



Grid'5000*

**a large scale and highly reconfigurable
Grid experimental testbed**

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Agenda

Motivation

Grid'5000 design

Grid'5000 Architecture

Configuration example

Deployment system evaluation

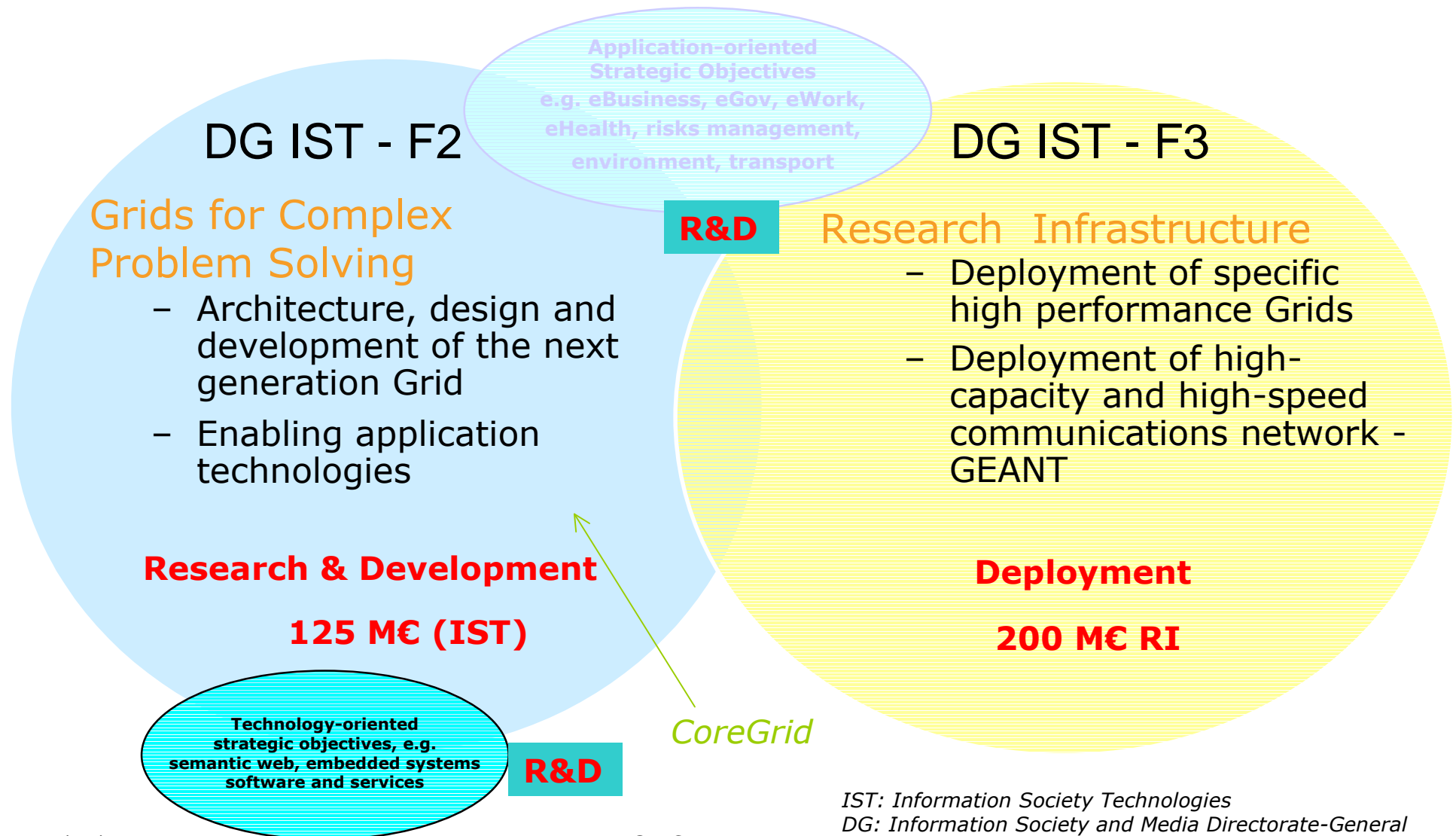
Conclusion

ACI GRID projects



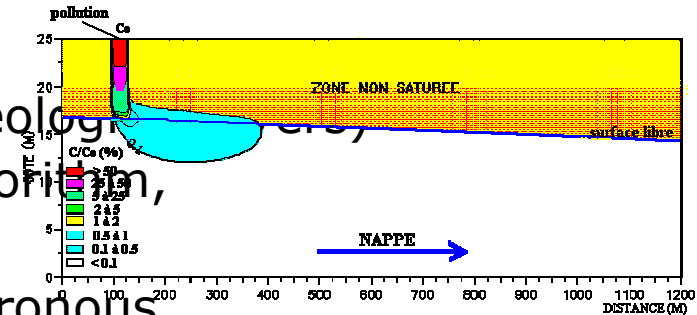
- Peer-to-Peer
 - CGP2P (F. Cappello, LRI/CNRS)
- Application Service Provider
 - ASP (F. Desprez, ENS Lyon/INRIA)
- Algorithms
 - TAG (S. Genaud, LSIIT)
 - ANCG (N. Emad, PRISM)
 - DOC-G (V-D. Cung, UVSQ)
- Compiler techniques
 - Métacompil (G-A. Silbert, ENMP)
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 - GriPPS (C. Blanchet, IBCP) - Bioinformatics
 - HydroGrid (M. Kern, INRIA) - Environment
 - Medigrid (J. Montagnat, INSA-Lyon) - Medical
- Grid Testbeds
 - CiGri-CIMENT (L. Desbat, UjF)
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 - GLOP (V. Breton, IN2P3)
 - GRID5000 (F. Cappello, INRIA)
- Support for disseminations
 - ARGE (A. Schaff, LORIA)
 - GRID2 (J-L. Pazat, IRISA/INSA)
 - DataGRAAL (Y. Denneulin, IMAG)

Research and Deployment in FP6 (2002-2006)



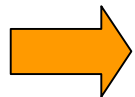
An Example on Fault tolerance

Consider an non trivial application:
 (transport of a polluting composite across geological layers),
 Using a parallel iterative finite difference algorithm,
 Implemented in MPI,
 With two variants : asynchronous and synchronous

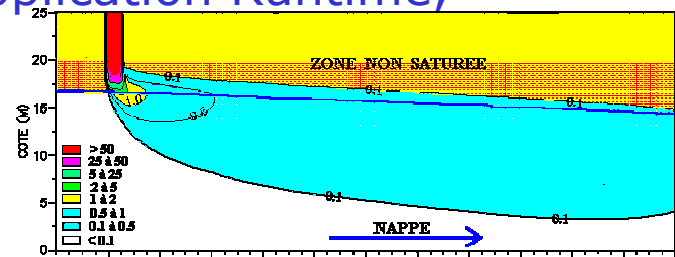


If you are considering any Grid software stack, there are several layers involved in fault tolerance:

- Network protocols, OS, Grid middleware, Application Runtime, Communication library, Application



Which layer(s) should be involved in the actual management of nodes and network failures? How to coordinate layer decisions?



What is the most efficient approach on the Grid:
 Synchronous or asynchronous iterative algorithm?



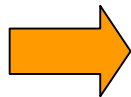
Grid & P2P raise research issues but also methodological challenges

Grid & P2P are complex systems:

Large scale, Deep stack of complex software

Grid & P2P raise a lot of research issues:

Security, Performance, Fault tolerance, Scalability, Load Balancing, Coordination, Message passing, Data storage, Programming, Algorithms, Communication protocols and architecture, Deployment, Accounting, etc.



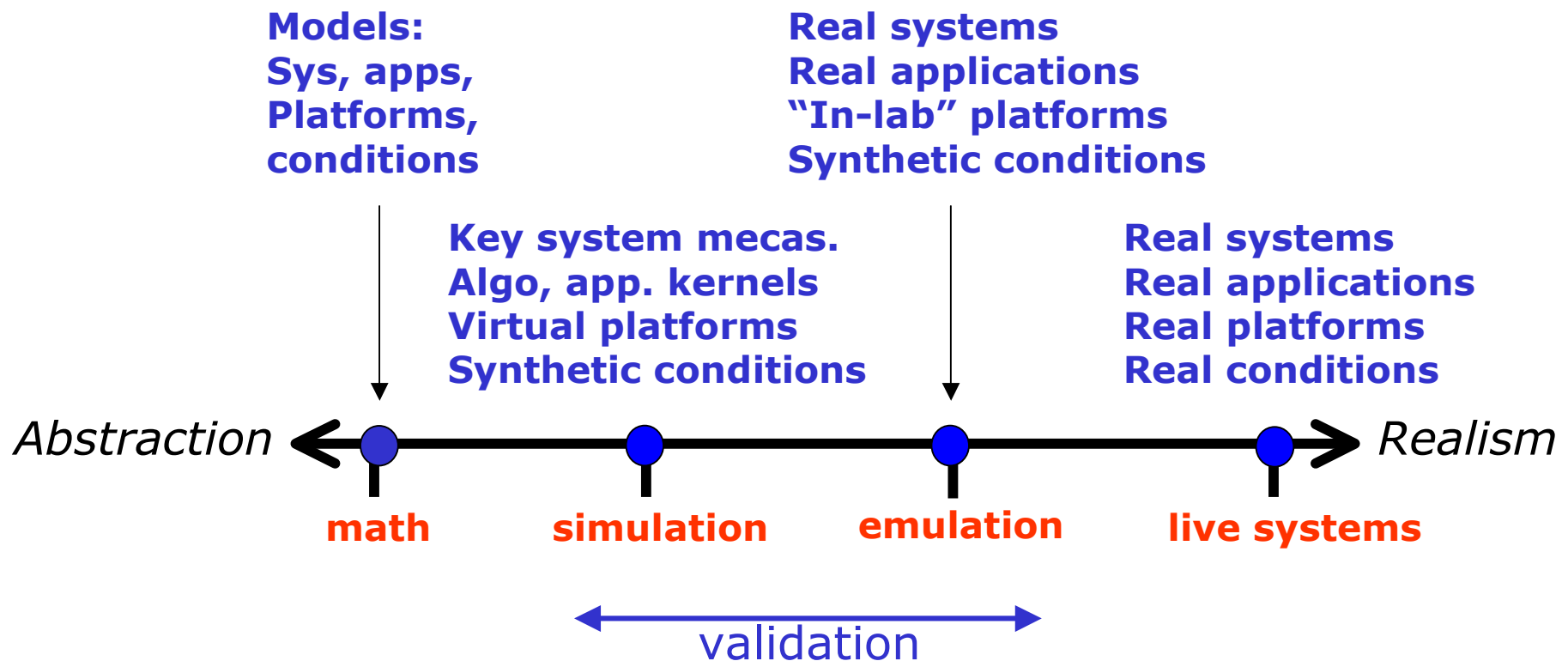
How to test and compare?

- Fault tolerance protocols
- Security mechanisms
- Networking protocols
- etc.

Tools for Distributed System Studies

To investigate Distributed System issues, we need:

1) Tools (model, simulators, emulators, experi. Platforms)



2) Strong interaction between these research tools



Existing Grid Research Tools

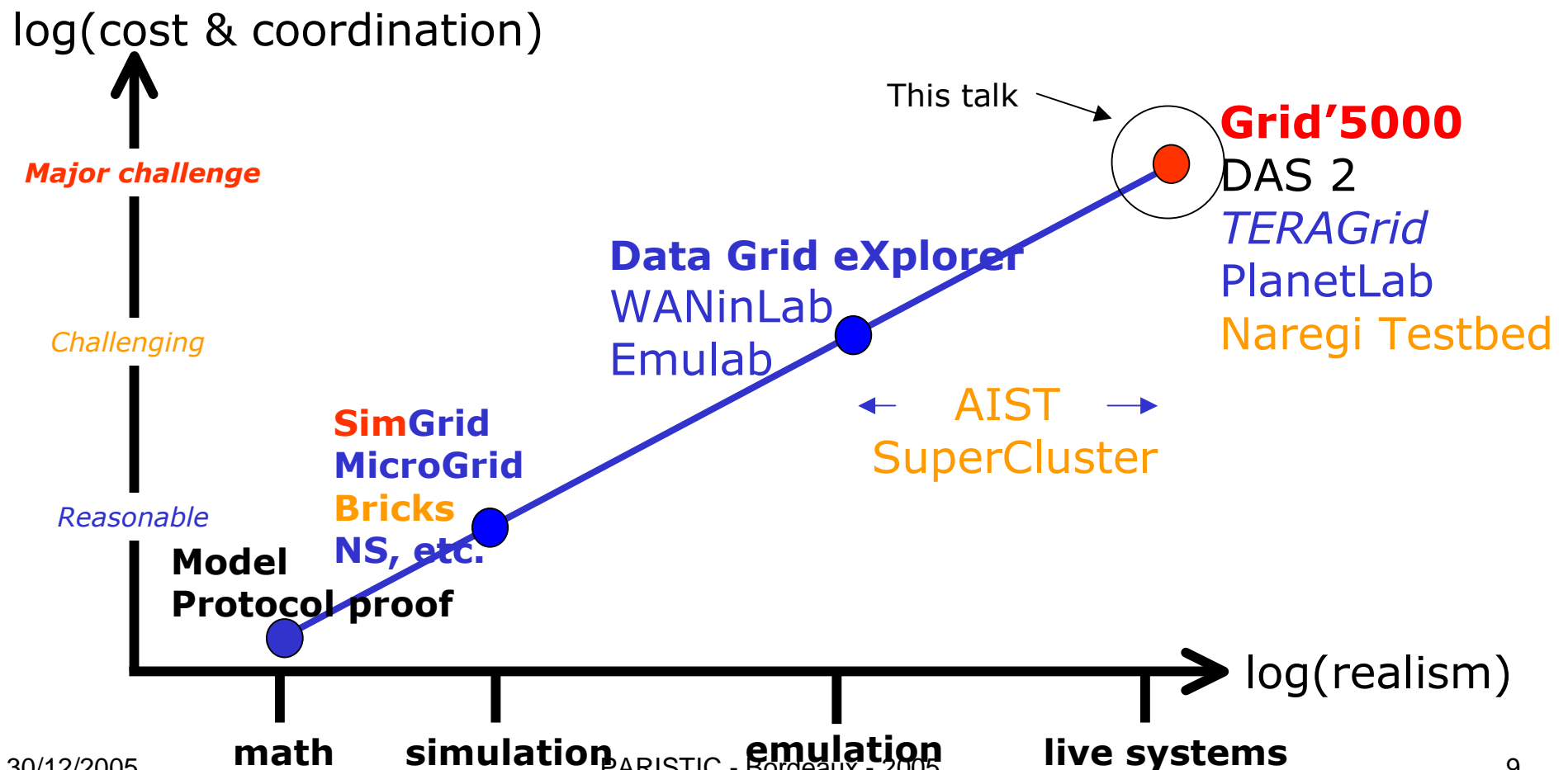
- **SimGRid and SimGrid2** ■ *France*
 - Discrete event simulation with trace injection ■ *USA*
 - Originally dedicated to scheduling studies ■ *Australia*
 - Single user, multiple servers ■ *Japan*
- **GridSim**
 - Dedicated to scheduling (with deadline), DES (Java)
 - Multi-clients, Multi-brokers, Multi-servers
- **Titech Bricks**
 - Discrete event simulation for scheduling and replication studies
- **GangSim**
 - Scheduling inside and between VOs
- **MicroGrid,**
 - Emulator, Dedicated to Globus, Virtualizes resources and time, Network (MaSSf)

à They do not capture 1) the complexity of real Grid software stack
2) the dynamic of real life Grid environments

We need Grid experimental tools

In the first ½ of 2003, the design and development of Grid experimental platform was decided:

à Grid'5000 as a real life system





The Grid'5000 Project

- 1) Building a nation wide experimental platform for Grid & P2P researches (like a particle accelerator for the computer scientists)
 - 9 geographically distributed sites
 - every site hosts a cluster (from 256 CPUs to 1K CPUs)
 - All sites are connected by RENATER (French Res. and Edu. Net.)
 - RENATER hosts probes to trace network load conditions
 - Design and develop a system/middleware environment for safely test and repeat experiments

- 2) Use the platform for Grid experiments in real life conditions
 - Address critical issues of Grid system/middleware:
 - Programming, Scalability, Fault Tolerance, Scheduling
 - Address critical issues of Grid Networking
 - High performance transport protocols, Qos
 - Port and test applications
 - Investigate original mechanisms
 - P2P resources discovery, Desktop Grids



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Grid'5000 foundations: Collection of experiments to be done

- **Networking**
 - End host communication layer (interference with local communications)
 - High performance long distance protocols (improved TCP)
 - High Speed Network Emulation
- **Middleware / OS**
 - Scheduling / data distribution in Grid
 - Fault tolerance in Grid
 - Resource management
 - Grid SSI OS and Grid I/O
 - Desktop Grid/P2P systems
- **Programming**
 - Component programming for the Grid (Java, Corba)
 - GRID-RPC
 - GRID-MPI
 - Code Coupling
- **Applications**
 - Multi-parametric applications (Climate modeling/Functional Genomic)
 - Large scale experimentation of distributed applications (Electromagnetism, multi-material fluid mechanics, parallel optimization algorithms, CFD, astrophysics)
 - Medical images, Collaborating tools in virtual 3D environment



Grid'5000 foundations: Collection of properties to evaluate

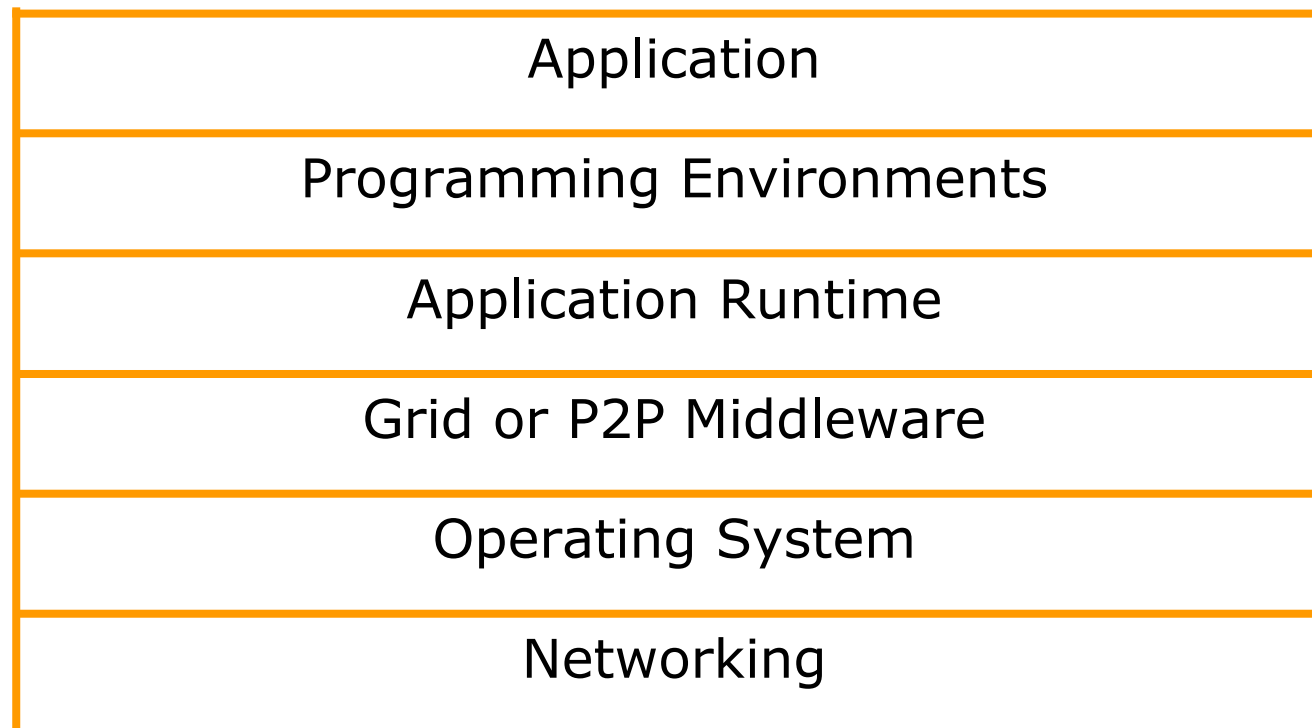
Quantitative metrics :

- Performance
 - Execution time, throughput, overhead
- Scalability
 - Resource occupation (CPU, memory, disc, network)
 - Applications algorithms
 - Number of users
- Fault-tolerance
 - Tolerance to very frequent failures (volatility), tolerance to massive failures (a large fraction of the system disconnects)
 - Fault tolerance consistency across the software stack.



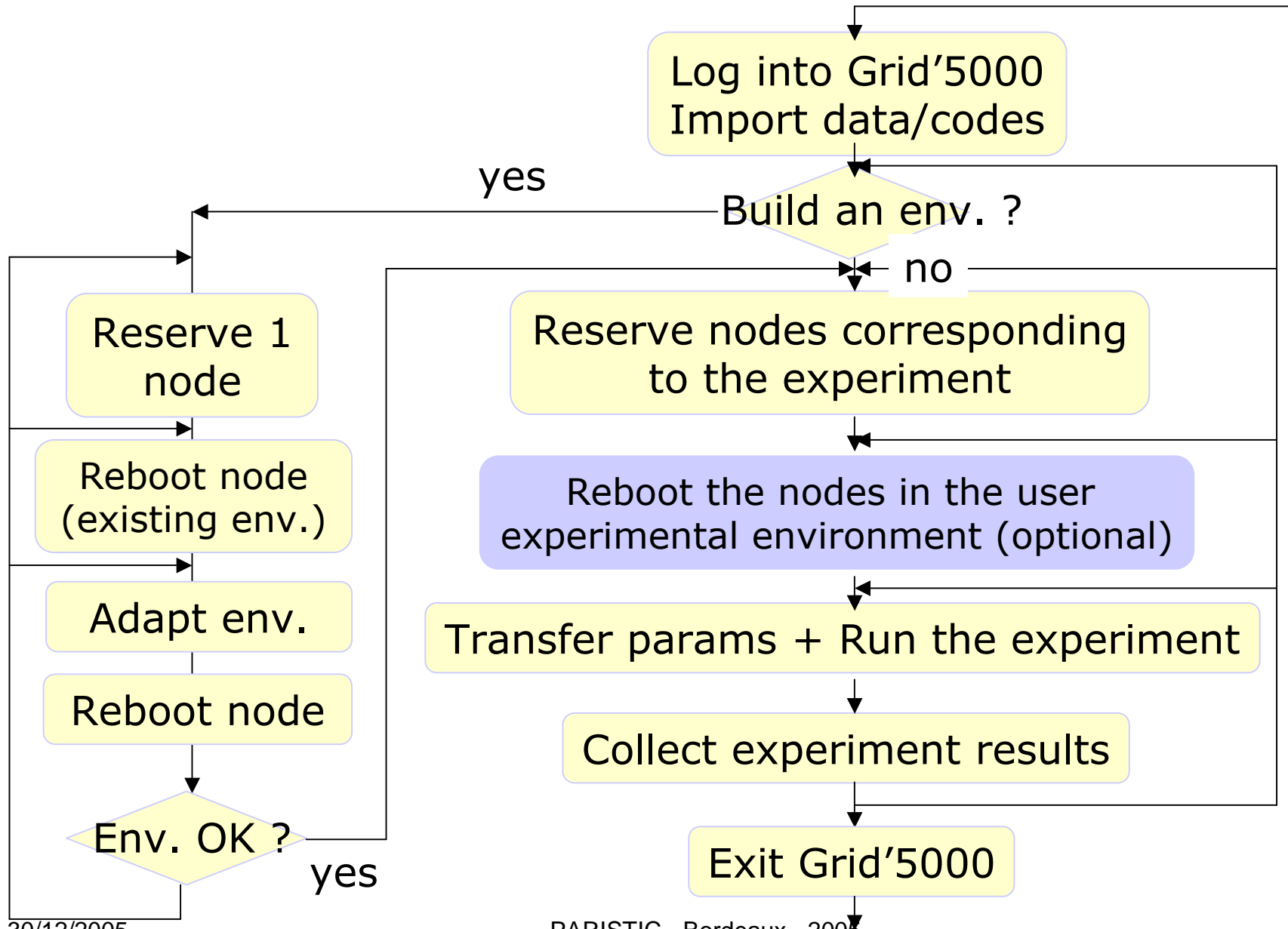
Grid'5000 goal:

Experimenting all layers of the Grid and P2P software stack



➔ A highly reconfigurable experimental platform

Experiment workflow





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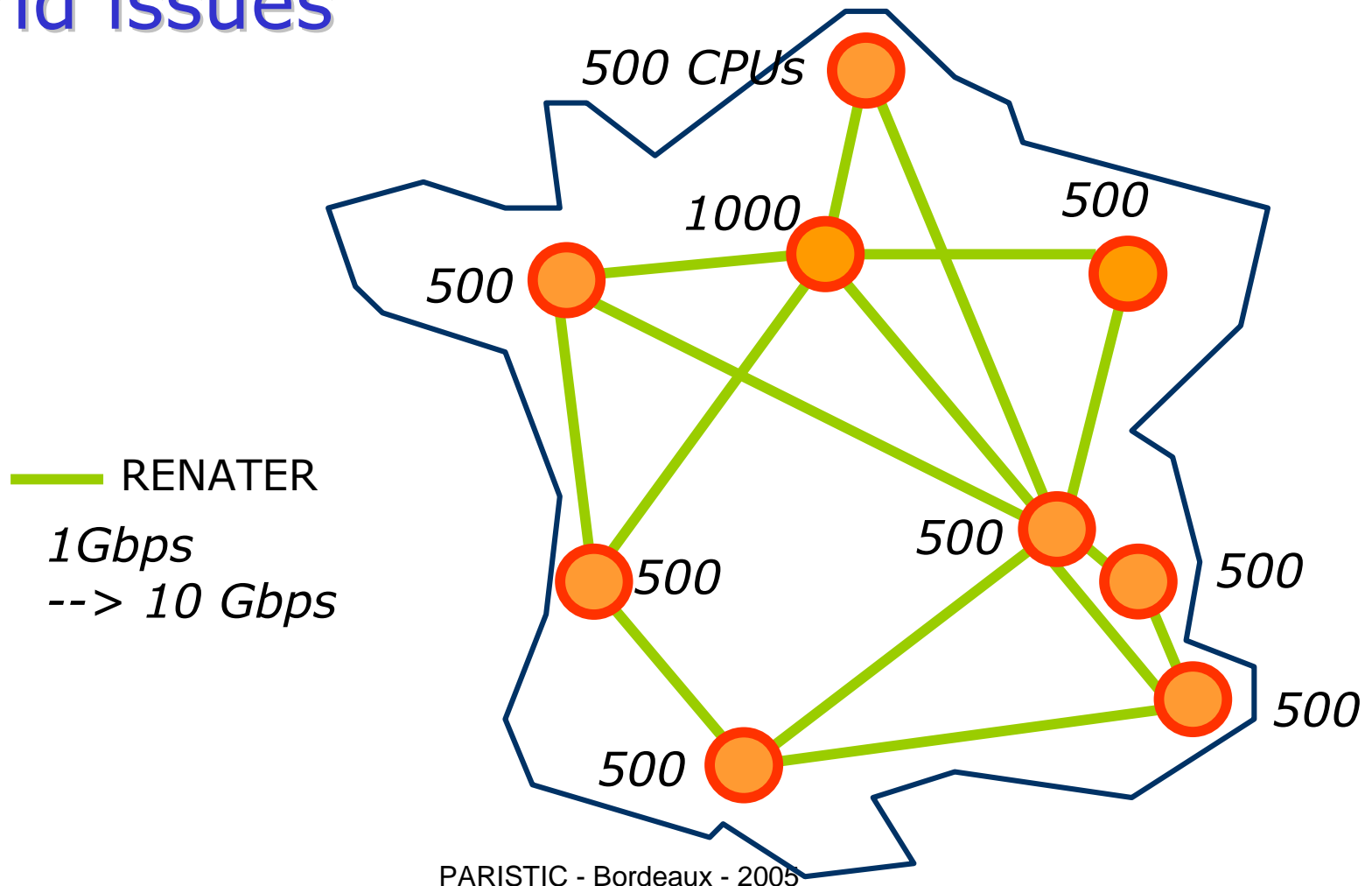
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Grid'5000 map

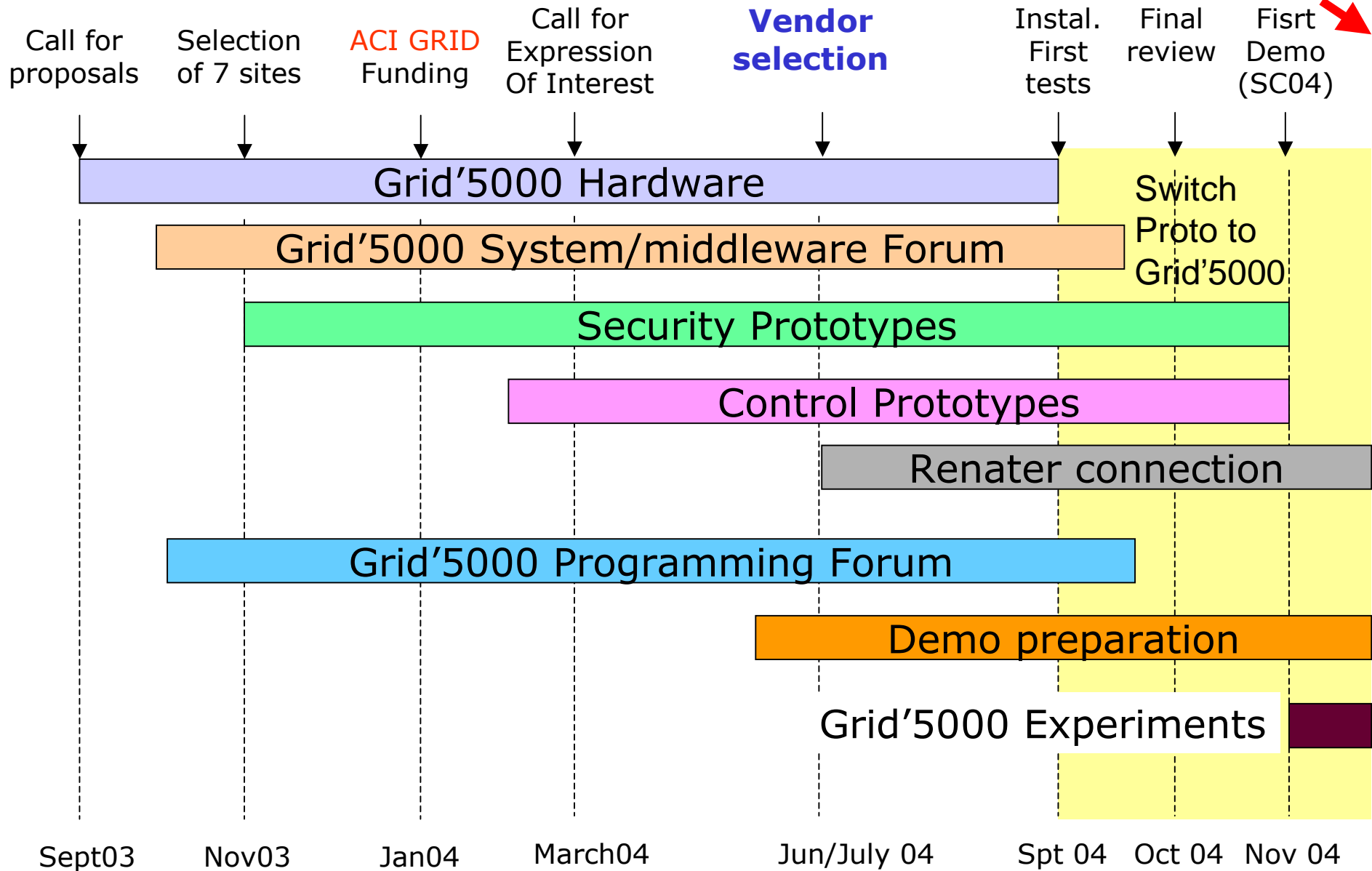
The largest Instrument to study Grid issues





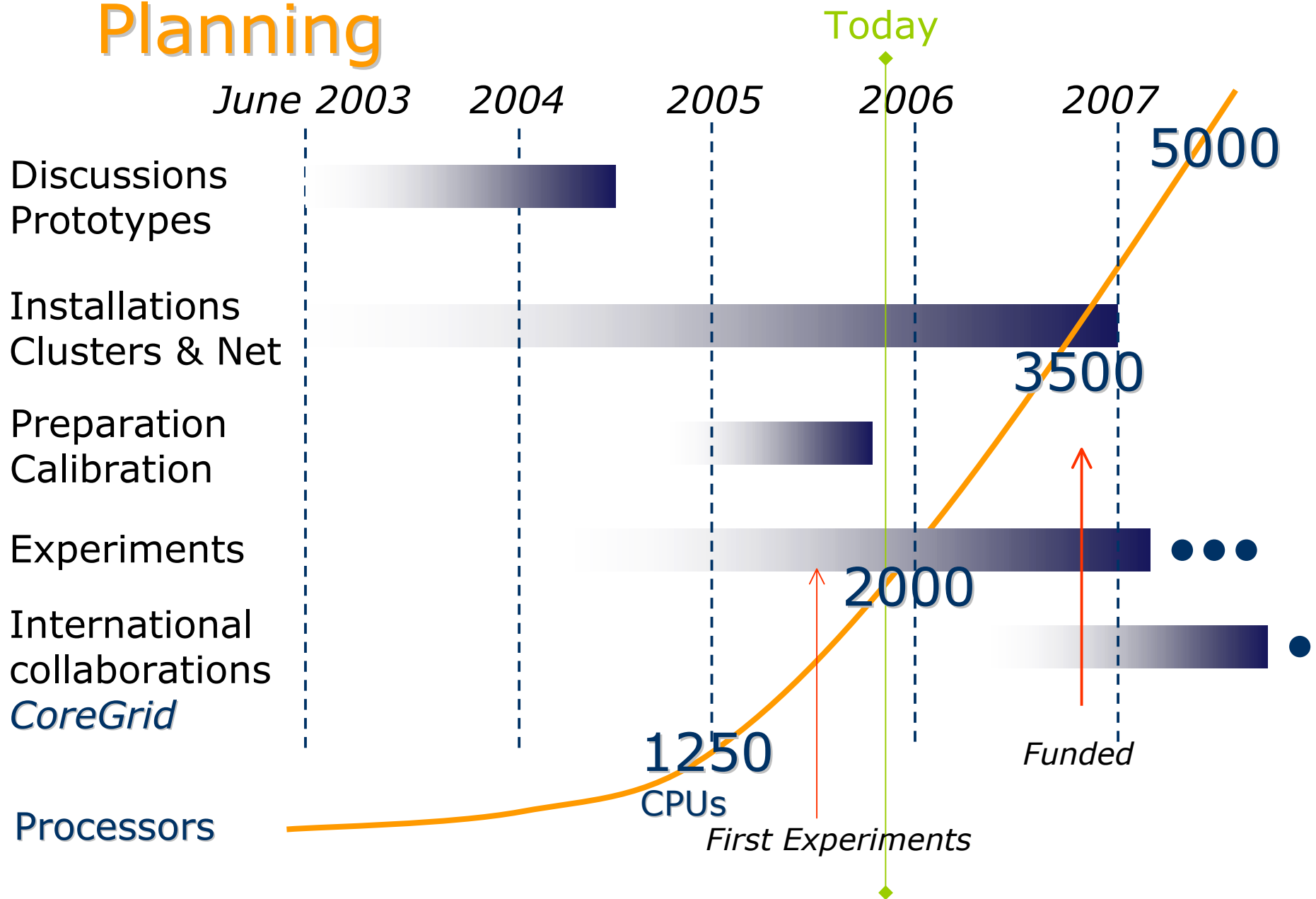
Schedule

today





Planning





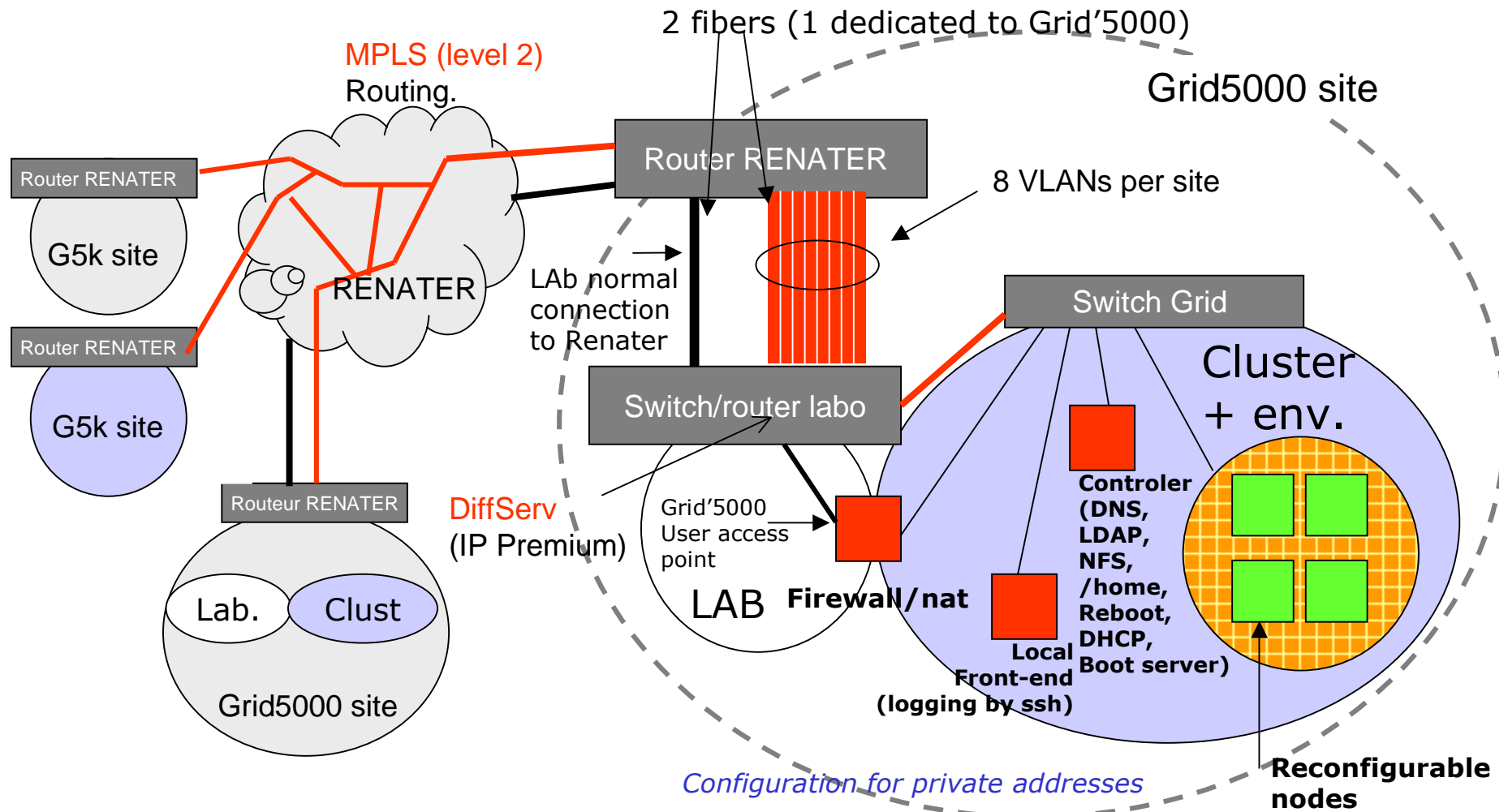
Grid'5000

Grid'5000 as an Instrument

Technical issues:

- Ensure security of Grid'5000 and the Internet according to the deep reconfiguration feature
- A software infrastructure allowing users to access Grid'5000 from any Grid'5000 site and have home dir in every site
- A reservation/scheduling tools allowing users to select node sets and schedule experiments
- A user toolkit to reconfigure the nodes and monitor experiments

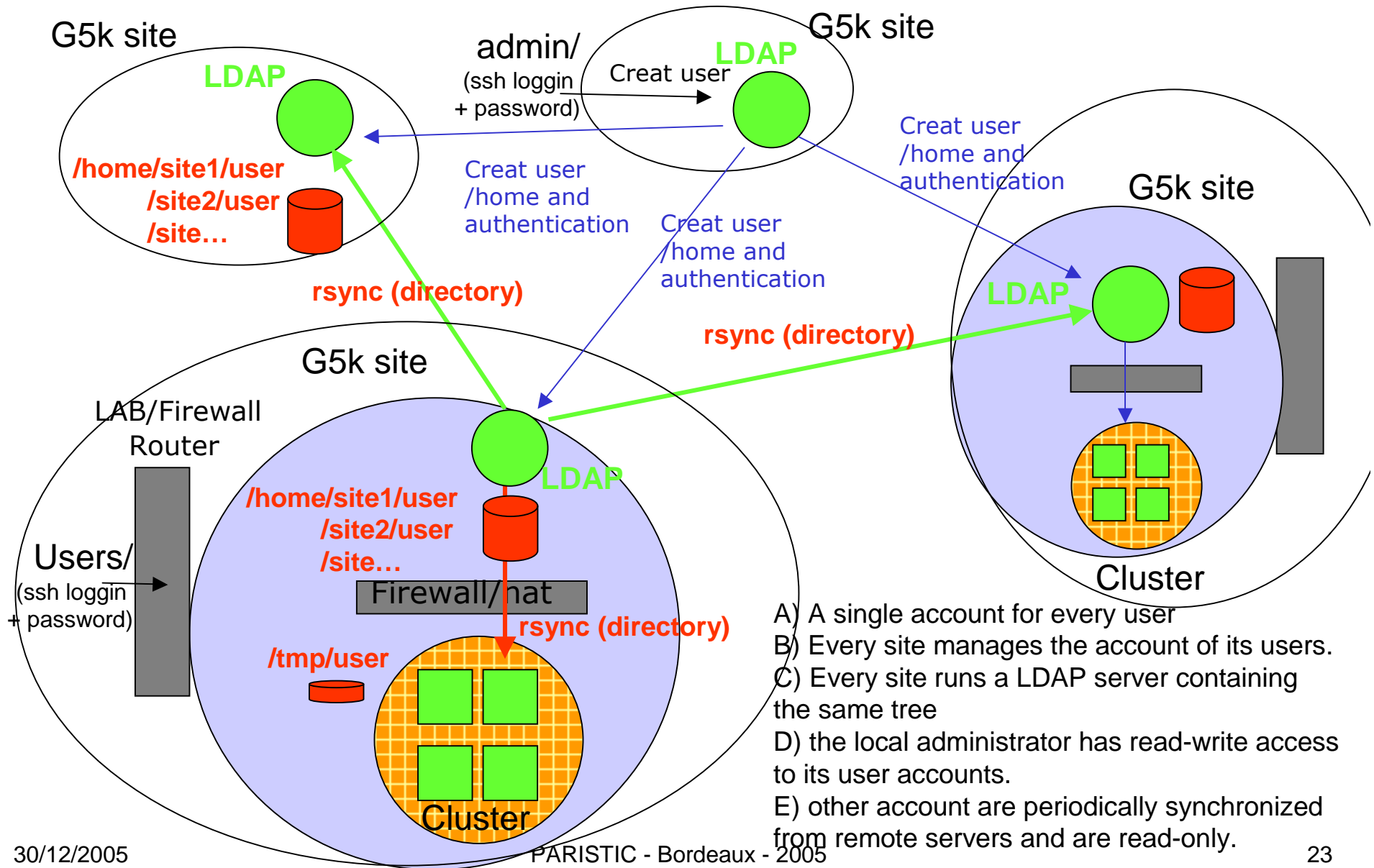
Grid'5000 Security architecture: A confined system



9 x 8 VLANs in Grid'5000 (1 VLAN per tunnel)

User environment

Single Account for every user + /home in every site for every user



- A) A single account for every user
- B) Every site manages the account of its users.
- C) Every site runs a LDAP server containing the same tree
- D) the local administrator has read-write access to its user accounts.
- E) other account are periodically synchronized from remote servers and are read-only.

Experiment Scheduling

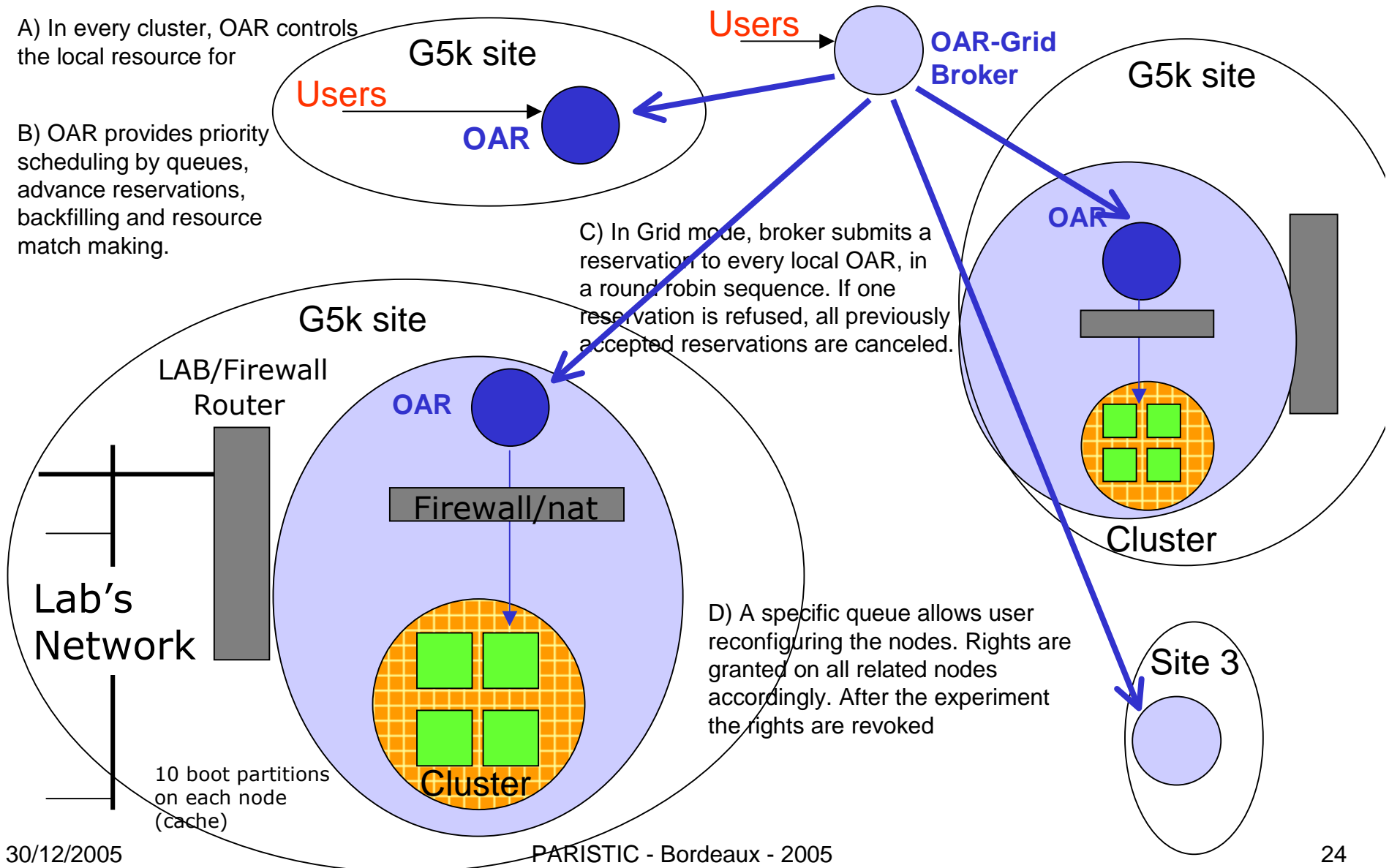
Reservation + Scheduling: OAR

A) In every cluster, OAR controls the local resource for

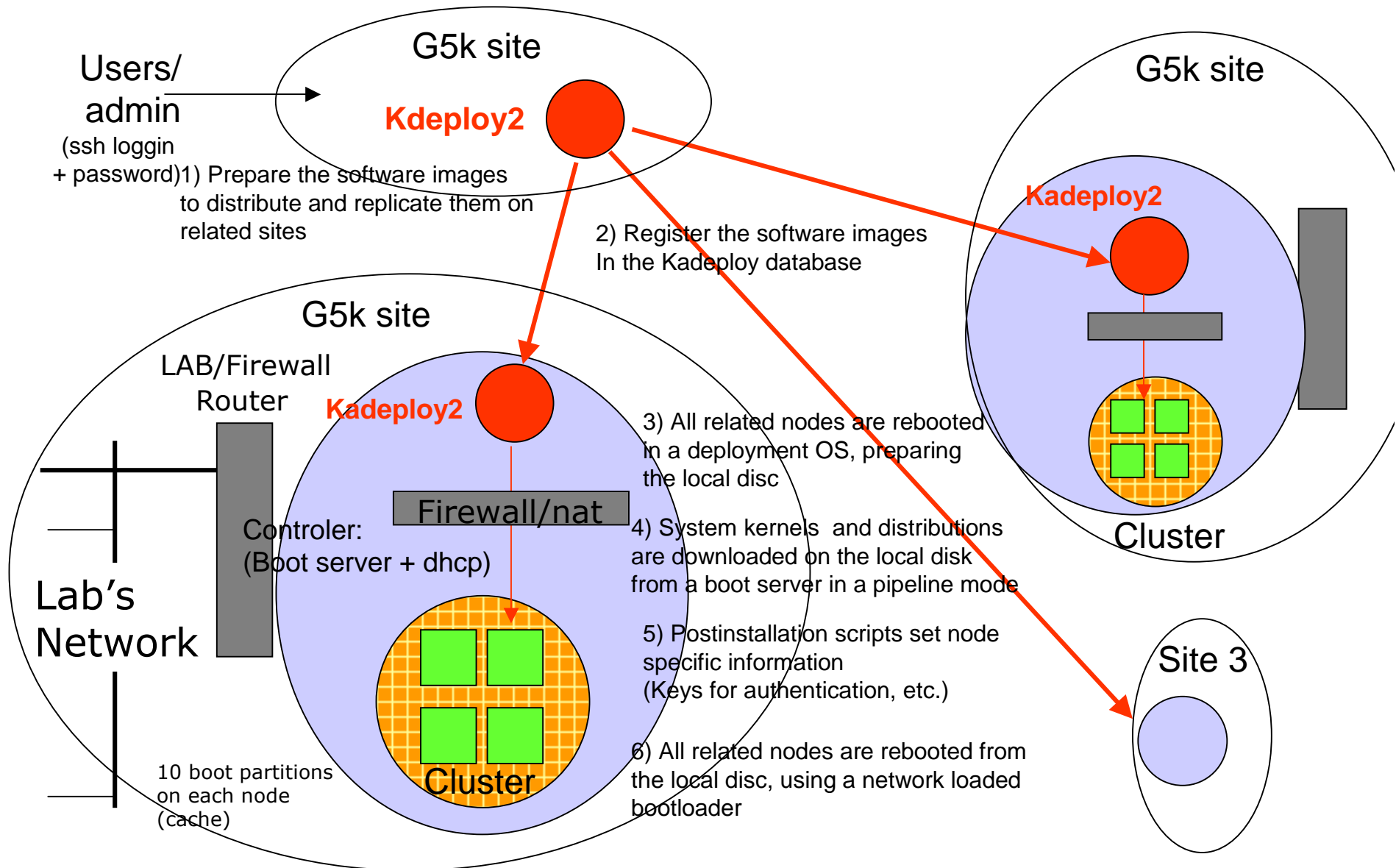
B) OAR provides priority scheduling by queues, advance reservations, backfilling and resource match making.

C) In Grid mode, broker submits a reservation to every local OAR, in a round robin sequence. If one reservation is refused, all previously accepted reservations are canceled.

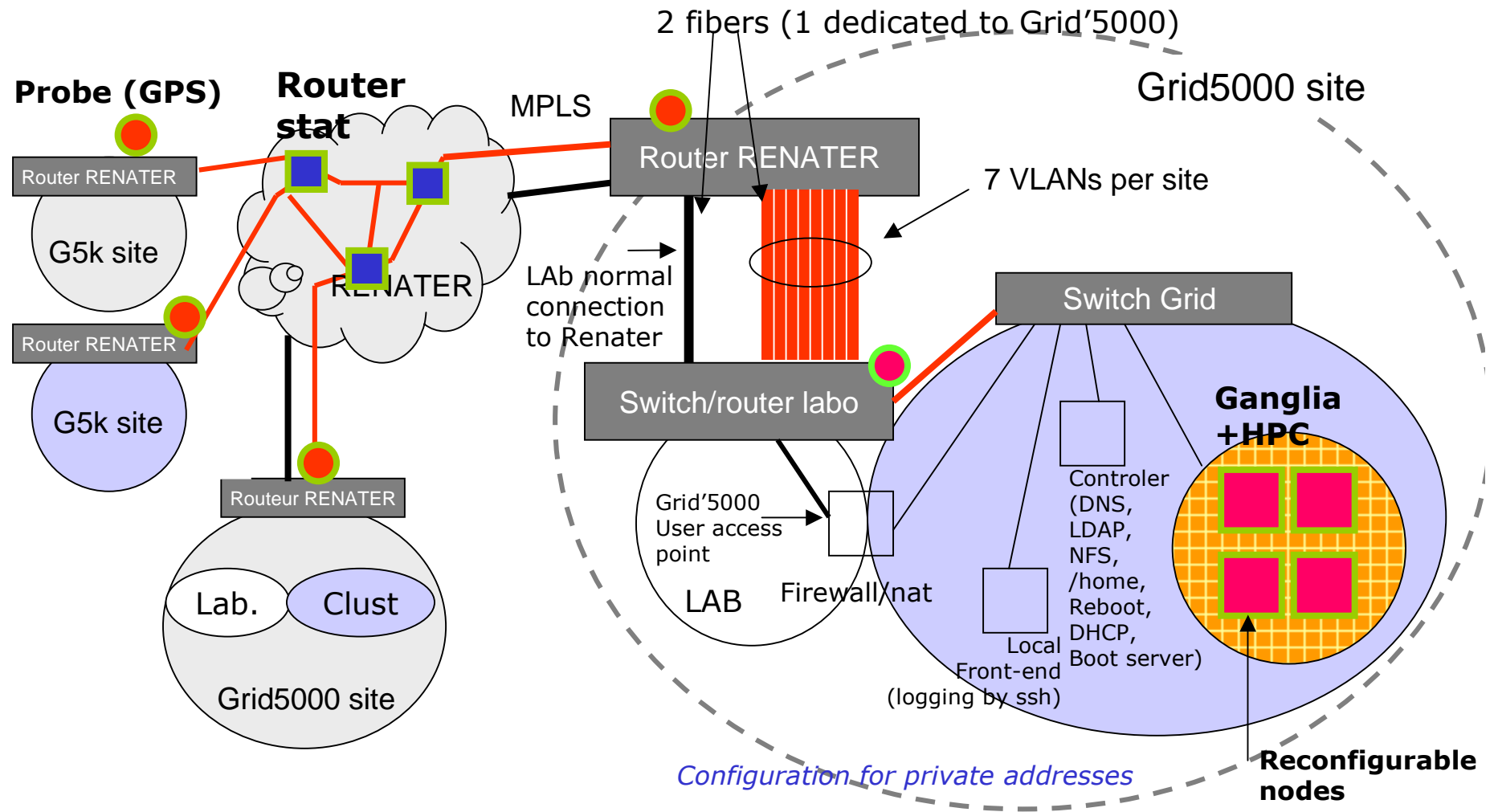
D) A specific queue allows user reconfiguring the nodes. Rights are granted on all related nodes accordingly. After the experiment the rights are revoked



Deployment procedure



Monitoring architecture





Rennes

Sophia

Lyon

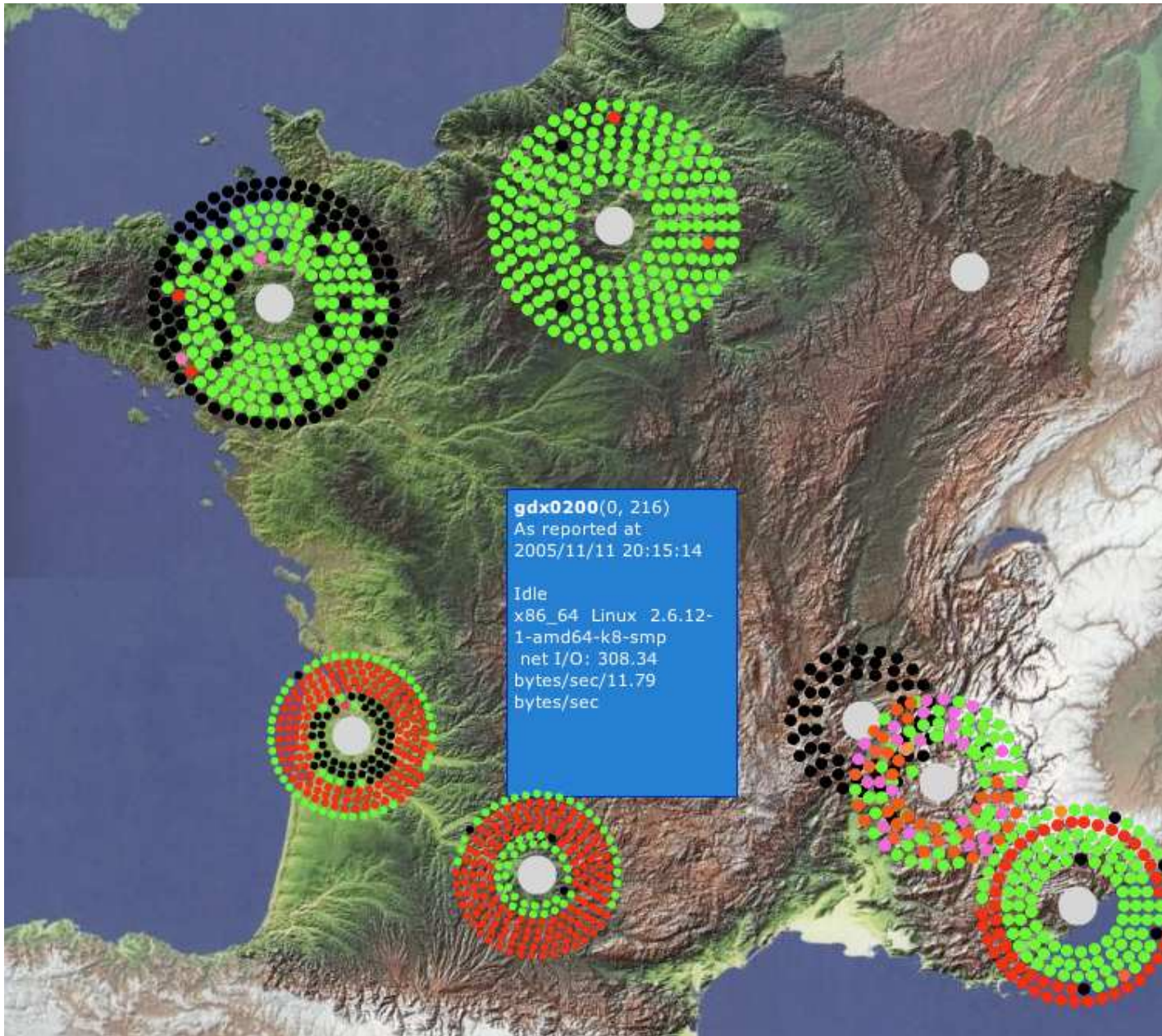
Grenoble

Orsay

Bordeaux

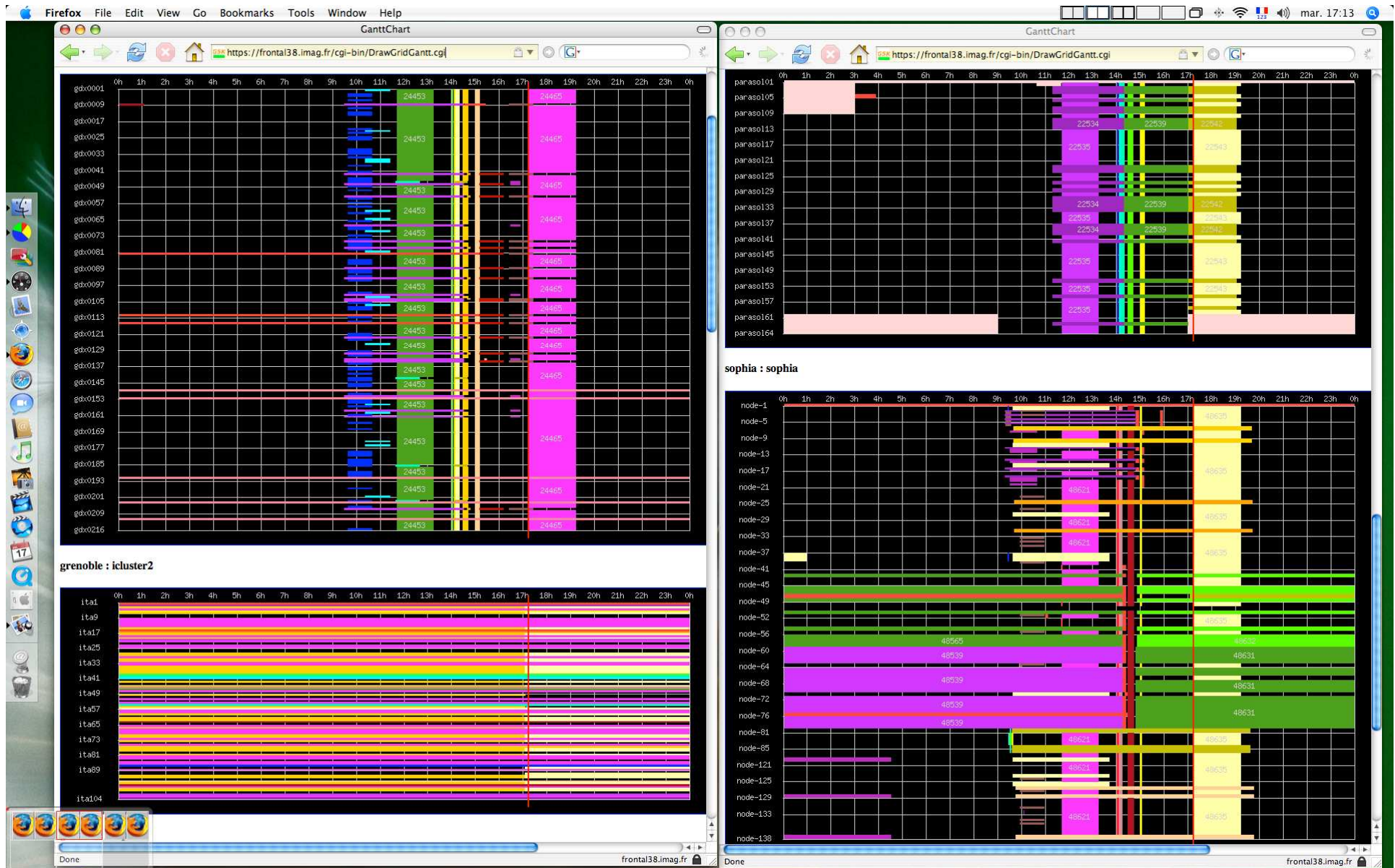
Toulouse

Grid'5000 global view





Grid'5000 reservations





Grid'5000 Resource usage

Grid5000 Grid (7 sources) (tree view)

CPU's Total: 1098
Hosts up: 548
Hosts unknown: 38
Hosts down: 4

Avg Load (15, 5, 1m): 14%, 17%, 46%

Localtime: 2005-10-25 15:07

Rennes (physical view)

CPU's Total: 336
Hosts up: 168
Hosts unknown: 1
Hosts down: 0

Avg Load (15, 5, 1m): 9%, 14%, 36%

Localtime: 2005-10-25 15:07

Bordeaux (physical view)

CPU's Total: 94
Hosts up: 47
Hosts unknown: 1
Hosts down: 0

Avg Load (15, 5, 1m): 50%, 75%, 96%

Localtime: 2005-10-25 15:08

Sophia (physical view)

CPU's Total: 160
Hosts up: 80
Hosts unknown: 27
Hosts down: 0

Avg Load (15, 5, 1m): 24%, 37%, 83%

Localtime: 2005-10-25 15:07

Orsay (physical view)

CPU's Total: 414
Hosts up: 207
Hosts unknown: 5
Hosts down: 4

Avg Load (15, 5, 1m): 0%, 0%, 0%

Toulouse (physical view)

CPU's Total: 60
Hosts up: 30
Hosts unknown: 1
Hosts down: 0

Avg Load (15, 5, 1m): 13%, 13%, 14%

Localtime: 2005-10-25 15:07

Lyon (physical view)

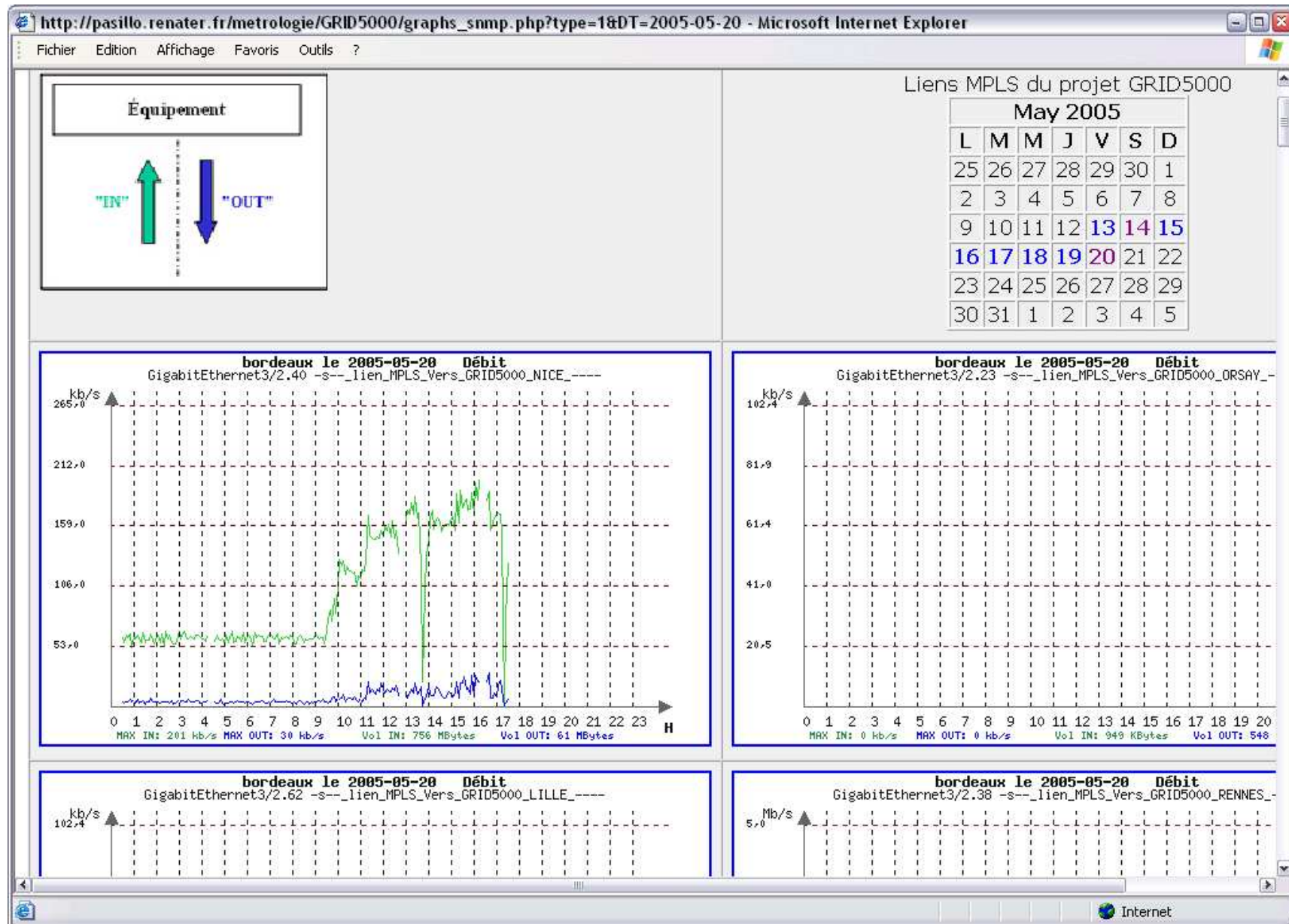
CPU's Total: 0
Hosts up: 0
Hosts unknown: 1
Hosts down: 0

Avg Load (15, 5, 1m): 0%, 0%, 0%

helpdesk.grid5000.fr



Grid'5000 Inter site com. trafic



Grid'5000 web site

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Grid5000:Home - Grid5000

https://www.grid5000.fr/index.php/Grid5000:Home

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project page discussion edit history move watch

Grid'5000

5000 CPUs distributed in 9 sites for research in Grid Computing, eScience and Cyber-infrastructures

Latest news

- November 21, 2005: **Grid'5000 @ PARISTIC**: After SC2005 last Week, Grid'5000 will be presented at [PARISTIC](#), Bordeaux.

more news [here](#)

Grid'5000 at a glance

- Grid'5000 project aims at building a **highly reconfigurable, controlable and monitorable experimental Grid platform** gathering **9 sites** geographically distributed in France featuring a total of 5000 CPUs:

Sites:

<ul style="list-style-type: none">BordeauxGrenobleLille	<ul style="list-style-type: none">LyonNancyOrsay	<ul style="list-style-type: none">RennesSophia-AntipolisToulouse
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Grid'5000 sites

- The main purpose of this platform is to serve as an experimental testbed for research in Grid Computing.
- This project is one initiative of the **French ACI Grid Incentive**

Introduction

- Grid'5000 is a research effort developing a **large scale nation wide infrastructure for Grid research**.
- 17 laboratories** are involved, nation wide, in the objective of providing the community of Grid researchers a testbed allowing experiments in all the software layers between the network protocols up to the applications:



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On going experiments

250 registered users

File Edit View Go Bookmarks Tools Window Help

Mozilla Firefox

Joining
News
Time line
Experiments
Publications
Press releases
Softwares

users portal
Users portal
Platform events
Platform status
User Reports
Documentation
FAQ

committees portal
Agenda
Members
Meetings
Workgroups
Administration

wiki special pages
Recent changes
All pages
Upload file
Wiki help

search
Go Search

toolbox
Upload file
Special pages

All Grid'5000 reports:

- Hamza Adamou (M2R), MESCAL ID IMAG Grenoble
- Guillaume ALLEON (Engineer), EADS CRC
- Lamine Aouad (PhD student), Grand Large LIFL Lille
- Carlos Jaime BARRIOS HERNÁNDEZ (PhD Student), MESCAL ID-IMAG Montbonnot Saint-Martin (Grenoble-France)
- Janet Bertot (ingé devexp), service Dream INRIA Sophia
- Raphaël Bolze (PhD student), GRAAL LIP-ENSL Lyon
- Hinde Lilia Bouziane (PhD student), PARIS IRISA/INRIA Rennes
- Jeremy BUISSON (PhD student), PARIS IRISA Rennes
- CHRISTOPHE CERIN (professor), Grid Explorer LIPN Paris XIII, Villetaneuse
- Arnaud Contes (Phd), OASIS INRIA Sophia
- Cedric Dalmasso (Internship), Oasis INRIA sophia
- Alexandre di Costanzo (PhD. Student), OASIS INRIA Sophia
- Fabrice Dupros (engineer), IGGI BRGM Orleans
- Thierry Gautier (CR INRIA), MOAIS ID-IMAG Grenoble
- Stéphane Genaud (Maitre de Conférences), TAG ICPS-LSIIT Strasbourg
- Yiannis Georgiou, Mescal ID-IMAG Grenoble
- Olivier GLUCK (Associate Professor), INRIA RESO LIP ENS-LYON
- Jens Gustedt (directeur de recherche), AlGorille INRIA Lorraine & LORIA Nancy, France
- Christophe Hamerling (Engineer), GRID-TLSE IRIT-ENSEEIH Toulouse
- Thomas Hérault (Assistant Professor), Grand-Large LRI Orsay
- Samir Jafar (PhD Student), MOAIS ID-IMAG Grenoble
- Emmanuel Jeannot (Chargé de recherche), Algorille LORIA Nancy
- Emmanuel Jeanvoine (PhD student), Paris IRISA Rennes
- Peyrard Johann (developer), kadeploy Id imag Montbonnot
- Nicolas LARRIEU (Postdoct fellow), Grid eXplorer LAAS-CNRS Toulouse
- Adrien Lebre (Phd Student), MESCAL ID-IMAG Montbonnot (Grenoble-France)
- Julien Leduc (Research Engineer), grid5000 LRI Orsay
- Laurent Lefevre (INRIA CR1 Researcher), RESO LIP Lyon
- Oleg Lodygensky (Phd student), XtremWeb LRI orsay, france
- Eric MAISONNAVE (Engineer), LEGO (submitted) Cerfacs Toulouse
- Maxime Martinasso (Phd student), Mescal ID-Imag Grenoble
- Sébastien Monnet (PhD student), PARIS IRISA Rennes
- Thierry Monteil (Assistant professor), AROMA LAAS-CNRS Toulouse
- Matthieu Morel (Ingénieur expert), Oasis INRIA Sophia Antipolis
- Grégory Mounié (Assistant Professor), MOAIS ID-IMAG Grenoble
- Frederic NIVOR (PhD), STM LAAS-CNRS Toulouse, France

Main information
Experiments
Publications
Collaboration
Results
Benefits

Render report
List all reports

Done PARISTIC - BUREAUX - 2005 www.grid5000.fr

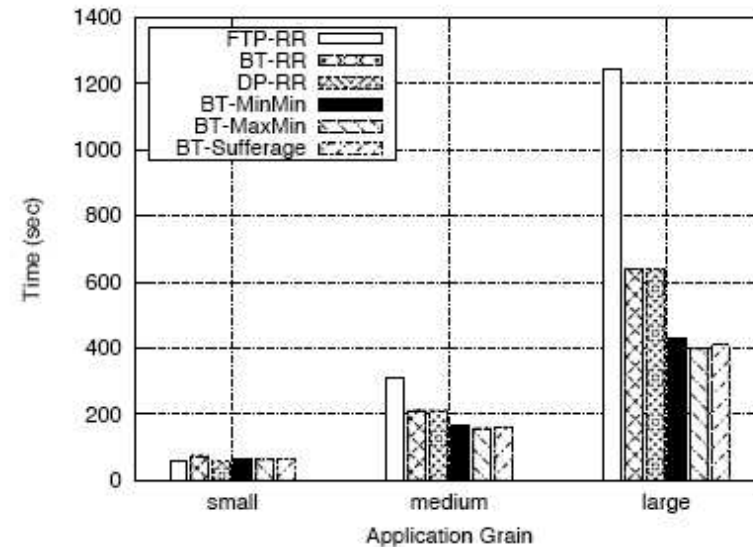
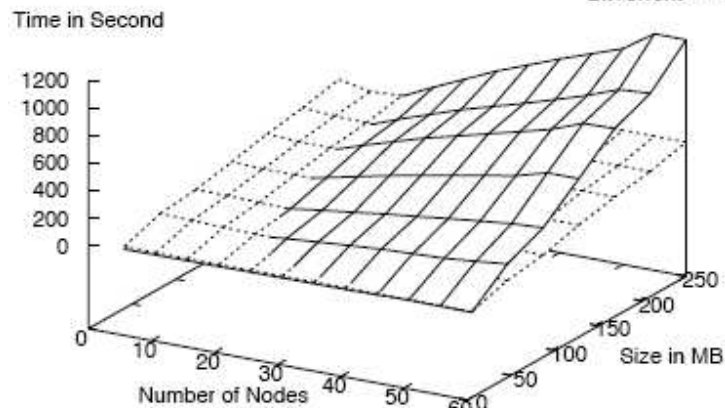
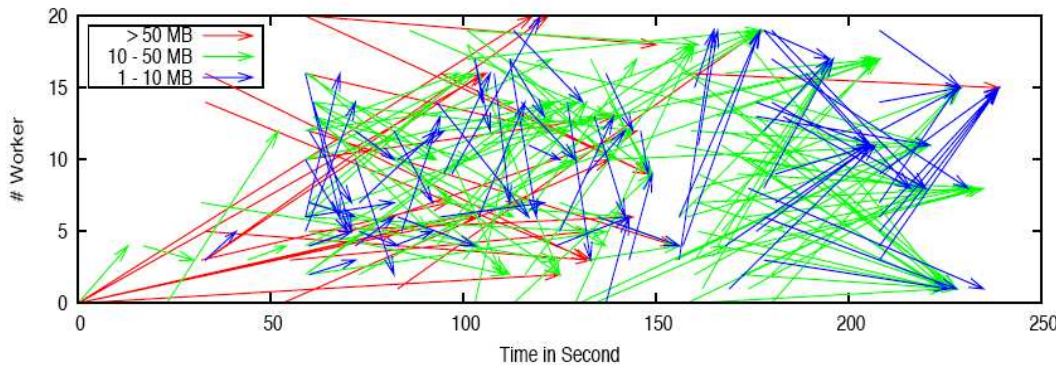
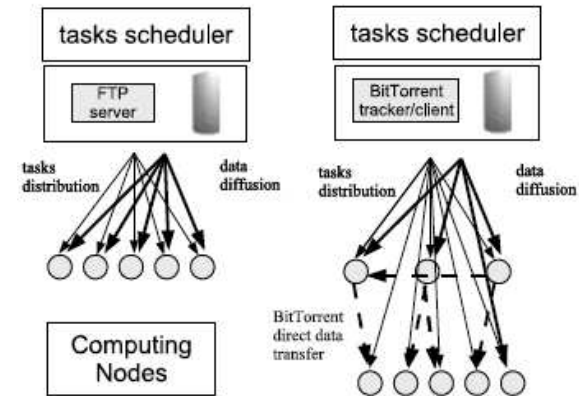
Protocol for DGrids

•XtremWeb

- Middleware pour Desktop Grid
- Research issues: distributed scheduling, data management, fault tolerance, result checking, etc.

•BitTorrent

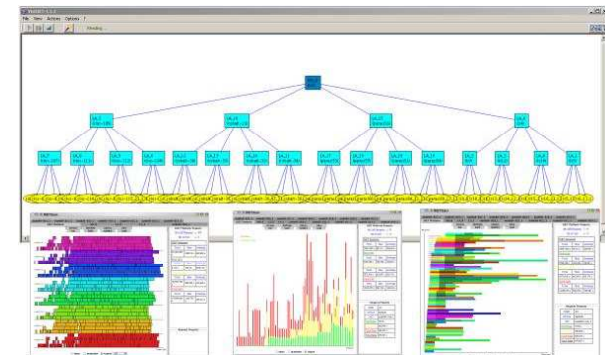
- Network protocol for cooperative data distribution



DIET and TLSE



- **DIET (Distributed Interactive Engineering Toolbox)**
 - Toolbox for client-server application over the grid
 - Following the GridRPC API from the GGF
 - Research issues: distributed scheduling, data management, automatic deployment
- **TLSE (Test for Large Systems of Equations)**
 - Expertise site for **sparse matrices**: help users to choose the best solvers for their problems
 - Provides an easy access to a large number of tools, software, bibliography, and sparse matrix
- **Grid'5000 experiment**
 - Validation of the **scalability** of the DIET platform
 - **Automatic deployment** of the DIET platform using machines available on several Grid'5000 centers taking into account the performance of the nodes
 - Experiments within TLSE for future production use
 - **Visualization** with VizDIET
- **<http://graal.ens-lyon.fr/DIET>**
- **<http://www.enseiht.fr/lima/tlse>**



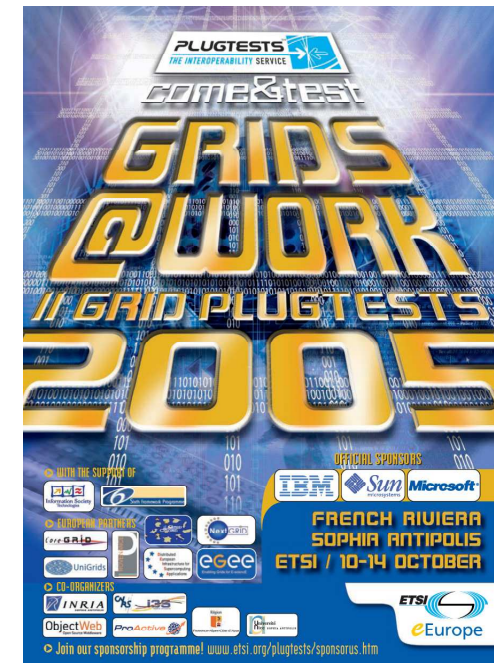


Grid@work (Octobre 10-14 2005)

- Series of conferences and tutorials including
- Grid PlugTest (N-Queens and Flowshop Contests).



The objective of this event was to bring together **ProActive** users, to present and discuss current and future features of the ProActive Grid platform, and to test the deployment and interoperability of ProActive Grid applications on various Grids.



The **N-Queens Contest** (4 teams) where the aim was to find the number of solutions to the N-queens problem, N being as big as possible, in a limited amount of time

The **Flowshop Contest** (3 teams)

1600 CPUs in total: **1200 provided by Grid'5000** + 50 by the other Grids (EGEE, DEISA, NorduGrid) + 350 CPUs on clusters.





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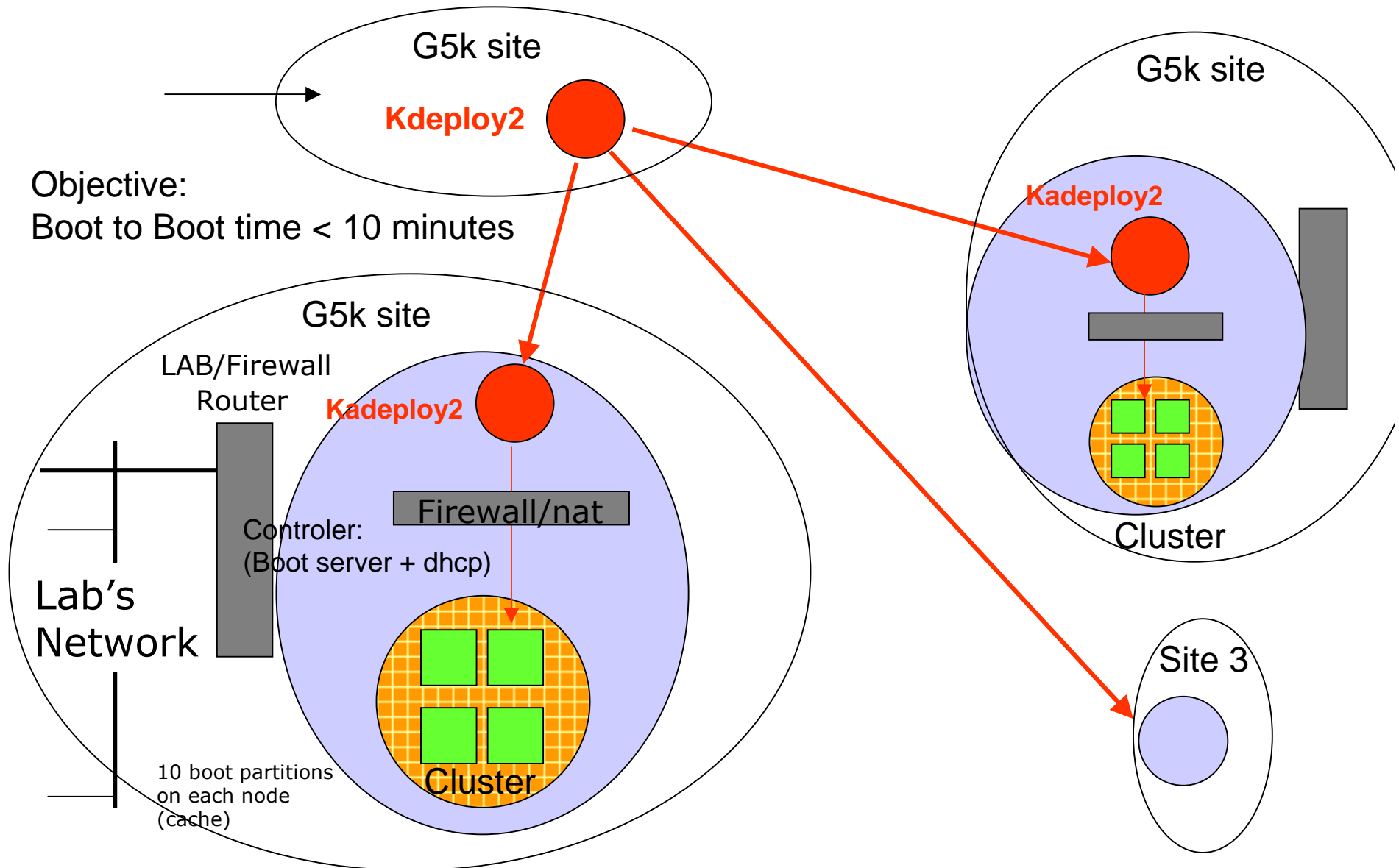
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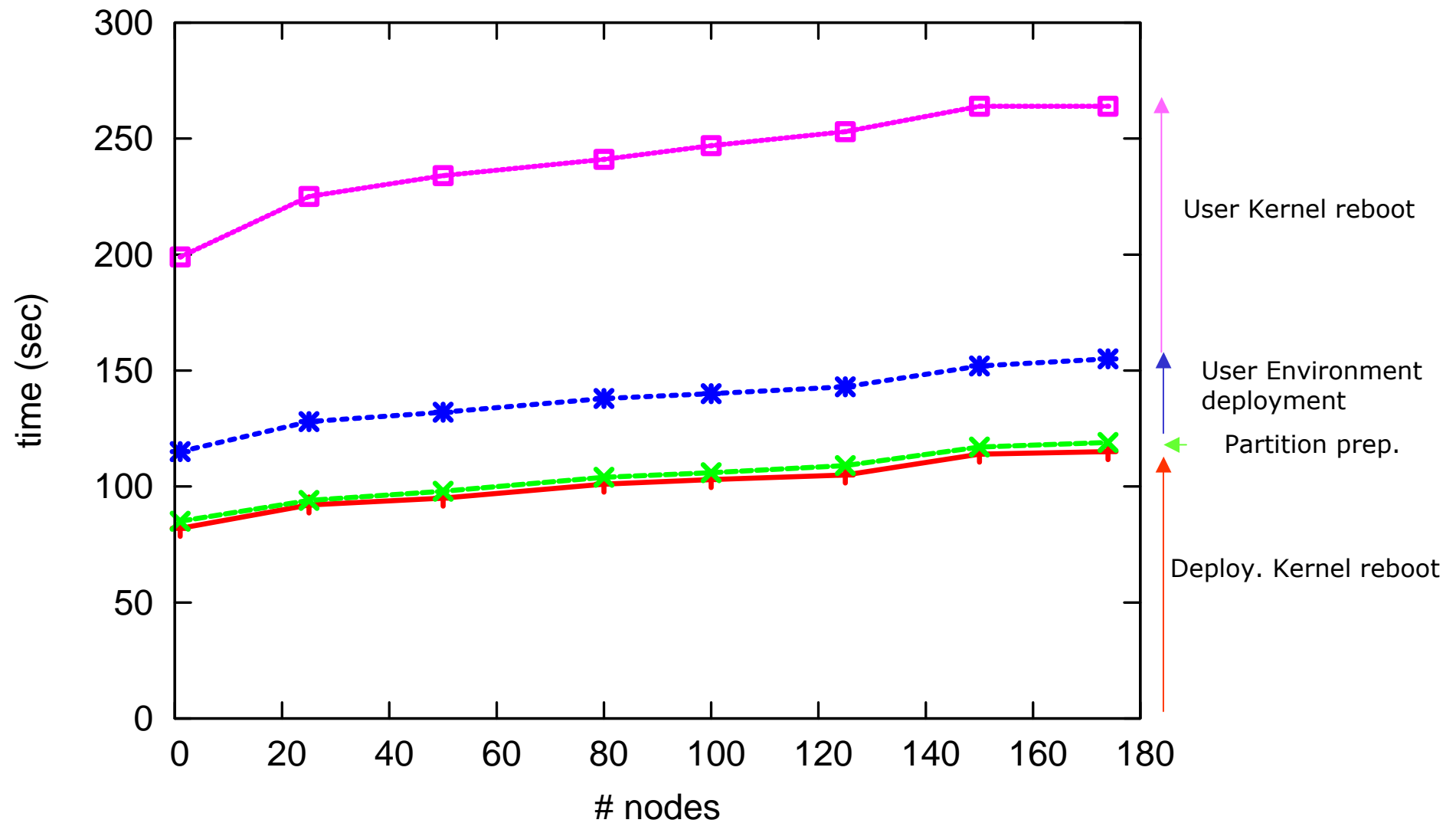


Measuring the Deployment procedure



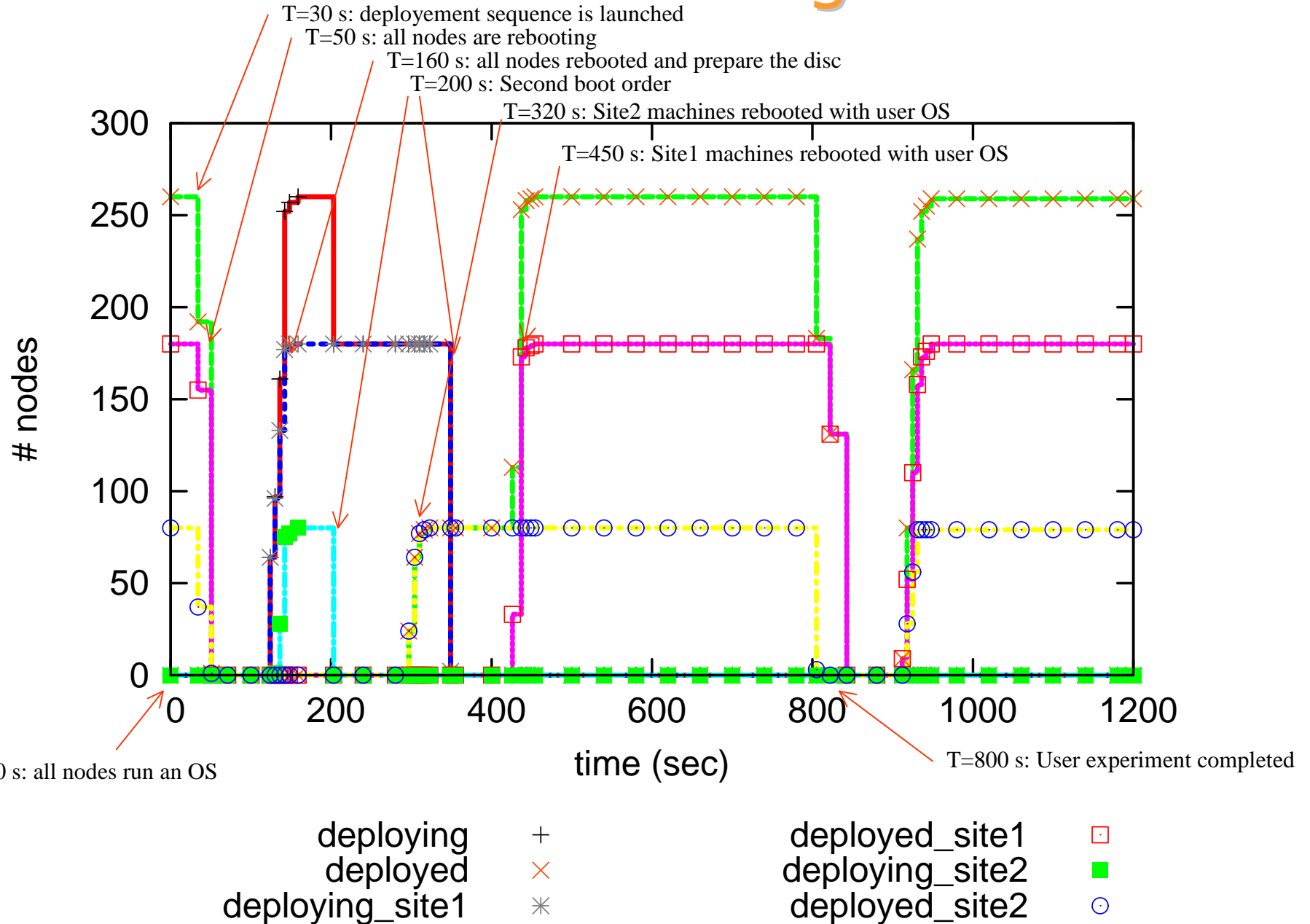
Objective:
Boot to Boot time < 10 minutes

Reconfiguration time (1 cluster)





Grid'5000 Reconfiguration





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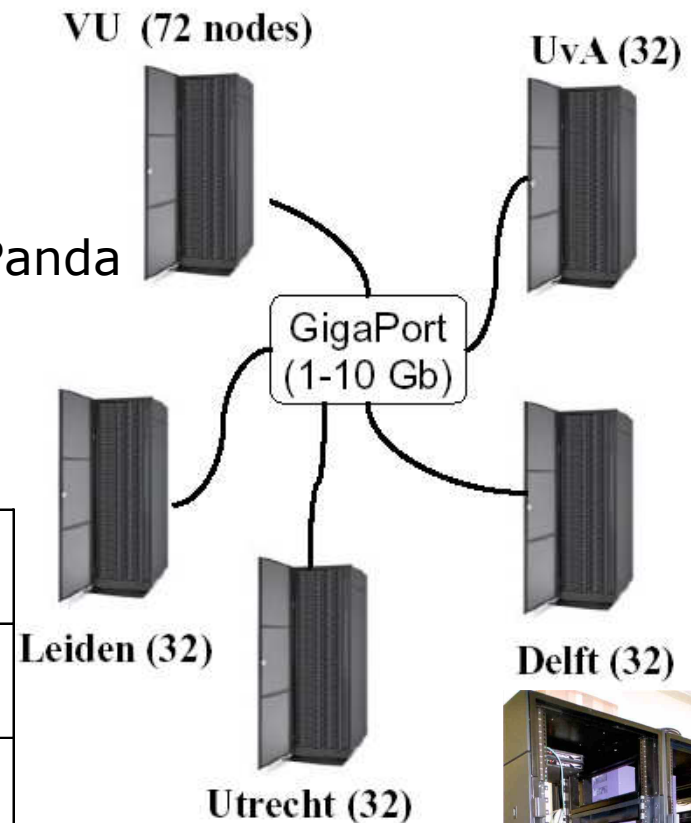
Deployment system evaluation

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DAS2: 400 CPUs exp. Grid

- Homogeneous nodes!
- Grid middleware
 - Globus 3.2 toolkit
 - PBS+Maui scheduler
- Parallel programming support
 - MPI (MPICH-GM, MPICH-G2), PVM, Panda
 - Pthreads
- Programming languages
 - C, C++, Java, Fortran 77/90/95

DAS2 (2002) :



	VU	UvA	Leiden	Delft	Utrecht
#nodes	72	32	32	32	32
Memory (GB)	1	1.5	1.5	1	1
Local disks (GB)	20	80	60	20	20
File server (GB)	6 * 36	6 * 36	6 * 36	2 * 18	2 * 18



Grid'5000 versus PlanetLab

PLANETLAB

An open platform for developing, deploying, and accessing planetary-scale services



	Grid'5000	PlanetLab
Cluster of clusters	V	-
Distributed PC		V
Capacity to reproduce experimental conditions	V	-
Capacity for dedicated usage for precise measurement	V	-
Experiments on virtual machines technologies	V	-
Precise network monitoring	V	-
Planet wide	-	V



La communauté ACI Grid & Grid'5000

Réunions fréquentes du comité de pilotage et du comité technique de Grid'5000

Présence importante des membres de l'ACI Grid et Grid'5000 dans les comités de programmes des grandes conférences

Organisation des grandes conférences Grilles (HPDC, IPDPS, CCGRID, etc.)

Organisation de Workshops (CCGRID, IPDPS)

Organisation d'écoles (Grid@work, Grid'5000)

Présence au Global Grid Forum (programmation et réseau)

Direction et présence dans de nombreux projets Européens (CoreGrid)

Discussions avancées et propositions de projets communs avec le Japon (financements INRIA, CNRS-JST, Sakura, etc.)

Projets avec les USA (équipes associées INRIA, NSF/INRIA)



Conclusion

- A large scale and highly reconfigurable Grid experimental testbed
- Grid'5000 will offer in 2005:
 - 9 clusters distributed over 9 sites in France,
 - about 2000 CPUs,
 - about 2,0 TB memory,
 - about 100 TB Disc,
 - about 8 Gigabit/s (directional) of bandwidth
 - about 5 à 10 Tera operations / sec
 - [the capability for all users to reconfigure the platform \[protocols/OS/Middleware/Runtime/Application\]](#)
- Grid'5000 is opened to French Grid researchers since July 2005
- Grid'5000 will be opened to others communities in 2006
- International extension currently under discussion (Netherlands, Japan)



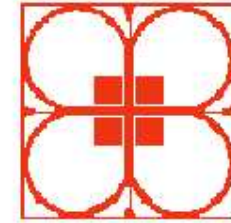
QUESTIONS?



HPDC-15

The 15th IEEE International Symposium on
High Performance Distributed Computing
June 19-23 2006
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The Fifteenth IEEE International Symposium on High-Performance Distributed Computing (HPDC) will be a forum for presenting the latest research findings on the design and use of parallel and distributed systems for high end computing, collaboration, data analysis, and other innovative applications.

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- Operating system technologies for high performance computing
- Multimedia, teleimmersive, and collaborative applications
- Terabit networks systems and services

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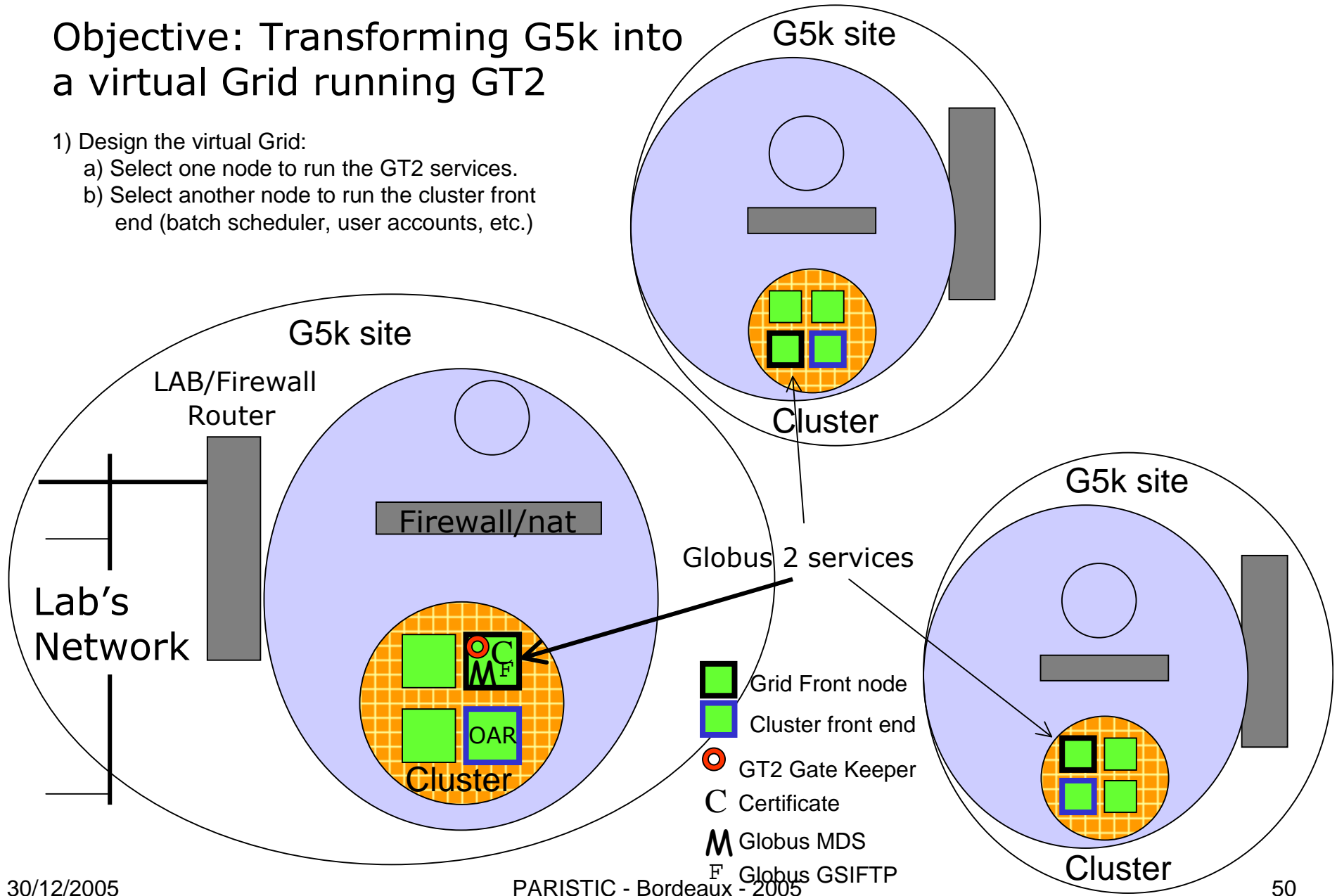
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Deployment example: Globus GT2

Objective: Transforming G5k into a virtual Grid running GT2

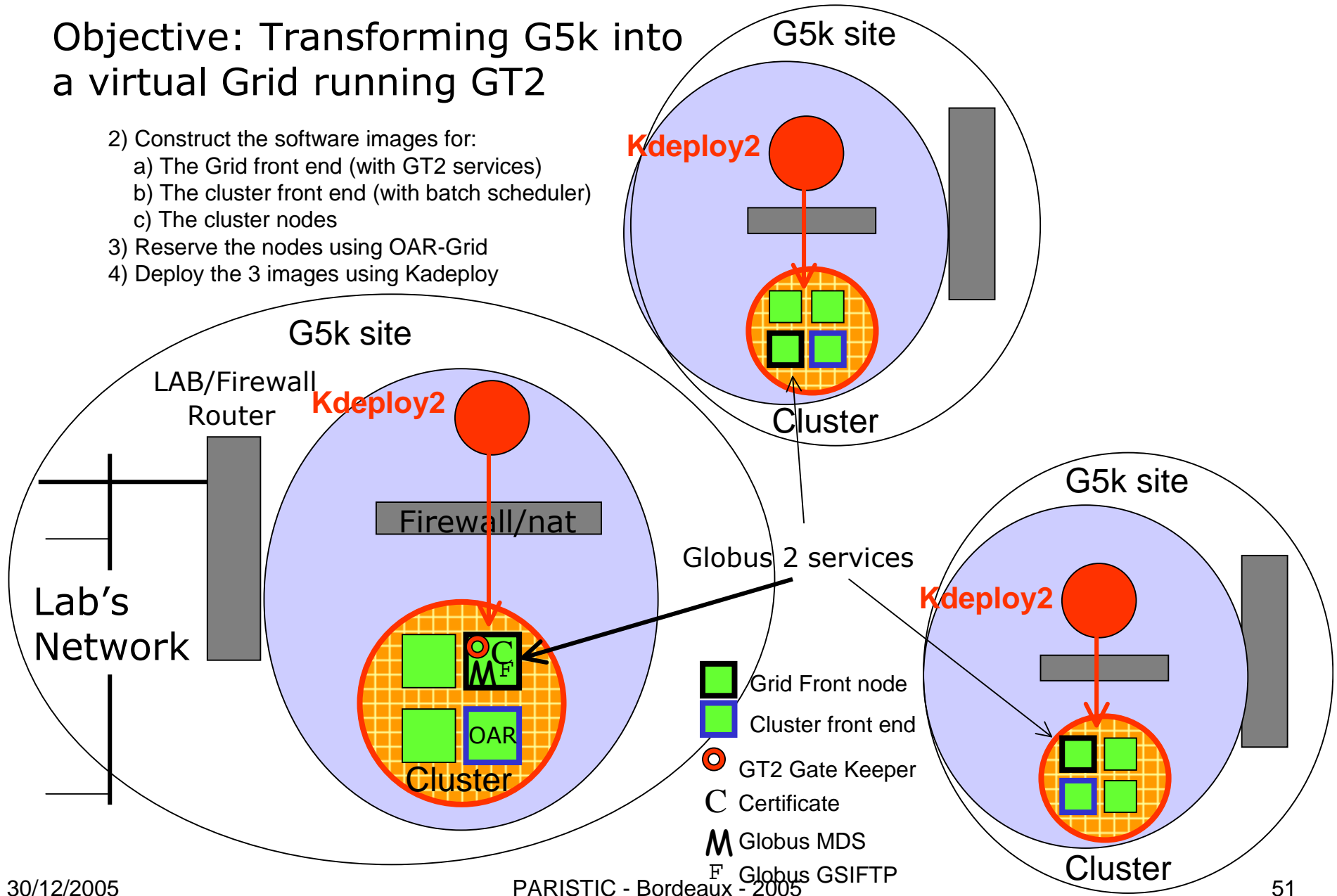
- 1) Design the virtual Grid:
 - a) Select one node to run the GT2 services.
 - b) Select another node to run the cluster front end (batch scheduler, user accounts, etc.)



Deployment example: Globus GT2

Objective: Transforming G5k into a virtual Grid running GT2

- 2) Construct the software images for:
 - a) The Grid front end (with GT2 services)
 - b) The cluster front end (with batch scheduler)
 - c) The cluster nodes
- 3) Reserve the nodes using OAR-Grid
- 4) Deploy the 3 images using Kadeploy



Deployment example: Globus GT2

Objective: Transforming G5k into a virtual Grid running GT2

5) Run the GT2 virtual Grid

