Monitoring experiences in large HPC infrastructures

From counters to clouds

A holistic point of view

Carlos Fernandez Sanchez
(Systems manager, Galicia Supercomputing Center)

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CESGA
XUNTA DE GALICIA
CONSELLERÍA DE INNOVACIÓN, E INDUSTRIA
CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS
MINISTERIO DE CIENCIA E INNOVACIÓN
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Agenda

- Monitoring in HPC (performance?)
  - Why monitor?
  - What monitor?
  - How to monitor? Tools (or lack of...). Holistic
- Accounting and billing
  - HPC infrastructures
  - Grid/Cloud infrastructures
- Other measurements & metrics
  - Power efficiency, productivity & others

FINIS TERRAE (2007)

Spanish National Singular Scientific & Technological Infrastructure

More than: **16 TFLOPS** **2,580 Itanium CPUs** **19 TB Memory**

LINUX, UNIX, WINDOWS

Why monitor

- Proactive problem solving
- Everything ok? Really?
- Users complain -> boss complains
- No performance (not expected level of performance)
- Maybe not because of system, but you need to know
- Efficient use of systems ->
  - Load balance among different supercomputers
  - Choose right system for the right problem
  - Detect incorrect use by users
  - Equal share among users
  - SLA fullfillment
- Batch system waiting time
- ....many more
- Mandatory to Plan and design new systems for the future

What monitor

- Core / Socket
- Chip Caches
- Memory & Memory buses
- IO devices (disk, networks) & PCI slots
- NUMA Challenges.... increasing topic
- Other hardware
- Whole Server
- Switches (Ethernet, Infiniband & FC)
- Use and performance of Services
- Performance? and performance modelling
- (Parallel) Filesystem use and performance
- Applications, software use & licensing
- Users
- Power usage, temperature (environment)
- Whole system (cluster + filesystems +....)
- Infrastructure support (UPS + Air conditioning + ...)
- **Correlate all these sensors**
  - **-> lot of experience -> Holistic approach -> use of AI**

How to monitor? Tools... and lack of

- Perfom
- Caliper
- Nagios
- Ganglia
- CMU
- Accounting tools
- Batch logs
- Top
- ps ...
- Who wants to join all of then?
- Correlate all these tools -> Holistic approach

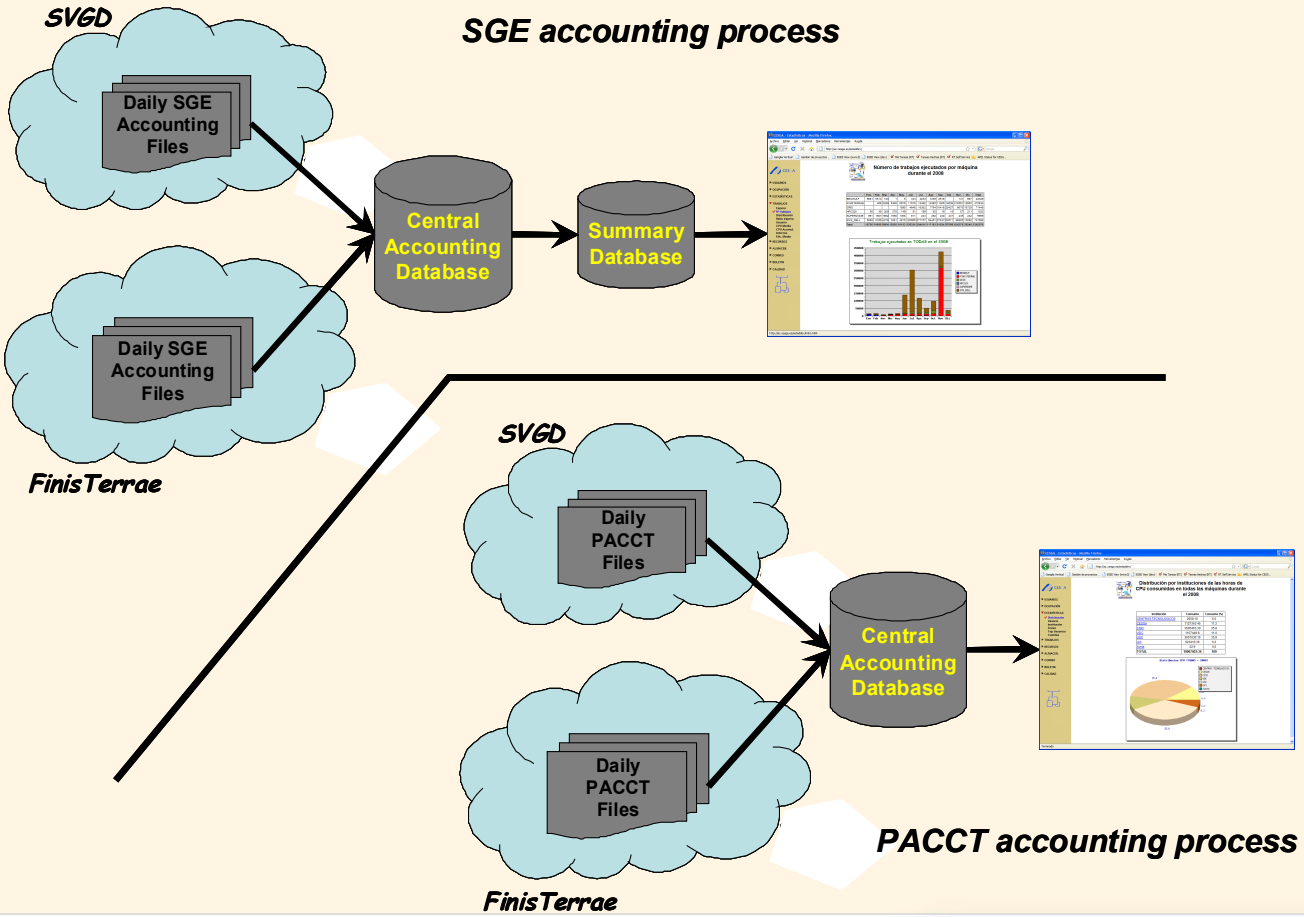
Tools (comparison)

Metrics|Tools	Ganglia	Nagios	Supermon	LLView	NWPerf	Monalisa	CMU
Lightweith sensors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Non intrusive sensors	Yes	Yes	No	Yes	Yes	Yes	Yes
Based on standard software	Yes	Yes	Yes	No (Unicore)	Yes	Yes	No (HP)
Real time analysis	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Port-mortem analysis (jobs) / Data repository	No/ Yes	No/Yes	No/Yes	Yes/Yes	Yes/Yes	Yes/Yes	No/Yes
Bottleneck detection	No	No	No	No	Yes	No	No
Performance analysis	No	No	No	No	Yes	No	No
System monitoring (cpu,mem,io..)	Yes	Yes	Yes	Yes	Yes	Yes (but need LISA)	Yes
Per-Job analysis	No	No	No	Yes	Yes	Yes	No
Per-user analysis	No	No	No	Yes	No	Yes	No
Intra-Job analysis (processes)	No	No	No	No	No	Yes	No
Visualization of results	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Database	Yes (RRDtool)	Yes (MySQL)	No	Yes (XML files)	Yes (posgresql)	Yes	Yes
Interactive interface	Yes	Yes	No	Yes	Yes	Yes	Yes

CESGA internal **accounting** tool

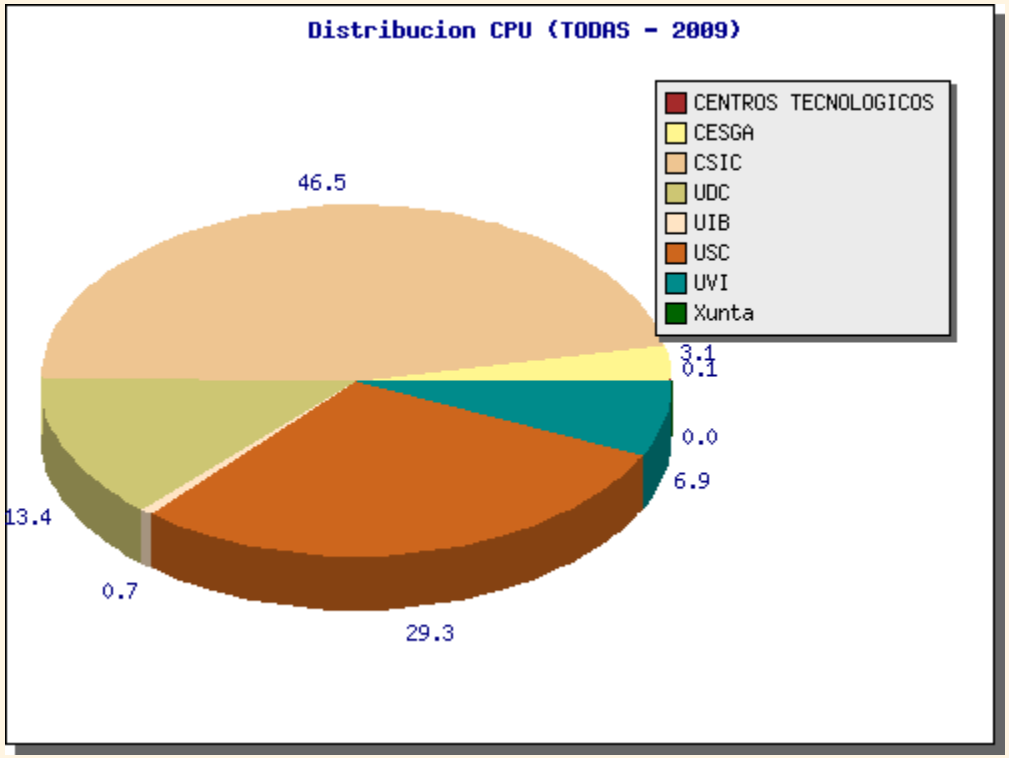
- Self developed over +10 years
- Web interface
- 3,000,000 records in DB
- Integrate User management (register, track, control)
- Accounts for the use of resources
- Principal statistics
  - CPU time, max memory, disk...
  - Resources reserved
  - Usage stats by user / institution /scientific area..

Accounting flow



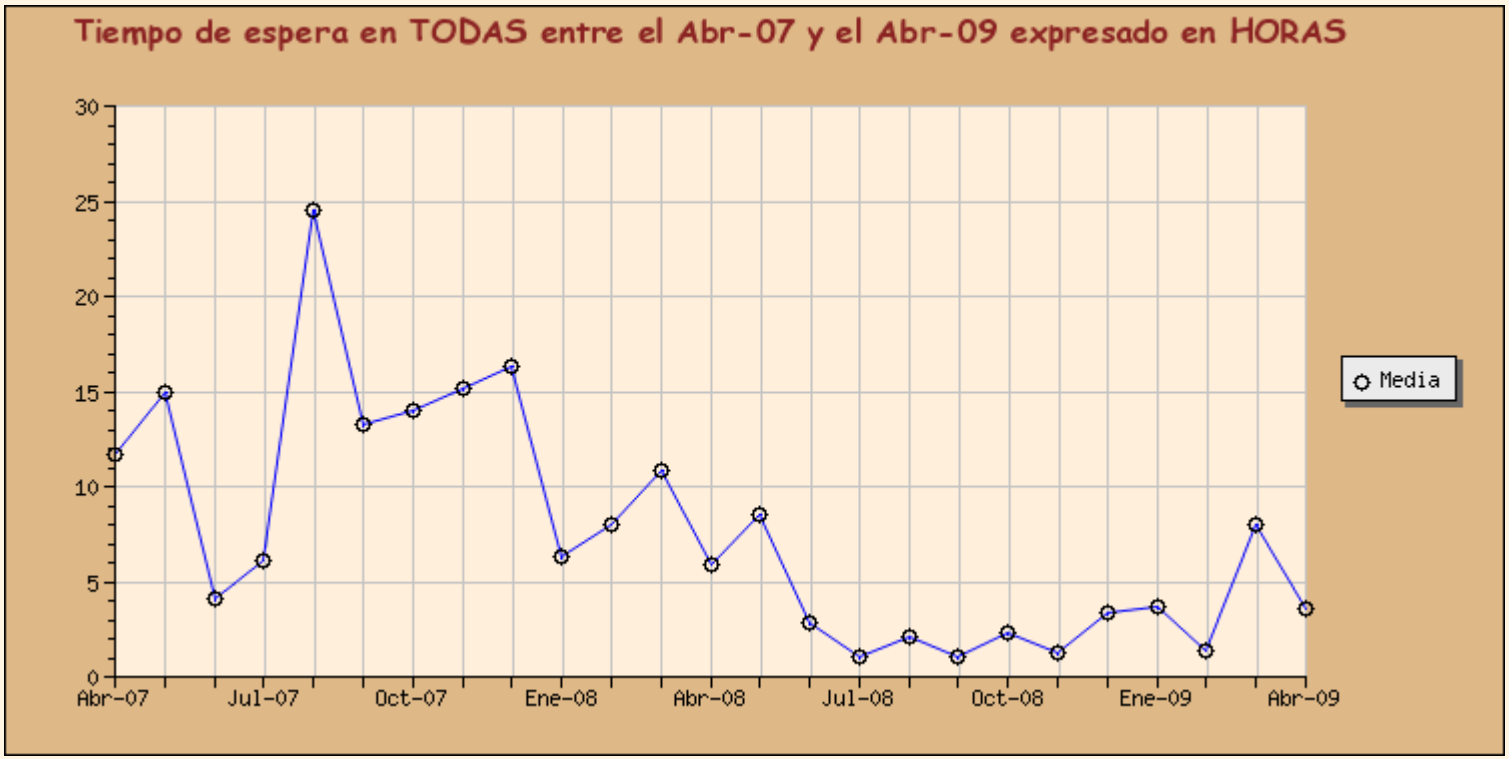
Examples: per institution use

Percentage of CPU use (all systems) by each institution



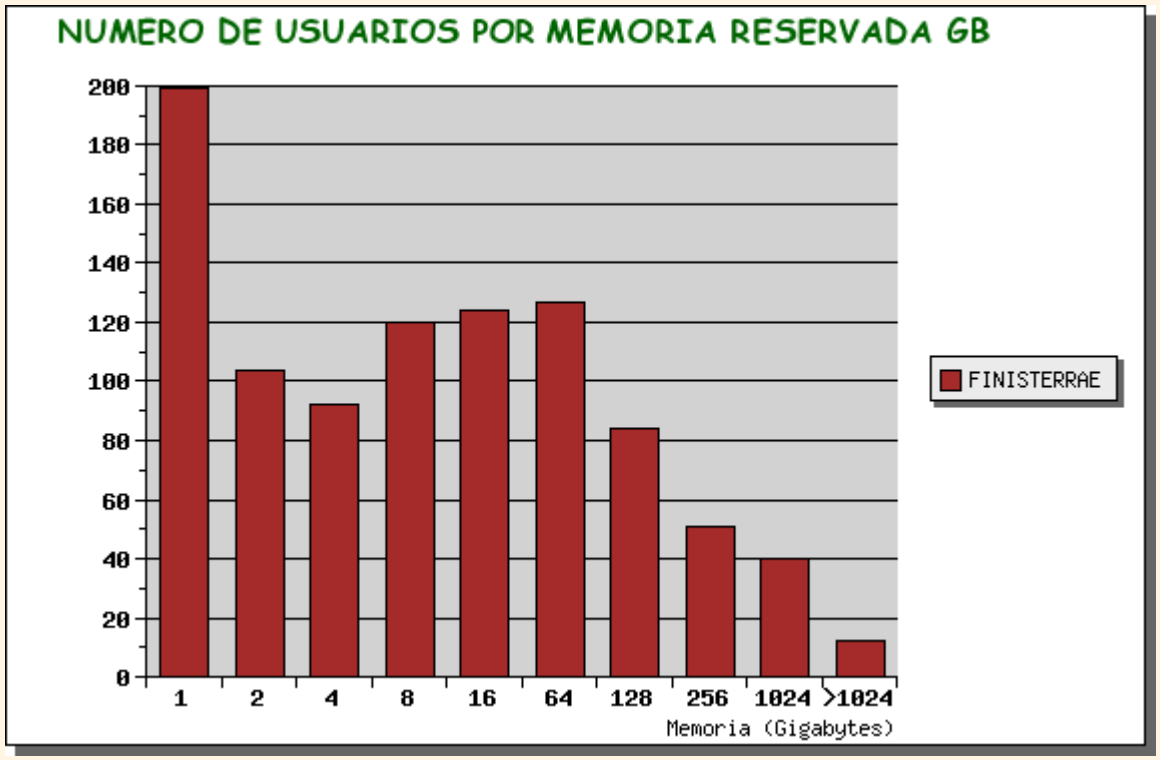
Examples: Batch system waiting time

Average waiting time (all systems) in hours since april 2007



Examples: resources reserved

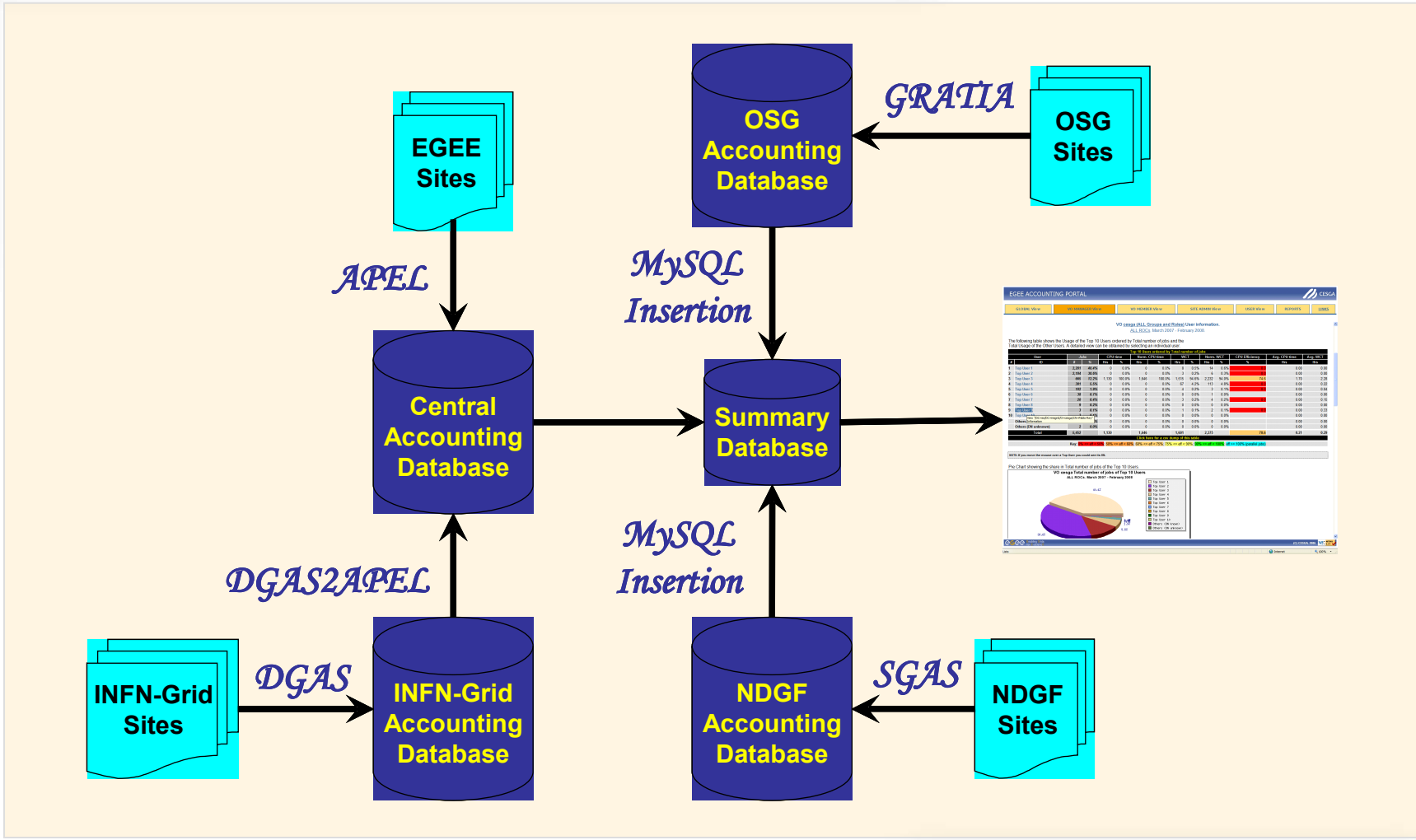
of users as a function of reserved memory



Grid Accounting in EGEE

- Largest production grid
- Key characteristics:
  - Over 267 sites, >50 countries, 114,000cpus
  - 200 Vos, > 16,000 users, > 150k jobs daily
- Accounting portal for EGEE:
  - Based on CESGA accounting tool
  - Collects per job usage records
  - Stores in centralized DB, >15,000,000 records
  - reports statistics about: per-VO, per-use, per-site, ... summarized by Region, tier, etc...

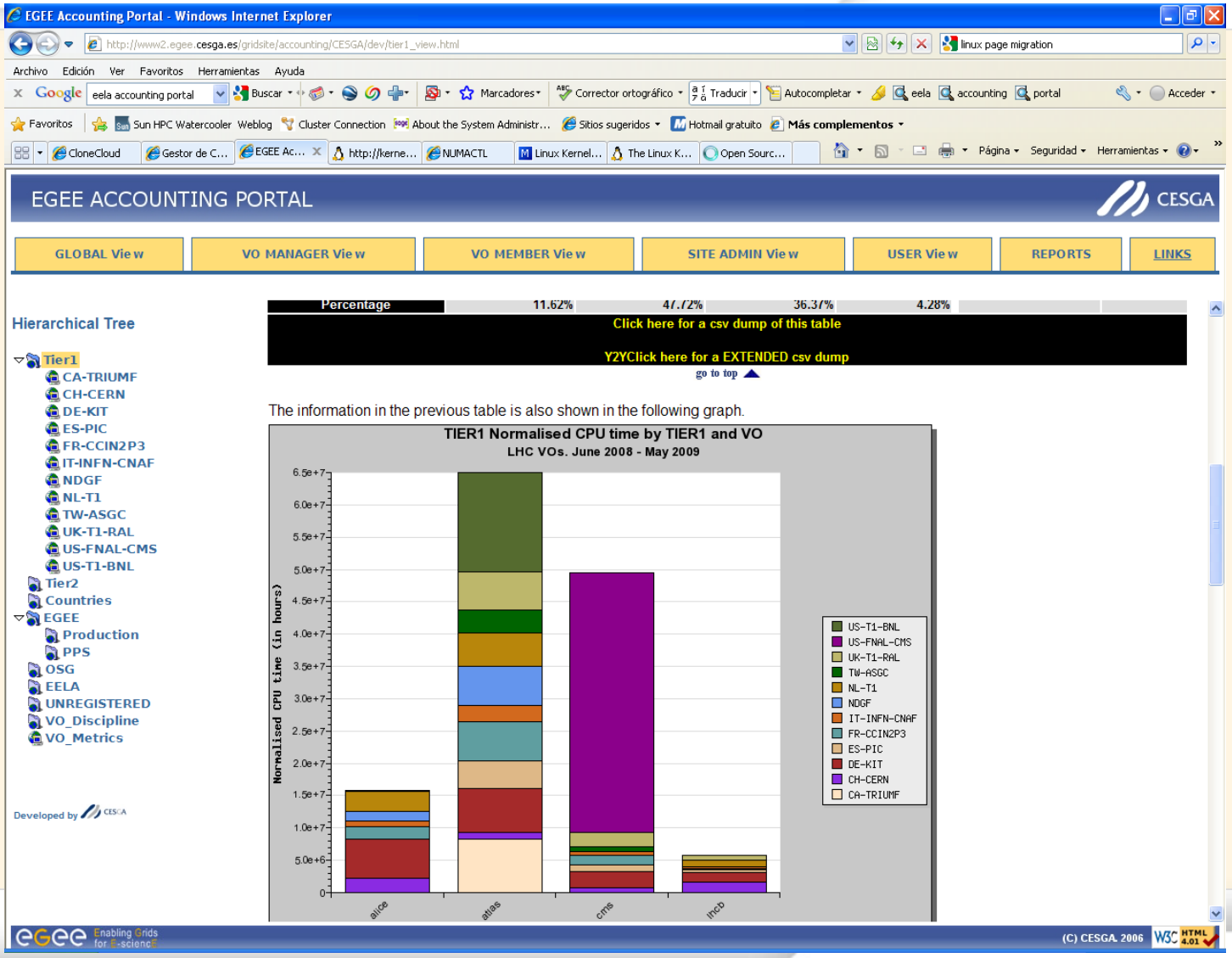
Accounting flow EGEE



Grid Accounting in EGEE

- Portal Access with user certificate (same for grid use)
- Consumed resources by VO/site/month:
  - number of jobs
  - Norm. Sum. CPU
  - Sum. CPU
  - Norm. Sum. Elapsed
  - Sum. Elapsed
  - CPU Job Efficiency
- Different views:
  - Tier1/2/Country/EGEE/OSG/VO Discipline View
  - Accounting per User
  - VO manager view
  - VO member view
  - Site admin view
  - User view

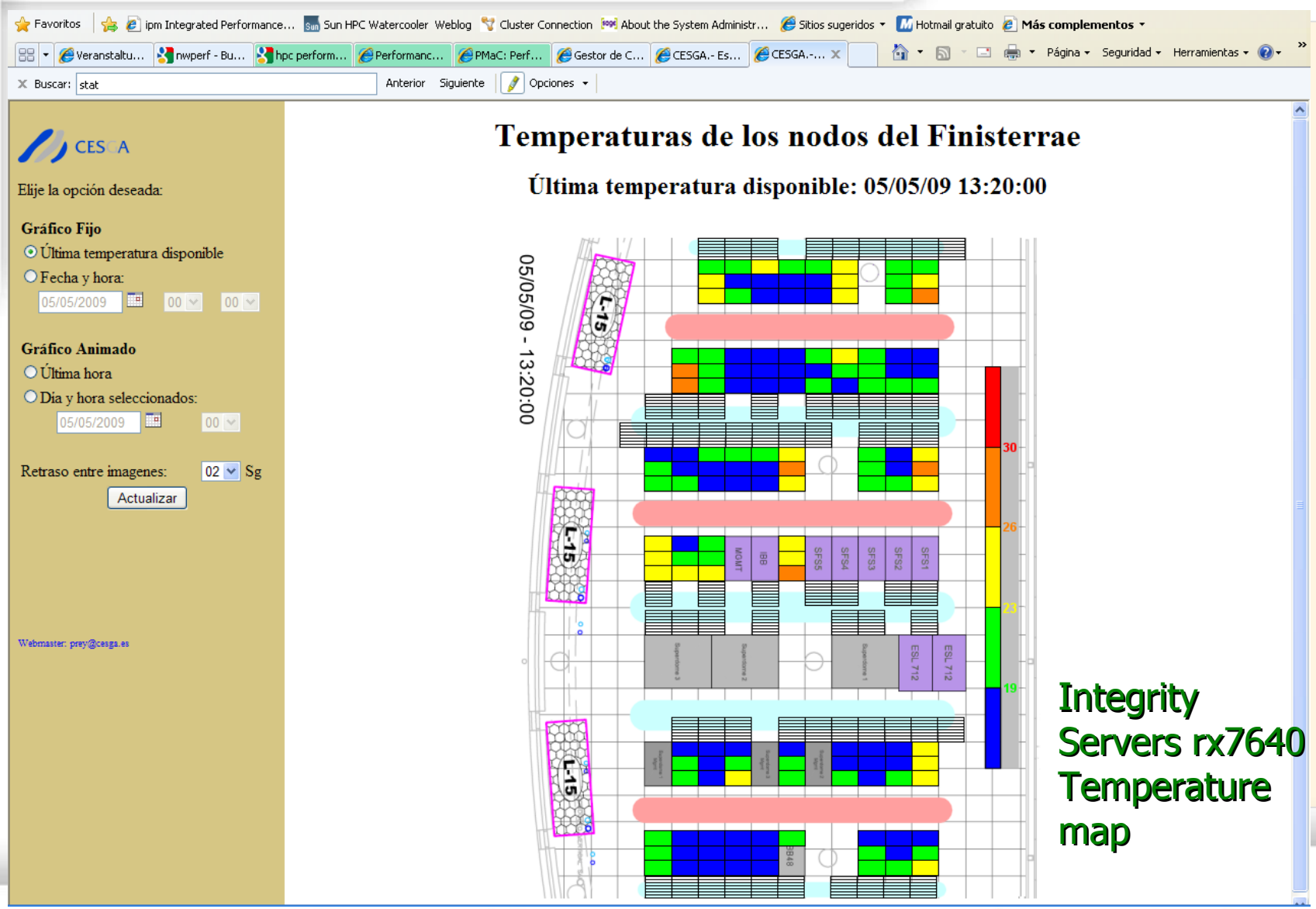
Grid Accounting/EGEE



Virtual servers
Accounting for cloud computing

- No warranty of CPU-use (accounting tools)
- 2 virtual CPUs over 1 CPU -> twice as much CPU time available!
- No real information about cpu use
- No isolation of systems -> Performance isolation?
- Xenmon (http://www.hpl.hp.com/techreports/2005/HPL-2005-187.pdf)
- Profiling -> Xenoprof
- Dom0 (hypervisor) cpu use corresponding to domx should be taken in account (domx+dom0)
- More monitoring issues (specially on performance)
- What happens with other virtualization systems:
  - KVM, vmware...

Environmental monitoring



Integrity Servers rx7640 Temperature map

Energy & Efficiency

the green grid℠
get connected to efficient IT

- Monitoring data center productivity
- Power Usage Effectiviness (PUE)=

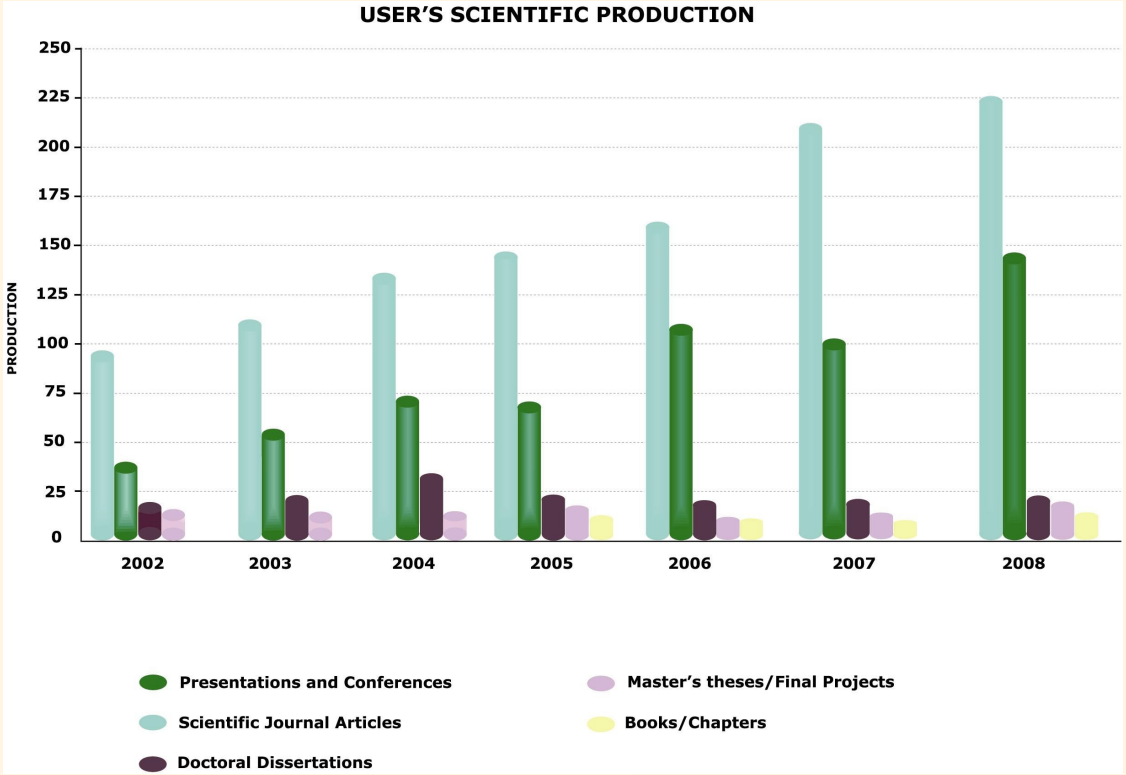
$$\frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

- Data Center Infrastructure Efficiency (DCiE) – Reciprocal of PUE
- Data Center Enery Productivity (DCeP)=

$$\frac{\text{Useful Work Produced}}{\text{Total Data Center Energy Consumed Producing this Work}}$$

Scientific Productivity

- This should be “the metric”?



Thanks for your attention!!!

- Q&A - carlosf@cesga.es