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Optimizing a public 3G/LTE wireless network and associated services for minimum energy consumption or emissions

For the COST 804 Training school on Energy savings in distributed systems, March 2011

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Issues

- 1. Characterize the energy consumption and emissions *jointly* of public wireless network *infrastructure* and of the actual services derived *traffic*
- 2. Characterize wireless infrastructure *technology* and *standards* migration effects (e.g. 3G,HSPDA, LTE
- 3. Offer a tool to industry allowing to *design basic and value-added service tariffs* in view of eventual investments in reneweable energy production, and of the introduction of « *green* » *telecommunications tariffs*

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Modelling approach

- Build from an industry tool a quasi-real *network infrastructure and traffic model*, with energy footprints for all main subsystems (radio, transmission , cooling) and traffic dependent energy consumption (circuit switched and IP); there is provisioning of a set of services to a subscriber base
- Structure the *economic sub-model* of CAPEX, OPEX, Billing, CRM, Network management,Content acquisition and net energy costs, as a model of the *marginal flows* linked to one additional user, on top of an existing subscriber base;use of estimated Cobb Douglas functions
- Include a *reverse auction bidding process*, whereby the incremental user states the service duration, his basic bundle price offer, and his value-added bundle offer for the service duration; operator then must select and configure network ressources accordingly allowing *fine-tuning of tariffs and incentives with profitability and emissions contraints*

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Infrastructure

- UTRAN (Radio): RBS* etc.. for:GSM/GPRS, EDGE/HSPDA , LTE (100 Mb)
- Transmission: line cards*, Microwave links*, ATM over IP*, WDM , SONET
- Backbone: MGW*, edge routers*, core routers*, AAA, signalling
- Storage : CDR , billing / CRM data , on-demand media, regulated security records
- Power: electrical grid power, local wind power, local sun power , backup local power
- Cooling: (*)
- Network capacity adapted to meet QoS thresholds given subscriber bids (incl, service mix); excess capacity not used by generic services may be used by value-added services ; if it is insufficient, extra capacity provisioned by SLA at higher rates

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Services

- Basic: Network management , billing / CRM
- Generic services: voice, SMS/MMS and metered IP traffic
- Value-added service : for illustration: M-Singing where a user download songs, and has interactive comments by a paid employee to improve his performance; extensively researched in terms of personalized tariffs
- Other value-added services studied : Mobile video, technical wireless field support , public ticketing

Incremental user bids e.g: 6 months, 60 Euros for generic services, and eventually 150 Euros for value-added service

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Energy

- Parametric proportion of distributed nodes (RBS, TRX , links) with renewable energy sources
- Provision of a minimum electrical grid / backup supply proportion of all distributed nodes in relation to infrastructure nodes' and local traffic power consumption (incl. cooling)
- All core infrastructure, real-time storage and backup transmission links on in-sourced electrical grid power
- Parametric mix wind/ solar with full imputation of CAPEX power source infrastructure costs to operator
- Excess reneweable power supply from the wireless network sold at eventually subsidized rates, reducing total OPEX

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Subsystem data

- Real technical data (power, volume, voltage, frequency, performance) used in most cases from 8 different worlwide suppliers, for different technologies / generations
- Real cost, power usage and investment data cross-validated between three public international operators
- When relevant statistical regression estimated or usage of different research groups approximation formula from physical measurements
- Available but no yet incorporated: building premises and eventual separate data center models; buildings model available from our COST804 partner Cenergia A/S

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Base case

- 10 Million subs
- Teledensity 576 users/ cell
- Typical average power consumption / user /month 18 kWh
- Parametric share of RBS with reneweable sources, typically 15 %

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Infrastructure emissions vs. Service based

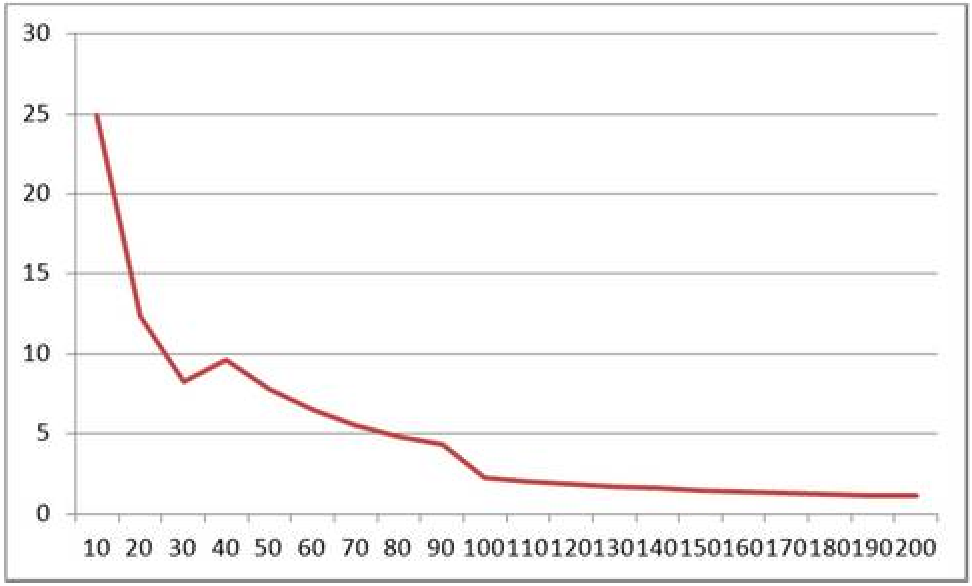
CASE 1:			
	Contract duration in month(s)	3	Mostly EDGE
	User proposed Msinging service bundle price (euro)	100	
	User basic bundle (euro)	50	

CO_2 emissions driven by capacity in kg/user/contract: 20,02
CO_2 emissions driven by capacity and generic services in kg/ user/ contract :21,05
CO_2 emissions driven by value-added service in kg/ user/ contract:0,45
Reneweable energy resold: 403 581 Euros

CASE 2:			
	Contract duration in month(s)	1	Mostly LTE
	User proposed Msinging service bundle price (euro)	50	
	User basic bundle (euro)	260	

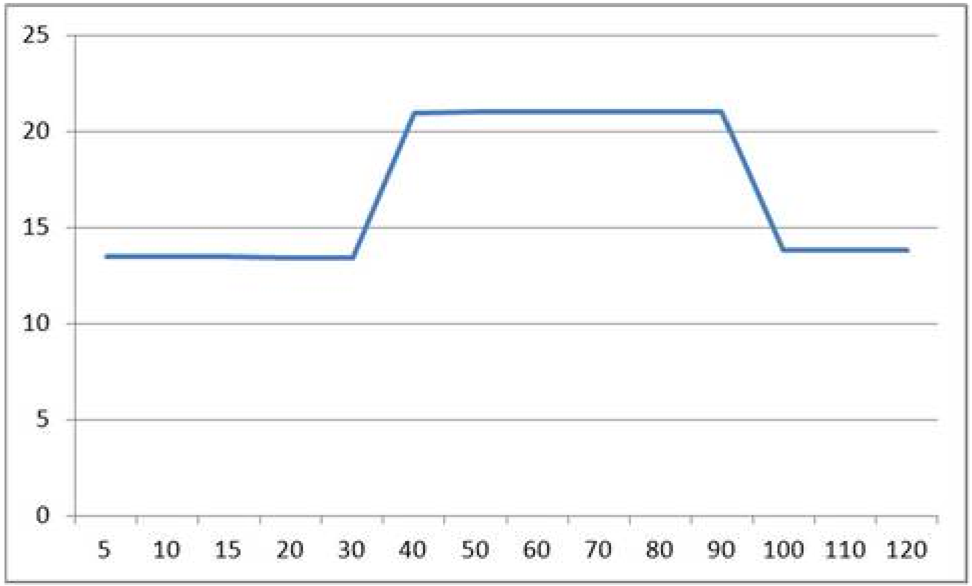
CO_2 emissions driven by capacity in kg/user/contract: 6,57
CO_2 emissions driven by capacity and generic services in kg/ user/ contract :7,09
CO_2 emissions driven by value-added service in kg/ user/ contract:0,00
Reneweable energy resold: 194 071 Euros

Net Energy costs per user in % of total OPEX vs Basic Bundle (Euros)



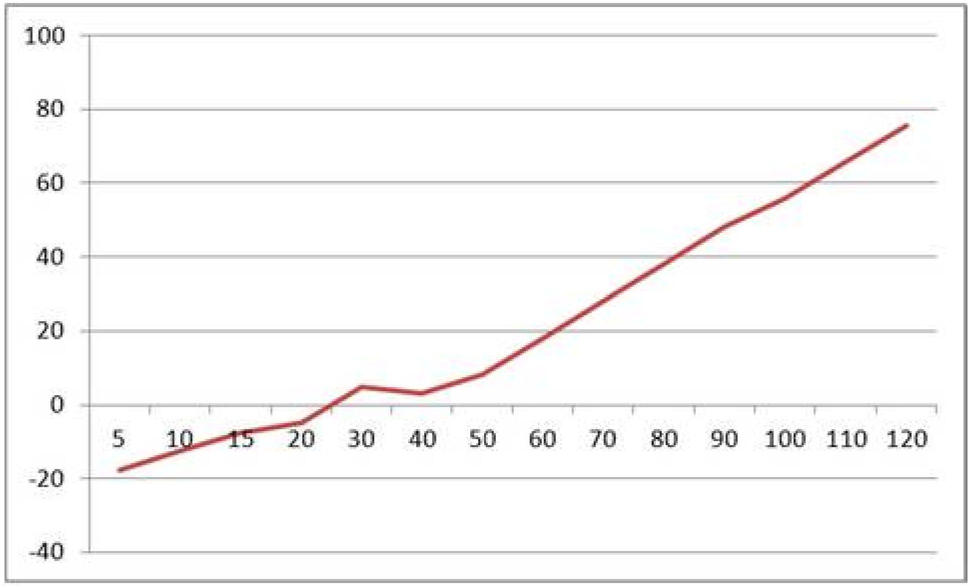
Contract duration in month(s)	3
User proposed Msinging service bundle price (euro)	100
User basic bundle (euro)	50

CO2 emissions per user in kg CO2 vs. Basic bundle offer (Euros) (access terminals excluded)



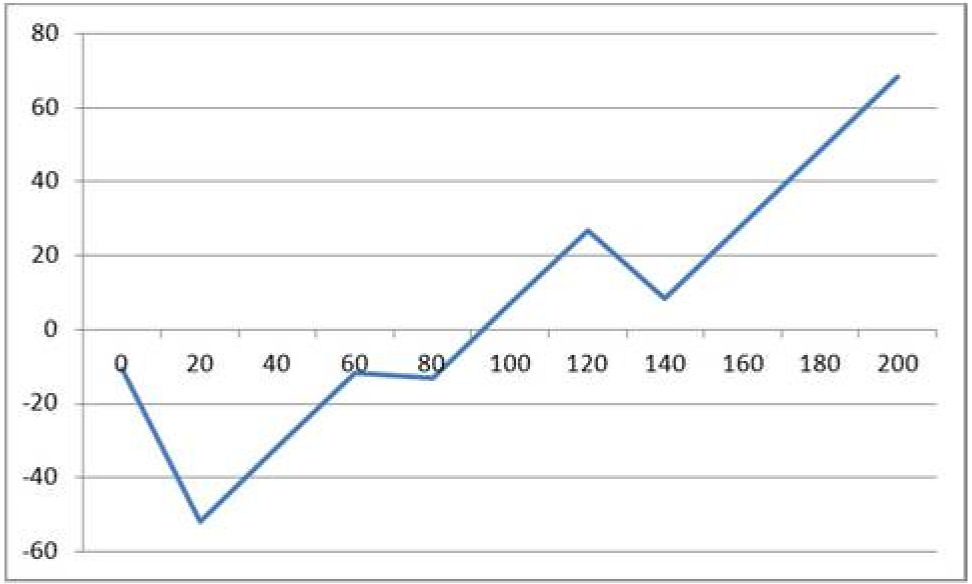
Contract duration in month(s)	3
User proposed Msinging service bundle price (euro)	100
User basic bundle (euro)	50

Net profit per incremental user from contract vs basic bundle offer (Euros)



Contract duration in month(s)	**3**
User proposed Msinging service bundle price (euro)	**100**
User basic bundle (euro)	**50**

Net profit per incremental user from contract vs value-added service bundle offer (Euros)



Contract duration in month(s)	3
User proposed Msinging service bundle price (euro)	100
User basic bundle (euro)	50

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Results

- General: There are very many interactions to account for,
- Issue 1: Although CO2 emissions due to infrastructure capacity / coverage dominate, the share of generic services and especially of value-added services grows rapidly with service/content richness and real-time performances
- Issue 2: While taking into account spectral system efficiency and frequency bands, emissions get slightly smaller with newer technologies, subject mostly to design and microelectronics progress; critical is the mix of low emissions green technologies in RBS nodes
- Issue 3: New « green » tariffs can be designed by: (a) personalized service characteristics reducing wasted capacity , and (b) incentivizing users to larger renewable power supply grades by OPEX bonus'es. The impact is though mostly from and for high traffic/ content users.

Further research

- Introduce technology learning curves, esp. from improved multicore DSP's/ASIC's , low power real-time storage, and migration to <0,25 micron designs
- Work and propose in standardization bodies « greener » node architectures
- Finalize a « green tariff » business case and package