Grid Scheduling Architectures with Globus GridWay and Sun Grid Engine

Sun Grid Engine Workshop 2007
Regensburg, Germany
September 11, 2007

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1. Computing Resources

1.1. Parallel and Distributed Computing

Goal of Parallel and Distributed Computing

- ***Efficient*** execution of computational or data-intensive applications

Types of Computing Environments

High Performance Computing (HPC) Environments

- Reduce the execution time of a single distributed or shared memory parallel application (MPI, PVM, HPF, OpenMP…)
- Performance measured in floating point operations per second
- Sample areas: CFD, climate modeling…

High Throughput Computing (HTC) Environments

- Improve the number of executions per unit time
- Performance measured in number of jobs per second
- Sample areas: HEP, Bioinformatics, Financial models…

1. Computing Resources

1.2. Types of Computing Platforms

Centralized
Coupled

- **Network Links**
- **Administration**
- **Homogeneity**

Decentralized
Decoupled

SMP (Symmetric Multi-processors)

MPP (Massive Parallel Processors)

Clusters

Network Systems Intranet/Internet

High Performance Computing

High Throughput Computing

1. Computing Resources

1.3. Local Resource Management Systems

Management of Computing Platforms

- Computing platforms are managed by **Local Resource Management (LRM) Systems**

  1 Batch queuing systems for HPC servers

  2 Resource management systems for dedicated clusters

  3 Workload management systems for network systems

- There aim is to maximize the system *performance*

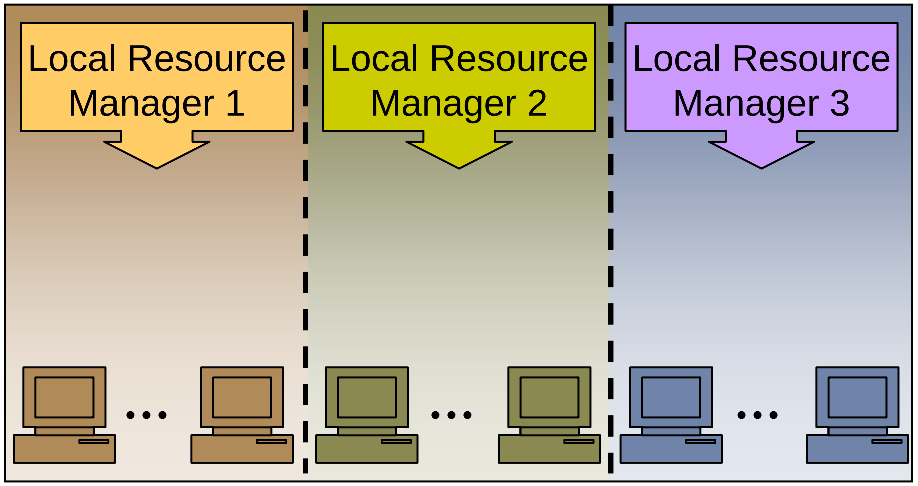
Independent Suppliers	*Open Source*	*OEM Proprietary*
2 *Platform Computing* 3 LSF	2 *Altair* Open PBS	1 *IBM* Load Leveler
2 *Altair* PBS Pro	3 *University of Wisconsin* Condor	1 *Cray* NQE
	2 *Sun Microsystems* 3 SGE	

1. Computing Resources

1.3. Local Resource Management Systems

LRM Systems Limitations

- Do not provide a common interface or security framework
- Based on proprietary protocols
- **Non-interoperable computing vertical silos** within a single organization
  - Requires specialized administration skills
  - Increases operational costs
  - Generates over-provisioning and global load unbalance



Only a small fraction of the infrastructure is available to the user

Infrastructure is fragmented in non-interoperable computational silos

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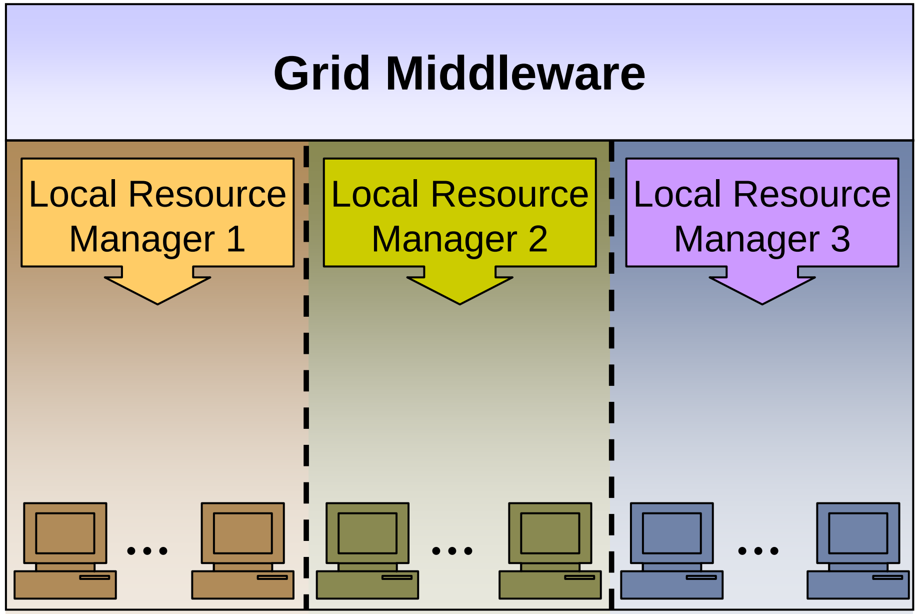
2. Globus GridWay Infrastructures

2.1. Integration of Different Administrative Domains

"Any problem in computer science can be solved with another layer of indirection… *But that usually will create another problem*.“ David Wheeler

A New Abstraction Level

“A (*computational*) grid offers a common layer to (1) **integrate heterogeneous computational platforms (vertical silos), that may belong to different administrative domains** (*systems managed by single administrative authority*), by defining a consistent set of abstraction and interfaces for access to, and management of, shared resources”



Common Interface for Each Type of Resources: User can access a wide set of resources.

Types of Resources: Computational, storage and network.

2. Globus GridWay Infrastructures

2.1. Integration of Different Administrative Domains

Grid Middleware (a computational view)

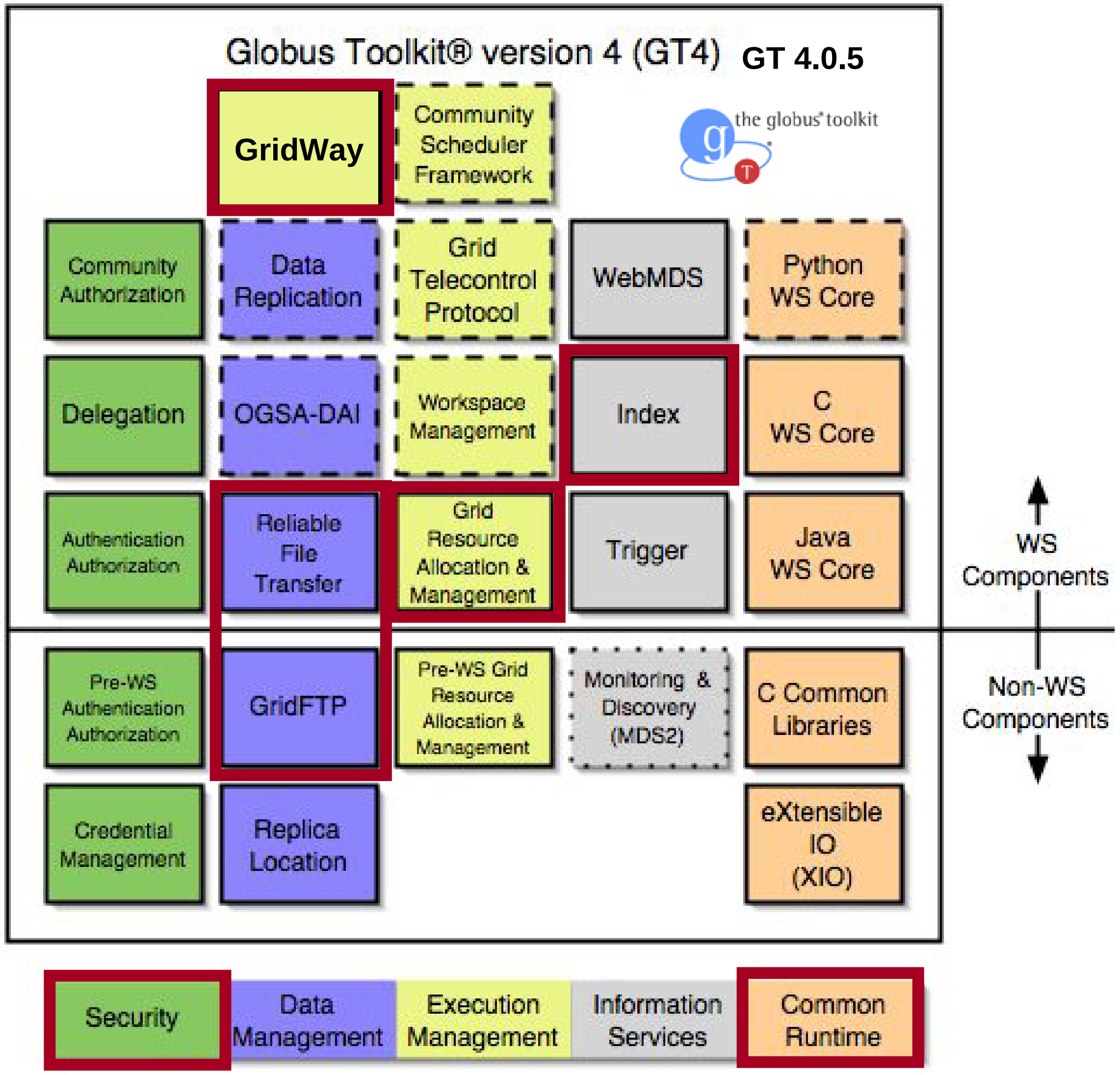
- **Services in the Grid Middleware layer:** Security, Information & Monitoring, Data Management, Execution and Meta-scheduling

- **Open Source Software Distributions**

glite.web.cern.ch www.unicore.org www.omii.ac.uk www.gria.org vdt.cs.wisc.edu www.gridbus.org

- **The Globus Toolkit**
  - Most widely used grid middleware
  - Software distribution that integrates a selected group of **Globus Alliance** technologies (Open Source Community)

Components for a Computational Grid



Globus Toolkit® version 4 (GT4) GT 4.0.5

GridWay

Community Scheduler Framework

Community Authorization

Data Replication

Grid Telecontrol Protocol

WebMDS

Python WS Core

Delegation

OGSA-DAI

Workspace Management

Index

C WS Core

Authentication Authorization

Reliable File Transfer

Grid Resource Allocation & Management

Trigger

Java WS Core

WS Components

Non-WS Components

Pre-WS Authentication Authorization

GridFTP

Pre-WS Grid Resource Allocation & Management

Monitoring & Discovery (MDS2)

C Common Libraries

Credential Management

Replica Location

eXtensible IO (XIO)

Security

Data Management

Execution Management

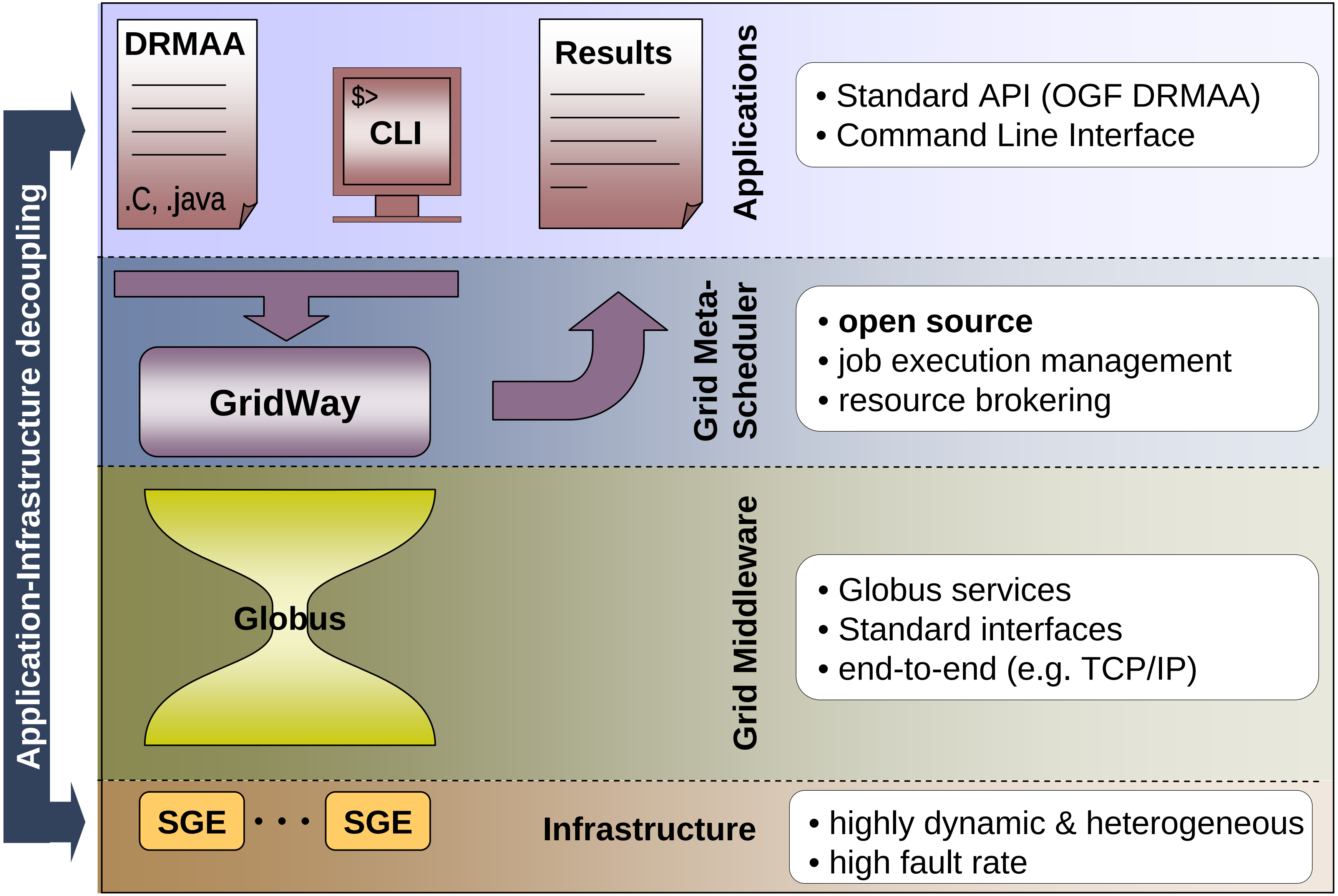
Information Services

Common Runtime

2. Globus GridWay Infrastructures

2.3. The GridWay Meta-scheduler

Global Architecture of a Computational Grid



- Standard API (OGF DRMAA)
- Command Line Interface

- **open source**
- job execution management
- resource brokering

- Globus services
- Standard interfaces
- end-to-end (e.g. TCP/IP)

- highly dynamic & heterogeneous
- high fault rate

2. Globus GridWay Infrastructures

2.3. The GridWay Meta-scheduler

Benefits

Integration of computational platforms (Organization)

- Establishment of a uniform and flexible infrastructure
- Achievement of greater utilization of resources, which could be heterogeneous
- Higher application throughput

Support for the existing platforms and LRM Systems (Sys. Admin.)

- Allocation of grid resources according to management specified policies
- Analysis of trends in resource usage
- Monitoring of user behavior

Familiar CLI and standard APIs (End Users & Developers)

- High Throughput Computing Applications
- Workflows

2.3. The GridWay Meta-scheduler

Features

Workload Management

- Advanced (Grid-specific) scheduling policies
- Fault detection & recovery
- Accounting
- Array jobs and DAG workflows

User Interface

- OGF standards: JSDL & DRMAA (C and JAVA)
  - **Your DRMAA application also runs on Globus infrastructures!**
- Command line interface, similar to that found on local LRM Systems

Integration

- Straightforward deployment as new services are not required
- Interoperability between different infrastructures

2. Globus GridWay Infrastructures

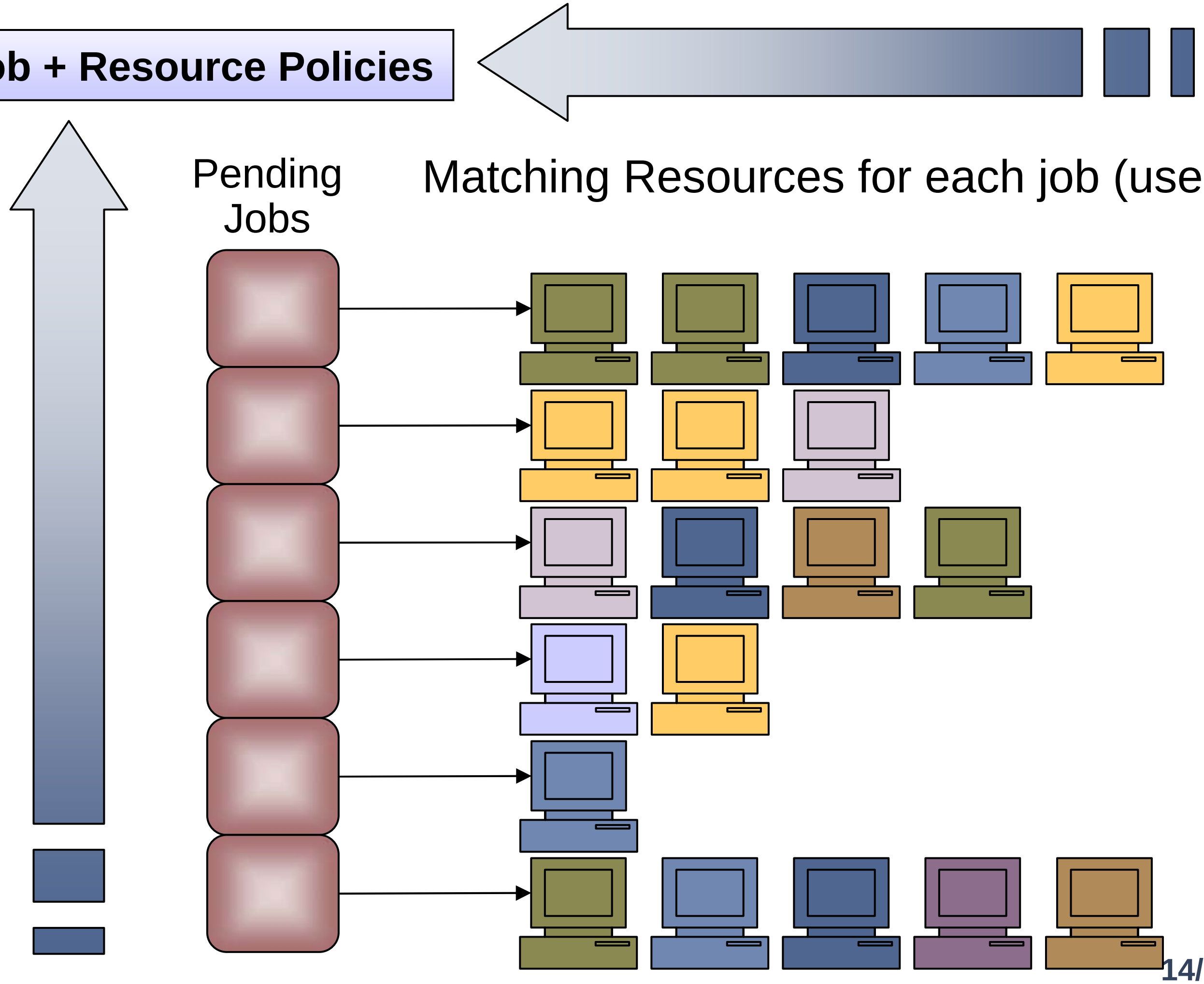
2.3. The GridWay Meta-scheduler

Grid-specific Scheduling Policies

Resource Policies

- Rank Expressions
- Fixed Priority
- User Usage History
- Failure Rate

Grid Scheduling = Job + Resource Policies



Job Policies

- Fixed Priority
- Urgent Jobs
- User Share
- Deadline
- Waiting Time

The GridWay Project

GridWay is a Globus Project

- Released under **Apache license v2.0**
- Adhering to Globus philosophy and guidelines for **collaborative development**
- Welcoming code and support contributions from individuals and corporations around the world

History of the Project

- The project started in 2002
- Since January 2005,
  - 5 stable software releases
  - More than 1.000 downloads from 80 different countries (25% Industry and 75% Academia and Research)
- Best-effort support provided (contract support is also available)
- **Widely used**: Success stories at http://www.gridway.org

2. Globus GridWay Infrastructures

2.4. Deployment Alternatives

Centralized
Coupled

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Clusters

Network Systems Intranet/Internet

Grid Infrastructures

High Performance Computing

High Throughput Computing

2.4. Deployment Alternatives

Enterprise Grid Infrastructures

Characteristics

- “Small” scale infrastructures (campus/enterprise) with one meta-scheduler instance providing access to resources within the same administration domain that may be running different LRMS and be geographically distributed

Goal & Benefits

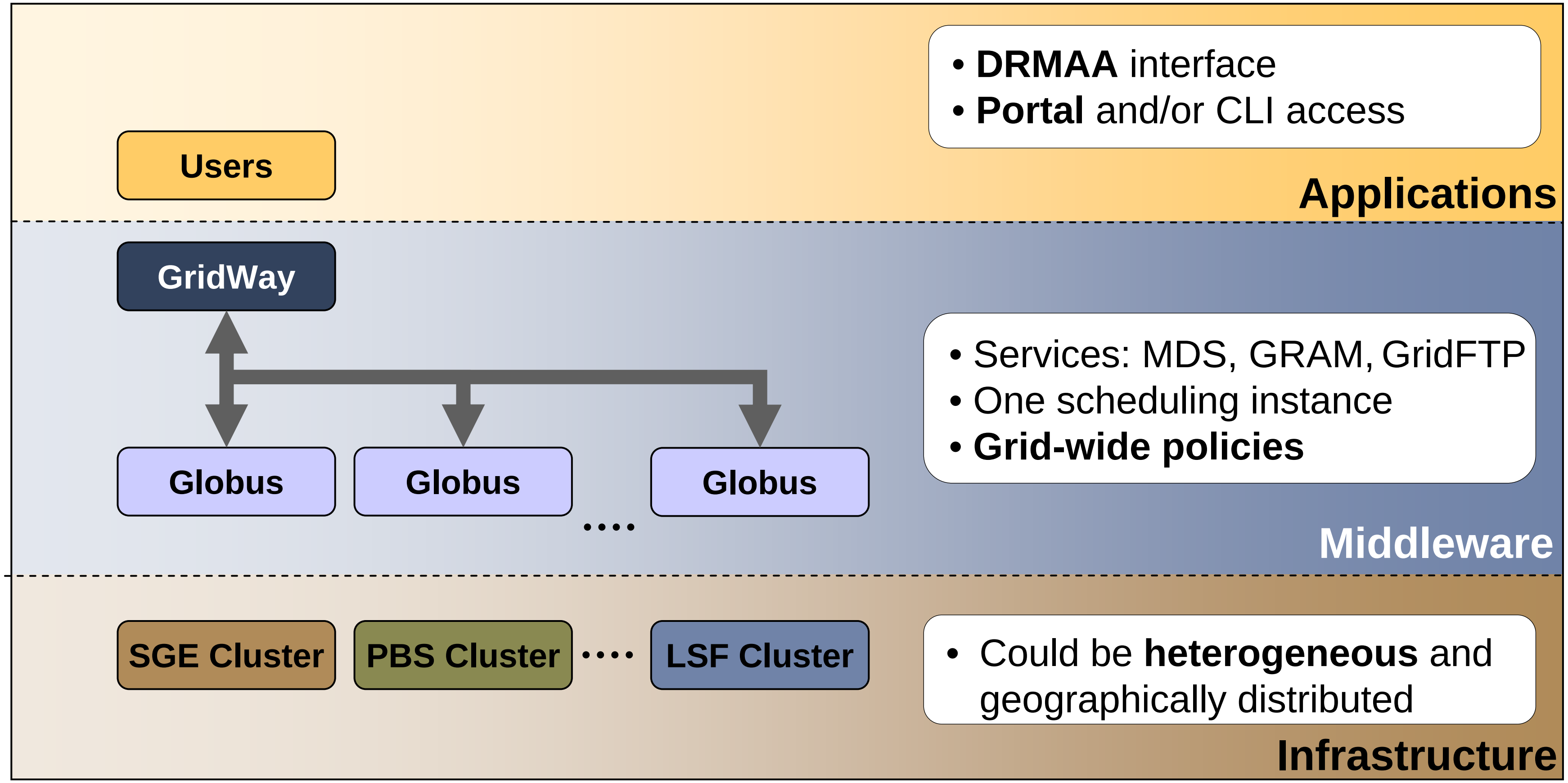
- Integrate multiple systems, that could be heterogeneous, in an *uniform/centralized* infrastructure
- Decoupling of applications and resources
- Improve return of IT investment
- Performance/Usage maximization

Scheduling

- Centralized meta-scheduler that allows the enforcement of **Grid-wide policies** (e.g. resource usage) and provides **centralized accounting**

2.4. Deployment Alternatives

Deploying Enterprise Grids with GridWay



- **DRMAA** interface
- **Portal** and/or CLI access

- Services: MDS, GRAM, GridFTP
- One scheduling instance
- **Grid-wide policies**

- Could be **heterogeneous** and geographically distributed

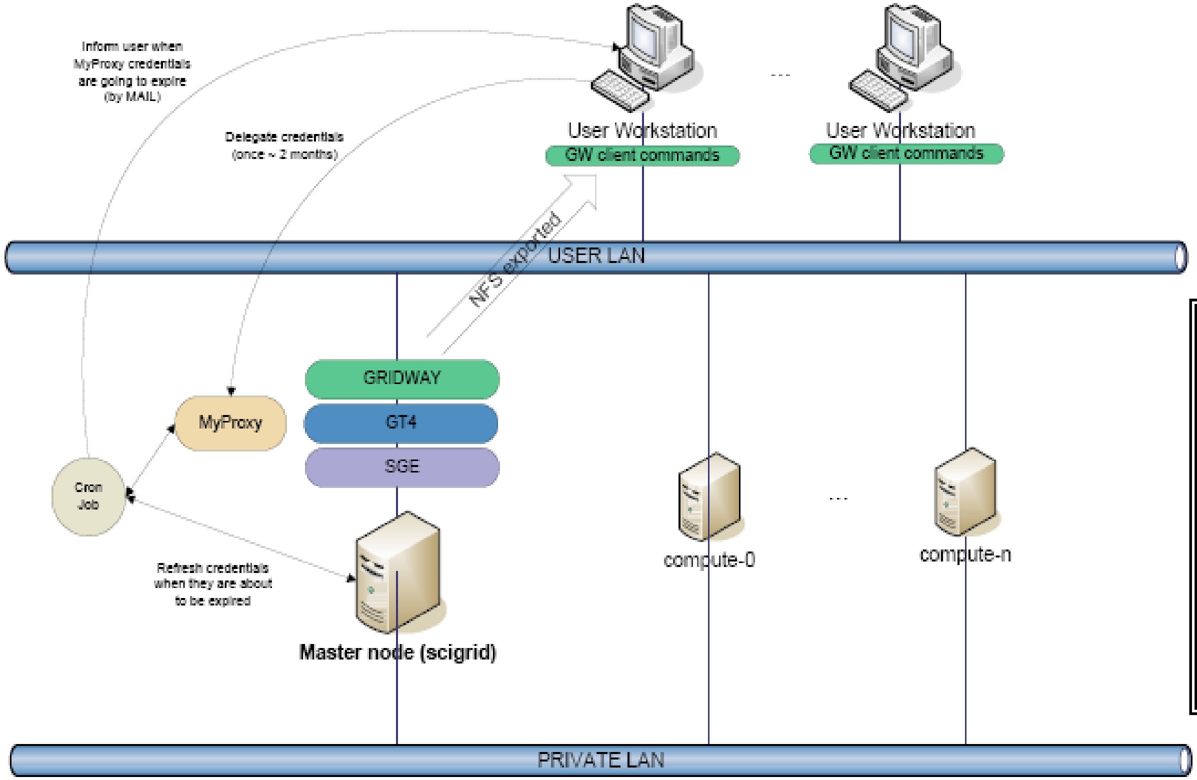
2. Globus GridWay Infrastructures

2.4. Deployment Alternatives

Enterprise Grids: Examples

European Space Astronomy Center

- Data Analysis from space missions (DRMAA)
- Site-level meta-scheduler
- Several clusters



2. Globus GridWay Infrastructures

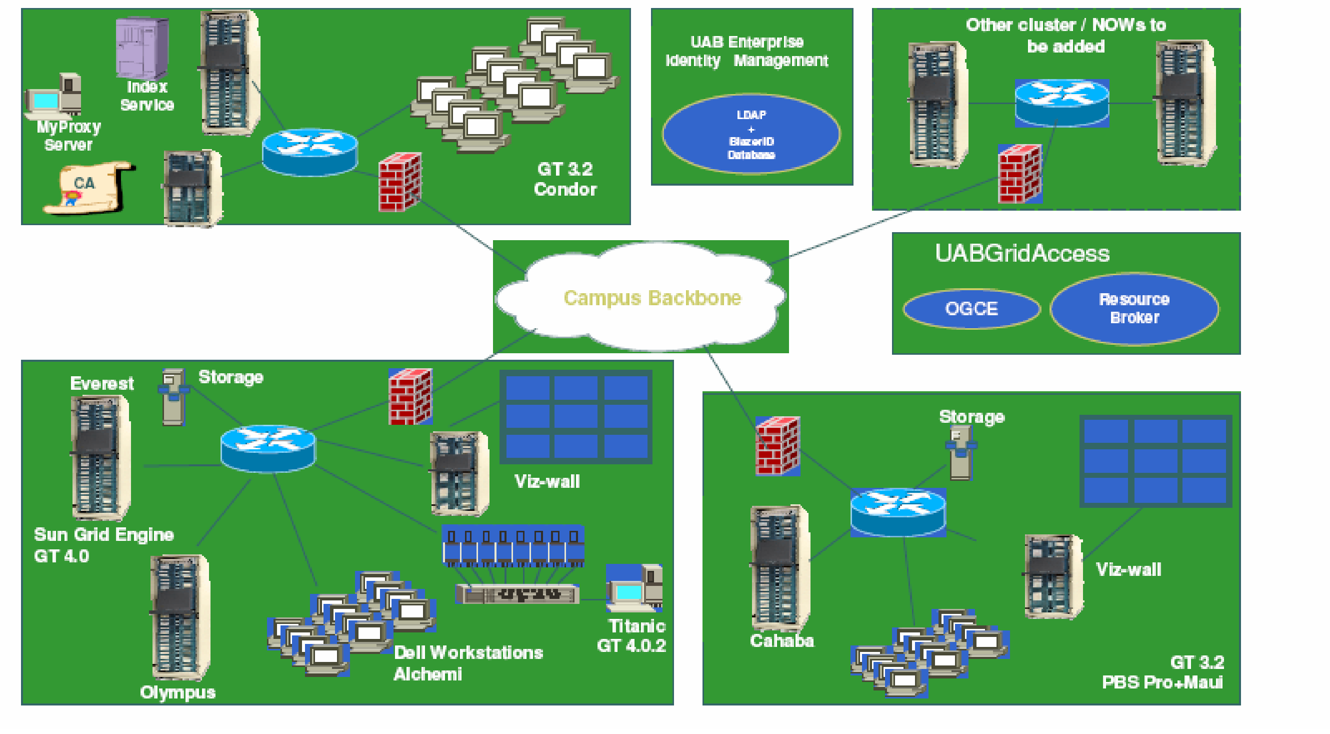
2.4. Deployment Alternatives

Enterprise Grids: Examples

UABGrid, University of Alabama at Birmingham

- Bioinformatics applications
- Campus-level meta-scheduler
- 3 resources (PBS, SGE and Condor)

UAB THE UNIVERSITY OF ALABAMA AT BIRMINGHAM



2. Globus GridWay Infrastructures

2.4. Deployment Alternatives

Partner Grid Infrastructures

Characteristics

- “Large” scale infrastructures with one or several meta-scheduler instances providing access to resources that belong to different administrative domains (different organizations or partners)

Goal & Benefits

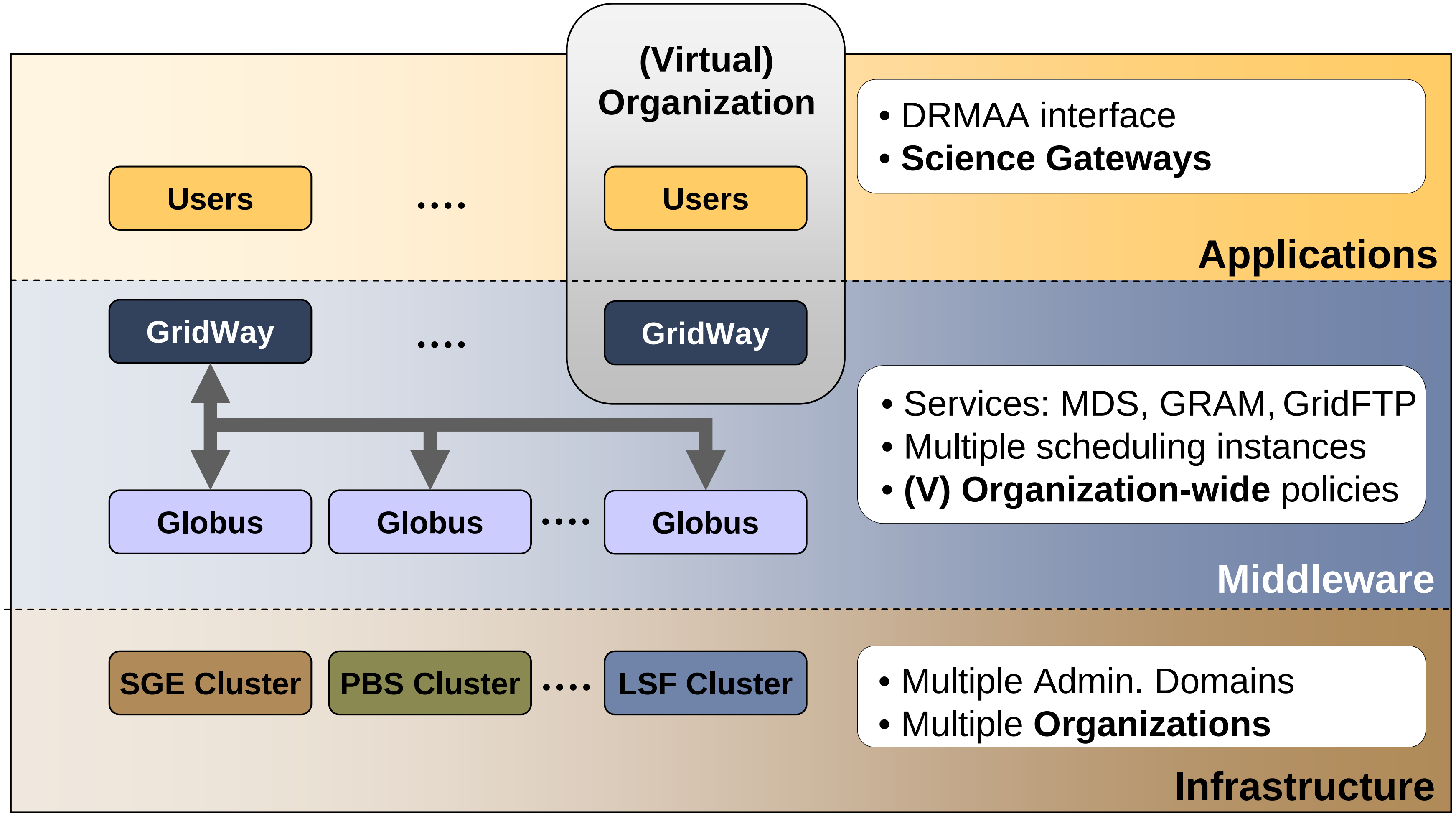
- Large-scale, secure and reliable sharing of resources between partners or supply-chain participants
- Support collaborative projects
- Access to higher computing power to satisfy peak demands

Scheduling

- Decentralized scheduling system that allows the enforcement of **organization-wide** policies

2.4. Deployment Alternatives

Deploying Partner Grids with GridWay



- DRMAA interface
- **Science Gateways**

- Services: MDS, GRAM, GridFTP
- Multiple scheduling instances
- **(V) Organization-wide** policies

- Multiple Admin. Domains
- Multiple **Organizations**

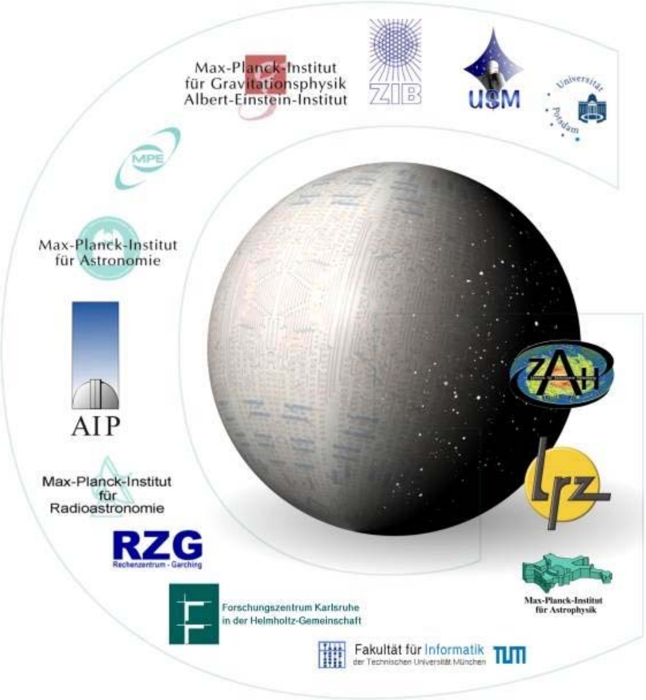
2. Globus GridWay Infrastructures

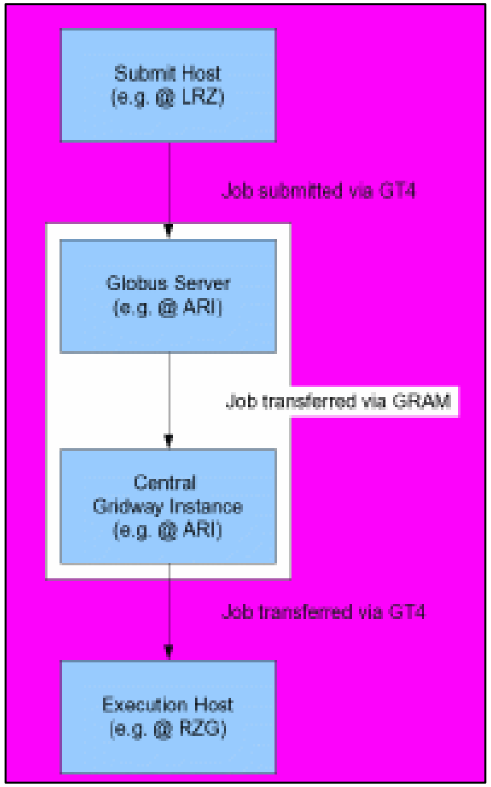
2.4. Deployment Alternatives

Partner Grids: Examples

AstroGrid-D, German Astronomy Community Grid

- Collaborative management of supercomputing resources & astronomy-specific resources
- Grid-level meta-scheduler (GRAM interface)
- 22 resources @ 5 sites, 800 CPUs


Max-Planck-Institut für Gravitationsphysik Albert-Einstein-Institut
ZIB
USM
Universität Potsdam
MPE
Max-Planck-Institut für Astronomie
AIP
ZAH
Max-Planck-Institut für Radioastronomie
lrz
RZG
Rechenzentrum · Garching
Max-Planck-Institut für Astrophysik
Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft
Fakultät für Informatik der Technischen Universität München
TUM


Submit Host (e.g. @ LRZ)

Job submitted via GT4

Globus Server (e.g. @ ARI)

Job transferred via GRAM

Central Gridway Instance (e.g. @ ARI)

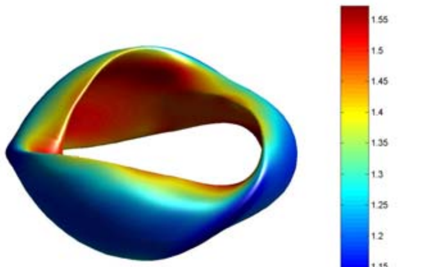
Job transferred via GT4

Execution Host (e.g. @ RZG)

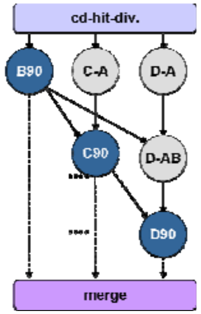
2. Globus GridWay Infrastructures

2.4. Deployment Alternatives

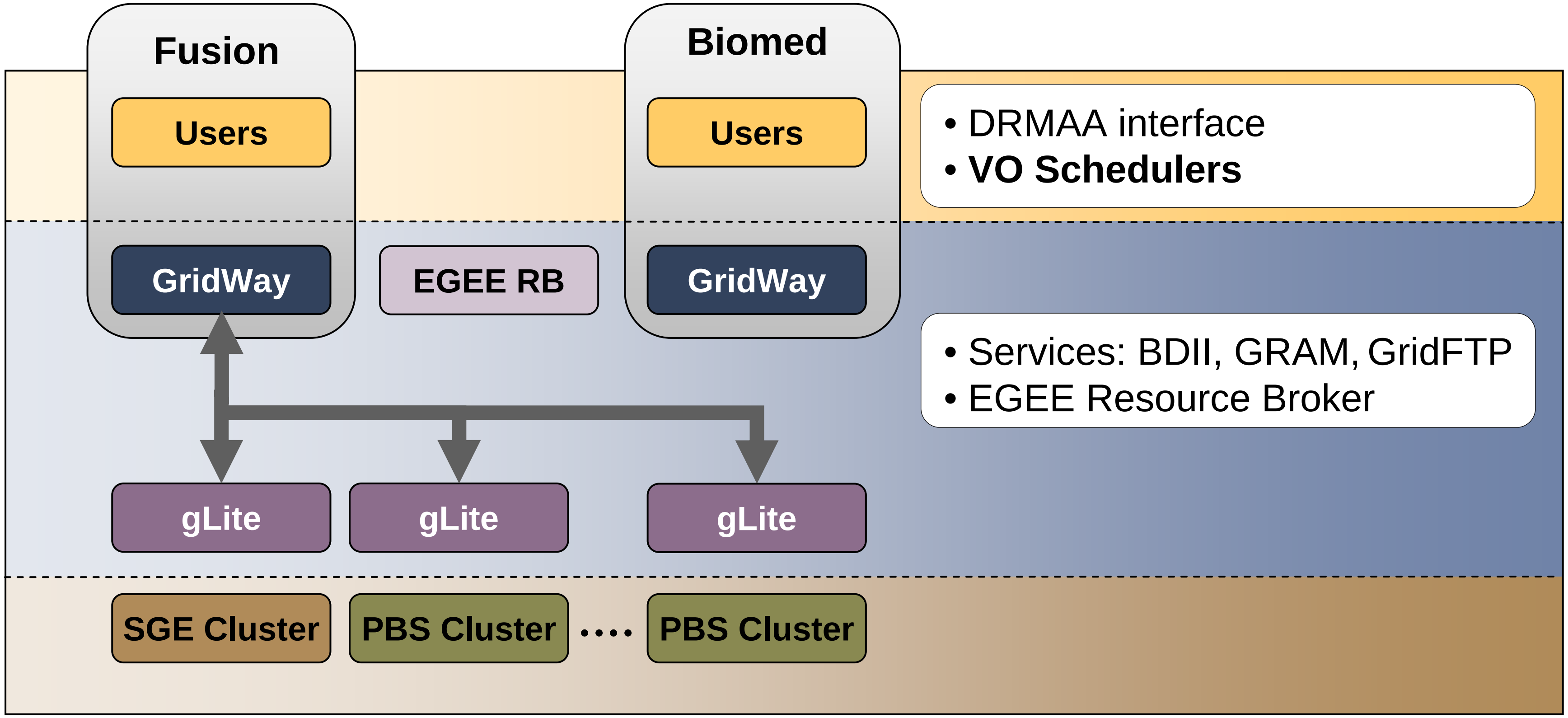
Partner Grids: Examples



Massive **Ray Tra**cing



CD-HIT workflow



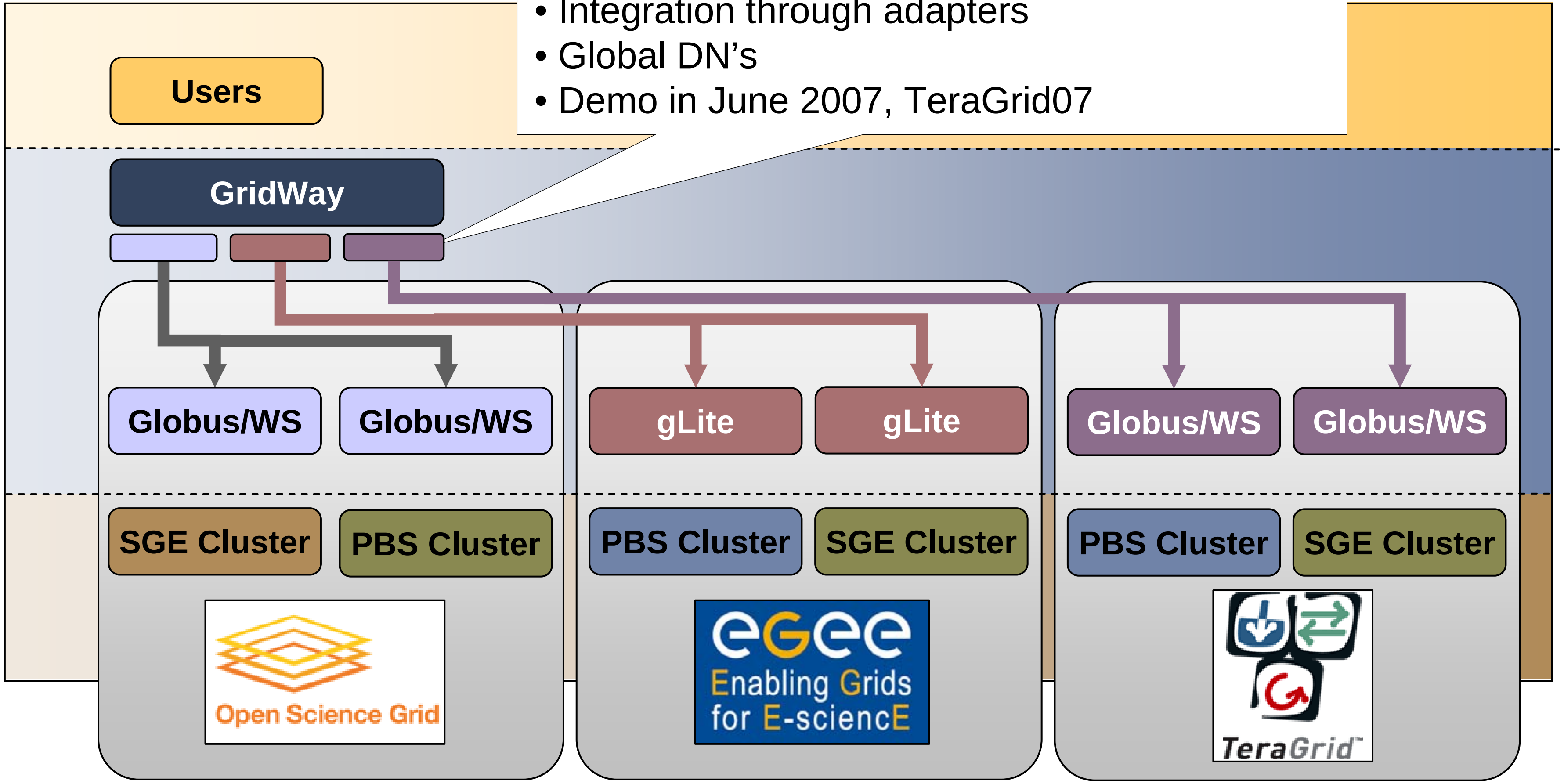
- DRMAA interface
- **VO Schedulers**

- Services: BDII, GRAM, GridFTP
- EGEE Resource Broker

2.4. Deployment Alternatives

A Tool for Interoperability

- Different Middlewares (e.g. WS and pre-WS)
- Different Data/Execution architectures
- Different Information models
- Integration through adapters
- Global DN's
- Demo in June 2007, TeraGrid07



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Interfaces Provided by Existing Grid Infrastructures

Grid specific commands & API's

- Applications must be ported to the Grid
- Process (submission, monitoring…) must be adapted to the Grid
- New interfaces (e.g. portal) to simplify Grid use

LRMS-like commands & API's => GridWay

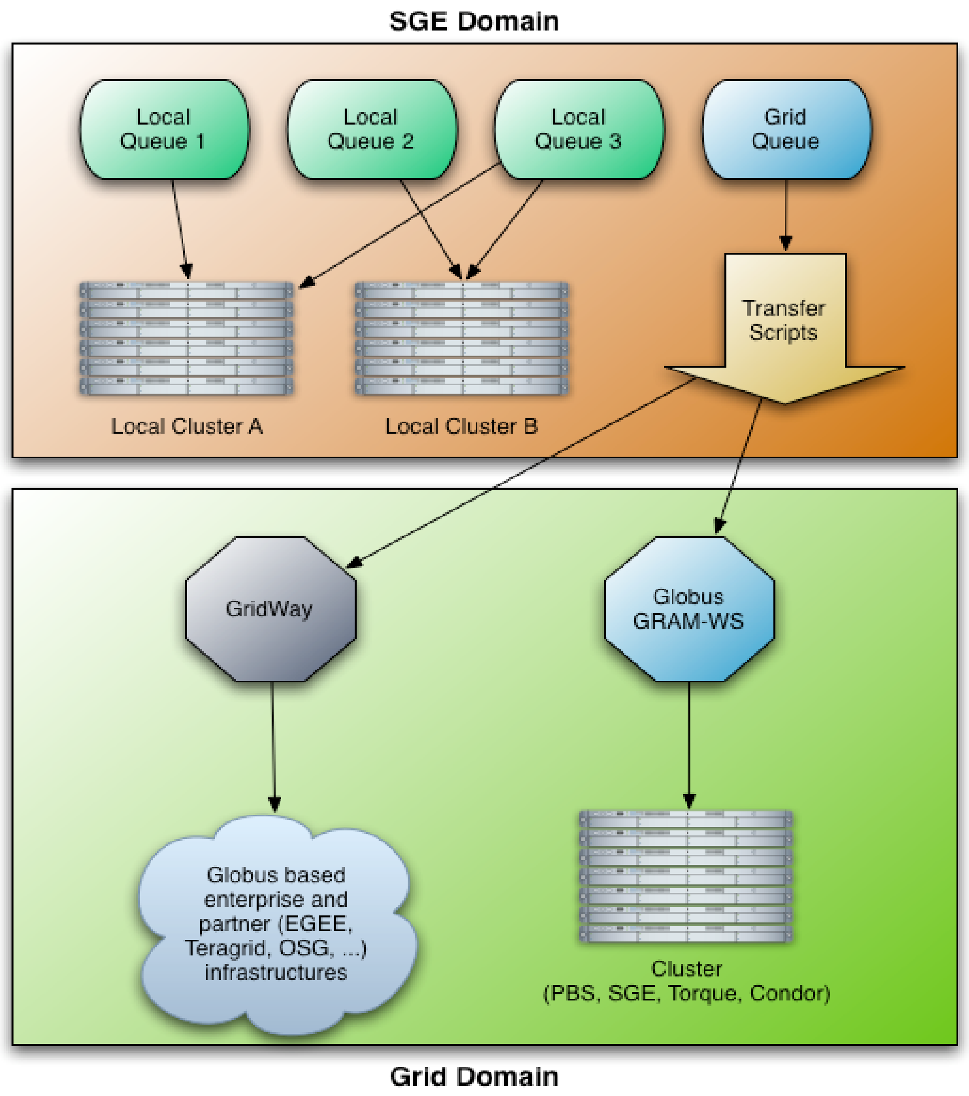
- A familiar environment to interact with a computational platform
- SGE-like environment for Computational Grids
- Process still need to be adapted
- Applications would greatly benefit from standards (DRMAA)

Transfer Queues: Seamless access to the Grid

3. A Taxonomy for Grid Scheduling Architectures

3.2. From the Cluster to the Grid

From SGE to a Grid Infrastructure or a Cluster (the other way)



3. A Taxonomy for Grid Scheduling Architectures

3.2. From the Cluster to the Grid

Transfer Queues: Seamless access to the Grid

- Access to a grid infrastructure (or remote cluster) on demand driven by SGE scheduling policies
- End users keep the same SGE interface
- Applications running on SGE are able to access the Grid

Transfer Queues: Limitations

- Requirements of system configuration (software, data…) on remote resources for job execution

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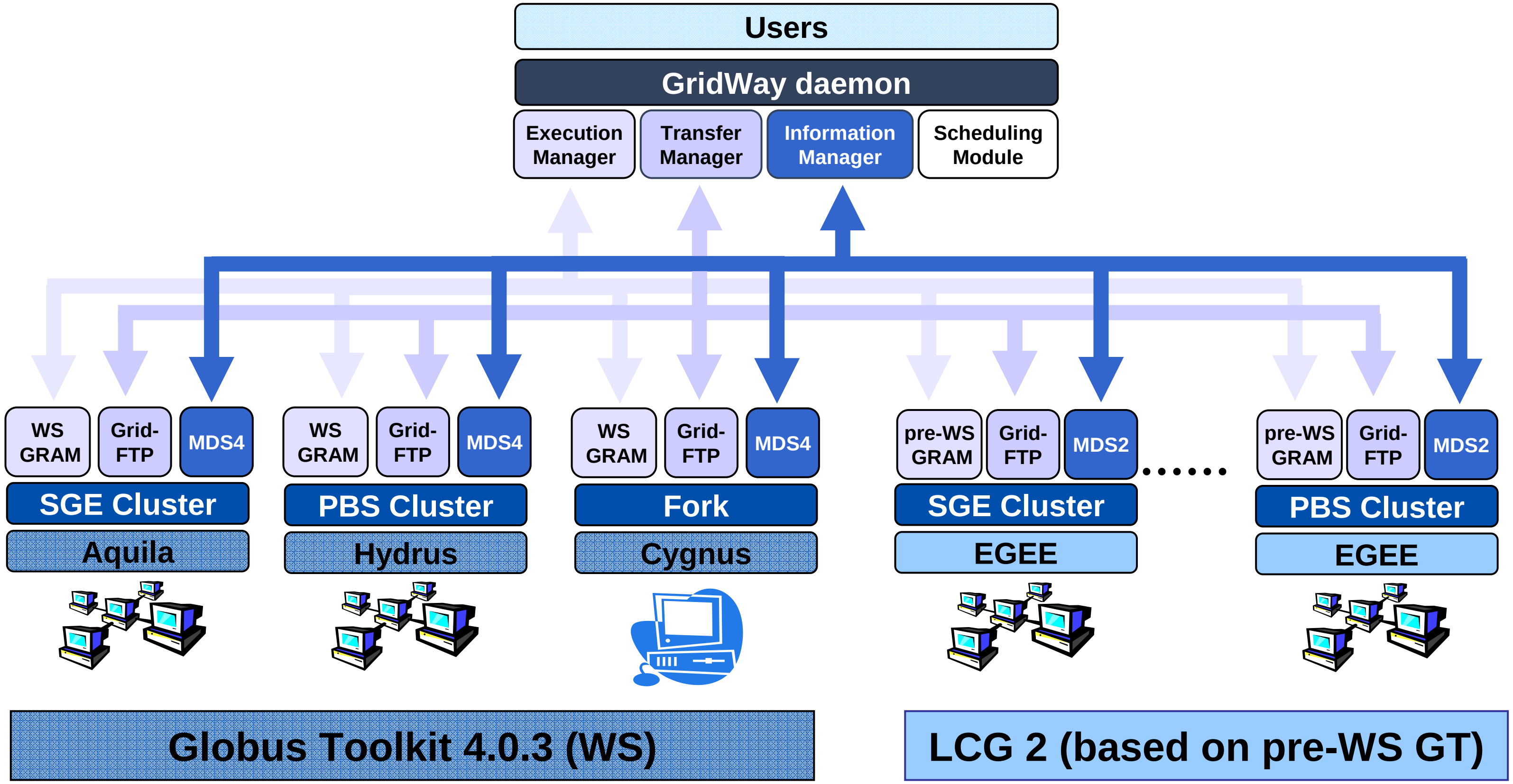
4. Demonstrations

4.1. Enterprise Grid

Testbed Configuration

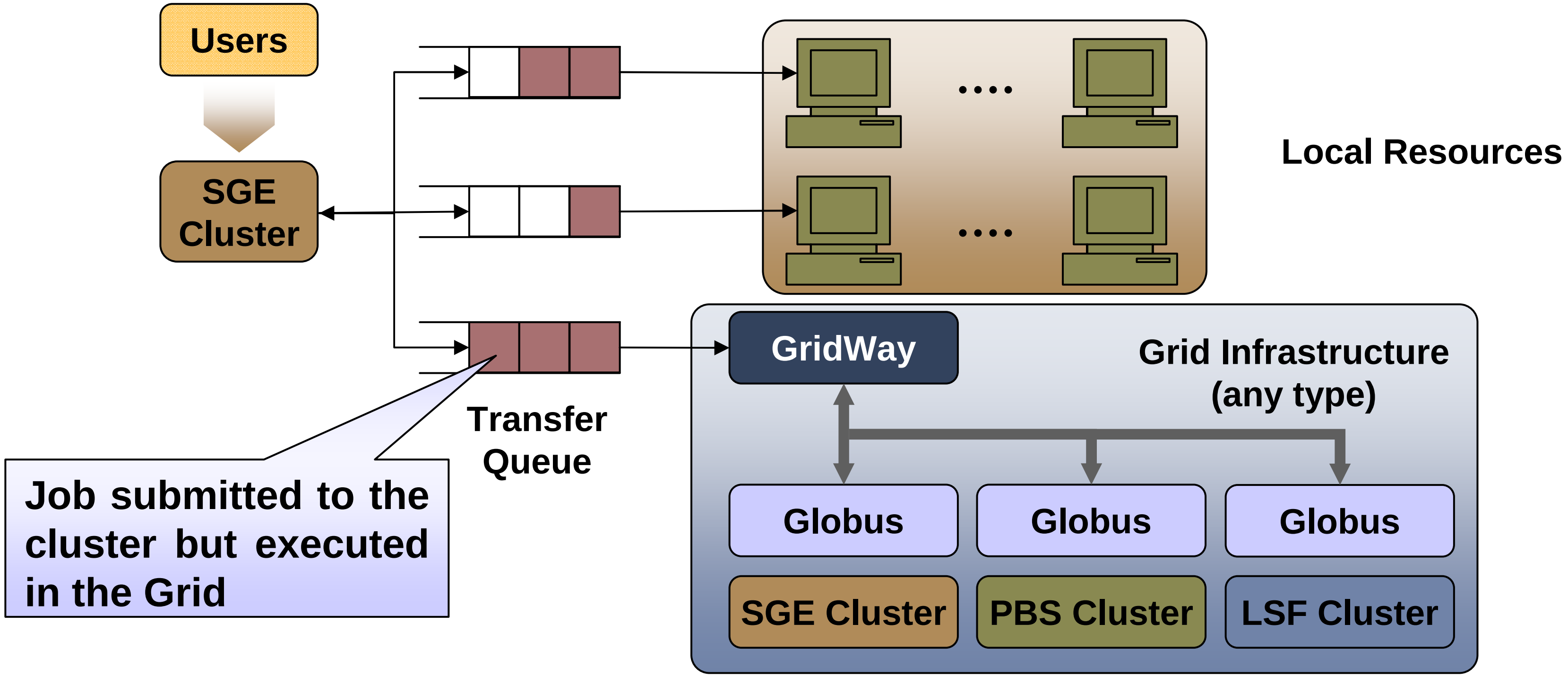
Information Manager: Static Discovery & Dynamic Monitoring (MDS2 & MDS4)
Execution Manager: Pre-WS and WS GRAM
Transfer Manager: GridFTP



4. Demonstrations

4.2. Transfer Queue to GridWay

Testbed Configuration



Job submitted to the cluster but executed in the Grid

Globus GridWay and SGE

Conclusions

Globus GridWay for SGE Users

Benefits

- Integration of SGE clusters within the organization
- Sharing of SGE clusters between partner organizations
- Provision of computing services to other organizations
- Inter-operability with other LRMS

Deployment Alternatives

- Enterprise grid with a single meta-scheduling instance
- Partner grids with several meta-scheduling instances
- Utility grids to access on demand to remote grids or clusters

Interface Alternatives

- SGE-like CLI, DRMAA API and Portal
- Transfer queues

Globus GridWay and SGE

Thank you

for your attention!

Backup Slides

2.4. Deployment Alternatives

Utility Grid Infrastructures

Characteristics

- Multiple meta-scheduler layers in a hierarchical structure
- Resource provision in a utility fashion (provider/consumer)

Goal & Benefits

- Supply resources on-demand, making resource provision more adaptive
- Access to *unlimited* computational capacity
- Transform IT costs from fixed to variable
- Seamless integration of different Grids (The Grid)

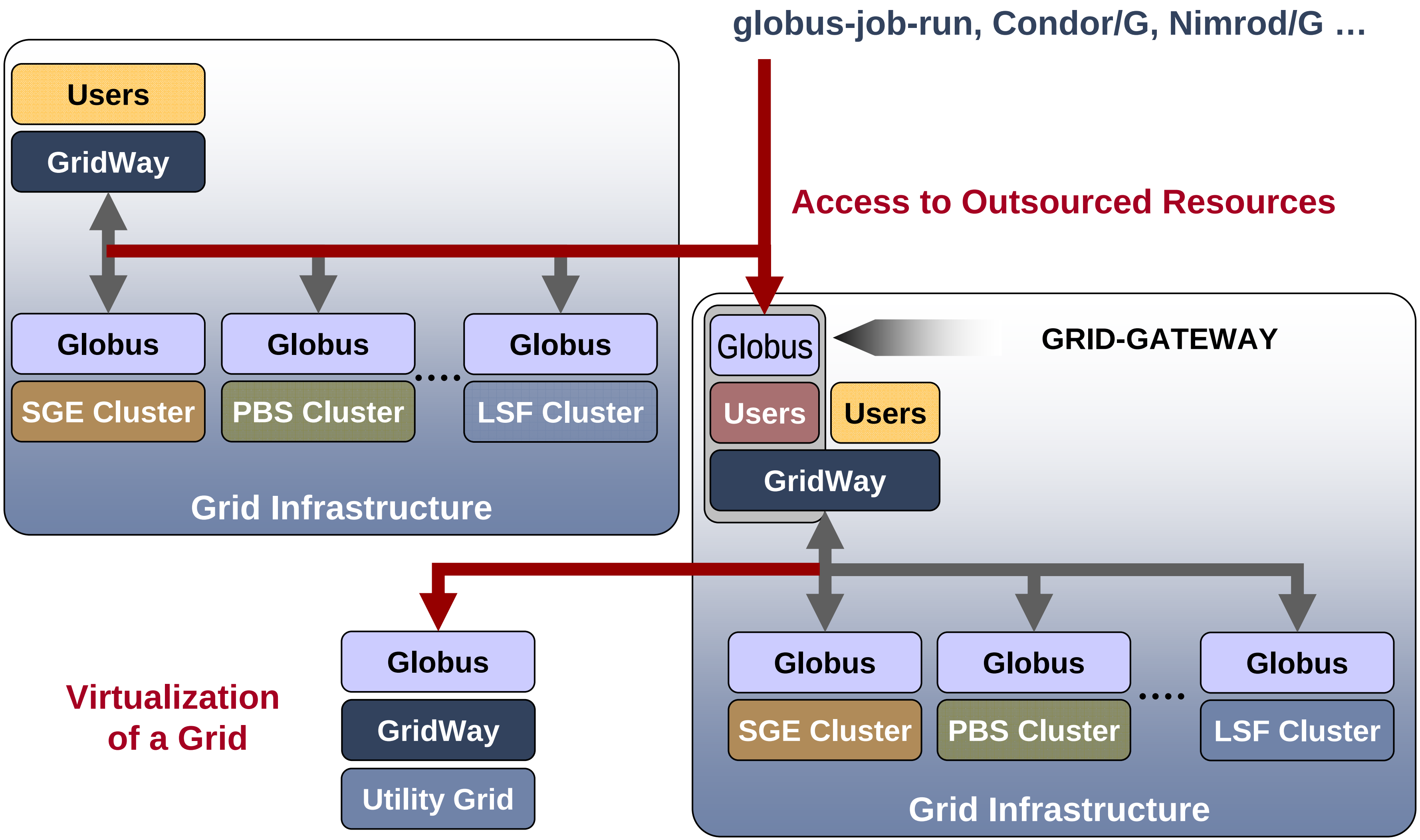
Scheduling

- Each Grid is handled as any other resource
- Characterization of a Grid as a single resource
- Use standard interfaces to virtualize a Grid infrastructure

2. Globus GridWay Infrastructures

2.4. Deployment Alternatives

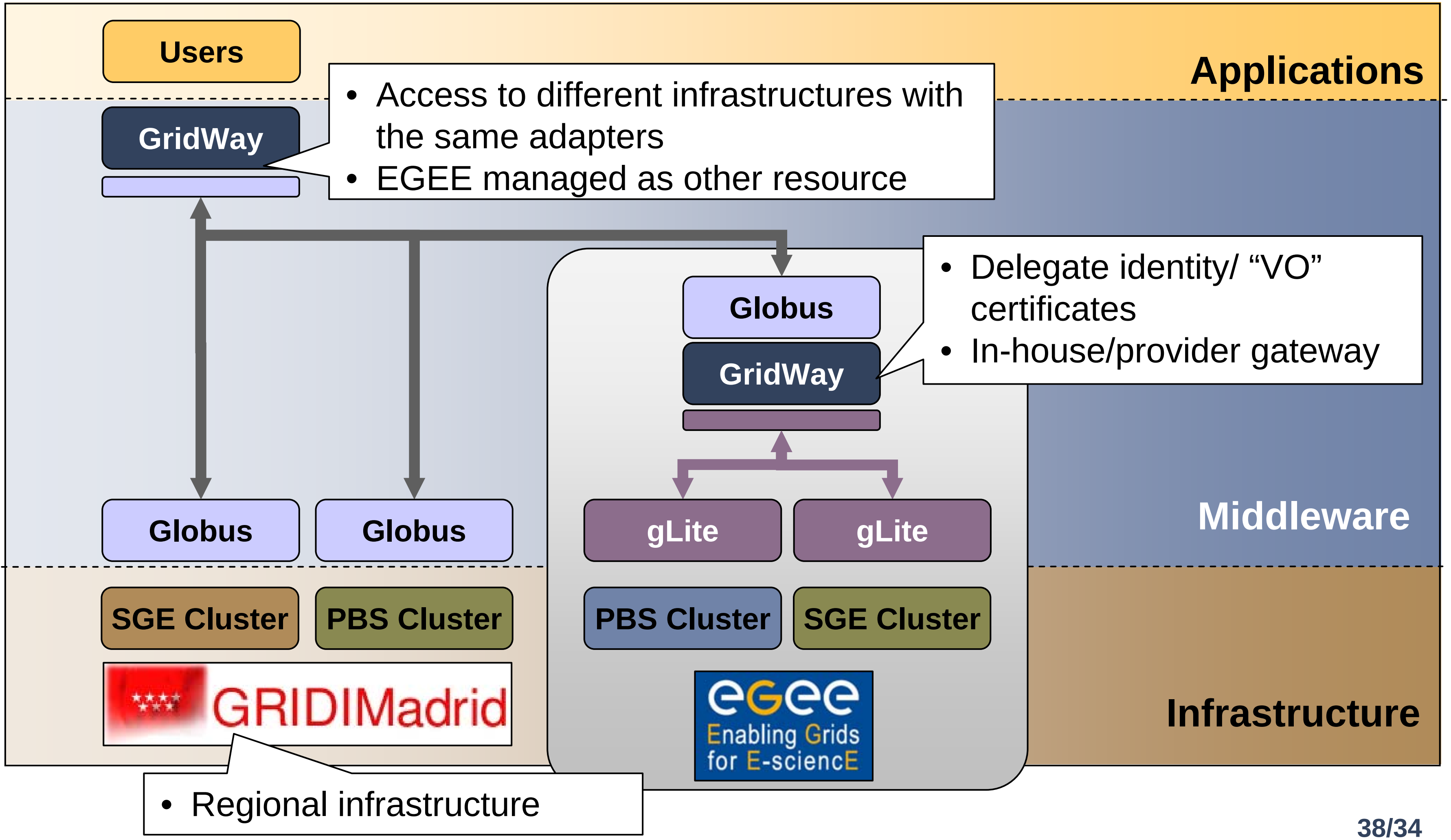
Deploying Utility Grid Infrastructures with GridWay



2. Globus GridWay Infrastructures

2.4. Deployment Alternatives

Utility Grids: Example



- Access to different infrastructures with the same adapters
- EGEE managed as other resource

- Delegate identity/ “VO” certificates
- In-house/provider gateway

- Regional infrastructure