An Energy-Aware Design and Reporting Tool for On-Demand Service Infrastructures

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TELEFÓNICA I+D

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Outline

01 Problem statement

Resource wasting in traditional infrastructures

- Many service architecture design decisions have a great impact in power consumption
  - Infrastructure architecture
  - Resource allocation
  - Performance or availability requirements
- Users are seldom confronted with information on
  - Resource utilization levels
  - Energy-related impact of their architecture decisions
  - Instant or periodic service power consumption
- Inefficient utilization of computing resources due to infrastructure user behavior
  - Overperforming architectures
  - Resource overprovisioning

01 Problem statement
Resource wasting in cloud-oriented infrastructures

- Cloud infrastructure users reproduce the traditional behavior
- User/service power consumption is more difficult to single out
  - Complete isolation from physical resources
  - Systems are shared both concurrently and over time
- No incentives for energy-saving
  - No energy-oriented infrastructure statistics
  - No energy-related charges or discounts

01 Energy-aware design and reporting tools

Main goals

- Energy-aware infrastructure architecture design tools
  - Expose the energy impact of design decisions
  - Show the influence of energy in operating expenditures
- Service-level energy chargeback tools
  - Report and expose service/user energy consumption
  - Turn energy/power into a billable parameter
- Expected impact
  - Raise energy awareness among infrastructure users
  - Promote a rational usage of computing resources

01 Energy chargeback tools

Background

- Hardware-level solutions
  - Monitor and track server power consumption with no need of external monitoring equipment
    - Embedded thermal and power sensors
    - Standard management protocols (IPMI, WBEM, etc.)
- Virtualization-level solutions
  - Host and guest resource monitoring
  - Per-host energy chargeback models
- Service-level solutions
  - Resource usage accounting and chargeback tools
  - Power is considered a fixed infrastructure cost
- No support in IaaS management APIs or dashboards

01 Energy-aware design tools

Background

- Hardware-level solutions
  - Power and thermal infrastructure CAD
- Virtualization-level solutions
  - Power profiling, prediction and capping for well known workloads
- Service-level solutions
  - Cloud simulators for resource scheduling and allocation policy selection for a given workload
- No support in IaaS management APIs or dashboards

Outline

02 Business-Oriented Dynamic Infrastructures (BODIes)

Infrastructure services model

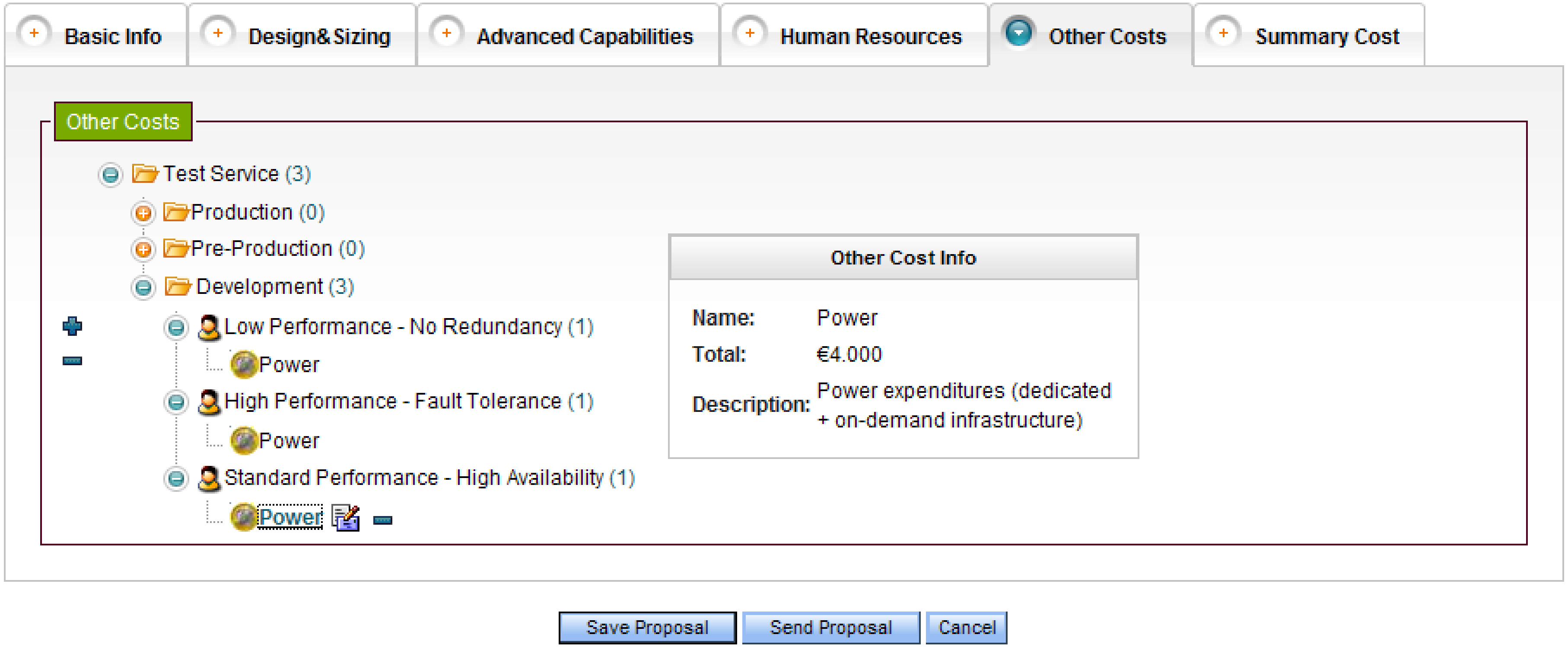
- Enhanced IaaS for service providers
  - Commoditize the deployment of service infrastructure architectures
  - Service providers only deploy their value-added logic
- Infrastructure Component
  - Sized Virtual Machine + Full SW stack (OS, middleware, etc.)
- Building Block
  - Set of Infrastructure Components tested and certified to work well in combination
- Scalability rules
  - Dedicated or fixed infrastructure
  - Variable or on-demand infrastructure (optional)

02 Energy-aware architecture design

Infrastructure architecture composition in BODIes

02 Energy-aware architecture design

Energy cost details



02 Energy-aware architecture design

Infrastructure architecture comparison and selection

Basic Info | Design&Sizing | Advanced Capabilities | Human Resources | Other Costs | Summary Cost

Summary Cost (thousands of euros per year)

Service Name: Test Service

Environment	Alternatives	Component Catalog (Dedicated)	Component Catalog (Pay per Use)	Advanced Capabilities	Human Resources	Others	Fixed Cost	Estimated Variable Cost	Price Imputed (Dedicated)	Price Imputed (Pay per Use)	Deploy
Development	Low Performance - No Redundancy	€15.811,5	€72	€0	€0	€1.000	€16.811,5	€72	0.0	0.0	
	High Performance - Fault Tolerance	€16.231,5	€80	€0	€0	€5.000	€21.231,5	€80	0.0	0.0	
	Standard Performance - High Availability	€10.060,5	€77	€0	€0	€4.000	€14.060,5	€77	0.0	0.0	

Accept proposal

Save Proposal | Send Proposal | Cancel

Outline

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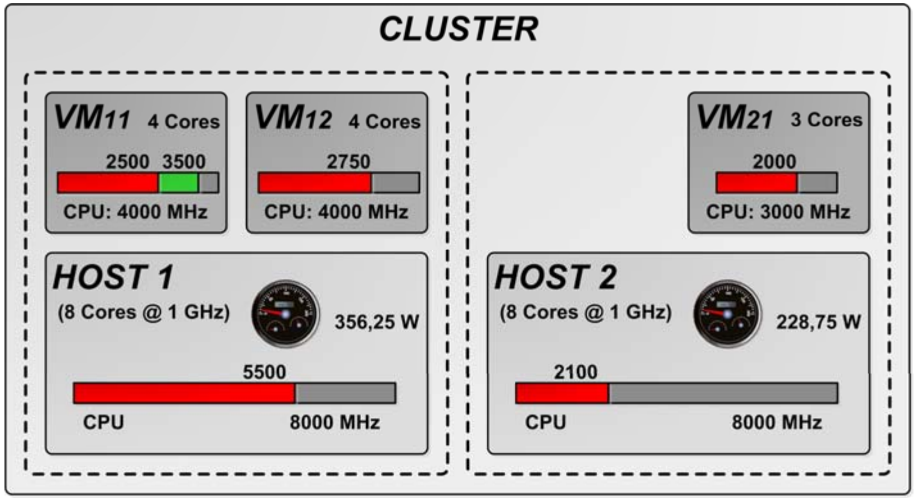
04 Service-level energy chargeback

Direct power consumption vs. power overhead

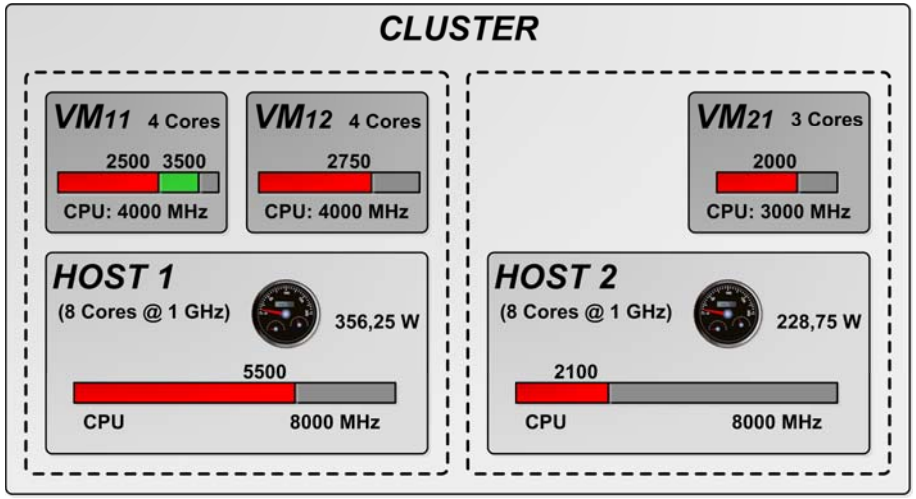


$$P_o = \sum_{i=1}^{n} \left(P_{idle_i} + \frac{\left(P_i - P_{idle_i}\right) \cdot \left(CPU_i - \sum_{j=1}^{m} CPU_{vm_{ij}} \right)}{CPU_i} \right)$$

	P (W)	Pidle (W)	P - Pidle (W)	CPU (MHz)	∑CPUvm (MHz)	Pd (W)	Po (W)
Host 1	356,25	150,00	206,25	5500	5250	196,88	159,38
Host 2	228,75	150,00	78,75	2100	2000	75,00	153,75
Total	585,00	300,00	285,00	7600	7250	271,88	**313,13**

04 Service-level energy chargeback

Virtual machine power consumption



$$P_{o_{ij}} = P_o \cdot \frac{Max(CPU_{vm_{ij}}, RES_{vm_{ij}})}{\sum_{k=1}^{n}\sum_{l=1}^{m} Max(CPU_{vm_{kl}}, RES_{vm_{kl}})}$$

$$P_{d_{ij}} = \frac{(P_i - P_{idle_i}) \cdot CPU_{vm_{ij}}}{CPU_i}$$

	CPU (MHz)	RES (MHz)	Pd (W)	Po (W)	P (W)
VM11	2500	3500	93,75	132,84	**226,59**
VM12	2750	0	103,13	104,38	**207,50**
VM22	2000	0	75,00	75,91	**150,91**
Total	7250	3500	271,88	313,13	**585,00**

04 Service energy consumption visualization

BODIes infrastructure usage summary report

Infrastructure Usage

Service Name: Test Service
Deparment: 3013
Telephone Number: +34913374000
Budget: €1.000.000

Email:
Sender Name: Miguel Gómez
Billing Period: 01/05/2009-31/05/2009
Emission Date: 31/05/2009

Servers								
Tier	Concept	CPU (days)	RAM (MB Days)	IO Read (MB)	IO Write (MB)	Net Read (MB)	Net Transfer (MB)	Power (Kwh)
FrontEnd	VM 4 CPU Intel Xeon - node1	4.23	1,254.23	124.41	722.76	65.59	304.91	334.00
FrontEnd	VM 4 CPU Intel Xeon - node2	1.18	633.21	52.48	258.17	20.24	110.14	120.42
FrontEnd	VM 4 CPU Intel Xeon - node3	1.16	680.13	54.65	259.14	19.14	111.27	135.31
BackEnd	2 Proc UltraSparc - Oracle	7.15	4,117.87	1,234.31	104.3	62.32	1,782.35	894.31

Operating System				
Tier	Concept	CPU (days)	Elapsed time (days)	IO (MB)
FrontEnd	Win2003 Server - Nodo 1	3.90	29.99	315.89
FrontEnd	Win2003 Server - Nodo 2	0.95	3,89	94.57
FrontEnd	Win2003 Server - Nodo 3	0.85	3,94	85.42
BackEnd	Solaris 10 - Database	6.01	29.99	1,720.44

Middleware					
Tier	Concept	Time usage (hours)	User Sessions	Recv Data (GB)	Sent Data (GB)
FrontEnd	Bea Weblogic Server 8.1 - node1	29.99	1855	60.24	281.14
FrontEnd	Bea Weblogic Server 8.1 - node2	12.74	435	17.14	89.77
FrontEnd	Bea Weblogic Server 8.1 - node3	15.75	355	16.28	91.27

Database											
Tier	Concept	Connect (Hours)	User Commits	DB Block Gets	Logins	Recv Msg	Sent Msg	PGA Mem (GB)	Rec CPU (Days)	Session CPU (Days)	UGA Mem (GB)
BackEnd	Oracle 10g	245.44	4,850	125	17	6,877	4,487	9,478	5.01	6.06	5,098

Outline

- Conclusions
- Future work
- Questions?

05 Conclusions

- Infrastructure user behavior has great impact on energy consumption
  - Service architecture design
  - Resource allocation
  - Performance/availability requirements
- Awareness and incentives are powerful energy saving tools
  - Promote resource saving and energy-responsible design
    - Energy consumption estimations and cost quotations
    - Easy comparison and selection across alternatives
  - Avoid resource wasting by matching infrastructure resource requests to the actual service demands
    - Turn energy consumption into an IaaS billable parameter
    - Allow users to consult their current and past energy consumption and associated costs

05 Future work

- Enhance the CPU-based energy chargeback model with further parameters (e.g., memory usage, disk and network I/O, etc.)
  - Applicable to design-time estimations and runtime chargeback
- Extend the energy consumption monitoring framework to storage and communications equipment
- Enhance the dynamic infrastructure management system to take power optimization into consideration

05 Questions?

- Miguel Gómez Rodríguez

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