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GridWay

Grid Scheduling Architectures with Globus

Workshop on Scheduling WS 07
Cetraro, Italy
July 28, 2007

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MINISTERIO DE EDUCACION Y CIENCIA

Contents

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 ← **Decentralized Decoupled**

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

SMP (Symmetric Multi-processors)	**MPP** (Massive Parallel Processors)	**Clusters**	**Network Systems Intranet/Internet**
			

High Performance Computing (SMP, MPP, Clusters)

High Throughput Computing (SMP, MPP, Clusters, Network Systems)

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*

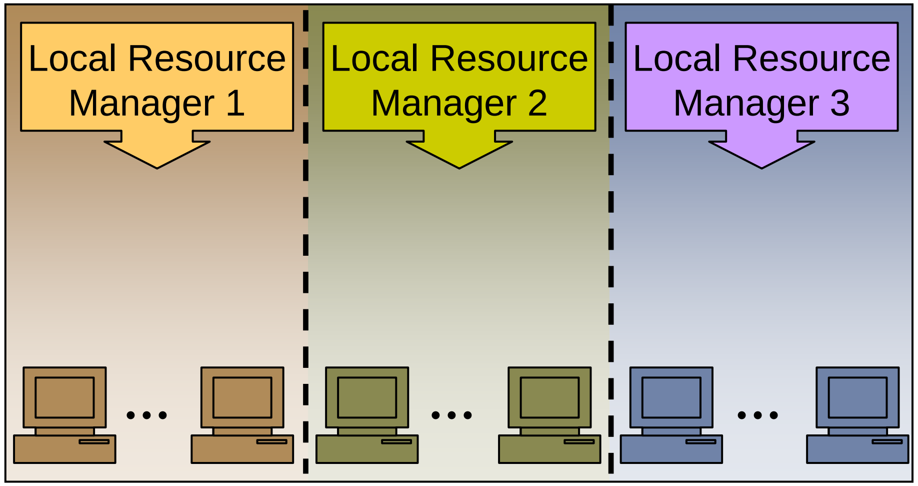
Independent Suppliers	*Open Source*	*OEM Proprietary*
2 *Platform Computing* 3 LSF	2 *Altair* Open PBS	1 *IBM* Load Leveler
2 *Altair* PBS Pro	3 *University of Wisconsin* Condor	1 *Cray* NQE
	2 *Sun Microsystems* 3 SGE	

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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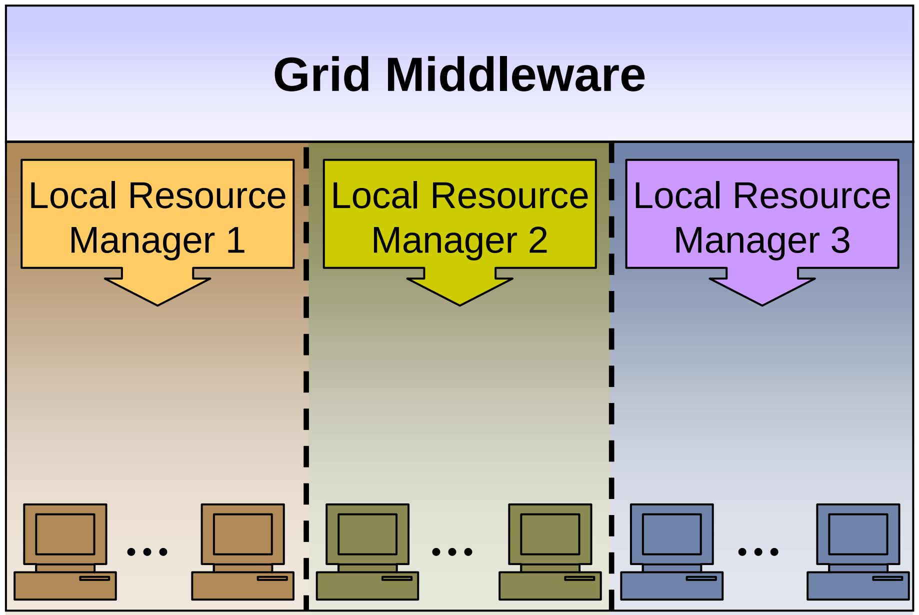
2. Grid Middleware

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 integrate heterogeneous computational platforms (vertical silos) and/or administrative domains 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.

2.1. Integration of Different Administrative Domains

Grid Middleware (a computational view)

- **Services in the Grid Middleware layer**
  - Security
  - Information & Monitoring
  - Data Management
  - Execution
  - Meta-scheduling
- **Open Source Software Distributions**

gLite — glite.web.cern.ch

UNICORE — www.unicore.org

open middleware infrastructure institute uk — www.omii.ac.uk

GRIA — www.gria.org

VDT Virtual Data Toolkit — vdt.cs.wisc.edu

- **Open Source Software Communities**

the globus alliance — **The Globus Alliance** (dev.globus.org)

The Globus Alliance Community

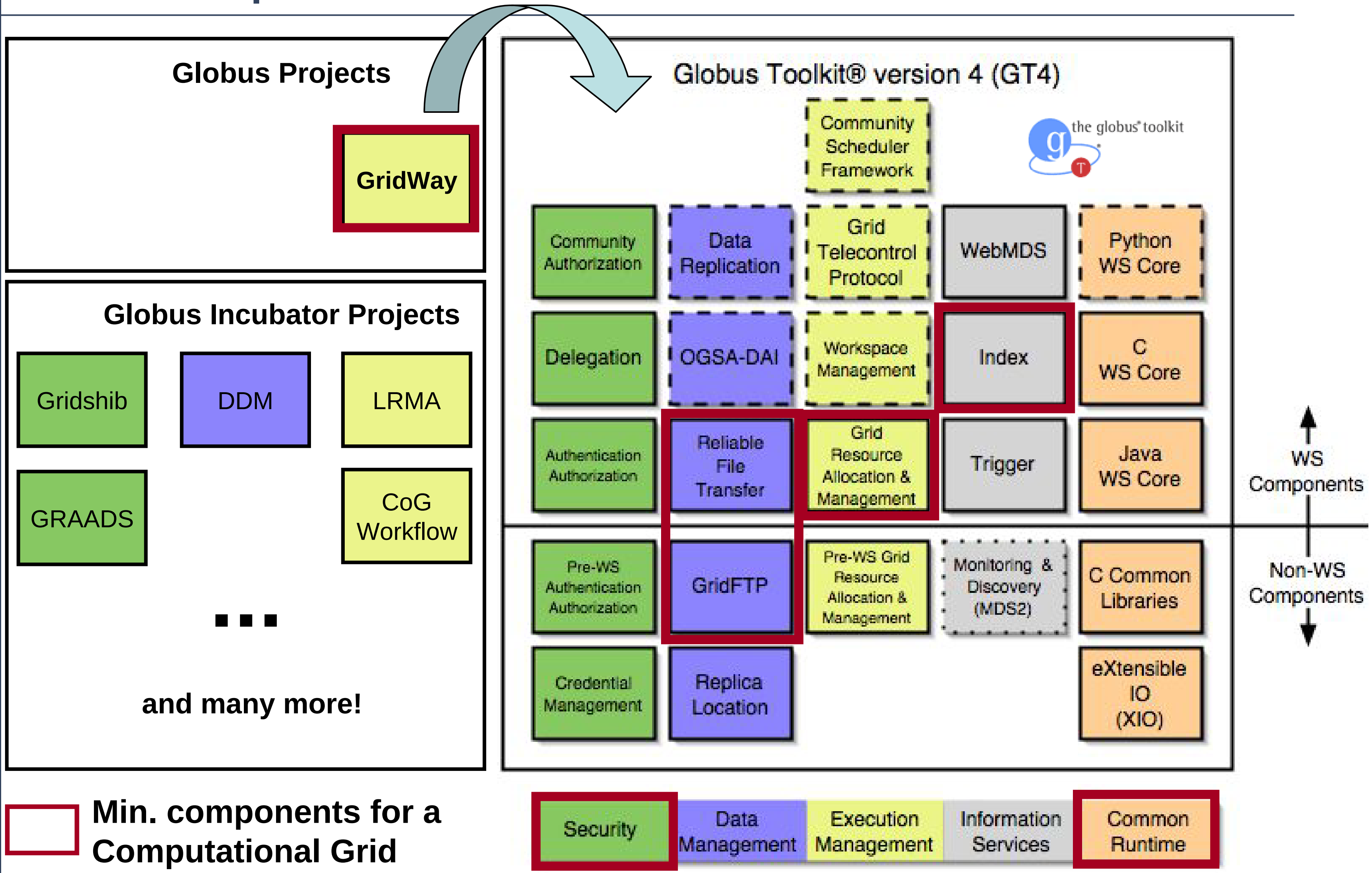
Open-Source Software Community =
Open-Source Software + Open Development Processes

- **Open Community Project** based on Apache Jakarta model:
  - Control of each individual project is in hands of the committers
  - Public development infrastructure for each project: CVS, bugzilla, mailing list, and Wiki
  - Each project goes through an incubation process before becoming a Globus project

The Globus Toolkit

- Software distribution that integrates a selected group of Globus technologies
- GT **provides basic services** to allow secure remote operation over multiple administrative domains with different LRM systems and access policies.

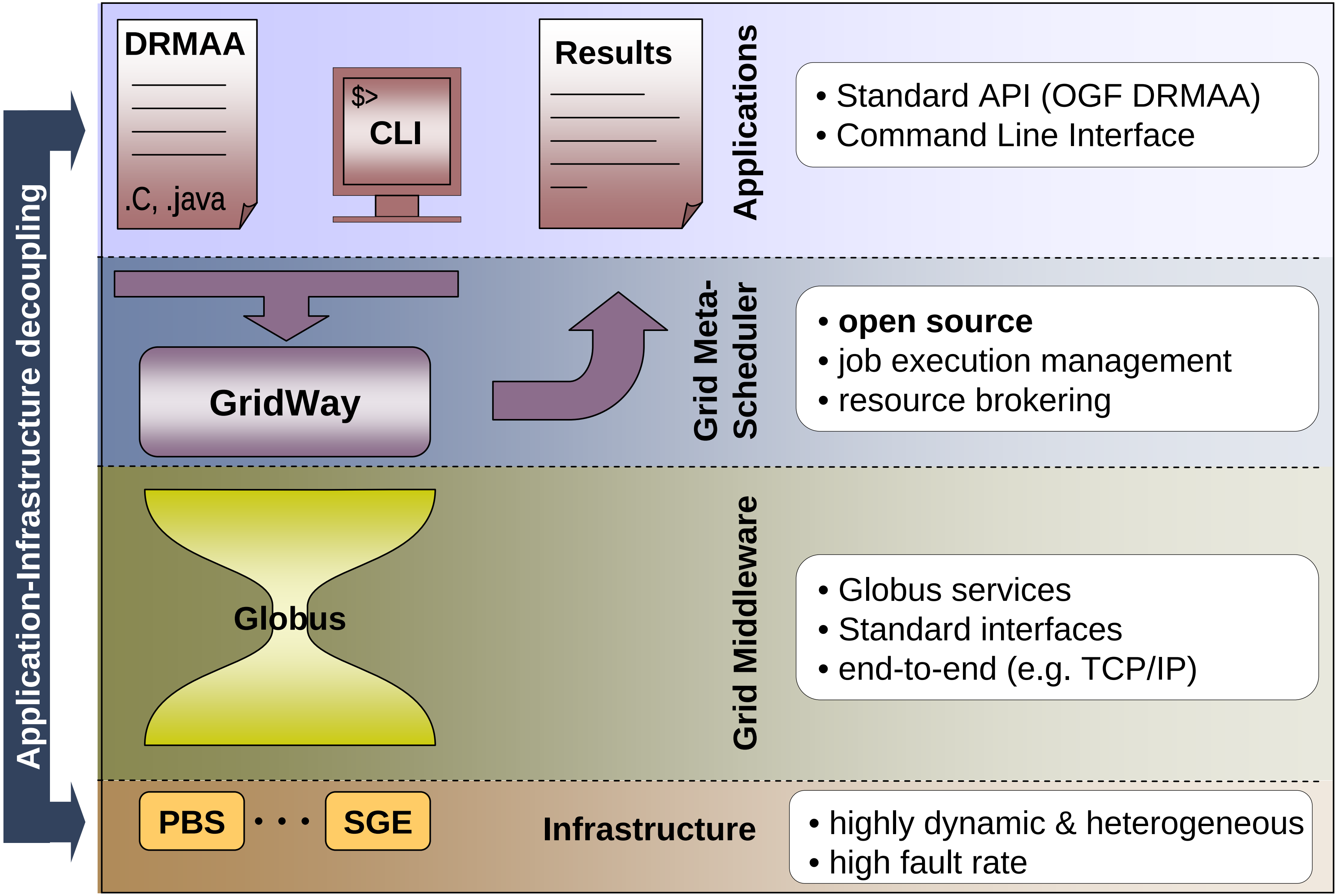
Globus Components



2. Grid Middleware

2.3. The GridWay Meta-scheduler

Global Architecture of a Computational Grid



GridWay

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Benefits

Integration of non-interoperable computational platforms (Organization)

- Establishment of a uniform and flexible infrastructure
- Achievement of greater utilization of resources and 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

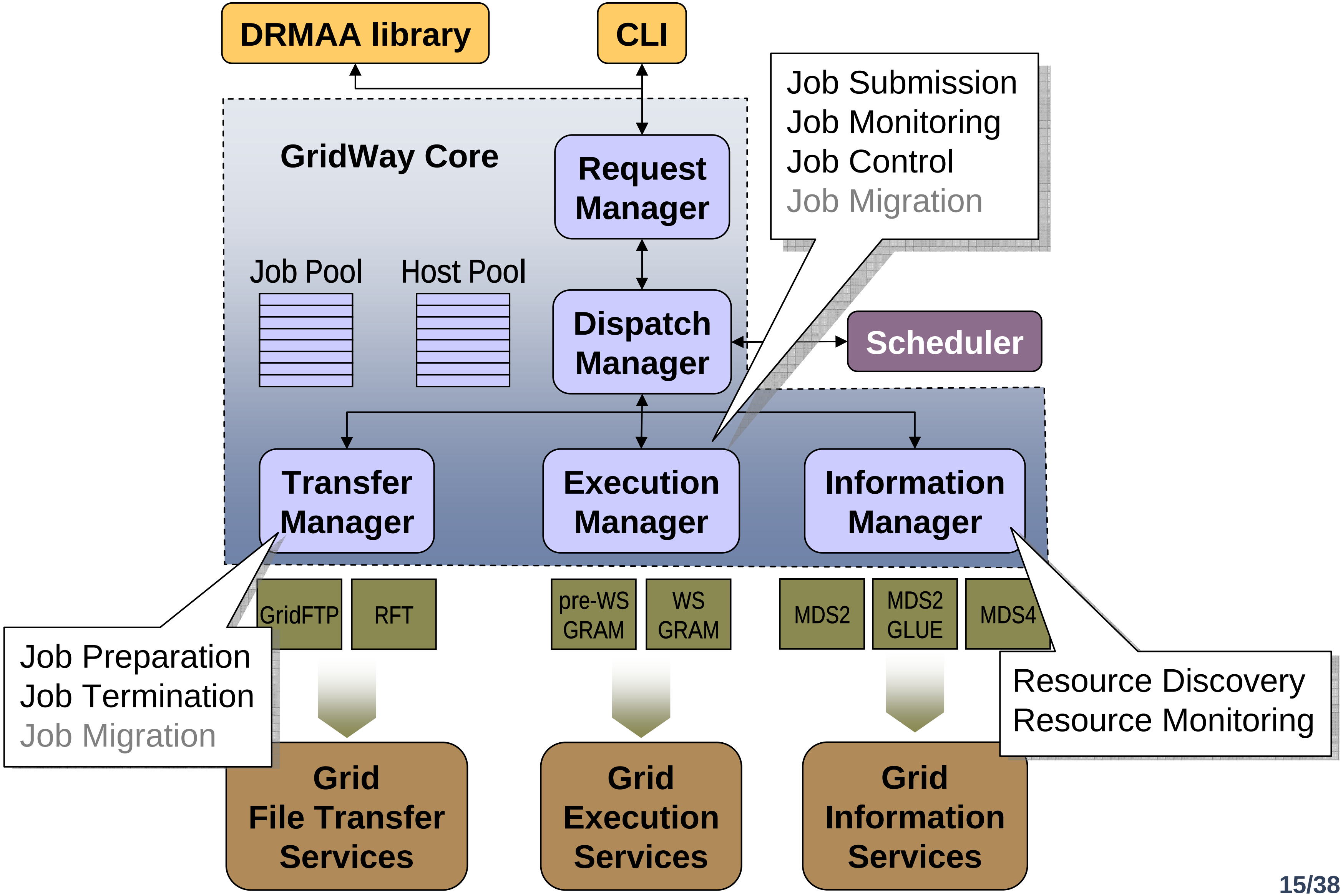
- OGF standards: JSDL & DRMAA (C and JAVA)
- Analysis of trends in resource usage
- Command line interface, similar to that found on local LRM Systems

Integration

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

2.3. The GridWay Meta-scheduler

GridWay Internals



GridWay

2. Grid Middleware

2.3. The GridWay Meta-scheduler

Grid-specific Scheduling Policies

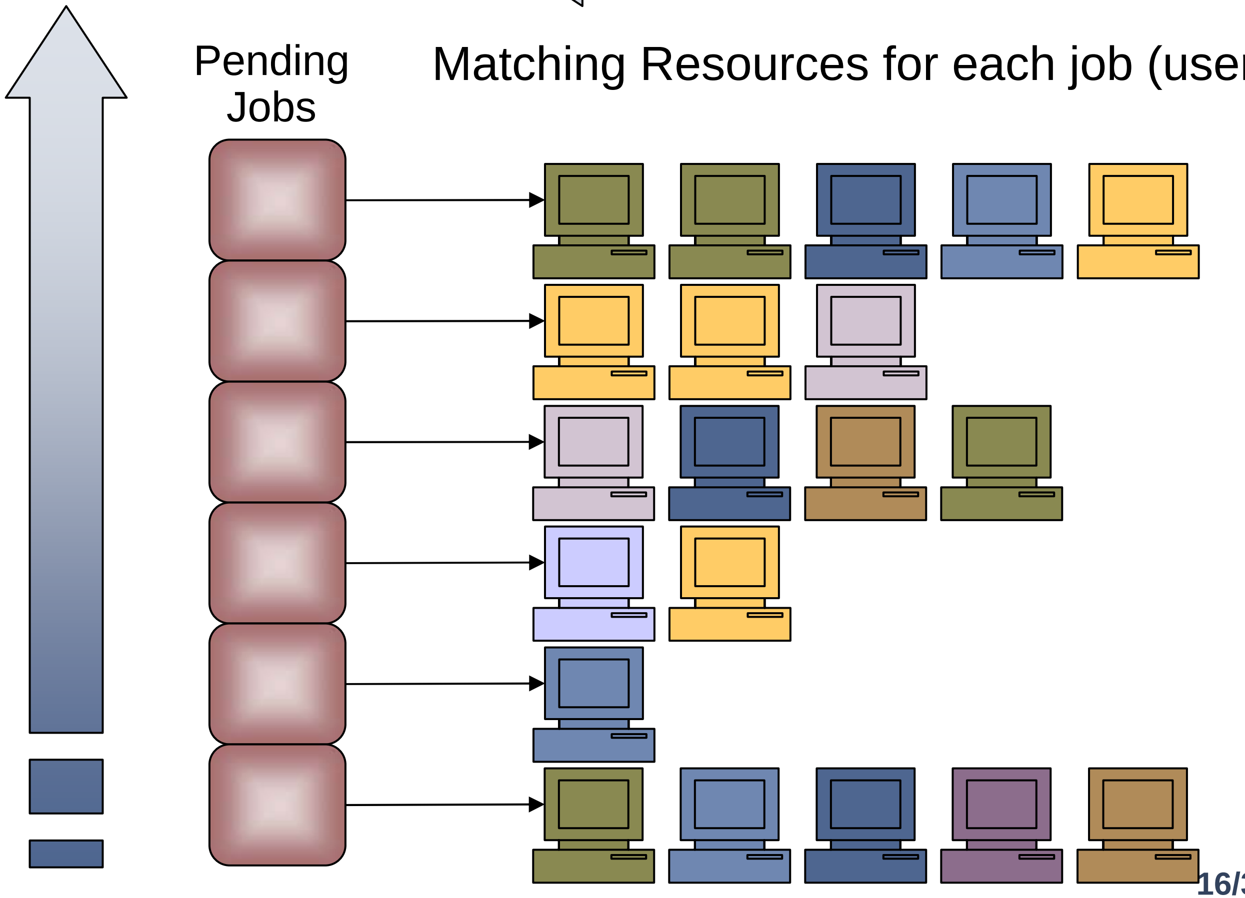
Resource Policies

- 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



DSA Group

2. Grid Middleware

2.3. The GridWay Meta-scheduler

Centralized Coupled

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

Decentralized Decoupled

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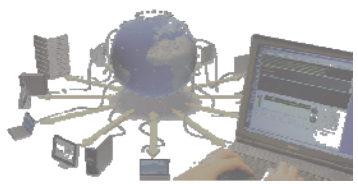

High Performance Computing

High Throughput Computing

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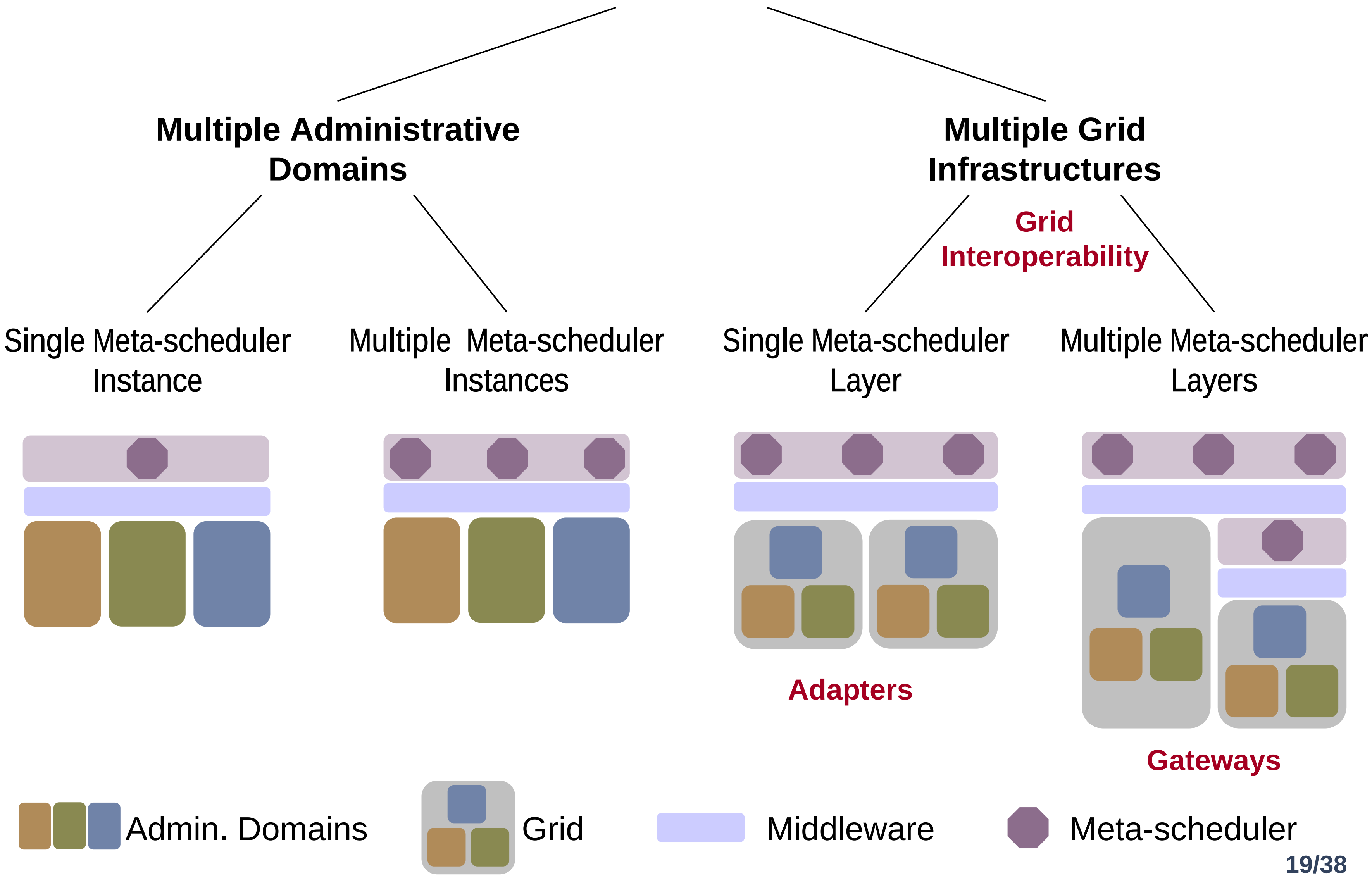
3. A Taxonomy for Grid Architectures

3.1. The Taxonomy



Single Meta-Scheduler Grids

Characteristics

- One meta-scheduler instance with access to resources that may belong to different administrative domains
- Small scale infrastructures (campus or enterprise) that may be geographically distributed in different sites

Goal & Benefits

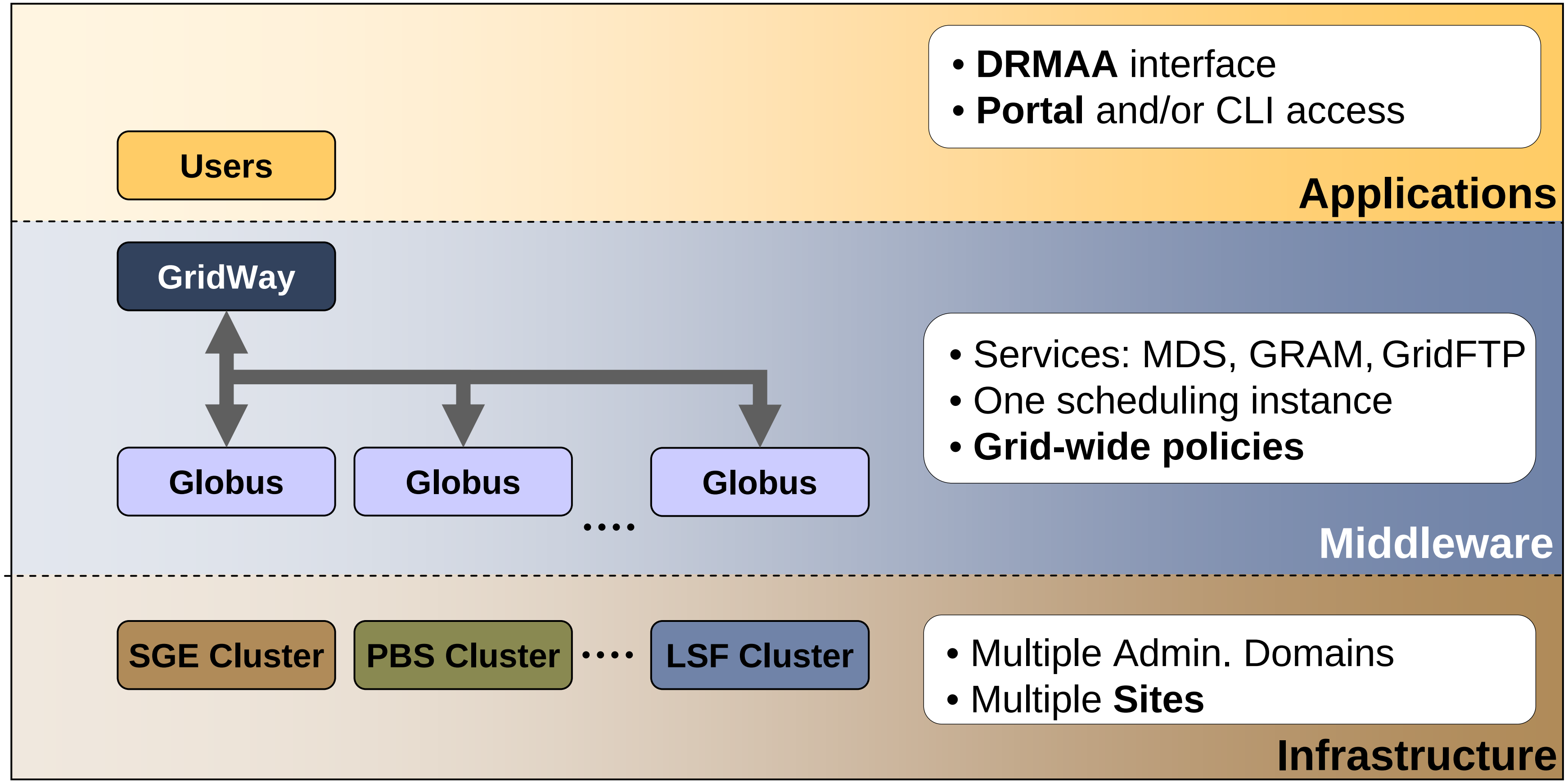
- Integrate multiple heterogeneous systems and/or administrative domains in an *uniform/centralized* infrastructure
- Improve return of IT investment
- Cost minimization
- Performance/Usage maximization

Scheduling

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

3.2. Multiple Administrative Domains

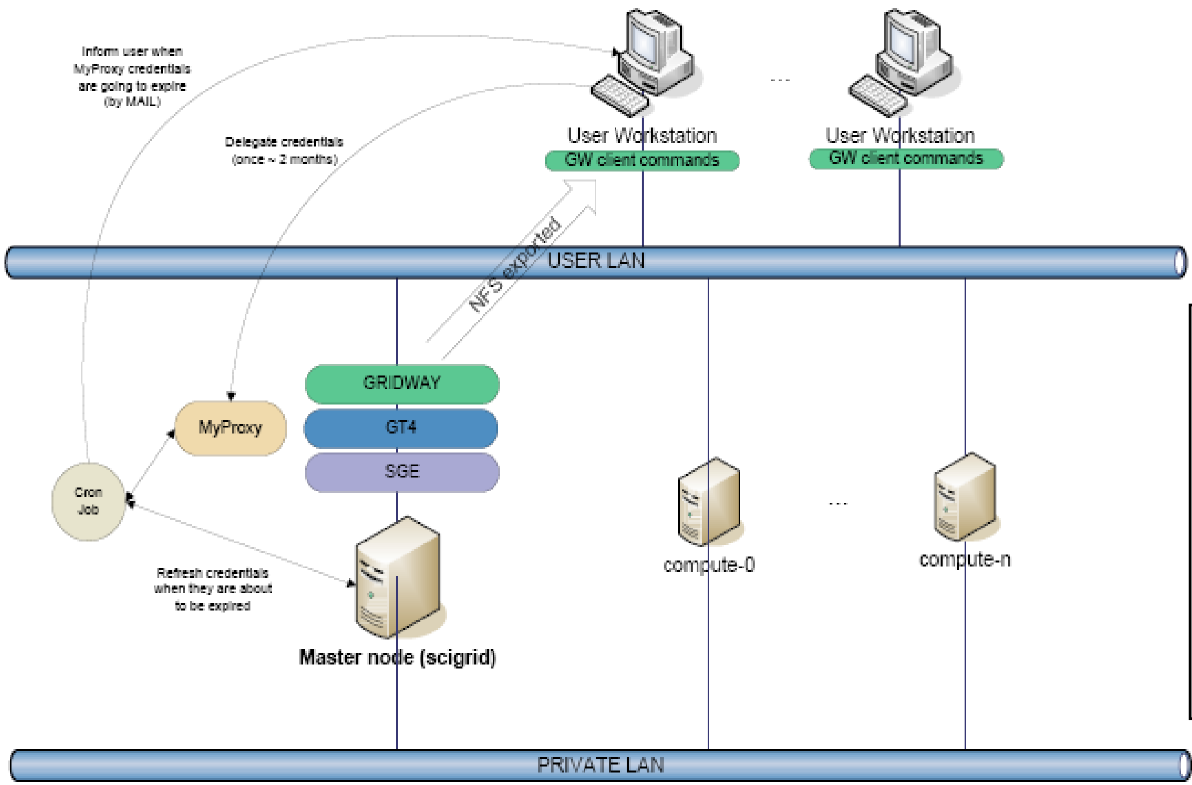
Deploying Single Meta-Scheduler Grids with GridWay



Single Meta-Scheduler Grids: Examples

European Space Astronomy Center

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



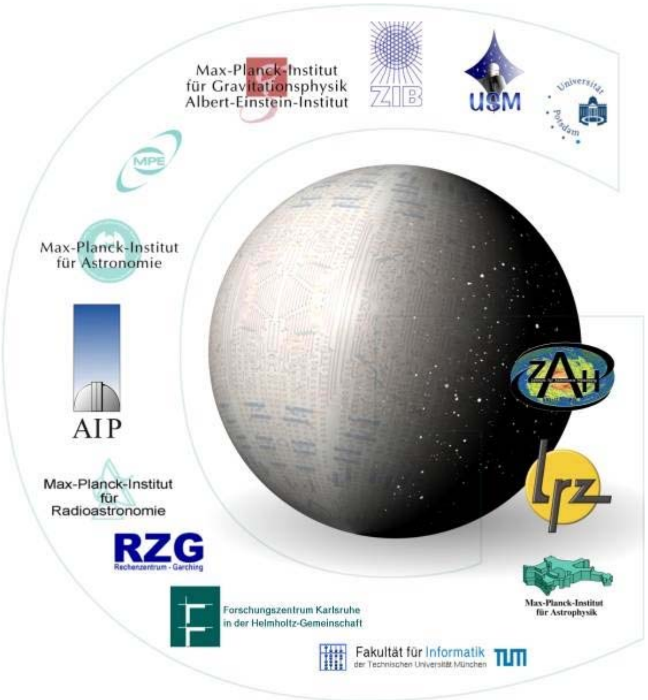
3. A Taxonomy for Grid Scheduling Architectures

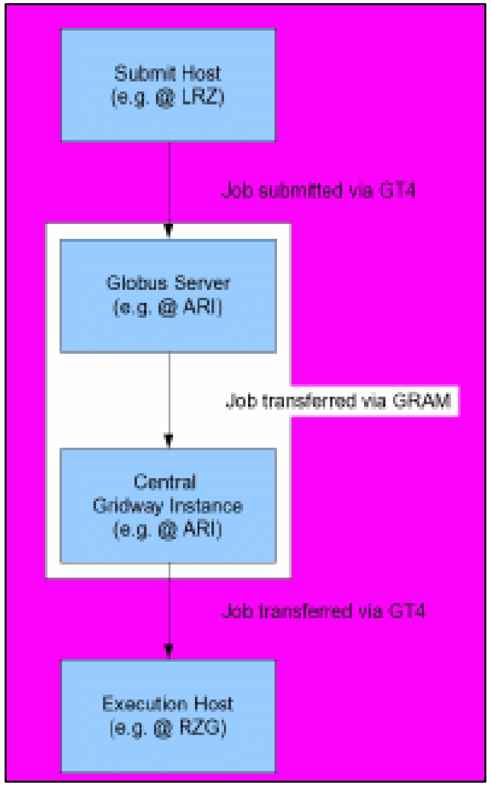
3.2. Multiple Administrative Domains

Single Meta-Scheduler 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





Single Meta-Scheduler Grids: Examples

UABGrid, University of Alabama at Birmingham

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

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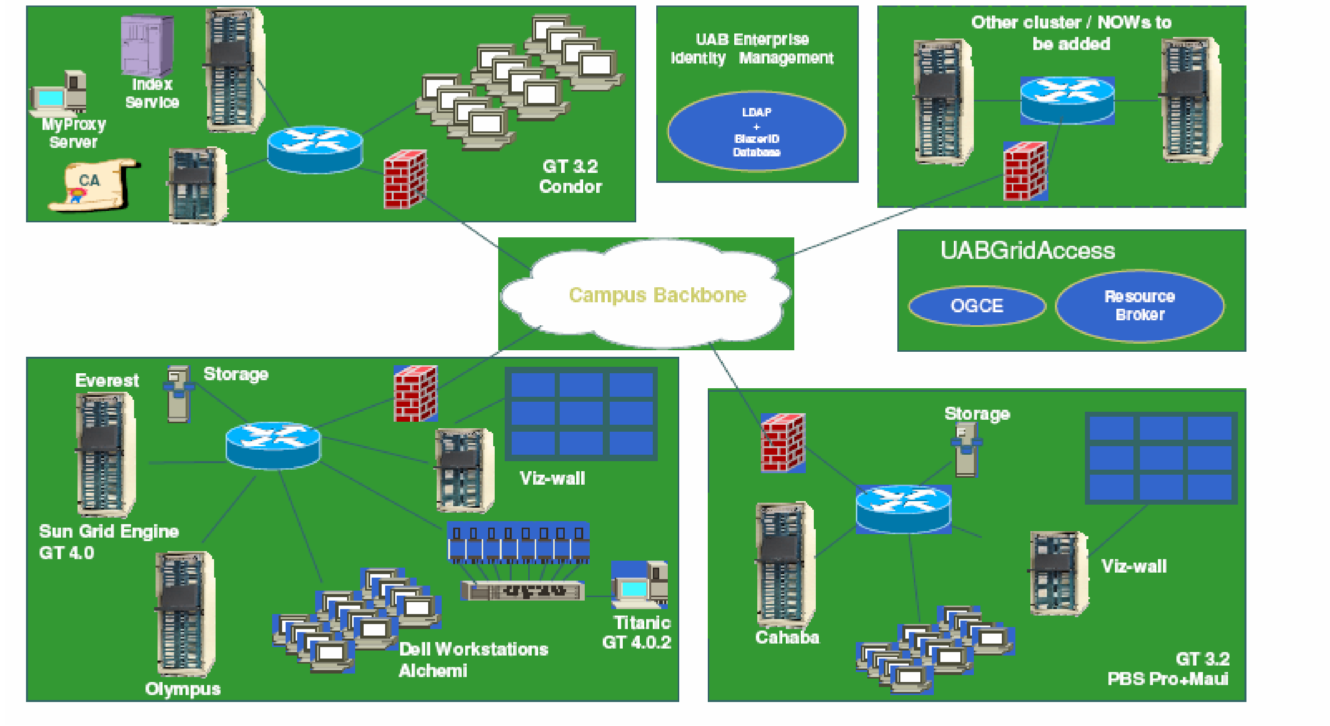


Multiple Meta-Scheduler Grids

Characteristics

- Multiple meta-scheduler instances with access to resources belonging to different administrative domains (different organizations or partners)
- Large scale, loosely-coupled infrastructures (Partner Grids) shared by several Virtual Organizations

Goal & Benefits

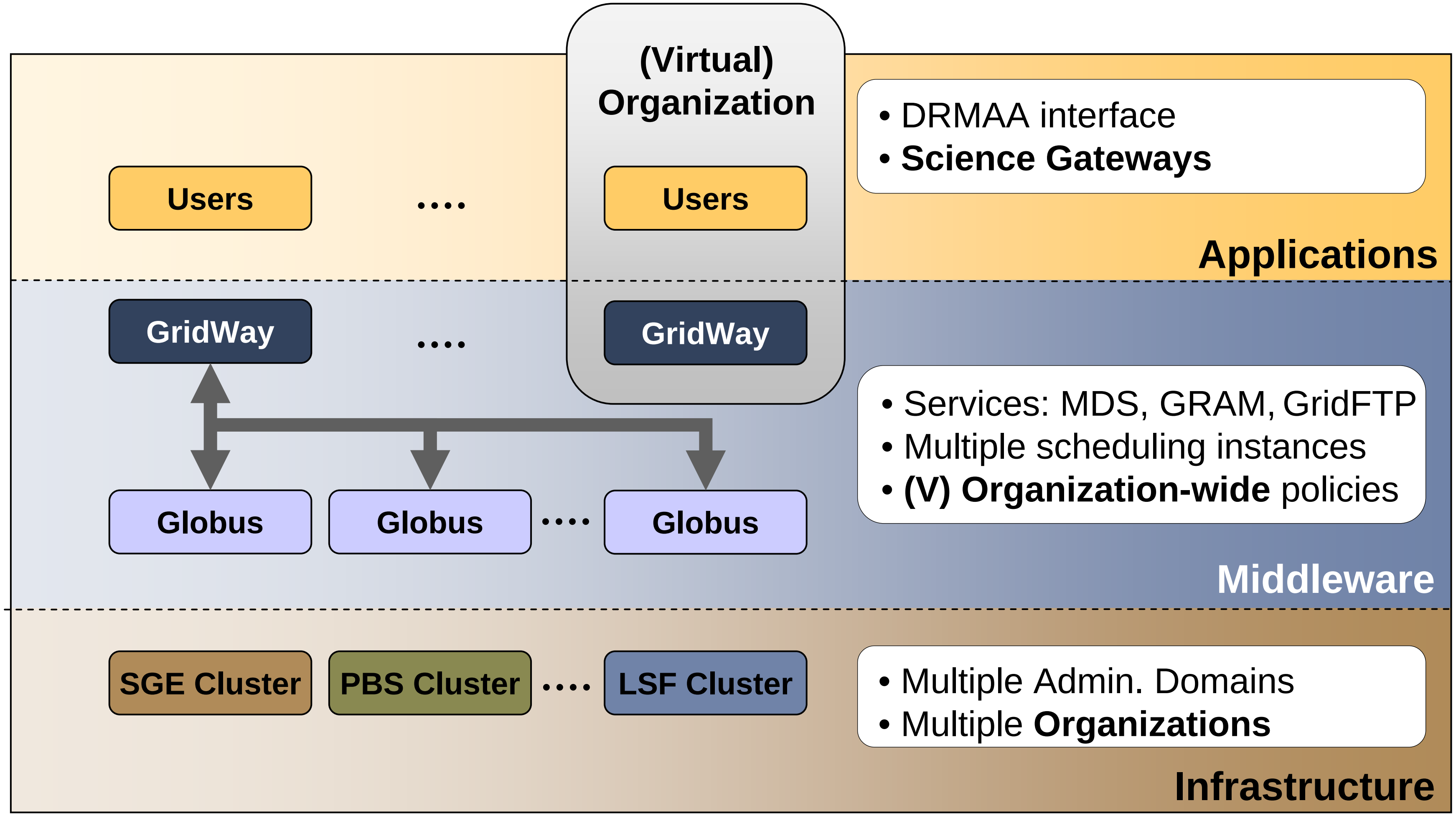
- Large-scale, secure and reliable sharing of resources
- Support collaborative projects
- Access to higher computing power to satisfy peak demands

Scheduling

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

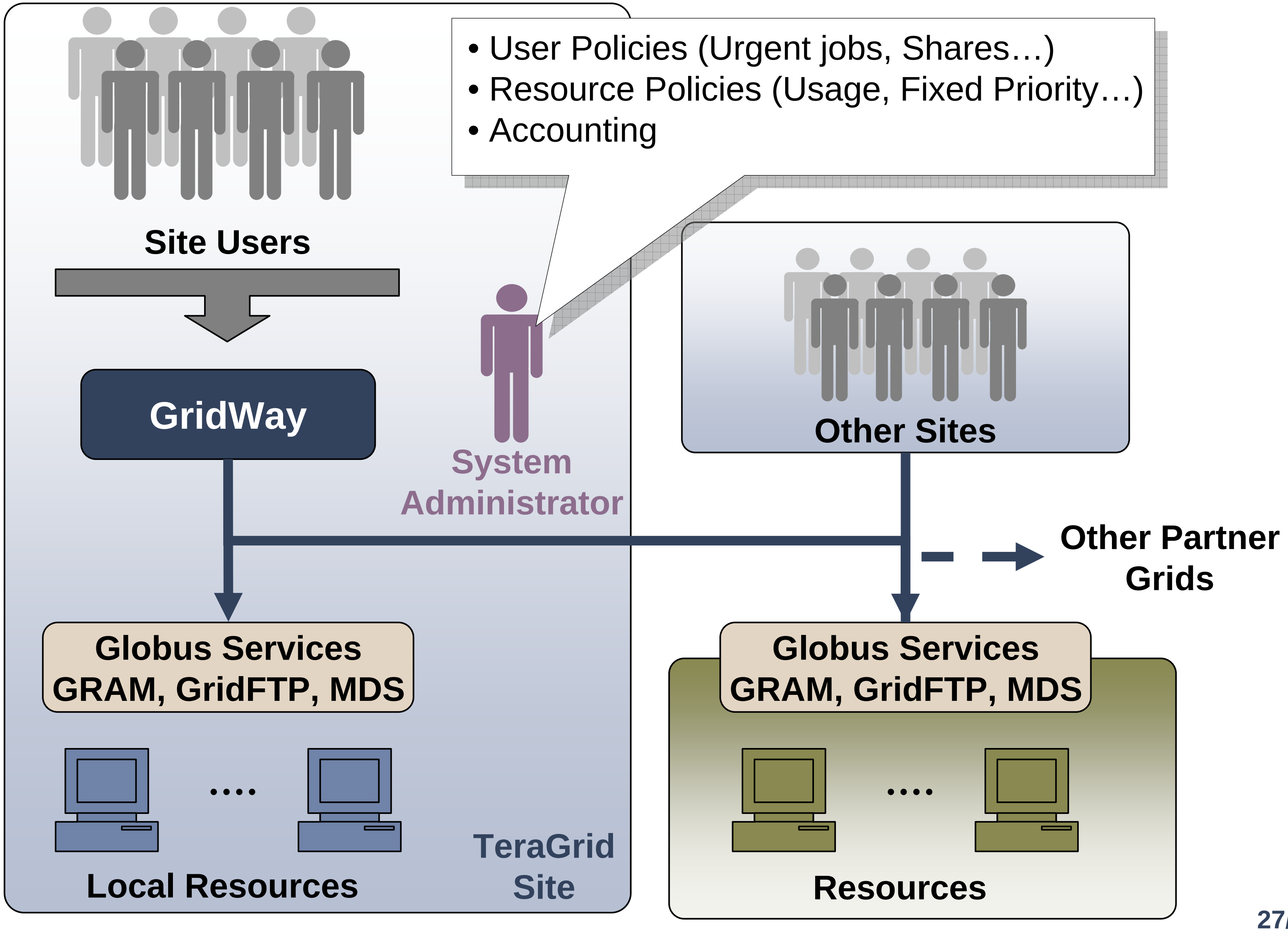
3.2. Multiple Administrative Domains

Deploying Multiple Meta-Scheduler Grids with GridWay



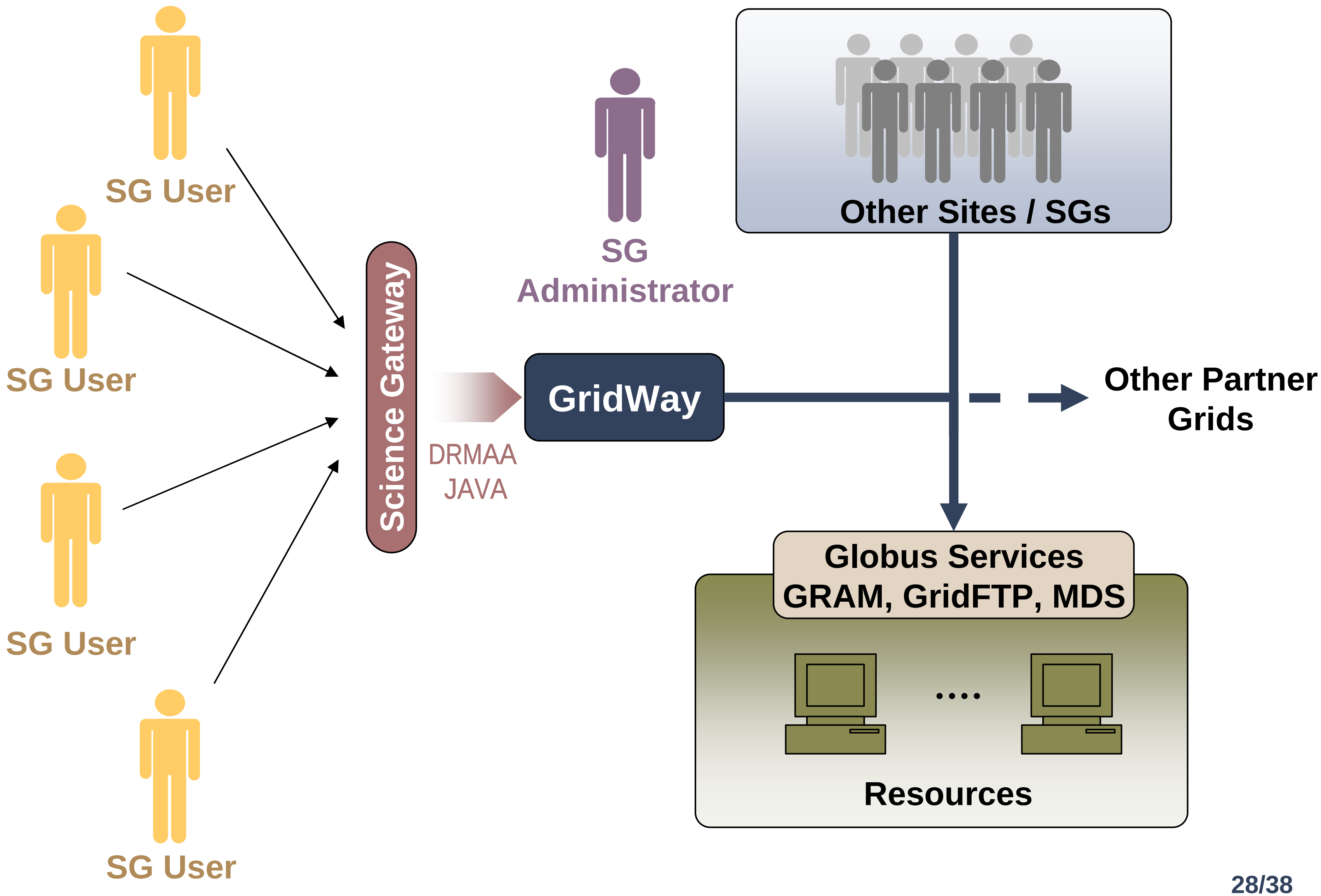
3.2. Multiple Administrative Domains

Multiple Meta-Scheduler Grids: Generic Examples



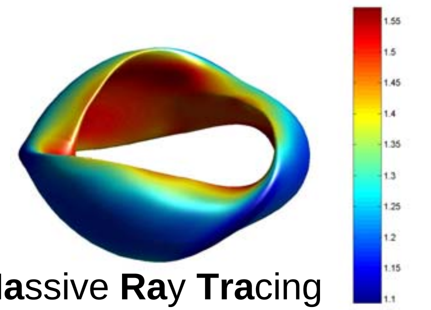
3.2. Multiple Administrative Domains

Multiple Meta-Scheduler Grids: Generic Examples

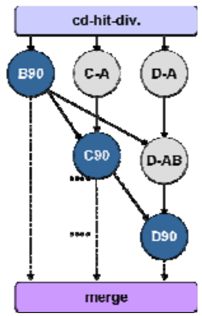


3.2. Multiple Administrative Domains

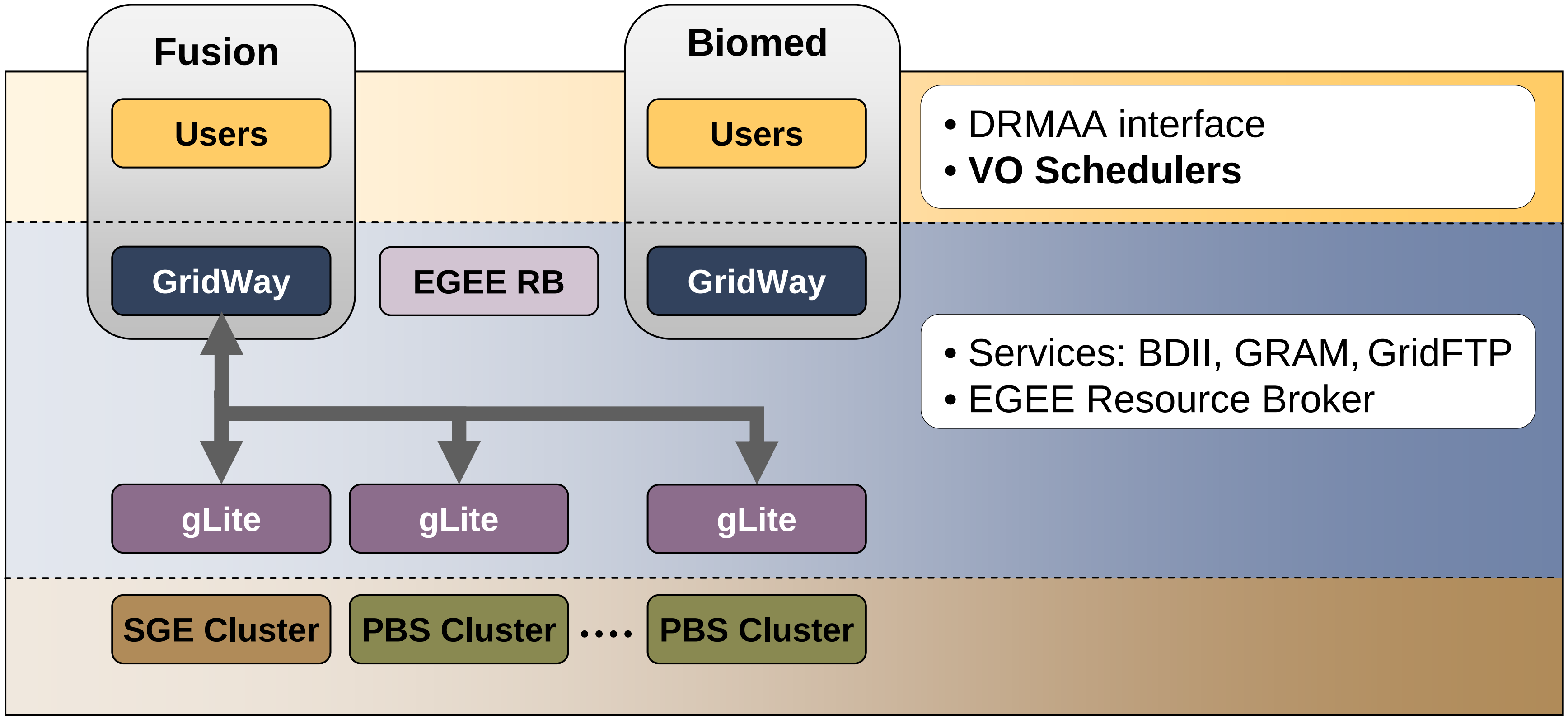
Multiple Meta-Scheduler Grids: Examples



Massive **Ray Tracing**



CD-HIT workflow



Single Meta-Scheduler Layer Grids

Characteristics

- Single layer (one ore more meta-schedulers) with *plain* access to the underlying Grids
- (Virtual) Organizations involved in different Grid infrastructures

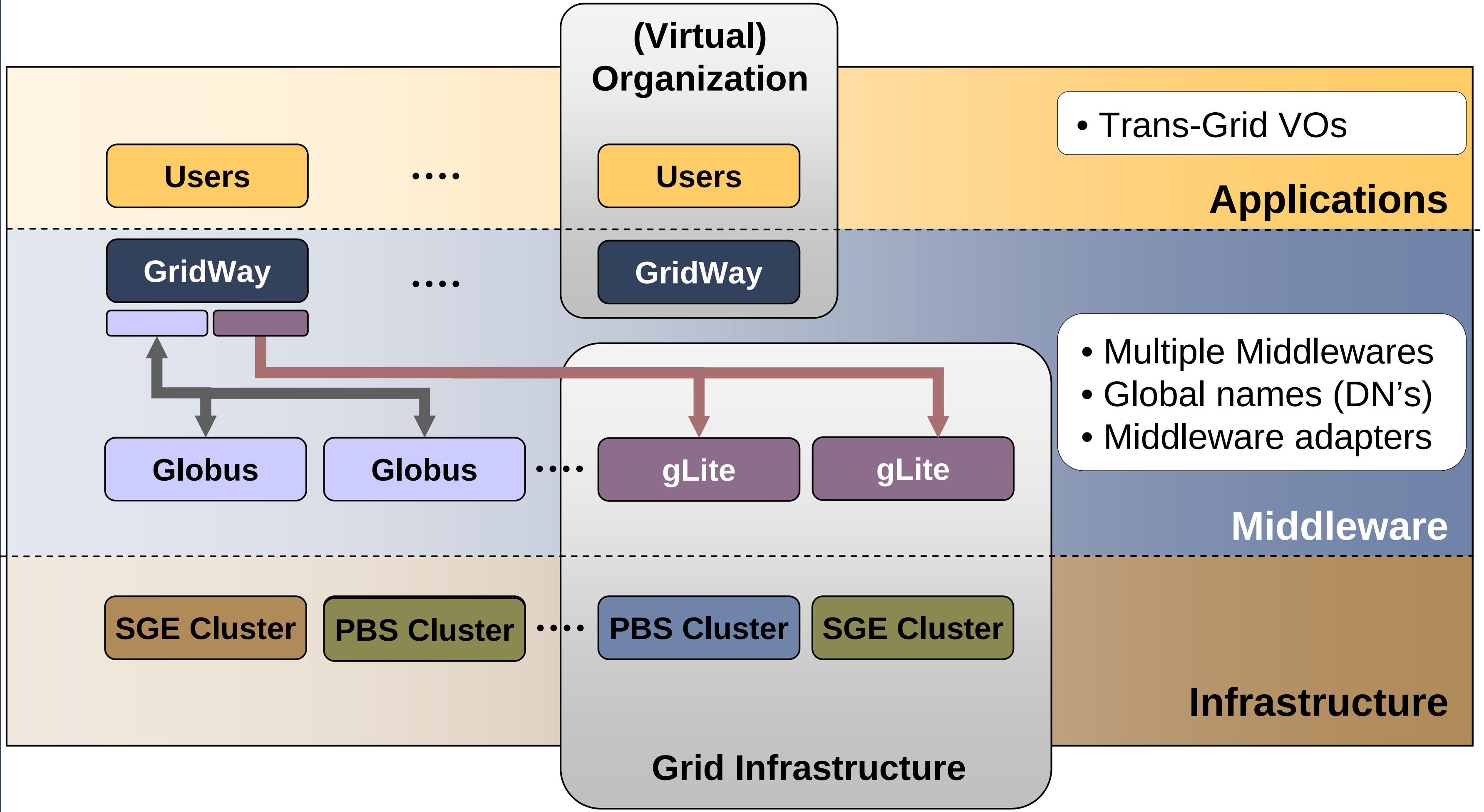
Goal & Benefits

- Integrate multiple Grids based on different middleware stacks
- Collaboration between trans-grid VOs

Scheduling

- Enforcement of organization-wide Grid-aware policies
- Adapters to interface different middleware stacks

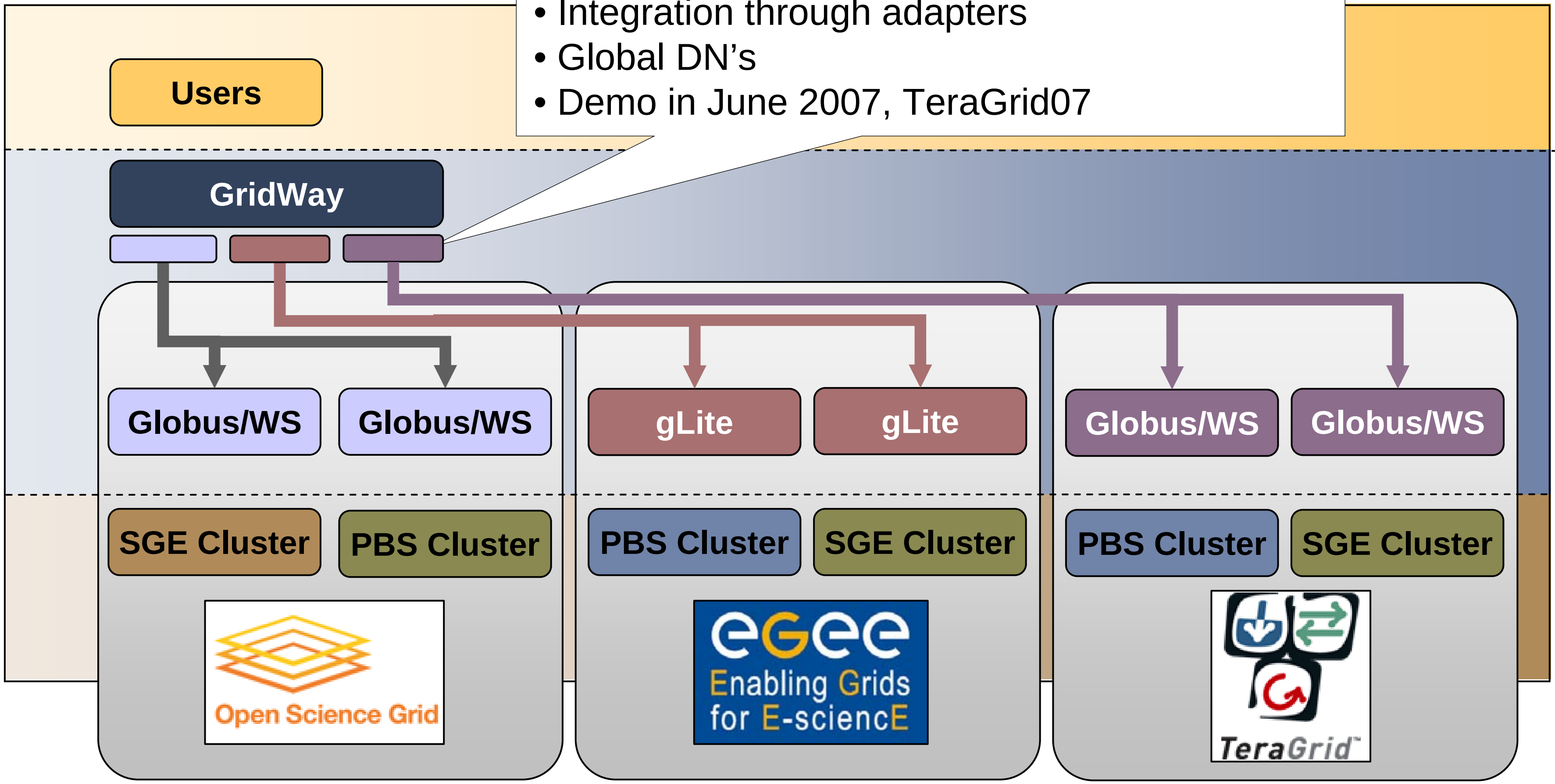
Deploying Single Meta-Scheduler Layer Grids with GridWay



3.3. Multiple Grid Infrastructures

Single Meta-Scheduler Layer Grids: Example

- 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



Multiple Meta-Scheduler Layer Grids

Characteristics

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

Goal & Benefits

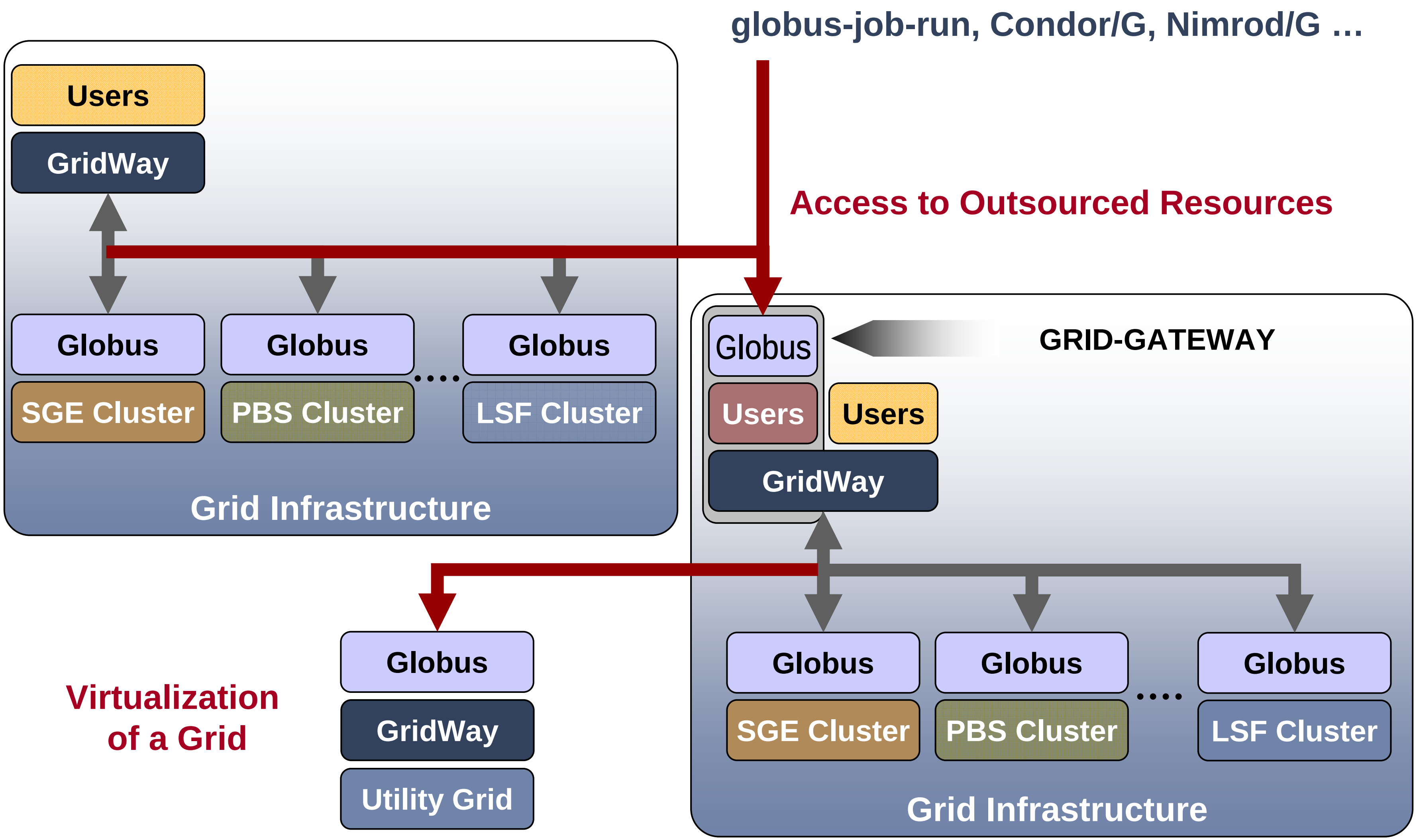
- Supply resources on-demand, making resource provision more adaptive
- Access to *unlimited* computational capacity
- Transform IT costs from fixed to variable
- Seamless integration of different Grids (The Grid)

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

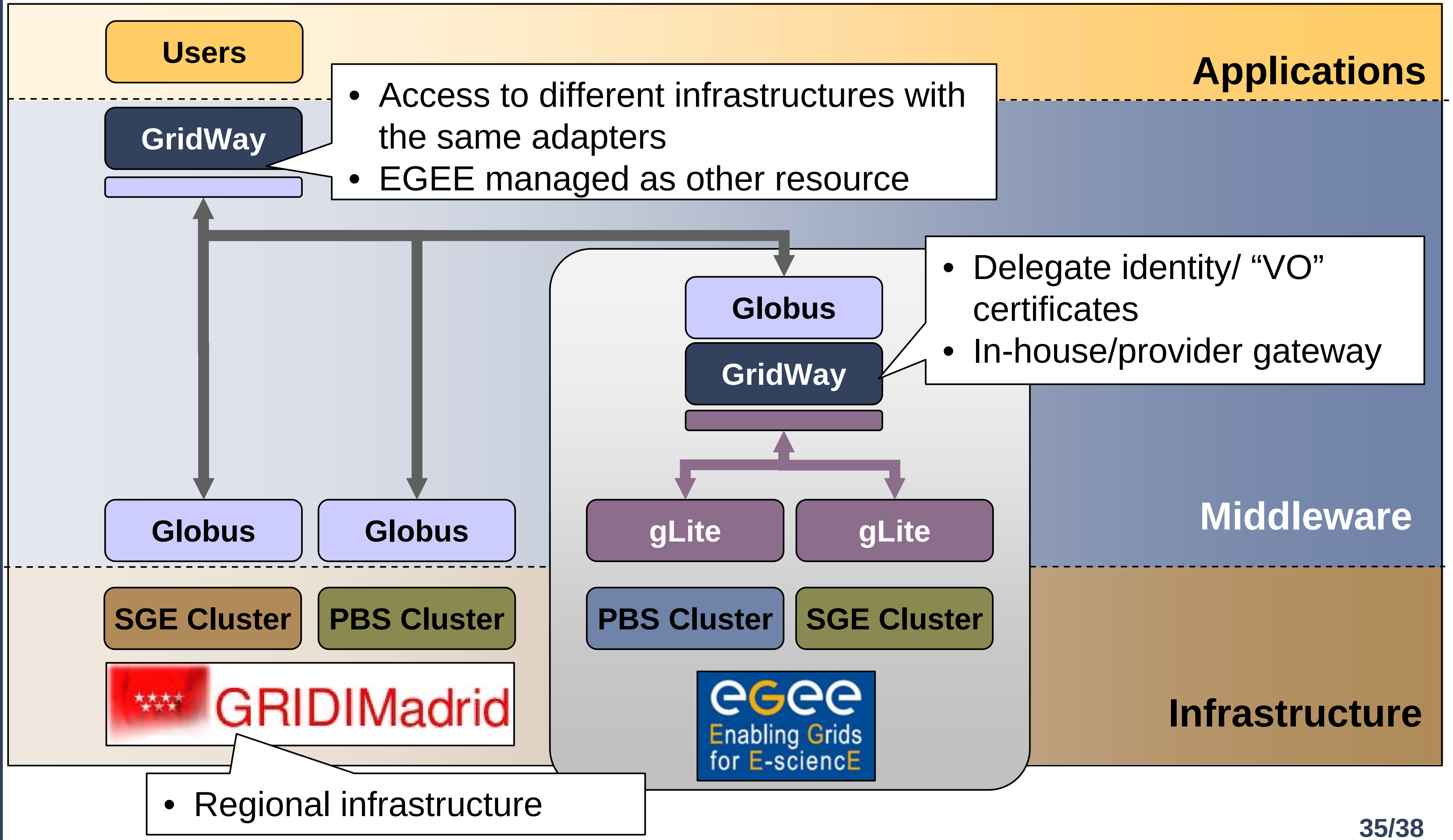
3.3. Multiple Grid Infrastructures

Deploying Multiple Meta-Scheduler Layer Grids with GridWay



3.3. Multiple Grid Infrastructures

Multiple Meta-Scheduler Layer Grids: Example



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

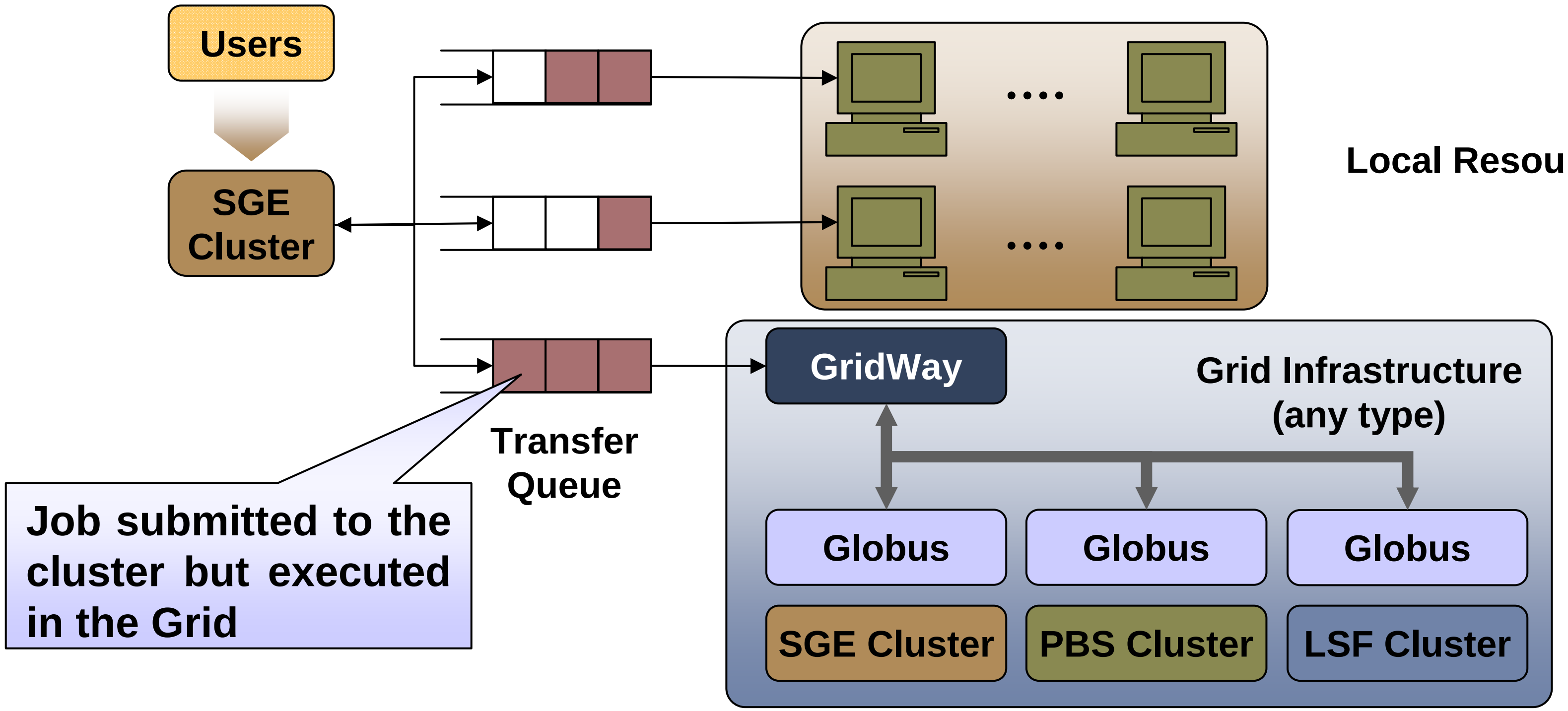
- A familiar environment to interact with a computational platform
- Some systems provide LRMS-like environment for Computational Grids
- Process still need to be adapted
- Applications would greatly benefit from standards (DRMAA)

Transfer Queues: Seamless access to the Grid

3.4. From the Cluster to the Grid

Transfer Queues: Seamless access to the Grid

- Communicate LRM systems with meta-schedulers (the other way)
- Users keep using the same interface, even applications (e.g. DRMAA)



Thank you
for your attention!