7(3):335–354, September 2009.

2010

[233] Narjess Ayari, Laurent Lefèvre, and Denis Barbaron. Design and evaluation of a session-aware admission-control framework for improving service providers profitability. *Journal of Internet Engineering - Special issue on Service Oriented Infrastructures*, 4(1), December 2010.

[234] Hinde Lilia Bouziane, Christian Pérez, and Thierry Priol. Extending Software Component Models with the Master-Worker Paradigm. *Parallel Computing*, 36(2-3):86–103, February 2010.

[235] Eddy Caron, Ajoy K. Datta, Benjamin Depardon, and Lawrence L. Larmore. A self-stabilizing k-clustering algorithm for weighted graphs. *Journal of Parallel and Distributed Computing*, 70(11):1159–1173, Nov 2010.

[236] Eddy Caron, Frédéric Desprez, Franck Petit, and Cédric Tedeschi. Snap-stabilizing prefix tree for peer-to-peer systems. *Parallel Processing Letters*, 20(1):15–30, March 2010.

[237] Henri Casanova, Frédéric Desprez, and Frédéric Suter. On cluster resource allocation for multiple parallel task graphs. *Journal of Parallel and Distributed Computing*, 70(12):1193–1203, December 2010.

[238] Laurent Lefèvre and Anne-Cécile Orgerie. Designing and evaluating an energy efficient cloud. *The Journal of SuperComputing*, 51(3):352–373, March 2010.

[239] Pablo Neira Ayuso, Rafael M. Gasca, and Laurent Lefèvre. Communicating between the kernel and user-space in linux using netlink sockets. *Journal Software: Practice and Experience*, 40(9):797–810, August 2010.

2011

[240] Eddy Caron, Frédéric Desprez, and Adrian Muresan. Forecasting for cloud computing on-demand resources based on pattern matching. *Journal of Grid Computing*, 9(1):49–64, March 2011.

[241] Oleksandr Gatsenko, Oleksandra Baskova, Oleg Lodygensky, Gilles Fedak, and Yuri Gordienko. Statistical Properties of Deformed Single-Crystal Surface under Real-Time Video Monitoring and Processing in the Desktop Grid Distributed Computing Environment. *Journal of Key Engineering Materials*, Materials Structure & Micromechanics of Fracture VI(465):306–309, January 2011.

[242] Anne-Cécile Orgerie and Laurent Lefèvre. Eridis: Energy-efficient reservation infrastructure for large-scale distributed systems. *Parallel Processing Letters*, 21:133–154, June 2011.

[243] Anne-Cécile Orgerie, Laurent Lefèvre, and Isabelle Guérin-Lassous. Energy-efficient bandwidth reservation for bulk data transfers in dedicated wired networks. *The Journal of SuperComputing - Special issue on Green Networks*, March 2011.

[244] Luis Rodero-Merino, Luis M. Vaquero, Eddy Caron, Adrian Muresan, and Frédéric Desprez. Building safe paas clouds: A survey on security in multitenant software platforms. *Computer and Security*, page 13, 2011. Article in press. Available online 2 November 2011.

[245] J. Rubio-Loyola, A. Galis, A. Astorga, J. Serrat, L. Lefevre, A. Fischer, A. Paler, and H. de Meer. Scalable service deployment on software defined networks. *IEEE Communications Magazine*, 49(12):84–93, December 2011. ISSN: 0163-6804.

2012

[246] Pablo Neira Ayuso, Rafael M. Gasca, and Laurent Lefevre. Ft-fw: A cluster-based fault-tolerant architecture for stateful firewalls. *Computers & Security*, 31(4):524–539, June 2012.

[247] Eddy Caron, Frédéric Desprez, Adrian Muresan, and Luis Rodero-Merino. Using Clouds to Scale Grid Resources: An Economic Model. *Future Generation Computer Systems*, Volume 28(Issue 4):633–646, 2012. Issue 4 Issue 4.

[248] A. Fernández-Montes, L. Gonzalez-Abril, Juan A. Ortega, and Laurent Lefèvre. Smart scheduling for saving energy in grid computing. *Expert Systems with Applications*, 39(10):9443 – 9450, 2012.

[249] Pablo Neira, M. Rafael, and Laurent Lefevre. FT-FW: A cluster-based fault-tolerant architecture for stateful firewalls. *Computers and Security*, 31(4):524–539, 2012. 4 4.

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2013

[251] Gabriel Antoniu, Julien Bigot, Cristophe Blanchet, Luc Bougé, François Briant, Franck Cappello, Alexandru Costan, Frédéric Desprez, Gilles Fedak, Sylvain Gault, Kate Keahey, Bogdan Nicolae, Christian Pérez, Anthony Simonet, Frédéric Suter, Bing Tang, and Raphael Terreux. Towards Scalable Data Management for Map-Reduce-based Data-Intensive Applications on Cloud and Hybrid Infrastructures. *International Journal of Cloud Computing (IJCC)*, 2(2/3), jan 2013.

[252] Julien Bigot, Zhengxiong Hou, Christian Pérez, and Vincent Pichon. A low level component model easing performance portability of HPC applications. *Computing*, November 2013.

[253] Mohammed El Mehdi Diouri, Ghislain Landry Tsafack Chetsa, Olivier Glück, Laurent Lefèvre, Jean-Marc Pierson, Patricia Stolf, and Georges Da Costa. Energy efficiency in high-performance computing with and without knowledge of applications and services. *International Journal of High Performance Computing Applications*, 27(3):232–243, August 2013.

[254] Ghislain Landry Tsafack Chetsa, Laurent Lefèvre, Jean-Marc Pierson, Patricia Stolf, and Georges Da Costa. Exploiting Performance Counters to Predict and Improve Energy Performance of HPC Systems. *Future Generation Computer Systems*, August 2013.

2014

[255] Henri Casanova, Frédéric Desprez, George S. Markomanolis, and Frédéric Suter. Simulation of MPI Applications with Time-Independent Traces. *Concurrency and Computation: Practice and Experience*, 2014. Available online (early view): `http://onlinelibrary.wiley.com/doi/10.1002/cpe.3278/pdf`.

[256] Henri Casanova, Arnaud Giersch, Arnaud Legrand, Martin Quinson, and Frédéric Suter. Versatile, Scalable, and Accurate Simulation of Distributed Applications and Platforms. *Journal of Parallel and Distributed Computing*, 74(10):2899 – 2917, June 2014.

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[258] Mohammed El Mehdi Diouri, Manuel Francisco Dolz, Olivier Glück, Laurent Lefèvre, Pedro Alonso, Sandra Catalán, Rafael Mayo, and Enrique Salvador Quintana-Ortí. Assessing power monitoring approaches for energy and power analysis of computers. *In Sustainable Computing Informatics and Systems*, 4(2):68–82, june 2014.

[259] R. Ferreira Da Silva, T. Glatard, and Frédéric Desprez. Controlling fairness and task granularity in distributed, online, non-clairvoyant workflow executions. *Journal of Concurrency and Computation: Practice and Experience*, page in press, 2014.

[260] Anne-Cécile Orgerie, Marcos Dias De Asuncao, and Laurent Lefevre. A Survey on Techniques for Improving the Energy Efficiency of Large Scale Distributed Systems. *ACM Computing Surveys*, 46(4), December 2014. To appear.

[261] Emalyan Vairavanathan, Samer Al-Kiswany, Abmar Barros, Lauro Beltrao Costa, Hao Yang, Gilles Fedak, Daniel Katz, Michael Wilde, and Materi Ripeanu. A Case for Workflow-Aware Storage: An Opportunity Study using MosaStore. *Journal of Grid Computing*, 2014. to appear.

National peer-reviewed journals [ACL]

2011

[262] Anne-Cécile Orgerie, Laurent Lefèvre, and Jean-Patrick Gelas. Etudier l'usage pour économiser l'énergie dans les systèmes distribués à grande echelle : l'approche eari. *TSI : Technique et Science Informatiques*, 30(5):515–538, May 2011.

Invited conferences [INV], seminars, and tutorials

2009

[263] Laurent Lefevre. Why hunting watts in large scale distributed systems ? the green-* approaches !, 2009. Opening Keynote Talk, Renpar 2009 : Rencontres francophones du Parallélisme, Toulouse, France, September 2009.

2011

[264] Anestis Antoniadis, Eddy Caron, Benjamin Depardon, Hubert Gallee, Celine Helbert, Clémentine Prieur, and Laurence Viry. Spatio-temporal modeling of western african monsoon. In *Les Ateliers de Modélisation de l'Atmosphère*, Toulouse, February 2011.

[265] Laurent Lefevre. Point de vue de l'utilisateur (chercheur) d'un datacenter vert - et sortons du datacenter pour aller faire un tour dans le réseau !, 2011. Formation "Datacentres : concilier faisabilité, performances et écoresponsabilité", Autrans, France, October 2011.

2012

[266] Laurent Lefevre. Monitoring electrical consumption of servers in datacenters : needs and challenges, 2012. ANF CNRS seminar, Eco-Info group, Villard de Lans and Satillieu, France, December 2012.

[267] Laurent Lefevre. Towards green-hpc : (some) challenges, approaches and expectations, 2012. Invited Keynote, The 8th Workshop on High-Performance, Power-Aware Computing (HPPAC 2012) in conjunction with the 26th Annual International Parallel & Distributed Processing Symposium (IPDPS 2012), Shanghai, China, May 2012.

2013

[268] Laurent Lefevre. Impact of application and service knowledge for energy efficiency in hpc, 2013. Invited Keynote, International Workshop on Energy Efficient High Performance Parallel and Distributed Computing (EEHPDC-2013), Co-located with ACM HPDC 2013, New York City, NY, USA, June 17th, 2013.

International peer-reviewed conference proceedings [ACT]

2009

[269] Marco Aldinucci, Hinde Lilia Bouziane, Marco Danelutto, and Christian Pérez. STKM on SCA: a Unified Framework with Components, Workflows and Algorthmic Skeletons. In *15th International European Conference on Parallel and Distributed Computing (Euro-Par 2009)*, LNCS, Delft, Netherlands, 2009.

[270] Françoise André, Guillaume Gauvrit, and Christian Pérez. Dynamic adaptation of the master-worker paradigm. In *Proceedings of the 2009 Ninth IEEE International Conference on Computer and Information Technology - Volume 02*, CIT '09, pages 185–190, Washington, DC, USA, 2009. IEEE Computer Society.

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[272] Julien Bigot and Christian Pérez. Increasing reuse in component models through genericity. In *Proceedings of the 11th International Conference on Software Reuse: Formal Foundations of Reuse and Domain Engineering*, ICSR '09, pages 21–30, Berlin, Heidelberg, 2009. Springer-Verlag.

[273] Gabriel Caillat, Oleg Lodygensky, Gilles Fedak, Haiwu He, Zoltan Balaton, Zoltan Farkas, Gabor Gombas, Peter Kacsuk, Robert Lovas, Attila Csaba Maros, Ian Kelley, Ian Taylor, Gabor Terstyanszky, Tamas Kiss, Miguel Cardenas-Montes, Ad Emmen, and Filipe Araujo. EDGeS: The art of bridging EGEE to BOINC and XtremWeb. In *Proceedings of Computing in High Energy and Nuclear Physics (CHEP'09) (Abstract)*, Prague, Czech Republic, March 2009.

[274] Yves Caniou, Eddy Caron, Ghislain Charrier, and Frédéric Desprez. Meta-scheduling and task reallocation in a grid environment. In *The Third IEEE International Conference on Advanced Engineering Computing and Applications in Sciences (ADVCOMP 2009)*, page 6p., Sliema, Malta, October 2009.

[275] Yves Caniou and Jean-Sébastien Gay. Simbatch: an API for simulating and predicting the performance of parallel resources managed by batch systems. In *Workshop on Secure, Trusted, Manageable and Controllable Grid Services (SGS), held in conjunction with EuroPar'08*, volume 5415 of *LNCS*, pages 223–234, 2009.

[276] Eddy Caron, Ajoy Datta, Benjamin Depardon, and Lawrence Larmore. A self-stabilizing k-clustering algorithm using an arbitrary metric. In *Euro-Par 2009*, volume LNCS 5704, pages 602–614, Delft, The Netherlands, August 25-28 2009. TU Delft.

[277] Eddy Caron, Frédéric Desprez, David Loureiro, and Adrian Muresan. Cloud computing resource management through a grid middleware: A case study with diet and eucalyptus. In *IEEE International Conference on Cloud Computing (CLOUD 2009)*, Bangalore, India, Septembre 2009. IEEE. Published In the Work-in-Progress Track from the CLOUD-II 2009 Research Track.

[278] Georges Da-Costa, Jean-Patrick Gelas, Yiannis Georgiou, Laurent Lefèvre, Anne-Cécile Orgerie, Jean-Marc Pierson, Olivier Richard, and Kamal Sharma. The green-net framework: Energy efficiency in large scale distributed systems. In *HPPAC 2009 : High Performance Power Aware Computing Workshop in conjunction with IPDPS 2009*, Rome, Italy, May 2009.

[279] Gilles Fedak. Recent advances and research challenges in desktop grid and volunteer computing. In *Proceedings of the EuroPAR 2009 Workshops, CoreGrid ERCIM Working Group Workshop on Grids, P2P and Service Computing*, pages 171–185, Delft, Netherlands, Aug 2009. LNCS.

[280] Alex Galis, Spyros Denazis, Alessandro Bassi, Pierpaolo Giacomin, Andreas Berl, Andreas Fischer, Hermann de Meer, John Srassner, Steven Davy, Daniel Macedo, Guy Pujolle, Javier R. Loyola, Joan Serrat, Laurent Lefèvre, and Abderhaman Cheniour. Management architecture and systems for future internet networks. In *FIA Book : "Towards the Future Internet - A European Research Perspective"*, pages 112–122, Prague, May 2009. IOS Press. ISBN 978-1-60750-007-0.

[281] Haiwu He, Gilles Fedak, Bing Tran, and Franck Cappello. BLAST Application with Data-aware Desktop Grid Middleware. In *Proceedings of 9th IEEE International Symposium on Cluster Computing and the Grid CCGRID'09*, pages 284–291, Shanghai, China, May 2009.

[282] Tchimou N'Takpé and Frédéric Suter. Concurrent Scheduling of Parallel Task Graphs on Multi-Clusters Using Constrained Resource Allocations. In *Proceedings of the 10th IEEE International Workshop on Parallel and Distributed Scientific and Engineering Computing (PDSEC)*, Rome, Italy, May 2009.

[283] Lucas Nussbaum, Fabienne Anhalt, Olivier Mornard, and Jean-Patrick Gelas. Linux-based virtualization for hpc clusters. In *Linux Symposium 2009*, July 2009.

[284] Anne-Cécile Orgerie and Laurent Lefèvre. When clouds become green: the green open cloud architecture. In *Parco2009 : International Conference on Parallel Computing*, pages 228–237, Lyon, France, September 2009.

2010

[285] Vlad Acretoaie, Eddy Caron, and Cédric Tedeschi. A practical study of self-stabilization for prefix-tree based overlay networks. In *MOSPAS 2010. Workshop on MOdeling and Simulation of Peer-to-Peer Architectures and Systems. As part of The International Conference on High Performance Computing and Simulation (HPCS 2010)*, pages 341–347, Caen. France., June 28-July 2 2010. IEEE.

[286] Nicolas Bard, Raphaël Bolze, Eddy Caron, Frédéric Desprez, Michaël Heymann, Anne Friedrich, Luc Moulinier, Ngoc-Hoan Nguyen, Olivier Poch, and Thierry Toursel. Décrypthon Grid - Grid Resources Dedicated to Neuromuscular Disorders. In *The 8th HealthGrid conference*, Paris, France, June 2010.

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[288] Eddy Caron, Benjamin Depardon, and Frédéric Desprez. Deployment of a hierarchical middleware. In LNCS, editor, *Euro-Par 2010*, volume 6271 Part I, pages 343–354, Ischia - Naples, Italy, August 31 to September 3 2010. Institute for High Performance Computing and Networking of the Italian National Research Council.

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[290] Eddy Caron, Frédéric Desprez, Tristan Glatard, Maheshwari Ketan, Johan Montagnat, and Damien Reimert. Workflow-based comparison of two distributed computing infrastructures. In *Workflows in Support of Large-Scale Science (WORKS10)*, New Orleans, November 14 2010. In Conjunction with Supercomputing 10 (SC'10), IEEE.

[291] Eddy Caron, Frédéric Desprez, and Adrian Muresan. Forecasting for Grid and Cloud Computing On-Demand Resources Based on Pattern Matching. In *IEEE CloudCom 2010*, Indianapolis, Indiana, USA, États-Unis, 2010. IEEE.

[292] Henri Casanova, Frédéric Desprez, and Frédéric Suter. Minimizing Stretch and Makespan of Multiple Parallel Task Graphs via Malleable Allocations. In *Proceedings of the 39th International Conference on Parallel Processing (ICPP)*, pages 71–80, San Diego, CA, September 2010.

[293] Georges Da-Costa, Marcos Dias de Assuncao, Jean-Patrick Gelas, Yiannis Georgiou, Laurent Lefèvre, Anne-Cécile Orgerie, Jean-Marc Pierson, Olivier Richard, and Amal Sayah. Multi-facet approach to reduce energy consumption in clouds and grids: The green-net framework. In *e-Energy 2010 : First International Conference on Energy-Efficient Computing and Networking*, pages 95–104, Passau, Germany, April 2010.

[294] Frédéric Desprez and Frédéric Suter. A Bi-Criteria Algorithm for Scheduling Parallel Task Graphs on Clusters. In *The 10th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid)*, pages 243–252, Melbourne, Australia, May 2010. IEEE/ACM.

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2011

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6.3 COMPSYS: Compilation and Embedded Computing Systems

6.3.1 Team composition

Current members

Permanent members
- Christophe Alias (CR Inria)
- Alain Darte (DR CNRS)
- Paul Feautrier (professor, ENS-Lyon, emeritus)
- Laure Gonnord (assistant professor, Lyon 1)
- Tomofumi Yuki (CR Inria, starting sep. 2014)

PhD students
- Guillaume Iooss (ENS-Lyon grant)
- Alexandre Isoard (ENS-Lyon grant)
- Maroua Maleej (Labex MILYON grant, starting sep. 2014)

Assistant
- Evelyne Blesle (Inria)

Former members

Permanent members
- Fabrice Rastello (CR Inria)

PhD students
- Benoit Boissinot (ENS-Lyon grant)
- Quentin Colombet (Mediacom grant)
- Alexandru Plesco (MESR grant)

Post-doc
- Florian Brandner (Mediacom project)

Assistant
- Laetitia Lecot (Inria)

Visitors

The team received only short-term visitors (usually at most a week), sometimes several times, in particular Florian Brandner (ENSTA, Paris), Albert Cohen (ENS, Parkas Inria team), Sebastian Hack (Sarrebrücken University), Alain Ketterlin (Strasbourg, Camus Inria team), Andreas Krall (Vienna University), David Monniaux (Grenoble, Verimag), Fernando Pereira (Minas Gerais, Brazil), Louis-Noël Pouchet (UCLA), Keshav Pingali (Austin, University of Texas), Sanjay Rajopadhye (Colorado State University), Ramanujam (Lousiana State University), P. Sadayappan (Ohio State University), Vivek Sarkar (Rice University), and, initially invited by the Plume team, Amir Ben Amram (Tel-Aviv University) to exchange on program termination and complexity.

6.3.2 Life of the team

Not all members were full-time in Compsys during the evaluation period. Laure Gonnord was, until sep. 2013, only an external collaborator, once a week in the team. Christophe Alias, since the end of 2010, is very involved (> 50%) in the Zettice/XtremLogic start-up. Fabrice Rastello was in sabbatical for a year in 2010-2011, then moved to Grenoble in fall 2012, to start building a new group, on new research directions (he officially left the group one year later).

Information circulates in the group mainly on a daily basis, through mails, lunches, or dedicated meetings, when needed. Paul Feautrier manages a regular meeting group, with discussions or work-in-progress presentations, sometimes with external speakers, sometimes joint with Tanguy Risset's group at Insa-Lyon, as well as Yann Orlarey (Grame).

All members take responsibilities to represent the team outside (contracts, industrial meetings, networks, teaching) and to work on the animation of its research communities (organization of community life, of schools, workshops, etc.).

The functional budget of the team is small and comes mainly from Inria (roughly 15 Keuros per year), from LIP (roughly 4 Keuros per year), and the industrial contracts (roughly 5 Keuros per year). As for PhD and post-doc salaries, they mainly come from the contracts with STMicroelectronics (Sceptre then Mediacom) and ENS-Lyon grants.

6.3.3 International collaborations resulting in joint publications

We have close contacts and long-term collaborations with the compilation team of STMicroelectronics (Christophe Guillon, François de Ferrière, Benoit Dupont de Dinechin now at Kalray), Albert Cohen (ENS Paris, Inria Parkas team), David Monniaux (Verimag Grenoble), Sebastian Hack (Sarrebrücken University), Florian Brandner (ENSTA, Paris), Abdoulaye Gamatié (Lille University), Alain Ketterlin and Eric Violard (University of Strasbourg, Inria Camus team), Sanjay Rajopadhye (Colorado State University), P. Sadayappan (Ohio State University), J. Ramanujam (Louisiana State University), Fernando Pereira (Minas Gerais, Brazil), Vijay Saraswat (IBM Yorktown).

6.3.4 Management of research projects and contracts

CNRS PEPS "HLS and real-time". Christophe Alias and Laure Gonnord initiated with the DART/Emeraude team at LIFL Laboratory (University of Lille) a CNRS PEPS ("Projets Exploratoire Premier Soutien") called "HLS and real time" (8 Keuros/year, during two years in 2011-2013). The goal was to investigate how to introduce real-time constraints in the high-level synthesis workflow.

Thematic Quarter on Compilation. Compsys, as a LIP team, is part of the Labex MILYON, which regroups Institut Camille Jordan, and the mathematics and computer science labs of ENS-Lyon. One of its goal is "to strengthen our international relationships, in particular by organizing thematic quarters which will allow world experts of a subject to gather in Lyon and work together in a stimulating environment." In this context, Alain Darte, helped by Alexandre Isoard and Laetitia Lecot, organized, from April to July 2013, a thematic quarter on compilation techniques[33], with a special focus on the interactions with languages and architectures for high performance computing. This thematic quarter, with a total budget of roughly 100 Keuros, was organized as a coherent research project, with, in addition to the "french compilation days" organized separately in Annecy by Laure Gonnord and Fabrice Rastello (April 4-7, 2013), three international scientific events, in Lyon or its vicinity.

- A **spring school on polyhedral code analysis and optimizations**[34], May 13-17, 2013, in Domaine des Hautannes in St Germain au Mont d'Or, the first international school on the polyhedral model and related optimizations. The school covered scheduling theory, algorithms and modeling with integer sets and relations, abstract interpretation, compilation for distributed platforms, array region analysis, vectorization and SIMD optimizations, through courses given by S. Rajopadhye (Colorado State Univ.), P. Feautrier (Compsys, ENS-Lyon), L.-N. Pouchet (UCLA), S. Verdoolaege (ENS Paris), A. Miné (ENS Paris), U. Bondhugula (IIS Bangalore), A. Darte (Compsys, CNRS), B. Creusillet (Silkan), P. Sadayappan (Ohio State Univ.), N. Vasilache (Reservoir Labs, New York). The school attracted 56 participants, half from France, but also from Germany, the USA, England, Belgium, Spain, China, India, Ireland, and Italy and, interestingly, also from groups that are not familiar with polyhedral optimizations. Roughly half of the participants were PhD students.

- A **dive in languages for high-performance computing**[35], June 29-July 2, 2013 in Résidence Villemanzy in Lyon, organized as a set of long keynotes on CAF (Coarray Fortran), UPC (Unified Parallel C), X10, Chapel, OpenACC & OpenHMPP, Liquid Metal, OmpSs, OpenStream, and some DSL approaches. The keynotes were given by a panel of international experts on compilation for high-performance computing: J. Mellor-Crummey and V. Sarkar (Rice), K. Yelick (Berkeley), R. Schreiber (HP Labs), B. Chamberlain (Cray), D. Grove and R. Rabbah (IBM Watson), A. Cohen (Inria, ENS Paris), R. Badia (UPC Barcelona), F. Bodin (Univ. Rennes, previously Caps Entreprise), Y. Orlarey (Grame), K. Knobe (Intel, Massachusets), P. Sadayappan (Ohio State Univ.). This event had 71 participants, including speakers, and, as we hoped, also attracted people from industry, and not only computer industry.

- **CPC'13, the 17th international workshop on compilers for parallel computing**[36], July 3-5, 2013, in Musée Gadagne, in (old) Lyon, a venue that is held every 18 months in Europe since 1989 and that encompasses all areas of parallelism and optimization linked to compilers. The program consisted in 29 talks, from the international community on compilers for HPC (from Japan & Taiwan to the USA, and of course Europe), with 47 participants.

The budget of the thematic quarter was 101 Keuros (taxes excluded): 66 Keuros from Labex MILYON, 4 Keuros from ENS-Lyon, 3.5 Keuros from DRI Inria, 26 Keuros from registration fees, and 1.5 Keuros from Compsys (CNRS funding).

[33] Thematic quarter on compilation: `http://labexcompilation.ens-lyon.fr`
[34] Spring school on polyhedral code analysis and optimizations: `http://labexcompilation.ens-lyon.fr/polyhedral-school`
[35] Keynotes on HPC languages: `http://labexcompilation.ens-lyon.fr/hpc-languages`
[36] CPC'13: `http://labexcompilation.ens-lyon.fr/cpc2013`

6.3.5 Participation in research projects and contracts

Inria AEN "Multicore". Since 2012, Fabrice Rastello is part of an Inria Large Scale Initiative (AEN: "action d'envergure nationale") called Multicore, which also regroups researchers from seven teams: Camus, Regal, Alf, Runtime, Algorille, Dali on "Large scale multicore virtualization for performance scaling and portability". One of the goals of this project is to enable loop transformations by combining dynamic and static analysis/compilation techniques.

6.3.6 Industrial contracts and collaborations

"Sceptre" project (2006-2009). In 2004, we started a tight collaboration with the compilation team of STMicroelectronics (Christian Bertin, Benoît Dupont de Dinechin, Christophe Guillon, François de Ferrière). From 2006 to 2012, this joint research effort was funded through larger governmental contracts, first Sceptre (2006-2009), then Mediacom (2009-2012), both coordinated by Alain Darte for the Inria Partners. Sceptre, funded by the "pôle de compétitivité" Minalogic[37], was led by STMicroelectronics. With many partners mainly from Rhône-Alpes, it aimed at the development of a toolkit to ease the implementation of multimedia algorithms and the generation of optimized codes for a multiprocessor reconfigurable platform. The specific task of Compsys was to work on combinatorial optimization problems coming from back-end optimization, in particular the removal of static single assignment (SSA), register allocation, and code placement for instruction cache optimization. This project was acknowledged at the end of 2009 by the government as a great success and as the first Minalogic project that ended on time and smoothly, i.e., fully in line with the initial objectives.

"Mediacom" project (2009-2012). This contract started in 2009 as part of the R&D funding mechanism Nano2012 and as the continuation of Sceptre. It focused on aggressive optimizations and on the application to just-in-time (JIT) compilation of the techniques developed in Sceptre. It implied four Inria teams: Alf, Alchemy, Arénaire, and Compsys. Unfortunately, due to a unilateral decision of the government, all Nano2012 fundings were frozen in 2011 & 2012. Inria guaranteed the salary of PhD students and of engineers/post-docs already in place, but all other salaries and the travelling budget were cut. Our activities continued, in a less ambitious format, finishing the work of post-doc and PhD students.

This long-term collaboration (since 2004) with the STMicro compilation team was a real success, with a gain for both parties. This gave us access to real industrial compilation problems, to representative benchmarks, to the STMicro assembly code optimizer in which we developed (LAO and Open64), and to an industrial expertise in compilers and processor architecture. Conversely, we helped them develop new strategies, understand previously-published approaches that needed accurate readings for a correct implementation, and our developments contributed to debug their compiler.

In terms of scientific results, our joint efforts led to important contributions in instruction cache optimization, register allocation, and static single assignment (SSA). In particular, Compsys was the first group to push the use of SSA for register allocation and to completely deconstruct the classic view on register allocation. With our colleagues from STMicro, we are now well-identified internationally for this contribution.[38] In addition to our results and publications, this research created a lot of activity in seminars, tutorials [484, 483], organization of workshops (e.g., we organized the first seminar on SSA in Autrans and were involved in the organization of CGO'11), research proposals, hiring of young researchers (in both directions), PhDs [560, 561, 563], etc. This success also contributed to the signature of a R&D national agreement between Inria and STMicro (to which Alain Darte participated) and the activation of several other Nano2012 projects.

"S2S4HLS" project (2009-2011). To support our second research axis (high-level loop transformations and high-level synthesis (HLS)), we established a second activity with STMicroelectronics, but with the HLS team (Pascal Urard, Roberto Guizzetti, Thierry Michel, Michel Favre). It was first supported by a CNRS/STMicroelectronics PhD funding (Clément Quinson, who did not finish his PhD), then as part of a second Nano2012 contract, S2S4HLS. S2S4HLS (source to source transformations for high-level synthesis) started in January 2009. The goal of this project, initiated by the Cairn Inria team, was the study and development of source-to-source program transformations, in particular loop transformations, that are worth applying on top of HLS tools. This includes restructuring transformations, program analysis, memory optimizations and array reshaping, etc. Our preliminary activities on the HLS tool UGH, then on the optimization of DDR communications with the HLS tool C2H [501], and on the analysis of while loops [500] arose in this context but we did not really succeed to find a good match between our activities and STMicroelectronics interests. Nevertheless, some of our tools (Cl@k and Bee) were integrated to Cairn's toolbox. Finally, we were about to hire a post-doc on this topic when all Nano2012 projects were frozen. These successive difficulties pushed us to quit the project in Spring 2011.

"ManycoreLabs" project (2012-2016). To compensate the funding difficulties of Nano2012 projects and to stay in line with the research directions of the team, Compsys started to be involved in 2012 in a new industrial project led by Kalray.

[37] Minalogic: `http://www.minalogic.org/`

[38] Our contribution was the heart of the recent keynote of B. Dupont de Dinechin at ETAPS'14, see `http://www.etaps.org/index.php/2014/invited-speakers`.

Kalray[39] is a french start-up, partly arising from CEA and STMicroelectronics, whose activity is to develop new manycore processors for embedded computing. The ManycoreLabs project, funded by the BGLE program ("briques génériques du logiciel embarqué"[40], is led by Kalray and involves many partners, both industrial (mainly potential customers for the Kalray MPPA architecture, such as Bull, CAPS Entreprise, Digigram, Thales, Renault) and academic (CEA, Inria Parkas and Compsys, Verimag). Our role in this project is to explore compilation techniques for streaming-like languages for this platform, in particular the analysis and compilation of streaming languages such as OpenStream. Some other studies concern cloning/specialization of code and register tiling, and are conducted by Fabrice Rastello, not as part of Compsys.

"Tirex" contract with Kalray (2012-2013). The goal of this project, collaboration between Fabrice Rastello and Kalray, was to prototype, within Tirex, some new profiling/analysis techniques necessary to enable cloning. Tirex is a toolbox to develop some low-level code optimizations on top of the minimalist intermediate code representation MinIR [536], introduced by F. Rastello, Kalray and STMicro. Because of the financial problems encountered by Kalray, some efforts related to this project were frozen in 2013.

Technological transfer towards Zettice/XtremLogic start-up. The Zettice start-up has been initiated in March 2011 by Alexandru Plesco and Christophe Alias, supported by Inria who paid Alexandru Plesco as ITT ("ingénieur transfert et innovation"). Zettice also benefited from the help of Adrian Muresan as software engineer. The goal of this initiative was to transfer some of the research concepts emerging from the polyhedral model to the context of high-level circuit synthesis, in particular by building on top of the results of Alexandru Plesco's PhD thesis [562] and on further developments linked to the Aric FloPoCo library for FPGA [476]. Since then, an important amount of applied research has been achieved to propose an effective technology for industrial transfer. From an academic perspective, Zettice is a unique opportunity to cover all aspects of high-level synthesis from the front-end aspects (polyhedral code analysis and optimization) to the back-end aspects (pipelining, retiming, FPGA mapping) providing a global knowledge of relevant industrial issues.

Zettice received in 2012 the *"lean start-up award"* of the startup weekend labs 2012, the *"most exciting start-up mention"* at SAME 2012, and the *concours Crealys Excel & Rate 2012* grant (30 Keuros). In 2013, Zettice won the *concours OSEO 2013* grant (Banque Publique d'Investissement, 40 Keuros) and the *"most promising start-up award"* at SAME 2013. Its name then changed into XtremLogic when the start-up was created (spring 2013). A patent protects some of its results [559]. The main software tools developed in the context of Zettice are Dcc [569], the front-end of the HLS tool, which takes as input an annotated C program and produces a regular process network with explicit transfers and synchronizations, and IceGEN, its back-end, which outputs both SystemC and VHDL.

6.3.7 Software production and contribution to research infrastructures

Some of our software tools are described and/or can be tested on Compsys tools webpage `http://www.ens-lyon.fr//LIP/COMPSYS/Tools/`. We developed three kinds of software tools:

- Compiler-like research tools that are used internally to implement, validate, and improve ideas presented in our papers. These tools are usually intended to be progressively extended (e.g., Syntol, PoCo, Chuba).
- Stand-alone software tools that solve particular polyhedral problems and whose goal is to contribute to the polyhedral community (e.g., PIP, Cl@k, Simple).
- Developments in external tools (e.g., in LAO, in Open64, in UGH) to incorporate specific algorithms designed by Compsys (e.g., register allocation, liveness analysis).

PIP Tool for parametric integer programming (`www.piplib.org`), developed by Paul Feautrier, then slightly improved in collaboration with Cédric Bastoul and Sven Verdoolaege. Freely available under the GPL and widely used (worldwide) in the polyhedral community.

Syntol Research tool developed by Paul Feautrier (with the help of Hadda Cherroun and Ouassila Labbani) for studying communicating regular processes (CRP) and their scheduling in a modular fashion. Not distributed.

Cl@k Stand-alone tool, developed by Fabrice Baray and Alain Darte for computing an admissible lattice (with reduced determinant) for a 0-symmetric polytope. Used to derive array mappings (linear mappings plus modulo operations) that enable the reuse of array cells (kind of sliding windows). Used in the S2S4HLS project in connexion with Bee.

Aspic Invariant generator for general counter automata. Used with C2fsm, it can be used to derivate invariant for numerical C programs, and also prove safety. Also part of the WTC (worst-case complexity) toolsuite[41], a set of examples to demonstrate the capability of the Rank tool for evaluating worse-case time complexity (number of transitions when executing an automaton). Aspic[42] implements the theoretical results of Laure Gonnord's PhD thesis on acceleration techniques and has been maintained and improved since 2007.

[39] Kalray: `http://www.kalray.eu/`
[40] BGLE: `http://www.industrie.gouv.fr/fsn/logiciel-embarque`
[41] WTC toolsuite: `http://compsys-tools.ens-lyon.fr/wtc/index.html`
[42] Aspic: `http://laure.gonnord.org/pro/aspic`

PoCo Polyhedral compilation framework [565], used by Bee, Chuba, and Rank, that provides many features to quickly prototype polyhedral analysis and optimizations. Front-end based on EDG (via Rose). Roughly 20000 lines of C++. Registered at APP ("agence de protection des programmes").

Bee Source-to-source optimizer [567] for array contraction, with analysis of the lifetime of array elements and memory mapping based on Cl@k. Roughly 2500 lines of C++. Binary of Bee+Cl@k made available for the Cairn HLS toolbox Gecos, through the S2S4HLS project. Registered at APP.

Chuba Source-level optimizer [568] that offloads a C kernel onto FPGA, with optimized communications to an external DDR memory [562, 522], initially designed to be used as a front-end to the Altera HLS tool C2H. Roughly 1000 lines of C++. Registered at APP. Software at the heart of the Zettice/XtremLogic start-up initiative.

C2fsm Extraction, from a C program, of an interpreted automaton [570]. Distributed on demand. Used to interface C programs with the abstract interpretation tool Aspic [506].

Dcc DPN ("data-aware process network") C compiler [569], front-end of the HLS tool transferred to Zettice/XtremLogic. Takes as input a C program annotated with pragmas and produces an optimized DPN, i.e., a regular process network that makes explicit the I/O transfers and the synchronizations, as exposed in [559]. Uses the analysis available in PoCo, e.g., dataflow analysis and control generation, and Bee for buffer sizing. More than 3000 lines of C++ code.

IceGen (Integrated Circuit Generator), back-end of the HLS tool transferred to the Zettice start-up. Takes as input the DPN produced by Dcc and generates a SystemC description relevant for fast and accurate circuit simulation and a VHDL description of the circuit, which can be mapped efficiently to an FPGA. Makes an extensive use of the pipelined arithmetic operators of the tool FloPoCo (Aric team). Represents more than 6000 lines of C++ code.

RanK Analysis tool [566] to decide (when possible) the termination of an interpreted automaton. Connected to 2̧fsm and Aspic to handle C while loops and to give an upper bound on their number of iterations (kind of WCET) [500]. Roughly 3000 lines of C++. See `http://www.ens-lyon.fr/LIP/COMPSYS/Tools/Ranking/`.

Simple Simplifier of affine Boolean expressions [555] and Quasts (quasi affine selection trees) used in the polyhedral community. Not yet distributed. See `http://www.ens-lyon.fr//LIP/COMPSYS/Tools/Simple/`.

SToP (Scalable Termination of Programs), extension of Rank based on the scalable technique of [518]. Conservatively checks the termination of a C program, by generating smaller programs whose termination (checked by Rank) implies the termination of the larger. In case of success, SToP infers a ranking (schedule) for the whole program. Represents more than 2000 lines of C++.

Termite LLVM implementation (in progress) of a termination algorithm that aims to scale better than Rank. Collaborative development with D. Monniaux and G. Radanne. Roughly 2000 lines of OCaml.

Developments in LAO and Open64 All our aggressive and JIT code optimizations were implemented within the compiler toolchain Open64/LAO of STMicroelectronics (mainly in the research branch, some are then rewritten in the industrial branch). These algorithms concern SSA construction and destruction, liveness analysis, instruction cache optimizations, register allocation (coalescing, spilling, register constraints). This enabled experimental studies, evaluation of algorithms, comparison of different approaches, and bug tracking as our techniques pushed the STMicroelectronics compiler beyond its limits.

MinIR MinIR (minimalist intermediate representation) is a new intermediate representation, designed to ease the interconnection of compilers, static analyzers, code generators, and other tools [536]. In addition to its specification, generic core tools have been developed to offer a basic toolkit and to help the connection of client tools.

6.3.8 Prizes and awards

- Paul Feautrier received, from the Euro-Par steering committee, an award "in recognition of his outstanding contributions to parallel processing" (2009). He was also honored in a special "P. Feautrier evening" organized during CGO'11, with all his past and present international colleagues. His 1988 "Array Expansion" seminal paper has been selected for the upcoming 25th anniversary retrospective of ICS (Int. Conf. on Supercomputing) with 34 other papers, among 1800 from 1987 to 2011.
- Our out-of-SSA paper [495] received the best paper award at CGO'09 (the third in a row after 2007 and 2008).
- The Zettice start-up received several awards, see Section 7.3.3, in particular the "concours OSEO 2013" with a prize of 40 Keuros.

6.3.9 Contribution to the scientific community and administrative responsibilities

In addition to some administrative responsibilities (see below), Compsys has put a lot of efforts in federating and animating the communities to which we belong, in particular the french community on compilation and the international community on polyhedral analysis and optimizations.

French compilation community

Until 2010, the french compiler community had no official national meetings. Laure Gonnord and Fabrice Rastello decided to motivate the different french actors to meet regularly. All groups whose activities are related to compilation were contacted and the first "compilation day" was organized in sep. 2010 in Lyon. The next sessions, in a form of 3-days workshops, took place in Aussois (winter 2010), Dinard (spring 2011), Saint-Hippolyte (autumn 2011), Rennes (summer 2012), Annecy (spring 2013, organized by Compsys again), Dammarie-les-lys (winter 2013), and Nice (summer 2014). This effort is a success: the community[43] is now well identified and such an event occurs at least once a year. The community is still animated by Laure Gonnord and Fabrice Rastello, and is now recognized as a sub-group of the CNRS GDRs ASR and GPL.

Polyhedral community

In 2011, as part of the organization of the workshops at CGO'11 (in which Fabrice Rastello and Laure Gonnord were involved), Christophe Alias (with C. Bastoul) organized IMPACT'11 (international workshop on polyhedral compilation techniques). This workshop in Chamonix was the very first international event on this topic, although it was introduced by Paul Feautrier in the late 80s. Alain Darte gave the introductory keynote [489]. After this first very successful edition (more than 60 people), IMPACT continued as a satellite workshop of the HIPEAC conference, in Paris (2012), Berlin (2013), Vienna (2014). Alain Darte is program chair for the next edition, in Amsterdam (2015). Christophe Alias is member of the steering committee, since its creation.

The creation of IMPACT[44], now *the* annual event of the polyhedral community, helped to identify this community and to make it more visible. This effort was complemented by the organization of the first (and for the moment unique) school on polyhedral code analysis and optimizations (see Section 6.3.11), in which Paul Feautrier and Alain Darte gave two courses. Compsys also manages two mailing lists for news and discussions on polyhedral code analysis and optimizations.

Other responsibilities

Administrative responsibilities

- Alain Darte is leading the Compsys team since 2004. He was vice-chair of the ENS-Lyon entrance examination (responsible for computer science), from 2001 until 2010. Until 2010, he was also in charge, with Alain Girault, of coordinating the joint research efforts of Inria and STMicroelectronics, which led to the signature of a global agreement in nov. 2008 and the initiation of Nano2012 projects.

Hiring committees ("comités de sélection")

- Alain Darte: Inria CR2 (Rocquencourt 2009, Lille 2010), Inria DR2 (2009), assistant professor at Verimag (2010), professor at ENS-Lyon in computer science (2011).
- Paul Feautrier: professor ENS-Lyon in computer science and computational biology (2009).

PhD committees

- Christophe Alias was member of the PhD jury of Antoine Morvan (Rennes, 2013).
- Alain Darte was reviewer for the PhD theses of Benoit Robillard (CNAM, 2010), Mehdi Amini (Mines ParisTech, 2012), and Cupertino Miranda (Paris 11, 2013). He will be member of the PhD jury of Romain Brillu (Univ. Nantes, nov. 2014).
- Paul Feautrier was reviewer for the PhD theses of Patrice Gérin (INPG, 2009), Louis-Noël Pouchet (Paris-Sud, 2010), Alexandre Becoulet (UPMC, 2010), and Nicolas Pouillon (UPMC, 2011). He was member of the PhD jury of Bogdan Pasca (ENS-Lyon, 2011) and will be a member of the PhD jury of Mikael Kruse (Paris Sud, sep. 2014).
- Laure Gonnord was member of the PhD jury of Clément Guy (Rennes, 2013) and reviewer for the PhD thesis of Van Chan Ngo (Rennes, 2014).
- Fabrice Rastello was member of the PhD juries of Antoniu Pop (Mines ParisTech, 2011), Boubacar Diouf (Paris-Sud, 2011), Artur Pietrek (Verimag, 2012), and Alexandre Carbon (2013).

Habilitation (HDR) committees

- Alain Darte was member of the HDR juries of Sid Touati (UVSQ, 2010) and Fabrice Rastello (ENS-Lyon, 2012).
- Paul Feautrier was reviewer for the HDR of Stéphane Mancini (TimA, 2013).

[43] Communauté française de compilation: `http://compilation.gforge.inria.fr/`
[44] IMPACT workshop series: `http://impact.gforge.inria.fr`

6.3.10 Editorial duties

- Alain Darte was member of the editorial board of *ACM Transactions on Embedded Computing Systems (ACM TECS)* until end of 2013.
- Paul Feautrier is member of the editorial boards of *Parallel Computing* and *International Journal of Parallel Programming*. He was also member of the scientific committee for the Encyclopedia of Parallel Programming, edited by David Padua, and published in 2011 by Springer. He contributed four entries [544, 545, 546, 547] (Alain Darte contributed one [543]) and reviewed more than ten entries on related subjects.
- Fabrice Rastello coordinated a book "SSA-based compiler design" [548], as a follow-up to the school on static single assignment he co-organized in 2009 (see Section 6.3.11). This book should be published soon by Springer.

6.3.11 Organization and committees of scientific conferences

Compsys organized or co-organized the following scientific events:

Spring School on Static Single Assignment In 2009, Fabrice Rastello and Sebastian Hack, with the help of Compsys members, organized the very first international event[45] entirely devoted to static single assignment (SSA), although SSA was introduced in the late 80s. It regrouped 55 people during 4 days including personalities involved in the very first developments of SSA. This unique initiative gave rise to a book [548] covering all aspects of SSA (semantics, analysis, optimizations, tools), see also Section 6.3.10.

French compilation days As explained in Section 6.3.9, Fabrice Rastello and Laure Gonnord are the two coordinators of the french community on compilation. They also organized the very first meeting in Lyon in sep. 2010, helped organizing the first 3-days meeting in Aussois in dec. 2010, and organized the 3-days meeting in Annecy in 2013.

CGO'11 In 2011, for the very first time, CGO was organized outside the USA.[46] Its organization involved members from the Alchemy and Compsys teams. Fabrice Rastello was responsible for the local organization in Chamonix, including the definition of new satellite workshops such as IMPACT'11 (organized by Christophe Alias), WIR'11 (organized by Florent Bouchez), ACCA'11 (organized by Laure Gonnord).

Streaming day Compsys has some common research interests with the Socrate Inria team from the CITI laboratory (Insa-Lyon), in particular streaming languages. In this context, Socrate and Compsys organized in apr. 2014, a thematic day on the "compilation and execution of streaming programs" in Domaine des Hautannes, St Germain au Mont d'Or, with 7 speakers and 32 participants (see the webpage of the event[47]).

Spring School on Polyhedral Code Analysis and Optimizations As part of the animation of the polyhedral community (see Section 6.3.9), Alain Darte organized in 2013 the first school related to its activities[48], including courses on the history of the polyhedral model, scheduling theory, algorithms and modeling with integer sets and relations, abstract interpretation, compilation for distributed platforms, array region analysis, vectorization and SIMD optimizations. Paul Feautrier gave a course on "The care of feeding of polyhedra" [493] and Alain Darte on "Array contraction with lattice-based memory allocation" [492], followed by a demo of Bee [567] by Christophe Alias.

Keynotes on HPC languages In 2013, Alain Darte organized a unique event, 4 days of long keynotes, on languages for HPC (high-performance/productivity computing). Different approaches and languages, such as CAF (Coarray Fortran), UPC (Unified Parallel C), X10, Chapel, OpenACC & OpenHMPP, Liquid Metal, OmpSs, OpenStream, were presented by international leaders of the field. All the material is available on the webpage[49] of the event.

Workshop on Compilers for Parallel Computing (CPC) Alain Darte organized the 17th edition of this workshop[50], a venue held every 18 months in Europe since 1989 and that encompasses all areas of parallelism and optimization linked to compilers.

Note: these last three events were part of a larger contract/research project, the **Labex MILYON thematic quarter on compilation**, see details in Section 7.3.1.

Compsys also participated to the following program and steering committees (without additional mention, the year indicates membership to the program committee):

ACCA *International workshop "analyze to compile, compile to analyze"*, Laure Gonnord (2011 – organizer).

CASES *ACM International Conference on Compilers, Architecture, and Synthesis for Embedded Systems*, Alain Darte (2009, 2011).

CC *International Conference on Compiler Construction*, Alain Darte (2011, 2012), Paul Feautrier (2009).

CGO *ACM/IEEE International Symposium on Code Generation and Optimization*, Fabrice Rastello (2009, 2011 – local chair, 2014).

[45] First Spring School on Static Single Assignment: `http://www.cdl.uni-saarland.de/ssasem`

[46] CGO'11: `http://www.cgo.org/cgo2011`

[47] Streaming day: `http://streaming.conf.citi-lab.fr`

[48] Spring School on Polyhedral Code Analysis and Optimizations: `http://labexcompilation.ens-lyon.fr/polyhedral-school`

[49] A dive in languages for high-performance computing: `http://labexcompilation.ens-lyon.fr/hpc-languages`

[50] CPC'13: `http://labexcompilation.ens-lyon.fr/cpc2013`

CPC *International Workshop on Compilers for Parallel Computing*, Alain Darte (steering committee, 2013 – organizer).
CRI *Conférence de Recherche en Informatique, Cameroun*, Fabrice Rastello (2013).
DATE *International Conference on Design, Automation, and Test in Europe*, Alain Darte (2011, 2012, 2013, 2014, 2015 – program chair of topic E2).
EUROPAR *International Conference on Parallel Computing*, Alain Darte (2009).
IMPACT *International workshop on polyhedral compilation techniques*, Christophe Alias (steering committee, 2011 – program chair, 2012, 2013, 2014), Paul Feautrier (2012, 2013, 2014, 2015), Alain Darte (2013, 2014, 2015 – program chair).
IPDPS *International Parallel and Distributed Processing Symposium*, Alain Darte (2013, 2014).
LCTES *ACM Conference on Languages, Compilers and Tools for Embedded Systems*, Alain Darte (2012).
ODES *Workshop on Optimizations for DSP and Embedded Systems*, Christophe Alias (2013).
PARCO *International Conference on Parallel Computing*, Paul Feautrier (2011, 2013, 2015).
PECCS *International Conference on Pervasive and Embedded Computing and Communication Systems*, Paul Feautrier (2015).
PLDI *ACM SIGPLAN Conference on Programming Language Design and Implementation*, Alain Darte (2009 – first FIT "fun ideas and thoughts" session).
SCOPES *International Workshop on Software and Compilers for Embedded Systems*, Alain Darte (2009, 2010).
TAPAS *Workshop on Tools for Automatic Program Analysis*, Laure Gonnord (2012).
WST *International Workshop on Termination*, Laure Gonnord (2014).

6.3.12 National and international boards and expertise, consulting activities

- Alain Darte was member of the "comité de pilotage" (steering committee) of the joint research activities of Inria and STMicroelectronics, until 2010.
- Paul Feautrier was a member of the evaluation board for the Exascale Software Stack projects of the US Departement of Energy (DOE) in 2012.
- Christophe Alias is taking an active part in the XtremLogic start-up, as co-founder and chief scientific advisor.

6.3.13 Patents, startups, and technology transfer

Compsys has always been involved in technology transfer through its industrial collaborations with STMicroelectronics and Kalray, see Section 7.3.3.

The PhD thesis of Alexandru Plesco [562], co-advised by Alain Darte and Tanguy Risset, then by Alain Darte and Christophe Alias, led to promising results for the automatic mapping of kernels to FPGA [501, 538, 522]. These results, combined with some other work [507, 476] by Christophe Alias, Alexandru Plesco, and Bogdan Pasca (from the Aric team) to exploit the pipelined operators defined by the Aric FloPoCo library, gave rise to the Zettice start-up, co-founded by Christophe Alias and Alexandru Plesco. A patent [559] describes some of the developments made in Zettice (called XtremLogic after its creation). See more details on Zettice/XtremLogic in Section 7.3.3.

6.3.14 Training and teaching activities

Laure Gonnord (from sep. 2013) is assistant professor thus has teaching duties. Christophe Alias is a full-time researcher but is also quite involved in teaching, at ENS-Lyon or elsewhere. The other members, except for a small number of teaching hours at Master 2 level, do not teach much, except through tutorials, school courses, or survey keynotes.

Teaching

- Christophe Alias (CR Inria) is in charge of the Master 1 compilation course at ENS-Lyon, since 2010 (this course was done by Paul Feautrier in 2009). He also gives a L3-level "introduction to compilation" course at ENSI Bourges and a L2-level lab on "computer architecture" at Lyon I.
- Compsys members share the Master 2 course on advanced code optimizations at ENS-Lyon: Alain Darte (2009 to 2012), Fabrice Rastello (2009, 2013, 2014), Paul Feautrier (2008, 2011), Christophe Alias (2013, 2014).
- Laure Gonnord teaches at Lyon I the L1 course on algorithmics and programming, the Master 1 compilation course, the Master 2 Pro course on system and networking.

Tutorials and "survey" keynotes

- Following our research on SSA and register allocation, Fabrice Rastello, Florent Bouchez, and Alain Darte, in collaboration with Sebastian Hack, Fernando Pereira, Jens Palsberg, and Philip Brisk, organized two tutorials on "SSA-based register allocation" CGO'09 [484] and LCPC'09 [483] (in addition to CASES'08).

- Alain Darte and Paul Feautrier gave several keynote talks on polyhedral optimizations, at LCPC'09 [487], MEMOCODE'10 [488], IMPACT'11 [489], Jornades Sarteco'14 [494], and two courses at the spring school on polyhedral code analysis and optimizations [492, 493]. Also, in sep. 2014, together with ten other specialists in automatic parallelization, Paul Feautrier will record a lecture on the "polyhedral model" for a video course on automatic parallelization to be published by the IEEE.

Organization of ENS-Lyon "Master schools" Christophe Alias and Laure Gonnord organized (i.e., defined the program and invited the speakers) 4 one-week courses for the students of the ENS-Lyon Master.

- "Beyond the PC. Application-specific systems: design and implementation", in 2010.
- "Verification and certification of software", in 2012.
- "Programming embedded systems with synchronous languages", in 2014.
- "Static analyses in the state- of-the-art compilers", to come in 2015.

PhD students Four students graduated in Compsys since 2009.

- Florent Bouchez, who graduated in 2009 [560], was co-advised by Alain Darte and Fabrice Rastello. He is now assistant professor in Grenoble.
- Benoit Boissinot, who graduated in 2010 [561], was advised by Fabrice Rastello. He is now R&D engineer at Google Zürich.
- Alexandru Plesco, who graduated in 2010, was first co-advised by Alain Darte and Tanguy Risset, then by Alain Darte and Christophe Alias. He is now CEO/CTO of XtremLogic.
- Quentin Colombet [563], who graduated in 2012, was co-advised by Alain Darte and Fabrice Rastello. He is now R&D engineer at Apple Cupertino.

Compsys has currently 3 PhD students, Guillaume Iooss (since sep. 2011), co-advised by Christophe Alias and Sanjay Rajopadhye (through a convention with Colorado State University), Alexandre Isoard (since sep. 2012), advised by Alain Darte, and Maroua Maleej (will start in sep. 2014), co-advised by Laure Gonnord and Alain Darte.

6.3.15 Interaction with the social and cultural environment

None.

6.3.16 Publications and productions

International and national peer-reviewed journals [ACL]

2009

[474] Philippe Grosse, Yves Durand, and Paul Feautrier. Methods for power optimization in SOC-based data flow systems. *ACM Transactions on Design Automation of Electronic Systems*, 14(3):1–20, 2009.

2010

2011

[475] Marie Rastello, Fabrice Rastello, Hervé Bellot, Frédéric Ousset, François Dufour, and Lorenz Meier. Size of snow particles in a powder-snow avalanche. *Journal of Glaciology*, 57(201):151–156(6), March 2011.

2012

[476] Christophe Alias, Bogdan Pasca, and Alexandru Plesco. FPGA-specific synthesis of loop nests with pipelined computational cores. *Microprocessors and Microsystems - Embedded Hardware Design*, 36(8):606–619, 2012.

[477] Benoit Boissinot, Philip Brisk, Alain Darte, and Fabrice Rastello. SSI properties revisited. *ACM Transactions on Embedded Computing Systems*, 11S(1), June 2012. Article 21, 23 pages.

[478] Paul Feautrier, Abdoulaye Gamatié, and Laure Gonnord. Enhancing the compilation of synchronous dataflow programs with a combined numerical-boolean abstraction. *CSI Journal of Computing*, 1(4):8:86 – 8:99, 2012.

2013

[479] Florian Brandner and Quentin Colombet. Elimination of parallel copies using code motion on data dependence graphs. *Computer Languages, Systems, and Structures*, 39(1):25 – 47, 2013.

[480] Naznin Fauzia, Venmugil Elango, Mahesh Ravishankar, J. Ramanujam, Fabrice Rastello, Atanas Rountev, Louis-Noël Pouchet, and P. Sadayappan. Beyond reuse distance analysis: Dynamic analysis for characterization of data locality potential. *Transactions on Architecture and Code Optimization*, 10(4), December 2013.

[481] Laure Gonnord and Peter Schrammel. Abstract acceleration in linear relation analysis. *Science of Computer Programming*, 2013. In press, Available online 10 October 2013, author version : http://hal.inria.fr/hal-00787212/en.

2014

Invited conferences [INV], seminars, and tutorials

2009

[482] Benoit Boissinot. Fast liveness checking under SSA. In *Static Single-Assignment Form Seminar*, Autrans, France, April 2009. http://www.cdl.uni-saarland.de/ssasem/.

[483] Florent Bouchez, Philip Brisk, Sebastian Hack, Jens Palsberg, and Fabrice Rastello. SSA-based register allocation. In *22nd International Workshop on Languages and Compilers for Parallel Computers (LCPC'09)*, Newark, October 2009. Tutorial.

[484] Philip Brisk, Alain Darte, Jens Palsberg, and Fabrice Rastello. SSA-based register allocation. In *International Symposium on Code Generation and Optimization (CGO'09)*, Seattle, March 2009. Tutorial.

[485] Alain Darte. Revisiting out-of-SSA translation for correctness, efficiency, and speed. In *14th Workshop on Compilers for Parallel Computing (CPC'09)*, IBM Research Center, Zurich, Switzerland, January 2009. Invited talk, http://research.ihost.com/cpc09/.

[486] Alain Darte. Translating out of SSA. In *Static Single-Assignment Form Seminar*, Autrans, France, April 2009. http://www.cdl.uni-saarland.de/ssasem/.

[487] Paul Feautrier. The polytope model, past, present, future. In *22nd International Workshop on Languages and Compilers for Parallel Computers (LCPC'09)*, Newark, October 2009. Keynote talk.

2010

[488] Alain Darte. Understanding loops: The influence of the decomposition of Karp, Miller, and Winograd. In *8th ACM/IEEE International Conference on Formal Methods and Models for Codesign (MEMOCODE'10)*, pages 139–148, Grenoble, France, July 2010. IEEE Computer Society. Invited paper and keynote talk.

2011

[489] Alain Darte. Approximations in the polyhedral model. In *1st International Workshop on Polyhedral Compilation Techniques (IMPACT'11), CGO'11 Workshop*, Chamonix, April 2011. Keynote talk.

2012

[490] Alain Darte. Kernel offloading for FPGA with optimized remote accesses. https://invasic.informatik.uni-erlangen.de/en/activities.php, May 2012. Invited seminar as part of the "invasive computing project" (Jürgen Teich).

[491] Alain Darte. Parametric tiling with pipelining, or how to automate double-buffering execution style. In *Scalable Approaches to High Performance and High Productivity Computing (ScalPerf'12)*, Bertinoro, Italy, September 2012. Invited talk. http://aacse.dei.unipd.it/cpc2012/.

2013

[492] Alain Darte. Array contraction with lattice-based memory allocation. http://labexcompilation.ens-lyon.fr/polyhedral-school/program/, May 2013. Course at the Spring School on Polyhedral Code Analysis and Optimizations.

[493] Paul Feautrier. The care and feeding of polyhedra. http://labexcompilation.ens-lyon.fr/polyhedral-school/program/, May 2013. Course at the Spring School on Polyhedral Code Analysis and Optimizations.

2014

[494] Alain Darte. Polyhedral optimizations? Not even scared! In *Jornadas Sarteco, Spanish Conference on Parallel Computing (JS'14)*, Valladolid, September 2014. Invited talk, http://www.jornadassarteco.org/?anyo=2014.

International and national peer-reviewed conference proceedings [ACT]

2009

[495] Benoit Boissinot, Alain Darte, Benoît Dupont de Dinechin, Christophe Guillon, and Fabrice Rastello. Revisiting out-of-SSA translation for correctness, code quality, and efficiency. In *International Symposium on Code Generation and Optimization (CGO'09)*, pages 114–125. IEEE Computer Society Press, March 2009. Best paper award.

[496] Laure Gonnord and Jean-Philippe Babau. Quantity of resource properties expression and runtime assurance for embedded systems. In *ACS/IEEE International Conference on Computer Systems and Applications (AICCSA'09)*, pages 428–435, Rabbat, Morocco, May 2009.

[497] Ouassila Labbani, Paul Feautrier, Eric Lenormand, and Michel Barreteau. Elementary transformation analyses for Array-OL. In *ACS/IEEE International Conference on Computer Systems and Applications (AICCSA'09)*, pages 362–367, Rabat, Morocco, May 2009.

[498] Qingda Lu, Christophe Alias, Uday Bondhugula, Sriram Krishnamoorthy, J. Ramanujam, Atanas Rountev, P. Sadayappan, Yongjian Chen, Haibo Lin, and Tin fook Ngai. Data layout transformation for enhancing locality on NUCA chip multiprocessors. In *International ACM/IEEE Conference on Parallel Architectures and Compilation Techniques (PACT'09)*, pages 348–357. ACM Press, September 2009.

[499] Marie Rastello, Fabrice Rastello, Hervé Bellot, Frédéric Ousset, and François Dufour. Size of snow particles in a powder-snow avalanche. In *ASME Fluids Engineering Division Summer Meeting 2009 (FEDSM'09)*, August 2009.

2010

[500] Christophe Alias, Alain Darte, Paul Feautrier, and Laure Gonnord. Multi-dimensional rankings, program termination, and complexity bounds of flowchart programs. In *17th International Static Analysis Symposium (SAS'10)*, pages 117–133, Perpignan, France, September 2010. ACM press.

[501] Christophe Alias, Alain Darte, and Alexandru Plesco. Optimizing DDR-SDRAM communications at C-level for automatically-generated hardware accelerators. an experience with the Altera C2H HLS tool. In *21st IEEE International Conference on Application-specific Systems, Architectures and Processors (ASAP'10)*, pages 329–332, Rennes, France, July 2010. IEEE Computer Society.

[502] Florent Bouchez, Quentin Colombet, Alain Darte, Christophe Guillon, and Fabrice Rastello. Parallel copy motion. In *13th International Workshop on Software & Compilers for Embedded Systems (SCOPES'10)*, pages 1–10, St. Goar, Germany, June 2010. ACM Press.

[503] Florian Brandner. Completeness of automatically generated instruction selectors. In *21st International Conference on Application-specific Systems Architectures and Processors (ASAP'10)*, pages 175–182, Rennes, France, July 2010. IEEE Computer Society.

[504] Florian Brandner, Viktor Pavlu, and Andreas Krall. Execution models for processors and instructions. In *28th Norchip Conference (NORCHIP'10)*, November 2010.

[505] Boubacar Diouf, Albert Cohen, Fabrice Rastello, and John Cavazos. Split register allocation: Linear complexity without the performance penalty. In *International Conference on High-Performance Embedded Architectures and Compilers (HiPEAC'10)*, volume 5952 of *Lecture Notes in Computer Science*, pages 66–80. Springer Verlag, January 2010.

[506] Paul Feautrier and Laure Gonnord. Accelerated invariant generation for C programs with Aspic and C2fsm. In *Workshop on Tools for Automatic Program Analysis (TAPAS'10)*, volume 267 of *Electronic Notes in Theoretical Computer Science*, pages 3–13, September 2010.

2011

[507] Christophe Alias, Bogdan Pasca, and Alexandru Plesco. Automatic generation of FPGA-specific pipelined accelerators. In *7th International Symposium on Applied Reconfigurable Computing (ARC'11)*, pages 53–66, Belfast, UK, March 2011. Springer Verlag.

[508] Benoit Boissinot, Florian Brandner, Alain Darte, Benoit Dupont de Dinechin, and Fabrice Rastello. A non-iterative data-flow algorithm for computing liveness sets in strict SSA programs. In *9th Asian Symposium on Programming Languages and Systems (APLAS'11)*, pages 137–154. Springer Verlag, December 2011.

[509] Quentin Colombet, Benoit Boissinot, Philip Brisk, Sebastian Hack, and Fabrice Rastello. Graph coloring and treescan register allocation using repairing. In *International Conference on Compilers, Architectures, and Synthesis of Embedded Systems (CASES'11)*, Taipei, Taiwan, October 2011. IEEE Computer Society.

[510] Quentin Colombet, Florian Brandner, and Alain Darte. Studying optimal spilling in the light of SSA. In *International Conference on Compilers, Architectures, and Synthesis of Embedded Systems (CASES'11)*, pages 25–34, Taipei, Taiwan, October 2011. IEEE Computer Society.

[511] Benoit Combemale, Laure Gonnord, and Vlad Rusu. A generic tool for tracing executions back to a DSML's operational semantics. In *7th European Conference on Modelling Foundations and Applications (ECMFA'11)*, volume 6698 of *Lecture Notes in Computer Science*, pages 35–51, Birmingham, United Kingdom, June 2011. Springer Verlag.

[512] Florent de Dinechin, Jean-Michel Muller, Bogdan Pasca, and Alexandru Plesco. An FPGA architecture for solving the table maker's dilemma. In *22nd IEEE International Conference on Application-specific Systems, Architectures and Processors (ASAP'11)*, Santa Monica, CA, September 2011. IEEE Computer Society.

[513] Abdoulaye Gamatié and Laure Gonnord. Static analysis of synchronous programs in Signal for efficient design of multi-clocked embedded systems. In *ACM SIGPLAN/SIGBED Conference on Languages, Compilers, and Tools for Embedded Systems (LCTES'11)*, pages 71–80, New York, NY, USA, 2011. ACM.

[514] David Monniaux and Laure Gonnord. Using bounded model checking to focus fixpoint iterations. In Eran Yahav, editor, *Static analysis (SAS'11)*, volume 6887 of *Lecture Notes in Computer Science*, pages 369–385. Springer Verlag, 2011.

[515] Martin Schoeberl, Pascal Schleuniger, Wolfgang Puffitsch, Florian Brandner, Christian W. Probst, Sven Karlsson, and Tommy Thorn. Towards a time-predictable dual-issue microprocessor: The Patmos approach. In *Bringing Theory to Practice: Predictability and Performance in Embedded Systems, DATE Workshop PPES'11*, volume 18, pages 11–21, Grenoble, France, March 2011.

[516] André Tavares, Quentin Colombet, Mariza Bigonha, Christophe Guillon, Fernando Pereira, and Fabrice Rastello. Decoupled graph-coloring register allocation with hierarchical aliasing. In *14th International Workshop on Software & Compilers for Embedded Systems (SCOPES'11)*, pages 1–10, St. Goar, Germany, June 2011. ACM Press.

2012

[517] Christophe Alias, Alain Darte, and Alexandru Plesco. Optimizing remote accesses for offloaded kernels: Application to high-level synthesis for FPGA. In *2nd International Workshop on Polyhedral Compilation Techniques (IMPACT'12)*, Paris, January 2012. PPoPP'12 extended version.

[518] Guillaume Andrieu, Christophe Alias, and Laure Gonnord. SToP: Scalable termination analysis of (C) programs (tool presentation). In *International Workshop on Tools for Automatic Program Analysis (TAPAS'12)*, Deauville, France, September 2012.

[519] Florian Brandner and Quentin Colombet. Copy elimination on data dependence graphs. In *27th Annual ACM Symposium on Applied Computing (SAC'12)*, pages 1916–1918, Trento, Italy, March 2012. ACM Press.

[520] Paul Feautrier. Approximating the transitive closure of a boolean-affine relation. In *2nd International Workshop on Polyhedral Compilation Techniques (IMPACT'12)*, Paris, January 2012.

2013

[521] Christophe Alias, Alain Darte, Paul Feautrier, and Laure Gonnord. Rank: A tool to check program termination and computational complexity. In *International Workshop on Constraints in Software Testing Verification and Analysis (CSTVA'13)*, page 238, Luxembourg, March 2013.

[522] Christophe Alias, Alain Darte, and Alexandru Plesco. Optimizing remote accesses for offloaded kernels: Application to high-level synthesis for FPGA. In *Design, Automation & Test in Europe (DATE'13)*, pages 575–580, Grenoble, France, March 2013.

[523] Boubacar Diouf, Albert Cohen, and Fabrice Rastello. A polynomial spilling heuristic: Layered allocation. In *International Symposium on Code Generation and Optimization (CGO'13)*, pages 1–10, Shenzhen, China, February 2013. IEEE Computer Society.

[524] Guillaume Iooss, Sanjay Rajopadhye, and Christophe Alias. Semantic tiling. In *International Workshop on Leveraging Abstractions and Semantics in High-performance Computing (LASH-C)*, Shenzhen, China, February 2013.

[525] Tomofumi Yuki, Paul Feautrier, Sanjay V. Rajopadhye, and Vijay Saraswat. Array dataflow analysis for polyhedral X10 programs. In *18th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (PPoPP'13)*, pages 23–34, Shenzhen, China, February 2013. ACM.

2014

[526] Alain Darte and Alexandre Isoard. Parametric tiling with inter-tile data reuse. In Sanjay Rajopadhye and Sven Verdoolaege, editors, *4th International Workshop on Polyhedral Compilation Techniques (IMPACT'14)*, Vienna, Austria, January 2014.

[527] Paul Feautrier, Eric Violard, and Alain Ketterlin. Improving X10 program performance by clock removal. In Albert Cohen, editor, *23rd International Conference on Compiler Construction (CC'14)*, volume 8409 of *Lecture Notes in Computer Science*, pages 113–132, Grenoble, France, April 2014. Springer.

[528] Guillaume Iooss, Christophe Alias, and Sanjay Rajopadhye. On program equivalence with reductions. In *21st International Static Analysis Symposium (SAS'14)*, Munich, Germany, September 2014.

[529] Guillaume Iooss, Sanjay Rajopadhye, Christophe Alias, and Yun Zou. CART: Constant aspect ratio tiling. In Sanjay Rajopadhye and Sven Verdoolaege, editors, *4th International Workshop on Polyhedral Compilation Techniques (IMPACT'14)*, Vienna, Austria, January 2014.

[530] Raphael Ernani Rodrigues, Péricles Alves, Fernando Pereira, and Laure Gonnord. Real-world loops are easy to predict: A case study. In *Workshop on Software Termination*, Vienne, Autriche, July 2014.

[531] Henrique Nazaré Willer Santos, Izabella Maffra, Leonardo Oliveira, Fernando Pereira, and Laure Gonnord. Validation of memory accesses through symbolic analyses. In *OOPSLA*, Portland, États-Unis, October 2014. Currently conditionnally accepted.

[532] André Tavares, Fabrice Rastello, Benoit Boissinot, and Fernando Pereira. Parameterized construction of program representations for sparse dataflow analyses. In Albert Cohen, editor, *23rd International Conference on Compiler Construction (CC'14)*, volume 8409, Grenoble, France, April 2014. Springer.

Short communications [COM] and posters [AFF] in conferences and workshops

2009

2010

[533] Christophe Alias, Alain Darte, and Alexandru Plesco. Optimizing DDR-SDRAM communications at C-level for automatically-generated hardware accelerators. an experience with the Altera C2H HLS tool. In *15th Workshop on Compilers for Parallel Computing (CPC'10)*, Vienna University of Technology, Vienna, Austria, July 2010. `http://www.complang.tuwien.ac.at/cpc10/`.

[534] Florent Bouchez, Quentin Colombet, Alain Darte, Christophe Guillon, and Fabrice Rastello. Parallel copy motion. In *15th Workshop on Compilers for Parallel Computing (CPC'10)*, Vienna University of Technology, Vienna, Austria, July 2010. `http://www.complang.tuwien.ac.at/cpc10/`.

2011

[535] Florian Brandner and Alain Darte. Compiler-driven optimization of the worst-case execution time. In Laure Gonnord and David Monniaux, editors, *Workshop "Analyse to Compile, Compile to Analyse" (ACCA'11), held with CGO'11*, Chamonix, April 2011.

[536] Julien Le Guen, Christophe Guillon, and Fabrice Rastello. MinIR, a minimalistic intermediate representation. In Florent Bouchez, Sebastian Hack, and Eelco Visser, editors, *Workshop on Intermediate Representations (WIR'11), held with CGO'11*, pages 5–12, Chamonix, April 2011.

2012

[537] Christophe Alias, Alain Darte, and Alexandru Plesco. Kernel offloading with optimized remote accesses. In *16th Workshop on Compilers for Parallel Computing (CPC'12)*, Padova, Italy, January 2012. `http://aacse.dei.unipd.it/cpc2012/`.

[538] Christophe Alias, Alain Darte, and Alexandru Plesco. Optimizing remote accesses for offloaded kernels: Application to high-level synthesis for FPGA. In *17th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (PPoPP'12)*, pages 285–286, New Orleans, USA, February 2012. IEEE Computer Society. Short paper.

[539] Quentin Colombet, Florian Brandner, and Alain Darte. Studying spilling in the light of ssa. In *16th Workshop on Compilers for Parallel Computing (CPC'12)*, Padova, Italy, January 2012. `http://aacse.dei.unipd.it/cpc2012/`.

2013

[540] Paul Feautrier, Alain Ketterlin, Sanjay Rajopadhye, Vijay Saraswat, Eric Violard, and Tomofumi Yuki. Determinacy analysis of polyhedral X10 programs. In *16th Workshop on Compilers for Parallel Computing (CPC'13)*, Lyon, France, July 2013. `http://labexcompilation.ens-lyon.fr/cpc2013/`.

[541] Guillaume Iooss, Christophe Alias, and Sanjay Rajopadhye. Semantic program optimization avoiding (some) data dependencies. Poster, 8th International Conference on High Performance and Embedded Architectures and Compilers (HiPEAC'13), January 2013. Berlin, Germany.

2014

[542] Alexandre Isoard. Data-reuse optimizations for pipelined tiling with parametric tile sizes. SRC Poster session, 23rd International Conference on Parallel Architectures and Compilation Techniques (PACT'14), August 2014. Edmonton, Alberta, Canada.

Scientific books and book chapters [OS]

2011

[543] Alain Darte. Optimal parallelism detection in nested loops. In David Padua, editor, *Encyclopedia of Parallel Programming*. Springer, 2011.

[544] Paul Feautrier. Array layout for parallel processing. In David Padua, editor, *Encyclopedia of Parallel Programming*. Springer, 2011.

[545] Paul Feautrier. Bernstein's conditions. In David Padua, editor, *Encyclopedia of Parallel Programming*. Springer, 2011.

[546] Paul Feautrier. Dependences. In David Padua, editor, *Encyclopedia of Parallel Programming*. Springer, 2011.

[547] Paul Feautrier and Christian Lengauer. The polyhedron model. In David Padua, editor, *Encyclopedia of Parallel Programming*. Springer, 2011.

Book or Proceedings editing [DO]

2014

[548] Fabrice Rastello, editor. *SSA-Based Compiler Design*. Springer, 2014. To appear.

Other Publications [AP]

2009

[549] Benoit Boissinot, Philip Brisk, Alain Darte, and Fabrice Rastello. SSI revisited. Technical Report RR2009-24, LIP, July 2009.

2010

2011

[550] Christophe Alias, Alain Darte, and Alexandru Plesco. Kernel offloading with optimized remote accesses. Research Report RR-7697, INRIA, July 2011.

[551] Christophe Alias, Alain Darte, and Alexandru Plesco. Program analysis and source-level communication optimizations for high-level synthesis. Research Report RR-7648, INRIA, June 2011.

[552] Christophe Alias, Bogdan Pasca, and Alexandru Plesco. FPGA-specific synthesis of loop-nests with pipelined computational cores. Research Report RR-7674, INRIA, July 2011.

[553] Florian Brandner, Benoit Boissinot, Alain Darte, Benoît Dupont de Dinechin, and Fabrice Rastello. Computing liveness sets for SSA-form programs. Research Report RR-7503, INRIA, April 2011.

[554] Florian Brandner and Quentin Colombet. Parallel copy elimination on data dependence graphs. Research Report RR-7735, INRIA, September 2011.

[555] Paul Feautrier. Simplification of boolean affine formulas. Technical Report RR-7689, INRIA, July 2011.

2012

[556] Guillaume Andrieu, Christophe Alias, and Laure Gonnord. Modular termination of C programs. Research Report 8166, INRIA, 12 2012.

2013

[557] Paul Feautrier, Abdoulaye Gamatié, and Laure Gonnord. Enhancing the compilation of synchronous dataflow programs with a combined numerical-boolean abstraction. Report 2nd Version, July 2013.

[558] Tomofumi Yuki, Paul Feautrier, Sanjay Rajopadhye, and Vijay Saraswat. Checking race freedom of clocked X10 programs. 11 pages, 2013.

2014

[559] Christophe Alias and Alexandru Plesco. Procédé de synthèse de circuits, dispositif et programme d'ordinateur associés. Patent number FR1453308, April 2014.

Doctoral Dissertations and Habilitation Theses [TH]

2009

[560] Florent Bouchez. *A Study of Spilling and Coalescing in Register Allocation as Two Separate Phases*. Phd, École Normale Supérieure de Lyon, April 2009.

2010

[561] Benoit Boissinot. *Towards an SSA-based Compiler Back-end: Some Interesting Properties of SSA and Its Extensions*. Phd, École Normale Supérieure de Lyon, September 2010.

[562] Alexandru Plesco. *Program Transformations and Memory Architecture Optimizations for High-Level Synthesis of Hardware Accelerators*. Phd, École Normale Supérieure de Lyon, September 2010.

2012

[563] Quentin Colombet. *Decoupled (SSA-based) Register Allocators: From Theory to Practice, Coping with Just-In-Time Compilation and Embedded Processors Constraints*. Phd, École Normale Supérieure de Lyon, December 2012.

[564] Fabrice Rastello. *On Sparse Intermediate Representations: Some Structural Properties and Applications to Just-In-Time Compilation*. HDR, École normale supérieure de Lyon, December 2012.

Other Productions: Software [AP]

[565] Christophe Alias. PoCo: A polyhedral compilation framework, 2006–2014.

[566] Christophe Alias. Rank: A tool to check program termination and computational complexity. `http://compsys-tools.ens-lyon.fr/rank/index.php`, 2010–2014.

[567] Christophe Alias and Alain Darte. Bee: A library for array contraction under scheduling constraints. `http://compsys-tools.ens-lyon.fr/bee/index.php`, 2006–2014.

[568] Christophe Alias, Alain Darte, and Alexandru Plesco. Chuba: A source-level optimizer of remote memory accesses for the HLS tool C2H of Altera, 2010–2011.

[569] Christophe Alias and Alexandru Plesco. DCC: A compiler for data-aware process networks, 2011–2014.

[570] Paul Feautrier. C2fsm: A tool to generate finite state machines from C code. `http://perso.ens-lyon.fr/paul.feautrier/c2fsm64.tgz`, 2010–2014.

[571] Paul Feautrier. A compiler for communicating regular processes. `http://perso.ens-lyon.fr/paul.feautrier/Syntol/crp64.tgz`, 2014. Work in Progress.

[572] Paul Feautrier and Cédric Bastoul. A library for parametric integer programming. `http://www.piplib.org`, 1988–2014.

[573] Laure Gonnord. Aspic: A tool to generate affine invariants from counter automata. `http://laure.gonnord.org/pro/aspic/aspic.html`, 2007-2014.

6.4 DANTE: Dynamic Networks

6.4.1 Team composition

Current members

Permanent members

Thomas Begin (Univ. Lyon I, Associate Professor (arrived in September 2009)).
Anthony Busson (Univ. Lyon I, Professor (arrived in September 2012)).
Christophe Crespelle (Univ. Lyon I, Associate Professor (arrived in September 2010)).
Éric Fleury (Team leader, ENS de Lyon, Professor / Inria Chair).[Habilite]
Paulo Gonçalves (Inria, Researcher).[Habilite]
Isabelle Guérin Lassous (Univ. Lyon I, Professor).[Habilite]
Márton Karsai (ENS de Lyon / Inria, Associate Professor / Inria Chair, from Sep 2013).

Assistant

Laetitia Lecot (Inria).

Nonpermanent members

Benjamin Guillon (Inria).
Gaetan Harter (Inria).
Huu Nghi Nguyen (ENS de Lyon, from Jan 2013).
Benjamin Girault (ENS de Lyon).
Yannick Leo (ENS de Lyon, from Feb 2013).
Lucie Martinet (ENS de Lyon).
Matteo Morini (ENS de Lyon, funded by Università degli Studi di Torino, Dep. of Economics and Public Finance, from Oct 2013).
Laurent Reynaud (France Telecom).
Thiago Wanderley Matos De Abreu (ENS de Lyon).

Former members

Researcher

Guillaume Chelius (Research Scientist, INRIA).
Pascale Vicat-Blanc (Research Scientist, INRIA).

PhD

Van Dan Nguyen (2010/2013 (Assistant Professor)).
Anne-Cécile Orgerie (2008/2011 (CR CNRS)).
Inès Doghri (2008/2011 (Engineer)).
Doreid Ammar (2009/2012 (PostDoc VTT, Finland)).
Shubhabrata Roy (2010/2013 (Engineer)).
Andreea Chis (2008 /2012 (Engineer)).
Qinna Wang (2008/2012, (Postdoc at LIP6)).
Adrien Friggeri (2009/2012, (Data scientist at Facebook)).
Elyes Ben Hamida (2007/2009 (Researcher)).
Marina Sokol (2009/2012, (Postdoc)).
Fabienne Anhalt (2008/2011 (Engineer Lyatiss)).
Dinil Mon Divakaran (2007/2010 (Assistant Professor Indian Institute of Technology Mandi)).
Pierre-Solen Guichard (2008/2010 – PhD aborted in 2nd year (Engineer EDF)).
Romaric Guillier (2006/2009 (Engineer Lyatiss)).
Guilherme Koslovski (2008/2011 (Engineer)).
Patrick Loiseau (2006/2009 (Assistant Professor Eurecom)).
Rémi Vannier (INRIA 2006/2009 (Engineer at Bretagne Telecom)).

Postdoc

Anne-Cécile Orgeriz (2011/2012 (CR CNRS)).
Sébastian Grauwin (2011/2012 (postdoc at Medialab, MIT)).

Mohamed Baslam (2012/2013 – ATER ENS de Lyon).
Qinna Wang (2012/2013 (Postdoc at LIP6)).
Émilie Diot (2011/2012 – ATER, ENS de Lyon (Professor High School)).
Ashley Chonka (2011/2012).
Manoj Dahal (2008/2009 (Professor at SMIT, India)).
Emmanouil Dramitinos (2008/2009 (engineer)).
Olivier Grémillet (2008/2009 (Engineer)).
Ibrahim Mouhamad (2009/2010).
Mohammad Jaber (2011/2012 (Researcher)).
Manoj Dahal (2008/2009 (Professor at SMIT, India)).
Emmanouil Dramitinos (2008/2009 (software engineer)).
Olivier Grémillet (2008/2009 (Engineer at Viveris Technologies)).

Engineers / Assistant

Sandrine Avakian (Inria, granted by ANR FLAB project).
Anthony Garcia (Inria, granted by Univ. Pierre et Marie Curie, until Dec 2013).
Fabien Vauvilliers (Inria, until Dec 2013).
Fabien Jammes (IC INRIA, ADT SensAS (15/10/2010 – 15/10/2012)).
Sèverine Morin (Assitant, until 15/10/2012).
Matthieu Imbert (Research Engineer INRIA – 40%).
Loïc Lemaître (IE INRIA, ADT SensTOOLS).
Jean-Pierre Poutcheu (IE INRIA, ANR SensLAB, 30/11/2009).
Rodolphe Heliot (IE INRIA, ESPAD, 15/09//2009).
Clément Burin des Rosiers (IJD INRIA, ADT SensTOOLS (10/2008 – 09/2010), IE INRIA SensLAB (10/2010 – 01/2010)).
Guillaume Roche (IE INRIA, ESPAD (11/12/2009 – 11/02/2011)).
François Lefebvre (IE INRIA, ANR SensLAB (09/05/2011 – 07/10/2011)).
Damien Ancelin (INRIA EC-GIN, 2008-2009).
Aurelien Cedeyn (ENS Lyon, 2008-2009).
Abderhaman Cheniour (INRIA AUTONOMIC INTERNET, 2008-2010).
Oana Goga (INRIA ADT ALADDIN, 2008-2009).
Philippe Martinez (INRIA DTI, 2008-2010): Engineer Sysfera).
Marcelo Pasin (INRIA EC-GIN, 2007-2008), Assistant Professor University of Lisbon).
Augustin Ragon (INRIA OGF EUROPE, 2009-2010): Engineer Sysfera).
Armel Soro (INRIA ADT ALADDIN, 2009-2010), Engineer Lyatiss).
Sébastien Soudan (INRIA EC-GIN, 2009-2010): Engineer Lyatiss).

Visitors

Céline Robardet (Délégation INRIA (sept 2008 – august 2009), INSA Lyon).
Alexandre Brandwajn ((UCSC, from April to June 2010)).
Mónica Aguilar-Igartua (Academy of Science and Technology in Vietnam, June 2011).
Renaud Lambiotte (University of Namur in Belgium, November 2011.).
Mariano Beiro (Intitut de la Francophonie pour l'Informatique in Hanoï (Vietnam), Master internship in the D-NET team for six months from March to September 2011).
Thi Ha Duong Phan (Academy of Science and Technology in Vietnam, May - June 2012).
Renaud Lambiotte (University of Namur in Belgium, January 2012).
Klaus Wehmuth (LNCC Brasil, April 2012).
Prasan Kumar Sahoo (Chang Gung University, Taïwan, November 2012).
Pranav Jindal (IIT Bombay, India, from May to July 2012, Master internship).
Jiri Spilka (ENS de Lyon, from Oct 2013 until Dec 2013).
Klaus Wehmuth (LNCC Brasil, 2013).
Artur Ziviani (LNCC Brasil, 2013).
Gerardo Iñiguez (Aalto University (Finland), 2013).
Thi Ha Duong Phan (Academy of Science and Technology in Vietnam, Mars-April 2014).

6.4.2 Life of the team

To foster the collaboration and discussion, we set up a team seminar that is usually held on Friday morning. The topics of the seminar oscillate between signal over graph sessions and network science sessions. The goal is to have a real "working session" on ongoing work, so most of the times, speakers are inter to ENS de lyon. This DANTE seminar is jointly organised with the SISYPHE (SIgnaux, SYstèmes et PHysiquE) team of the physic lab at ENS de Lyon. The seminar is hosted by IXXI and thus open to all IXXI residents. Note that Paulo Gonçalves also initiate at the beginning of the DANTE team a series of short tutorials on signal processing so that every member may get a common vocabulary and notions on the subject.

We also organise jointly with the MC2 team, a seminar on graphs and discrete structures. It is usually held on Tuesday afternoons. Most talks are given by visitors. In addition to members of the two organizing teams, this seminar regularly attracts some audience from Université Lyon I. The seminar's web page is `http://www.ens-lyon.fr/LIP/MC2/groupe-de-travail-graphes-et-structures-discretes/`.

The DANTE team is hosted by IXXI. The IXXI institute is not in the main ENS de lyon building but very close.

6.4.3 International collaborations resulting in joint publications

We have close collaboration with Alexandre Brandwajn (UCSC, USA) (he'll be a invited professor within DANTE in 2015) ; with Artur Ziviani (LNCC, Brazil); A. Vespignani (Northeastern University, Boston, USA); Jiri Spilka. (Czech Technical University in Prague); R. Lambiotte (University of Namur, Belgium); Thi Ha Duong Phan (Hanoi, Vietrnam); Bijan Jabbari (G. Manson University - Washington); Mónica Aguilar-Igartua (UPC Spain)

6.4.4 Management of research projects and contracts

- SENSLAB (ANR, Inria). The purpose of the SensLAB project is to deploy a very large scale open wireless sensor network platform. SensLAB's main and most important goal is to offer an accurate and efficient scientific tool to help in the design, development, tuning, and experimentation of real large-scale sensor network applications. The sensLAB platform is distributed among 4 sites and is composed of 1,024 nodes. Each location hosts 256 sensor nodes with specific characteristics in order to offer a wide spectrum of possibilities and heterogeneity. The four test beds are however part of a common global testbed as several nodes have global connectivity such that it is possible to experiment a given application on all 1K sensors at the same time.

- DyVi (INRIA ARC) The goal of the ARC DyVi is to build a foundation for dynamic graph theory in order to be able to describe properties and design efficient and specific algorithmic for dynamic graph and overlapping communities The goal is to be able to tackle multi time scale visualization tools based on TULIP, to implement data structure / handling / time scale aggregation / browsing within the TULIP software developed by the INRIA GRAVITE team. We also target epidemic process visualization in order to be able to run and "see" dynamic processes on dynamic networks

- SensAS (INRIA ADT) The ambition of SensAS is to deploy wireless sensor and actuator applications. From the strong expertise gather in MOSAR, SensLAb and SensTOOLS, the goal is to transfer and help other INRIA research team to deploy their own application, not in the restricted networking area: flying drones, robots fleet, biologging, health, management.

- SensTOOLS (INRIA ADT) The main and most important goal of the SensTOOLS ADT project is to foster the design, development, tuning, and experimentation of real large scale sensor network applications. Sensor networks have recently emerged as a premier research topic. However, due to their massively distributed nature, the design, implemen- tation, and evaluation of sensor network applications, middleware, and communication protocols are difficult time-consuming tasks. The purpose of the SensTOOLS is to provide both software and hardware toolboxes in order to offer the developer appropriate tools and methods for designing, testing and managing his/her large scale wireless sensor network applications.

- Dispop (IXXI) Dispop is a biologging project funded by the Rhône-Alpes Institute of Complex Sciences. Biologging consists in equipping animals with tracking and sensing devices such that its mobility, environmental conditions and social interactions can be monitored. This project's goal is more particularly to explore and develop the measure and analysis tools which could help in modeling the dynamic of populations as a response to environmental factors. This project hosts members of the D-NET team and the DEPE – Département Ecologie, Physiologie et Ethologie department of the IPHC – Institut Pluridisciplinaire Hubert Curien (Strasbourg, France).

- ESPAD (FEDER) The ESPAD (Embedded Sport Performance Analysis Data) is bio-mechanics / physiology logging project funded by FEDER. The goal is to contributed to the design of a distributed multi-sensor architecture that can be worn by an individual and that records bio-mechanical, physiological and environmental data.

6.4.5 Participation in research projects and contracts

National initiatives

- IGTMD (ANR, ENSL, 2006-2009) The aim of this project is to design, develop and validate mechanisms that concretely make the interoperability of heterogeneous grids a reality. The project concentrates on the following topics: a) Bulk data transfers, b) replication and referring mechanisms, c) information system and job management interoperability, d) grid control and monitoring, e) usage of statistics and accounting data.

- HIPCAL[51] (ANR, Inria, 2007-2010). The goal of this project was to explore an approach in a break with current services-oriented principles developed in grids, to enhance the application portability, the communications performance control and their security, simultaneoulsy. HIPCAL studied a new paradigm (grid substrate) based on confined virtual private execution infrastructure for resource control in grids. In particular, we proposed and implemented new approaches for bandwidth sharing and end to end network quality of service guarantees. Use-cases in biomedical applications deployed on GRID'5000, served as proof-of-concept. Joint project between Inria (REDO, GRAND LARGE, PLANETE) and CNRS (IBPC, I3S).

- RESCUE[52] (ANR, ENSL, 2010-2013). RESCUE follows the ARC MISSION project. In RESCUE, we investigate both the underlying mechanisms and the deployment of a substitution network, aimed at overcoming local failures on a base network, maintaining a satisfactory level of service to the users. Unlike many projects and other scientific works that consider mobility as a drawback, in RESCUE we use the controlled mobility of the substitution network (composed of a fleet of dirigible wireless mobile routers) to help the base network reduce contention or to create an alternative network in case of failure. The advantages of an on-the-fly substitution network are manifold: Reusability and cost reduction; Deployability; Adaptability. Other partners of this project are the Inria team POPS, LIP6, LAAS, and France Telecom.

- MISSION (Inria, 2010-2011) stands for MobIle SubStitutIOn Networks and is focused on the performance study and the feasibility to deploy a fleet of mobile wireless routers to help a wired network that can not offered its services anymore (e.g., due to a failure). Other partners are: LIP6 (Paris) and Inria Lille.

- PETAFLOW[53] (ANR, ENSL, 2009-2012) Generation or processing of peta-scale data benefits from the emergence of adequate *Information and communication technologies* with respect to high performance *computing-networking-visualization* and their mutual *awareness*. In this project, RESO aims at proposing network solutions to guarantee the Quality of Service (in terms of reliability level and of transfer delay properties) of a high speed, transnational long-distance connection used in an interactive, high performance computing application. Another specificity of this application is the peta-scale volume of the treated data corresponding to the upper airway flow modeling.

- DMASC (ANR, Inria, 2008-2012) The main objective is to develop advanced multifractal analysis tools, from mathematically ground results to efficient estimators. We apply these methods to the analysis, to the modeling and to the classification (for non invasive diagnoses) of cardiovascular systems. This project, leaded by J. Barral (Univ. Paris 13), is a partnership between Inria (SISYPHE and RESO), university of Paris 12 and Paris 13 and Paris Sud (équipe d'accueil EA 4046 Service de Réanimation Médicale CHU de Bicêtre).

- Complex Networks Metrology (RNSC) D-NET is a member of the project Complex Networks Metrology involving LIP6 (Université Paris 6), LSIIT (Université de Strasbourg) and LIP (ENS de Lyon, Université Lyon 1). The project, funded by RNSC (Réseau National des Systèmes Complexes), started in January 2011 and ended in December 2011. Its goal is to design rigorous methods for measuring complex networks. The originality of our appraoch is to lead measurements dedicated to a specific property instead of trying to get a complete view of the network, which has been showed to lead to significant biases in the obtained view. Its major domain of application is Internet measurements.

- FLAB (ANR, Inria). As proposed by initiatives in Europe and worldwide, enabling an open, general-purpose, and sustainable large-scale shared experimental facility fosters the emergence of the Future Internet. There is an increasing demand among researchers and production system architects to federate testbed resources from multiple

[51] http://www.ens-lyon.fr/LIP/RESO/Projects/HIPCAL/ProjetsHIPCAL.html
[52] http://rescue.lille.inria.fr/
[53] http://petaflow.gforge.inria.fr/

autonomous organizations into a seamless/ubiquitous resource pool, thereby giving users standard interfaces for accessing the widely distributed and diverse collection of resources they need to conduct their experiments. The F-Lab project builds on a leading prototype for such a facility: the OneLab federation of testbeds. OneLab pioneered the concept of testbed federation, providing a federation model that has been proven through a durable interconnection between its flagship testbed PlanetLab Europe (PLE) and the global PlanetLab infrastructure, mutualizing over five hundred sites around the world. One key objective of F-Lab is to further develop an understanding of what it means for autonomous organizations operating heterogeneous testbeds to federate their computation, storage and network resources, including defining terminology, establishing universal design principles, and identifying candidate federation strategies. On the operational side, F-Lab enhances OneLab with the contribution of the unique sensor network testbeds from SensLAB, and LTE based cellular systems. In doing so, F-Lab continues the expansion of OneLab's capabilities through federation with an established set of heterogeneous testbeds with high international visibility and value for users, developing the federation concept in the process, and playing a major role in the federation of national and international testbeds. F-Lab also develops tools to conduct end-to-end experiments using the OneLab facility enriched with SensLAB and LTE.

- ANR INFRA DISCO (DIstributed SDN COntrollers for rich and elastic network services) project: the DANTE team will explore the way SDN (Software Designed Network) can change network monitoring, control, urbanisation and abstract description of network resources for the optimisation of services. More specifically, the team will address the issues regarding the positioning of SDN controllers within the network, and the implementation of an admission control that can manage IP traffic prioritisation.

- ANR FETUSES: The goals of this ANR project consist in the development of statistical signal processing tools dedicated to per partum fetal heat rate characterisation and acidosis detection, and are organised as follows: – construction of a large dataset of per partum fetal heart rate recordings, which is well documented and of significant clinical value; – Developments of adaptive (*e.g.* data driven) algorithms to separate data into trend (deceleration induced by contractions) and fluctuation (cardiac variability) components; – Developments of algorithms to characterise the non stationary and multifractal properties of per partum fetal heart rate ; – Acidosis detection and assessment using the large datasets; – Algorithm implementation for performing tests in real clinical situations. ANR is a joint project between DANTE, the Physics Lab of ENS Lyon (SiSyPhe team) and the *Hôpital Femme-Mère-Enfant* of Bron (Lyon). Fetuses started in january 2012.

- ANR CONTINT CODDDE accepted in December 2013: It is a collaborative project between the ComplexNetwork team at LIP6/UPMC; Linkfluence and Inria Dante. The CODDDE project aims at studying critical research issues in the field of real-world complex networks study:

  - How do these networks evolve over time?
  - How does information spread on these networks?
  - How can we detect and predict anomalies in these networks?

  In order to answer these questions, an essential feature of complex networks will be exploited: the existence of a community structure among nodes of these networks. Complex networks are indeed composed of densely connected groups of that are loosely connected between themselves.

  The CODDE project will therefore propose new community detection algorithms to reflect complex networks evolution, in particular with regards to diffusion phenomena and anomaly detection.

  These algorithms and methodology will be applied and validated on a real-world online social network consisting of more than 10 000 blogs and French media collected since 2009 on a daily basis (the dataset comprises all published articles and the links between these articles).

- EQUIPEX FIT (Futur Internet of Things) FIt is one of 52 winning projects in the Equipex research grant program. It set up a competitive and innovative experimental facility that brings France to the forefront of Future Internet research. FIT benefits from 5.8 million grant from the French government Running from 2011 to 2019. The main ambition is to create a first-class facility to promote experimentally driven research and to facilitate the emergence of the Internet of the future.

European projects

- AEOLUS (FP6, Inria, 2005-2009). Acronym for "Algorithmic Principles for Building Efficient Overlay Computers", AEOLUS investigated the principles and developed the algorithmic methods for building an overlay computer that enables an efficient and transparent access to the resources of an Internet-based global computer. The university of Patras (Greece) was the prime contractor.

- EURO NF (FP7 NoE, 2008 - 2010). Anticipating the Network of the Future - From Theory to Design. Euro-NF is a Network of Excellence on the Network of the Future, formed by 35 institutions (from the academia and industry) from 16 countries. Its main target is to integrate the research effort of the partners to be a source of innovation and a think tank on possible scientific, technological and socio-economic trajectories towards the network of the future.

- EC-GIN[54] (FP6, Inria, 2006-2009) Based on a number of properties that make Grids unique from the network perspective, the project EC-GIN has developed a tailored network technology in dedicated support of Grid applications. These technical solutions have been supplemented with a secure and incentive-based Grid Services network traffic management system, which balanced the conflicting performance demand and the economic use of resources in the network and within the Grid. EC-GIN outcomes stemmed from a close academic collaboration between Europe (Inria, UIBK, UniZH, ULANC, UniS, UIO) and China (BUPT, CTTL, CMDI).

- GEYSERS[55] (FP7, Inria, 2009-2012) The goal was to qualify optical infrastructure providers and network operators with a new architecture, to enhance their traditional business operations. Following this objective, GEYSERS specifies and implements a novel optical-network architecture able to support "Optical Network+Any-IT" resource provisioning seamlessly and efficiently. Energy-consumption metrics for the end-to-end service routing are part of this efficiency. The consortium involves more than 20 academic and industrial partners from Europe (Italy, Switzerland, Germany, Poland, The Netherlands, Greece, Belgium, UK, Spain) and India.

- SAIL[56] (FP7, Inria, 2009-2012) Sought objective is the research and the development of novel networking technologies using proof-of-concept prototypes to lead the way from current networks to the Network of the Future. SAIL leverages state of the art architectures and technologies, extends them as needed, and integrates them using experimentally-driven research, producing interoperable prototypes to demonstrate utility for a set of concrete use-cases. REDO contributes to workpackage D on *Cloud Networking*. The consortium comprises 25 academic and industrial partners from Europe (Sweden, Germany, Finland, UK, France, Spain, Portugal, Ireland) and from Israel and Australia.

- WASP (FP6-IST) WASP is an Integrated Project supported for 4 years by the European Commission under the Information Society Technologies of the Sixth Framework Program. An important class of collaborating objects is represented by the myriad of wireless sensors, which will constitute the infrastructure for the ambient intelligence vision. The academic world actively investigates the technology for Wireless Sensor Networks (WSN). Industry is reluctant to use these results coming from academic research. A major cause is the magnitude of the mismatch between research at the application level and the node and network level. The WASP project aims at narrowing this mismatch by covering the whole range from basic hardware, sensors, processor, communication, over the packaging of the nodes, the organization of the nodes, towards the information distribution and a selection of applications. The emphasis in the project lays in the self- organization and the services, which link the application to the sensor network. Research into the nodes themselves is needed because a strong link lies between the required flexibility and the hardware design. Research into the applications is necessary because the properties of the required service influence the configuration of both sensor network and application for optimum efficiency and functionality. All inherent design decisions cannot be handled in isolation as they depend on the hardware costs involved in making a sensor and the market size for sensors of a given type.

- MOSAR (FP5, Inria, 2008-2012). MOSAR brings together internationally recognized experts to address the issue of antimicrobial resistance in a comprehensive manner. MOSAR consideres the major issue of antimicrobial resistance in the perspective of a complex system and not only through the prism of a single discipline.

  To achieve its objectives MOSAR builds on advances generated by basic sciences, through dedicated and trans-disciplinary cooperation. This project integrates studies from epidemiology and basic laboratory sciences, clinical medicine, statistical sciences, behavioural sciences, and health economics. MOSAR network is structured into 10 interacting groups centered on the patients.

  MOSAR focuses on major endemic and epidemic nosocomial pathogens such as Methicillin-resistant Staphylococcus aureus (MRSA), Vancomycin-resistant Enterococci (VRE), Extended-Spectrum Beta-Lactamases (ESBL) Enterobacteriaeceae, and Carbapenem-resistant Acinetobacter spp, and in interventional trials in high-risk areas (Intensive Care Units, Surgery and Rehabilitation centers) of countries with high-level of resistance.

[54] http://www.ec-gin.eu/corpsite/display/main.asp
[55] https://www.geysers.eu/
[56] http://www.sail-project.eu/

Associated teams and other international projects

- GRID-NET (Associated team Inria-AIST Japan, 2007-2009). Thanks to this collaboration, we investigated four main directions: 1) High speed transport protocol over very high speed links, 2) Bandwidth allocation and control in Grids, 3) Optimisation of MPI communications in Grids, and 4) Co-design of GtrcNET-packet capture functionality. The integration of the Gtrc-Net 1 and 10 (developed at AIST) into the GRID'5000 infrastructure led us to a series of noticeable results that are described in the scientific achievements of axes 2, 3 and 4 (e.g BDTS, Metroflux, MPI5000).

- NEGST (JSPT-CNRS). The objective of this project was to promote the collaborations between Japan and France on grid computing technology. We considered three main lines of investigation: 1) Grid interoperability and applications; 2) GridMetrics and 3) Instant Grid and virtualization of grid computing resources. RESO mainly participates to the Grid Metrics topic.

- CoDyN (Inria/FAPERJ – Complex Dynamic Networks) between LNCC and DNET/Inria. The main goal of the CoDyN project is to lay solid foundations to the characterization of dynamically evolving networks, and to the field of dynamical processes occurring on large scale dynamic interaction networks.

- PICS CNRS Combinatorial Structures for Complex Network Modeling. DANTE is a member of a PICS project of the CNRS between the Academy of Science and Technology in Vietnam and the Laboratoire d'Informatique de Paris 6 (LIP6) and Université Claude Bernard Lyon 1 in France. Its goal is to design models of complex networks that are able to capture at the same time two of their most relevant properties : their heterogeneous degree distribution and their high local density. The goal is to provide very general models that do not make stronger assumptions on the structure of the graphs to be modeled. Our approach is based on the overlapping structure of cliques in complex networks and uses mainly tools coming from combinatorics, graph theory and statistics.

- STIC AMSUD – DYNAMICS OF LAYERED COMPLEX NETWORKS D-NET is a member of a STIC AMSUD project between the National Laboratory for Scientific Comput- ing (LNCC) in Brazil, the Faculdad de Ingeniera Universidad de Buenos Aires in Argentina, Laboratoire d'Informatique de Paris 6 (LIP6) and ENS Lyon in France. The goal of the project is mainly to investigate the fundamental characteristics of dynamic graphs and their applicability to the analysis of layered complex networks.

6.4.6 Industrial contracts and collaborations

- CARRIOCAS[57] (Competitive pole System@tic, Inria, 2006-2009). In this collaborative work we studied and implemented an ultra high bit rate (up to 40 Gbps per wavelength) network interconnecting super computers, storage servers and high resolution visualization devices to support data and computing intensive applications in industrial and scientific domains. This testbed was intended to be the experimental first step towards a transition from local to external storage and computing systems. More specifically, RESO was in charge of the design and the prototyping of the "Resource Scheduling Reconfiguration and Virtualization - SRV" component. As a regional initiative, this project gathered under the coordination of Alcatel-Lucent, more than 20 academic and industrial IT actors from *Ile de France* (participation of RESO stemmed from our close collaboration with the Inria team GRAND LARGE).

- INRIA ALCATEL LUCENT BELL LABS[58] (Common laboratory, 2008-2012)
  RESO participates in the Research Action *Semantic Networking* (SEM- NET) which advocates a new paradigm for the networks of the future bringing together *flow-based networking*, *traffic-awareness* and *self-management* concepts to get *plug-and-play* networks. The natural traffic granularity is the flow. RESO's task is to elaborate on the admission control of flows in routers having in mind the current status of the network and the underlying applications. In a different work, we also consider the problem of graph-based semi-supervised approaches applied to content- and user-based classifications in networks.
  Besides Alcatel Lucent, we are mostly working with the Inria team MAESTRO.

- INRIA ALCATEL-LUCENT BELL LABS JOINT LABORATORY. DANTE participate in the research action *Network Science*. The main scientific objectives of network science are:

  - to design efficient tools for measuring specific properties of large scale complex networks and their dynamics;
  - to propose accurate graph and dynamics models (*e.g.*, generators of random graph fulfilling measured properties);

[57] http://www.systematic-paris-region.org/fr/projets/carriocas
[58] http://inria.bell-labs.commonlab.homeip.net/

- to use this knowledge with an algorithmic perspectives, for instance, for improving the QoS of routing schemes, the speed of information spreading, the selection of a target audience for advertisements, etc.

The ADR will focus on:

- Network sampling
- Epidemics in networks
- Search in networks
- Clustering of networks
- Detecting network central nodes
- Network evolution and anomaly detection

• FRANCE TELECOM R&D (Cifre, Inria, 2005-2008). The subject of this industrial contract was “Network load balancing on layer 7 switching for high performance and high available Linux based platforms".

• ANAGRAN (Inria, 2008). We have designed and ran experimentations of the ANAGRAN FR router within GRID'5000.

• A bilateral contract has been signed between the DANTE Inria team and ACT750 to formalize their collaboration in the context of churn prediction.

• A bilateral contract has been signed between the DANTE Inria team and KRDS to formalize their collaboration in the context of Facebook marketing / cascade analysis.

• A bilateral contract has been signed between the DANTE Inria team and HiKoB to formalize their collaboration in the context of the Equipex FIT (Futur Internet of Things) FIt is one of 52 winning projects in the Equipex research grant program. It will set up a competitive and innovative experimental facility that brings France to the forefront of Future Internet research. FIT benefits from 5.8 euros million grant from the French government Running from 22.02.11 – 31.12.2019. The main ambition is to create a first-class facility to promote experimentally driven research and to facilitate the emergence of the Internet of the future.

• A bilateral contract has been signed between the DNET INRIA and SALOMON to formalize their collaboration in the context of the XtremLog projet. This collaboration is based on an exchange of good services : SALOMON offers to adapt its equipments to integrate the sensor nodes designed by the INRIA for the Marathon des Sables experiment

6.4.7 Software production and contribution to research infrastructures

• *Lyatiss Weaver Suite*. The following list of softwares, whose development was initiated at Reso, represent a direct outcome of the research carried out at Resountil Aug. 2011. They also form the core of the technological transfer to Lyatiss; embedded in the *Lyatiss Weaver Suite*, they implement the solutions for virtual resources orchestration and infrastructure services:

BDTS Dynamic network bandwidth allocation, bulk data transfers scheduling.
APP: JBDTS version 1, Dec. 15, 2007: IDDN.FR.001.220025.000.S.P.2008.000.10700

FLOC Limitation and triggering of flow rate.
APP: version 0.12, Feb. 17, 2009: IDDN.FR.001.290009.000.S.P.2009.000.10200

NXE Definition, configuration, deployment, run and analysis of a large scale experiment for protocol evaluation.
APP: version 1.0, Nov. 2008: IDDN.FR.001.030005.000.S.P.2009.000.10800

VXcore Resource temporal database manager.
APP: version 1.0, March 15, 2009: IDDN.FR.001.290012.000.S.P.2009.000.10800

VXtopology Resource spacial database manager.
APP: version 1.0, March 15, 2009: IDDN.FR.001.290012.000.S.P.2009.000.10800

VXScheduler Adaptation of virtual infrastructure request and scheduling.
Patent version 1.0, March 15, 2009: IDDN.FR.001.290010.000.S.P.2009.000.10800

VXDL Parser interpretation and XML traduction of virtual infrastructures specifications.
Patent version 2.0, March 20, 2009: IDDN.FR.001.260009.000.S.P.2009.000.10800)

SRVdemonstrator Scheduling, Reconfiguration and Virtualization of Network resources for intensive computing environment.

PATHNIF Systematic analysis and evaluation of the capacity of potential bottlenecks and of end to end network paths.
APP: version 1.0, March 2009: IDDN.FR.001.260002.000.S.P.2009.000.10800

HIPerNet v0.5 Cloud solution HIPerNet engine is a software implementing discovery, selection, allocation, scheduling and management of virtual private execution infrastructures over the Internet. HIPerNET v0.5 is focusing on virtual end-resource deployment and configuration.
Distributed under GPL license.

- *Classical queueing systems solver*. This tool provides a simple web application[59] to promote the use of our algorithms for solving classical queueing systems. It currently features the numerical solution to the steady-state distribution for the number of customers in the system and other customary performance parameters for a queue with multiple servers, general arrivals, exponential service times and a possibly finite buffer, (i.e., $G/M/c$-like and $G/M/c/N$-like queue). The steady-state solution to this queue is based on a simple and stable recurrence whose leverages the use of conditonal probabilities [608]. This tool is a joint work with Pr. Brandwajn (University of California Santa Cruz). We will include new models to this tool in the near future. As of beginning of 2012, this site is averaging over 15 unique visits per day.

- *Sensor Network Tools: drivers, OS and more*. As a outcomes of the ANR SensLAB project and the INRIA ADT SensTOOLS and SensAS, several softwares (from low level drivers to OSes) were delivered and made available to the research community. The main goal is to lower the cost of developing/deploying a large scale wireless sensor network application. All software are gathered under the SensLAB web site: http://www.senslab.info/ web page where one can find:
  - low C-level drivers to all hardware components;
  - ports of the main OS, mainly TinyOS, FreeRTOS and Contiki;
  - ports and development of higher level library like routing, localization.

- *WSnet*. WSnet is a wireless sensor network simulator that was designed to offer the following features:
  - a modular, flexible and accurate simulation of the radio physical medium;
  - support for the simulation of environmental phenomena;
  - support for interaction between nodes and their environment (sensor-actuator architecture);
  - interconnection with the sensor platform emulator WSim to support the distributed emulation of wireless sensor networks.

  WSNet is currently in its second release. The number of WSNet users is still growing and several research works reference the software. Many pointers can be found on the project website. Maintenance and support of the software is handled by the D-NET project but also by several contributors from the CITI laboratory (INSA de Lyon), Orange R&D. The WSNet community is quietly spreading in France as well as abroad.‘

- *WSIM*. WSim is a platform simulator. It relies on cycle accurate full platform simulation using microprocessor instruction driven timings. The simulator is able to perform a full simulation of hardware events that occur in the platform and to give back to the developer a precise timing analysis of the simulated software.

  The native software of the node can be used in the simulator without the need to reconfigure or recompile the software. We use a classical GCC cross-compiler toolchain and the simulation is not attached to any particular language nor operating system. We are thus able to debug and evaluate performances of the full system at the assembly level. A precise estimation of timings, memory consumption and power can be obtained during simulation. FreeRTOS, Contiki and TinyOS operating systems have been successfully tested on simulation platforms.

  The simulator can be used in standalone mode for debuging purposes when no radio device is used in the design (or when the radio simulation is not needed). But one of the main WSim feature is its interface with the WSNet simulator to perform the simulation of a complete sensor network.

  See also the `http://wsim.gforge.inria.fr/` web page.

[59] `http://queueing-systems.ens-lyon.fr`

- *Sensor node hardware*. As a outcomes of the ANR SensLAB project, the INRIA ADT SensTOOLS and equipped FIT, several hardware modules and daughter cards were delivered and made available to the research community. One goal is to provide both generic and specialized sensor boards (GPS accelerometer, Test, Strain, Bluetooth, Motion capture, Heart rate) in order to span a large class of sensor network applications.

  All the hardware designed are gathered under the SensLAB web site: https://www.iot-lab.info/hardware/ and all are released under a creative common license.

6.4.8 Prizes and awards

- Classification of Content and Users in BitTorrent by Semi-supervised Learning Methods [] was granted the best paper award at the 3rd International Workshop on Traffic Analysis and Classification (in conjunction with the 8th International Wireless Communications and Mobile Computing Conference, 2012).
- Hurst Exponent IntraPartum Fetal Heart Rate: Impact of Decelerations [] was granted the best paper award in the 26th IEEE International Symposium on Computer-Based Medical Systems (CBMS 2013).
- Automated Traffic measurements and analysis in Grid'5000[] was granted for the Best Demonstration award at ACM SIGMETRICS/PERFORMANCE (Seattle, US) (2009)
- Community detection with fuzzy community structure [] was granted the best paper award at ASONAM 2011
- Pascale Vicat-Blanc: Prix Inria – Académie des sciences – Dassault Systèmes de l'innovation 2013
- The technological transfer to the startup Lyatiss was awarded several national and international prizes to Lyatiss.
- The technological transfer to the startup HiKoB was awarded several national and international prizes to HiKoB[60].

6.4.9 Contribution to the scientific community and administrative responsibilities

Guillaume Chelius was a member of the IXXI – Complex Systems Institute scientific board.

Christophe Crespelle : Christophe Crespelle is in the in the steering committee of the IXXI – Rhône-Alpes Complex Systems Institute and elected member of the sterring committe of the LIP laboratory.

Éric Fleury : He is the head of the Inria team DANTE. He is co-chair of the Networking group ResCom of the CNRS GDR ASR. He is also a member of the scientific committee of the CNRS GDR ASR and was member of the "Networks" expert committee of the CNRS. He is in the steering committee of the IXXI – Rhône-Alpes Complex Systems Institute. He is Vice-Chairman of the projects committee of Inria Grenoble Rhône-Alpes research center and member of the Inria Evaluation committee. He is member of the executive committee of the Labex MILYON. He was the head of the computer science department of ENS de Lyon until 2013 and head of the Inria project team DNET. He was member of the national PES board for the computer science section (2009 - 2011).

Paulo Gonçalves : He was the head of the Inria project team Reso from 2010 to 2013. He is scientific correspondent of the International Relations for Inria Grenoble - Rhône-Alpes and the scientific correspondent of the International Relations for the Computer Science Department at ENS Lyon and member of the Commission of Technological Development of Inria Grenoble RA

Isabelle Guérin Lassous : Isabelle Guérin Lassous is member of the CNRS National Committee for section 06 (Computer Science). She was the member of the jury of the second competition of ENS Cachan (2012). She was member of the CNU 27 (2010-2011). She is member of the CNRS hiring committee for research position.

Pascale Vicat-Blanc Primet : was member of the "Networks" expert committee of the CNRS. She was within the Grid5000 project and ADT ALADDIN, member of the steering committee and co-leader of the Grid5000@Lyon site.

[60] http://www.hikob.com/awards/

Hiring committees ("comités de sélection")

Thomas Begin : Member of hiring committee for the computer science department of University Lyon 1 (2013)

Anthony Busson : Anthony Busson: Member of hiring committee for the computer science department of University Lyon 1 (2013), and University Paul Sabatier (2014).

Christophe Crespelle : Member of the Expert Group of UPMC, member of hiring committees in 2012, 2013, 2014 at UPMC.

Éric Fleury : Vice president of the hiring committee for the computer science department of ENS de Lyon (2009 - 2013). Member of hiring committee at Bordaux, UPMC, Grenoble UJF, Rennes. Member of the Inria hiring committee for CR position in Rennes, Sophia Antipolis and Grenoble.

Paulo Gonçalves : Comité de Sélection poste MC1724, Université de Rennes 1 (2012).

Isabelle Guérin Lassous : President of the hiring committee for the CS department of Lyon 1 (2009, 2012). Member of the hiring committee of PSud (2014), Ensimag (2010), UJF (2012).

Márton Karsai

Pascale Vicat-Blanc Pirmet : President of the hearing committee of INRIA Rhône-Alpes;

PhD committees

Thomas Begin : He was member of the Ph.D. jury of El Hachemi Bendahmane (University of Grenoble, France); of "Ahmed HERBAOUI (Université de Grenoble, 2011)

Anthony Busson : Anthony Busson: member of the PhD jury and reviewer of Tien Le Anh (Télécom Sud Paris - 2012), Donglai Sun (University of Burgundy - 2012) and Mariem Thaalbi (Sup' Com Tunis - 2013).

Guillame Chelius was member of the Ph.D. jury of Sadaf Tanvir (Drakkar team, IMAG), Thomas Claveirole (LIP6, Université Paris 6, France).

Christophe Crespelle : He was member of the Ph.D. jury of Massoud Seifi (UPMC, France); Assia Hamzaoui (LIP6, Université Paris 6, France); Xiaomin Wang (LIP6, Université Paris 6, France).

Éric Fleury : Jury of Tony Ducrocq (Université des Sciences et technologies de Lille, reviewer); Jury of Robin Lamarche-Perrin (Université de Grenoble, Reviewer); Jury of Anh Dung Nguyen (Université de Toulouse, ISAE, reviewer); Mikaila Toko Worou (Université de Nice - INRIA Sophia Antipolis, France); DIANA Rémi (Université de Toulouse, Reviewer); Afshin Moin (Université de Rennes); Fabio Rocha-Jimenez-Vieira (UPMC); Thomas Ferrandiz (ISAE); Lamia Benamara (LIP6, UPMC, Reviewer); Thomas Aynaud (LIP6, UPMC, France); Dorian Mazauric (Université de Nice – INRIA Sophia Antipolis, Reviewer); Oussama Allali (LIP6, UPMC, Reviewer).

He was president of the Ph. D. jury of Mikaila Toko Worou (Université de Nice - INRIA Sophia Antipolis, France).

Paulo Gonçalves : member of the Ph.D. jury of Maude Pasquier (Université de Grenoble, INRIA); Jerôme Van Zaen (EPFL, Switzerland); M. Jaber (Univ. de Nice, 2011) ; B. Kauffmann, (UPMC, 2011) ;

Isabelle Guérin Lassous : member of the following Ph.D. jurys: Frédéric Besse (Université de Toulouse, ISAE, reviewer), Ichrak Amdouni (Université Pierre et Marie Curie, INRIA, reviewer), Muhammad Yousaf (University of Engineering and Technology, Taxila, Pakistan, reviewer), Nicolas Gouvy (Université Lille 1, reviewer), Ana Bildea (Université de Grenoble, reviewer), Karen Miranda (Université Lille 1, president); Giorgio Corbellini (Grenoble); Mauricio Ituralde (Toulouse); Scott McKenzie Raynel (University of Waikato, New Zealand); Bafing Sambou (Toulouse); S. Calomme (Louvain, Belgique, 2009) ; D. Triantafyllidou (Paris-Sud, 2009) ; F. Khadar (Lille 1, 2009) ; L. Landmark (NTNU, Norway, 2009) ; J. Ram. (Paris-Sud, 2010) ; E. Schiller (INPG, 2010) ; C. Gueguen (UPMC, 2010) ; M. O. Cherif (UTC, 2010) ; R. N. Bin Rais (Nice, 2011) ; P. Velho (INPG, 2011) ; C. T. Kone (Nancy 1, 2011) ; A. Ben Nacef (INPT, 2011) and president of PhD board of L. Ben Saad (ENS Lyon, 2011) ; N. El Rachkidy (Clermont, 2011).

Pascale Vicat-Blanc Pirmet : member of the PhD examining board of F. Dijkstra (University of Amsterdam, reviewer); Lila Boukhatem (University of Orsay, reviewer, 2009), Nicolas Van Wambeke (Laas, Toulouse, reviewer), Ala Resmerita (LRI, Orsay, reviewer), Carlos Barrios Hernandez (LIG, Grenoble, reviewer)

Habilitation (HDR) committees

Anthony Busson : Anthony Busson: member of the HdR jury of Guillaume Villemaud (INSA - 2013).

Éric Fleury : was president of the HDR jury of Emmanuel Baccelli (UPMC, France); Anthony Busson (Université Paris Sud, France); Nathalie Mitton (Université de Lille – INRIA Nord Europe, France);

Paulo Gonçalves : He was member of the HDR jury of Sandrine Vaton (Telecom Bretagne, France).

Isabelle Guérin Lassous : Président of president of the HdR jury of Anne Fladenmuller (UPMC) and member of the following HDR jury: Céline Robardet (Université Lyon 1, INSA de Lyon); Bilel Romdhani (INSA Lyon); Aruna Bianzino (Telecom ParisTech); F. Filali (Eurecom, 2008) ; F. Peyrard (Toulouse 2, 2008) ; M. Senouci (INPT/Orange Labs, 2009) ; E. Exposito (INPT, 2010) ; E. Lochin (INPT, 2011) et A. Busson (Paris 11, 2011).

6.4.10 Editorial duties

Anthony Busson : Anthony Busson is member of the editorial board of Computer Communications.

Guillaume Chelius was a Guest Editor of the Eurasip JWCN Special Issue on Simulators and Experimental Testbeds Design and Development for Wireless Networks

Éric Fleury was guest Editors for Computer Networks Journal with José Ignacio Alvarez-Hamelin (UBA, AR); Alessandro Vespignani (Indiana Univ, US) and Artur Ziviani (LNCC, BR).

Paulo Gonçalves : Paulo Gonçalves is officer of the local liaison board of EURASIP

Isabelle Guérin Lassous : Isabelle Guérin Lassous is a member of the editorial board of: Computer Communications (Elsevier), Ad Hoc Networks (Elsevier) and Discrete Mathematics & Theoretical Computer Science.

Pascale Vicat-Blanc Primet : *Future Generation Computer Systems (FGCS)*, Elsevier, , Guest Editor of Special issue on "High Speed Networks for Grid Applications"; *Annals of Telecoms* P. Vicat-Blanc Primet, Guest Editor of a special issue on "Grid, Cloud and Utility computing"; *Lecture Notes in Computer Science* P. Vicat-Blanc Primet, Guest Editor

6.4.11 Organisation and committees of scientific conferences

Thomas Begin : Thomas Begin is PC member of ACM PE-WASUN 2013, 2012.

Anthony Busson : Anthony Busson was TPC (Technical Program Chair) of ISNCC 2014 and ISCC 2013.

Guillaume Chelius was a member of the ACM PEWASUN 2010 Program Committee.

Christophe Crespelle : Christophe Crespelle was PC member of AlgoTel 2013 and 2014. He was co-chair of the Discrete Mathematics Session of the SMF-VMS Joint Congress of Mathematics in Vietnam, co-organiser of the 14èmes Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications (AlgoTel 2012).

Éric Fleury : Éric Fleury was PC member of 4th Workshop on Complex Networks (CompleNet 2013, 2012, 2011). He was the co-chair of the conference "Alan Turing's Heritage". He was PC member of ASE/IEEE International Conference on Social Computing (SocialCom); member of the Interdisciplinary Workshop on Information and Decision in Social Networks scientific committee, MIT; co chair of the Social networks, from structures to politics workshop; 20th International Conference on Computer Communications and Networks (ICCCN 2011) program committee; topic chair for Euro-Par 2011; International Workshop on Dynamic Networks (WDN 2010); ACM DCOSS program committee.

Paulo Gonçalves : Paulo Gonçalves was organiser of the 4th Workshop on High Speed Network and Computing Environments (COMPSAC 2013, Kyoto). He is PC member of IWCMC - TRAC 2014, PC member of the 3rd Workshop on High Speed Network and Computing Environments (SAINT 2012). PC member of *International Workshop on High Speed Network and Computing Environments for Scientific Applications* (2010, 2012); *International Workshop on World Wide Computing Environments for Knowledge Discovery* (2011).

Isabelle Guérin Lassous : Isabelle Guérin Lassous was Program co-Chair of ACM International Symposium on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks (PE-WASUN) from 2009, 2010, 2011, 2013, 2014 and General Chair in 2012. Poster Chair of ACM MobiHoc in 2009. She was member of the following program committees in 2013: IPDPS, MSWiM, ITC, ICC, Globecom 2013, ISCC, IWCMC, ITC 2013, IWCMC 2013, ICC 2013, MedHocNet 2013, IPDPS 2013, ICC 2012, Globecom 2012.

Márton Karsai : Organiser of the Computational Social Science, ECCS 2013. Member of the programme committee of Quantifying Success , ECCS 2013 satellite and organiser of the Computational Social Science, ECCS 2014 satellite.

Pascale Vicat-Blanc Primet was co-chair of the *IEEE BroadNet 2009*. She was member of the following program committees: ITC 2009, IEEE/ACM CCGrid 2009, ITCSS 2009. She is member of the steering cimittees of ACM GridNets since 2006 and PFLDNET workshop series since 2005.

6.4.12 National and international boards and expertise, consulting activities

Thomas Begin : Thomas Begin was an expert for ANR on program INFRA.

Anthony Busson : Anthony Busson was an expert/reviewer for ANR on program INFRA 2013, JCJC SIMI 2013, and for the ANR Emergence in 2012.

Christophe Crespelle : Christophe Crespelle was an expert for ANR on program JCJC - SIMI 2 Information Science and Applications. Expert for ANR program Modéles Numériques in 2012. Expert for Nafosted (National funding agaency for research in Vietnam) in Computer Science in 2014.

Éric Fleury : Éric Fleury is President of the expert committee for the ANR INFRA call in 2013, vice president in 2012 and member of the committee board in 2010-2011. Éric Fleury has been an expert for the Fund for Scientific Research - FNRS. He was the president of the AERES visiting committee of the PRISM laboratory, member of the AERE board for the LI3S at Sophia. He was an expert for Swiss National Science Foundation (SNSF), for the Natural Sciences and Engineering Research Council of Canada (NSERC) and for the Fond de la Recherche Scientifique of Belgium (FNRS).

Paulo Gonçalves : Member of the AERES evaluation committee of LTSI Lab., Univ. of Rennes 1 (2010). ANR expert for the “Software Technologies" program SIMI3 (2008-2010).

Isabelle Guérin Lassous was vice-chair of the expert committee for the ANR Blanc call (2012). Member of the AERES evaluation committee of CAMS (2012) and LRI (2013).

Márton Karsai : consulting for STACC Oy/Skype Microsoft Labs in Estonia

6.4.13 Patents, startups, and technology transfer

- Most of the results relating to Virtualization (VxSwitch and VXDL notably) gave rise to patents licensing. It is this outstanding break-through that partly motivated the creation in 2010 of the Lyatiss start-up by P. Vicat-Blanc (CEO) and S. Soudan (CTO).
  - VXSwitch Patent - INPI: No 10/00368, 2010. LYaTiss, INRIA, ENS Lyon
  - VXAlloc Patent - INPI: 10/01626, 2010, LYaTiss, INRIA, ENS Lyon
  - VXCap Patent - INPI: 10/01624, 2010, LYaTiss, INRIA, ENS Lyon.
- Experience, know how on designing, developing, building large scale wireless sensor network application gave rise to patents licensing and also greatly motivated the creation in 2011 of the Hikob start-up by G. Chelius (CEO).
  - DECOUVERTE DE VOISINAGE POUR OBJETS COMMUNICANTS, patent no. 1059043
- A System And A Method For Detecting Cheating Applications, patent no. Patent Alcatel Lucent, INRIA No. 12305956.0

6.4.14 Training and teaching activities

Supervision / Phd in progress

- PhD in progress: Lucie Martinet, iBird: Individual Based Investigation of Resistance Dissemination, September 2011, Éric Fleury & Christophe Crespelle
- PhD in progress: Benjamin Girault, Ondelettes et graphe d’interactions dynamique: échelle temporelle et spatiale, September 2012, Éric Fleury & Paulo Gonçalves
- PhD in progress: Thiago Abreu, Integration of Traffic Awareness in Substitution Networks, March 2011, Isabelle Guérin Lassous & Thomas Begin

- PhD in progress: Elie Rotenberg, Complex Network Metrology, September 2010, Matthieu Latapy and Christophe Crespelle
- PhD in progress: Anh Tuan GIANG, Modeling and Improving the Capacity of Vehicular Ad hoc network, April 2011, Anthony Busson (registered at University Paris XI).
- PhD in progress: Sabrina Naimi, Mobility metrics in wireless mobile networks, September 2010, Véronique Vèque and Anthony Busson (registered at University Paris XI).
- PhD in progress: Laurent Reynaud, Optimized mobility stratgegy in wireless networks for reliability and energy consumption, March 2013, Isabelle Guérin Lassous.
- PhD in progress: Yannick Léo, Diffusion Processes and Community Structures in Dynamic Complex Networks, September 2013, Éric Fleury & Christophe Crespelle

Teaching by Anthony Busson

Anthony Busson is professor at IUT (Institut Universitaire de technologie) Lyon 1. Therefore, he mainly teaches at BAC+1, BAC+2 levels (networking and operating systems). Also, he teaches in the following master:

- Master: "Networking" (M1). ENS-LYON, France.
- Master: "Spontaneous network" (M2). UCBL - IFI (Hanoi), Vietnam.

Teaching by Paulo Gonçalves

- Master: Responsible for the teaching axis “Models and Optimization for Emergent Infrastructure". M1/M2 of the Department of Computer Sciences at ENS Lyon *(Informatique fondamentale)*
- Eng. school: Signal processing, lab classes (4th year), CPE Lyon, France
- Eng. school: "Introduction to Compressive Sensing" (5th year), CPE Lyon, France

Teaching by Thomas Begin

Thomas Begin is an Assistant Professor at Université Claude Bernard Lyon 1 in the Computer Science since 2009. He mostly lectures at the University, though he has a teaching activity at ENS Lyon as well.

- Licence: "Networks" (L3), University Lyon 1, France
- Master: "Networking" (M1), University Lyon 1, France
- Master: "Advanced Networks" (M2), University Lyon 1, France
- Master: "Computer Networks" (M1), ENS de Lyon, France
- Master: "Performance Evaluation of Green Networks" (M2), ENS de Lyon, France

Teaching by Isabelle Guérin Lassous

- Master: "QoS and multimedia networking applications" (M2), University Lyon 1, France
- Master: "Networking" (M2), University Lyon 1, France
- Master: "Wireless Networks" (M2), University Lyon 1, France
- Master: "Ad Hoc Networks" (M1), University Lyon 1, France
- Master: "Network Algorithms" (M1), ENS de Lyon, France
- Master 2 Computer Science, University Lyon 1: Responsible of the speciality Réseaux.
- Professor at the computer science department of University Lyon 1, teaching in Master 1 and Master 2, Networking, Quality of Service, Wireless Networks, Multimedia networking applications.

Teaching by Christophe Crespelle

Christophe Crespelle is an Assistant Professor at Université Claude Bernard Lyon 1 (UCBL) in the Computer Science department since 2010. He mostly lectures at UCBL, though he has a teaching activity at ENS Lyon as well.

- Licence: "Programming" (L2), UCBL, France
- Master: "Calculability and Complexity" (M1), UCBL, France
- Master: "Network Security Architecture" (M2), UCBL, France
- Master: "Security" (M2), UCBL, France
- Master: "Future Networks" (M2), UCBL, France
- Master: "Complex Networks" (M2), ENS Lyon, France
- Master : Recherche opérationnelle, Université Claude Bernard Lyon 1, France
- Master : Grands graphes de terrain, ENS de Lyon, France

Teaching by Eric Feury

Eric FLeury is a full professor at ENS de Lyon. He was the head of the Computer Science Department from 2009 to 2013. He was in charge for the CS department of the option in *modeling complex systems*.

- Licence: "Introduction to Algorithm" (L3), ENS de Lyon, France
- Licence: "Architecture, System and Networking" (L3), ENS de Lyon, France

Teaching by Guillaume Chelius

- Master : *Wireless Networks* class in the Master 2 System and Networks, IFI (Hanoi, Vietnam)
- Master :Algorithms for Networks and Communications in the Fundamental Computer Sciences Master at Department of computer science of ENS Lyon (Lyon, France)

6.4.15 Interaction with the social and cultural environment

Eric Fleury was the co-chair of the conference "Alan Turing's Heritage". This Turing Centenary Conference has been held in Lyon on July 2-4, 2012. At this occasion, a short movie The Turing Machine Comes True was released on the "Real Turing Machine" built from a student team from the Computer Science Department of ENS de Lyon. We do not mean to simulate a Turing machine as it is indeed very easy to simulate a Turing machine on a modern computer. The challenge was really to build a purely mechanical Turing's machine y using only LEGO bricks, gear, rod, pneumatic jack...

Eric Fleury has participated in the event All connected, an investigation on new numerical usages, co production with CCSTI Grenoble – La Casemate / Universcience – Cité des sciences et de l'industrie. The exhibition is an action of the NANOYOU project (FP7/2007-2013)

Guillaume Chelius made various television (TV5 monde, France 5), radio interventions (RFI, France Inter, RMC Sport) related to the XtremLog project and its participation to 25th Sultan the Marathon des Sables.

Pascale Vica-Banc Primet made an Interstice Podcast on "Very High Speed Networks" and an interview on "Construire l'Internet de demain" for the magazine Usine Nouvelle.

6.4.16 Publications and productions

International and national peer-reviewed journals [ACL]

2009

[574] Fabienne Anhalt and Pascale Vicat-Blanc Primet. Analysis and Experimental Evaluation of Network Data-Plane Virtualization Mechanisms. *International Journal On Advances in Intelligent Systems*, 2(4):434–445, 2009.

[575] Elyes Ben Hamida, Guillaume Chelius, and Jean-Marie Gorce. Impact of the Physical Layer Modeling on the Accuracy and Scalability of Wireless Network Simulation. *Simulation*, 85(9):574–588, September 2009.

[576] Alexandre Brandwajn and Thomas Begin. Higher-order distributional properties in closed queueing networks. *Performance Evaluation*, 66(11):607 – 620, November 2009.

[577] Eric Fleury and Céline Robardet. Communities detection and the analysis of their dynamics in collaborative networks. *International Journal of Web Based Communities*, 2009.

[578] Sébastien Soudan, Bin Bin Chen, and Pascale Vicat-Blanc Primet. Flow scheduling and endpoint rate control in GridNetworks. *Future Generation Computer Systems*, 25(8):904–911, 2009.

[579] Piero Spinnato, Pascale Vicat-Blanc Primet, Chris Edwards, and Michael Welzl. Editorial Special Section on Networks for Grid Applications. *International Journal on Future Generation Computer Systems*, 2009.

[580] Pascale Vicat-Blanc Primet, Sébastien Soudan, and Dominique Verchere. Virtualizing and scheduling optical network infrastructure for emerging IT services. *IEEE/OSA Journal of Optical Communications and Networking*, 1(2):A121 – A132, 2009.

2010

[581] Fabienne Anhalt, Guilherme Koslovski, and Pascale Vicat-Blanc Primet. Specifying and provisioning Virtual Infrastructures with HIPerNET. *International Journal of Network Management*, 20(3):12–148, 2010.

[582] Faouzi Bader, Guillaume Chelius, Christian Ibars, Mohamed Ibnkahla, Nikos Passas, and Arnd-Ragnar Rhiemeier. Editorial: Simulators and Experimental Testbeds Design and Development for Wireless Networks. *Eurasip Journal on Wireless Communications and Networking*, 2010, May 2010.

[583] Thomas Begin, Bruno Baynat, Francis Sourd, and Alexandre Brandwajn. A DFO technique to calibrate queueing models. *Computers & Operations Research / Computers and Operations Research*, 37(2):273 – 281, February 2010.

[584] Thomas Begin, Alexandre Brandwajn, Bruno Baynat, Bernd Wolfinger, and Serge Fdida. High-level Approach to Modeling of Observed System Behavior. *Performance Evaluation*, 67(5):386–405, May 2010.

[585] Hugo Carr
ao, Paulo Gonçalves, and Mário Caetano. A nonlinear model for satellite images time series: analysis and prediction of land cover dynamics. *IEEE Transactions in Geosciences and Remote Sensing*, 48 (2)(4):1919–1930, 2010.

[586] Christophe Crespelle and Philippe Gambette. Unrestricted and complete Breadth-First Search of trapezoid graphs in O(n) time. *Information Processing Letters*, 110:497–502, 2010.

[587] Christophe Crespelle and Christophe Paul. Fully Dynamic Algorithm for Modular Decomposition and Recognition of Permutation Graphs. *Algorithmica*, 58(2):405–432, 2010.

[588] Muriel Doret, Hannes Helgason, Patrice Abry, Paulo Gonçalves, Claude Gharib, and Pascal Gaucherand. Multifractal analysis of fetal heart rate variability in fetuses with and without severe acidosis during labor. *American Journal of Perinatology*, 2010.

[589] Marton Karsai, Jean-Christian Anglès D'Auriac, and F. Igloi. Interface mapping in two-dimensional random lattice models. *Journal of Statistical Mechanics: Theory and Experiment*, page P08027, 2010. 7 pages, 6 figures.

[590] Loiseau Patrick, Paulo Gonçalves, Guillaume Dewaele, Pierre Borgnat, Patrice Abry, and Pascale Primet Vicat-Blanc. Investigating self-similarity and heavy-tailed distributions on a large scale experimental facility. *IIEEE/ACM Transactions on Networking*, (99):1, March 2010.

[591] Tram Truong Huu, Guilherme Koslovski, Fabienne Anhalt, Johan Montagnat, and Pascale Vicat-Blanc Primet. Joint elastic cloud and virtual network framework for application performance optimization and cost reduction. *Journal of Grid Computing*, 9(1):27–47, 2010.

2011

[592] Julien Barral and Paulo Gonçalves. On the estimation of the large deviations spectrum. *Journal of Statistical Physics*, 144(6):1256–1283, 2011. 6 6.

[593] Pierre Borgnat, Céline Robardet, Jean-Baptiste Rouquier, Patrice Abry, Eric Fleury, and Patrick Flandrin. Shared Bicycles in a City: A Signal Processing and Data Analysis Perspective. *Advances in Complex Systems*, 14(3):415–438, June 2011.

[594] Anthony Busson. Analysis and simulation of a message dissemination algorithm for VANET. *International Journal of Communication Systems*, 24(9):1212–1229, 2011.

[595] Anthony Busson, Alain Lambert, Dominique Gruyer, and Denis Gingras. Analysis of Intervehicle Communication to Reduce Road Crashes. *IEEE Transactions on Vehicular Technology*, 60(9):4487–4496, November 2011.

[596] Guillaume Chelius, Christophe Braillon, Maud Pasquier, Nicolas Horvais, Roger Pissard-Gibollet, Bernard Espiau, and Christine Azevedo Coste. A Wearable Sensor Network for Gait Analysis: A 6-Day Experiment of Running Through the Desert. *IEEE/ASME Transactions on Mechatronics*, 16(5):878–883, 2011.

[597] Christophe Crespelle and Fabien Tarissan. Evaluation of a New Method for Measuring the Internet Degree Distribution: Simulation Results. *Computer Communications*, 34(5):635–648, 2011.

[598] Adrien Friggeri, Guillaume Chelius, Eric Fleury, Antoine Fraboulet, France Mentré, and Jean-Christophe Lucet. Reconstructing Social Interactions Using an unreliable Wireless Sensor Network. *Computer Communications*, 34(5):609–618, April 2011. This work was supported by a public grant from the French National Agency for Food, Environmental and Occupational Health Safety (ANSES/AFSSET, EST 2007-50).

[599] Adrien Friggeri, Jean-Philippe Cointet, Matthieu Latapy, and Matthieu. A Real-World Spreading Experiment in the Blogosphere. *Complex Systems*, 19(3), 2011.

[600] Paulo Gonçalves, Flávio Oliveira Francisco, Rute Brito, Alayne Domingues-Yamada, Fabiana Pioker, Ademilson Soares, and Maria Arias. A scientific note on the isolation and characterization of microsatellite loci of Frieseomelitta varia (Hymenoptera, Apidae, Meliponini). *Apidologie*, 42(5):560–563, 2011.

[601] Hannes Helgason, Patrice Abry, Paulo Gonçalves, Claude Gharib, Pierre Gaucherand, and Muriel Doret. Adaptive Multiscale Complexity Analysis of Fetal Heart Rate. *IEEE, Transactions on Biomedical Engineering*, 58(8):2186–2193, 2011. 8 8.

[602] Yesid Jarma, Golnaz Karbaschi, Marcelo Dias De Amorim, Farid Benbadis, and Guillaume Chelius. Volume-Aware Positioning in the Context of a Marine Port Terminal. *Computer Communications*, 34(8):962–972, February 2011.

[603] Cédric Laouénan, Guillaume Chelius, D. Lepelletier, Eric Fleury, France Mentré, and Jean-Christophe Lucet. Mesurer les contacts entre soignants et patients au moyen de capteurs électroniques : le cas de la tuberculose. *Revue d'Epidémiologie et de Santé Publique*, S1:33, April 2011. Doi : 10.1016/j.respe.2011.02.055.

[604] Patrick Loiseau, Pascale Vicat-Blanc, and Paulo Gonçalves. A long-range dependent model for network traffic with flow-scale correlations. *Stochastic Models*, 27(2):333–361, 2011.

[605] Nathalie Mitton, Bruno Sericola, Sébastien Tixeuil, Eric Fleury, and Isabelle Guérin Lassous. Self-stabilization in Self-organized Multihop Wireless Networks. *Ad Hoc & Sensor Wireless Networks (AHSWN)*, 11(1-2):1–34, 2011.

[606] Anne-Cécile Orgerie, Laurent Lefèvre, and Isabelle Guerin-Lassous. On the Energy Efficiency of Centralized and Decentralized Management for Reservation-Based Networks. *IEEE Global Communications Conference (GLOBECOM)*, December 2011.

[607] Tram Truong Huu, Guilherme Koslovski, Fabienne Anhalt, Johan Montagnat, and Pascale Vicat-Blanc Primet. Joint Elastic Cloud and Virtual Network Framework for Application Performance-cost Optimization. *Journal of Grid Computing*, 9(1):27–47, March 2011.

2012

[608] Alexandre Brandwajn and Thomas Begin. A recurrent solution of Ph/M/c/N-like and Ph/M/c-like queues. *Journal of Applied Probability*, 49(1):84–99, 2012.

[609] Paulo Gonçalves, Shubhabrata Roy, Thomas Begin, and Patrick Loiseau. Dynamic Resource Management in Clouds: A Probabilistic Approach. *IEICE Transactions on Communications, special session on Networking Technologies for Cloud Services*, E95-B(08), 2012. Invited paper 08 08.

[610] Sebastian Grauwin, Guillaume Beslon, Eric Fleury, Sara Franceschelli, Céline Robardet, Jean-Baptiste Rouquier, and Pablo Jensen. Complex Systems Science: Dreams of Universality, Reality of Interdisciplinarity. *Journal of the American Society for Information Science and Technology*, page 10.1002/asi.22644, 2012.

[611] Patrick Loiseau, Claire Médigue, Paulo Gonçalves, Najmeddine Attia, Stéphane Seuret, François Cottin, Denis Chemla, Michel Sorine, and Julien Barral. Large deviations estimates for the multiscale analysis of heart rate variability. *Physica A*, 391(22):5658–5671, June 2012.

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6.5 MC2: Models of Computation, Complexity, Combinatorics

6.5.1 Team composition

Current members

Pablo Arrighi (MCF Univ. Joseph Fourier, Grenoble), Nathalie Aubrun (CR CNRS), Pascal Koiran (Prof. ENS Lyon), Irena Penev (post-doc), Natacha Portier (MCF ENS Lyon), Michael Rao (CR CNRS), Mathieu Sablik (MCF Univ. de Provence), Maxime Senot (ATER), Eric Thierry (MCF ENS Lyon), Stéphan Thomassé (Prof. ENS Lyon), Nicolas Trotignon (CR CNRS), Petru Valicov (ATER).

PhD students: Aurélie Lagoutte, Sébastien Tavenas, Théophile Trunck.

Former members

Associate professor: Eric Rémila.

Post-docs: Jonathan Grattage, Camilo La Rota, Zhentao Li.

ATER: Emilie Diot.

PhD students: Florent Becker, Irénée Briquel, Bruno Grenet, Laurent Jouhet, Mathilde Noual, Damien Régnault, Julien Robert, Jean-Baptiste Rouquier, Kévin Perrot, Pierre Aboulker.

Engineers (complex systems projects): Eric Boix, Jorge Beltran Salazar, Gina Chiquillo Mojica, Arnaud Grignard, Mathieu Malaterrre, Ricardo Uribe-Lobello, Vincent Hobeika, Mathieu Malaterre, Yves Quemener.

Administrative assistant (complex systems projects): Soline Beaud.

Visitors

Main visitors: Ron Aharoni (Technion), Maria Chudnosky (Columbia), Jacob Fox (MIT), Anahi Gajardo (Conception, Chile) Neeraj Kayal (Microsoft Research, Bangalore), Ivan Rapaport (Universidad de Chile, Santiago) Maurice Rojas (Texas A & M), Nitin Saxena (IIT Kanpur), Alex Scott (Oxford), Paul Seymour (Princeton), Kristina Vuskovic (Leeds).

6.5.2 Life of the team

There was considerable change in the team's composition: among current team members, only Pascal Koiran, Natacha Portier and Eric Thierry were present at the beginning of the evaluation period (January 2009). Thanks to our recent hires, combinatorics has become a new strength of the team. To reflect this, the team's name was changed from *Modèles de Calcul and Complexité* to *Modèles de calcul, Complexité, Combinatoire* while keeping the acronym MC2.

The team's seminar is usually held on Wednesday morning. A few talks are given by team members, but most talks are given by visitors (see www.ens-lyon.fr/LIP/MC2/groupe-de-travail/).

We also organize jointly with the Dante team a seminar on graphs and discrete structures (www.ens-lyon.fr/LIP/MC2/groupe-de-travail-graphes-et-structures-discretes/). It is usually held on Tuesday afternoon, and again most talks are given by visitors. In addition to members of the two organizing teams, this seminar regularly attracts some audience from Université Lyon I.

6.5.3 International collaborations resulting in joint publications

Pascal Koiran and Natacha Portier visited the University of Toronto from September 2009 to September 2011. They collaborated with Arkadev Chattopadhyay on the factorization of sparse polynomials, and with Anastasios Zouzias [1000, 862] on the complexity of the restricted isometry property (a property of matrices that is useful in compressed sensing). They also collaborated [1012] with Maurice Rojas (Texas A & M) during his visits to ENS Lyon.

In symbolic dynamics, Nathalie Aubrun collaborated [986] with Jarkko Kari (Turku, Finland).

In graph theory, some of our main collaborators are Maria Chudnovsky (Columbia), Paul Seymour (Princeton) and Kristina Vuskovic (Leeds).

6.5.4 Management of research projects and contracts

- **ANR project Stint (structures interdites):** this project is coordinated by Nicolas Trotignon and got started in January 2014. It focuses on graphs with (or should we say *without*) forbidden structures. The permanent team members that are involved in this project are Nicolas Trotignon, Michael Rao and Stéphan Thomassé. Two other teams are member of this project (COATI in Nice, G-SCOP in Grenoble).

Induced subgraphs play a central role in both structural and algorithmic graph theory. A graph H is an *induced subgraph* of a graph G if one can delete vertices of G to obtain H. This is the strongest notion of subgraph, hence being H*-free* (that is not containing H as an induced subgraph) is not a very restrictive requirement. Weaker notions of containment, like for instance minors, are now well understood, and the next achievement in Graph Theory should certainly be the understanding of forbidden induced structures. We focus in this project on the following very general question:
Given a (possibly infinite) family ψ of graphs, what properties does a ψ-free graph have?

This is the key question of many important and longstanding problems, because many crucial graph classes are defined in terms of forbidden induced subgraphs. This field is now quickly growing, and new techniques and tools have been recently developed.

Our first goal is to establish bounds on some classical graph parameters for ψ-free graphs, such as the clique number, the stability number and the chromatic number. A second goal is to design efficient algorithms to recognize ψ-free graphs and to determine or approximate some parameters for those graphs.

For this purpose, we plan to use and develop various proof techniques, some of these being recently discovered, such as the structural description of graph classes, the regularity lemma, graph limits, flag algebras, VC-dimension, discharging method as well as computer-assisted proofs.

- **ANR project CompA (complexité algébrique):** this project is coordinated by Pascal Koiran and got started in February 2014. The permanent team members that are involved in this project are Pascal Koiran, Natacha Portier and Stéphan Thomassé. The other partner is Paris 7; three individual researchers from Grenoble, Lyon 1 and Versailles also participate.
- **Institut Universitaire de France** : Pascal Koiran was a junior member of IUF from 2007 to 2011.
- **Marie Curie outgoing fellowship:** This fellowhip enabled Natacha Portier to visit the Fields Institute and the University of Toronto from September 2009 to September 2011.
- **European project Morphex (2007-2010):** This project was coordinated by Michel Morvan, who left ENS Lyon in December 2008. The project developed a complex systems approach to the modeling of gene regulatory networks in plants and animals. It involved researchers from MC2, from the plant reproduction lab (RDP) at ENS Lyon, from several other academic institutions in Chile, Germany, The Netherlands, and from a small Lyon-based company (Oslo).

6.5.5 Participation in research projects and contracts

In addition to the projects that we are coordinating, we participated in:

- ANR jeunes chercheurs DORSO "Decomposition of Relational Structures: Combinatorial Optimisation" (Michael Rao, 2011-2015). Project coordinator: Frédéric Mazoit, LaBRI.
- PEPS GraphIQ : Informatique quantique et théorie des graphes : étude des états graphes (Michael Rao, 2010-2012). Project coordinator: Simon Perdrix.
- PHC Pavle Savic grant (Nicolas Trotignon), jointly awarded by EGIDE, an agency of the French Ministere des Affaires etrangeres et européennes, and Serbian Ministry for Science and Technological Development, 2010-2011.
- ANR jeune chercheur Heredia (Nicolas Trotignon), 2011–2014.
- Project 174033 (Nicolas Trotignon), supported by the Ministry of Science, Technology and Development, Republic of Serbia. Graph theory and mathematical programming with applications to chemistry and computer science. Leader: Slobodan Simic.
- ANR project Pegase (2009-2012): “Peformances Garanties dans les Systèmes Embarqués communicants". Within this project, Eric Thierry worked on $(\min, +)$ algorithms for performance evaluation using the network calculus formalism. The project partners were Thales Alenia Space, Thales Avionics, ONERA (leader), ENS Cachan - Bretagne, LIP, Real-Time at Work, INRIA Rhône-Alpes.
- Subcontracting work for Onera: “Etude des courbes de service strict en calcul réseau" (Eric Thierry, 2009). The project partners were LIP, ENS Cachan and Onera.
- IXXI project RAP: Réseaux d’automates probabilistes (Eric Thierry). The partners were LIP, IXXI and LIAFA.
- ANR project Geneshape. This complex systems project was focused on the modeling of morphogenesis in plants and animals.

6.5.6 Industrial contracts and collaborations

Several industrial partners were involved in ANR project Pegase (see above section). We also did some subcontracting work for Onera.

6.5.7 Software production and contribution to research infrastructures

An integer is said to be perfect if it is equal to the sum of its divisors. Even perfect numbers are well characterized (they are in bijection with Mersenne primes), but the existence of an odd perfect number has been an open problem for centuries. We only know some necessary conditions that an hypothetical perfect odd number should respect. For instance, the first such condition, due to Euler, states that $N = p^q * m^2$ where p is prime and $q = 1$ mod 4. In collaboration with Pascal Ochem (LIRMM), Michael Rao wrote a computer program to find new conditions that any odd perfect number must satisfy. This work has led so far to 2 publications in Mathematics of Computation [864, 907].

6.5.8 Prizes and awards

Two of our PhD students obtained scientific awards. Mathilde Noual obtained the EADS thesis prize and the second Gilles Kahn prize for the year 2012 (this thesis prize is awarded by SIF, the Société Informatique de France). Sébastien Tavenas obtained a best paper award and a best student paper award at MFCS 2013.

6.5.9 Contribution to the scientific community and administrative responsibilities

In 2014, Natacha Portier was member of two hiring committees for associate professors in computer science (Marseille and ENS Lyon). Stéphan Thomassé is in charge of the M2 year at ENS Lyon, and Eric Thierry of the L3 year. Pascal Koiran has been head of MC2 since September 2007; Eric Thierry was co-head during Pascal Koiran's visit to Toronto (September 2009 to September 2011).

6.5.10 Editorial duties

Natacha Portier is editor of Mathematical Logic Quarterly.

6.5.11 Organisation and committees of scientific conferences

- STACS 2014 (local organization and PC chair: Natacha Portier; edition of proceedings: Nathalie Aubrun). A one-day workshop on algebraic complexity was organized by Pascal Koiran just before the conference.
- Pascal Koiran is currently president of the French part of the STACS steering committee.
- Workshop on Dynamical Systems and Computability organized by Nathalie Aubrun, Mathieu Sablik and Maxime Sénot (ENS Lyon, December 2013).
- Pascal Koiran was an organizer (with Peter Bürgisser, Leslie Goldberg and Mark Jerrum) of the Dagstuhl workshop on computational counting (January 2013).
- We helped organize a conference on Alan Turing's heritage (ENS Lyon, July 2012, http://www.turing2012.fr) and the award of a doctorate honoris causa to Leslie Valiant (a first for computer science at ENS Lyon). These events were followed by a workshop on complexity and finite models, which we also organized.
- Organization of a "workshop on χ-bounded classes" (ENS Lyon, 11 to 16 March, 2012) with the participation of Paul Seymour (Princeton), Maria Chudnovski (Columbia), Jacob Fox (MIT), Alexander Scott (Oxford), Kristina Vuskovic (Leeds).
- JCRAA 2012 at ENS Lyon (journées combinatoires Rhône-Alpes Auvergne).

6.5.12 National and international boards and expertise, consulting activities

6.5.13 Patents, startups, and technology transfer

Eric Boix (a former engineer in team MC2) and Michel Morvan (formerly professor of computer science at ENS Lyon) co-founded the CoSMo company in 2010. It provides tools for the modeling and simulation of complex systems.

6.5.14 Training and teaching activities

We are heavily involved in the CS curriculum of ENS Lyon since 4 of our members (Pascal Koiran, Natacha Portier, Stéphan Thomassé and Eric Thierry) have a professor or an associate professor position in this institution. Our CNRS researchers contribute to M2 classes (Nicolas Trotignon, 2013-2014 and 2014-2015; Nathalie Aubrun, 2014-2015). Eric Thierry is in charge of the L3 year and Stéphan Thomassé of the M2 year.

6.5.15 Interaction with the social and cultural environment

1. The MMI (Maison des Mathématiques et de l'Informatique) organizes exhibits, conferences, and various activities for schoolchildren and for the general public. It is funded by labex MiLyon and began its operations in 2012. Natacha Portier and Nicolas Trotignon are members of its steering committee and participate in its outreach activities (e.g., programming of Lego robots for high-school students).
2. One of our PhD students, Kevin Perrot, supervised a student project which resulted in the construction of the world's first entirely mechanical Lego Turing machine. This project has received a substantial media coverage (see http://rubens.ens-lyon.fr).
3. Pablo Arrighi was interviewed by Marie-Odile Monchicourt on France Info (September 12, 2012). Topics covered: quantum physics, quantum information, quantum computing. He is the coauthor of an article in the September 2012 issue of La Recherche: "Le monde est un ordinateur quantique".
4. Pascal Koiran was interviewed by the CNRS journal for its special issue on Alan Turing. He was interviewed by science journalist David Larousserie for his article "Alan Turing, l'héritage d'un géant" (Le Monde, cahier "sciences et technologies", June 23, 2012).

6.5.16 Publications and productions

International and national peer-reviewed journals [ACL]

2009

[810] Anne Benoit, Yves Robert, and Eric Thierry. On the complexity of mapping linear chain applications onto heterogeneous platforms. *Parallel Processing Letters*, 19(3):383–397, 2009.

[811] Pascal Koiran and Sylvain Perifel. VPSPACE and a transfer theorem over the complex field. *Theor. Comput. Sci.*, 410(50):5244–5251, 2009.

[812] Pascal Koiran and Sylvain Perifel. VPSPACE and a transfer theorem over the reals. *Computational Complexity*, 18(4):551–575, 2009.

[813] Damien Regnault, Nicolas Schabanel, and Eric Thierry. Progresses in the analysis of stochastic 2D cellular automata: A study of asynchronous 2D minority. *Theor. Comput. Sci.*, 410(47-49):4844–4855, 2009.

2010

[814] Florent Becker, Sergio Rajsbaum, Ivan Rapaport, and Eric Rémila. Average long-lived binary consensus: Quantifying the stabilizing role played by memory. *Theor. Comput. Sci.*, 411(14-15):1558–1566, 2010.

[815] Sylvain Béal, Eric Rémila, and Philippe Solal. Rooted-tree solutions for tree games. *European Journal of Operational Research*, 203(2):404–408, 2010.

[816] Pascal Koiran, Jürgen Landes, Natacha Portier, and Penghui Yao. Adversary lower bounds for nonadaptive quantum algorithms. *J. Comput. Syst. Sci.*, 76(5):347–355, 2010.

[817] Olivier Raynaud and Eric Thierry. The complexity of embedding orders into small products of chains. *Order*, 27(3):365–381, 2010.

[818] Damien Regnault, Nicolas Schabanel, and Eric Thierry. On the analysis of "simple" 2D stochastic cellular automata. *Discrete Mathematics & Theoretical Computer Science*, 12(2):263–294, 2010.

2011

[819] Julio Aracena, Eric Fanchon, Marco Montalva, and Mathilde Noual. Combinatorics on update digraphs in Boolean networks. *Discrete Applied Mathematics*, 159(6):401–409, 2011.

[820] Pablo Arrighi and Alejandro Díaz-Caro. Scalar system F for linear-algebraic λ-calculus: Towards a quantum physical logic. *Electr. Notes Theor. Comput. Sci.*, 270(2):219–229, 2011.

[821] Pablo Arrighi, Vincent Nesme, and Reinhard F. Werner. One-dimensional quantum cellular automata. *IJUC*, 7(4):223–244, 2011.

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[827] Hans L. Bodlaender, Stéphan Thomassé, and Anders Yeo. Kernel bounds for disjoint cycles and disjoint paths. *Theor. Comput. Sci.*, 412(35):4570–4578, 2011.

[828] Irénée Briquel, Pascal Koiran, and Klaus Meer. On the expressive power of CNF formulas of bounded tree- and clique-width. *Discrete Applied Mathematics*, 159(1):1–14, 2011.

[829] Alejandro Díaz-Caro, Pablo Arrighi, Manuel Gadella, and Jonathan Grattage. Measurements and confluence in quantum lambda calculi with explicit qubits. *Electr. Notes Theor. Comput. Sci.*, 270(1):59–74, 2011.

[830] Daniel Gonçalves, Alexandre Pinlou, Michaël Rao, and Stéphan Thomassé. The domination number of grids. *SIAM J. Discrete Math.*, 25(3):1443–1453, 2011.

[831] Jonathan Grattage. An overview of QML with a concrete implementation in haskell. *Electr. Notes Theor. Comput. Sci.*, 270(1):165–174, 2011.

[832] Bruno Grenet, Erich Kaltofen, Pascal Koiran, and Natacha Portier. Symmetric determinantal representation of formulas and weakly skew circuits. *Contemporary Mathematics*, 556, 2011.

[833] Flavio Guiñez, Martín Matamala, and Stéphan Thomassé. Realizing disjoint degree sequences of span at most two: A tractable discrete tomography problem. *Discrete Applied Mathematics*, 159(1):23–30, 2011.

[834] Pascal Koiran and Sylvain Perifel. Interpolation in Valiant's theory. *Computational Complexity*, 20(1):1–20, 2011.

[835] Roman Kolpakov and Michaël Rao. On the number of Dejean words over alphabets of 5, 6, 7, 8, 9 and 10 letters. *Theor. Comput. Sci.*, 412(46):6507–6516, 2011.

[836] Maurice Pouzet, Hamza Si Kaddour, and Nicolas Trotignon. Claw-freeness, 3-homogeneous subsets of a graph and a reconstruction problem. *Contributions to Discrete Mathematics*, 6(1), 2011.

[837] Michaël Rao. Last cases of Dejean's conjecture. *Theor. Comput. Sci.*, 412(27):3010–3018, 2011.

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[839] Nicolas Trotignon and Kristina Vuskovic. On Roussel-Rubio-type lemmas and their consequences. *Discrete Mathematics*, 311(8-9):684–687, 2011.

2012

[840] Pierre Aboulker, Marko Radovanovic, Nicolas Trotignon, and Kristina Vuskovic. Graphs that do not contain a cycle with a node that has at least two neighbors on it. *SIAM J. Discrete Math.*, 26(4):1510–1531, 2012.

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2014

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[908] Olivier Simonin, François Charpillet, and Eric Thierry. Revisiting wavefront construction with collective agents: an approach to foraging. *Swarm Intelligence*, 8(2):113–138, 2014.

Invited conferences [INV], seminars, and tutorials

2009

[909] Pascal Koiran. Colloquium Jacques Morgenstern (Sophia-Antipolis), 2009.

[910] Pascal Koiran. Complexity theory workshop (Oberwolfach, Allemagne), 2009.

[911] Pascal Koiran. Thematic program on Foundations of Computational Mathematics: members' seminar, 2009.

2010

[912] Pascal Koiran. Computer algebra seminar (University of Waterloo), 2010.

[913] Pascal Koiran. Dagstuhl wokshop on Computational Counting, 2010.

[914] Pascal Koiran. Exposé au Banff workshop on Randomization, Relaxation, and Complexity (Banff International Research Station), 2010.

[915] Pascal Koiran. Keynote speaker at the international workshop "Logical approaches to barriers in computing and complexity" (Greifswald, Allemagne), 2010.

[916] Pascal Koiran. Symbolic Computation seminar (North Carolina State University), 2010.

[917] Pascal Koiran. Theory lunch seminar (Department of Computer Science, Princeton University), 2010.

[918] Pascal Koiran. Theory seminar (Department of Computer Science, University of Toronto), 2010.

[919] Pascal Koiran. Working algebraic geometry seminar (Purdue), 2010.

2011

[920] Pascal Koiran. Fall school of logic and complexity (Prague), 2011.

[921] Pascal Koiran. Seminar at "Université de Montréal", 2011.

[922] Pascal Koiran. Workshop on “Mathematical aspects of P versus NP and its variants” at ICERM (NSF Institute for Computational and Experimental Research in Mathematics) (Brown University), 2011.

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2012

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2013

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2012

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2013

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[1010] Mourad Baïou, Laurent Beaudou, Zhentao Li, and Vincent Limouzy. On a class of intersection graphs. *CoRR*, abs/1306.2498, 2013.

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[1014] Aurélie Lagoutte and Sébastien Tavenas. The complexity of shortest common supersequence for inputs with no identical consecutive letters. *CoRR*, abs/1309.0422, 2013.

[1015] Aurélie Lagoutte and Théophile Trunck. Clique-stable set separation in perfect graphs with no balanced skew-partitions. *CoRR*, abs/1312.2730, 2013.

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2014

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[1023] Nathalie Aubrun and Mathieu Sablik. Row-constrained effective sets of colourings are sofic in the hyperbolic plane. Manuscript, 2014.

[1024] Nicolas Delfosse, Zhentao Li, and Stéphan Thomassé. A note on the minimum distance of quantum LDPC codes. *CoRR*, abs/1404.6441, 2014.

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[1028] Irena Penev, Stéphan Thomassé, and Nicolas Trotignon. Isolating highly connected induced subgraphs. Submitted, 2014.

[1029] Michael Rao and Elise Vaslet. Dejean words with frequency constraint. Manuscript, 2014.

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2009

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2010

2011

[1031] Irénée Briquel. *Complexity issues in counting, polynomial evaluation and zero finding*. PhD thesis, École Normale Supérieure de Lyon and City University of Hong Kong, 2011.

2012

[1032] Bruno Grenet. *Représentations des polynômes, algorithmes et bornes inférieures*. PhD thesis, École Normale Supérieure de Lyon, 2012.

[1033] Laurent Jouhet. *Algorithmique du Network Calculus*. PhD thesis, École Normale Supérieure de Lyon, 2012.

[1034] Mathilde Noual. *Updating Automata Networks*. PhD thesis, École Normale Supérieure de Lyon, 2012.

2013

[1035] Pierre Aboulker. *Excluding slightly more than a cycle*. PhD thesis, Université Paris 7, 2013.

[1036] Kevin Perrot. *Les piles de sable Kadanoff*. PhD thesis, École Normale Supérieure de Lyon, 2013.

2014

[1037] Sébastien Tavenas. *Bornes inférieures et supérieures dans les circuits arithmétiques*. PhD thesis, École Normale Supérieure de Lyon, 2014.

6.6 PLUME: Programs and Proofs

6.6.1 Team composition

Current members

Permanent members

Philippe Audebaud (Associate Professor, ENS de Lyon), Patrick Baillot (DR CNRS from 10/2014), Filippo Bonchi (CR CNRS), Pierre Clairambault (CR CNRS), Russell Harmer (CR CNRS), Daniel Hirschkoff (Associate Professor, ENS de Lyon), Olivier Laurent (DR CNRS), Pierre Lescanne (Emeritus Professor, ENS de Lyon), Damien Pous (CR CNRS), Colin Riba (Associate Professor, ENS de Lyon).

Non-permanent members

Federico Aschieri (Postdoc, Labex MILYON), Valentin Blot (PhD student, ENS de Lyon), Paul Brunet (PhD student, Univ. Lyon I), Erika De Benedetti (PhD student, cotutelle Univ. of Torino/ ENS de Lyon), Jean-Marie Madiot (PhD student, cotutelle ENS de Lyon/ Univ. of Bologna), Matthieu Perrinel (PhD student, ENS de Lyon), Daniela Petrisan (Postdoc, ANR Picoq), Athanasios Tsouanas (PhD student, ENS de Lyon), Fabio Zanasi (PhD student, ENS de Lyon).

Assistant

Catherine Desplanches (Assistant, CNRS).

Former members

Associate Professors

Jean Duprat (until 8/2011), Alexandre Miquel (until 8/2013).

Postdocs

Alexander Kreuzer (10/2012-3/2014), Paolo Tranquilli (9/2009-8/2011).

PhD students

Romain Demangeon (9/2007-8/2010), Marc Lasson (10/2009-8/2012), Aurélien Pardon (9/2006-12/2010), Barbara Petit (9/2008-8/2011), Lionel Rieg (9/2010-8/2013), Silvia Vecchiato (visiting PhD student from Univ. Siena, 9/2009-2/2010).

Visitors

The team has received many international visitors, both for short and long stays. Among them let us mention:

Paolo Baldan (Padova); Amir Ben-Amram (Tel Aviv); Ulrich Berger (Swansea); Ugo Dal Lago (Bologna; invited ass. prof. ENS Lyon, 2010); Dan Ghica (Birmingham); Martin Hofmann (Munich; invited prof. UCBL, 2010); Barbara Koenig (Duisburg-Essen); Ulrich Kohlenbach (Darmstadt); Alexandra Silva (Nijmegen; invited ass. prof. ENS Lyon, 2014); Andrzej Murawski (Warwick); Paolo Oliva (Queen Mary London); Frank Pfenning (Carnegie Mellon); Simona Ronchi Della Rocca (Torino); Jan Rutten (Amsterdam); Antonino Salibra (Venice); Davide Sangiorgi (Bologna); Pawel Sobocinski (Southampton; invited ass. prof. ENS Lyon 2012); Thomas Streicher (Darmstadt); Kazushige Terui (Kyoto); Lorenzo Tortora de Falco (Roma Tre).

6.6.2 Life of the team

Séminaire d'équipe, etc. Analyse budgétaire globale. Éventuellement Fonctionnement de l'équipe. Rôles des ingénieurs.

Meetings. We have weekly scientific meetings (*groupe de travail*) (see the webpage) gathering all team members.

We also organise meetings on a monthly basis, to gather researchers of the French community working on proof theory, semantics, and related topics. These meetings are called CHoCoLa (Curry-Howard, Logic and Computation) and are the follow-up of the former meetings of the ANR project "Choco". Beside the CHoCoLa meetings we also have some team seminars (see the webpage) .

During the year 2009-2010 Plume also animated with AriC a specialized joint working group on formalization with the Coq proof assistant.

Life of the team.

From 11/2011 to 2/2013 Plume has been located in another building (UCBL building) than the main building of ENS Lyon and this has been a delicate period for the everyday life of the team, since we had fewer contacts with the rest of the lab.

Budget.

On this period a typical year of budget (2013) of the Plume team has been approximatively as follows:

support from LIP:	7 kE (incl. 3 kE of regular funding for the team and 4 kE of support for two new recruited staff)
ANR projects (Complice, Pace, PiCoq, Récré):	69.1 kE (including 31.4 kE of postdoc salary)
european ITN project Maloa:	39.3 kE (including 29.2 kE of postdoc salary)
chaire cnrs MdC Colin Riba:	28.6 kE (including 10.4kE of postdoc salary)
ENSL fonds recherche project:	5 kE
CNRS projects (PEPS,PICS):	1.2 kE
Total:	**150.2 kE** (including **79.2 kE** of *fonctionnement* and equipment and **71kE** of salaries)

The *fonctionnement* part of the budget is essentially used for travels to conferences and for collaborations, and invitations of visitors in the team. Let us mention that the ITN Maloa project and the *chaire cnrs maitre de conference Colin Riba* have finished in 2014, and so currently the team is largely dependent on ANR projects to carry out its activities.

6.6.3 International collaborations resulting in joint publications

At a national level, we have collaborations with researchers from

- ENS Paris (J. Feret).
- Paris 7 (J. Krivine).
- Paris 13 (V. Mogbil, J.-Y. Moyen).
- Rennes (A. Schmitt).
- Grenoble (F. Boyer, D. Duval, O. Gruber, J.G. Dumas).

The Plume team has several active collaborations outside France, leading to copublications:

- with Torino, Italy (S. Ronchi della Rocca). The PhD of E. De Benedetti is under joint supervision.
- with Bologna, Italy (D. Sangiorgi, U. Dal Lago). The PhD of J.-M. Madiot is under joint supervision.
- with Nijmegen-CWI, NL (A. Silva, J. Rutten, M. Bonsangue).
- with Pisa, Italy (U. Montanari, F. Gadducci).
- with Harvard Medical School, US (W. Fontana).
- with Shanghai, China (X. Xu).
- with Cambridge, UK (G. Winskel).
- with Edinburgh, UK (V. Danos).
- with Dundee, UK (M. Gaboardi).
- with Southampton, UK (P. Sobocinski).
- with Amsterdam, NL (Y. Venema).
- with Warsaw, Poland (A. Facchini).
- with Cracow, Poland (M. Zaionc).
- with Novi Sad, Serbia (S. Ghilezan).
- with Munich, Germany (M. Hofmann)

6.6.4 Management of research projects and contracts

ANR PACE project. The ANR PACE project (ANR Blanc International II, France-China) (*beyond plain Processes: Analysis techniques, Coinduction and Expressiveness*) is headed by D. Hirschkoff. The project involves partners in China (Shanghai Jiao Tong University) and France (ENS Lyon, INRIA Saclay and INRIA Sophia). The duration is 2013-2016. The PACE project investigates the use of coinduction in reasoning about programs and systems, with applications to the verification of behavioural properties of systems.

ANR COMPLICE project. The ANR project COMPLICE (*Complexité Implicite, Concurrence et Extraction*) (ANR Blanc 2008) was headed by P. Baillot. It lasted from 1/2009 to 4/2013. The project partners sites were LIP (ENS Lyon), LIPN (Université Paris 13), LORIA-INPL (Nancy). The permanent participants in Plume were P. Baillot, D. Hirschkoff, O. Laurent.

This project dealt with implicit complexity, whose goal is to design static criteria on programs allowing to certify complexity time or space bounds on their execution. It addressed 2 main challenges: 1. expressiveness: the programming disciplines employed to guarantee complexity bounds should not be too constraining, and in particular should allow to write natural programs. 2. generality: the method should apply to common programming paradigms, such as imperative or concurrent programming. For reaching this double goal we have used techniques coming on the one hand from rewriting theory, and on the other hand from logic.

ANR RÉCRÉ project. The RÉCRÉ project (*Realizability for classical logic, concurrency, references and rewriting*) was first headed by A. Miquel, and then after his departure for Uruguay in September 2013 by C. Riba. It is an ANR Blanc SIMI2 2011 project, whose duration is from 01/11/11 to 31/10/15. The partner sites are: LIP (ENS Lyon); PPS-pi.r2 ; I2M (ex IML) ; LAMA - Université de Savoie. Permanent participants in Plume are : D. Hirschkoff, O. Laurent, C. Riba (and formerly A. Miquel).

The RÉCRÉ project focuses on the proofs-as-programs correspondence for classical logic and its extension to computational effects (concurrency, side effects). Central to the project is *classical realizability*, which was introduced by J.-L. Krivine. The main aim of the project is the study of classical realizability and its application to the semantics and proof of programs with computational effects (e.g. non-determinism, parallelism, references, global memory, inputs/outputs).

PEPS project COGIP. The Project (PEPS-CNRS) on COalgebras- and Games- based Interpretations of Processes (COGIP) was headed by F. Bonchi. The project (from April 2012 to December 2013) has been used to organize several meetings in Lyon and hosting many international guests (Jan Rutten, Alexandra Silva, Marcello Bonsangue, Matteo Mio, Ichiro Hasuo and Fabio Gadducci). The project involved five French laboratories: LIP (ENS Lyon), LIG (Grenoble), LAMA (Univ. de Savoie), PPS (Paris 7) and LIST (CEA Saclay).

PICS project LLa. P. Baillot has been coordinator, with U. Dal Lago on the Italian side, of the PICS project (Projet International de Coopération Scientifique) of CNRS, **Logique linéaire et applications** France-Italie (PICS 5276). The partner sites were in France: LIP (ENS Lyon), LIPN (Univ. Paris 13), PPS (Univ. Paris 7), and in Italy: Univ of Bologna, Univ. of Torino, Univ. of Roma Tre. This project supported short crossed visits of researchers and PhD students between the italian sites and the French sites.

PHC bilateral project with Serbia. P. Lescanne has been coordinator of a PHC bilateral project with Serbia (Pavel Savic) in 2010-2011 and 2012-2013. The principal investigator on the Serbian side was Silvia Ghilezan (Novi Sad). Partner sites: Univ. of Novi Sad; ENS Lyon; Univ. of Paris 7; Univ. of Toulouse.The project dealt with the study of lambda-calculi and explicit substitutions for investigating the computational content of classical logic.

6.6.5 Participation in research projects and contracts

ITN European project MaLoA. O. Laurent has been coordinator of the ENS Lyon sub-site of the MaLoA ITN project (Initial Training Network on Mathematical Logic and Applications) funded by EU in 2009-2013 (partners: Leeds, Manchester, Oxford, CNRS-Lyon, Paris, Munich, Muenster, Prague). This project provided a PhD fellowship for Athanasios Tsouanas.

ANR CHOCO project. The CHoCo project (Curry-Howard and Concurrency), 2007-2010 was funded by the ANR. The main goal of the project was to develop the interactions between proof theory (notably linear logic, proof nets, types,..) and concurrency theory (process calculi, behavioural equivalences). D. Hirschkoff was site leader for Lyon (other sites involved were Paris 7 and Marseille). As mentioned above, the monthly meetings, in Lyon, which started during this project are still ongoing (ChoCoLa meetings).

ANR PiCoq project. D. Hirschkoff is site coordinator for the ANR PiCoq project (2011-2014). The sites involved in the project are INRIA Grenoble and Université de Savoie. The PiCoq project investigates questions related to the mechanisation of reasoning about concurrent and mobile systems (with applications in theorem proving).

6.6.6 Industrial contracts and collaborations

6.6.7 Software production and contribution to research infrastructures

D. Pous developed an implementation of the algortihm presented in the papers published at POPL and APLAS conferences in 2013. The tool is available at `http://perso.ens-lyon.fr/damien.pous/hknt/`.

The work by D. Pous on relation algebra and Kleene algebra with tests has fostered a Coq library, available at `http://perso.ens-lyon.fr/damien.pous/ra/`.

6.6.8 Prizes and awards

- Best paper award at CALCO 2013 for the paper F.Bonchi and F.Zanasi, *Saturated Semantics for Coalgebraic Logic Programming*. In the proc. of the 5th Conference on Algebra and Coalgebra in Computer Science, LNCS 8089, pp. 80-94. Springer, 2013.
- The paper by F. Bonchi and D. Pous published at POPL'13 was later invited for publication in the CACM Research Highlights.

6.6.9 Contribution to the scientific community and administrative responsibilities

Responsibilities

- P. Lescanne, *Directeur adjoint des études* at ENS Lyon in 2010-2011.

Hiring committees (Comités de sélection)

- P. Baillot: MCF Univ. Aix-Marseille I 2010
- D. Hirschkoff: MCF ENS Lyon 2009, MCF Univ. Bordeaux 2009, CR INRIA Saclay 2009, MCF Univ. Paris 11 2010, MCF Univ. Paris 7 2011, MCF Univ. Nancy 2 2011, MCF ENS Cachan 2012, MCF Univ. Paris 7 2013, MCF ENS Lyon 2013
- O. Laurent: MCF Univ. Aix-Marseille (maths) 2009, MCF ENS Lyon 2009, MCF Univ. Paris 13 2009, MCF Univ. Paris 7 2010, MCF Univ. Savoie (maths) 2012
- D. Pous: MCF Univ. Savoie / IUT 2012
- C. Riba: MCF Univ. Paris 7 2013

PhD and habilitation committees

- P. Baillot has been referee of 4 PhD theses (2 in France and 2 in Italy) and a member of 1 habilitation and 4 PhD committees.
- F. Bonchi has been member of 2 PhD committees (1 in France and 1 in the Netherlands).
- D. Hirschkoff has been a referee for 2 PhD theses (Univ. Paris 7, and Uppsala, Sweden – "opponent"), and a member of 1 habilitation and 6 PhD (4 in France, 1 in Italy, 1 in Switzerland) committees.
- O. Laurent has been referee of 1 habilitation and 3 PhD theses (2 in France and 1 in Italy), and a member of 1 habilitation and 8 PhD committees.
- P. Lescanne has been referee of 4 PhD theses (1 in France, 2 in Serbia, 1 in the Netherlands).

Others

- P. Baillot, member of examination committee for admission to ENS Cachan, Lyon and Ulm, 2012 and 2013 (*jury du concours d'entrée des ENS, oraux d'informatique fondamentale*).

6.6.10 Editorial duties

Editorial boards P. Lescanne is member of the editorial board of the international journal *Applicable Algebra in Engineering, Communication and Computing* (Springer).

Edition of proceedings and special issues

Ph. Audebaud has been guest co-editor of the Proceedings of the 2008 International Conference on the Mathematics of Program Construction, published as a special issue of Science of Computer Programming [1145].

F. Bonchi was editor for the special issue of Mathematical Structures in Computer Science collecting papers of the ICE, EXPRESS and SOS 2009 workshops.

P. Baillot has been guest editor or co-editor of the following volumes or proceedings:

Proceedings of workshop DICE 2010 [1144] (Electronic Proceedings in Theoretical Computer Science); Selected Papers of the Conference LICS'11 [1149], as Special Issue of Logical Methods in Computer Science (with M. Grohe and S. Kreutzer); Selected Papers of the Conference TLCA'09 [1148], as a Special Issue of Logical Methods in Computer Science, 2012; Special Issue on Implicit Computational Complexity of ACM Transactions on Computational Logic [1143], 2009 (with J.-Y. Marion and S. Ronchi Della Rocca).

O. Laurent has been guest co-editor of "Girard's Festschrift" special issue ofTheoretical Computer Science, 2011.

6.6.11 Organisation and committees of scientific conferences

- Participation to Programme Committees of conferences:
  - P. Baillot: TLCA'09, FoSSaCS'10, LICS'11, TLCA'13, CSR'13; workshops: FOPARA'09, LCC'09 (co-chair), DICE'10 (Chair), DICE'11, LI'12, LCC'12, LSFA'12.
  - F. Bonchi: APLAS'13, CALCO'11, CALCO'13; workshops: SOS'11, EXPRESS'11, EXPRESS/SOS'13, CMCS'12, CMCS'14, ICE'11, ICE'12, ICE'13.
  - P. Clairambault: RTATLCA'14, MFPS'14; workshops: GaLoP'14 and DICE'14.
  - R. Harmer: workshops: DCM'14 (co-chair), LSB'14 (co-chair), CS2Bio'14.
  - D. Hirschkoff: FoSSaCS'11, ICALP'12, TGC'14.
  - O. Laurent: FoSSaCS'12, LICS'12, CSL'13; workshops: GaLoP'10 (co-chair), LCC'10, LI'12, DICE'12, GaLoP'12.
  - P. Lescanne: SCSS 2012; workshop: CMCS 2014;
  - A. Miquel: CSL'12.
  - D. Pous: RAMiCS'13 and '14, JFLAs 2010-2013 (twice co-chair).
  - C. Riba: workshops: IWC'14.
- Organisation of events:

  Baillot co-organized with Guiraud and Malbos in 2014 the thematic session *Mathematical Structures of Computation* in Lyon, which consisted in 5 weeks of workshops and was supported by the Labex MILYON. It attracted altogether around 170 participants.

  As part of this session, one workshop, entitled *Concurrency, Logic and Types* was organized by Baillot, Hirschkoff and Pous. Another one, *Formal Proof, Symbolic Computation and Computer Arithmetic* was organized by members of the AriC team, Brisebarre and Muller.

  As part of the thematic session *Logic and Interactions* 2012 at the CIRM in Marseille, Laurent co-organized two workshops, *Logic and interaction* and *Proofs and programs*, and Baillot co-organized one workshop, *Complexity*.

  Baillot created the DICE (*Developments in Implicit Computational complExity*) workshop series, which started in 2010 and has since then been held annually as part of the ETAPS multi-conference.

  Harmer co-organized the workshops LSB 2014 (*5th Workshop on Logic and Systems Biology*, Vienna, July 2014) and DCM 2014 (*10th Workshop on Developments in Computational Models*, Vienna, July 2014).

  Lescanne is co-organizer of the Dagstuhl seminar *Coalgebraic Semantics of Reflexive Economics*, january 2015, Dagstuhl (Germany).
- The team organises the CHoCoLa meetings (formerly Choco, active since 2007), which play an important rôle in gathering researchers working in the areas covered by Plume, at a national level.

6.6.12 National and international boards and expertise, consulting activities

Committees

- GDR IM: O. Laurent head of "Géométrie du Calcul" (Geocal) working group since 2013
- GaLoP workshops (Games for Logic and Programming languages): O. Laurent, steering committee member
- DICE workshops (Developments in Implicit Computational complExity): P. Baillot, chair of steering committee
- *Prix de thèse Gilles Kahn / SPECIF*: D. Hirschkoff has been member of the committee for 2009-2011

Expertise

- P. Lescanne has been a reviewer for: ANR 2009; Fond de Recherche nature et technologies Québec; STIC Amsud; Austrian Science Fund.

6.6.13 Patents, startups, and technology transfer

None.

6.6.14 Training and teaching activities

Ph. Audebaud, D. Hirschkoff and C. Riba hold a teaching position at ENS Lyon. As such, they teach in the Computer Science Department of ENS Lyon, and typically teach courses related to the areas close to Plume. Moreover, Ph. Audebaud has been in charge of the preparation of the "Option D de l'Agrégation de Mathématiques", and D. Hirschkoff has been in charge of the first year of Masters in Computer Science (M1).

D. Hirschkoff has also organized a Research School as part of the local Master (these research schools last for one week and are mainly directed towards Master students): 2011: *Separation logic and applications*.

The researchers of the Plume team are also involved in an important way in teaching at ENS Lyon:

- F. Bonchi has served as local organiser for two Research Schools at ENS Lyon, at Masters level (2013: *Semantics and tools for low-level concurrent programming*; 2014: *Logic of dynamical systems*). He has also taught a course at M2 level (in 2011).
- P. Baillot has served as local organizer for a Research School at ENS Lyon (2010: *Game semantics and linear logic*).

  He has also taught a course on Computational Complexity for two years, at M1 level, as well as 3 courses at M2 level.
- O. Laurent has organised a research school at Masters level (2011: *Rule-based modeling and application to biomolecular networks*), has co-organised, with P. Clairambault and R. Harmer, a reading group on Category Theory (M1), and has taught three courses at M2 level.
- D. Pous has taught a course at M2 level, with colleagues from the AriC team and from INRIA Sophia Antipolis, for two years.

Here are some examples of M2 courses given at ENS Lyon since 2011:

- <u>F. Bonchi</u> and <u>D. Hirschkoff</u>, on *"Categories and Concurrency"* (2011).
- <u>P. Baillot</u> and <u>D. Pous</u>, on *"Concurrency, Implicit Complexity"* (2012).
- <u>C. Riba</u>, with A. Carayol (Paris-Est) and S. Salvati (Bordeaux), on *"Infinite words, verification and λ-calculus"* (2013).
- <u>P. Clairambault</u>, <u>R. Harmer</u> and <u>O. Laurent</u>, on *"Linear Logic and Game Semantics"* (2013).
- <u>D. Pous</u>, with J-M. Muller (AriC team) and L. Théry (Sophia-Antipolis), on *"Floating-point arithmetic and formal proof"* (2013).

Lectures at Research Schools or in other Universities.

- P. Lescanne has given courses at: the 6th International School on Rewriting, at the 20th Escuela de Verano de Ciencias Informaticas in Argentina, and at the University of Cracow (Poland) (Master course) in 2013 and 2014.
- O. Laurent and A. Miquel have given a lecture at the Logic School, Paraty, Rio de Janeiro, Brazil, in August 2012.
- O. Laurent has given a lecture at the School on Linear logic and Geometry of Interaction in Torino, Italy, in august 2013.
- R. Harmer – with V. Danos, J. Feret and J. Krivine – has taught in 2013 in the M1 class on *Rule-based modeling* at the CRI (Centre de Recherches Interdisciplinaires) at Univ. Paris 5.

PhD students. Since 2009, 5 PhD theses have been defended in the Plume team.

- **Romain Demangeon** has defended his PhD in November 2010, in cotutelle between ENSL and University of Bologna. His work is about type systems to guarantee termination in process calculi, with application to the termination of sequential calculi.

  He is now Maître de Conférences at Université Paris 6.
- **Barbara Petit** has defended her PhD in July 2011. Her work was on the operational and denotational semantics of a λ-calculus with pattern matching. She works now as a software developer in a private company.

- **Marc Lasson** has defended his PhD in November 2012. His thesis dealt with type theory, the extraction of program from formal proofs, and the techniques of realizability and parametricity to reason on programs.

  He is now postdoc at INRIA (EPI PiR2).

- **Lionel Rieg** has defended his PhD in June 2014. His thesis deals with the computational content of Cohen's forcing in classical realizability and how we can use forcing as a programming feature.

  He is now ATER at Univ. Évry.

- **Athanasios Tsouanas** has defended his PhD in July 2014. His work dealt with game semantics for logic programming languages.

3 PhD theses by students in other universities have also been co-directed by members of the team:

- **Severine Maingaud** has defended her PhD at Univ. Paris 7 in 2011, co-directed by A. Miquel. Her thesis dealt with the certification of imperative programs by dynamic logic.
- **Antoine Madet** has defended his PhD at Univ. Paris 7 in December 2012, co-directed by P. Baillot. His thesis dealt with the study of implicit complexity criteria for concurrent lambda-calculi.
- **Guilhem Jaber** has defended his PhD at École des mines de Nantes in july 2014, co-directed by A. Miquel. His thesis deals with the logical study of program equivalence.

As we are writing these lines (June 2014), we expect 4 PhDs to be defended soon:

- **Valentin Blot** shall defend his PhD in November 2014.
- **Erika De Benedetti** shall defend her PhD in February 2015 (cotutelle between University of Torino and ENSL).
- **Matthieu Perrinel** shall defend his PhD in winter 2015.
- **Jean-Marie Madiot** shall defend his PhD in winter 2015 (cotutelle between ENSL and University of Bologna).

Let us stress that among the PhD theses mentioned above, defended or on-going, three are in *cotutelle* (2 with Univ. of Bologna, and 1 with Univ. of Torino, in Italy).

Internships supervising.

- Baillot has supervised the M1 internship of L. Capdevielle (2010) and the M2 internships of M. Lasson (with Laurent) (2009), A. Madet (at Paris 7, with Amadio) (2009) and M. Perrinel (2011).
- Hirschkoff has supervised the Erasmus internship of I. Cristescu (Univ. of Cluj, Rumania) (2009), the L3 internships of A. Fouilhé (2010), S. Castellan (with Riba) (2011) and R. Kavanagh (Univ. of Kingston, Canada) (2014), and the M1 internships of H. Hajji (2010) and I. Cristescu (2011).
- Laurent has supervised the L3 internships of P.-M. Pedrot (2009) and S. Maulat (2010), the M2 internships of M. Lasson (with Baillot), P.-M. Pedrot (2011) and S. Castellan (2013), as well as a 6 month PhD internship of S. Vecchiato (PhD student at University of Siena, Italy) in 2009-2010.
- Lescanne has supervised the L3 internships of M. Perrinel (2009) and O. Blumberg (2011).
- Miquel has supervised the M2 internships of L. Rieg (2010) and E. Miquey (2013).
- Pous has supervised the M2 internship of P. Brunet (2013).
- Riba has supervised the M2 internship of V. Blot (2011).

6.6.15 Interaction with the social and cultural environment

P. Lescanne wrote several articles of scientific popularization: 4 articles for *Images des Mathématiques* (CNRS) and one article for *Pour la Science* (No 74 - Janvier - Mars 2012). He is also active in Wikipedia on the topics of logic and of computer science.

D. Hirschkoff is involved in the "Maths en Jeans" activity. He has co-organised some "research activities" with schools in Villeurbanne and Rillieux la Pape (at *collège* level, that is, pupils between 11 and 15 years old) for three years (2011-2014).

O. Laurent gave a talk *"Ordinateur, mon bel ordinateur, dis-moi si ma preuve est juste"* at the Cité Scolaire Internationale de Lyon, for the "2014 science week".

D. Pous gave a talk in a high school at Puy-en-Velay (april 2014), as part of the "cordées de la réussite".

6.6.16 Publications and productions

International and national peer-reviewed journals [ACL]

2009

[1038] Ariel Arbiser, Alexandre Miquel, and Alejandro Rios. The lambda-calculus with constructors: Syntax, confluence and separation. *Journal of Functional Programming*, 19(5):581–631, 2009.

[1039] Philippe Audebaud and Christine Paulin-Mohring. Proofs of randomized algorithms in coq. *Science of Computer Programming*, 74(8):568–589, 2009.

2010

[1040] Patrick Baillot and Damiano Mazza. Linear logic by levels and bounded time complexity. *Journal of Theoretical Computer Science*, 411(2):pp. 470–503, January 2010.

[1041] Frédéric Blanqui, Claude Kirchner, and Colin Riba. On the confluence of lambda-calculus with conditional rewriting. *Theoretical Computer Science*, 411(37):3301–3327, August 2010.

[1042] Romain Demangeon, Daniel Hirschkoff, and Davide Sangiorgi. Termination in higher-order concurrent calculi. *Journal of Logic and Algebraic Programming*, 79(7):550–577, 2010.

[1043] Thomas Ehrhard and Olivier Laurent. Interpreting a finitary pi-calculus in differential interaction nets. *Information and Computation*, 208(6):606–633, June 2010.

2011

[1044] Patrick Baillot, Paolo Coppola, and Ugo Dal Lago. Light logics and optimal reduction: Completeness and complexity. *Information and Computation*, 209(2):118–142, February 2011.

[1045] Filippo Bonchi, Paolo Baldan, Andrea Corradini, Tobias Heindel, and Barbara König. A lattice-theoretical perspective on adhesive categories. *Journal of Symbolic Computation*, 46(3):222–245, 2011.

[1046] Filippo Bonchi, Marcello Bonsangue, Jan Rutten, and Alexandra Silva. Quantitative Kleene coalgebras. *Information and Computation*, 209(5):822–849, 2011.

[1047] Olivier Laurent. Intuitionistic Dual-intuitionistic Nets. *Journal of Logic and Computation*, 21(4):561–587, August 2011.

[1048] Alexandre Miquel. Existential witness extraction in classical realizability and via a negative translation. *Logical Methods in Computer Science*, 7(2):LMCS–7(2:2), 2011.

[1049] Barbara Petit. Semantics of Typed Lambda-Calculus with Constructors. *Logical Methods in Computer Science (LMCS)*, 7(1:2):1–24, March 2011.

[1050] Paolo Tranquilli. Intuitionistic differential nets and lambda-calculus. *Theor. Comput. Sci.*, 412(20):1979–1997, 2011.

2012

[1051] Patrick Baillot, Ugo Dal Lago, and Jean-Yves Moyen. On quasi-interpretations, blind abstractions and implicit complexity. *Mathematical Structures in Computer Science*, 22(04):549–580, February 2012.

[1052] Filippo Bonchi, Marcello Bonsangue, Michele Boreale, Jan Rutten, and Alexandra Silva. A Coalgebraic Perspective on Linear Weighted Automata. *Information and Computation*, 211:77–105, 2012.

[1053] Filippo Bonchi, Buscemi Maria Grazia, Ciancia Vincenzo, and Fabio Gadducci. A Presheaf Environment for the Explicit Fusion Calculus. *Journal of Automated Reasoning*, 49(2):161–183, August 2012.

[1054] Filippo Bonchi and Ugo Montanari. Symbolic and Asynchronous Semantics via Normalized Coalgebras. *Logical Methods in Computer Science*, 7(2-7):1–53, 2012.

[1055] Alexander P. Kreuzer. A logical analysis of the generalized Banach contractions principle. *Journal of Logic and Analysis*, 4:17, p. 1–16, November 2012.

[1056] Alexander P. Kreuzer. On the strength of weak compactness. *Computability*, 1(2):171–179, December 2012.

[1057] Olivier Laurent. Intersection Types with Subtyping by Means of Cut Elimination. *Fundamenta Informaticae*, 121(1-4):203–226, December 2012.

[1058] Pierre Lescanne and Matthieu Perrinel. “Backward” Coinduction, Nash equilibrium and the Rationality of Escalation. *Acta Informatica*, 49(3):117–137, 2012.

[1059] Giulio Manzonetto and Paolo Tranquilli. Strong normalization of ml^{f} via a calculus of coercions. *Theor. Comput. Sci.*, 417:74–94, 2012.

2013

[1060] Federico Aschieri. Interactive Realizability for Second-Order Heyting Arithmetic with EM1 and SK1. *Mathematical Structures in Computer Science*, page N, October 2013.

[1061] Pierre Lescanne. On counting untyped lambda terms. *Theoretical Computer Science*, 474:80–97, February 2013.

[1062] Pierre Lescanne and Katarzyna Grygiel. Counting and generating lambda terms. *Journal of Functional Programming*, 23(05):594–628, October 2013.

[1063] Alexandra Silva, Filippo Bonchi, Marcello M. Bonsangue, and Jan J. M. M. Rutten. Generalizing determinization from automata to coalgebras. *Logical Methods in Computer Science*, 9(1), 2013.

[1064] Thanos Tsouanas. A game semantics for disjunctive logic programming. *Annals of Pure and Applied Logic*, 164(11):144–1175, November 2013.

2014

[1065] Patrick Baillot. On the expressivity of elementary linear logic: characterizing Ptime and an exponential time hierarchy. *Information and Computation*, page 47, April 2014. to appear.

[1066] Filippo Bonchi, Marcello M. Bonsangue, Helle Hvid Hansen, Prakash Panangaden, Jan J. M. M. Rutten, and Alexandra Silva. Algebra-coalgebra duality in brzozowski’s minimization algorithm. *ACM Trans. Comput. Log.*, 15(1):3, 2014.

[1067] Filippo Bonchi, Fabio Gadducci, and Giacoma Valentina Monreale. RPO semantics for mobile ambients. *Mathematical Structures in Computer Science*, 24(4), 2014.

[1068] Filippo Bonchi and Damien Pous. Checking NFA Equivalence with Bisimulations up to Congruence. *Communications of the ACM (Section: Research Highlights)*, 57(11), November 2014.

[1069] Pierre Clairambault and Peter Dybjer. The Biequivalence of Locally Cartesian Closed Categories and Martin-Löf Type Theories. *Mathematical Structures in Computer Science*, 24(05), April 2014.

[1070] Matthieu Perrinel. On paths-based criteria for polynomial time complexity in proof-nets. *Lecture notes in computer science*, page 16, July 2014.

[1071] Juliaan Rot, Filippo Bonchi, Marcelo Bonsangue, Damien Pous, Jan Rutten, and Alexandra Silva. Enhanced Coalgebraic Bisimulation. *Mathematical Structures in Computer Science*, 2014. to appear.

Invited conferences [INV], seminars, and tutorials

2011

[1072] Alexandre Miquel. A Survey of Classical Realizability. In *TLCA*, volume 6690 of *Lecture Notes in Computer Science*, pages 1–2, Novi Sad, Serbie, 2011. Springer.

2013

[1073] Damien Pous. Coalgebraic Up-to Techniques. In *Proc. CALCO 2013*, volume 8089 of *LNCS*, Warsaw, Pologne, September 2013. Springer.

[1074] Damien Pous. Using relation algebraic methods in the Coq proof assistant. Proc. 13th International conference on Relational and Algebraic Methods in Computer Science (RAMICS 13), 2013. Invited Talk.

International and national peer-reviewed conference proceedings [ACT]

2009

[1075] Romain Demangeon, Daniel Hirschkoff, and Davide Sangiorgi. Mobile processes and termination. In *Semantics and Algebraic Specification, Essays Dedicated to Peter D. Mosses on the Occasion of His 60th Birthday*, volume 5700 of *Lecture Notes in Computer Science*, pages 250–273. Springer, 2009.

[1076] Daniel Hirschkoff, Aurélien Pardon, Tom Hirschowitz, Samuel Hym, and Damien Pous. Encapsulation and Dynamic Modularity in the Pi-Calculus. In *Proceedings of the First Workshop on Programming Language Approaches to Concurrency and Communication-cEntric Software (PLACES 2008)*, volume 241 of *Electronic Notes in Theoretical Computer Science*, pages 85 – 100, Oslo, Norvège, 2009. Elsevier.

[1077] Alexandre Miquel. Relating Classical Realizability and Negative Translation for Existential Witness Extraction. In *Typed Lambda Calculi and Applications, 9th International Conference, TLCA 2009, Brasilia, Brazil, July 1-3, 2009. Proceedings*, volume 5608 of *Lecture Notes in Computer Science*, pages 188–202, Brasilia, Brésil, 2009. Springer.

[1078] Barbara Petit. A polymorphic type system for the lambda-calculus with constructors. In *Typed Lambda Calculi and Applications, 9th International Conference, TLCA 2009, Brasilia, Brazil, July 1-3, 2009. Proceedings*, volume 5608 of *Lecture Notes in Computer Science*, pages 234–248, 2009.

[1079] Colin Riba. On the Values of Reducibility Candidates. In Pierre-Louis Curien, editor, *Typed Lambda Calculi and Applications*, volume 5608 of *Lecture Notes in Computer Science*, pages pp 264–278, Brasilia, Brésil, 2009. Springer.

2010

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2013

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2011

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2013

2014

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Other Publications [AP]

2009

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2010

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2011

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[1155] Silvia Ghilezan, Jelena Ivetic, Pierre Lescanne, and Silvia Likavec. Resource control and strong normalisation. December 2011.

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[1157] Pierre Lescanne. Rationality and Escalation in Infinite Extensive Games. May 2011.

[1158] Colin Riba. On the Representation of Stream Functions in Denotational Domains. August 2011.

[1159] Paolo Tranquilli. Termination of Threads with Shared Memory via Infinitary Choice. February 2011.

2012

[1160] Silvia Ghilezan, Jelena Ivetic, Pierre Lescanne, and Silvia Likavec. Resource control and strong normalisation (old version). April 2012.

[1161] Silvia Ghilezan, Pierre Lescanne, and Dragisa Zunic. Computational interpretation of classical logic with explicit structural rules. March 2012.

[1162] Katarzyna Grygiel and Pierre Lescanne. Counting and generating lambda terms. October 2012.

[1163] Chantal Keller and Marc Lasson. The Refined Calculus of Inductive Construction: Parametricity and Abstraction. LICS - 27th Annual IEEE Symposium on Logic in Computer Science - 2012, June 2012. short presentation.

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2014

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[1168] Jean-Marie Madiot, Damien Pous, and Davide Sangiorgi. Bisimulations up-to: beyond first-order transition systems. Technical report, March 2014.

Doctoral Dissertations and Habilitation Theses [TH]

2009

[1169] Daniel Hirschkoff. *Calculs de processus: observations et inspections*. HDR, Ecole normale supérieure de lyon - ENS LYON, December 2009.

[1170] Alexandre Miquel. *De la formalisation des preuves à l'extraction de programmes*. HDR, Université Paris-Diderot - Paris VII, 2009.

2010

[1171] Romain Demangeon. *Termination of Concurrent SSystems*. PhD thesis, École Normale Supérieure de Lyon, November 2010.

[1172] Olivier Laurent. *Investigations classiques, complexes et concurrentes à l'aide de la logique linéaire*. HDR, Université Paris-Diderot - Paris VII, February 2010.

2011

[1173] Barbara Petit. *Autour du lambda-calcul avec constructeurs*. PhD thesis, École Normale Supérieure de Lyon, July 2011.

2012

[1174] Marc Lasson. *Réalisabilité et Paramétricité dans les Systèmes de Types Purs*. PhD thesis, École Normale Supérieure de Lyon, November 2012.

2013

2014

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[1176] Athanasios Tsouanas. *On the semantics of disjunctive logic programs*. PhD thesis, École Normale Supérieure de Lyon, July 2014.

6.7 ROMA: Resource Optimization : Models, Algorithms and Scheduling

6.7.1 Team composition

Current members

Permanent members
Anne Benoit (ENS Lyon associate professor (MCF) and Institut Universitaire de France junior member, HdR)
Jean-Yves L'Excellent (INRIA junior researcher (CR), HdR)
Loris Marchal (CNRS junior researcher (CR))
Yves Robert (ENS Lyon professor and Institut Universitaire de France senior member)
Bora Uçar (CNRS junior researcher (CR))
Frédéric Vivien (INRIA senior researcher (DR), HdR)
Nonpermanent members
Guillaume Aupy (PhD student, ENS Lyon)
Julien Herrmann (PhD student, ENS Lyon)
Enver Kayaaslan (Post-doctoral researcher, INRIA)
Chiara Puglisi (INRIA DTI funding)
Mohamed Wissam Sid-Lakhdar (PhD student, ENS Lyon)
Hongyang Sun (Post-doctoral researcher, Labex MILYON)
Dounia Zaidouni (PhD student, INRIA, ANR Rescue)
Administrative assistant
Laetitia Lecot (ENS Lyon)

Former members

PhD sudents
Fanny Dufossé (ENS Lyon, Jan. 1, 2009 – Aug 31, 2012)
Matthieu Gallet (ENS Lyon, Jan 1, 2009 – Sep 30, 2010)
Mathias Jacquelin (ENS Lyon, Jan 1, 2009 – Sep 30, 2011)
Veronika Rehn-Sonigo (ENS Lyon, Jan 1, 2009 – Sep 30, 2009)
Paul Renaud-Goud (ENS Lyon, Sep 1, 2009 – Sep 30, 2012)
Clément Rezvoy (ENS Lyon, Jan 1, 2009 – Sep 30, 2011)
PostDocs
Marin Bougeret (ATER ENS Lyon, Oct 1, 2010 – Aug 31, 2011)
Hinde Bouziane (INRIA, Sep 1, 2009 – Aug 31, 2010)
Indranil Chowdhury (ANR Solstice, May 21, 2009 – March 5, 2010)
Amina Guermouche (ANR Rescue, Dec 12, 2011 – Dec 11, 2012)
Johannes Langguth (ENS Lyon, Oct 1, 2011 – Sep 30, 2012)
Mark Stillwell (INRIA, Dec 1, 2010 – Jan 15, 2012)
Engineer
Guillaume Joslin: 24 (INRIA, ADT MUMPS, Oct. 12, 2009 – Oct. 11, 2011)
Administrative assistant
Evelyne Blesle (INRIA, Sep. 1, 2009 – Jun. 15, 2014)
Caroline Suter (INRIA, Jan. 1, 2009 – Aug. 1, 2009)

Visitors

Long-term visitors (at least one month)
Javier Celaya (PhD student), University of Saragossa, Spain, Apr. 27–Jul. 27, 2009.
Domingo Gimenez, University of Murcia, Spain, May 27–Jun. 22, 2010.
Thomas Herault, University of Tennesse, Knoxville, USA, Dec. 4–14, 2012 and Sep. 14–Oct. 15, 2013.
Oguz Kaya (Master student), Georgia Tech, USA, Jun. 22–Aug. 18, 2012.
Rami Melhem, University of Pittsburgh, USA, May 8–June 6, 2010.
Oliver Sinnen, University of Auckland, New-Zealand, Apr. 3–June 29, 2012.
Mark L. Stillwell (PhD student), University of Hawai'i at Mānoa, USA, Oct. 3–17, 2009, and March 13–27, 2010.

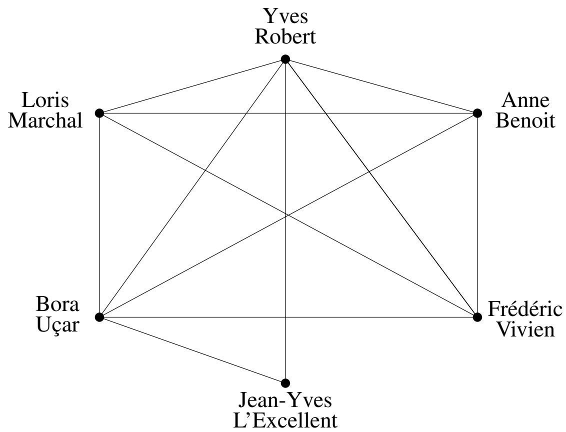

Figure .1: Graph of co-publications between ROMA permanent team members.

Short-term visitors

Georges Bosilca, University of Tennesse, Knoxville, USA, Dec. 10–14, 2012.
Louis-Claude Canon, University of Bordeaux, Oct. 8–16, 2009.
Tim Davis, University of Florida (now at Texas A& M University), USA, Sep. 23–26, 2012.
Ana Gainaru, University of Illinois at Urbana-Champaign, USA, Oct. 21–Nov. 15, 2013.
John Gilbert, University of California, Santa Barbara, US, ASep. 23–27, 2012.
Kamer Kaya, CERFACS, Toulouse, Apr. 6–9, 2010 and July 25–28, 2011.
Philip Knight, University of Strathclyde, UK, Dec. 12–15, 2012.
Julien Langou, University of Colorado, Denver, USA, May 23–29, 2011.
Hubert Larchevêque, University of Bordeaux, Jan. 30– February 3, 2011.
Arnold Rosenberg, University of Massachusetts Amherst, USA, Sep. 3–7, 2011.

6.7.2 Life of the team

The ROMA team was created during the evaluation period, on April 1, 2010. During the last evaluation of the laboratory, in December 2009, the splitting of the GRAAL team was presented and approved. One half of GRAAL lead to the creation of the ROMA team, and the other to the creation of the AVALON team (see Section 3).

The creation of ROMA gave us the opportunity of having a far more tightly knit group, far more focused scientifically. Furthermore, there is a strong will among the ROMA team members to collaborate. Consequently, most of the PhD students in the team are co-advised by team members (even when both advisors have the Habilitation). This also leads to joint research work between permanent team members not involving any students. Therefore, there are strong interactions, on a daily basis, between permanent team members. In turn, this leads to strong interactions between students (in PhD or in PostDoc) and joint work between students. The strong interactions between permanent team members is illustrated by the graph of their co-publications, which is almost complete (see Figure .1).

The team has several strong, long-term international collaborations. Most of our PhD students are involved in these collaborations. Furthermore, every year the team organizes an invitation-only workshop. Almost all team members, including students, take part in this workshop. This gives us the opportunity to gather our main international collaborators along with representatives of other closely-related teams. This enables us to present and discuss our recent advances, and to foster new collaborations.

Budget. We compiled the average budget of Roma during the 2010-2013 period:

- 20k€ of INRIA recurrent funding;
- 4k€ of laboratory recurrent funding;
- 56k€ of ANR funding, half of which for hiring personal;
- 25.5k€ of IUF funding;
- 2.8k€ of industrial funding;
- 8k€ of INRIA funding for associate-teams;
- 13.5k€ of institutional fundings (e.g., MILYON LabEx) for workshop organization.

6.7.3 International collaborations resulting in joint publications

- Bilkent University, Turkey. Work with Cevdet Aykanat on hypergraph partitioning and its applications [1184, 1187, 1197, 1330].

- The Ohio State University, USA. Work with Ümit V. Çatalyürek and Kamer Kaya (now at Sabanci University, Turkey) on combinatorial scientific computing [1184, 1187, 1265, 1275, 1287, 1288, 1308, 1320, 1307, 1337, 1336, 1215, 1216, 1330], and work with Erik Saule and Ümit V. Çatalyürek on streaming applications [1207].
- Lawrence Berkeley Laboratory, USA. Work with Xiaoye Sherry Li on sparse linear solvers [1294, 1313].
- LSTC (Livermore Software Technology Corporation), USA. Work with Cleve Ashcraft [1355, 1357].
- Padova University, Italy. Work with Cristian Pozza and Michele Forzan on the application of sparse direct solvers to electromagnetics applications [1295, 1217].
- University of Hawai'i at Mānoa, USA. Work with Henri Casanova on application resilience, virtual machine scheduling and streaming applications [1205, 1190, 1221, 1213, 1195, 1189, 1186, 1271, 1293, 1305, 1260, 1306, 1274, 1249, 1235, 1234, 1264, 1261, 1276]. Work with Henri Casanova and Lipyeow Lim on the scheduling of Boolean query trees [1316].
- University of Illinois at Urbana-Champaign, USA. Work with Franck Cappello on application resilience [1195, 1260, 1212, 1309, 1304, 1280]. Work with Franck Cappello and Marc Snir on tape archival policies [1273].
- University of Tennessee, Knoxville, USA. Work with Aurélien Bouteiller, George Bosilca, Jack Dongarra, Thomas Hérault, Jakub Kurzak and Piotr Luszczek on dense linear algebra and on application resilience [1304, 1214, 1212, 1289, 1297, 1310, 1296, 1299, 1318].
- University of Strathclyde, UK. Work with Philip A. Knight on matrix scaling methods [1223].
- Rutherford Appleton Laboratory, Didcot, UK. Work with Iain S. Duff on algorithms for sparse matrices [1185, 1200, 1196, 1333, 1329, 1328].
- University of Colorado, Denver, USA. Work with Julien Langou on dense linear algebra [1214, 1289, 1318, 1272].
- Washington University in St. Louis, USA. Work with Kunal Agrawal on streaming applications [1199, 1250, 1232]. (This collaboration was initiated while Kunal Agrawal was a PhD student at MIT.)
- Northeastern University, USA. Work with Arnold Rosenberg on application resilience [1211, 1193, 1242].
- University of Pittsburgh, USA. Work with Rami Melhem on energy-aware scheduling [1210, 1286, 1298, 1268].
- University of Memphis, USA. Work with Qishi Wu on streaming applications [1245, 1246].
- University of Auckland, New Zealand. Work with Oliver Sinnen on pipeline applications [1256] and on memory-aware scheduling [1312].

6.7.4 Management of research projects and contracts

European projects

European FP7 Marie Curie Action – IOF – MetagenoGrids (2008-2009), 1 year. In the scope of the associate-team MetagenoGrid described below, Frédéric Vivien was on sabbatical at the University of Hawai'i at Mānoa for one year, from July 17, 2008 until July 16, 2009. This sabbatical was funded by a Marie Curie Action – International Outgoing Fellowship from the European Commission.

National projects

ANR White Project RESCUE (2010-2014), 4 years. The ANR White Project RESCUE was launched in November 2010, for a duration of 48 months. It gathers three INRIA partners (ROMA, Grand-Large, and Hiepacs) and is led by Yves Robert. The main objective of the project is to develop new algorithmic techniques and software tools to solve the *exascale resilience problem*. Solving this problem implies a departure from current approaches, and calls for yet-to-be-discovered algorithms, protocols, and software tools. The proposed research follows three main research thrusts. The first thrust deals with novel *checkpoint protocols*. The second thrust entails the development of novel *execution models*, i.e., accurate stochastic models to predict (and, in turn, optimize) the expected performance (execution time or throughput) of large-scale parallel scientific applications. In the third thrust, we will develop novel *parallel algorithms* for scientific numerical kernels.

ANR White Project Stochagrid (2007-2010), 3 years Grid computing platforms and components are subject to a great variability. Statistical models are mandatory to deal with changes in resource performance, such as CPU speeds or link bandwidths. Traditionally, Markov chains are used to capture the inherent uncertainty linked to parameter estimation. However, Markov chains lack a key feature: because they are memoryless, they cannot accurately model the performance of parallel systems periodically interacting through message exchanges in steady-state mode. In contrast, sophisticated static scheduling strategies have been developed to map workflow applications on static Grid computing platforms. Optimal algorithms have been designed to map simple pipeline skeleton kernels onto heterogeneous clusters and Grids. Such applications operate in pipeline mode, and standard objective functions include maximizing the throughput and/or minimizing the response time (latency), for each data set. A major goal of this project is to fill the gap between both approaches. On the one hand, statistical models are mandatory to account for the variability and dynamicity of resources. On the other hand, efficient scheduling algorithms only exist for static, dedicated platforms. We need a new stochastic model able to capture the performance of dynamic parallel systems accurately. This new model will be non-Markov for system interaction but will be Markov-based for platform characteristics (fault-tolerance and variability). The design and evaluation of this new model will be the first key contribution of the project. New, robust, scheduling algorithms will be designed and evaluated on top of this model, thereby providing the first stochastic testbed for workflow applications on Grid platforms. The third key contribution of the project will be the design of a prototype library for deploying workflow applications on computational Grids.

This project was entirely conducted within the team.

INRIA associate-team ALOHA (2012-2014), 3 years. The ALOHA associate-team is a joint project of the ROMA team and of the Information and Computer science Department of the University of Hawai‘i (UH) at Mānoa, Honolulu, USA. This project is lead by Frédéric Vivien.

Building on a vast array of theoretical techniques and expertise developed in the field of parallel and distributed computing, and more particularly application *scheduling*, we tackle database questions from a fresh perspective. To this end, this proposal includes:

- a group that specializes in database systems research and who has both industrial and academic experience, the group of Lipyeow Lim (UH);
- a group that specializes in practical aspects of scheduling problems and in simulation for emerging platforms and applications, and who has a long experience of multidisciplinary research, the group of Henri Casanova (UH);
- a group that specializes in the theoretical aspects of scheduling problems and resource management (the ROMA team).

The research work focuses on the following three thrusts: 1) Online, multi-criteria query optimization; 2) Fault-Tolerance for distributed databases; 3) Query scheduling for distributed databases.

INRIA associate-team MetagenoGrid (2008-2010), 3 years. The collaboration is done with the Concurrency Research Group (CoRG) of Henri Casanova, and the Bioinformatics Laboratory (BiL) of Guylaine Poisson of the Information and Computer Sciences Department, of the University of Hawai‘i at Manoā, USA. Frédéric Vivien was the leader of this associate-team.

The associated-team targets the efficient scheduling of large-scale scientific applications on clusters and Grids. To provide context for this research, we focus on applications from the domain of bioinformatics, in particular comparative genomics and metagenomics applications, which are of interest to a large user community today. So far, applications (in bioinformatics or other fields) that have been successfully deployed at a large scale fall under the “independent task model”: they consist of a large number of tasks that do not share data and that can be executed in any order. Furthermore, many of these application deployments rely on the fact that the application data for each task is “small”, meaning that the cost of sending data over the network can be ignored in the face of long computation time. However, both previous assumptions are not valid for all applications, and in fact many crucial applications, such as the aforementioned bioinformatics applications, require computationally dependent tasks sharing very large data sets. This project had two main research thrusts: 1) Scheduling of applications with data requirements; 2) Scheduling of multiple concurrent applications.

CNRS-USA grant SchedLife, University of Hawai‘i (2007-2009), 3 years. This grant covered the same collaboration than the INRIA associate-team MetagenoGrid described above. This grant was lead by Anne Benoit.

INRIA ADT MUMPS (2009-2012), 3 years. ADT-MUMPS was an action of technological development funded by INRIA. Tools for experimentation, validation, and performance study of MUMPS were being developed; one of the goals was also to efficiently use and benefit from the common porting, testing, and compilation cluster from INRIA, pipol.

6.7.5 Participation in research projects and contracts

European projects

European FP7 project SCORPIO (2013-2016), 3 years. The European Project SCORPIO was launched in June 2013, for a duration of 36 months. In addition to INRIA which is repesented by the ROMA team, it gathers five academic partners: CERTH, Greece (coordinator); EPFL, Switzerland; RWTH Aachen University, Germany; The Queen’s University of Belfast, UK; and IMEC, Belgium. This project is centered around a new computing paradigm that exploits uncertainty to design systems that are energy-efficient and scale gracefully under hardware errors by operating below the nominal operating point, in a controlled way, without inducing massive or fatal errors. In this project, ROMA focuses on the design and optimization of ABFT solutions.

National projects

ANR Project SOLHAR (2013-2017), 4 years. The ANR Project SOLHAR was launched in November 2013, for a duration of 48 months. It gathers five academic partners (the HiePACS, Cepage, ROMA, and Runtime INRIA project-teams, and CNRS-IRIT) and two industrial partners (CEA/CESTA and EADS-IW). This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computers equipped with accelerators. The proposed research is organized along three distinct research thrusts. The first objective deals with linear algebra kernels suitable for heterogeneous computing platforms. The second one focuses on runtime systems to provide efficient and robust implementation of dense linear algebra algorithms. The third one is concerned with scheduling this particular application on a heterogeneous and dynamic environment.

ANR grant ANR-06-CIS-010: SOLSTICE – SOlveurs et simulaTIon en Calcul Extrême (2007-2010), 3.5 years. The objective of this project was to design and develop high-performance parallel linear solvers that will be efficient to solve complex multi-physics and multi-scale problems of very large size (10 to 100 millions of equations). To demonstrate the impact of our research, the work produced in the project will be integrated in real simulation codes to perform simulations that could not be considered with today technologies. This project also comprises LABRI (coordinator), CERFACS, INPT-IRIT, CEA-CESTA, EADS-CCR, EDF R&D, and CNRM. We were more particularly involved in tasks related to out-of-core factorization and solution, parallelization of the analysis phase of sparse direct solvers, rank detection, hybrid direct-iterative methods and expertise site for sparse linear algebra.

Inria Project Lab C2S@Exa - Computer and Computational Sciences at Exascale. Since January 2013, the team is participating to the C2S@Exa Inria Project Lab (IPL). This national initiative aims at the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society.

INRIA-UIUC-NCSA Joint Laboratory for Petascale Computing. The Joint Laboratory for Petascale Computing focuses on software challenges found in complex high- performance computers. The Joint Laboratory is based at the University of Illinois at Urbana-Champaign and includes researchers from the French national computer science institute called INRIA, Illinois' Center for Extreme-Scale Computation, and the National Center for Supercomputing Applications. Much of the Joint Laboratory's work focuses on algorithms and software that will run on Blue Waters and other petascale computers.

6.7.6 Industrial contracts and collaborations

There are many industrial collaborations around MUMPS, since it counts many industrial users. Exchanges are mainly via direct contacts, but also via the mumps-users mailing list, or via the organization of MUMPS users days (last editions were hosted by INP Toulouse in 2010 and by EDF in Clamart in 2013). We cite below a few formal collaborations or contracts concerning MUMPS.

Software agreement, MUMPS, 2012. In 2012, a contract was signed between CERFACS, CNRS, ENS Lyon, INP Toulouse, Université of Bordeaux 1, in which these institutions agreed on the way they collaborate on MUMPS. They confirmed their will to freely distribute MUMPS releases under an open-source licence, defined the conditions of use of intermediate development versions, and settled a technical committee to supervise the technical and scientific decisions concerning the software.

Contract with SAMTECH, 2008-2010. Samtech (Belgium) develops the finite element software package SAMCEF, which uses MUMPS as one of the internal solvers. The goal of this work was to study various aspects related to the memory usage of the MUMPS solver and offer the possibility to address larger amounts of memory. We also studied how performance could be improved on Samtech problems by allowing the forward substitution step to be performed simultaneously with the matrix factorization. This last point is particularly interesting in the case of out-of-core executions.

EDF R&D and LSTC, 2010-2014. The work on low-rank solvers mentioned in 8.3.1 was done in the context of a collaboration with INP Toulouse and with the EDF and LSTC companies. A contract with EDF funded a PhD thesis at INPT between 2010 and 2013 on the subject and we provided several prototype versions of MUMPS with low-rank features to EDF in that context.

CERFACS, TOTAL, and HUTCHINSON, 2012-2013. We worked on rank detection algorithms and null space basis computations in the context of a collaboration with CERFACS, INPT, and TOTAL. TOTAL funded an engineer on MUMPS for one year located at CERFACS, Toulouse.

Collaboration with ESI Group, 2013. We participated to a contract with ESI Group in which some numerical aspects of the MUMPS solver related to pivoting strategies had to be revisited to ensure numerical stability on some hard indefinite problems from ESI Group. This contract funded a few months of an engineer on MUMPS at INPT.

EMGS, 2014. A new collaboration with EMGS (Norway) has started. The objective of the work is to understand the feasibility of using low-rank compression and more generally the MUMPS solver to solve numerical problems from EMGS in the context of geophysics applications.

6.7.7 Software production and contribution to research infrastructures

The software package MUMPS

Most of our software activities in the field of sparse linear algebra take place in the scope of the MUMPS solver, for *MUltifrontal Massively Parallel Solver*[61]. With the APO team of INPT-ENSEEIHT-IRIT, we lead the development of MUMPS. It is both an experimental platform for academics in the field of sparse linear algebra, and a software package that is widely used in both academia and industry. The software package MUMPS enables us to (i) confront our research to the real world, (ii) develop contacts and collaborations, and (iii) receive continuous feedback from real-life applications, which is extremely critical to validate our research work. The feedback from a large user community also enables us to direct our long-term objectives towards meaningful directions.

We start by listing the main features of MUMPS and then evaluate MUMPS according to INRIA software standard evaluation format. Then we describe our relations with industry in the scope of MUMPS.

Features. MUMPS is a software package for the solution of large sparse systems of linear equations. MUMPS implements a direct method, the multifrontal method; it is a parallel code capable of exploiting distributed-memory computers; its main originalities are its numerical robustness and the wide range of functionalities available:

- various types of systems: symmetric positive definite, general symmetric, or unsymmetric,
- several matrix input formats: assembled or expressed as a sum of elemental matrices, centralized on one processor or pre-distributed on the processors,
- dense, sparse, possibly multiple right-hand sides, centralized or distributed solution,
- detection of null pivots and null space estimate,
- parallel analysis, parallel scaling algorithms,
- out-of-core execution to solve larger problems,
- partial factorization and Schur complement matrix,
- real or complex arithmetic, single or double precision,
- partial threshold pivoting, backward error analysis,
- inertia, determinant, computation of entries of the inverse,
- fully asynchronous approach with overlap of computation and communication,
- distributed dynamic scheduling of the computational tasks to allow for a good load balancing even in case of numerical pivoting at runtime.

Software positioning. The development of MUMPS was initiated by the European project PARASOL (Esprit 4, LTR project 20160, 1996-1999), whose results and developments were public domain. Since then, MUMPS has been supported by CERFACS, CNRS, ENS Lyon, INPT(ENSEEIHT)-IRIT, INRIA, and the University of Bordeaux.

Description of the state of the art, placement of the software w.r.t. the competition:
MUMPS is unique thanks to its wide range of functionalities, original approach to parallelism, numerical robustness in a distributed environment, and the variety of application fields that it covers. This is a critical aspect that motivates its use in renowned simulation software (Code_Aster, Telemac, Samcef, Pam-Crash Petsc, Actran, ...). MUMPS is taken as a reference in many comparisons with approaches that are specific to a given application field. Other freely-available software with close or complementary features include:

- PaStiX: smaller spectrum of applications, but well adapted to large-scale high performance computers;
- SuperLU: parallel code dedicated to unsymmetric matrices.

Size of the software, languages used, and size of the development team: 250 000 lines of Fortran/C. Development team with between 3 and 10 members since 10 years (2 before that).

Software distribution and licensing: MUMPS is both redistributed in Linux packages (e.g., Debian distribution), in open-source packages (such as Code_Aster from EDF, PETSc from Argonne), in academic packages (AGMG from Université Libre de Bruxelles), and in commercial products (such as Pam-Crash from ESI-Group, samcef from Samtech, or Actran and FEMTown from Free Field Technologies). The next version of MUMPS (5.0) will be distributed under the Cecill-C license.

Users community: The users community includes academics and industrials (more than 1000 downloads per year from the MUMPS website). Several companies use MUMPS daily (e.g., EDF, ESI Group, Samtech, . . .); it could be problematic (costly) for some of them to find alternative solutions.
There are around 500 emails per year on the MUMPS users mailing list (450 subscribers) and 800 emails per year between developers and users. MUMPS benefits from considerable feedback from the users community regarding validation, performance analysis on challenging test cases, leading to new research directions. Some discussion on transfer activities and relation with industry is available in Section 6.7.13.

[61] `http://mumps-solver.org`

Other software activities

Our other significant software activities take place in the scope of *Combinatorial scientific computing*. There, our efforts in the standard hypergraph partitioning problem sometimes result in additions to the PaToH tool[62] —for example [1187]— which is distributed under the GNU Lesser General Public license. We have implemented almost all known variants of bipartite matching algorithms in sequential in the Matchmaker software[63], and some of them for GPUs in the Matchmaker2 software[64]; this software is publicly available. There is an in-house library for testing the effects of hypergraph partitioning methods in parallel sparse matrix-vector multiply operations. This last library is not publicly available. Some other tiny projects resulting from research work that perform some common tasks on sparse matrices are publicly made available[65].

6.7.8 Prizes and awards

- Yves Robert was awarded the 2014 IEEE TCSC Award for Excellence. "The IEEE TCSC Award for Excellence in Scalable Computing is awarded for significant and sustained contributions to the scalable computing community through the IEEE Technical Committee on Scalable Computing (TCSC), coupled with an outstanding record of high quality and high impact research."[66]
- Anne Benoit was appointed junior member of the Institut Universitaire de France (IUF) in 2009, and Yves Robert was renewed as a senior member in 2011.
- Best paper award of the HeteroPar'2009 workshop: A. Benoit, H. Casanova, V. Rehn-Sonigo, Y. Robert. Resource allocation for multiple concurrent in-network stream-processing applications. In Proceedings of HeteroPar'2009, the 7th Int. Workshop on Algorithms, Models and Tools for Parallel Computing on Heterogeneous Platforms, Delft, The Netherlands, August 2009.
- Best paper award of the ISPDC'2010 conference: A. Benoit, H. L. Bouziane, Y. Robert. Optimizing the reliability of pipelined applications under throughput constraints. In Proceedings of ISPDC'2010, the 9th Int. Symposium on Parallel and Distributed Computing, Istanbul, Turkey, July 2010.
- Bora Uçar ranked second in the 10th DIMACS Implementation Challenge, with U. V. Çatalyürek, M. Deveci, and K. Kaya for the graph partitioning challenge with the paper [1336].
- Best poster award at the PhD Forum of the IPDPS 2011 conference for Mathias Jacquelin, "Memory-Aware Algorithms and Scheduling Techniques: From Multicore Processors to Petascale Supercomputers".

6.7.9 Contribution to the scientific community and administrative responsibilities

- Anne Benoit was responsible of the 3rd year students in computer science at ENS Lyon, 2006-2010.

- Bora Uçar was appointed (by election) as the Secretary of the SIAM activity group on Supercomputing (the term covers 1 January 2014 – 12 December 2015).

- Jean-Yves L'Excellent was a member of the recruitment board for postdocs at Inria ("Commission des emplois scientifiques" – every year during the reporting period). Since 2011, he is a member of the research committee of the MILYON "excellence laboratory". He is also the representant for the laboratory in the "Fédération lyonnaise de calcul haute performance", which mutualizes parallel computing resources shared by institutions of higher education in Lyon. He was local head of the GRAAL team for 1 year (until July 2009) during the sabbatical year of the scientific leader F. Vivien.

- Yves Robert was a member of the selection commitee for junior members of Institut Universitaire de France (IUF) in 2009. He is a member of the Fellow Selection Committee of IEEE since 2011. He was a reviewer for the European Commission, Bruxelles (Feb. 25-28, 2013).

- Frédéric Vivien has been head of the GRAAL and then of the ROMA team for the whole reporting period. Since 2013, he is head of the PhD committee of the laboratory, and the representative of the laboratory to the *École doctorale*; he was co-head of that committee since 2010. He was a member of the 2011 AERES committee for the evaluation of the FEMTO-ST laboratory, Besançon, France. Frédéric Vivien has been elected at the Scientific Council of ENS Lyon in 2014.

[62] http://bmi.osu.edu/~umit/software.html
[63] http://bmi.osu.edu/~kamer/research.html
[64] http://bmi.osu.edu/hpc/software/matchmaker2/
[65] http://perso.ens-lyon.fr/bora.ucar/codes.html
[66] https://www.ieeetcsc.org/awards/award_for_excellence

Hiring committees ("comités de sélection")

- Anne Benoit: MCF Univ. Grenoble 2013, MCF Univ. Tours 2014, MCF ENS Lyon 2014.
- Loris Marchal: MCF Univ. Besançon 2012, MCF Univ. Tours 2013.
- Jean-Yves L'Excellent: recruitment board of Inria junior research scientists for the Grenoble – Rhône-Alpes center, 2010.

PhD committees

- Anne Benoit was a member of the following PhD defense committees: Mohamad Al Hajj Hassan (Orléans, 2009, rapporteur); Hubert Larchevêque (Bordeaux, 2010, examinateur); Meriem Zidouni (Grenoble, 2010, examinateur); Alexandru Dobrila (Besançon, 2011, examinateur); Przemysław Uznański (Bordeaux, 2013, rapporteur).
- Jean-Yves L'Excellent was a member of the PhD defense committee of Sethy Montan (Université Paris 6, 2013, rapporteur).
- Loris Marchal was a member of the PhD defense committee of Sékou Diakité (Besançon, 2011, examinateur).
- Bora Uçar was a member of the following PhD defense committees: Clément Vuchener (L'Université de Bordeaux, 2014, rapporteur); Bastian Onne Fagginger Auer (Utrecht University, the Netherlands, 2013, evaluator=rapporteur); Md. Mostofa Ali Patwary (University of Bergen, Norway, 2011, opponent=rapporteur).
- Frédéric Vivien was a member of the following PhD defense committees: Abir Benabid (Université Paris 6, 2011, rapporteur); Amina Guermouche (Université Paris Sud, 2011, examinateur); Javier Celaya (Universidad de Zaragoza, Spain, 2013, examinateur); Marco Meoni (École Polytechnique Fédérale de Lausanne, Suisse, 2013, rapporteur).
- Yves Robert was a member of the following PhD defense committees: Xavier Gréhant (ENST Paris, Sep. 2010, rapporteur); Mohamed Slim Bouguerra (INP Grenoble, Apr. 2012, rapporteur).

Habilitation (HDR) committees

- Yves Robert was a member of the Habilitation committee of Laurent Lefèvre (ENS Lyon, Nov. 2013, examinateur).

6.7.10 Editorial duties

- Anne Benoit is an associate editor of the *Journal of Parallel and Distributed Computing (JPDC)* and of the *Journal of Sustainable Computing: Informatics and Systems (SUSCOM)*.
  Anne Benoit co-edited a special issue of *SUSCOM*, entitled *Energy-Aware Resource Management and Scheduling*.
- Yves Robert is an associate editor of *International Journal of High Performance Computing Applications (IJHPCA)*, *International Journal of Grid and Utility Computing (IJGUC)*, and *Journal of Computational Science (JOCS)*.
  Yves Robert co-edited a special issue of *Parallel Computing*, as a follow-on of ISPDC'2009 and HeteroPar'2010 that gathered extended versions of the best contributions to these events.
- Frédéric Vivien is an associate editor of *Parallel Computing*.

6.7.11 Organisation and committees of scientific conferences

- The ROMA team co-organized with the AVALON team ICPP'2013, the 2013 International Conference on Parallel Processing, October 1-4, 2013, Lyon.
- The ROMA team organizes each year an invitation-only workshop on *Scheduling for Large Scale Systems*. This workshop took place in Knoxville in 2009[67], Aussois in 2010[68] and 2011[69], Pittsburgh in 2012[70], Dagstuhl in 2013[71] and Lyon in 2014[72]. Each workshop gathered 30 to 40 participants for 3 days.
- Anne Benoit co-organized the 6th International Workshop on aPplications of declArative and object-oriented Parallel Programming (PAPP 2009), Baton Rouge, Louisiana, USA, May 2009, around 20 participants for 1 day.
- Anne Benoit co-organized the 7th International Workshop on Practical Aspects of high-level Parallel Programming (PAPP 2010) in Amsterdam, The Netherlands, May 2010, around 20 participants for 1 day.
- Anne Benoit was part of the organization committee of the Forum 2013 des Jeunes Mathématicien-ne-s, November 2013, Lyon, around 50 participants for 3 days.

[67] http://graal.ens-lyon.fr/~abenoit/knoxville/
[68] http://graal.ens-lyon.fr/~bucar/aussois/
[69] http://perso.ens-lyon.fr/evelyne.blesle/aussois/
[70] http://perso.ens-lyon.fr/evelyne.blesle/pittsburgh/
[71] http://www.dagstuhl.de/no_cache/en/program/calendar/semhp/?semnr=13381
[72] http://scheduling2014.sciencesconf.org/

- Jean-Yves L'Excellent co-organized the second MUMPS Users days at INP Toulouse in 2010, and the third at EDF, Clamart, May 29-30, 2013, 52 participants.
- Bora Uçar organized the CSC14 workshop, the *Sixth SIAM Workshop on Combinatorial Scientific Computing* in Lyon, 21–23 July 2014. There were 54 participants.

Chairs and vice-chairs of program committees

Anne Benoit was vice-program chair, for the track *Algorithms*, of IPDPS 2014; workshops co-chair of ICPP 2014 and ICPP 2013; program vice co-chair of IEEE Cluster 2012, for track "Applications and Algorithms"; member of the organizing committee of SIAM PP 2012, and organizer of a mini-symposium in SIAM PP12; general chair of HCW 2011; program vice-chair of AINA 2012, for track 5: "Distributed and Parallel Systems"; member of the organizing committee of SIAM PP 2012; program chair of HCW 2010.

Yves Robert was program vice-chair for the track *Algorithms* of SC'14; program chair of ICPP 2013; program chair of HiPC 2013; program vice-chair, for the track *Algorithms*, of HiPC 2012; program vice-chair of HiPC'2010 for the track *Algorithms and Applications*; program co-vice-chair of ICPP'2011, for the track *Algorithm Design and Parallelization*; program chair of the IEEE TCPP PhD Forum; program chair of ISPDC'09.
Yves Robert is a member of the Steering Committee of HCW of IPDPS, and of HeteroPar.

Bora Uçar was the vice-program chair for the *Applications* track of ICPP 2013, and was an organizer of a mini-symposium in SIAM PP12.

Frédéric Vivien was program vice-chair, for the *Algorithms* track, of IPDPS 2013; program vice-chair, for the *Algorithms* track, of HiPC 2014; co-responsible of the stream "Algorithmes distribués, multi-agents et calcul parallèle" for ROADEF 2014; local chair for the Theory topic of Euro-Par 2011; program chair of HeteroPar 2010.

Other participations in program committees

Anne Benoit was a member of the program committees of the following conferences and workshops: HCW 2014, PDP 2014, Ena-HPC 2014, CCGrid 2014, ICPP 2013, IGCC 2013, HiPC 2013, ICPE 2013, CCGrid 2013, IPDPS 2013, CLOSER 2013, HCW 2013, IGCC 2013, CCGrid 2012, HPDC 2012, IPDPS 2012, SPAA 2011, IPDPS 2011, HiPC 2011, IPDPS 2010, HiPC 2010, HLPP 2010, APDCM 2010, ICCS 2010, ICCS 2009, HPCC 2009, ISPDC 2009, ISCIS 2009, TCPP PhD Forum 2009.

Jean-Yves L'Excellent was a member of the program committees of Vecpar'10, Vecpar'12, RenPar'21-ComPAS 2013, ICPP 2013 (also local arrangements co-chair), ComPAS 2014, Vecpar 2014, CSC 2014.

Loris Marchal was a member of the program committees of IPDPS'2014, IPDPS'2013, ICPP'2013, IPDPS'2012, ICPP 2012, IPDPS 2011, ICPP 2011, HCW 2011, ICNC 2010, LaSCoG 2010, ISPDC 2009.

Yves Robert was a member of the program committees of the following conferences and workshops: EduPar 2013, FTXS 2013, ICCS 2013, IGCC 2013, ISC tutorials 2013, ISC 2013, SC 2013, EduPar 2012, FTXS 2012, ISC 2012, ISCIS 2012.

Bora Uçar was was a member of the program committee for MPP2014 (a workshop of SBAC-PAD2014), HiPC14, IPDPS 2014, PMAA14, PCO 2014 (a workshop of IPDPS), IPDPS 2013, PCO 2013 (a workshop of IPDPS), PPAM 2013, HiPC12, IEEE Cluster 12, EuroPar 2012, PCO'12, PMAA2012, 2012 TCPP PhD Forum, ICNC'11, HPSS 2011, PCO'11, SIAM CSC11, ICNC'10, 2010 TCPP PhD forum, ICPADS'09, ISCIS 2009, 2009 TCPP PhD Forum.

Frédéric Vivien was a member of the program committee of the following conferences and workshops: SC'14, posters of SC'14, IPDPS 2014, ComPAS'2014, PDP 2014, EduHPC'14, SC'13, EduPDHPC, ICPP 2013, EduPar-13, PDP 2013, ROADEF 2013, RenPar'21 - ComPAS'2013, EuroPDP 2013, SC'13, CCGrid 2012, Cluster 2012, ROADEF 2012, AHPAA 2012, ROADEF 2011, IPDPS 2011, ICDCS 2011, HiPC 2011, PDP 2012, EuroPDP 2010, HiPC'2010, Cluster 2010, NPC 2009, CCGrid 09 (only as member of the backup team), RenPar 2009, ISPDC'2009, EuroPDP 2009.

6.7.12 National and international boards and expertise, consulting activities

Yves Robert is a member of the "NSF/TCPP Curriculum Initiative on Parallel and Distributed Computing" that defined the "core topics in parallel and distributed computing that a student graduating with a Bachelors degree in Computer Science or Computer Engineering is expected to have covered". Out of the twenty members of this committee, Yves Robert is the only one not coming from North America.

6.7.13 Patents, startups, and technology transfer

There were no startups created or patents registered during the evaluation period. Following the agreement signed in 2012 between CERFACS, CNRS, ENS Lyon, INPT, Inria and ENS Lyon (see Section 6.7.6), we have since then been working on setting up a consortium of industrial users as a first economic model which should help guaranteeing the future of MUMPS and help organizing the collaborations and contracts with industry. A Transfer and Innovation engineer (so called ITI) now funded by Inria on a temporary contract is leading this project of consortium. The main objective would be to obtain the necessary funding for longer term engineer positions, in order to enable the constant transfer of research into the software.

6.7.14 Training and teaching activities

Habilitation theses

Two permanents members of ROMA defended their Habilitation thesis (HDR) at ENS Lyon since 2009: Anne Benoit in July 2009, and Jean-Yves L'Excellent in October 2012.

PhD students

Since January 2009, six ROMA students have defended their PhD: Fanny Dufossé (September 2011), Matthieu Gallet (October 2009), Mathias Jacquelin (July 2011), Veronika Rehn-Sonigo (July 2009), Paul Renaud-Goud (July 2012), Clément Rezvoy (September 2011). Three additional PhD students should defend their PhD before the end of 2014: Guillaume Aupy, Mohammed Wissam Sid-Lakhdar, and Dounia Zaidouni.

Among the 5 students who defended their PhDs before december 2011, 4 have a permanent position: Veronika Rehn-Sonigo is associate professor at IUT Besançon-Vesoul; Fanny Dufossé is an INRIA junior research scientist at Lille; Matthieu Gallet is a research engineer at the French Department of Defense; and Clément Rezvoy is an engineer in a start-up company. The last one, Mathias Jacquelin is a post-doctoral student at Lawrence Berkeley National Laboratory, USA.

National or International Courses and Tutorials

- An overview of fault-tolerance techniques for HPC: Yves Robert, half-day tutorial given at SC'12, ICS'13, and SC'13.
- Fault-tolerance techniques for HPC – theory and practice: Yves Robert, full-day tutorial given at SC'14.
- Parallel sparse matrix vector multiplies, iterative solvers, and models and methods for efficient parallelization: Bora Uçar, 3-hour course at University of Murcia, Spain, 28 and 29 November 2011.
- Sparse Direct Linear Solvers: Jean-Yves L'Excellent, 4 hour PhD level lecture, University of Aachen, Germany.

Master level courses

- Algorithms for High-Performance Computing Platforms: Frédéric Vivien ENS Lyon, 2013-2015.
- Combinatorial Scientific Computing: Bora Uçar, ENS Lyon, 2013-2015.
- Parallel Algorithms: Anne Benoit, ENS Lyon, 2007-2010.
- Parallel Algorithms and Parallel Programming: Frédéric Vivien, ENS Lyon, 2010-2015.
- Scheduling: Loris Marchal, ENS Lyon, 2008, 2011-2013.
- Sparse matrix computations: Jean-Yves L'Excellent and Bora Uçar, ENS Lyon, 2009-2011.

License level courses

- Algorithms: Anne Benoit, ENS Lyon, 2006-2010.
- Algorithms: Yves Robert, ENS Lyon, 2013-2015.
- Operating systems and networks: Anne Benoit, ENS Lyon, 2012-2015.
- Probability: Yves Robert, ENS Lyon, 2010-2013.

6.7.15 Interaction with the social and cultural environment

6.7.16 Publications and productions

International peer-reviewed journals [ACL]

2009

[1177] Anne Benoit, Eric Thierry, and Yves Robert. On the complexity of mapping linear chain applications onto heterogeneous platforms. *Parallel Processing Letters*, 19(3):383–397, 2009.

[1178] Kamer Kaya and Bora Uçar. Exact algorithms for a task assignment problem. *Parallel Processing Letters*, 19(3):451–465, 2009.

[1179] Florent Sourbier, Stéphane Operto, Jean Virieux, Patrick Amestoy, and Jean-Yves L'Excellent. FWT2D: A massively parallel program for frequency-domain full-waveform tomography of wide-aperture seismic data-Part 1: Algorithm. *Computer & Geosciences*, 35(3):487–495, 2009.

[1180] Florent Sourbier, Stéphane Operto, Jean Virieux, Patrick Amestoy, and Jean-Yves L'Excellent. FWT2D: A massively parallel program for frequency-domain full-waveform tomography of wide-aperture seismic data-Part 2: Numerical examples and scalability analysis. *Computer & Geosciences*, 35(3):496–514, 2009.

2010

[1181] Emmanuel Agullo, Abdou Guermouche, and Jean-Yves L'Excellent. Reducing the I/O Volume in an Out-of-core Sparse Multifrontal Solver. *SIAM Journal on Scientific Computing*, 31(6):4774–4794, 2010.

[1182] Anne Benoit, Mourad Hakem, and Yves Robert. Multi-criteria scheduling of precedence task graphs on heterogeneous platforms. *The Computer Journal*, 53(6):772–785, 2010.

[1183] Anne Benoit, Loris Marchal, Jean-François Pineau, Yves Robert, and Frédéric Vivien. Scheduling concurrent bag-of-tasks applications on heterogeneous platforms. *IEEE Transactions on Computers*, 59(2):202–2017, 2010.

[1184] Ümit V. Çatalyürek, Cevdet Aykanat, and Bora Uçar. On two-dimensional sparse matrix partitioning: Models, methods, and a recipe. *SIAM Journal on Scientific Computing*, 32(2):656–683, 2010.

[1185] Iain S. Duff and Bora Uçar. On the block triangular form of symmetric matrices. *SIAM Review*, 52(3):455–470, 2010.

[1186] Mark Stillwell, David Schanzenbach, Frédéric Vivien, and Henri Casanova. Resource allocation algorithms for virtualized service hosting platforms. *Journal of Parallel and Distributed Computing*, 70(9):962–974, May 2010.

[1187] Bora Uçar, Ümit V. Çatalyürek, and Cevdet Aykanat. A Matrix partitioning interface to PaToH in MATLAB. *Parallel Computing*, 36(5–6):254–272, 2010.

2011

[1188] Anne Benoit, Hinde Lilia Bouziane, and Yves Robert. Optimizing the reliability of streaming applications under throughput constraints. *International Journal of Parallel Programming*, 39(5):584–614, 2011.

[1189] Anne Benoit, Henri Casanova, Veronika Rehn-Sonigo, and Yves Robert. Resource allocation strategies for constructive in-network stream processing. *International Journal of Foundations of Computer Science*, 22(3):621–638, 2011.

[1190] Anne Benoit, Henri Casanova, Veronika Rehn-Sonigo, and Yves Robert. Resource allocation strategies for multiple concurrent in-network stream processing applications. *Parallel Computing*, 37(8):331–348, 2011.

[1191] Anne Benoit, Alexandru Dobrila, Laurent Philippe, and Jean-Marc Nicod. Mapping workflow applications with types on heterogeneous specialized platforms. *Parallel Computing*, 37(8):410–427, 2011.

[1192] Anne Benoit, Paul Renaud-Goud, and Yves Robert. Models and complexity results for performance and energy optimization of concurrent streaming applications. *International Journal of High Performance Computing Applications*, 25(3):261–273, 2011.

[1193] Anne Benoit, Yves Robert, Arnold Rosenberg, and Frédéric Vivien. Static worksharing strategies for heterogeneous computers with unrecoverable interruptions. *Parallel Computing*, 37(8):365–378, 2011.

[1194] Olivier Bournez and Guillaume Aupy. On the Number of Binary-Minded Individuals Required To Compute $\sqrt{\frac{1}{2}}$. *Theoretical Computer Science*, 411(22):2262–2267, 2011.

[1195] Franck Cappello, Henri Casanova, and Yves Robert. Preventive migration vs. preventive checkpointing for extreme scale supercomputers. *Parallel Processing Letters*, 21(2):111–132, 2011.

[1196] Iain S. Duff, Kamer Kaya, and Bora Uçar. Design, implementation, and analysis of maximum transversal algorithms. *ACM Transactions on Mathematical Software*, 38:13:1–13:31, 2011.

[1197] Eray Ozkural, Cevdet Aykanat, and Bora Uçar. Parallel Frequent Item Set Mining with Selective Item Replication. *IEEE Transactions on Parallel and Distributed Systems*, 22:1632–1640, 2011.

[1198] Jean-François Pineau, Yves Robert, and Frédéric Vivien. Energy-aware scheduling of bag-of-tasks applications on master-worker platforms. *Concurrency and Computation: Practice and Experience*, 23(2):145–157, 2011.

2012

[1199] Kunal Agrawal, Anne Benoit, Fanny Dufossé, and Yves Robert. Mapping filtering streaming applications. *Algorithmica*, 62(1):258–308, 2012.

[1200] Patrick R. Amestoy, Iain S. Duff, Jean-Yves L'Excellent, Yves Robert, François-Henry Rouet, and Bora Uçar. On computing inverse entries of a sparse matrix in an out-of-core environment. *SIAM Journal on Scientific Computing*, 34(4):A1975–A1999, July 2012.

[1201] Anne Benoit, Louis-Claude Canon, Emmanuel Jeannot, and Yves Robert. Reliability of task graph schedules with transient and fail-stop failures: complexity and algorithms. *Journal of Scheduling*, 15(5):615–627, October 2012.

[1202] Tudor David, Mathias Jacquelin, and Loris Marchal. Scheduling streaming applications on a complex multicore platform. *Concurrency and Computation: Practice and Experience*, 24(15):1726–1750, 2012.

[1203] Sushil Prasad, K., Anshul Gupta, Krishna Kant, Andrew Lumsdaine, David Padua, A., Yves Robert, Arnold Rosenberg, Alan Sussman, Charles Weems, and C. Literacy for all in parallel and distributed computing: guidelines for an undergraduate core curriculum. *CSI Journal of Computing*, 1(2), 2012.

[1204] Sushil Prasad, K., Anshul Gupta, Krishna Kant, Andrew Lumsdaine, David Padua, A., Yves Robert, Arnold Rosenberg, Alan Sussman, Charles Weems, and C. Toward a core undergraduates curriculum in parallel and distributed computing. *Computer Education (China)*, pages 76–90, 2012.

[1205] Mark L. Stillwell, Frédéric Vivien, and Henri Casanova. Dynamic Fractional Resource Scheduling versus Batch Scheduling. *IEEE Transactions on Parallel and Distributed Systems*, 23(3), 2012.

2013

[1206] Guillaume Aupy, Anne Benoit, Fanny Dufossé, and Yves Robert. Reclaiming the energy of a schedule: models and algorithms. *Concurrency and Computation: Practice and Experience*, 25:1505–1523, 2013.

[1207] Anne Benoit, Umit V. Catalyurek, Yves Robert, and Erik Saule. A Survey of Pipelined Workflow Scheduling: Models and Algorithms. *ACM Computing Surveys*, 45(4), 2013.

[1208] Anne Benoit, Alexandru Dobrila, Jean-Marc Nicod, and Laurent Philippe. Scheduling linear chain streaming applications on heterogeneous systems with failures. *Future Generation Computer Systems*, 29(5):1140–1151, 2013.

[1209] Anne Benoit, Fanny Dufossé, Alain Girault, and Yves Robert. Reliability and performance optimization of pipelined real-time systems. *Journal of Parallel and Distributed Computing*, 73(6):851–865, 2013.

[1210] Anne Benoit, Rami Melhem, Paul Renaud-Goud, and Yves Robert. Assessing the performance of energy-aware mappings. *Parallel Processing Letters*, 23(2), 2013.

[1211] Anne Benoit, Yves Robert, Arnold Rosenberg, and Frédéric Vivien. Static strategies for worksharing with unrecoverable interruption. *Theory of Computing Systems*, 53(3):386–423, 2013.

[1212] George Bosilca, Aurélien Bouteiller, Élisabeth Brunet, Franck Cappello, Jack Dongarra, Amina Guermouche, Thomas Hérault, Yves Robert, Frédéric Vivien, and Dounia Zaidouni. Unified Model for Assessing Checkpointing Protocols at Extreme-Scale. *Journal of Concurrency and Computation: Practice and Experience*, November 2013.

[1213] Henri Casanova, Fanny Dufossé, Yves Robert, and Frédéric Vivien. Mapping Applications on Volatile Resources. *International Journal of High Performance Computing Applications*, 2013.

[1214] Jack Dongarra, Mathieu Faverge, Thomas Hérault, Mathias Jacquelin, Julien Langou, and Yves Robert. Hierarchical QR factorization algorithms for multi-core clusters. *Parallel Computing*, 39(4-5):212–232, 2013.

[1215] Kamer Kaya, Johannes Langguth, Fredrik Manne, and Bora Uçar. Push-relabel based algorithms for the maximum transversal problem. *Computers & Operations Research*, 40(5):1266–1275, 2013.

[1216] Kamer Kaya and Bora Uçar. Constructing elimination trees for sparse unsymmetric matrices. *SIAM Journal on Matrix Analysis and Applications*, 34(2):345–354, April 2013.

2014

[1217] Patrick Amestoy, Alfredo Buttari, Guillaume Joslin, Jean-Yves L'Excellent, Wissam M. Sid-Lakhdar, Clément Weisbecker, Michele Forzan, Cristian Pozza, Rémy Perrin, and Valène Pellissier. Shared memory parallelism and low-rank approximation techniques applied to direct solvers in FEM simulation. *IEEE Transactions on Magnetics, Extended selected short papers from Compumag 2013 conference*, 50(2), February 2014.

[1218] Guillaume Aupy, Anne Benoit, Matthieu Journault, and Yves Robert. Power-aware replica placement in tree networks with multiple servers per client. *Sustainable Computing*, 2014.

[1219] Guillaume Aupy, Yves Robert, Frédéric Vivien, and Dounia Zaidouni. Checkpointing algorithms and fault prediction. *Journal of Parallel and Distributed Computing*, 74:2048–2064, November 2014.

[1220] Anne Benoit, Matthieu Gallet, Bruno Gaujal, and Yves Robert. Computing the throughput of probabilistic and replicated streaming applications. *Algorithmica*, 69(4):925–957, 2014.

[1221] Marin Bougeret, Henri Casanova, Yves Robert, Frédéric Vivien, and Dounia Zaidouni. Using group replication for resilience on exascale systems. *International Journal of High Performance Computing Applications*, 28(2):210–224, 2014.

[1222] Julien Herrmann, Loris Marchal, and Yves Robert. Memory-aware tree traversals with pre-assigned tasks. *Journal of Parallel and Distributed Computing*, 2014.

[1223] Philip A. Knight, Daniel Ruiz, and Bora Uçar. A symmetry preserving algorithm for matrix scaling. *SIAM Journal on Matrix Analysis and Applications*, 35(3):931–955, 2014.

[1224] Jean-Yves L'Excellent and Wissam M. Sid-Lakhdar. A study of shared-memory parallelism in a multifrontal solver. *Parallel Computing*, 40(3-4):34–46, 2014.

National peer-reviewed journals [ACL]

2012

[1225] Bel Dumé, Frédéric Desprez, and Yves Robert. L'essor et l'accessibilité du calcul distribué. *Collection "20 ans d'avancées et de perspectives en sciences du numérique" par les chercheurs d'équipes Inria de Grenoble et Lyon.*, page 2 p., October 2012.

Invited conferences [INV], seminars, and tutorials

2013

[1226] Yves Robert. An overview of fault-tolerant techniques for hpc, 2013. Invited keynote, 6th International Conference on Contemporary Computing (IC3), New Delhi, India, August 8.

[1227] Yves Robert. An overview of fault-tolerant techniques for hpc, 2013. Invited keynote, Sixth Int. Workshop on Parallel Programming Models and Systems Software for High-End Computing (P2S2), Lyon, France, October 1.

[1228] Yves Robert. Scheduling for exascale platforms: new challenges, 2013. Invited keynote, Exascale Supercomputing Workshop (ExaComp 2013), Seoul, Korea, January 29.

[1229] Bora Uçar. A sparse matrix scaling algorithm and its efficient parallelization, 2013. Invited plenary talk, HPCSE 2013: High Performance Computing in Science and Engineering, Solan, Czech Republic, May 30, 2013.

2014

[1230] Yves Robert. Algorithms for coping with silent errors, 2014. Invited keynote, 7th Workshop on Resiliency in High Performance Computing with Clouds, Grids, and Clusters, Porto, Portugal, August 25.

[1231] Yves Robert. Fault-tolerance techniques for computing at scale, 2014. Invited keynote, IEEE/ACM CCGrid 2014, Chicago, USA, May 29.

International peer-reviewed conference proceedings [ACT]

2009

[1232] Kunal Agrawal, Anne Benoit, Fanny Dufossé, and Yves Robert. Mapping Filtering Streaming Applications with Communication Costs. In *Proceedings of the Twenty-first Annual Symposium on Parallelism in Algorithms and Architectures (SPAA)*, pages 19–28, New York, NY, États-Unis, 2009. ACM.

[1233] Anne Benoit. Comparison of Access Policies for Replica Placement in Tree Networks. In Henk Sips, Dick Epema, and Hai-Xiang Lin, editors, *Euro-Par 2009 Parallel Processing*, volume 5704, pages 253–264. Springer Berlin Heidelberg, 2009.

[1234] Anne Benoit, Henri Casanova, Veronika Rehn, and Yves Robert. Resource Allocation for Multiple Concurrent In-network Stream-processing Applications. In *Seventh International Workshop on Algorithms, Models and Tools for Parallel Computing on Heterogeneous Platforms*, Delft, Netherlands, October 2009.

[1235] Anne Benoit, Henri Casanova, Veronika Rehn, and Yves Robert. Resource allocation strategies for constructive in-network stream processing. In *11th Workshop on Advances in Parallel and Distributed Computational Models*, Rome, Italy, May 2009.

[1236] Anne Benoit, Alexandru Dobrila, Jean-Marc Nicod, and Laurent Philippe. Throughput optimization for micro-factories subject to failures. In *ISPDC'2009, 8th Int. Symposium on Parallel and Distributed Computing*, pages 11–18, Portugal, 2009.

[1237] Anne Benoit, Fanny Dufossé, and Yves Robert. Filter placement on a pipelined architecture. In *APDCM - Workshop on Advances in Parallel and Distributed Computational Models - 2009*, Rome, Italy, 2009.

[1238] Anne Benoit, Fanny Dufossé, and Yves Robert. On the complexity of mapping pipelined filtering services on heterogeneous platforms. In *IPDPS - IEEE International Parallel and Distributed Processing Symposium - 2009*, pages 1–12, Rome, Italy, 2009.

[1239] Anne Benoit, Matthieu Gallet, Bruno Gaujal, and Yves Robert. Computing the throughput of replicated workflows on heterogeneous platforms. In *Int. conf. on Parallel Processing, ICPP*, pages 204–211, Vienna, Austria, 2009.

[1240] Anne Benoit, Mourad Hakem, and Yves Robert. Optimizing the Latency of Streaming Applications under Throughput and Reliability Constraints. In *ICPP '09. International Conference on Parallel Processing, 2009.*, pages 325–332, Vienna, Autriche, 2009. IEEE.

[1241] Anne Benoit, Loris Marchal, Jean-François Pineau, Yves Robert, and Frédéric Vivien. Resource-aware allocation strategies for divisible loads on large-scale systems. In *HCW 2009 - 18th International Heterogeneity in Computing Workshop*, Rome, Italy, 2009. IEEE Computer Society Press.

[1242] Anne Benoit, Yves Robert, Arnold Rosenberg, and Frédéric Vivien. Static strategies for worksharing with unrecoverable interruptions. In *IPDPS*, Rome, Italy, May 2009.

[1243] Sékou Diakité, Loris Marchal, Jean-Marc Nicod, and Laurent Philippe. Steady-State for Batches of Identical Task Graphs. In *Euro-Par'09*, pages 203–215, Netherlands, 2009.

[1244] Matthieu Gallet, Loris Marchal, and Frédéric Vivien. Efficient Scheduling of Task Graph Collections on Heterogeneous Resources. In *IPDPS'2009 - International Parallel and Distributed Processing Symposium*, Rome, Italy, 2009. IEEE Computer Society Press.

[1245] Yi Gu, Qishi Wu, Anne Benoit, and Yves Robert. Complexity analysis and algorithmic development for pipeline mappings in heterogeneous networks. In *PODC - 28th ACM Symposium on Principles of Distributed Computing - 2009*, Calgary, Canada, 2009.

[1246] Yi Gu, Qishi Wu, Anne Benoit, and Yves Robert. Optimizing end-to-end performance of distributed applications with linear computing pipelines. In *ICPADS - International Conference on Parallel and Distributed Systems - 2009*, pages 252–259, Shenzhen, China, 2009.

[1247] Mathias Jacquelin, Loris Marchal, and Yves Robert. Complexity Analysis and Performance Evaluation of Matrix Product on Multicore Architectures. In *ICPP '09. International Conference on Parallel Processing, 2009.*, pages 196–203, Vienna, Autriche, 2009. IEEE.

[1248] Jean-François Pineau, Yves Robert, and Frédéric Vivien. Energy-Aware Scheduling of Flow Applications on Master-Worker Platforms. In Henk Sips, Dick Epema, and Hai-Xiang Lin, editors, *Euro-Par 2009 Parallel Processing*, volume 5704, pages 281–292. Springer Berlin Heidelberg, August 2009.

[1249] Mark Stillwell, David Schanzenbach, Henri Casanova, and Frédéric Vivien. Resource Allocation Using Virtual Clusters. In *9th IEEE/ACM International Symposium on Cluster Computing and the Grid, 2009. CCGRID '09.*, Shanghai, China, 2009.

2010

[1250] Kunal Agrawal, Anne Benoit, Loic Magnan, and Yves Robert. Scheduling algorithms for linear workflow optimization. In *IPDPS - 24th IEEE International Parallel and Distributed Processing Symposium - 2010*, pages 1–12, Atlanta, GA, US, 2010.

[1251] Anne Benoit, Hinde Lilia Bouziane, and Yves Robert. General vs. Interval Mappings for Streaming Applications. In *IEEE 16th International Conference on Parallel and Distributed Systems (ICPADS)*, Shanghai, China, 2010. IEEE Computer Society Press.

[1252] Anne Benoit, Hinde Lilia Bouziane, and Yves Robert. Optimizing the reliability of pipelined applications under throughput constraints. In *9th International Symposium on Parallel and Distributed Computing (ISPDC)*, pages 1–8, Istanbul, Turkey, 2010.

[1253] Anne Benoit, Alexandru Dobrila, Laurent Philippe, and Jean-Marc Nicod. Throughput optimization for micro-factories subject to task and machine failures. In *APDCM'10, 12th Workshop on Advances on Parallel and Distributed Processing Symposium*, pages 11–18, US, 2010.

[1254] Anne Benoit, Fanny Dufossé, Matthieu Gallet, Bruno Gaujal, and Yves Robert. Computing the throughput of probabilistic and replicated streaming applications. In *22nd Symposium on Parallelism in Algorithms and Architectures (SPAA)*, pages 166–175, Santorini, Greece, 2010. ACM.

[1255] Anne Benoit, Fanny Dufossé, Alain Girault, and Yves Robert. Reliability and performance optimization of pipelined real-time systems. In *International Conference on Parallel Processing*, page 20, San Diego, US, September 2010.

[1256] Anne Benoit, Loris Marchal, and Oliver Sinnen. Mapping pipelined applications with replication to increase throughput and reliability. In *International Symposium on Computer Architecture and High Performance Computing (SBAC-PAD)*, Petropolis, Brasil, 2010.

[1257] Anne Benoit, Paul Renaud-Goud, and Yves Robert. Performance and energy optimization of concurrent pipelined applications. In *2010 IEEE International Symposium on Parallel & Distributed Processing (IPDPS)*, Atlanta, GA, États-Unis, April 2010. IEEE.

[1258] Anne Benoit, Paul Renaud-Goud, and Yves Robert. Sharing Resources for Performance and Energy Optimization of Concurrent Streaming Applications. In *Computer Architecture and High Performance Computing (SBAC-PAD), 2010 22nd International Symposium on*, pages 79–86, Petropolis, Brésil, 2010.

[1259] Anne Benoit, Yves Robert, Arnold L. Rosenberg, and Frédéric Vivien. Static Worksharing Strategies for Heterogeneous Computers with Unrecoverable Failures. In Hai-Xiang Lin, Michael Alexander, Martti Forsell, Andreas Knüpfer, Radu Prodan, Leonel Sousa, and Achim Streit, editors, *Euro-Par 2009 - Parallel Processing Workshops*, volume 6043, pages 71–80. Springer Berlin Heidelberg, 2010.

[1260] Franck Cappello, Henri Casanova, and Yves Robert. Checkpointing vs. migration for post-petascale supercomputers. In *ICPP'2010 - the 39th International Conference on Parallel Processing*, San Diego, US, 2010. IEEE Computer Society Press.

[1261] Henri Casanova, Matthieu Gallet, and Frédéric Vivien. Non-clairvoyant Scheduling of Multiple Bag-of-Tasks Applications. In *Euro-Par 2010*, volume 6271 of *Lecture Notes in Computer Science*, pages 168–179, Ischia, Italy, August 2010. Springer.

[1262] Matthieu Gallet, Mathias Jacquelin, and Loris Marchal. Scheduling complex streaming applications on the Cell processor. In *4th Workshop on Multi-threaded Architectures and Applications (MTAAP 2010)*, pages 1–8, Atlanta, GA, États-Unis, 2010. IEEE.

[1263] Matthieu Gallet, Nezih Yigitbasi, Bahman Javadi, Derrick Kondo, Alexandru Iosup, and Dick Epema. A Model for Space-Correlated Failures in Large-Scale Distributed Systems. In *Euro-Par 2010 - Proceedings of the 16th International Euro-Par Conference*, volume 6271, pages 168–179, Ischia, Italy, 2010. Springer.

[1264] Mark Stillwell, Frédéric Vivien, and Henri Casanova. Dynamic Fractional Resource Scheduling for HPC Workloads. In *IEEE International Symposium on Parallel & Distributed Processing (IPDPS), 2010*, pages 1–12, Atlanta, GA, US, May 2010. IEEE.

[1265] Bora Uçar and Ümit V. Çatalyürek. On the scalability of hypergraph models for sparse matrix partitioning. In M. Danelutto, J. Bourgeois, and T. Gross, editors, *18th Euromicro International Conference on Parallel, Distributed and Network-Based Processing (PDP 2010)*, pages 593–600, Pisa, Italy, February 2010. IEEE.

[1266] Nezih Yigitbasi, Matthieu Gallet, Derrick Kondo, Alexandru Iosup, and Dick Epema. Analysis and Modeling of Time-Correlated Failures in Large-Scale Distributed Systems. In *Grid 2010 - Proceedings of the 11th ACM/IEEE International Conference on Grid Computing*, pages 355–366, Bruxelles, Belgium, 2010. ACM / IEEE Computer Society Press.

2011

[1267] Leon Atkins, Guillaume Aupy, Daniel Cole, and Kirk Pruhs. Speed Scaling to Manage Temperature. In *TAPAS - 1st International ICST Conference on Theory and Practice of Algorithms in (Computer) Systems*, pages 9–20, Rome, Italy, 2011.

[1268] Anne Benoit, Rami Melhem, Paul Renaud-Goud, and Yves Robert. Energy-aware mappings of series-parallel workflows onto chip multiprocessors. In *ICPP'2011, the 40th International Conference on Parallel Processing*, Taipei, Taiwan, 2011. IEEE Computer Society Press.

[1269] Anne Benoit, Paul Renaud-Goud, and Yves Robert. On the performance of greedy algorithms for energy minimization. In *ICPP'2011, the 40th International Conference on Parallel Processing*, Taipei, Taiwan, 2011. IEEE Computer Society Press.

[1270] Anne Benoit, Paul Renaud-Goud, and Yves Robert. Power-aware replica placement and update strategies in tree networks. In *IPDPS'2011, the 25th IEEE International Parallel and Distributed Processing Symposium*, Anchorage, Alaska, US, 2011. IEEE Computer Society Press.

[1271] Marin Bougeret, Henri Casanova, Mikael Rabie, Yves Robert, and Frédéric Vivien. Checkpointing strategies for parallel jobs. In *SuperComputing (SC) - International Conference for High Performance Computing, Networking, Storage and Analysis, 2011*, pages 1–11, US, 2011.

[1272] Henricus Bouwmeester, Mathias Jacquelin, Julien Langou, and Yves Robert. Tiled QR factorization algorithms. In *SC'2011, the IEEE/ACM Conference on High Performance Computing Networking, Storage and Analysis*, Seattle, WA, US, 2011. ACM Press.

[1273] Franck Cappello, Mathias Jacquelin, Loris Marchal, Yves Robert, and Marc Snir. Comparing archival policies for BlueWaters. In *International Conference on High Performance Computing (HiPC'2011)*, Bangalore, India, 2011. IEEE Computer Society Press.

[1274] Henri Casanova, Fanny Dufossé, Yves Robert, and Frédéric Vivien. Scheduling parallel iterative applications on volatile resources. In *IPDPS'2011, the 25th IEEE International Parallel and Distributed Processing Symposium*, Anchorage, Alaska, US, 2011. IEEE Computer Society Press.

[1275] Ümit V. Çatalyürek, Kamer Kaya, and Bora Uçar. Integrated data placement and task assignment for scientific workflows in clouds. In *Proceedings of the fourth international workshop on Data-intensive distributed computing*, pages 45–54, New York, NY, US, 2011. ACM.

[1276] Pierre-Nicolas Clauss, Mark Stillwell, Stéphane Genaud, Frédéric Suter, Henri Casanova, and Martin Quinson. Single Node On-Line Simulation of MPI Applications with SMPI. In *International Parallel & Distributed Processing Symposium*, Anchorage, Alaska, US, May 2011. IEEE.

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Appendix 7. Contracts

This appendix gathers the information on the contracts for every team of the laboratory.

7.1 Contracts for Team ARIC

7.1.1 Management of research projects and contracts

TaMaDi ANR Project. The TaMaDi project (Table Maker's Dilemma, 2010-2013) was funded by the ANR and headed by Jean-Michel Muller. It started in October 2010 and finished in October 2013. The other French teams involved in the project were the MARELLE team-project of INRIA Sophia Antipolis-Méditerranée, and the PEQUAN team of LIP6 lab., Paris.

The aim of the project was to find "hardest to round" (HR) cases for the most common functions and floating-point formats. In floating-point (FP) arithmetic having fully-specified "atomic" operations is a key-requirement for portable, predictable and provable numerical software. Since 1985, the four arithmetic operations and the square root are IEEE specified (it is required that they should be correctly rounded: the system must always return the floating-point number nearest the exact result of the operation). This is not fully the case for the basic mathematical functions (sine, cosine, exponential, etc.). Indeed, the same function, on the same argument value, with the same format, may return significantly different results depending on the environment. As a consequence, numerical programs using these functions suffer from various problems. The lack of specification is due to a problem called the Table Maker's Dilemma (TMD). To compute $f(x)$ in a given format, where x is a FP number, we must first compute an approximation to $f(x)$ with a given precision, which we round to the nearest FP number in the considered format. The problem is the following: finding what the accuracy of the approximation must be to ensure that the obtained result is always equal to the "exact" $f(x)$ rounded to the nearest FP number. In the last years, our team-project and the CACAO team-project of INRIA Nancy-Grand Est designed algorithms for finding hardest-to-round cases. These algorithms do not allow to tackle with large formats. The TaMaDi project mainly focused on three aspects:

- big precisions: we must get new algorithms for dealing with precisions larger than double precision. Such precisions will become more and more important (even if double precision may be thought as more than enough for a final result, it may not be sufficient for the intermediate results of long or critical calculations);
- formal proof: we must provide formal proofs of the critical parts of our methods. Another possibility is to have our programs generating certificates that show the validity of their results. We should then focus on proving the certificates;
- aggressive computing: the methods we have designed for generating HR points in double precision require weeks of computation on hundreds of PCs. Even if we design faster algorithms, we must massively parallelize our methods, and study various ways of doing that.

ANR EVA-Flo Project. The EVA-Flo project (Évaluation et Validation Automatiques de calculs Flottants, 2006-2010) was headed by N. Revol (Arénaire). The other teams participating in this project were DALI (Eliaus, U. Perpignan), Measi (LIST, CEA Saclay) and Tropics (INRIA Sophia-Antipolis).

This project focused on the way a mathematical formula is evaluated in floating-point arithmetic. The approach was threefold: study of algorithms for approximating and evaluating mathematical formulae, validation of such algorithms, and automation of the process.

Grant from Minalogic/EMSOC. This project was headed by C.-P. Jeannerod and J.-M. Muller. From October 2006 to September 2009, we have been involved in Sceptre, a project of the EMSOC cluster of the Minalogic Competitivity Centre. This project, led by STMicroelectronics, aims at providing new techniques for implementing software on system-on-chips. Within Arénaire, we were focusing on the generation of optimized code for accurate evaluation of mathematical functions; our partner at STMicroelectronics is the Compiler Expertise Center (Grenoble).

PHC Sakura - INRIA Ayame junior program (France-Japan). The project "Software and Hardware Components for Pairing-Based Cryptography", (2008-2009), was headed by G. Hanrot (CACAO/LORIA then Arénaire/LIP) and E. Okamoto (LCIS, Univ. of Tsukuba).

The participants belonged to the Arénaire (LIP, ENS Lyon) and CACAO (LORIA, Nancy) teams for the French part and to the LCIS (Univ. of Tsukuba, Japan) and the Future Univ. of Hakodate (Japan). The goal of this project was the enhancement of software and hardware implementations of pairings defined over algebraic curves. We worked on the development of a more efficient arithmetic over Jacobian of (hyper)elliptic curves, implementing genus 2 curve based pairings and designing algorithms and implementations resistant to side channel attacks.

7.1.2 Participation in research projects and contracts

ANR HPAC Project. "High-performance Algebraic Computing" (HPAC) is a four year ANR project that started in January 2012. HPAC is headed by Jean-Guillaume Dumas (CASYS team, LJK laboratory, Grenoble); it involves AriC as well as the INRIA project-team MOAIS (LIG, Grenoble), the INRIA project-team PolSys (LIP6 lab., Paris), the ARITH group (LIRMM laboratory, Montpellier), and the HPC Project company.

The overall ambition of HPAC is to provide international reference high-performance libraries for exact linear algebra and algebraic systems on multi-processor architecture and to influence parallel programming approaches for algebraic computing. The central goal is to extend the efficiency of the LinBox and FGb libraries to new trend parallel architectures such as clusters of multi-processor systems and graphics processing units in order to tackle a broader class of problems in lattice-based cryptography and algebraic cryptanalysis. HPAC conducts researches along three axes:

- A domain specific parallel language (DSL) adapted to high-performance algebraic computations;
- Parallel linear algebra kernels and higher-level mathematical algorithms and library modules;
- Library composition, their integration into state-of-the-art software, and innovative high performance solutions for cryptology challenges.

ANR TCHATER Project. The TCHATER project (Terminal Cohérent Hétérodyne Adaptatif TEmps Réel, 2008-2011) was a collaboration between Alcatel-Lucent France, E2V Semiconductors, GET-ENST and the INRIA Arénaire and ASPI project/teams. Its purpose was to demonstrate a coherent terminal operating at 40Gb/s using real-time digital signal processing and efficient polarization division multiplexing. In Lyon, we studied the FPGA implementation of specific algorithms for polarization demultiplexing and forward error correction with soft decoding.

ANR LaRedA Project. The LaRedA project (Lattice Reduction Algorithms, 2008-2011) was funded by the ANR and headed by Brigitte Vallée (CNRS/GREYC) and Valérie Berthé (CNRS/LIRMM). The aim of the project was to finely analyze lattice reduction algorithms such as LLL, by using experiments, probabilistic tools and dynamic analysis. Among the major goals were the average-case analysis of LLL and its output distribution. In Lyon, we have concentrated on the experimental side of the project (by using fpLLL and MAGMA) and the applications of lattice reduction algorithms to cryptography.

7.1.3 Industrial contracts and collaborations

Contracts with STMicroelectronics. We have been involved in Mediacom in 2009-2013. Mediacom was a 40-month joint project with the Compiler Expertise Center (STMicroelectronics Grenoble) and INRIA project-teams Alchemy, Alf, AriC, and Compsys, and a Nano 2012 partner project. For us, in particular, it has funded the 3-year MEFI PhD grant of David Pfannholzer.

A contract between STMicroelectronics and Inria supported our work on floating-point arithmetic code generation and specialization for embedded processors (duration: 36 months; amount: 36,000 euros; signature: fall 2010). This contract, which was done jointly with the Compilation Expertise Center of STMicroelectronics Grenoble, was also supporting the PhD CIFRE grant of Jingyan Jourdan-Lu.

Collaboration with Bosch. Bosch (Stuttgart) ordered us a study on the choice of an adequate representation of numbers (fixed-point or floating-point) for some embedded systems. The study was conducted by Florent de Dinechin and Jean-Michel Muller.

Contracts with Kalray. A 2.5 month contract covered the development of synthesizable register-transfer level description of a floating-point unit for the Kalray processor, as well as compatible C models, for evaluation purposes. Details are confidential at this point.

Nicolas Brunie has been supported by a CIFRE PhD grant (from 15/04/2011 to 14/04/2014) from Kalray. The purpose was the study of a tightly coupled reconfigurable accelerator to be embedded in the Kalray multicore processor. Advisors: Florent de Dinechin and, within Kalray, Benoît de Dinechin.

Orange Labs PhD Grant. Marie Paindavoine is supported by an Orange Labs PhD Grant (from October 2013 to November 2016). She works on privacy-preserving encryption mechanisms.

Collaboration with Intel. INTEL made a $20000 donation in recognition of our work on the correct rounding of functions.

Altera hardware donation. Altera donated to the team an FPGA-based acceleration card (Altera DK-DEV-4SGX530N) for the Table-Maker's Dilemma acceleration project.

Adacsys contract. Adacsys granted Arénaire free access to their RAVA remote hardware validation tool to help develop the FloPoCo project.

7.2 Contracts for Team AVALON

7.2.1 Management of research projects and contracts

The team has managed 12 projects: 1 regional project, 1 CNRS PICS, 1 Inria ARC, 2 Inria ADT, 1 Inria large scale initiative, 4 French ANR, 1 French GIS, and 1 ERCIM working group.

Regional Projet "Calcul Hautes Performances et Informatique Distribuée", 2008-2011. E. Caron leads (with C. Prudhomme from LJK, Grenoble) the "Calcul Hautes Performances et Informatique Distribuée" project of the cluster "Informatique, Signal, Logiciels Embarqués". Together with several research laboratories from the Rhône-Alpes region, we initiate collaborations between application researchers and distributed computing experts

PICS CNRS DimSim: Dimensioning Through Simulation, 2010-2012. More and more sciences rely on computing infrastructures to produce scientific results from large amounts of data. Then Data- and Computing-Centers constantly have to upgrade their resources to keep pace with the increasing demands. The common practice is to rely on the expertise of system administrators and/or users to take empirical decisions about what should be the next upgrade. A sound alternative is to resort to simulation to obtain objective indicators on candidate solutions. In this collaborative project with the University of Hawai'i at Manoa, we focus on parallel MPI applications as a representative workload. We aim at evaluating, comparing, solidying, and integrating within a single framework two complementary approaches: Off-line simulation, in which a trace of an instrumented execution is then replayed in a simulation context. We proposed and developed a Time-Independent Trace Replay Framework that follows this approach; and On-line simulation, in which the actual execution is executed while parts of it are intercepted and simulated. We proposed and develop the SMPI simulator that allows the user to simulate the execution of unmodified MPI applications on a single node. Both developments have been integrated with the SimGrid toolkit. This project is led by Frédéric Suter.

Inria ARC Green-Net, 2008-2010 The ARC (Action de Recherche Cooperative Inria) "GREEN-NET : Power aware software frameworks for high performance data transport and computing in large scale distributed systems" explored the design of energy-aware software frameworks dedicated to large scale distributed systems. These frameworks collect energy usage information and provide them to resources managers and schedulers. Large scale experimental deployment on Grid5000 and DSLLAB platforms have been validated. The project was leaded by Laurent Lefevre and included Inria Mescal team (Grenoble), IRIT Lab. (Toulouse) and Virginia Tech. (USA).

Inria ADT BitDew, 2010-2012. ADT BitDew is an INRIA support action of technological development for the BitDew middleware. Objectives are several fold : i/ provide documentation and education material for end-users, ii/ improve software quality and support, iii/ develop new features allowing the management of Cloud and Grid resources. The ADT BitDew, leaded by G. Fedak, allows to recruit a young engineer for 24 months.

Inria ADT Aladdin, 6 years, 2008-2014. ADT ALADDIN is an Inria support action of technological development which supports the GRID'5000 instrument. Frédéric Desprez is leading this action (with David Margery from Rennes as the Technical Director).

GIS GRID'5000, 4 years, 2012-2016. GRID'5000 is now managed through a GIS [1] leaded by F. Desprez and signed in May 2012. Its role is to allow GRID'5000 to handle new issues of large distributed systems and platforms and to ensure the persistency of the infrastructure.

Its partners are CDEFI (Conférence des Directeurs des Ecoles Françaises d'Ingénieurs), Commissariat à l'énergie atomique et aux énergies alternatives (CEA), Centre national de la recherche scientifique (CNRS), Conférence des Présidents d'Université (CPU), Inria, institut Mines-Telecom, and Renater.

Inria Large Scale Initiative HEMERA, 2010-2014. The goal of HEMERA[2] is to demonstrate ambitious up-scaling techniques for large scale distributed computing by carrying out several dimensioning experiments on the GRID'5000 infrastructure, to animate the scientific community around GRID'5000, and to enlarge the GRID'5000 community by helping newcomers to make use of GRID'5000. It aims at making progress in the understanding and management of large scale infrastructure by leveraging competences distributed in various French teams. Hemera addresses several scientific challenges and supports some working groups. The project involves around 24 teams located in all around France.

Christian Pérez is leading the project. Avalon participates to various challenges that cover almost all the research topics addressed by Avalon.

[1] Groupement d'Intérêt Scientifique
[2] `https://grid5000.fr/Hemera`

ANR EMERGENCE CloudPower: a Cloud Service Providing High Performance Computing to SMEs. HPC is a key factor in knowledge and innovation in many fields of industry and service, with high economic and social issues: aerospace, finance and business intelligence, energy and environment, chemicals and materials, medicine and biology , digital art and games, Web and social networks, ... Today, acquiring HPC supercomputer is very expensive, making HPC unreachable to SMIs / SMEs for their research and development. The CloudPower project The goal of CloudPower is to offer a low cost Cloud HPC service for small and medium-sized innovative companies. With CloudPower, companies and scientists will run their simulations to design and develop new products on a powerful, scalable, economical, reliable and secure infrastructure.

The project[3] will lead the creation of a new and innovative company operating the platform implemented in the framework of the ANR Emergence. CloudPower will leverage on the open-source software XtremWeb-HEP previously developed by the CNRS and INRIA.

Avalon is the leader of the project. Building on the network of SMIs from the competitiveness clusters System@tic and LyonBiopole, Avalon will implement scenarios and/or demonstrators which illustrate the ability of CloudPower to increase competitiveness, research and marketing of innovative SMEs.

ANR LEGO: League for Efficient Grid Operation, CICG-05-11, 2006-2009. The aim of this project is to provide algorithmic and software solutions for large scale architectures; our focus is on performance issues. The software component provides a flexible programming model where resource management issues and performance optimizations are handled by the implementation. On the other hand, current component technology does not provide adequate data management facilities, needed for large data in widely distributed platforms, and does not deal efficiently with dynamic behaviors. We choose three applications: ocean-atmosphere numerical simulation, cosmological simulation, and sparse matrix solver. We propose to study the following topics: Parallel software component programming; Data sharing model; Network-based data migration solution; Co-scheduling of CPU, data movement and I/O bandwidth; High- perf. network support. The GRID'5000 platform provides the ideal environment for testing and validation of our approaches. E. Caron is leading the project, which comprises six teams: GRAAL/LIP (Lyon), PARIS/IRISA (Rennes), RUNTIME/LaBRI (Bordeaux), ENSEEIHT/IRIT (Toulouse), CERFACS (Toulouse) and CRAL/ENS-Lyon (Lyon). The project has ended in June 2009.

ANR COSINUS COOP: Multi Level Cooperative Resource Management, ANR-09-COSI-001-01, 2009-2013. The main goals of COOP[4] are to set up such a cooperation as general as possible with respect to programming models and resource management systems and to develop algorithms for efficient resource selection. In particular, the project targets the SALOME platform and GRID-TLSE expert-site (http://gridtlse. org/) as an example of programming models, and Marcel/PadicoTM, DIET and XtreemOS as examples of multithread scheduler/communication manager, grid middleware and distributed operating systems. The project is led by Christian Pérez.

ANR ARPEGE SPADES: Servicing Petascale Architectures and DistributEd System, 2009-2012. Today's emergence of Petascale architectures and evolutions of both research grids and computational grids increase a lot the number of potential resources. However, existing infrastructures and access rules do not allow to fully take advantage of these resources. One key idea of the SPADES project[5] is to propose a non-intrusive but highly dynamic environment able to take advantage of the available resources without disturbing their native use. In other words, the SPADES vision is to adapt the desktop grid paradigm by replacing users at the edge of the Internet by volatile resources. These volatile resources are in fact submitted via batch schedulers to reservation mechanisms which are limited in time or susceptible to preemption (best-effort mode). One of the priorities of SPADES is to support platforms at a very large scale. Petascale environments are therefore particularly considered. Nevertheless, these next-generation architectures still suffer from a lack of expertise for an accurate and relevant use. One of the SPADES goal is to show how to take advantage of the power of such architectures. Another challenge of SPADES is to provide a software solution for a service discovery system able to face a highly dynamic platform. This system will be deployed over volatile nodes and thus must tolerate failures. SPADES will propose solutions for the management of distributed schedulers in Desktop Computing environments, coping with a co-scheduling framework. The project is led by Eddy Caron.

ERCIM Working Group CoreGrid, 2009-2012. Following the success of the network of excellence CoreGRID, an ERCIM WG was started in 2009, leaded by F. Desprez. This working group gathers 31 research teams from all over Europe working on Grids, service oriented architectures and Clouds.

7.2.2 Participation in research projects and contracts

We have participated to 29 projects: 5 international collaborations, 1 international industrial project, 8 European projects, 1 CHIST-ERA, 3 COST, 1 CETIC+, 1 FUI, 1 FSN, 6 ANR, 1 Inria large scale initiative, and 1 CNRS/Inria project.

[3] `http://www.iexec.fr`
[4] urlhttp://coop.gforge.inria.fr/
[5] `http://graal.ens-lyon.fr/SPADES`

OGF-Europe European Project (SSA), 2008-2010. We have participated in the OGF-Europe to reinforce the french participation to OGF standardization activities. We mainly concentrate our contribution on Telco interaction and Energy-efficiency in Grid context.

CNRS-USA grant SchedLife, University of Hawai'i (2007-2009). We have been awarded a CNRS grant in the framework of the CNRS/USA funding scheme, which runs for three years starting in 2007. The collaboration is done with the Concurrency Research Group (CoRG) of Henri Casanova, and the Bioinformatics Laboratory (BiL) of Guylaine Poisson of the Information and Computer Sciences Department, of the University of Hawai'i at Mano'a, USA.

Japanese-French REDIMPS: Research and Development of International Matrix Prediction System, 2007-2009. REDIMPS[6] (Research and Development of International Matrix Prediction System) is a project funded by the Strategic Japanese-French Cooperative Program on "Information and Communications Technology including Computer Science" with the CNRS and the JST. The goal of this international collaboration is building an international sparse linear equation solver expert site. Among the objectives of the project, one resides in the cooperation of the TLSE partners and the JAEA in the testing, the validation and the promotion of the TLSE system that is currently released. JAEA, who is one of the leading institute and organization of Japanese HPC, is studying high-performance numerical simulation methods on novel supercomputers, and is expecting to find the best linear solver within this collaboration. By integrating knowledge and technology of JAEA and TLSE partners, it is expected that we will achieve the construction

Inria-UIUC-NCSA Joint Laboratory for Petascale Computing. The Joint Laboratory for Petascale Computing[7] focuses on software challenges found in complex high-performance computers. The Joint Laboratory is based at the University of Illinois at Urbana-Champaign and it includes researchers from Inria, Illinois' Center for Extreme-Scale Computation, and the National Center for Supercomputing Applications. Much of the Joint Laboratory's work will focus on algorithms and software that will run on Blue Waters and other petascale computers.

Avalon is working on energy consumption of fault tolerant algorithms, large scale data management, and parallel programming models.

GreenTouch, 2012-2015. GreenTouch[8] is a consortium of leading Information and Communications Technology (ICT) industry, academic and non-governmental research experts dedicated to fundamentally transforming communications and data networks, including the Internet, and significantly reducing the carbon footprint of ICT devices, platforms and networks.

Avalon is involved in this consortium and participates in several projects concerning the consolidation of services in virtualized environments in order to reduce energy consumption of networked equipments at large scale. As an example, Avalon collaborates with Bells Labs on the scalability issues of large scale virtualization of virtual home gateways services.

Intelligent Energy Europe PrimeEnergyIT project: Efficient DataCenters, 2010-2012. The fast development of IT services and IT performance in many areas of the public and private service sector (e.g. administration, health services, entertainment etc.). has led to a rapid increase of energy consumption and energy costs for central IT equipment. A broad implementation of energy efficient technology in the EU however would allow a reduction of energy demand of about 60% compared to the business as usual scenario. Energy efficient technology is available but needs to be broadly implemented in the demand side market. To exploit the enormous saving potentials concerted action is needed across the EU member states. The PrimeEnergyIT[9] project deals with the development and implementation of hardware and service based energy efficiency criteria as major tools to support IT and infrastructure managers in the selection and management of IT hardware and cooling equipment; the demonstration and evaluation of energy efficient IT solutions in best practice; Education and training of IT managers and experts to support energy efficient procurement and management and Implementation of energy efficiency criteria for central IT equipment and cooling in public procurement. Inria has been mainly involved in energy efficiency criteria in the context of storage for small and medium datacenters.

FP7 AuToI: Autonomic Internet, 2008-2010. Autonomic Internet[10] (AutoI - FP7.ICT.2007.Call1-216404 - 2008-2010) project suggests a transition from a service agnostic Internet to service-aware network, managing resources by applying autonomic principles. In order to achieve the objective of service-aware resources and to overcome the ossification of the current Internet AutoI will develop a self-managing virtual resource overlay that can span across heterogeneous networks that can support service mobility, security, quality of service and reliability. In this overlay network, multiple virtual networks co-exist on top of a shared substrate with uniform control. The overlay will be self-managed based on the system's business goals, which drive the service specifications, the subsequent changes in these goals (service context) and changes in the resource environment (resource context). This will be realized by the successful co-operation of the following activities: autonomic control principles, resource virtualization, enhanced control algorithms, information modeling, policy based management and programmability. Wa have been mainly involved in the programmability of the AUTOI overlay by proposing an Autonomic Network Programming Interface which will support large scale service deployment. Laurent Lefèvre was leader of of the workpackage 5 on "Service Deployment".

[6] http://redimps.org/
[7] http://jointlab.ncsa.illinois.edu
[8] http://greentouch.org
[9] http://www.efficient-datacenter.eu/
[10] http://ist-autoi.eu

FP7 EDGeS: Enabling Desktop Grids for e-Science, 2008-2010. This project is lead by P. Kacsuk, and involves the following partners : SZTAKI, INRIA, CIEMAT, Fundecyt, University of Westminster, Cardiff University, University of Coimbra. Grid systems are currently being used and adopted by a growing number of user groups and diverse application domains. However, there still exist many scientific communities whose applications require much more computing resources than existing Grids like EGEE can provide. The main objective of this project is to interconnect the existing EGEE Grid infrastructure with existing Desktop Grid (DG) systems like BOINC or X TREM W EB in a strong partnership with EGEE. The interconnection of these two types of Grid systems will enable more advanced applications and provide extended compute capabilities to more researchers. In this collaboration G. Fedak represents the GRAAL team and is responsible for JRA1: Service Grids-Desktop Grids Bridges Technologies and is involved in JRA3 : Data Management, as well as NA3 : Standardization within the OGF group.

FP7 EDGI: European Desktop Grid Initiative, 2010-2012. The project EDGI[11] will develop middleware that consolidates the results achieved in the EDGeS project concerning the extension of Service Grids with Desktop Grids in order to support EGI and NGI user communities that are heavy users of DCIs and require extremely large number of CPUs and cores. EDGI will go beyond existing DCIs that are typically cluster Grids and supercomputer Grids, and will extend them with public and institutional Desktop Grids and Clouds. EDGI will integrate software components of ARC, gLite, Unicore, BOINC, XWHEP, 3G Bridge, and Cloud middleware such as OpenNebula and Eucalyptus into SG=>DG=>Cloud platforms for service provision and as a result EDGI will extend ARC, gLite and Unicore Grids with volunteer and institutional DG systems. Our partners in EDGI are : SZTAKI, INRIA, CIEMAT, Fundecyt, University of Westminster, Cardiff University, University of Coimbra. In this project, G. Fedak is the INRIA representative and lead the JRA2 work package which is responsible for providing QoS to Desktop Grids.

FP7 IP BonFire: Building service testbeds on FIRE BonFIRE, 2010-2013. BonFIRE[12] will design, build and operate a multi-site Cloud prototype FIRE facility to sup- port research across applications, services and systems at all stages of the R&D lifecycle, targeting the services research community on Future Internet. The BonFIRE vision is to give researchers in these areas access to a facility that supports large scale multi- disciplinary experimentation of their systems and applications addressing all aspects of research across all layers. We will develop and support a framework which allows service-based computing practitioners to experiment with their latest ideas in service orientation and distributed computing. We have elaborated 3 usage scenarios. Our overall goal is to encourage new communities of experimenters to take advantage of the opportunities offered by the FIRE infrastructure to guide the development of the Future Internet from a service-based applications standpoint. The facility will be demand-driven, open, standards-based and dynamic. It will provide additional functionality to that currently available. It will adopt the principle of "open coordinated federation of testbeds" and will provide innovative usage scenarios. We will stimulate research through 2 open calls to establish a methodology of experimentally driven research. The facility shall be open not only to the researchers selected and funded by BonFIRE through the open calls but also to a wider researcher community in order to encourage the usage and involvement of a significant number of end users.

FP7 PRACE: Second Implementation Phase Project, 2011-2014. The purpose of the PRACE RI[13] is to provide a sustainable high-quality infrastructure for Europe that can meet the most demanding needs of European HPC user communities through the provision of user access to the most powerful HPC systems available worldwide at any given time. In tandem with access to Tier-0 systems, the PRACE-2IP project will foster the coordination between national HPC resources (Tier-1 systems) to best meet the needs of the European HPC user community. To ensure that European scientific and engineering communities have access to leading edge supercomputers in the future, the PRACE-2IP project evaluates novel architectures, technologies, systems, and software. Optimizing and scaling of application for Tier-0 and Tier-1 systems is a core service of PRACE.

Avalon participates to Work Package 12 which is about novel programming techniques. Avalon validates its component models (L2C, HLCM) for HPC applications on supercomputers such as Curie.

FP7 PaaSage: Model-based Cloud Platform Upperware, 2012-2016. PaaSage[14] will deliver an open and integrated platform, to support both deployment and design of cloud applications, together with an accompanying methodology that allows model-based development, configuration, optimization, and deployment of existing and new applications independently of the existing underlying cloud infrastructures. Specifically it will deliver an IDE (Integrated Development Environment) incorporating modules for design time and execution time optimizations of applications specified in the CLOUD Modeling Language (CloudML), execution-level mappers and interfaces, and a metadata database.

Avalon aims at proposing mapping algorithms for deploying (and adapting) an application on multi cloud systems with respect to user constraints. Avalon is using in particular SimGrid to validate solutions.

[11] `http://edgi-project.eu/`
[12] `http://www.bonfire-project.eu`
[13] `http://prace-ri.eu`
[14] `http://paasage.eu`

EuroNF JRA.S.1.44 project SPEC, 2010-2012. We have participated to the SPEC on "Security and Privacy Concerns in Energy Efficient Computing". To design highly energy efficient systems is one of the most important design goals which are under investigation currently. The underlying motifs to design such systems are economical as well as environmental in nature. However, it has been identified that while focusing solely on energy efficiency mechanisms, the other design parameters must also be considered to achieve a well balanced system. Security and privacy aspects are among those very important parameters. This SJRP focuses on the security and privacy aspects involved in the application of modern energy efficiency mechanisms. We focus on two of the key technologies including virtualization for energy efficiency and smart metering. In first part of the project, we investigate the security issues within virtualized environments for energy efficiency while the second part focus on the end user privacy concerns when monitoring physical resources in clouds.

CHIST-ERA STAR: SwiTching And tRansmission project, 2013-2015. The Internet power consumption has continued to increase over the last decade as a result of a bandwidth growth of at least 50 to 100 times. Further bandwidth growth between 40% and 300% is predicted in the next 3 years as a result of the growing popularity of bandwidth intensive applications. Energy efficiency is therefore increasingly becoming a key priority for ICT organizations given the obvious ecological and economic drivers. In this project we adopt the GreenTouch energy saving target of a factor of a 100 for Core Switching and Routing and believe this ambitious target is achievable should the research in this proposal prove successful. A key observation in core networks is that most of the power is consumed in the IP layer while optical transmission and optical switching are power efficient in comparison, hence the inspiration for this project. Initial studies by the applicants show that physical topology choices in networks have the potential to significantly reduce the power consumption, however network optimization and the consideration of traffic and the opportunities afforded by large, low power photonic switch architectures will lead to further power savings. Networks are typically over provisioned at present to maintain quality of service. We will study optimum resource allocation to reduce the over-provisioning factor while maintaining the quality of service. Protection is currently provided in networks through the allocation of redundant paths and resources, and for full protection there is a protection route for every working route.

Avalon is contributing to STAR[15] in terms of software network protocols and services optimizations which will be combined with more efficient photonic switches in order to obtain a factor of 100 power saving in core networks can be realized through this project with significant potential for resulting impact on how core photonic networks are designed and implemented.

European COST IC804: Energy efficiency in Large Scale Distributed Systems, 2009-2013. The COST Action IC0804[16] proposes realistic energy-efficient alternate solutions to share IT distributed resources. As large scale distributed systems gather and share more and more computing nodes and Storage resources, their energy consumption is exponentially increasing. While much effort is nowadays put into hardware specific solutions to lower energy consumptions, the need for a complementary approach is necessary at the distributed system level, i.e. middleware, network and applications. This Action characterizes the energy consumption and energy efficiencies of distributed applications. Then based on the current hardware adaptation possibilities and innovative algorithms it proposes adaptive and alternative approaches taking into account the energy saving dimension of the problem. This Action also characterizes the trade-off between energy savings and functional and non-functional parameters, including the economic dimension. Deliverables includes workshop proceedings, books, good practice leaflets fostering consciousness rise at ICT researchers, scientists, managers and users levels. Finally, benefits addresses scientific and societal needs.

European COST IC805: Open Network for High Performance Computing onComplex Environments, 2009-2013. In different fields of science and engineering it is necessary to solve complex and challenging problems with high computational cost. For this purpose, scientists and engineers normally use homogeneous high performance computers. Nowadays, the emergence of heterogeneous computing allows research groups, enterprise and educational institutions to use networks of processors which are already available. On the other hand, high performance computers have become more and more hierarchical and heterogeneous (e.g., a cluster of multiprocessor nodes using multicore processors). These modern hierarchical and heterogeneous computing infrastructures are hard to program and use efficiently, particularly for extreme-scale computing. Consequently, none of the state-of-the-art solutions are able to efficiently use such environments. The The COST Action IC0805[17] established a European research network focused on high performance heterogeneous computing in order to address the whole range of challenges posed by these new platforms including models, algorithms, programming tools and applications.

European COST IC1305: Network for Sustainable Ultrascale Computing, 2014-2018. In the COST Action IC1305[18], Ultrascale systems are envisioned as large-scale complex systems joining parallel and distributed computing systems that

[15] `http://www.chistera.eu/projects/star`
[16] `http://www.cost804.org/`
[17] `http://complexhpc.org/`
[18] `http://www.nesus.eu/`

will be two to three orders of magnitude larger that today's systems. The goal of the NESUS Action is to establish an open European research network targeting sustainable solutions for ultrascale computing aiming at cross fertilization among HPC, large scale distributed systems, and big data management. The network will contribute to glue disparate researchers working across different areas and provide a meeting ground for researchers in these separate areas to exchange ideas, to identify synergies, and to pursue common activities in research topics such as sustainable software solutions (applications and system software stack), data management, energy efficiency, and resilience. Avalon is involved in Energy profiling and efficiency networking of such ultrascale scenario. Laurent Lefevre is Management Committee Substitute and co chair of the Nesus working group on energy efficiency.

SEED4C: Security Embedded Element and Data privacy for the Cloud, 2012-2015. SEED4C[19] is a Celtic-Plus project: an industry-driven European research initiative to define, perform and finance through public and private funding common research projects in the area of telecommunications, new media, future Internet, and applications and services focusing on a new "Smart Connected World" paradigm. Celtic-Plus is a EUREKA ICT cluster and is part of the inter-governmental EUREKA network.

The cloud security challenge not only reflects on the secure running of software on one single machine, but rather on managing and guaranteeing security of a computer group or cluster seen as a single entity. Seed4C focus is to evolve from a cloud security with an isolated point or centralized points of enforcement for security to a cloud security with cooperative points of enforcement for security.

Avalon contributes to design a generic security policy model and associated scheduling algorithms.

FUI CompatibleOne Project, 2010-2012. The CompatibleOne project[20] (Nov 2010-Nov 2012) funded by the Fonds Unique Interministériel (FUI) is dealing with the building of a cloud architecture open software stack.

CompatibleOne is an open source project with the aim of providing interoperable middleware for the description and federation of heterogeneous clouds comprising resources provisioned by different cloud providers. Services provided by Inria participation (module COEES) should allow to act on the system's core by offering a scenario for the broker using energy constraints. These constraints should allow virtual machines placement and displacement using energy profile. Collected data must be available for CO and other systems for future researches. We took part in the analysis of the specification of the system. Mainly, we are in charge of the energy efficiency module. We also had participation in several modules like COMONS (monitoring module), ACCORDS (brokering module), EZVM (virtualization module) and CONETS (networking module). To make energy measurement, we used hardware probes and we studied software probes too. We evaluated several probes providers like Eaton and Schleifenbauer which provide smart PDU (Power Distribution Unit). We also evaluated IPMI board provided by DELL, our computers manufacturer, and OmegaWatt, a small company which provides custom hardware for energy measurement.

In this project, our work is focused on the design and provisioning of energy aware and energy efficient components in order to include energy aspects in QoS, SLAs and billing in clouds architectures. We lead the task T3.4 on energy management and will participate in activities on virtual machines design and migration.

FSN XLcloud, 2012-2014. Focused on High-Performance Computing, the XLcloud[21] collaborative project sets out to define and demonstrate a cloud platform based on *HPC-as-a-Service*. This is designed for computational intensive workloads, with interactive remote visualization capabilities, thus allowing different users to work on a common platform. XLcloud project's members design, develop and integrate the software elements of a High Performance cloud Computing (HPCC) System.

Expected results of the projects include: Functional and technical specification of the XLcloud platform architecture, open source API of the XLcloud platform, implementation of algorithms for 3D and video streaming display, prototype of the XLcloud platform including the support of on-demand virtual clusters and remote visualization service, use cases for validation, illustrating the performance and suggesting future improvements.

XLcloud aims at overcoming some of the most important challenges of implementing operationally high performance applications in the cloud. The goal is to allow partners of the project to take leadership position in the market, as cloud service providers, or as technology providers. XLcloud relies on a consortium of various partners (BULL (project leader), TSP, Silkan, EISTI, Ateme, Inria, CEA List, OW2, AMG.Lab).

Avalon investigates the issue of energy awareness and energy efficiency in OpenStack cloud based platforms.

ANR MDCA Gwendia: Grid Workflow Efficient Enactment for Data Intensive Applications), ANR-06-MDCA-009, 2007-2010. The objective of the Gwendia project is to design and develop workflow management systems for applications involving large amounts of data. It is a multidisciplinary project involving researchers in computer science (including GRAAL) and in life science (medical imaging and drug discovery). Our work consists in designing algorithms for the management of several workflows in distributed and heterogeneous platforms and to validate them within DIET over the GRID'5000 platform.

[19] `http://www.celticplus-seed4c.org`
[20] `http://compatibleone.org`
[21] `http://xlcloud.org`

ANR ARPEGE USS SimGrid: Ultra Scalable Simulation with SimGrid, 2009-2012. Unlike other sciences such as biology or physics, where experimental protocols are carefully described using standard tools and methodology, in computer science such information are generally poorly described and overlooked. Many works involving distributed application study merely describe the workload and analysis and usually rely on *ad hoc* tools that are not made publicly available. This prevents the reproduction of presented experiments as well as the comparison of new results with those available in the literature. Only widely available and accepted tools and methodology can fill this gap.

The USS-SimGrid[22] project aims at providing such an environment for the simulation of distributed applications and systems. We rely on SimGrid, one of the main grid infrastructure simulator, and extend it so that it fits the needs of the large scale distributed system community. We aim at having a deep methodological reflection allowing users to easily conduct "good" experiments thanks to realistic and scalable simulations as well as associated tools helping to manage simulation campaigns and analysis.

ANR JCJC Clouds@Home: Cloud Computing over Unreliable, Shared Resources, ANR-09-JCJC-0056-01, 2009-2012. Recently, a new vision of cloud computing has emerged where the complexity of an IT infrastructure is completely hidden from its users. At the same time, cloud computing platforms provide massive scalability, 99.999% reliability, and speedy performance at relatively low costs for complex applications and services. This project[23], lead by D. Kondo from INRIA MESCAL investigates the use of cloud computing for large-scale and demanding applications and services over unreliable resources. In particular, we target volunteered resources distributed over the Internet. In this project, G. Fedak leads the Data management task (WP3).

ANR ARPEGE MapReduce: Scalable data management for Map-Reduce-based data-intensive applications on cloud and hybrid infrastructures, 2010-2014. MapReduce is a parallel programming paradigm successfully used by large Internet service providers to perform computations on massive amounts of data. After being strongly promoted by Google, it has also been implemented by the open source community through the Hadoop project, maintained by the Apache Foundation and supported by Yahoo! and even by Google itself. This model is currently getting more and more popular as a solution for rapid implementation of distributed data-intensive applications. The key strength of the MapReduce model is its inherently high degree of potential parallelism.

Avalon participates to several work packages of this project[24] which address key issues such as efficient scheduling of several MapReduce applications, integration using components on large infrastructures, security and dependability, and MapReduce for desktop grids.

ANR INFRA SONGS: Simulation Of Next Generation Systems, 2012-2015. The last decade has brought tremendous changes to the characteristics of large scale distributed computing platforms. Large grids processing terabytes of information a day and the peer-to-peer technology have become common even though understanding how to efficiently such platforms still raises many challenges. As demonstrated by the USS SimGrid project, simulation has proved to be a very effective approach for studying such platforms. Although even more challenging, we think the issues raised by petaflop/exaflop computers and emerging cloud infrastructures can be addressed using similar simulation methodology.

The goal of the SONGS[25] project is to extend the applicability of the SimGrid simulation framework from grids and peer-to-peer systems to clouds and HPC systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

Avalon extends SimGrid with respect to cloud and hierarchical data-storage system concerns.

ANR INFRA MOEBUS: Multi-objective scheduling for large scale parallel systems, 2013-2016. The MOEBUS[26] project focuses on the efficient execution of parallel applications submitted by various users and sharing resources in large-scale high-performance computing environments.

We propose to investigate new functionalities to add at low cost in actual large scale schedulers and programming standards, for a better use of the resources according to various objectives and criteria. We also propose to revisit the principles of existing schedulers after studying the main factors impacted by job submissions. Then, we will propose novel efficient algorithms for optimizing the schedule for unconventional objectives like energy consumption and to design provable approximation multi-objective optimization algorithms for some relevant combinations of objectives (performance, fairness, energy consumption, etc.). An important characteristic of the project is its right balance between theoretical analysis and practical implementation. The most promising ideas will lead to integration in reference systems such as SLURM and OAR as well as new features in programming standards implementations such as MPI or OpenMP. We expect MOEBUS results to impact further use of very large scale parallel platforms.

Avalon brings its expertise about resource management systems, workflow scheduling algorithms, and energy profiles of applications and systems.

[22] http://uss-simgrid.gforge.inria.fr
[23] http://clouds.gforge.inria.fr/
[24] http://mapreduce.inria.fr
[25] http://infra-songs.gforge.inria.fr
[26] http://moebus.gforge.inria.fr/

Inria Large Scale Initiative C2S@Exa, 2013-2017. Computer and Computational Sciences at Exascale[27] (C2S@Exa) is concerned with the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society.

At the current state of the art in technologies and methodologies, a multidisciplinary approach is required to overcome the challenges raised by the development of highly scalable numerical simulation software that can exploit computing platforms offering several hundreds of thousands of cores. Hence, the main objective of the C2S@Exa Inria large-scale initiative is the establishment of a continuum of expertise in the computer science and numerical mathematics domains, by gathering researchers from Inria project-teams whose research and development activities are tightly linked to high performance computing issues in these domains.

Avalon is a core-team member, co-leading Pole 4 on Programming models. Avalon is collaborating with GYSELA[28] developers to improve the application with concepts coming from the component approach.

Action Interfaces Recherche en grille – Grilles de production. Institut des Grilles du CNRS – Action Aladdin INRIA. This action addresses economical issues concerning greenness in scientific and production grids. Different issues are addressed like the confrontation of energy models in place in experimental grids versus the operational realities in production grids, the study of new energy prediction models related to real measures of energy consumption in production grids, and the design of energy aware scheduling heuristics.

7.2.3 Industrial contracts and collaborations

Collaboration with CapRézo. One goal of the CapRézo company is to provide an original tool to make 2D/3D animation films. This tool is an innovative and distributed numerical platform. This platform is built on software developed by Avalon like DIET. Technologies developed in collaboration between CapRézo and Inria are based on Cloud federation environment. The collaboration, started in 2014, is scheduled for the next 5 years. Two M2 internships and one engineer (G. Verger) are working in relationship of this collaboration.

Collaboration with EDF. Vincent Pichon was supported by an EDF R&D PhD Grant (From April 2009 to November 2012). He worked on improving component models for parallel scientific applications in general, and for SALOME in particular.

FastExpand: Regional Grant. The FastExpand startup asked to take benefit of the knowledge of the GRAAL research team on distributed and middleware systems. The aim of this company is to create games of new generation using a new distributed architecture. E. Caron and F. Desprez participated to this action. In 2011, a distributed prototype that works on burst requests from the MMORPG (Massively Multiplayer Online Role Playing Games) was successfully designed. The required performance has been reached.

Collaboration with NewGeneration-SR. We have a collaboration with the company NewGeneration-SR. The aim of this company is to reduce the energy impact through solutions on each layer of the energy consumption (from the data-center design and the production to usage). NewGeneration-SR improve the life cycle (design, production, recycling) in order to reduce the environmental impact of it. NewGeneration-SR was member of the Nu@ge consortium: one of five national Cloud Computing projects with "emprunts d'avenir" funding. With a CIFRE PhD student (Daniel Balouek), we are developing models to reduce the energy consumption for the benefit of data-center

[27] `http://www-sop.inria.fr/c2s_at_exa/`

[28] A code Gyrokinetic Semi-Lagrangian in 5D. `http://gyseladoc.gforge.inria.fr/`

7.3 Contracts for Team COMPSYS

7.3.1 Management of research projects and contracts

CNRS PEPS "HLS and real-time". Christophe Alias and Laure Gonnord initiated with the DART/Emeraude team at LIFL Laboratory (University of Lille) a CNRS PEPS ("Projets Exploratoire Premier Soutien") called "HLS and real time" (8 Keuros/year, during two years in 2011-2013). The goal was to investigate how to introduce real-time constraints in the high-level synthesis workflow.

Thematic Quarter on Compilation. Compsys, as a LIP team, is part of the Labex MILYON, which regroups Institut Camille Jordan, and the mathematics and computer science labs of ENS-Lyon. One of its goal is "to strengthen our international relationships, in particular by organizing thematic quarters which will allow world experts of a subject to gather in Lyon and work together in a stimulating environment." In this context, Alain Darte, helped by Alexandre Isoard and Laetitia Lecot, organized, from April to July 2013, a thematic quarter on compilation techniques[29], with a special focus on the interactions with languages and architectures for high performance computing. This thematic quarter, with a total budget of roughly 100 Keuros, was organized as a coherent research project, with, in addition to the "french compilation days" organized separately in Annecy by Laure Gonnord and Fabrice Rastello (April 4-7, 2013), three international scientific events, in Lyon or its vicinity.

- A **spring school on polyhedral code analysis and optimizations**[30], May 13-17, 2013, in Domaine des Hautannes in St Germain au Mont d'Or, the first international school on the polyhedral model and related optimizations. The school covered scheduling theory, algorithms and modeling with integer sets and relations, abstract interpretation, compilation for distributed platforms, array region analysis, vectorization and SIMD optimizations, through courses given by S. Rajopadhye (Colorado State Univ.), P. Feautrier (Compsys, ENS-Lyon), L.-N. Pouchet (UCLA), S. Verdoolaege (ENS Paris), A. Miné (ENS Paris), U. Bondhugula (IIS Bangalore), A. Darte (Compsys, CNRS), B. Creusillet (Silkan), P. Sadayappan (Ohio State Univ.), N. Vasilache (Reservoir Labs, New York). The school attracted 56 participants, half from France, but also from Germany, the USA, England, Belgium, Spain, China, India, Ireland, and Italy and, interestingly, also from groups that are not familiar with polyhedral optimizations. Roughly half of the participants were PhD students.

- A **dive in languages for high-performance computing**[31], June 29-July 2, 2013 in Résidence Villemanzy in Lyon, organized as a set of long keynotes on CAF (Coarray Fortran), UPC (Unified Parallel C), X10, Chapel, OpenACC & OpenHMPP, Liquid Metal, OmpSs, OpenStream, and some DSL approaches. The keynotes were given by a panel of international experts on compilation for high-performance computing: J. Mellor-Crummey and V. Sarkar (Rice), K. Yelick (Berkeley), R. Schreiber (HP Labs), B. Chamberlain (Cray), D. Grove and R. Rabbah (IBM Watson), A. Cohen (Inria, ENS Paris), R. Badia (UPC Barcelona), F. Bodin (Univ. Rennes, previously Caps Entreprise), Y. Orlarey (Grame), K. Knobe (Intel, Massachusets), P. Sadayappan (Ohio State Univ.). This event had 71 participants, including speakers, and, as we hoped, also attracted people from industry, and not only computer industry.

- **CPC'13, the 17th international workshop on compilers for parallel computing**[32], July 3-5, 2013, in Musée Gadagne, in (old) Lyon, a venue that is held every 18 months in Europe since 1989 and that encompasses all areas of parallelism and optimization linked to compilers. The program consisted in 29 talks, from the international community on compilers for HPC (from Japan & Taiwan to the USA, and of course Europe), with 47 participants.

The budget of the thematic quarter was 101 Keuros (taxes excluded): 66 Keuros from Labex MILYON, 4 Keuros from ENS-Lyon, 3.5 Keuros from DRI Inria, 26 Keuros from registration fees, and 1.5 Keuros from Compsys (CNRS funding).

7.3.2 Participation in research projects and contracts

Inria AEN "Multicore". Since 2012, Fabrice Rastello is part of an Inria Large Scale Initiative (AEN: "action d'envergure nationale") called Multicore, which also regroups researchers from seven teams: Camus, Regal, Alf, Runtime, Algorille, Dali on "Large scale multicore virtualization for performance scaling and portability". One of the goals of this project is to enable loop transformations by combining dynamic and static analysis/compilation techniques.

[29] Thematic quarter on compilation: `http://labexcompilation.ens-lyon.fr`
[30] Spring school on polyhedral code analysis and optimizations: `http://labexcompilation.ens-lyon.fr/polyhedral-school`
[31] Keynotes on HPC languages: `http://labexcompilation.ens-lyon.fr/hpc-languages`
[32] CPC'13: `http://labexcompilation.ens-lyon.fr/cpc2013`

7.3.3 Industrial contracts and collaborations

"Sceptre" project (2006-2009). In 2004, we started a tight collaboration with the compilation team of STMicroelectronics (Christian Bertin, Benoît Dupont de Dinechin, Christophe Guillon, François de Ferrière). From 2006 to 2012, this joint research effort was funded through larger governmental contracts, first Sceptre (2006-2009), then Mediacom (2009-2012), both coordinated by Alain Darte for the Inria Partners. Sceptre, funded by the "pôle de compétitivité" Minalogic[33], was led by STMicroelectronics. With many partners mainly from Rhône-Alpes, it aimed at the development of a toolkit to ease the implementation of multimedia algorithms and the generation of optimized codes for a multiprocessor reconfigurable platform. The specific task of Compsys was to work on combinatorial optimization problems coming from back-end optimization, in particular the removal of static single assignment (SSA), register allocation, and code placement for instruction cache optimization. This project was acknowledged at the end of 2009 by the government as a great success and as the first Minalogic project that ended on time and smoothly, i.e., fully in line with the initial objectives.

"Mediacom" project (2009-2012). This contract started in 2009 as part of the R&D funding mechanism Nano2012 and as the continuation of Sceptre. It focused on aggressive optimizations and on the application to just-in-time (JIT) compilation of the techniques developed in Sceptre. It implied four Inria teams: Alf, Alchemy, Arénaire, and Compsys. Unfortunately, due to a unilateral decision of the government, all Nano2012 fundings were frozen in 2011 & 2012. Inria guaranteed the salary of PhD students and of engineers/post-docs already in place, but all other salaries and the travelling budget were cut. Our activities continued, in a less ambitious format, finishing the work of post-doc and PhD students.

This long-term collaboration (since 2004) with the STMicro compilation team was a real success, with a gain for both parties. This gave us access to real industrial compilation problems, to representative benchmarks, to the STMicro assembly code optimizer in which we developed (LAO and Open64), and to an industrial expertise in compilers and processor architecture. Conversely, we helped them develop new strategies, understand previously-published approaches that needed accurate readings for a correct implementation, and our developments contributed to debug their compiler.

In terms of scientific results, our joint efforts led to important contributions in instruction cache optimization, register allocation, and static single assignment (SSA). In particular, Compsys was the first group to push the use of SSA for register allocation and to completely deconstruct the classic view on register allocation. With our colleagues from STMicro, we are now well-identified internationally for this contribution.[34] In addition to our results and publications, this research created a lot of activity in seminars, tutorials [484, 483], organization of workshops (e.g., we organized the first seminar on SSA in Autrans and were involved in the organization of CGO'11), research proposals, hiring of young researchers (in both directions), PhDs [560, 561, 563], etc. This success also contributed to the signature of a R&D national agreement between Inria and STMicro (to which Alain Darte participated) and the activation of several other Nano2012 projects.

"S2S4HLS" project (2009-2011). To support our second research axis (high-level loop transformations and high-level synthesis (HLS)), we established a second activity with STMicroelectronics, but with the HLS team (Pascal Urard, Roberto Guizzetti, Thierry Michel, Michel Favre). It was first supported by a CNRS/STMicroelectronics PhD funding (Clément Quinson, who did not finish his PhD), then as part of a second Nano2012 contract, S2S4HLS. S2S4HLS (source to source transformations for high-level synthesis) started in January 2009. The goal of this project, initiated by the Cairn Inria team, was the study and development of source-to-source program transformations, in particular loop transformations, that are worth applying on top of HLS tools. This includes restructuring transformations, program analysis, memory optimizations and array reshaping, etc. Our preliminary activities on the HLS tool UGH, then on the optimization of DDR communications with the HLS tool C2H [501], and on the analysis of while loops [500] arose in this context but we did not really succeed to find a good match between our activities and STMicroelectronics interests. Nevertheless, some of our tools (Cl@k and Bee) were integrated to Cairn's toolbox. Finally, we were about to hire a post-doc on this topic when all Nano2012 projects were frozen. These successive difficulties pushed us to quit the project in Spring 2011.

"ManycoreLabs" project (2012-2016). To compensate the funding difficulties of Nano2012 projects and to stay in line with the research directions of the team, Compsys started to be involved in 2012 in a new industrial project led by Kalray. Kalray[35] is a french start-up, partly arising from CEA and STMicroelectronics, whose activity is to develop new manycore processors for embedded computing. The ManycoreLabs project, funded by the BGLE program ("briques génériques du logiciel embarqué"[36], is led by Kalray and involves many partners, both industrial (mainly potential customers for the Kalray MPPA architecture, such as Bull, CAPS Entreprise, Digigram, Thales, Renault) and academic (CEA, Inria Parkas and Compsys, Verimag). Our role in this project is to explore compilation techniques for streaming-like languages for this platform, in particular the analysis and compilation of streaming languages such as OpenStream. Some other studies concern cloning/specialization of code and register tiling, and are conducted by Fabrice Rastello, not as part of Compsys.

[33] Minalogic: `http://www.minalogic.org/`

[34] Our contribution was the heart of the recent keynote of B. Dupont de Dinechin at ETAPS'14, see `http://www.etaps.org/index.php/2014/invited-speakers`.

[35] Kalray: `http://www.kalray.eu/`

[36] BGLE: `http://www.industrie.gouv.fr/fsn/logiciel-embarque`

"Tirex" contract with Kalray (2012-2013). The goal of this project, collaboration between Fabrice Rastello and Kalray, was to prototype, within Tirex, some new profiling/analysis techniques necessary to enable cloning. Tirex is a toolbox to develop some low-level code optimizations on top of the minimalist intermediate code representation MinIR [536], introduced by F. Rastello, Kalray and STMicro. Because of the financial problems encountered by Kalray, some efforts related to this project were frozen in 2013.

Technological transfer towards Zettice/XtremLogic start-up. The Zettice start-up has been initiated in March 2011 by Alexandru Plesco and Christophe Alias, supported by Inria who paid Alexandru Plesco as ITT ("ingénieur transfert et innovation"). Zettice also benefited from the help of Adrian Muresan as software engineer. The goal of this initiative was to transfer some of the research concepts emerging from the polyhedral model to the context of high-level circuit synthesis, in particular by building on top of the results of Alexandru Plesco's PhD thesis [562] and on further developments linked to the Aric FloPoCo library for FPGA [476]. Since then, an important amount of applied research has been achieved to propose an effective technology for industrial transfer. From an academic perspective, Zettice is a unique opportunity to cover all aspects of high-level synthesis from the front-end aspects (polyhedral code analysis and optimization) to the back-end aspects (pipelining, retiming, FPGA mapping) providing a global knowledge of relevant industrial issues.

Zettice received in 2012 the *"lean start-up award"* of the startup weekend labs 2012, the *"most exciting start-up mention"* at SAME 2012, and the *concours Crealys Excel & Rate 2012* grant (30 Keuros). In 2013, Zettice won the *concours OSEO 2013* grant (Banque Publique d'Investissement, 40 Keuros) and the *"most promising start-up award"* at SAME 2013. Its name then changed into XtremLogic when the start-up was created (spring 2013). A patent protects some of its results [559]. The main software tools developed in the context of Zettice are Dcc [569], the front-end of the HLS tool, which takes as input an annotated C program and produces a regular process network with explicit transfers and synchronizations, and IceGEN, its back-end, which outputs both SystemC and VHDL.

7.4 Contracts for Team DANTE

7.4.1 Management of research projects and contracts

- SENSLAB (ANR, Inria). The purpose of the SensLAB project is to deploy a very large scale open wireless sensor network platform. SensLAB's main and most important goal is to offer an accurate and efficient scientific tool to help in the design, development, tuning, and experimentation of real large-scale sensor network applications. The sensLAB platform is distributed among 4 sites and is composed of 1,024 nodes. Each location hosts 256 sensor nodes with specific characteristics in order to offer a wide spectrum of possibilities and heterogeneity. The four test beds are however part of a common global testbed as several nodes have global connectivity such that it is possible to experiment a given application on all 1K sensors at the same time.
- DyVi (INRIA ARC) The goal of the ARC DyVi is to build a foundation for dynamic graph theory in order to be able to describe properties and design efficient and specific algorithmic for dynamic graph and overlapping communities The goal is to be able to tackle multi time scale visualization tools based on TULIP, to implement data structure / handling / time scale aggregation / browsing within the TULIP software developed by the INRIA GRAVITE team. We also target epidemic process visualization in order to be able to run and "see" dynamic processes on dynamic networks
- SensAS (INRIA ADT) The ambition of SensAS is to deploy wireless sensor and actuator applications. From the strong expertise gather in MOSAR, SensLAb and SensTOOLS, the goal is to transfer and help other INRIA research team to deploy their own application, not in the restricted networking area: flying drones, robots fleet, biologging, health, management.
- SensTOOLS (INRIA ADT) The main and most important goal of the SensTOOLS ADT project is to foster the design, development, tuning, and experimentation of real large scale sensor network applications. Sensor networks have recently emerged as a premier research topic. However, due to their massively distributed nature, the design, implemen- tation, and evaluation of sensor network applications, middleware, and communication protocols are difficult time-consuming tasks. The purpose of the SensTOOLS is to provide both software and hardware toolboxes in order to offer the developer appropriate tools and methods for designing, testing and managing his/her large scale wireless sensor network applications.
- Dispop (IXXI) Dispop is a biologging project funded by the Rhône-Alpes Institute of Complex Sciences. Biologging consists in equipping animals with tracking and sensing devices such that its mobility, environmental conditions and social interactions can be monitored. This project's goal is more particularly to explore and develop the measure and analysis tools which could help in modeling the dynamic of populations as a response to environmental factors. This project hosts members of the D-NET team and the DEPE – Département Ecologie, Physiologie et Ethologie department of the IPHC – Institut Pluridisciplinaire Hubert Curien (Strasbourg, France).
- ESPAD (FEDER) The ESPAD (Embedded Sport Performance Analysis Data) is bio-mechanics / physiology logging project funded by FEDER. The goal is to contributed to the design of a distributed multi-sensor architecture that can be worn by an individual and that records bio-mechanical, physiological and environmental data.

7.4.2 Participation in research projects and contracts

National initiatives

- IGTMD (ANR, ENSL, 2006-2009) The aim of this project is to design, develop and validate mechanisms that concretely make the interoperability of heterogeneous grids a reality. The project concentrates on the following topics: a) Bulk data transfers, b) replication and referring mechanisms, c) information system and job management interoperability, d) grid control and monitoring, e) usage of statistics and accounting data.
- HIPCAL[37] (ANR, Inria, 2007-2010). The goal of this project was to explore an approach in a break with current services-oriented principles developed in grids, to enhance the application portability, the communications performance control and their security, simultaneoulsy. HIPCAL studied a new paradigm (grid substrate) based on confined virtual private execution infrastructure for resource control in grids. In particular, we proposed and implemented new approaches for bandwidth sharing and end to end network quality of service guarantees. Use-cases in biomedical applications deployed on GRID'5000, served as proof-of-concept. Joint project between Inria (REDO, GRAND LARGE, PLANETE) and CNRS (IBPC, I3S).
- RESCUE[38] (ANR, ENSL, 2010-2013). RESCUE follows the ARC MISSION project. In RESCUE, we investigate both

[37] http://www.ens-lyon.fr/LIP/RESO/Projects/HIPCAL/ProjetsHIPCAL.html
[38] http://rescue.lille.inria.fr/

the underlying mechanisms and the deployment of a substitution network, aimed at overcoming local failures on a base network, maintaining a satisfactory level of service to the users. Unlike many projects and other scientific works that consider mobility as a drawback, in RESCUE we use the controlled mobility of the substitution network (composed of a fleet of dirigible wireless mobile routers) to help the base network reduce contention or to create an alternative network in case of failure. The advantages of an on-the-fly substitution network are manifold: Reusability and cost reduction; Deployability; Adaptability. Other partners of this project are the Inria team POPS, LIP6, LAAS, and France Telecom.

- MISSION (Inria, 2010-2011) stands for MobIle SubStitutIOn Networks and is focused on the performance study and the feasibility to deploy a fleet of mobile wireless routers to help a wired network that can not offered its services anymore (e.g., due to a failure). Other partners are: LIP6 (Paris) and Inria Lille.

- PETAFLOW[39] (ANR, ENSL, 2009-2012) Generation or processing of peta-scale data benefits from the emergence of adequate *Information and communication technologies* with respect to high performance *computing-networking-visualization* and their mutual *awareness*. In this project, RESO aims at proposing network solutions to guarantee the Quality of Service (in terms of reliability level and of transfer delay properties) of a high speed, transnational long-distance connection used in an interactive, high performance computing application. Another specificity of this application is the peta-scale volume of the treated data corresponding to the upper airway flow modeling.

- DMASC (ANR, Inria, 2008-2012) The main objective is to develop advanced multifractal analysis tools, from mathematically ground results to efficient estimators. We apply these methods to the analysis, to the modeling and to the classification (for non invasive diagnoses) of cardiovascular systems. This project, leaded by J. Barral (Univ. Paris 13), is a partnership between Inria (SISYPHE and RESO), university of Paris 12 and Paris 13 and Paris Sud (équipe d'accueil EA 4046 Service de Réanimation Médicale CHU de Bicêtre).

- Complex Networks Metrology (RNSC) D-NET is a member of the project Complex Networks Metrology involving LIP6 (Université Paris 6), LSIIT (Université de Strasbourg) and LIP (ENS de Lyon, Université Lyon 1). The project, funded by RNSC (Réseau National des Systèmes Complexes), started in January 2011 and ended in December 2011. Its goal is to design rigorous methods for measuring complex networks. The originality of our appraoch is to lead measurements dedicated to a specific property instead of trying to get a complete view of the network, which has been showed to lead to significant biases in the obtained view. Its major domain of application is Internet measurements.

- FLAB (ANR, Inria). As proposed by initiatives in Europe and worldwide, enabling an open, general-purpose, and sustainable large-scale shared experimental facility fosters the emergence of the Future Internet. There is an increasing demand among researchers and production system architects to federate testbed resources from multiple autonomous organizations into a seamless/ubiquitous resource pool, thereby giving users standard interfaces for accessing the widely distributed and diverse collection of resources they need to conduct their experiments. The F-Lab project builds on a leading prototype for such a facility: the OneLab federation of testbeds. OneLab pioneered the concept of testbed federation, providing a federation model that has been proven through a durable interconnection between its flagship testbed PlanetLab Europe (PLE) and the global PlanetLab infrastructure, mutualizing over five hundred sites around the world. One key objective of F-Lab is to further develop an understanding of what it means for autonomous organizations operating heterogeneous testbeds to federate their computation, storage and network resources, including defining terminology, establishing universal design principles, and identifying candidate federation strategies. On the operational side, F-Lab enhances OneLab with the contribution of the unique sensor network testbeds from SensLAB, and LTE based cellular systems. In doing so, F-Lab continues the expansion of OneLab's capabilities through federation with an established set of heterogeneous testbeds with high international visibility and value for users, developing the federation concept in the process, and playing a major role in the federation of national and international testbeds. F-Lab also develops tools to conduct end-to-end experiments using the OneLab facility enriched with SensLAB and LTE.

- ANR INFRA DISCO (DIstributed SDN COntrollers for rich and elastic network services) project: the DANTE team will explore the way SDN (Software Designed Network) can change network monitoring, control, urbanisation and abstract description of network resources for the optimisation of services. More specifically, the team will address the issues regarding the positioning of SDN controllers within the network, and the implementation of an admission control that can manage IP traffic prioritisation.

- ANR FETUSES: The goals of this ANR project consist in the development of statistical signal processing tools dedicated to per partum fetal heat rate characterisation and acidosis detection, and are organised as follows: –

[39] `http://petaflow.gforge.inria.fr/`

construction of a large dataset of per partum fetal heart rate recordings, which is well documented and of significant clinical value; – Developments of adaptive (*e.g.* data driven) algorithms to separate data into trend (deceleration induced by contractions) and fluctuation (cardiac variability) components; – Developments of algorithms to characterise the non stationary and multifractal properties of per partum fetal heart rate ; – Acidosis detection and assessment using the large datasets; – Algorithm implementation for performing tests in real clinical situations. ANR is a joint project between DANTE, the Physics Lab of ENS Lyon (SiSyPhe team) and the *Hôpital Femme-Mère-Enfant* of Bron (Lyon). Fetuses started in january 2012.

- ANR CONTINT CODDDE accepted in December 2013: It is a collaborative project between the ComplexNetwork team at LIP6/UPMC; Linkfluence and Inria Dante. The CODDDE project aims at studying critical research issues in the field of real-world complex networks study:

  - How do these networks evolve over time?
  - How does information spread on these networks?
  - How can we detect and predict anomalies in these networks?

  In order to answer these questions, an essential feature of complex networks will be exploited: the existence of a community structure among nodes of these networks. Complex networks are indeed composed of densely connected groups of that are loosely connected between themselves.

  The CODDE project will therefore propose new community detection algorithms to reflect complex networks evolution, in particular with regards to diffusion phenomena and anomaly detection.

  These algorithms and methodology will be applied and validated on a real-world online social network consisting of more than 10 000 blogs and French media collected since 2009 on a daily basis (the dataset comprises all published articles and the links between these articles).

- EQUIPEX FIT (Futur Internet of Things) FIt is one of 52 winning projects in the Equipex research grant program. It set up a competitive and innovative experimental facility that brings France to the forefront of Future Internet research. FIT benefits from 5.8 million grant from the French government Running from 2011 to 2019. The main ambition is to create a first-class facility to promote experimentally driven research and to facilitate the emergence of the Internet of the future.

European projects

- AEOLUS (FP6, Inria, 2005-2009). Acronym for “Algorithmic Principles for Building Efficient Overlay Computers", AEOLUS investigated the principles and developed the algorithmic methods for building an overlay computer that enables an efficient and transparent access to the resources of an Internet-based global computer. The university of Patras (Greece) was the prime contractor.

- EURO NF (FP7 NoE, 2008 - 2010). Anticipating the Network of the Future - From Theory to Design. Euro-NF is a Network of Excellence on the Network of the Future, formed by 35 institutions (from the academia and industry) from 16 countries. Its main target is to integrate the research effort of the partners to be a source of innovation and a think tank on possible scientific, technological and socio-economic trajectories towards the network of the future.

- EC-GIN[40] (FP6, Inria, 2006-2009) Based on a number of properties that make Grids unique from the network perspective, the project EC-GIN has developed a tailored network technology in dedicated support of Grid applications. These technical solutions have been supplemented with a secure and incentive-based Grid Services network traffic management system, which balanced the conflicting performance demand and the economic use of resources in the network and within the Grid. EC-GIN outcomes stemmed from a close academic collaboration between Europe (Inria, UIBK, UniZH, ULANC, UniS, UIO) and China (BUPT, CTTL, CMDI).

- GEYSERS[41] (FP7, Inria, 2009-2012) The goal was to qualify optical infrastructure providers and network operators with a new architecture, to enhance their traditional business operations. Following this objective, GEYSERS specifies and implements a novel optical-network architecture able to support “Optical Network+Any-IT" resource provisioning seamlessly and efficiently. Energy-consumption metrics for the end-to-end service routing are part of this efficiency. The consortium involves more than 20 academic and industrial partners from Europe (Italy, Switzerland, Germany, Poland, The Netherlands, Greece, Belgium, UK, Spain) and India.

[40] http://www.ec-gin.eu/corpsite/display/main.asp
[41] https://www.geysers.eu/

- SAIL[42] (FP7, Inria, 2009-2012) Sought objective is the research and the development of novel networking technologies using proof-of-concept prototypes to lead the way from current networks to the Network of the Future. SAIL leverages state of the art architectures and technologies, extends them as needed, and integrates them using experimentally-driven research, producing interoperable prototypes to demonstrate utility for a set of concrete use-cases. REDO contributes to workpackage D on *Cloud Networking*. The consortium comprises 25 academic and industrial partners from Europe (Sweden, Germany, Finland, UK, France, Spain, Portugal, Ireland) and from Israel and Australia.

- WASP (FP6-IST) WASP is an Integrated Project supported for 4 years by the European Commission under the Information Society Technologies of the Sixth Framework Program. An important class of collaborating objects is represented by the myriad of wireless sensors, which will constitute the infrastructure for the ambient intelligence vision. The academic world actively investigates the technology for Wireless Sensor Networks (WSN). Industry is reluctant to use these results coming from academic research. A major cause is the magnitude of the mismatch between research at the application level and the node and network level. The WASP project aims at narrowing this mismatch by covering the whole range from basic hardware, sensors, processor, communication, over the packaging of the nodes, the organization of the nodes, towards the information distribution and a selection of applications. The emphasis in the project lays in the self- organization and the services, which link the application to the sensor network. Research into the nodes themselves is needed because a strong link lies between the required flexibility and the hardware design. Research into the applications is necessary because the properties of the required service influence the configuration of both sensor network and application for optimum efficiency and functionality. All inherent design decisions cannot be handled in isolation as they depend on the hardware costs involved in making a sensor and the market size for sensors of a given type.

- MOSAR (FP5, Inria, 2008-2012). MOSAR brings together internationally recognized experts to address the issue of antimicrobial resistance in a comprehensive manner. MOSAR consideres the major issue of antimicrobial resistance in the perspective of a complex system and not only through the prism of a single discipline.

  To achieve its objectives MOSAR builds on advances generated by basic sciences, through dedicated and trans-disciplinary cooperation. This project integrates studies from epidemiology and basic laboratory sciences, clinical medicine, statistical sciences, behavioural sciences, and health economics. MOSAR network is structured into 10 interacting groups centered on the patients.

  MOSAR focuses on major endemic and epidemic nosocomial pathogens such as Methicillin-resistant Staphylococcus aureus (MRSA), Vancomycin-resistant Enterococci (VRE), Extended-Spectrum Beta-Lactamases (ESBL) Enterobacteriaeceae, and Carbapenem-resistant Acinetobacter spp, and in interventional trials in high-risk areas (Intensive Care Units, Surgery and Rehabilitation centers) of countries with high-level of resistance.

Associated teams and other international projects

- GRID-NET (Associated team Inria-AIST Japan, 2007-2009). Thanks to this collaboration, we investigated four main directions: 1) High speed transport protocol over very high speed links, 2) Bandwidth allocation and control in Grids, 3) Optimisation of MPI communications in Grids, and 4) Co-design of GtrcNET-packet capture functionality. The integration of the Gtrc-Net 1 and 10 (developed at AIST) into the GRID'5000 infrastructure led us to a series of noticeable results that are described in the scientific achievements of axes 2, 3 and 4 (e.g BDTS, Metroflux, MPI5000).

- NEGST (JSPT-CNRS). The objective of this project was to promote the collaborations between Japan and France on grid computing technology. We considered three main lines of investigation: 1) Grid interoperability and applications; 2) GridMetrics and 3) Instant Grid and virtualization of grid computing resources. RESO mainly participates to the Grid Metrics topic.

- CODYN (Inria/FAPERJ – Complex Dynamic Networks) between LNCC and DNET/Inria. The main goal of the CoDyN project is to lay solid foundations to the characterization of dynamically evolving networks, and to the field of dynamical processes occurring on large scale dynamic interaction networks.

- PICS CNRS Combinatorial Structures for Complex Network Modeling. DANTE is a member of a PICS project of the CNRS between the Academy of Science and Technology in Vietnam and the Laboratoire d'Informatique de Paris 6 (LIP6) and Université Claude Bernard Lyon 1 in France. Its goal is to design models of complex networks that are able to capture at the same time two of their most relevant properties : their heterogeneous degree distribution and their high local density. The goal is to provide very general models that do not make stronger assumptions on

[42] `http://www.sail-project.eu/`

the structure of the graphs to be modeled. Our approach is based on the overlapping structure of cliques in complex networks and uses mainly tools coming from combinatorics, graph theory and statistics.

- STIC AMSUD – DYNAMICS OF LAYERED COMPLEX NETWORKS D-NET is a member of a STIC AMSUD project between the National Laboratory for Scientific Comput- ing (LNCC) in Brazil, the Faculdad de Ingeniera Universidad de Buenos Aires in Argentina, Laboratoire d'Informatique de Paris 6 (LIP6) and ENS Lyon in France. The goal of the project is mainly to investigate the fundamental characteristics of dynamic graphs and their applicability to the analysis of layered complex networks.

7.4.3 Industrial contracts and collaborations

- CARRIOCAS[43] (Competitive pole System@tic, Inria, 2006-2009). In this collaborative work we studied and implemented an ultra high bit rate (up to 40 Gbps per wavelength) network interconnecting super computers, storage servers and high resolution visualization devices to support data and computing intensive applications in industrial and scientific domains. This testbed was intended to be the experimental first step towards a transition from local to external storage and computing systems. More specifically, RESO was in charge of the design and the prototyping of the "Resource Scheduling Reconfiguration and Virtualization - SRV" component. As a regional initiative, this project gathered under the coordination of Alcatel-Lucent, more than 20 academic and industrial IT actors from *Ile de France* (participation of RESO stemmed from our close collaboration with the Inria team GRAND LARGE).

- INRIA ALCATEL LUCENT BELL LABS[44] (Common laboratory, 2008-2012)
  RESO participates in the Research Action *Semantic Networking* (SEM- NET) which advocates a new paradigm for the networks of the future bringing together *flow-based networking*, *traffic-awareness* and *self-management* concepts to get *plug-and-play* networks. The natural traffic granularity is the flow. RESO's task is to elaborate on the admission control of flows in routers having in mind the current status of the network and the underlying applications. In a different work, we also consider the problem of graph-based semi-supervised approaches applied to content- and user-based classifications in networks.
  Besides Alcatel Lucent, we are mostly working with the Inria team MAESTRO.

- INRIA ALCATEL-LUCENT BELL LABS JOINT LABORATORY. DANTE participate in the research action *Network Science*. The main scientific objectives of network science are:

  - to design efficient tools for measuring specific properties of large scale complex networks and their dynamics;
  - to propose accurate graph and dynamics models (*e.g.*, generators of random graph fulfilling measured properties);
  - to use this knowledge with an algorithmic perspectives, for instance, for improving the QoS of routing schemes, the speed of information spreading, the selection of a target audience for advertisements, etc.

  The ADR will focus on:

  - Network sampling
  - Epidemics in networks
  - Search in networks
  - Clustering of networks
  - Detecting network central nodes
  - Network evolution and anomaly detection

- FRANCE TELECOM R&D (Cifre, Inria, 2005-2008). The subject of this industrial contract was "Network load balancing on layer 7 switching for high performance and high available Linux based platforms".

- ANAGRAN (Inria, 2008). We have designed and ran experimentations of the ANAGRAN FR router within GRID'5000.

- A bilateral contract has been signed between the DANTE Inria team and ACT750 to formalize their collaboration in the context of churn prediction.

- A bilateral contract has been signed between the DANTE Inria team and KRDS to formalize their collaboration in the context of Facebook marketing / cascade analysis.

[43] http://www.systematic-paris-region.org/fr/projets/carriocas
[44] http://inria.bell-labs.commonlab.homeip.net/

- A bilateral contract has been signed between the DANTE Inria team and HiKoB to formalize their collaboration in the context of the Equipex FIT (Futur Internet of Things) FIt is one of 52 winning projects in the Equipex research grant program. It will set up a competitive and innovative experimental facility that brings France to the forefront of Future Internet research. FIT benefits from 5.8 euros million grant from the French government Running from 22.02.11 – 31.12.2019. The main ambition is to create a first-class facility to promote experimentally driven research and to facilitate the emergence of the Internet of the future.

- A bilateral contract has been signed between the DNET INRIA and SALOMON to formalize their collaboration in the context of the XtremLog projet. This collaboration is based on an exchange of good services : SALOMON offers to adapt its equipments to integrate the sensor nodes designed by the INRIA for the Marathon des Sables experiment

7.5 Contracts for Team MC2

7.5.1 Management of research projects and contracts

- **ANR project Stint (structures interdites):** this project is coordinated by Nicolas Trotignon and got started in January 2014. It focuses on graphs with (or should we say *without*) forbidden structures. The permanent team members that are involved in this project are Nicolas Trotignon, Michael Rao and Stéphan Thomassé. Two other teams are member of this project (COATI in Nice, G-SCOP in Grenoble).

  Induced subgraphs play a central role in both structural and algorithmic graph theory. A graph H is an *induced subgraph* of a graph G if one can delete vertices of G to obtain H. This is the strongest notion of subgraph, hence being H-*free* (that is not containing H as an induced subgraph) is not a very restrictive requirement. Weaker notions of containment, like for instance minors, are now well understood, and the next achievement in Graph Theory should certainly be the understanding of forbidden induced structures. We focus in this project on the following very general question:
  Given a (possibly infinite) family ψ of graphs, what properties does a ψ-free graph have?

  This is the key question of many important and longstanding problems, because many crucial graph classes are defined in terms of forbidden induced subgraphs. This field is now quickly growing, and new techniques and tools have been recently developed.

  Our first goal is to establish bounds on some classical graph parameters for ψ-free graphs, such as the clique number, the stability number and the chromatic number. A second goal is to design efficient algorithms to recognize ψ-free graphs and to determine or approximate some parameters for those graphs.

  For this purpose, we plan to use and develop various proof techniques, some of these being recently discovered, such as the structural description of graph classes, the regularity lemma, graph limits, flag algebras, VC-dimension, discharging method as well as computer-assisted proofs.

- **ANR project CompA (complexité algébrique):** this project is coordinated by Pascal Koiran and got started in February 2014. The permanent team members that are involved in this project are Pascal Koiran, Natacha Portier and Stéphan Thomassé. The other partner is Paris 7; three individual researchers from Grenoble, Lyon 1 and Versailles also participate.

- **Institut Universitaire de France** : Pascal Koiran was a junior member of IUF from 2007 to 2011.

- **Marie Curie outgoing fellowship:** This fellowhip enabled Natacha Portier to visit the Fields Institute and the University of Toronto from September 2009 to September 2011.

- **European project Morphex (2007-2010):** This project was coordinated by Michel Morvan, who left ENS Lyon in December 2008. The project developed a complex systems approach to the modeling of gene regulatory networks in plants and animals. It involved researchers from MC2, from the plant reproduction lab (RDP) at ENS Lyon, from several other academic institutions in Chile, Germany, The Netherlands, and from a small Lyon-based company (Oslo).

7.5.2 Participation in research projects and contracts

In addition to the projects that we are coordinating, we participated in:

- ANR jeunes chercheurs DORSO "Decomposition of Relational Structures: Combinatorial Optimisation" (Michael Rao, 2011-2015). Project coordinator: Frédéric Mazoit, LaBRI.

- PEPS GraphIQ : Informatique quantique et théorie des graphes : étude des états graphes (Michael Rao, 2010-2012). Project coordinator: Simon Perdrix.

- PHC Pavle Savic grant (Nicolas Trotignon), jointly awarded by EGIDE, an agency of the French Ministere des Affaires etrangeres et européennes, and Serbian Ministry for Science and Technological Development, 2010-2011.

- ANR jeune chercheur Heredia (Nicolas Trotignon), 2011–2014.

- Project 174033 (Nicolas Trotignon), supported by the Ministry of Science, Technology and Development, Republic of Serbia. Graph theory and mathematical programming with applications to chemistry and computer science. Leader: Slobodan Simic.

- ANR project Pegase (2009-2012): “Peformances Garanties dans les Systèmes Embarqués communicants". Within this project, Eric Thierry worked on $(\min, +)$ algorithms for performance evaluation using the network calculus formalism. The project partners were Thales Alenia Space, Thales Avionics, ONERA (leader), ENS Cachan - Bretagne, LIP, Real-Time at Work, INRIA Rhône-Alpes.
- Subcontracting work for Onera: “Etude des courbes de service strict en calcul réseau" (Eric Thierry, 2009). The project partners were LIP, ENS Cachan and Onera.
- IXXI project RAP: Réseaux d'automates probabilistes (Eric Thierry). The partners were LIP, IXXI and LIAFA.
- ANR project Geneshape. This complex systems project was focused on the modeling of morphogenesis in plants and animals.

7.5.3 Industrial contracts and collaborations

Several industrial partners were involved in ANR project Pegase (see above section). We also did some subcontracting work for Onera.

7.6 Contracts for Team PLUME

7.6.1 Management of research projects and contracts

ANR PACE project. The ANR PACE project (ANR Blanc International II, France-China) (*beyond plain Processes: Analysis techniques, Coinduction and Expressiveness*) is headed by D. Hirschkoff. The project involves partners in China (Shanghai Jiao Tong University) and France (ENS Lyon, INRIA Saclay and INRIA Sophia). The duration is 2013-2016. The PACE project investigates the use of coinduction in reasoning about programs and systems, with applications to the verification of behavioural properties of systems.

ANR COMPLICE project. The ANR project COMPLICE (*Complexité Implicite, Concurrence et Extraction*) (ANR Blanc 2008) was headed by P. Baillot. It lasted from 1/2009 to 4/2013. The project partners sites were LIP (ENS Lyon), LIPN (Université Paris 13), LORIA-INPL (Nancy). The permanent participants in Plume were P. Baillot, D. Hirschkoff, O. Laurent.

This project dealt with implicit complexity, whose goal is to design static criteria on programs allowing to certify complexity time or space bounds on their execution. It addressed 2 main challenges: 1. expressiveness: the programming disciplines employed to guarantee complexity bounds should not be too constraining, and in particular should allow to write natural programs. 2. generality: the method should apply to common programming paradigms, such as imperative or concurrent programming. For reaching this double goal we have used techniques coming on the one hand from rewriting theory, and on the other hand from logic.

ANR RÉCRÉ project. The RÉCRÉ project (*Realizability for classical logic, concurrency, references and rewriting*) was first headed by A. Miquel, and then after his departure for Uruguay in September 2013 by C. Riba. It is an ANR Blanc SIMI2 2011 project, whose duration is from 01/11/11 to 31/10/15. The partner sites are: LIP (ENS Lyon); PPS-pi.r2 ; I2M (ex IML) ; LAMA - Université de Savoie. Permanent participants in Plume are : D. Hirschkoff, O. Laurent, C. Riba (and formerly A. Miquel).

The RÉCRÉ project focuses on the proofs-as-programs correspondence for classical logic and its extension to computational effects (concurrency, side effects). Central to the project is *classical realizability*, which was introduced by J.-L. Krivine. The main aim of the project is the study of classical realizability and its application to the semantics and proof of programs with computational effects (e.g. non-determinism, parallelism, references, global memory, inputs/outputs).

PEPS project COGIP. The Project (PEPS-CNRS) on COalgebras- and Games- based Interpretations of Processes (COGIP) was headed by F. Bonchi. The project (from April 2012 to December 2013) has been used to organize several meetings in Lyon and hosting many international guests (Jan Rutten, Alexandra Silva, Marcello Bonsangue, Matteo Mio, Ichiro Hasuo and Fabio Gadducci). The project involved five French laboratories: LIP (ENS Lyon), LIG (Grenoble), LAMA (Univ. de Savoie), PPS (Paris 7) and LIST (CEA Saclay).

PICS project LLa. P. Baillot has been coordinator, with U. Dal Lago on the Italian side, of the PICS project (Projet International de Coopération Scientifique) of CNRS, **Logique linéaire et applications** France-Italie (PICS 5276). The partner sites were in France: LIP (ENS Lyon), LIPN (Univ. Paris 13), PPS (Univ. Paris 7), and in Italy: Univ of Bologna, Univ. of Torino, Univ. of Roma Tre. This project supported short crossed visits of researchers and PhD students between the italian sites and the French sites.

PHC bilateral project with Serbia. P. Lescanne has been coordinator of a PHC bilateral project with Serbia (Pavel Savic) in 2010-2011 and 2012-2013. The principal investigator on the Serbian side was Silvia Ghilezan (Novi Sad). Partner sites: Univ. of Novi Sad; ENS Lyon; Univ. of Paris 7; Univ. of Toulouse.The project dealt with the study of lambda-calculi and explicit substitutions for investigating the computational content of classical logic.

7.6.2 Participation in research projects and contracts

ITN European project MaLoA. O. Laurent has been coordinator of the ENS Lyon sub-site of the MaLoA ITN project (Initial Training Network on Mathematical Logic and Applications) funded by EU in 2009-2013 (partners: Leeds, Manchester, Oxford, CNRS-Lyon, Paris, Munich, Muenster, Prague). This project provided a PhD fellowship for Athanasios Tsouanas.

ANR CHOCO project. The CHoCo project (Curry-Howard and Concurrency), 2007-2010 was funded by the ANR. The main goal of the project was to develop the interactions between proof theory (notably linear logic, proof nets, types,..) and concurrency theory (process calculi, behavioural equivalences). D. Hirschkoff was site leader for Lyon (other sites involved were Paris 7 and Marseille). As mentioned above, the monthly meetings, in Lyon, which started during this project are still ongoing (ChoCoLa meetings).

ANR PiCoq project. D. Hirschkoff is site coordinator for the ANR PiCoq project (2011-2014). The sites involved in the project are INRIA Grenoble and Université de Savoie. The PiCoq project investigates questions related to the mechanisation of reasoning about concurrent and mobile systems (with applications in theorem proving).

7.6.3 Industrial contracts and collaborations

7.7 Contracts for Team ROMA

7.7.1 Management of research projects and contracts

European projects

European FP7 Marie Curie Action – IOF – MetagenoGrids (2008-2009), 1 year. In the scope of the associate-team MetagenoGrid described below, Frédéric Vivien was on sabbatical at the University of Hawai'i at Mānoa for one year, from July 17, 2008 until July 16, 2009. This sabbatical was funded by a Marie Curie Action – International Outgoing Fellowship from the European Commission.

National projects

ANR White Project Rescue (2010-2014), 4 years. The ANR White Project Rescue was launched in November 2010, for a duration of 48 months. It gathers three INRIA partners (ROMA, Grand-Large, and Hiepacs) and is led by Yves Robert. The main objective of the project is to develop new algorithmic techniques and software tools to solve the *exascale resilience problem*. Solving this problem implies a departure from current approaches, and calls for yet-to-be-discovered algorithms, protocols, and software tools. The proposed research follows three main research thrusts. The first thrust deals with novel *checkpoint protocols*. The second thrust entails the development of novel *execution models*, i.e., accurate stochastic models to predict (and, in turn, optimize) the expected performance (execution time or throughput) of large-scale parallel scientific applications. In the third thrust, we will develop novel *parallel algorithms* for scientific numerical kernels.

ANR White Project Stochagrid (2007-2010), 3 years Grid computing platforms and components are subject to a great variability. Statistical models are mandatory to deal with changes in resource performance, such as CPU speeds or link bandwidths. Traditionally, Markov chains are used to capture the inherent uncertainty linked to parameter estimation. However, Markov chains lack a key feature: because they are memoryless, they cannot accurately model the performance of parallel systems periodically interacting through message exchanges in steady-state mode. In contrast, sophisticated static scheduling strategies have been developed to map workflow applications on static Grid computing platforms. Optimal algorithms have been designed to map simple pipeline skeleton kernels onto heterogeneous clusters and Grids. Such applications operate in pipeline mode, and standard objective functions include maximizing the throughput and/or minimizing the response time (latency), for each data set. A major goal of this project is to fill the gap between both approaches. On the one hand, statistical models are mandatory to account for the variability and dynamicity of resources. On the other hand, efficient scheduling algorithms only exist for static, dedicated platforms. We need a new stochastic model able to capture the performance of dynamic parallel systems accurately. This new model will be non-Markov for system interaction but will be Markov-based for platform characteristics (fault-tolerance and variability). The design and evaluation of this new model will be the first key contribution of the project. New, robust, scheduling algorithms will be designed and evaluated on top of this model, thereby providing the first stochastic testbed for workflow applications on Grid platforms. The third key contribution of the project will be the design of a prototype library for deploying workflow applications on computational Grids.

This project was entirely conducted within the team.

INRIA associate-team ALOHA (2012-2014), 3 years. The ALOHA associate-team is a joint project of the ROMA team and of the Information and Computer science Department of the University of Hawai'i (UH) at Mānoa, Honolulu, USA. This project is lead by Frédéric Vivien.

Building on a vast array of theoretical techniques and expertise developed in the field of parallel and distributed computing, and more particularly application *scheduling*, we tackle database questions from a fresh perspective. To this end, this proposal includes:

- a group that specializes in database systems research and who has both industrial and academic experience, the group of Lipyeow Lim (UH);
- a group that specializes in practical aspects of scheduling problems and in simulation for emerging platforms and applications, and who has a long experience of multidisciplinary research, the group of Henri Casanova (UH);
- a group that specializes in the theoretical aspects of scheduling problems and resource management (the ROMA team).

The research work focuses on the following three thrusts: 1) Online, multi-criteria query optimization; 2) Fault-Tolerance for distributed databases; 3) Query scheduling for distributed databases.

INRIA associate-team MetagenoGrid (2008-2010), 3 years. The collaboration is done with the Concurrency Research Group (CoRG) of Henri Casanova, and the Bioinformatics Laboratory (BiL) of Guylaine Poisson of the Information and Computer Sciences Department, of the University of Hawai'i at Manoā, USA. Frédéric Vivien was the leader

of this associate-team.
The associated-team targets the efficient scheduling of large-scale scientific applications on clusters and Grids. To provide context for this research, we focus on applications from the domain of bioinformatics, in particular comparative genomics and metagenomics applications, which are of interest to a large user community today. So far, applications (in bioinformatics or other fields) that have been successfully deployed at a large scale fall under the "independent task model": they consist of a large number of tasks that do not share data and that can be executed in any order. Furthermore, many of these application deployments rely on the fact that the application data for each task is "small", meaning that the cost of sending data over the network can be ignored in the face of long computation time. However, both previous assumptions are not valid for all applications, and in fact many crucial applications, such as the aforementioned bioinformatics applications, require computationally dependent tasks sharing very large data sets. This project had two main research thrusts: 1) Scheduling of applications with data requirements; 2) Scheduling of multiple concurrent applications.

CNRS-USA grant SchedLife, University of Hawai'i (2007-2009), 3 years. This grant covered the same collaboration than the INRIA associate-team MetagenoGrid described above. This grant was lead by Anne Benoit.

INRIA ADT MUMPS (2009-2012), 3 years. ADT-MUMPS was an action of technological development funded by INRIA. Tools for experimentation, validation, and performance study of MUMPS were being developed; one of the goals was also to efficiently use and benefit from the common porting, testing, and compilation cluster from INRIA, pipol.

7.7.2 Participation in research projects and contracts

European projects

European FP7 project SCORPIO (2013-2016), 3 years. The European Project SCORPIO was launched in June 2013, for a duration of 36 months. In addition to INRIA which is repesented by the ROMA team, it gathers five academic partners: CERTH, Greece (coordinator); EPFL, Switzerland; RWTH Aachen University, Germany; The Queen's University of Belfast, UK; and IMEC, Belgium. This project is centered around a new computing paradigm that exploits uncertainty to design systems that are energy-efficient and scale gracefully under hardware errors by operating below the nominal operating point, in a controlled way, without inducing massive or fatal errors. In this project, ROMA focuses on the design and optimization of ABFT solutions.

National projects

ANR Project SOLHAR (2013-2017), 4 years. The ANR Project SOLHAR was launched in November 2013, for a duration of 48 months. It gathers five academic partners (the HiePACS, Cepage, ROMA, and Runtime INRIA project-teams, and CNRS-IRIT) and two industrial partners (CEA/CESTA and EADS-IW). This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computers equipped with accelerators. The proposed research is organized along three distinct research thrusts. The first objective deals with linear algebra kernels suitable for heterogeneous computing platforms. The second one focuses on runtime systems to provide efficient and robust implementation of dense linear algebra algorithms. The third one is concerned with scheduling this particular application on a heterogeneous and dynamic environment.

ANR grant ANR-06-CIS-010: SOLSTICE – SOlveurs et simulaTIon en Calcul Extrême (2007-2010), 3.5 years. The objective of this project was to design and develop high-performance parallel linear solvers that will be efficient to solve complex multi-physics and multi-scale problems of very large size (10 to 100 millions of equations). To demonstrate the impact of our research, the work produced in the project will be integrated in real simulation codes to perform simulations that could not be considered with today technologies. This project also comprises LABRI (coordinator), CERFACS, INPT-IRIT, CEA-CESTA, EADS-CCR, EDF R&D, and CNRM. We were more particularly involved in tasks related to out-of-core factorization and solution, parallelization of the analysis phase of sparse direct solvers, rank detection, hybrid direct-iterative methods and expertise site for sparse linear algebra.

Inria Project Lab C2S@Exa - Computer and Computational Sciences at Exascale. Since January 2013, the team is participating to the C2S@Exa Inria Project Lab (IPL). This national initiative aims at the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society.

INRIA-UIUC-NCSA Joint Laboratory for Petascale Computing. The Joint Laboratory for Petascale Computing focuses on software challenges found in complex high- performance computers. The Joint Laboratory is based at the University of Illinois at Urbana-Champaign and includes researchers from the French national computer science institute called INRIA, Illinois' Center for Extreme-Scale Computation, and the National Center for Supercomputing Applications. Much of the Joint Laboratory's work focuses on algorithms and software that will run on Blue Waters and other petascale computers.

7.7.3 Industrial contracts and collaborations

There are many industrial collaborations around MUMPS, since it counts many industrial users. Exchanges are mainly via direct contacts, but also via the mumps-users mailing list, or via the organization of MUMPS users days (last editions were hosted by INP Toulouse in 2010 and by EDF in Clamart in 2013). We cite below a few formal collaborations or contracts concerning MUMPS.

Software agreement, MUMPS, 2012. In 2012, a contract was signed between CERFACS, CNRS, ENS Lyon, INP Toulouse, Université of Bordeaux 1, in which these institutions agreed on the way they collaborate on MUMPS. They confirmed their will to freely distribute MUMPS releases under an open-source licence, defined the conditions of use of intermediate development versions, and settled a technical committee to supervise the technical and scientific decisions concerning the software.

Contract with SAMTECH, 2008-2010. Samtech (Belgium) develops the finite element software package SAMCEF, which uses MUMPS as one of the internal solvers. The goal of this work was to study various aspects related to the memory usage of the MUMPS solver and offer the possibility to address larger amounts of memory. We also studied how performance could be improved on Samtech problems by allowing the forward substitution step to be performed simultaneously with the matrix factorization. This last point is particularly interesting in the case of out-of-core executions.

EDF R&D and LSTC, 2010-2014. The work on low-rank solvers mentioned in 8.3.1 was done in the context of a collaboration with INP Toulouse and with the EDF and LSTC companies. A contract with EDF funded a PhD thesis at INPT between 2010 and 2013 on the subject and we provided several prototype versions of MUMPS with low-rank features to EDF in that context.

CERFACS, TOTAL, and HUTCHINSON, 2012-2013. We worked on rank detection algorithms and null space basis computations in the context of a collaboration with CERFACS, INPT, and TOTAL. TOTAL funded an engineer on MUMPS for one year located at CERFACS, Toulouse.

Collaboration with ESI Group, 2013. We participated to a contract with ESI Group in which some numerical aspects of the MUMPS solver related to pivoting strategies had to be revisited to ensure numerical stability on some hard indefinite problems from ESI Group. This contract funded a few months of an engineer on MUMPS at INPT.

EMGS, 2014. A new collaboration with EMGS (Norway) has started. The objective of the work is to understand the feasibility of using low-rank compression and more generally the MUMPS solver to solve numerical problems from EMGS in the context of geophysics applications.

Annexe 8. Document d'évaluation des risques

Document Unique d'Évaluation des Risques du laboratoire (DUER 2014)

- Fiche d'Évaluation des Risques.
- Plan d'Actions.

Document Unique du LIP
2014

Fiche d'Évaluation des Risques
Plan d'Actions
Annexes

Gilles VILLARD
Directeur du LIP

Fiche d'identification et évaluation des Risques du LIP

UNITE DE TRAVAIL

Laboratoire de l'Informatique du Parallélisme

Lieu de travail	Dangers communs ou équipement ou matériel ou produit	Risques associés	Description des risques	F	Caractéristique d'exposition	G	Moyens de prévention existants	Moyens de prévention inexistants ou dysfonctionnements	Correct	A améliorer	A redéfinir ou à mettre en place	M	NRR	Améliorations possibles
LIP + LUG + IXXI	manutention manuelle	Chute d'objet, coupures, écorchures, éraflures	Manutention de cartons, de mobiliers, d'ordinateurs... lors des déménagements	1	chutes d'objets, manutention de charges encombrantes, manutention de charges lourdes < et > 30Kg, prise en charge aux sol	10		pas d'EPI. Informations manquantes. Consignes non généralisées et non inscrites sur le site intranet.			X	1	10	Chaussures de sécurité, gants de manutention (pour 4 personnes) Rappel des consignes concernant les ports de charges (encombrantes, lourdes, en position basse). Mise à disposition d'EPI en salle machines. Affichage de la liste des EPI disponibles et des formations les ports de charges
LIP + LUG + IXXI	Équipements de travail	Travail sur écran	Mauvaise ergonomie du poste de travail (ex: écran trop haut, clavier trop haut, absence de rideaux...)	10	Mauvaise ergonomie du poste de travail	10	Quelques rehausseurs d'écran à disposition ... (4 ou 5)	Informations manquantes. Consignes non généralisées et non inscrites sur le site intranet.			X	1	100	Formation ergonomie du poste de travail, matériel adapté aux personnes, étudier l'existant Mise à disposition de sièges réglables, d'écrans réglables, de supports rehausseurs d'écran, élimination évacuation des matériels non réglables.
LIP + LUG + IXXI	Ambiance	Gène dans les déplacements de personnes	Circulation et Encombrement de l'espace commun de travail (le bureau, le couloir, le balcon, l'ascenseur, ...) par des Vélos.	4	Encombrement des circulations	100	Garage à vélo commun. Utilisateurs déjà informés.	Garage à vélo commun peu utilisé. Informations manquantes. Consignes non généralisées et non inscrites sur le site intranet.			X	1	400	Mise à jour / documenter le site intranet concernant les garages à vélos des (afficher les consignes de la commission de sécurité).
LIP + LUG + IXXI	Incendie	Électricité	Câblage électrique des appareillages de bureau (portables, écrans, commutateurs, lampes, appareils chauffants électriques) Usages de multiprises électriques.	7	Nombreuses multiprises	100	Consignes Orales ou par email données ponctuellement par l'ACMO ou la commission de sécurité	Informations manquantes. Consignes non généralisées et non inscrites sur le site intranet. Re câblage électrique des bureaux.		X	X	1	700	Mise à jour / documenter le site intranet concernant le câblage des appareils de bureau (afficher les consignes de la commission de sécurité). Contacter la DPMG pour un plan de re câblage des bureaux.
LIP + LUG + IXXI	Incendie	Cartons / Emballages / Papiers	Cartons / Emballages / Papiers / Archives sans valeurs réelles stockés sur les armoires dans les bureaux	10	stockage d'archives	100	Consignes Orales ou par email données ponctuellement par l'ACMO ou la commission de sécurité	Informations manquantes. Consignes non généralisées et non inscrites sur le site intranet.		X	X	1	1000	Mise à jour / documenter le site intranet concernant le stockage au dessus des armoires de bureau (afficher les consignes de la commission de sécurité).
LIP + LUG + IXXI	organisation	Travail isolé	Travail isolé	10	Travail isolé	10		Informations manquantes. Consignes non généralisées et non inscrites sur le site intranet.		X	X	1	100	Mise à jour / documenter le site intranet concernant le travail isolé (afficher les consignes des tutelles).
LIP + LUG + IXXI	organisation	Panique / manque d'organisation en cas d'urgence	Absence / visibilité des consignes d'urgences	10		100	Visibilité des consignes d'urgence ou par email insuffisantes	Informations manquantes. Consignes non généralisées et non inscrites sur le site intranet.		X	X	1	1000	Mise en place de consignes en cas d'urgence sur les panneaux d'affichages et sur le site intranet.
LIP + LUG + IXXI	organisation	Intoxication alimentaire	Procédure d'entretien des réfrigérateurs (coin repos) absentes.	7	Intoxication alimentaire	10	Consignes Orales ou par email données ponctuellement.	Informations manquantes. Consignes non généralisées et non inscrites sur le site intranet. Pas de nettoyage organisé régulièrement.		X	X	1	70	Mise en place d'une procédure d'entretien des réfrigérateurs des salles de repos.
IXXI	Incendie	organisation	Absence de plan d'évacuation	10	Absence de plan d'évacuation	100				X	X	1	1000	La DPMG est au courant d'après le secrétariat de l'IXXI. RELANCER si nécessaire.
LUG	Incendie	organisation	Signalétique extincteur absente	10	Signalétique extincteur absente	10		Signalétique extincteur absente		X	X	1	100	Contacter et transmettre à l'ACMO (UCBL1).
Bureaux GN1 SUD CENTRE NORD 3ième étage	Ambiance	Températures élevées	Les écrans, les ordinateurs sont sources de chaleurs supplémentaires. L'exposition SUD de certains bureaux apporte des températures élevées du mois de mai à septembre, les ordinateurs s'arrêtent de fonctionner, et les personnels ? Les autres bureaux sont affectés par des températures élevées, les courants d'air véhiculant la chaleur	10	Exposition aux températures élevées (à l'intérieur) dues à l'activité (chaud) + Locaux mal tempérés (très chaud)	110	Store intérieur, film sur vitrage sont insuffisants.	Les moyens de préventions déjà utilisés sont détériorés (climatisation rapportée) ou insuffisants (store intérieur, film sur vitrage).			X	1	1100	Isolation des façades. Climatisation de tout le laboratoire (GN1 SUD, CENTRE, NORD 3ième étage)

Gilles VILLARD
Directeur du LIP
Signature

Fiche d'identification et évaluation des Risques du LIP

UNITE DE TRAVAIL

Laboratoire de l'Informatique du Parallélisme

Lieu de travail	Dangers communs ou équipement ou matériel ou produit	Risques associés	Description des risques	F	Caractéristique d'exposition	G	Moyens de prévention existants	Moyens de prévention inexistants ou dysfonctionnements	Correct	A améliorer	A redéfinir ou à mettre en place	M	NRR	Améliorations possibles
Salles autocom et salles machines + LR6	manutention manuelle	TMS	Manutention de cartons, d'ordinateurs, de tiroirs racks informatiques ...	4	Torsion, poids supérieurs à 30 kg, bras au dessus du cœur	20	chariots, port à deux				X	1	80	Formation gestes et postures.
Salles autocom et salles machines + LR6	manutention mécanique	Écrasement	chute de charge	4	risque de chute d'objet	20	Transpalette de l'atelier de mécanique en mauvais état (roulettes détériorées, stabilité remis en cause).	* Transpalette de l'atelier de mécanique en mauvais état (roulettes détériorées, stabilité remis en cause). * EPI des pieds (chaussures de sécurité)			X	1	80	Achat d'EPI des pieds Réparation, renouvellement du transpalette commun pour qu'il soit en bon état. Se renseigner sur la disponibilité, la mise à disposition, l'état de ce matériel.
Coin Café	Ambiance	Charge mentale	Amélioration de la luminosité et convivialité du coin repos, lumière naturelle insuffisante	7	Lumière naturelle insuffisante pour le coin repos	10		Puits de lumière insuffisant			X	1	70	Contacter la DPMG pour adapter l'éclairage et répondre au besoin luminothérapie.
Coin Repos	Ambiance	Charge mentale	pas de prise en charge ponctuelle : * des décalages horaires (retour de mission) * insomnies chroniques * du travail en horaires décalés (de fait)	7	* Troubles de la vigilance * Difficulté de concentration.	10	Pas de coin repos permettant l'allongement favorisant l'endormissement (faible luminosité et faible niveau de bruit).	Dans les locaux de l'ENS, mutualisation d'un espace commun de repos adapté à l'endormissement (sieste) autre que l'infirmerie.			X	1	70	Contacter la DPMG, pour la mutualisation d'un espace commun de repos adapté à l'endormissement (sieste) autre que l'infirmerie.
Armoire d'archives GN1 SUD et NORD	Incendie	Incendie	Problème d'extinction en cas d'incendie des archives	1	stockage d'archives	100	Des extincteurs EPA à bonne distance pas forcément visible	Signalétique d'archives absentes. Pas d'Extincteur EPA à proximité immédiate			X	1	100	Contacter le service de sécurité pour conseil et action à entreprendre.
Vides sanitaires	Incendie	Accessibilité des vides sanitaire	Matériaux / Matériels combustibles ou encombrants entreposés dans les Vides Sanitaires GN1 SUD et NORD.	10	Encombrement des circulations	10		Évacuation des cartons, des consommables, des matériaux de construction, des portes d'armoire informatique.			X	1	100	Faire procéder par le LIP : Évacuation des cartons, des consommables, des matériaux de construction, des portes d'armoire informatique.
Bureau GN1 NORD 320	Électricité, Ambiance, Inondation	Électricité, Ambiance, Chute.	Risque d'électrocution, de chutes, exposition aux intempéries.	10	Fuites de toiture, inondation à chaque pluie, fort risque d'électrocution	100	Évacuation de l'agent. Changer l'usage du local tant que le local n'est pas hors d'eau.	Évacuation de l'agent. Changer l'usage du local tant que le local n'est pas hors d'eau.			X	1	1000	Faire procéder par le LIP : * Évacuation de l'agent tant que le local n'est pas hors d'eau. * Changer l'usage du local tant qu'il n'est pas hors d'eau.
GN1 3ième étage	Ambiance	Ambiance	Risque d'exposition aux intempéries	10	Courant d'air extérieur sur les agents, surface froide aux contacts des agents	1	Isolant, masticage			X	X	1	10	Faire procéder par la DPMG, la réfection de l'étanchéité à l'air et à l'isolation thermique des parois extérieures.
GN1 3ième étage	Ambiance	Ambiance	Risque d'exposition aux intempéries	10	Courant d'air extérieur	1	Réparation des baies vitrées d'accès aux balcons.			X	X	1	10	Faire procéder par la DPMG, la réfection de l'étanchéité à l'air et à l'isolation thermique des parois extérieures.
GN1 SUD 3ième étage	Ambiance	Ambiance	Gêne visuelle, maux de tête, dégradation oculaire	10	Éblouissement par le soleil	10	Store intérieur insuffisant	Store intérieur insuffisant		X	X	1	100	Pose de brise soleil extérieur.
GN1 CENTRE 3 03	Incendie	Incendie	Salle des machines informatique, consommation électrique élevé. risque incendie élevé.	10	Risque de développement important du feu avant détection.	100	Arrêt d'urgence / extincteur	Absence de détection incendie spécifique à cette salle			X	1	1000	Mise en place d'un système de détection incendie
GN1 CENTRE 3 08	Incendie	Incendie	Salle des machines informatique, consommation électrique élevé. risque incendie élevé.	10	Risque de développement important du feu avant détection.	100	Arrêt d'urgence / extincteur	Absence de détection incendie spécifique à cette salle			X	1	1000	Mise en place d'un système de détection incendie

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Plan d'actions 2014

Laboratoire de l'Informatique du Parallélisme (LIP)

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LIP + LUG + IXXI	Manutention manuelle	Chute d'objet, coupures, écorchures, éraflures	Manutention de cartons, de mobiliers, d'ordinateurs... lors des déménagements	10	Rédiger et publier les informations et recommandations et références de l'INRS sur IntraLIP concernant les problèmes de santés dûs aux : * port de charges lourdes (<>30kg), * manutention de charges encombrantes, * prise en charges au sol.		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
LIP + LUG + IXXI	Équipement de travail	Travail sur écran	Mauvaise ergonomie du poste de travail (ex: écran trop haut, clavier trop haut, absence de rideaux...)	100	Rédiger et publier les informations, recommandations et références de l'INRS sur IntraLIP concernant les problèmes de santé dû à : * l'ergonomie des postes de travail =>> Politique d'achats de matériel adapté (écrans et fauteuils réglables)		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
LIP + LUG + IXXI	Ambiance	Gène dans les déplacements de personnes	Circulation et Encombrement de l'espace commun de travail (le bureau, le couloir, le balcon, l'ascenseur, ...) par des Vélos.	400	Rédiger et publier la procédure / consigne sur IntraLIP concernant le stockage de Vélos dans le laboratoire en compte les recommandations de la Commission de Sécurité.		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
LIP + LUG + IXXI	Incendie	Électricité	Câblage électrique des appareils de bureau (portables, écrans, commutateurs, lampes, appareils chauffants électriques) Usages de multiprises électriques.	700	Mettre en place un plan pluriannuel de re-câblage des bureaux. Prévoir : * 8 prises de courant par poste de travail * 2 prises réseaux informatique GigaBit/s par poste de travail		Direction du LIP ACMO du LIP Assistant(e)s du LIP		2013 2014 2015 2016	À ce jour, projet constitué en 2013 soumis à la DPMG, à la DSI, reporté au budget 2014, en attente de décision. À SUIVRE en 2014 Suspendu / annulé par le Plan CAMPUS ? Pris en compte par le Plan CAMPUS ?
LIP + LUG + IXXI	Incendie	Cartons / Emballages / Papiers	Cartons / Emballages / Papiers / Archives sans valeurs réelles stockées sur les armoires dans les bureaux	1000	Rédiger et publier la procédure / consigne sur IntraLIP concernant le stockage sur les étagères en prenant en compte les recommandations de la Commission de Sécurité.		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
LIP + LUG + IXXI	organisation	Travail isolé	Travail isolé	100	Rédiger / publier sur IntraLIP : * les consignes des tutelles * l'extrait du règlement intérieur du LIP Concernant le travail isolé		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
LIP + LUG + IXXI	organisation	Panique / manque d'organisation en cas d'urgence	Absence / visibilité des consignes d'urgences	1000	Rédiger / Publier sur IntraLIP / Afficher sur les tableaux d'affichages de chaque site : * les consignes de sécurité		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
LIP + LUG + IXXI	organisation	Intoxication alimentaire	Procédure d'entretien des réfrigérateurs (coin repos) absentes.	70	Rédiger / Publier sur IntraLIP / Afficher sur les réfrigérateurs de chaque site : * les consignes d'hygiène. Mettre en place un nettoyage systématique et récurrent à date fixe (périodicité ?)		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	Déjà FAIT Les consignes sont affichés sur le frigo du LIP.

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IXXI	Incendie	organisation	Absence de plan d'évacuation	1000	La DPMG est au courant d'après le secrétariat de l'IXXI. RELANCER si nécessaire.		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
LUG	Incendie	organisation	Signalétique extincteur absente	100	Contacter et transmettre à l'ACMO (UCBL1).		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
Bureaux chercheur LIP GN1 SUD CENTRE NORD 3ième étage	Ambiance	Températures élevées	Les écrans, les ordinateurs sont sources de chaleurs supplémentaires. L'exposition SUD de certains bureaux apporte des températures élevées du mois de mai à septembre, les ordinateurs s'arrêtent de fonctionner, et les personnels ? Les autres bureaux sont affectés par des températures élevées, les courants d'air véhiculant la chaleur	1100	Prendre contact avec la DPMG pour la mise en place de la climatisation du 3ième Étage GN1 SUD NORD et CENTRE. Mise en place de protection solaire extérieure.	DPMG	Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	À ce jour, à ma connaissance, verbalement avec la DPMG, programmation d'un étude de faisabilité pour 2014 NON FAIT, hors budget DPMG, nécessite la décision de la direction de l'ENS.
Salles autocom et salles machines + LR6	Manutention manuelle	TMS	Manutention de cartons, d'ordinateurs, de tiroirs racks informatiques …	80	* Formation gestes et postures pour les personnels travaillant en salle machine. * Achat d'un appareil de levage pour les racks (dispositif de manipulation et de transport de tiroir rack lourd) (mise en commun DPMG) * Documenter intraLIP : « Ou trouver ce matériel ? »		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	FAIT Dispositif de levage disponible auprès de la DPMG. Documenter dans l'intranet du LIP.
Salles autocom et salles machines + LR6	Manutention mécanique	Écrasement	chute de charge	80	* Achat d'EPI pour protéger les pieds (4 paires de coquilles sur-chaussures) * Se renseigner, contacter la DPMG, sur la disponibilité, la mise à disposition, l'état d'un transpalette commun. * Documenter intraLIP : « Ou trouver ce matériel ? »		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	FAIT Transpalettes manuel / électrique (conduit par agent de la DPMG) disponible auprès de la DPMG. À FAIRE : Achat d'une paire de chaussure de sécurité par membre de l'équipe MILIP élargie aux ingénieurs et chercheurs intervenants dans les déplacements d'équipements lourds.
Coin Café	Ambiance	Charge mentale	Amélioration de la luminosité et convivialité du coin repos, lumière naturelle insuffisante	70	* Contacter les électriciens pour l'installation / le remplacement des tubes classiques par des tubes fluorescents de luminothérapie		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	

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Plan d'actions 2014

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Coin Repos	Ambiance	Charge mentale	pas de prise en charge ponctuelle : * des décalages horaires (retour de mission) * insomnies chroniques * du travail en horaires décalés (de fait)	70	* Contacter la DPMG, pour la mutualisation d'un espace commun de repos adapté à l'endormissement (sieste) autre que l'infirmerie.		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
Armoire d'archives GN1 SUD et NORD	Incendie	Incendie	Problème d'extinction en cas d'incendie des archives	100	* Contacter l'équipe de sécurité et/ou DPMG en leur signalant la présence d'armoire d'archives. * Installer une signalétique et/ou moyen d'extinction à proximité des zone d'archivages.		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	Signalé verbalement à 2 agents sécurité, à ce jour, non réalisée. NON FAIT.
Vides sanitaires	Incendie	Accessibilité des vides sanitaire	Matériaux / Matériels combustibles ou encombrants entreposés dans les Vides Sanitaires GN1 SUD et NORD.	100	* Procéder à l'évacuation définitive des matériels et matériaux stocker dans les 2 vides sanitaires. * Installer une signalétique interdisant formellement tout dépôt dans ces vides sanitaires.		Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	À ce jour, signalétiques installées, évacuation non réalisée. Ticket : 35304 [ACMO] Évacuation de plaques de plâtre et nettoyage d'un sanitaire à proximité du bureau GN1 CENTRE 3 15. À SUIVRE 2014
Bureau GN1 NORD 320	Électricité, Ambiance, Inondation	Électricité, Ambiance, Chute.	Risque d'électrocution, de chutes, exposition aux intempéries.	1000	* Procéder à l'évacuation de l'agent. * Changer l'usage du local tant que le local n'est pas hors d'eau.	DPMG	Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	À ce jour, NON FAIT.
GN1 3ième étage	Ambiance	Ambiance	Risque d'exposition aux intempéries	10	Faire procéder au masticage des parois	DPMG	Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	FAIT sur parois de l'aile NORD
GN1 3ième étage	Ambiance	Ambiance	Risque d'exposition aux intempéries	10	Réparation de la fermeture des baies vitrées	DPMG	Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	FAIT sur baie de l'aile NORD-EST. NON FAIT sur baie de l'aile NORD-OUEST
GN1 SUD 3ième étage	Ambiance	Ambiance	Gêne visuelle, maux de tête, dégradation oculaire	100	Pose de brise soleil extérieur	DPMG	Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2015	
GN1 CENTRE 3 03	Incendie	Incendie	Salle des machines informatique, consommation électrique élevé, risque incendie élevé.	1000	Signalement service de sécurité pour la mise en place d'un système de détection incendie	DPMG / Sécurité	Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	
GN1 CENTRE 3 08	Incendie	Incendie	Salle des machines informatique, consommation électrique élevé, risque incendie élevé.	1000	Signalement service de sécurité pour la mise en place d'un système de détection incendie	DPMG / Sécurité	Direction du LIP ACMO du LIP Assistant(e)s du LIP		Courant 2014	

Gilles VILLARD
Directeur du LIP

Annexe 9. Liste des personnels

aeres
agence d'évaluation de la recherche et de l'enseignement supérieur

Vague A :
Campagne d'évaluation 2014 - 2015
Dossier d'évaluation des unités de recherche

Données du prochain contrat

Liste prévisionnelle des personnels de l'unité au 1er janvier 2016

à classer par ordre alphabétique

Nomenclatures à respecter, voir :
feuille MenusR (corps-grades)
feuille UAI_Etab_Org (UAI établissements-organismes)

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	ALIAS	Christophe	H	1977	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E3		
Ch_tit	AUBRUN	Nathalie	F	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E5		
EC_tit	AUDEBAUD	Philippe	H	1956	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E6		
Ch_tit	BAILLOT	Patrick	H	1972	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E6		
EC_tit	BEGIN	Thomas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E4		
EC_tit	BENOIT	Anne	F	1977	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E7		voir annexe 1
AP_tit	BLESLE	Evelyne	F	1974	TCS	J - Gestion et pilotage (GP)		INRIA		MESR et MINEFI	SC		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	BONCHI	Filippo	H	1981	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
AP_tit	BOZO	Marie	F	1974	TCH	J - Gestion et pilotage (GP)		ENS LYON		MESR	SC		
Ch_tit	BRISEBARRE	Nicolas	H	1971	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E1		
EC_tit	BUSSON	Anthony	H	1973	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MESR	E4		
EC_tit	CANIOU	Yves	H	1974	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E2		
EC_tit	CARON	Eddy	H	1972	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E2		
Ch_tit	CLAIRAMBAULT	Pierre	H	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
EC_tit	CRESPELLE	Christophe	H	1979	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E4		voir annexe2
Ch_tit	DARTE	Alain	H	1968	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E3		
AP_tit	DELAMARE	Simon	H	1983	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS		MESR	SC		
AP_tit	DESPLANCHES	Catherine	F	1962	TCH	J - Gestion et pilotage (GP)		CNRS		MESR	SC		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
EC_tit	FAWZI	Omar	H	1985	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E5		
EC_aut	FEAUTRIER	Paul	H	1940	PREM	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E3		
Ch_tit	FEDAK	Gilles	H	1972	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E2		
EC_tit	FLEURY	Eric	H	1969	PR1	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E4		
AP_tit	GAUTHE	Laetitia	F	1982	TCH	J - Gestion et pilotage (GP)		INRIA		MESR et MINEFI	SC		
EC_tit	GELAS	Jean-Patrick	H	1973	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E2		
EC_tit	GLUCK	Olivier	H	1976	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E2		
Ch_tit	GONCALVES	Paulo	H	1967	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E4		
EC_tit	GONNORD	Laure	F	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E3		
EC_tit	GUERIN-LASSOUS	Isabelle	F	1971	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MESR	E4		
EC_tit	HANROT	Guillaume	H	1973	PR1	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E1		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	HARMER	Russell spencer	H	1973	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		R S Harmer
EC_tit	HIRSCHKOFF	Daniel	H	1971	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E6		[illegible]
Ch_tit	JEANNEROD	Claude-Pierre	H	1974	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		CPJeannerod
EC_tit	KARSAI	Marton	H	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E4		[illegible]
EC_tit	KOIRAN	Pascal	H	1969	PRCE	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E5		P Koiran
EC_tit	LAGUILLAUMIE	Fabien	H	1978	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MESR	E1		[illegible]
Ch_tit	LAURENT	Olivier	H	1977	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E6		[illegible]
Ch_tit	LEFEVRE	Vincent	H	1973	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		VLefèvre
Ch_tit	LEFEVRE	Laurent	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E2		[illegible]
Ch_tit	L'EXCELLENT	Jean-Yves	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E7		J.Y. L'Excellent
Ch_aut	LIBERT	Benoit	H	1976	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E1		B. L. Libert

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_aut	LOUP	David	H	1994	IR	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E2		Recrutement au 1er octobre
EC_tit	LOUVET	Nicolas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E1		
Ch_tit	MARCHAL	Loris	H	1980	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E7		
AP_tit	MIGNOT	Jean-christophe	H	1965	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS		MESR	SC E2		
Ch_tit	MIO	Matteo	H	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		Recrutement au 1er octobre
Ch_tit	MULLER	Jean-michel	H	1961	DRCE	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E1		
Ch_tit	PEREZ	Christian	H	1972	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E2		
AP_tit	PONSARD	Dominique	H	1967	IE	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS		MESR	SC		
EC_tit	PORTIER	Natacha	F	1971	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E5		
Ch_tit	POUS	Damien	H	1982	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
Ch_tit	RAO	Michael	H	1979	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E5		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	REVOL	Nathalie	F	1967	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		Revol
EC_tit	RIBA	Colin	H	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E6		
EC_tit	ROBERT	Yves	H	1958	PREX	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E7		
~~Ch_aut~~	~~ROSSIGNEUX~~	~~François~~	~~H~~	~~1990~~	~~IR~~	~~ST6 Sciences et technologies de l'information et de la communication~~		~~INRIA~~		~~MESR et MINEFI~~	~~E2~~		
Ch_tit	SALVY	Bruno	H	1965	DR2	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		
AP_tit	SEON	Damien	H	1985	TCH	J - Gestion et pilotage (GP)		ENS LYON		MESR	SC		
EC_tit	STEHLE	Damien	H	1981	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E1		Stehlé
Ch_aut	SUN	Hongyang	H	1981	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		PRES U LYON		MESR	E7		
EC_tit	THIERRY	Eric	H	1973	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E5		
EC_tit	THOMASSE	Stéphan	H	1968	PR1	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E5		
AP_tit	TORRES	Serge	H	1953	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		ENS LYON		MESR	SC E7		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	TROTIGNON	Nicolas	H	1971	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E5		
Ch_tit	UCAR	Bora	H	1976	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E7		
Ch_tit	VILLARD	Gilles	H	1963	DR1	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E1		
Ch_tit	VIVIEN	Frédéric	H	1971	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E7		F. Vivien
Ch_tit	YUKI	Tomofumi	H	1985	CR	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E3		Recrutement au 1er octobre
Insérer les lignes supplémentaires juste au dessus de la ligne jaune, ne pas laisser de ligne non remplie													

(1) Sélectionner les informations dans le menu déroulant, si besoin voir feuille MenusR pour les détails des nomenclatures.
(2) Inscrire « oui » dans les cases correspondant aux personnels habilités à diriger des recherches.
(3) Sélectionner les informations dans le menu déroulant.
Si l'établissement ou l'organisme n'est pas présent dans la liste ou la feuille UAI_Etab_Org, indiquer le nom en clair.
Pour les émérites, indiquer le dernier établissement ou organisme employeur.
(4) Ne rien saisir dans cette colonne.
NB : Certaines entités listées peuvent ne pas avoir de code UAI et et la case restera vide.
(5) Voir nomenclature proposée en bas de la colonne.
En cas de tutelles multiples, il est possible de compléter la saisie, ex. MESR, MAEE.
(6) Utiliser le numéro de la liste rappelant les équipes composant l'unité pour le prochain contrat de la feuille "Structure unité"
(7) Utiliser le numéro de la liste rappelant les unités concernées par la restructuration pour le prochain contrat de la feuille "Structure unité".

AGRICULTURE	Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt
CULTURE	Ministère de la Culture et de la Communication
DEFENSE	Ministère de la Défense
INTERIEUR	Ministère de l'Intérieur
JUSTICE	Ministère de la Justice
MAEE	Ministère des Affaires Étrangères et Européennes
MED	Ministère de l'Écologie, du Développement Durable et de l'Énergie
MEN	Ministère de l'Éducation nationale
MESR	Ministère de l'Enseignement supérieur et de la Recherche
MINEFI	Ministère de l'Économie et des Finances
R PROD	Ministère du Redressement Productif
SANTE	Ministère des Affaires Sociales et de la Santé
SPORTS	Ministère des Sports, de la Jeunesse, de l'Éducation populaire et de la vie associative
	Autre préciser

agence d'évaluation de la recherche et de l'enseignement supérieur

Vague A :
Campagne d'évaluation 2014 - 2015
Dossier d'évaluation des unités de recherche

Données du prochain contrat

Liste prévisionnelle des personnels de l'unité au 1er janvier 2016

à classer par ordre alphabétique

Nomenclatures à respecter, voir : feuille MenusR (corps-grades) feuille UAI_Etab_Org (UAI établissements-organismes)

Annexe 1

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	ALIAS	Christophe	H	1977	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E3		
Ch_tit	AUBRUN	Nathalie	F	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E5		
EC_tit	AUDEBAUD	Philippe	H	1956	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E6		
Ch_tit	BAILLOT	Patrick	H	1972	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E6		
EC_tit	BEGIN	Thomas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MEN	E4		
EC_tit	BENOIT	Anne	F	1977	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E7		AB
AP_tit	BLESLE	Evelyne	F	1974	TCS	J - Gestion et pilotage (GP)		INRIA		MESR et MINEFI	SC		
Ch_tit	BONCHI	Filippo	H	1981	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		

Annexe 2

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
AP_tit	BOZO	Marie	F	1974	TCH	J - Gestion et pilotage (GP)		ENS LYON		MESR	SC		
Ch_tit	BRISEBARRE	Nicolas	H	1971	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E1		
EC_tit	BUSSON	Anthony	H	1973	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MEN	E4		
EC_tit	CANIOU	Yves	H	1975	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MEN	E2		
EC_tit	CARON	Eddy	H	1972	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E2		
Ch_tit	CLAIRAMBAULT	Pierre	H	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
EC_tit	CRESPELLE	Christophe	H	1979	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MEN	E4		Crespelle
Ch_tit	DARTE	Alain	H	1968	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E3		
AP_tit	DELAMARE	Simon	H	1983	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS		MESR	SC		
AP_tit	DESPLANCHES	Catherine	F	1962	TCH	J - Gestion et pilotage (GP)		CNRS		MESR	SC		
EC_tit	FAWZI	Omar	H	1985	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E5		
Ch_tit	FEAUTRIER	Paul	H	1940	PREM	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E3		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
EC_tit	KARSAI	Marton	H	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E4		
EC_tit	KOIRAN	Pascal	H	1969	PRCE	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E5		
EC_tit	LAGUILLAUMIE	Fabien	H	1978	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MEN	E1		
Ch_tit	LAURENT	Olivier	H	1977	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E6		
Ch_tit	LEFEVRE	Vincent	H	1973	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		
Ch_tit	LEFEVRE	Laurent	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E2		
EC_aut	LESCANNE	Pierre	H	1947	PREM	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E6		
Ch_tit	L'EXCELLENT	Jean-Yves	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E7		
Ch_aut	LIBERT	Benoit	H	1976	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E1		
Ch_aut	LOUP	David	H	1994	IR	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E2		
EC_tit	LOUVET	Nicolas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MEN	E1		
Ch_tit	MARCHAL	Loris	H	1980	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E7		

Additif

Personnels INRIA hébergés au LIP

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
AP_tit	BOYER	Sylvie	F	1959	IE	J		INRIA		MESR et MINEFI	SC	Janvier 2001	
AP_tit	IMBERT	Matthieu	H	1970	IR	E		INRIA		MESR et MINEFI	E2	octobre 2007	

(1) Sélectionner les informations dans le menu déroulant, si besoin voir feuille MenusR pour les détails des nomenclatures.
(2) Inscrire « oui » dans les cases correspondant aux personnels habilités à diriger des recherches.
(3) Sélectionner les informations dans le menu déroulant.
Si l'établissement ou l'organisme n'est pas présent dans la liste ou la feuille UAI_Etab_Org, indiquer le nom en clair.
Pour les émérites, indiquer le dernier établissement ou organisme employeur.
(4) Ne rien saisir dans cette colonne.
NB : Certaines entités listées peuvent ne pas avoir de code UAI et et la case restera vide.
(5) Voir nomenclature proposée en bas de la colonne.
En cas de tutelles multiples, il est possible de compléter la saisie, ex. MESR, MAEE.
(6) Utiliser le numéro de la liste rappelant les équipes composant l'unité pour le prochain contrat de la feuille "Structure unité"
(7) Utiliser le numéro de la liste rappelant les unités concernées par la restructuration pour le prochain contrat de la feuille "Structure unité".

AGRICULTURE	Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt
CULTURE	Ministère de la Culture et de la Communication
DEFENSE	Ministère de la Défense
INTERIEUR	Ministère de l'Intérieur
JUSTICE	Ministère de la Justice
MAEE	Ministère des Affaires Étrangères et Européennes
MED	Ministère de l'Écologie, du Développement Durable et de l'Énergie
MEN	Ministère de l'Éducation nationale
MESR	Ministère de l'Enseignement supérieur et de la Recherche
MINEFI	Ministère de l'Économie et des Finances
R.PROD	Ministère du Redressement Productif
SANTE	Ministère des Affaires Sociales et de la Santé
SPORTS	Ministère des Sports, de la Jeunesse, de l'Éducation populaire et de la vie associative
	Autre préciser

Annexe 10. Données du contrat en cours

aeres
agence d'évaluation de la recherche et de l'enseignement supérieur

Vague A : campagne d'évaluation 2014 - 2015
Dossier d'évaluation des unités de recherche
Données du contrat en cours

1 – Informations administratives sur l'unité au 30 juin 2014

Intitulé complet de l'unité de recherche
intitulé en français : Laboratoire de l'Informatique du Parallélisme
intitulé en anglais : Computer Science Laboratory

Responsable

M./Mme	Nom	Prénom	corps	établissement d'enseignement supérieur d'affectation ou organisme d'appartenance
M	Villard	Gilles	DR1	CNRS

☐ J'autorise la diffusion de mon nom sur internet (annuaire des unités de recherche)

Label(s) et n°
UMR 5668

Établissement(s) et organisme(s)de rattachement de l'unité (tutelles)

Tout dossier déposé doit être préalablement validé par l'ensemble des tutelles de l'unité

établissement(s) d'enseignement supérieur et de recherche
(sélectionner l'établissement souhaité dans les menus déroulants)
établissement : ENS LYON; U LYON 1

organisme(s) de recherche
(sélectionner l'organisme souhaité dans les menus déroulants)
organisme : CNRS
institut, département, commission de rattachement : ....
...

préciser l'établissement ou organisme responsable du dépôt du dossier : ENS LYON
(sauf exception, le dossier est déposé par l'hébergeur de l'unité de recherche)

préciser le cas échéant le délégataire unique de gestion : ....

Autres partenaires de l'unité (hors tutelles)
(sélectionner l'établissement ou l'organisme souhaité dans les menus déroulants)
établissement(s) d'enseignement supérieur et de recherche : PRES U LYON
organisme(s) de recherche : INRIA
entreprise(s) : ....
autres : ....

École(s) doctorale(s) de rattachement au 30 juin 2014 *(n°, intitulé, responsable, établissement support)*
Ecole Doctorale Informatique et Mathématiques (ED 512), Sylvie CALABRETTO, Université Claude Bernard Lyon1.

Participation à une (exceptionnellement plusieurs) structure fédérative au 30 juin 2014 *(label et n°, intitulé , responsable, établissement support)*
FLMSN, Fédération Lyonnaise de Modélisation et Sciences Numériques, Marc Buffat, Université Claude Bernard 1

Classement thématique de l'unité *(sélectionner le domaine souhaité dans les menus déroulants situés sous les intitulés)*

domaine disciplinaire principal	domaine disciplinaire secondaire 1	domaine disciplinaire secondaire 2	domaine disciplinaire secondaire 3 ...
ST6 Sciences et technologies de l'information et de la communication	ST1 Mathématiques		
domaine applicatif principal	domaine applicatif secondaire 1	domaine applicatif secondaire 2	domaine applicatif secondaire 3 ...
Technologies de l'information et de la communication			

mots-clés
libres (*5 maximum*) : Informatique et applications, Mathématiques et leurs interactions

Coordonnées de l'unité
Localisation et établissement : ENS DE LYON
Numéro, voie : 46, allée d'Italie
Boîte postale : 69364
Code Postal et ville : Lyon

Téléphone : 04 72 72 87 42
Adresse électronique : guillaume.hanrot@ens-lyon.fr
gilles.villard@ens-lyon.fr

Date et signature du responsable de l'unité
(Document à signer puis à numériser)

29 septembre 2014

Gilles VILLARD
Directeur du LIP

agence d'évaluation de la recherche et de l'enseignement supérieur

2 – Thématiques de recherche et structuration de l'unité au 30 juin 2014

N°	Intitulé de l'équipe interne (sous-composante fonctionnelle correspondant à l'organigramme de l'unité, une ligne par équipe)	Responsable	Etablissement ou organisme hébergeant l'équipe interne	Effectifs EC, chercheurs EPST et cadres scientifiques EPIC en ETPT (1)	Effectifs ITA, BIATSS et non-cadres EPIC permanents en ETPT (2)	Le cas échéant, ED de rattachement des équipes internes (n°, intitulé, étab. support)	Thématiques de recherche de l'unité (Ajouter des colonnes si nécessaire)	Discipline principale (3)	Discipline secondaire 1 (3)	Discipline secondaire 2 (3)	Discipline secondaire 3 (3)
Cas d'une unité sans équipes internes : inscrire ci-contre les thématiques de recherche de l'unité.											
Cas d'une unité comprenant des équipes internes : remplir la partie ci-dessous.											
E1	Aric	Jean-Michel Muller	ENSL	10,00	0,50		Arithmétique et Calcul	ST1 Mathématiques			
E2	Avalon	Christian Perez	ENSL	6,00	0,90		Algoritmes et architectures logicielles pour les plates formes distribuées et à haute performance	ST1 Mathématiques			
E3	Compsys	Alain Darte	ENSL	3,00			Compilation, systèmes enfouis et calcul intensif	ST1 Mathématiques			
E4	Dante	Eric Fleury	ENSL	4,00			Réseaux dynamiques	ST1 Mathématiques			
E5	Mc2	Pascal Koiran	ENSL	6,00			Modèles de calcul, complexité et combinatoire	ST1 Mathématiques			
E6	Plume	Patrick Baillot	ENSL	8,00			Théorie de la preuve et sémantique formelle	ST1 Mathématiques			
E7	Roma	Frédéric Vivien	ENSL	5,00			Optimisation des ressources : modèles, algorithmes et ordonnancement	ST1 Mathématiques			
SC	Services communs recherche, le cas échéant	Gilles Villard	ENSL		8,80						
			Total en ETPT	42,00	10,20						

Ne remplir ces colonnes (Discipline secondaire 1, 2, 3) que dans le cas d'une **unité ou d'équipes pluri disciplinaires**. Ajouter des colonnes si nécessaire

Si nécessaire, insérer des lignes au dessus de la ligne SC et compléter les N° : E6, E7…

(1) Equivalent temps plein travaillé. Les enseignants-chercheurs et chercheurs intervenant dans plusieurs équipes internes seront décomptés au prorata des temps respectifs.
Exemples : Un EC travaillant dans une seule équipe interne = 0,5. Un EC travaillant dans deux équipes internes à égalité de temps = 0,25 dans chacune d'entre elles.
Un chercheur travaillant dans une seule équipe interne = 1. Un chercheur travaillant dans deux équipes internes à égalité de temps = 0,5 dans chacune d'entre elles.
Les cadres scientifiques des EPIC seront comptabilisés dans cette colonne.

(2) En équivalent temps plein travaillé. Les ITA / BIATSS intervenant dans plusieurs équipes internes sont décomptés au prorata des temps respectifs.
Exemple : Un personnel à temps plein dans l'unité qui travaille dans 2 équipes internes à égalité de temps comptera 0,5 dans chacune d'entre elles (0,25 s'il est à mi-temps).

(3) Sélectionner la discipline dans le menu déroulant.

3 – Ressources humaines

3.1 - Composition de l'unité au 30 juin 2014

Renseigner ce tableau en indiquant le nombre de **personnes physiques** correspondant

	* Ajouter des colonnes si nécessaire								
Personnels permanents en activité (1)	Enseignement supérieur* (6) :					Organismes de recherche employeur* (6) :		Autres :	Total
	ENS LYON	U LYON 1	U AIX-MARSEILLE	U GRENOBLE 1	U PARIS 6	CNRS	INRIA	…………..	
Professeurs et assimilés	6	3							**9**
Maîtres de conférences et assimilés	8	6	1	2	1				**18**
Directeurs de recherche et assimilés						4	4		**8**
Chargés de recherche et assimilés						12	8		**20**
Conservateurs, cadres scientifiques EPIC, fondations, industries…									**0**
Professeurs du secondaire détachés dans le supérieur									**0**
ITA-BIATSS autres personnels cadre et non cadre EPIC...	3					4	4		**11**
Sous-total personnels permanents en activité	**17**	**9**	**1**	**2**	**1**	**20**	**16**	**0**	**66**
Enseignants-chercheurs non titulaires, émérites et autres (2)									**5**
Chercheurs non titulaires, émérites et autres (3)									**8**
Autres personnels non titulaires et autres (4)									**8**
Sous-total personnels non titulaires, émérites et autres									**21**
Total personnels de l'unité									**87**
Nombre total de doctorants									**36**
dont doctorants bénéficiant d'un contrat spécifique au doctorat									**14**
Nombre de thèses soutenues (5)									**56**
Nombre d'HDR soutenues (5)									**8**
Nombre de professeurs invités (5)									**62**
Nombre de stagiaires accueillis (5)									**217**

(1) Personnels permanents titulaires (ou stagiaires) en activité, cf. feuille MenusR.
(2) Type d'emploi EC_aut de la feuille MenusR.
(3) Type d'emploi Ch_aut de la feuille MenusR.
(4) Type d'emploi AP_aut de la feuille MenusR.
(5) Entre le 1er janvier 2009 (ou la date de création de l'unité si celle-ci est postérieure) et le 30 juin 2014.

agence d'évaluation de la recherche et de l'enseignement supérieur

3 – Ressources humaines

3.2 - Liste nominative des personnels de l'unité de recherche au 30 juin 2014.
Ne pas inclure dans cette liste les doctorants (feuille 3.3.), ni les stagiaires de Master.

à classer par ordre alphabétique

Nomenclatures à respecter, voir :
feuille MenusR (corps-grades)
feuille UAI_Etab_Org (UAI établissements-organismes)

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession. (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne de rattachement, le cas échéant (6)	Date d'arrivée dans l'unité (7)
Ch_tit	ALIAS	Christophe	H	1977	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E3	janvier 2009
EC_tit	ARRIGHI	Pablo	H	1978	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	U GRENOBLE 1	0381838S	MESR	E5	septembre 2009
Ch_aut	ASCHIERI	Federico	H	1981	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		LABEX	0694094A	MESR	E6	octobre 2012
Ch_tit	AUBRUN	Nathalie	F	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E5	octobre 2012
EC_tit	AUDEBAUD	Philippe	H	1956	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E6	octobre 1992
Ch_tit	BAILLOT	Patrick	H	1972	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS	0753639Y	MESR	E6	octobre 2008
EC_tit	BEGIN	Thomas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1	0691774D	MESR	E4	septembre 2009
AP_aut	BEN AMOR	Chiraz	F	1983	TCH	J - Gestion et pilotage (GP)		CNRS	0753639Y	MESR	SC	avril 2013
EC_tit	BENOIT	Anne	F	1977	MCF	J - Gestion et pilotage (GP)	juillet 2009	ENS LYON	0693259T	MESR	E7	septembre 2005
AP_aut	BERNARD	Sylvain	H	1989	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		ENS LYON	0693259T	MESR	E2	janvier 2013
AP_tit	BLESLE	Evelyne	F	1974	TCS	J - Gestion et pilotage (GP)		INRIA	0780491K	MESR et MINEFI	SC	septembre 2009
Ch_tit	BONCHI	Filippo	H	1981	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E6	octobre 2010
AP_tit	BOYER	Sylvie	F	1969	IE	J - Gestion et pilotage (GP)		INRIA	0780491K	MESR et MINEFI	SC	janvier 2001
AP_tit	BOZO	Marie	F	1974	AJT	J - Gestion et pilotage (GP)		ENS LYON	0693259T	MESR	SC	septembre 2013
Ch_tit	BRISEBARRE	Nicolas	H	1971	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E1	septembre 2002
EC_tit	BUSSON	Anthony	H	1973	PR	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1	0691774D	MESR	E4	septembre 2012
EC_tit	CARON	Eddy	H	1972	MCF	ST6 Sciences et technologies de l'information et de la communication	octobre 2010	ENS LYON	0693259T	MESR	E2	septembre 2002
Ch_tit	CLAIRAMBAULT	Pierre	H	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E6	octobre 2013
EC_tit	CRESPELLE	Christophe	H	1979	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1	0691774D	MESR	E4	octobre 2010
Ch_tit	DARTE	Alain	H	1968	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS	0753639Y	MESR	E3	janvier 1999
AP_tit	DELAMARE	Simon	H	1983	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS	0753639Y	MESR	SC	octobre 2010
AP_tit	DESPLANCHES	Catherine	F	1962	TCH	J - Gestion et pilotage (GP)		CNRS	0753639Y	MESR	SC	septembre 2005
Ch_tit	DESPREZ	Frédéric	H	1964	DR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA	0780491K	MESR et MINEFI	E2	janvier 1999
Ch_aut	DIAS DE ASSUNCAO	Marcos	H	1979	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E2	juin 2014
EC_aut	FEAUTRIER	Paul	H	1940	PREM	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON	0693259T	MESR	E3	septembre 2002
Ch_tit	FEDAK	Gilles	H	1972	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E2	septembre 2008
EC_tit	FLEURY	Eric	H	1969	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON	0693259T	MESR	E4	septembre 2007
AP_tit	GAUTHE	Laetitia	F	1982	TCH	J - Gestion et pilotage (GP)		INRIA	0780491K	MESR et MINEFI	SC	octobre 2009
EC_tit	GELAS	Jean-Patrick	H	1973	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1	0691774D	MESR	E2	octobre 2005
EC_tit	GLUCK	Olivier	H	1976	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1	0691774D	MESR	E2	septembre 2003
Ch_tit	GONCALVES	Paulo	H	1967	CR1	ST6 Sciences et technologies de l'information et de la communication	mars 2010	INRIA	0780491K	MESR et MINEFI	E4	avril 2006
EC_tit	GONNORD	Laure	F	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1	0691774D	MESR	E3	septembre 2013
EC_tit	GRAILLAT	Stef	H	1978	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	U PARIS 6	0751722P	MESR	E5	septembre 2013
EC_tit	GUERIN-LASSOUS	Isabelle	F	1971	PR	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1	0691774D	MESR	E4	septembre 2006
EC_tit	HANROT	Guillaume	H	1973	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON	0693259T	MESR	E1	octobre 2009
Ch_tit	HARMER	Russell spencer	H	1973	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E6	septembre 2013
EC_tit	HIRSCHKOFF	Daniel	H	1971	MCF	ST6 Sciences et technologies de l'information et de la communication	décembre 2009	ENS LYON	0693259T	MESR	E6	septembre 1999
AP_tit	IMBERT	Matthieu	H	1970	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		INRIA	0780491K	MESR et MINEFI	E2	octobre 2007
Ch_tit	JEANNEROD	Claude-Pierre	H	1974	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E1	février 2002
EC_tit	KARSAI	Marton	H	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E4	septembre 2013
Ch_aut	KAYAASLAN	Enver	H	1985	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E7	octobre 2013
EC_tit	KOIRAN	Pascal	H	1969	PRCE	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON	0693259T	MESR	E5	septembre 2000
EC_tit	LAGUILLAUMIE	Fabien	H	1978	PR	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1	0691774D	MESR	E1	septembre 2011
Ch_tit	LAURENT	Olivier	H	1977	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS	0753639Y	MESR	E6	septembre 2008
Ch_tit	LEFEVRE	Vincent	H	1973	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E1	septembre 2006
Ch_tit	LEFEVRE	Laurent	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	novembre 2013	INRIA	0780491K	MESR et MINEFI	E2	septembre 2001
EC_aut	LESCANNE	Pierre	H	1947	PREM	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON	0693259T	MESR	E6	septembre 1997
Ch_tit	L'EXCELLENT	Jean-Yves	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	septembre 2012	INRIA	0780491K	MESR et MINEFI	E7	septembre 2001
Ch_aut	LIBERT	BENOIT	H	1976	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E1	avril 2014
EC_tit	LOUVET	Nicolas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1	0691774D	MESR	E1	novembre 2008
Ch_tit	MARCHAL	Loris	H	1980	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E7	septembre 2003
AP_tit	MIGNOT	Jean-Christophe	H	1965	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS	0753639Y	MESR	SC	janvier 1999
Ch_tit	MULLER	Jean-michel	H	1961	DRCE	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS	0753639Y	MESR	E1	janvier 1999
Ch_aut	PENEV	Irena	F	1983	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		LABEX	0694094A	MESR	E5	septembre 2013

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession. (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne de rattachement, le cas échéant (6)	Date d'arrivée dans l'unité (7)
Ch_tit	PEREZ	Christian	H	1972	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA	0780491K	MESR et MINEFI	E2	octobre 2008
EC_tit	PERNET	Clément	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U GRENOBLE 1	0381838S	MESR	E1	septembre 2013
Ch_aut	PETRISAN	Daniela	F	1983	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E6	novembre 2013
AP_aut	PINHEDE	MARC	H	1990	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		INRIA	0780491K	MESR et MINEFI	E2	février 2014
AP_tit	PONSARD	Dominique	H	1967	IE	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS	0753639Y	MESR	SC	juin 1999
EC_tit	PORTIER	Natacha	F	1971	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E5	septembre 2000
AP_aut	POUILLOUX	Laurent	H	1981	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		INRIA	0780491K	MESR et MINEFI	E2	septembre 2012
Ch_tit	POUS	Damien	H	1982	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E6	février 2012
AP_aut	PUGLISI	Chiara	F	1963	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		INRIA	0780491K	MESR et MINEFI	E7	janvier 2014
Ch_tit	RAO	Michael	H	1979	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E5	octobre 2011
Ch_tit	REVOL	Nathalie	F	1967	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E1	septembre 2000
EC_tit	RIBA	Colin	H	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E6	septembre 2008
EC_tit	ROBERT	Yves	H	1958	PREX	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON	0693259T	MESR	E7	janvier 1999
AP_aut	ROSSIGNEUX	François	H	1990	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		INRIA	0780491K	MESR et MINEFI	E2	octobre 2012
Ch_aut	ROUZAUD CORNABAS	Jonathan	H	1983	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E2	septembre 2011
EC_tit	SABLIK	Mathieu	H	1978	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	IUT AIX MARSEILLE	0133908C	MESR	E5	septembre 2013
Ch_tit	SALVY	Bruno	H	1965	DR2	ST6 Sciences et technologies de l'information et de la communication		INRIA	0780491K	MESR et MINEFI	E1	septembre 2012
EC_aut	SENOT	Maxime	H	1983	ATER	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E5	septembre 2013
AP_tit	SEON	Damien	H	1985	TCH	J - Gestion et pilotage (GP)		ENS LYON	0693259T	MESR	SC	octobre 2010
EC_tit	STEHLE	Damien	H	1981	PR2	ST6 Sciences et technologies de l'information et de la communication	octobre 2011	ENS LYON	0693259T	MESR	E1	septembre 2012
Ch_aut	SUN	Hongyang	H	1981	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		LABEX	0694094A	MESR	E7	juin 2014
Ch_tit	SUTER	Frédéric	H	1976	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E2	septembre 2012
EC_tit	THIERRY	Eric	H	1973	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E5	septembre 2003
EC_tit	THOMASSE	Stéphan	H	1968	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON	0693259T	MESR	E5	septembre 2011
AP_tit	TORRES	Serge	H	1953	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		ENS LYON	0693259T	MESR	SC E1	septembre 2001
Ch_tit	TROTIGNON	Nicolas	H	1971	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS	0753639Y	MESR	E5	mars 2011
EC_aut	TSAFACK CHETSA	Ghislain Landry	H	1985	ATER	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E2	septembre 2013
Ch_tit	UCAR	Bora	H	1976	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS	0753639Y	MESR	E7	janvier 2009
EC_aut	VALICOV	Petru	H	1986	ATER	ST6 Sciences et technologies de l'information et de la communication		ENS LYON	0693259T	MESR	E5	septembre 2013
AP_aut	VERGER	Guillaume	H	1981	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		INRIA	0780491K	MESR et MINEFI	E2	novembre 2012
Ch_tit	VILLARD	Gilles	H	1963	DR1	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS	0753639Y	MESR	E1	décembre 2000
Ch_tit	VIVIEN	Frédéric	H	1971	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA	0780491K	MESR et MINEFI	E7	septembre 2002
AP_aut	ZHANG	Huaxi	F	1983	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		INRIA	0780491K	MESR et MINEFI	E2	décembre 2012
Insérer les lignes supplémentaires juste au dessus de la ligne jaune, ne pas laisser de ligne non remplie												

(1) Sélectionner les informations dans le menu déroulant, si besoin voir feuille MenusR pour le détail des nomenclatures.
(2) Inscrire « oui » dans les cases correspondant aux personnels habilités à diriger des recherches.
Pour les personnels ayant soutenu leur HDR entre le 1er janvier 2009 (ou depuis la création de l'unité de recherche si celle-ci est intervenue après cette date) et le 30 juin 2014, indiquer le mois et l'année de la soutenance.
(3) Sélectionner les informations dans le menu déroulant.
Si l'établissement ou l'organisme n'est pas présent dans la liste ou la feuille UAI_Etab_Org, indiquer le nom en clair.
Pour les émérites, indiquer le dernier établissement ou organisme employeur.
(4) Ne rien saisir dans cette colonne.
NB : Certaines entités listées peuvent ne pas avoir de code UAI. La case restera vide.
(5) Voir nomenclature proposée en bas de la colonne.
En cas de tutelles multiples, il est possible de compléter la saisie, ex. MESR, MAEE.
(6) Indiquer le numéro de l'équipe dans la liste de la feuille 2 "Thématiques et équipes".
(7) Mois et année.

AGRICULTURE	Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt
CULTURE	Ministère de la Culture et de la Communication
DEFENSE	Ministère de la Défense
INTERIEUR	Ministère de l'Intérieur
JUSTICE	Ministère de la Justice
MAEE	Ministère des Affaires Étrangères et Européennes
MED	Ministère de l'Écologie, du Développement Durable et de l'Énergie
MEN	Ministère de l'Éducation nationale
MESR	Ministère de l'Enseignement supérieur et de la Recherche
MINEFI	Ministère de l'Économie et des Finances
R PROD	Ministère du Redressement Productif
SANTE	Ministère des Affaires Sociales et de la Santé
SPORTS	Ministère des Sports, de la Jeunesse, de l'Éducation populaire et de la vie associative
	Autre préciser

3 – Ressources humaines

3.3 - Liste des docteurs diplômés depuis le 1er janvier 2009 (ou depuis la date de création de l'unité si celle-ci est postérieure) ET des doctorants présents dans l'unité au 30 juin 2014

(à classer par équipe interne s'il en existe)

Nom	Prénom	H/F	Année de naissance (XXXX)	Etablissement ayant délivré le master (ou diplôme équivalent) du doctorant (1)	Directeur(s) de thèse (2)	Date de début de thèse (3)	Date de soutenance (pour les diplômés) (3)	Financement du doctorant (4)	Situation professionnelle deux ans après soutenance (5)	Nombre d'articles (6)	Nombre de communications (7)	N° de l'équipe interne de rattachement, le cas échéant (8)	ED de rattachement
AMMAR	Doreid	M.	1986	U LYON 1	Isabelle GUERIN LASSOUS	octobre-09	décembre-12	CDO	RBI	0	2	E4	ED MATH INFO
ANHALT	Fabienne	Mme	1983	INSA LYON	Pascale VICAT BLANC PRIMET	septembre-08	juillet-11	CDO	RPS	4	2	E4	ED MATH INFO
AUPY	Guillaume	M.	1988	U PARIS 7	BENOIT Anne	septembre-11		CDENSX		4	9	E7	ED MATH INFO
BALOUEK-THOMERT	Daniel	M.	1988	U PARIS 6	CARON Eddy	janvier-11		INDUSTR		0	1	E2	ED MATH INFO
BEN-SAAD	Leila	Mme	1982	U LYON 1	TOURANCHEAU B	septembre-08	novembre-11	AM	RBS	0	4	E7	ED MATH INFO
BLOT	Valentin	M.	1986	ENS LYON	LAURENT Olivier	septembre-11		CDENSX		0	2	E6	ED MATH INFO
BOISSINOT	Benoît	M.	1983	ENS LYON	Fabrice RASTELLO	septembre-06	septembre-10	CDENSX	RPS	1	4	E3	ED MATH INFO
BOUCHEZ	Florent	M.	1986	ENS LYON	Alain DARTE	septembre-05	avril-09	CDENSX	RPI	0	1	E3	ED MATH INFO
BRIQUEL	Irénée	M.	1984	ENS LYON	KOIRAN Pascal	septembre-08	novembre-11	AC	RBI	1	1	E5	ED MATH INFO
BRUNET	Paul	M.	1988	U PARIS 7	POUS Damien	octobre-13		CDE		0	1	E6	ED MATH INFO
BRUNIE	Nicolas	M.	1987	ENS LYON	DUPONT DE DINECHIN Florent	décembre-10	mai-14	INDUSTR		1	5	E1	ED MATH INFO
CHARRIER	Ghislain	M.	1984	U BESANCON	CANIOU Yves	octobre-07	décembre-10	CDO	RPS	0	4	E2	ED MATH INFO
CHEVILLARD	Sylvain	M.	1983	ENS LYON	MULLER Jean-Michel	septembre-06	juillet-09	AC	RBS	1	2	E1	ED MATH INFO
CHIS	Andreea	Mme	1982	ENS LYON	FLEURY Eric	septembre-07	janvier-12	CDO	INC	0	2	E4	ED MATH INFO
COLOMBET	Quentin	M.	1981	U GRENOBLE 1	Alain DARTE	décembre-09	décembre-12	CDO	RPS	1	5	E3	ED MATH INFO
De-Benedetti	Erika	Mme	1985	Université de Turin	BAILLOT Patrick	octobre-12		(…); allocation université de Turin		0	1	E6	ED MATH INFO
DEMANGEON	Romain	M.	1984	ENS LYON	HIRSCHKOFF Daniel	février-07	novembre-10	AC	RBI	1	2	E6	ED MATH INFO
DEPARDON	Benjamin	M.	1984	ENS LYON	CARON Eddy	septembre-07	octobre-10	AM	RPS	1	7	E2	ED MATH INFO
DIOURI	Mohammed-El-Medhi	M.	1987	INSA LYON	LEFEVRE Laurent	octobre-10	septembre-13	CDE		1	11	E2	ED MATH INFO
DIVAKARAN	Dinil-Mon	M.	1980	IIT MADRAS	Pascale VICAT BLANC PRIMET	avril-07	juillet-10	CDO	RBS	0	2	E4	ED MATH INFO
DOGHRI	Inès	M.	1982	Ecole nationale d'ingénieurs de Tunis	Isabelle GUERIN LASSOUS	mars-09	mai-12	CIFRE	RPS	0	1	E4	ED MATH INFO
DUFOSSE	Fanny	Mme	1984	ENS LYON	BENOIT Anne	septembre-08	septembre-11	AC	RBI	4	8	E7	ED MATH INFO
FAYE	Maurice-Djibril	M.	1980	Université Gaston Berger de Saint-Louis (Sénégal)	CARON Eddy	septembre-11		ETR		0	1	E2	ED MATH INFO
FILIP	Silviu	M.	1989	ENS LYON	BRISEBARRE Nicolas	septembre-13		CDE		0	0	E1	ED MATH INFO
FRIGGERI	Adrien	M.	1985	ENS LYON	Eric FLEURY	septembre-09	août-12	CDENSX	RPS	3	6	E4	ED MATH INFO

Nom	Prénom	H/F	Année de naissance (XXXX)	Etablissement ayant délivré le master (ou diplôme équivalent) du doctorant (1)	Directeur(s) de thèse (2)	Date de début de thèse (3)	Date de soutenance (pour les diplômés) (3)	Financement du doctorant (4)	Situation professionnelle deux ans après soutenance (5)	Nombre d'articles (6)	Nombre de communications (7)	N° de l'équipe interne de rattachement, le cas échéant (8)	ED de rattachement
GALLET	Matthieu	M.	1982	ENS LYON	VIVIEN Frédéric	septembre-06	octobre-09	AC	RBS	1	6	E7	ED MATH INFO
GAULT	Sylvain	M.	1986	U POITIERS	DESPREZ Frédéric	octobre-10		CDO		1	2	E2	MATH INFO
GIRAULT	Benjamin	M.	1987	ENS CACHAN	FLEURY Eric	octobre-12		CDE		0	3	E4	MATH INFO
GRENET	Bruno	M.	1987	ENS LYON	PORTIER Natacha	octobre-09	novembre-12	CDENSX	RPI	3	4	E5	MATH INFO
GUILLIER	Romaric	M.	1980	U GRENOBLE 1	Pascale VICAT BLANC PRIMET	juillet-06	octobre-09	(…),ingénieur	RPS	0	2	E4	MATH INFO
HABLOT	Ludovic	M.	1982	INSA LYON	Pascale VICAT BLANC PRIMET	septembre-06	décembre-09	AM	CHO	0	1	E4	MATH INFO
HERRMANN	Julien	M.	1989	ENS LYON	ROBERT Yves	septembre-12		CDENSX		1	2	E7	MATH INFO
IOOSS	Guillaume	M.	1989	ENS DE LYON	DARTE Alain	septembre-12		CDENSX		0	3	E3	MATH INFO
ISOARD	Alexandre	M.	1989	ENS DE LYON	DARTE Alain	septembre-12		CDENSX		0	1	E3	MATH INFO
JACQUELIN	Matthias	M.	1986	INSA LYON	L. MARCHAL	octobre-08	juillet-11	AM	RBS	1	6	E7	MATH INFO
JOLDES	Mioara	Mme	1984	ENS LYON	BRISEBARRE Nicolas	septembre-08	septembre-11	COLLTERR	RBS	1	7	E1	MATH INFO
JOUHET	Laurent	M.	1983	ENS LYON	THIERRY Eric	septembre-07	novembre-12	AC	RBS	0	1	E5	MATH INFO
JOURDAN-LU	Jingyan	Mme	1982	East China Normal University	CP. JEANNEROD	mars-09	novembre-12	CIFRE	RBI	0	4	E1	MATH INFO
KLEIN	Cristian	M.	1985	ENS LYON	PEREZ Christian	octobre-09	novembre-12	CDO	INC	0	6	E2	MATH INFO
KOSLOVSKI	Guilherme	M.	1983	U LYON 1	Pascale VICAT BLANC PRIMET	octobre-08	juillet-11	CDO	RPI	3	6	E4	MATH INFO
LAGOUTTE	Aurélie	Mme	1990	ENS CACHAN	THOMASSÉ Stéphane	octobre-12		CDENSX		3	2	E5	MATH INFO
LANGLOIS	Adeline	Mme	1986	ENS CACHAN	STEHLE Damien	septembre-11		CDENSX		0	4	E1	MATH INFO
LANORE	Vincent	M.	1989	ENS LYON	PEREZ Christian	septembre-12		CDENSX		0	1	E2	MATH INFO
LASSON	Marc	M.	1985	U NICE	LAURENT Olivier	octobre-09	novembre-12	CDE	RBI	0	3	E6	MATH INFO
LEFRAY	Arnaud	M.	1989	U PARIS 6	CARON Eddy	octobre-12		CDE		0	1	E2	MATH INFO
LEO	Yannick	M.	1989	ENS LYON	FLEURY Eric	octobre-13		CDENSX		0	0	E4	MATH INFO
LOISEAU	Patrick	M.	1982	ENS LYON	Pascale VICAT BLANC PRIMET	septembre-06	décembre-09	A,CDO	RBS	3	5	E4	MATH INFO
MADIOT	Jean-Marie	M.	1988	ENS LYON	HIRSCHKOFF Daniel	septembre-11		CDENSX		0	3	E6	MATH INFO
MARKOMANOLIS	Georgios	M.	1981	ENS LYON	DESPREZ Frédéric	novembre-10	20 janvier 2014	CDO		1	2	E2	MATH INFO
MARTIN-DOREL	Erik	M.	1986	U MONTPELLIER 2	JM. MULLER	septembre-09	septembre-12	CDE	RBI	1	3	E1	MATH INFO
MARTINET	Lucie	Mme	1988	ENS LYON	FLEURY Eric	octobre-11		CDE		0	0	E4	MATH INFO
MORINI	Matéo	M.	1974	Université de Turin	FLEURY Eric	janvier-14		(…), Personnel ITA de l'Université de Turin		0	0	E4	MATH INFO
MOUILLERON	Christophe	M.	1984	ENS LYON	JEANNEROD Claude-Pierre	septembre-08	novembre-11	CDENSX	RBS	0	4	E1	MATH INFO
MURESAN	Adrian	M.	1985	ENS LYON	F. DESPREZ	octobre-09	décembre-12	CDE	INC	5	4	E2	MATH INFO
NEIGER	Vincent	M.	1989	ENS LYON	VILLARD Gilles	septembre-13		CDENSX		0	1	E1	MATH INFO
NGUYEN-A	Hong-Diep	M.	1982	U PARIS 6	REVOL Nathalie	octobre-07	janvier-11	CDO	RBI	1	2	E1	MATH INFO
NGUYEN-B	Van-Nam	M.	1978	Institut de la francophonie pour l'informatique (Vietnam)	Isabelle GUERIN LASSOUS	octobre-07	décembre-12	(…),Bourse AUF Egide INSCRIT EN THESE A L' UCB Lyon 1 - Juillet 2009	INC	0	2	E4	MATH INFO
NGUYEN-C	HUU NGHI	M.	1982	Institut de la francophonie pour l'informatique (Vietnam)	GUERIN LASSOUS Isabelle	juin-14		CDE		0	0	E4	MATH INFO

Nom	Prénom	H/F	Année de naissance (XXXX)	Etablissement ayant délivré le master (ou diplôme équivalent) du doctorant (1)	Directeur(s) de thèse (2)	Date de début de thèse (3)	Date de soutenance (pour les diplômés) (3)	Financement du doctorant (4)	Situation professionnelle deux ans après soutenance (5)	Nombre d'articles (6)	Nombre de communications (7)	N° de l'équipe interne de rattachement, le cas échéant (8)	ED de rattachement
NOUAL	Mathilde	Mme	1983	ENS LYON	REMILA Eric	septembre-09	juin-12	CDE	INC	3	5	E5	MATH INFO
ORGERIE	Anne-Cécile	Mme	1986	ENS LYON	L. LEFEVRE	septembre-08	septembre-11	AM	RBS	6	13	E2	MATH INFO
PAINDAVOINE	Marie	Mme	1990	U VERSAILLES ST-QUENTIN	LAGUILLAUMIE Fabien	novembre-13		INDUSTR		0	0	E1	MATH INFO
PANHALEUX	Adrien	M.	1985	ENS LYON	MULLER Jean-Michel	septembre-08	juin-12	CDENSX	INC	2	2	E1	MATH INFO
PARDON	Aurélien	M.	1983	ENS CACHAN	HIRSCHOWITZ T	septembre-06	avril-11	AM	NPS	0	1	E6	MATH INFO
PASCA	Bogdan	M.	1984	ENS LYON	DUPONT DE DINECHIN Florent	octobre-08	septembre-11	AM	RPS	3	9	E1	MATH INFO
PERRINEL	Matthieu	M.	1989	ENS LYON	BAILLOT Patrick	septembre-11		CDENSX		2	1	E6	MATH INFO
PERROT	Kevin	M.	1987	U NICE	REMILA Eric	octobre-10	27 juin 2013	CDE		1	3	E5	MATH INFO
PETIT	Barbara	Mme	1984	Lycée Janson de Sailly	MIQUEL A	septembre-08	juillet-11	AM	RBI	1	0	E6	MATH INFO
PICHON	Vincent	M.	1980	U NICE	PEREZ Christian	avril-09	novembre-12	CIFRE	INC	1	2	E2	MATH INFO
PLESCO	Alexandru	M.	1983	ENS LYON	Alain DARTE	octobre-06	septembre-10	AM,ATER	RPS	1	5	E3	MATH INFO
RENAUD-GOUD	Paul	M.	1986	INP TOULOUSE	A. BENOIT	septembre-09	juillet-12	CDE	RBI	1	9	E7	MATH INFO
REVY	Guillaume	M.	1982	ENS LYON	VILLARD Gilles	septembre-06	décembre-09	A,CDO	RBS	1	6	E1	MATH INFO
REYNAUD	Laurent	M.	1972	ID (M.Sc. IT), Ecole Supérieure d'Ingénieurs en Informatique et Génie des Télécommunications	GUERIN LASSOUS Isabelle	janvier-13		(…),salarié de l'entreprise Orange		0	1	E4	MATH INFO
REZVOY	Clément	M.	1983	U LYON 1	VIVIEN Frédéric	septembre-07	septembre-11	AM	INC	1	1	E7	MATH INFO
RIEG	Lionel	M.	1986	ENS LYON	MIQUEL A	septembre-10	17 juin 2014	CDENSX		0	1	E6	MATH INFO
ROBERT	Julien	M.	1983	ENS CACHAN	Nicolas Schabanel	septembre-06	décembre-09	AC	RBI	0	5	E5	MATH INFO
ROY	SHUBHABRATA	M.	1981	SCUOLA SUPERIORE SANT'ANNA DI PISA	GONCALVES Paulo	décembre-10	18 juin 2014	CDO		1	3	E4	MATH INFO
SID-LAKHDAR	Mohamed	M.	1989	INP TOULOUSE	L'EXCELLENT Jean-Yves	octobre-11		CDE		2	3	E7	MATH INFO
SIMONET	Anthony	M.	1987	U BORDEAUX 1	FEDAK Gilles	novembre-11		CDO		1	3	E2	MATH INFO
SONIGO-Rehn	Véronika	Mme	1980	ENS LYON	ROBERT Yves	septembre-06	juillet-09	AM	RBS	3	10	E7	MATH INFO
SOUDAN	Sébastien	M.	1982	ENS LYON	Pascale VICAT BLANC PRIMET	octobre-06	novembre-09	AM	RPS	2	4	E4	MATH INFO
TAVENAS	Sébastien	M.	1987	U PARIS 7	KOIRAN Pascal	septembre-11		CDENSX		3	1	E5	MATH INFO
THEVENY	Philippe	M.	1971	U VERSAILLES ST-QUENTIN	REVOL Nathalie	octobre-11		CDE		3	1	E1	MATH INFO
TORRES	Serge	M.	1953	CNAM PARIS	MULLER Jean-Michel	septembre-10		(…),Fonctionnaire titulaire ITA Ingénieur de recherche		1	0	E1	MATH INFO
TRUNCK	Théophile	M.	1988	ENS DE LYON	TROTIGNON Nicolas	septembre-11		CDENSX		2	1	E5	MATH INFO
TSAFACK-CHETSA	Ghislain-Landry	M.	1985	Université de Yaoundé	LEFEVRE Laurent	janvier-11	décembre-13	CDO,ATER		2	6	E2	MATH INFO
TSOUANAS	Athanasios	M.	1983	Université d'Athènes	LAURENT Olivier	octobre-10		CDO		1	0	E6	MATH INFO
VANNIER	Rémi	M.	1979	ESE CESSON	Isabelle GUERIN LASSOUS	octobre-06	décembre-09	CDO	NBS	0	1	E4	MATH INFO
VILLEBONNET	Violaine	Mme	1991	INP TOULOUSE	Laurent LEFEVRE	octobre-13		CDO		0	0	E2	MATH INFO
WANDERLEY-MATOS	Thiago	M.	1985	Universidade Federal do Pará - Belém-PA, Brazil	GONCALVES Paulo	mars-11		CDE		0	0	E4	MATH INFO
WANG	Qinna	M.	1984	U PARIS 6	Eric FLEURY	septembre-08	avril-12	CDE	INC	1	3	E4	MATH INFO
ZAIDOUNI	Dounia	Mme	1988	INSA LYON	VIVIEN Frédéric	octobre-11		CDO		3	4	E7	MATH INFO
ZANASI	Fabio	M.	1988	University of Amsterdam	HIRSCHKOFF Daniel	octobre-12		CDE		0	5	E6	MATH INFO

Insérer les lignes supplémentaires au dessus de la ligne jaune (ne rien inscrire dans cette ligne jaune)

Total des doctorants au 30 juin 2014 :	**36,00**
Total des thèses soutenues avant le	**56,00**
dont thèses avec publications ou brevets :	55

(1) Sélectionner l'établissement dans le menu déroulant.
Si l'établissement n'est pas présent dans la liste ou la feuille UAI_Etab_Org, indiquer le nom en clair.
(2) En cas de direction partagée, les noms des directeurs seront séparés par des virgules.
(3) Mois et année.
(4) Voir nomenclature dans la feuille « MenusR », s'il y a plusieurs financements, inscrire les codes séparés par des virgules.
(5) Voir nomenclature dans la feuille « MenusR ».
(6) Nombre d'articles publiés dans des revues à comité de lecture.
(7) Nombre de communications orales ou affiches, suivies de publications dans des actes.
(8) Inscrire le numéro correspondant au numéro de l'équipe de la feuille « 2. Equipes et thématiques ».

4. – Ressources financières de l'unité pour les années 2012 et 2013, en euros

I. Crédits provenant des établissements de rattachement ou partenaires de l'unité *(4)	2012 Fonctionnement (1)	2012 Investissement (1)	2012 Masse salariale (2)	2013 Fonctionnement (1)	2013 Investissement (1)	2013 Masse salariale (2)
CNRS	79 607	0	0	110 988	0	0
ENS LYON	161 610	37 000	62 165	208 527	35 800	28 360
U LYON 1	45 149	0	0	54 006	0	0
PRES U LYON	52 474	0	54 143	121 939	0	0
INRIA	193 200	0	0	185 644	6 819	83 000
	0	0	0	0	0	0
	0	0	0	0	0	0
Total	532 040	37 000	116 308	681 104	42 619	111 360

** Ajuster le nombre de lignes à la structure de l'unité*

II. Crédits sur programmes, sur contrats ou opérations particulières	2012 Fonctionnement (1)	2012 Investissement (1)	2012 Masse salariale (3)	2013 Fonctionnement (1)	2013 Investissement (1)	2013 Masse salariale (3)
II.1 Appels à projets internationaux						
Programmes internationaux						
Programmes Européens hors ERC	40 917	7 100	133 616	176 320		249 068
Grants ERC						
sous-total appels à projets internationaux	**40 917**	**7 100**	**133 616**	**176 320**	**0**	**249 068**
II.2 Appels à projets nationaux						
Appels à projet ANR	209 902	21 500	280 279	199 374	82 838	410 706
Autres financements sur appels à projets nationaux du MESR	16 953	1 598		54 155	3 845	10 800
Appels à projets des ministères hors MESR						
Programmes Investissements d'Avenir	7 800	626 500	27 078	11 725	20 833	109 020
sous-total appels à projet nationaux	**234 655**	**649 598**	**307 357**	**265 254**	**107 516**	**530 526**
II.3 Autres sources de financement						
Financement public hors tutelles						
Fondations,associations caritatives, Institut Carnot, RTRA, RTRS						
Collectivités territoriales	13 130	11 261		21 033	8 800	
Contrats de recherche industriels	106 364	10 680	258 637	63 259	3 115	22 287
Licences d'exploitation des brevets, certificat d'obtention végétale						
Prestations d'expertise						
Autres						
sous-total autres sources de financement	**119 494**	**21 941**	**258 637**	**84 292**	**11 915**	**22 287**
Total	**395 066**	**678 639**	**699 610**	**525 866**	**119 431**	**801 881**

III. Budget consolidé	2012 Montant	2013 Montant
	2 458 663	**2 282 261**

NB : Ne pas fusionner de cellules sur cette feuille.

(1) Indiquer les crédits ouverts sur le budget des unités, hors report, les montants seront indiqués en euros HT.
S'il n'est pas possible de distinguer les crédits de fonctionnement, d'investissement et de masse salariale, saisir le montant dans la colonne fonctionnement.

(2) Pour les établissements d'enseignement supérieur et les EPST indiquer la masse salariale globale approximative des personnels affectés à l'unité.
On pourra utiliser la grille de référence des organismes et/ou des établissements d'enseignement supérieur.

(3) Indiquer les crédits obtenus sur financements externes permettant de rémunérer des personnels

Annexe 11. Données du prochain contrat

agence d'évaluation de la recherche et de l'enseignement supérieur

Vague A :
Campagne d'évaluation 2014 - 2015
Dossier d'évaluation des unités de recherche

Données du prochain contrat

Description de la structure de l'unité au 1er janvier 2016

Cas 1 : Renouvellement sans restructuration

Situation actuelle → **Situation proposée pour le prochain contrat**

Contrat 2010-2011/2015	Nom de l'unité	LIP UMR 5668
	Nom du responsable	VILLARD

Equipes de l'unité durant le contrat 2010-2011/2015

N° équipe	Nom du Responsable	Nom de l'équipe
E1	Jean-Michel Muller	ARIC
E2	Christian Perez	AVALON
E3	Alain Darte	COMPSYS
E4	Eric Fleury	DANTE
E5	Pascal Koiran	MC2
E6	Patrick Baillot	PLUME
E7	Frédéric Vivien	ROMA

Ajuster le nombre de lignes au nombre d'équipes

Contrat 2016/2020	Nom de l'unité	LIP UMR 5668
	Nom du responsable	HANROT

Equipes de l'unité durant le contrat 2016/2020

N° équipe	Nom du Responsable	Nom de l'équipe
E1	Bruno Salvy / Gilles Villard	ARIC
E2	Christian Perez	AVALON
E3	Alain Darte	COMPSYS
E4	Eric Fleury	DANTE
E5	Nicolas Trotignon	MC2
E6	Patrick Baillot	PLUME
E7	Frédéric Vivien	ROMA

Ajuster le nombre de lignes au nombre d'équipes

Cas 2 : Restructuration d'unités

Situation actuelle → **Situation proposée pour le prochain contrat**

Reproduire autant de fois que nécessaire le tableau ci-dessous

Contrat 2010-2011/2015	Nom de l'unité	
	Nom du responsable de l'unité	
	N° de l'unité	
N° équipe	**Nom du Responsable de l'équipe**	**Nom de l'équipe**

Ajuster le nombre de lignes au nombre d'équipes

Contrat 2010-2011/2015	Nom de l'unité	
	Nom du responsable de l'unité	
	N° de l'unité	
N° équipe	**Nom du Responsable de l'équipe**	**Nom de l'équipe**

Ajuster le nombre de lignes au nombre d'équipes

Contrat 2016/2020	Nom de l'unité	
	Nom du responsable	

Equipes de l'unité durant le contrat 2016/2020

N° équipe	Nom du Responsable	Nom de l'équipe

Ajuster le nombre de lignes au nombre d'équipes

agence d'évaluation de la recherche et de l'enseignement supérieur

Vague A :
Campagne d'évaluation 2014 - 2015
Dossier d'évaluation des unités de recherche

Données du prochain contrat

Liste prévisionnelle des personnels de l'unité au 1er janvier 2016

à classer par ordre alphabétique

Nomenclatures à respecter, voir :
feuille MenusR (corps-grades)
feuille UAI_Etab_Org (UAI établissements-organismes)

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	ALIAS	Christophe	H	1977	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E3		
Ch_tit	AUBRUN	Nathalie	F	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E5		
EC_tit	AUDEBAUD	Philippe	H	1956	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E6		
Ch_tit	BAILLOT	Patrick	H	1972	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E6		
EC_tit	BEGIN	Thomas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E4		
EC_tit	BENOIT	Anne	F	1977	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E7		voir annexe 1
AP_tit	BLESLE	Evelyne	F	1974	TCS	J - Gestion et pilotage (GP)		INRIA		MESR et MINEFI	SC		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	BONCHI	Filippo	H	1981	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
AP_tit	BOZO	Marie	F	1974	TCH	J - Gestion et pilotage (GP)		ENS LYON		MESR	SC		
Ch_tit	BRISEBARRE	Nicolas	H	1971	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E1		
EC_tit	BUSSON	Anthony	H	1973	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MESR	E4		
EC_tit	CANIOU	Yves	H	1974	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E2		
EC_tit	CARON	Eddy	H	1972	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E2		
Ch_tit	CLAIRAMBAULT	Pierre	H	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
EC_tit	CRESPELLE	Christophe	H	1979	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E4		voir annexe2
Ch_tit	DARTE	Alain	H	1968	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E3		
AP_tit	DELAMARE	Simon	H	1983	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS		MESR	SC		
AP_tit	DESPLANCHES	Catherine	F	1962	TCH	J - Gestion et pilotage (GP)		CNRS		MESR	SC		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
EC_tit	FAWZI	Omar	H	1985	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E5		
EC_aut	FEAUTRIER	Paul	H	1940	PREM	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E3		
Ch_tit	FEDAK	Gilles	H	1972	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E2		
EC_tit	FLEURY	Eric	H	1969	PR1	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E4		
AP_tit	GAUTHE	Laetitia	F	1982	TCH	J - Gestion et pilotage (GP)		INRIA		MESR et MINEFI	SC		
EC_tit	GELAS	Jean-Patrick	H	1973	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E2		
EC_tit	GLUCK	Olivier	H	1976	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E2		
Ch_tit	GONCALVES	Paulo	H	1967	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E4		
EC_tit	GONNORD	Laure	F	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E3		
EC_tit	GUERIN-LASSOUS	Isabelle	F	1971	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MESR	E4		
EC_tit	HANROT	Guillaume	H	1973	PR1	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E1		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	HARMER	Russell spencer	H	1973	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
EC_tit	HIRSCHKOFF	Daniel	H	1971	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E6		
Ch_tit	JEANNEROD	Claude-Pierre	H	1974	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		
EC_tit	KARSAI	Marton	H	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E4		
EC_tit	KOIRAN	Pascal	H	1969	PRCE	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E5		
EC_tit	LAGUILLAUMIE	Fabien	H	1978	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MESR	E1		
Ch_tit	LAURENT	Olivier	H	1977	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E6		
Ch_tit	LEFEVRE	Vincent	H	1973	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		
Ch_tit	LEFEVRE	Laurent	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E2		
Ch_tit	L'EXCELLENT	Jean-Yves	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E7		
Ch_aut	LIBERT	Benoit	H	1976	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E1		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_aut	LOUP	David	H	1994	IR	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E2		Recrutement au 1er octobre
EC_tit	LOUVET	Nicolas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MESR	E1		
Ch_tit	MARCHAL	Loris	H	1980	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E7		
AP_tit	MIGNOT	Jean-christophe	H	1965	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS		MESR	SC E2		
Ch_tit	MIO	Matteo	H	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		Recrutement au 1er octobre
Ch_tit	MULLER	Jean-michel	H	1961	DRCE	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E1		
Ch_tit	PEREZ	Christian	H	1972	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E2		
AP_tit	PONSARD	Dominique	H	1967	IE	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS		MESR	SC		
EC_tit	PORTIER	Natacha	F	1971	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E5		
Ch_tit	POUS	Damien	H	1982	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
Ch_tit	RAO	Michael	H	1979	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E5		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	REVOL	Nathalie	F	1967	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		Revol
EC_tit	RIBA	Colin	H	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E6		
EC_tit	ROBERT	Yves	H	1958	PREX	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E7		
~~Ch_aut~~	~~ROSSIGNEUX~~	~~François~~	~~H~~	~~1990~~	~~IR~~	~~ST6 Sciences et technologies de l'information et de la communication~~		~~INRIA~~		~~MESR et MINEFI~~	~~E2~~		
Ch_tit	SALVY	Bruno	H	1965	DR2	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		
AP_tit	SEON	Damien	H	1985	TCH	J - Gestion et pilotage (GP)		ENS LYON		MESR	SC		
EC_tit	STEHLE	Damien	H	1981	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E1		Stehlé
Ch_aut	SUN	Hongyang	H	1981	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		PRES U LYON		MESR	E7		
EC_tit	THIERRY	Eric	H	1973	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E5		
EC_tit	THOMASSE	Stéphan	H	1968	PR1	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E5		
AP_tit	TORRES	Serge	H	1953	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		ENS LYON		MESR	SC E7		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	TROTIGNON	Nicolas	H	1971	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E5		
Ch_tit	UCAR	Bora	H	1976	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E7		
Ch_tit	VILLARD	Gilles	H	1963	DR1	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E1		
Ch_tit	VIVIEN	Frédéric	H	1971	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E7		F. Vivien
Ch_tit	YUKI	Tomofumi	H	1985	CR	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E3		Recrutement au 1er octobre
Insérer les lignes supplémentaires juste au dessus de la ligne jaune, ne pas laisser de ligne non remplie													

(1) Sélectionner les informations dans le menu déroulant, si besoin voir feuille MenusR pour les détails des nomenclatures.
(2) Inscrire « oui » dans les cases correspondant aux personnels habilités à diriger des recherches.
(3) Sélectionner les informations dans le menu déroulant.
Si l'établissement ou l'organisme n'est pas présent dans la liste ou la feuille UAI_Etab_Org, indiquer le nom en clair.
Pour les émérites, indiquer le dernier établissement ou organisme employeur.
(4) Ne rien saisir dans cette colonne.
NB : Certaines entités listées peuvent ne pas avoir de code UAI et et la case restera vide.
(5) Voir nomenclature proposée en bas de la colonne.
En cas de tutelles multiples, il est possible de compléter la saisie, ex. MESR, MAEE.
(6) Utiliser le numéro de la liste rappelant les équipes composant l'unité pour le prochain contrat de la feuille "Structure unité"
(7) Utiliser le numéro de la liste rappelant les unités concernées par la restructuration pour le prochain contrat de la feuille "Structure unité".

AGRICULTURE	Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt
CULTURE	Ministère de la Culture et de la Communication
DEFENSE	Ministère de la Défense
INTERIEUR	Ministère de l'Intérieur
JUSTICE	Ministère de la Justice
MAEE	Ministère des Affaires Étrangères et Européennes
MED	Ministère de l'Écologie, du Développement Durable et de l'Énergie
MEN	Ministère de l'Éducation nationale
MESR	Ministère de l'Enseignement supérieur et de la Recherche
MINEFI	Ministère de l'Économie et des Finances
R PROD	Ministère du Redressement Productif
SANTE	Ministère des Affaires Sociales et de la Santé
SPORTS	Ministère des Sports, de la Jeunesse, de l'Éducation populaire et de la vie associative
	Autre préciser

aeres
agence d'évaluation de la recherche et de l'enseignement supérieur

Vague A :
Campagne d'évaluation 2014 - 2015
Dossier d'évaluation des unités de recherche

Données du prochain contrat

Liste prévisionnelle des personnels de l'unité au 1er janvier 2016

à classer par ordre alphabétique

Nomenclatures à respecter, voir :
feuille MenusR (corps-grades)
feuille UAI_Etab_Org (UAI établissements-organismes)

Annexe 1

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
Ch_tit	ALIAS	Christophe	H	1977	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E3		
Ch_tit	AUBRUN	Nathalie	F	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E5		
EC_tit	AUDEBAUD	Philippe	H	1956	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E6		
Ch_tit	BAILLOT	Patrick	H	1972	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E6		
EC_tit	BEGIN	Thomas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MEN	E4		
EC_tit	BENOIT	Anne	F	1977	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E7		
AP_tit	BLESLE	Evelyne	F	1974	TCS	J - Gestion et pilotage (GP)		INRIA		MESR et MINEFI	SC		
Ch_tit	BONCHI	Filippo	H	1981	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		

Annexe 2

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
AP_tit	BOZO	Marie	F	1974	TCH	J - Gestion et pilotage (GP)		ENS LYON		MESR	SC		
Ch_tit	BRISEBARRE	Nicolas	H	1971	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E1		
EC_tit	BUSSON	Anthony	H	1973	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MEN	E4		
EC_tit	CANIOU	Yves	H	1975	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MEN	E2		
EC_tit	CARON	Eddy	H	1972	MCF	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E2		
Ch_tit	CLAIRAMBAULT	Pierre	H	1983	CR2	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E6		
EC_tit	CRESPELLE	Christophe	H	1979	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MEN	E4		Crespelle
Ch_tit	DARTE	Alain	H	1968	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E3		
AP_tit	DELAMARE	Simon	H	1983	IR	E - Informatique, Statistique et Calcul Scientifique (ICS)		CNRS		MESR	SC		
AP_tit	DESPLANCHES	Catherine	F	1962	TCH	J - Gestion et pilotage (GP)		CNRS		MESR	SC		
EC_tit	FAWZI	Omar	H	1985	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E5		
Ch_tit	FEAUTRIER	Paul	H	1940	PREM	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E3		

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
EC_tit	KARSAI	Marton	H	1981	MCF	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E4		
EC_tit	KOIRAN	Pascal	H	1969	PRCE	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E5		
EC_tit	LAGUILLAUMIE	Fabien	H	1978	PR2	ST6 Sciences et technologies de l'information et de la communication	oui	U LYON 1		MEN	E1		
Ch_tit	LAURENT	Olivier	H	1977	DR2	ST6 Sciences et technologies de l'information et de la communication	oui	CNRS		MESR	E6		
Ch_tit	LEFEVRE	Vincent	H	1973	CR1	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E1		
Ch_tit	LEFEVRE	Laurent	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E2		
EC_aut	LESCANNE	Pierre	H	1947	PREM	ST6 Sciences et technologies de l'information et de la communication	oui	ENS LYON		MESR	E6		
Ch_tit	L'EXCELLENT	Jean-Yves	H	1970	CR1	ST6 Sciences et technologies de l'information et de la communication	oui	INRIA		MESR et MINEFI	E7		
Ch_aut	LIBERT	Benoit	H	1976	POST-DOC	ST6 Sciences et technologies de l'information et de la communication		ENS LYON		MESR	E1		
Ch_aut	LOUP	David	H	1994	IR	ST6 Sciences et technologies de l'information et de la communication		INRIA		MESR et MINEFI	E2		
EC_tit	LOUVET	Nicolas	H	1980	MCF	ST6 Sciences et technologies de l'information et de la communication		U LYON 1		MEN	E1		
Ch_tit	MARCHAL	Loris	H	1980	CR1	ST6 Sciences et technologies de l'information et de la communication		CNRS		MESR	E7		

Additif

Personnels INRIA hébergés au LIP

Type d'emploi (1)	Nom	Prénom	H/F	Année de naissance (XXXX)	Corps-grade (1)	Disciplines AERES / Branches d'Activités Profession (BAP) (1)	HDR (2)	Etablissement ou organisme employeur (3)	Code UAI de l'établissement ou organisme employeur (4)	Ministère(s) de tutelle (5)	N° de l'équipe interne du prochain contrat, le cas échéant (6)	N° de l'unité d'origine, le cas échéant (7)	Signature des personnels
AP_tit	BOYER	Sylvie	F	1959	IE	J		INRIA		MESR et MINEFI	SC	Janvier 2001	
AP_tit	IMBERT	Matthieu	H	1970	IR	E		INRIA		MESR et MINEFI	E2	octobre 2007	

(1) Sélectionner les informations dans le menu déroulant, si besoin voir feuille MenusR pour les détails des nomenclatures.
(2) Inscrire « oui » dans les cases correspondant aux personnels habilités à diriger des recherches.
(3) Sélectionner les informations dans le menu déroulant.
Si l'établissement ou l'organisme n'est pas présent dans la liste ou la feuille UAI_Etab_Org, indiquer le nom en clair.
Pour les émérites, indiquer le dernier établissement ou organisme employeur.
(4) Ne rien saisir dans cette colonne.
NB : Certaines entités listées peuvent ne pas avoir de code UAI et et la case restera vide.
(5) Voir nomenclature proposée en bas de la colonne.
En cas de tutelles multiples, il est possible de compléter la saisie, ex. MESR, MAEE.
(6) Utiliser le numéro de la liste rappelant les équipes composant l'unité pour le prochain contrat de la feuille "Structure unité"
(7) Utiliser le numéro de la liste rappelant les unités concernées par la restructuration pour le prochain contrat de la feuille "Structure unité".

AGRICULTURE	Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt
CULTURE	Ministère de la Culture et de la Communication
DEFENSE	Ministère de la Défense
INTERIEUR	Ministère de l'Intérieur
JUSTICE	Ministère de la Justice
MAEE	Ministère des Affaires Étrangères et Européennes
MED	Ministère de l'Écologie, du Développement Durable et de l'Énergie
MEN	Ministère de l'Éducation nationale
MESR	Ministère de l'Enseignement supérieur et de la Recherche
MINEFI	Ministère de l'Économie et des Finances
R.PROD	Ministère du Redressement Productif
SANTE	Ministère des Affaires Sociales et de la Santé
SPORTS	Ministère des Sports, de la Jeunesse, de l'Éducation populaire et de la vie associative
	Autre préciser