UVA HPC & BIG DATA COURSE

Grid Computing

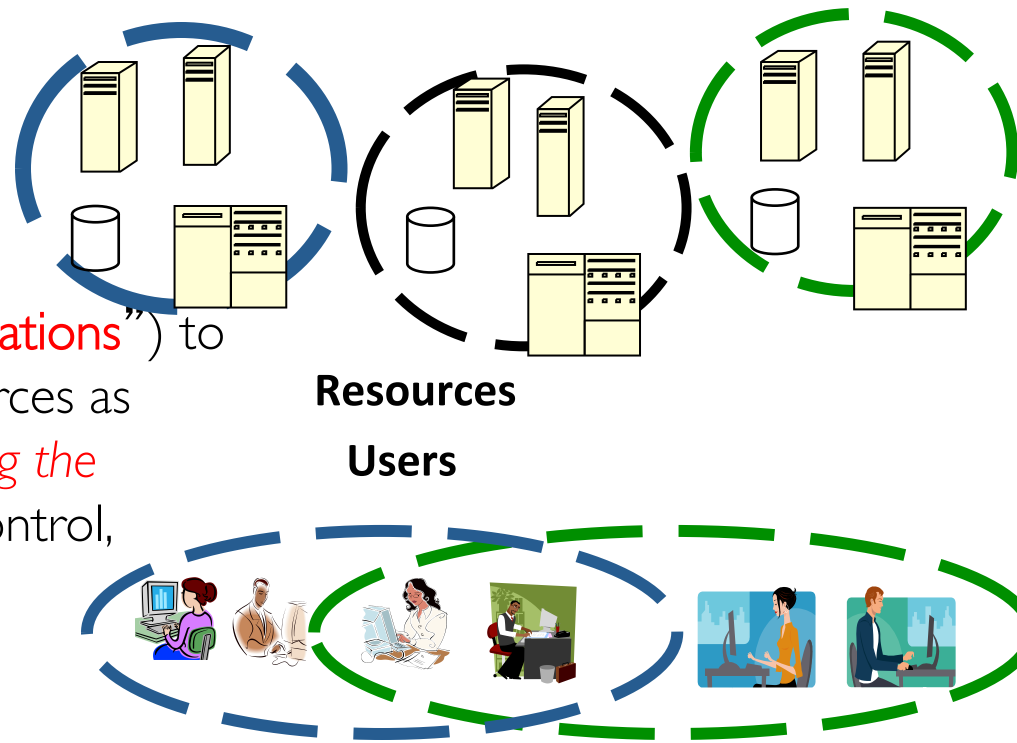
Adam Belloum

outline

- Grid computing: Approach and vision
- Potential Application for Grid computing:
- Grid-middleware
- Example of Services provided by Grid Systems

Grand Vision of Grid systems

- Flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions, and resources



- Enable communities ("Virtual Organizations") to share geographically distributed resources as they pursue common goals -- *assuming the absence* of : central location, central control, existing trust relationships.

From the Grid tutorials available at : http:.//www.globus.org

Grand Vision of Grid Computing

- Grid computing is the use of hundreds, or thousands of **geographically** and **organizationally** disperse and diverse resources to solve:

  ➔ problems that require more computing power than is available from a single machine or from a local area distributed system

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Potential Grid Applications

- An application which requires the grid solution is likely distributed (Distributed Computing) and fit in one of the following paradigms:
  - High throughput Computing
  - High performance Computing

Grid computing will be mainly needed for large-scale, high-performance computing.

Distributed Computing

- Distributed computing is a programming model in which processing occurs in many geographically distributed places.
  - Processing can occur wherever it makes the most sense, whether that is on a server, Web site, personal computer, etc.

- Distributed computing and grid computing either
  - overlap or distributed computing is a subset of grid computing

From "The Anatomy of the Grid: Enabling Scalable Virtual Organizations" Foster et al

High Throughput Computing

- HTC employs large amounts of computing power for very lengthy periods
  - HTC is needed for doing sensitivity analyses, parametric studies or simulations to establish statistical confidence.
- The features of HTC are
  - Availability of computing power for a long period of time
  - Efficient fault tolerance mechanism
- The key to HTC in grids
  - Efficiently harness the use of all available resources across organizations.

High Performance Computing

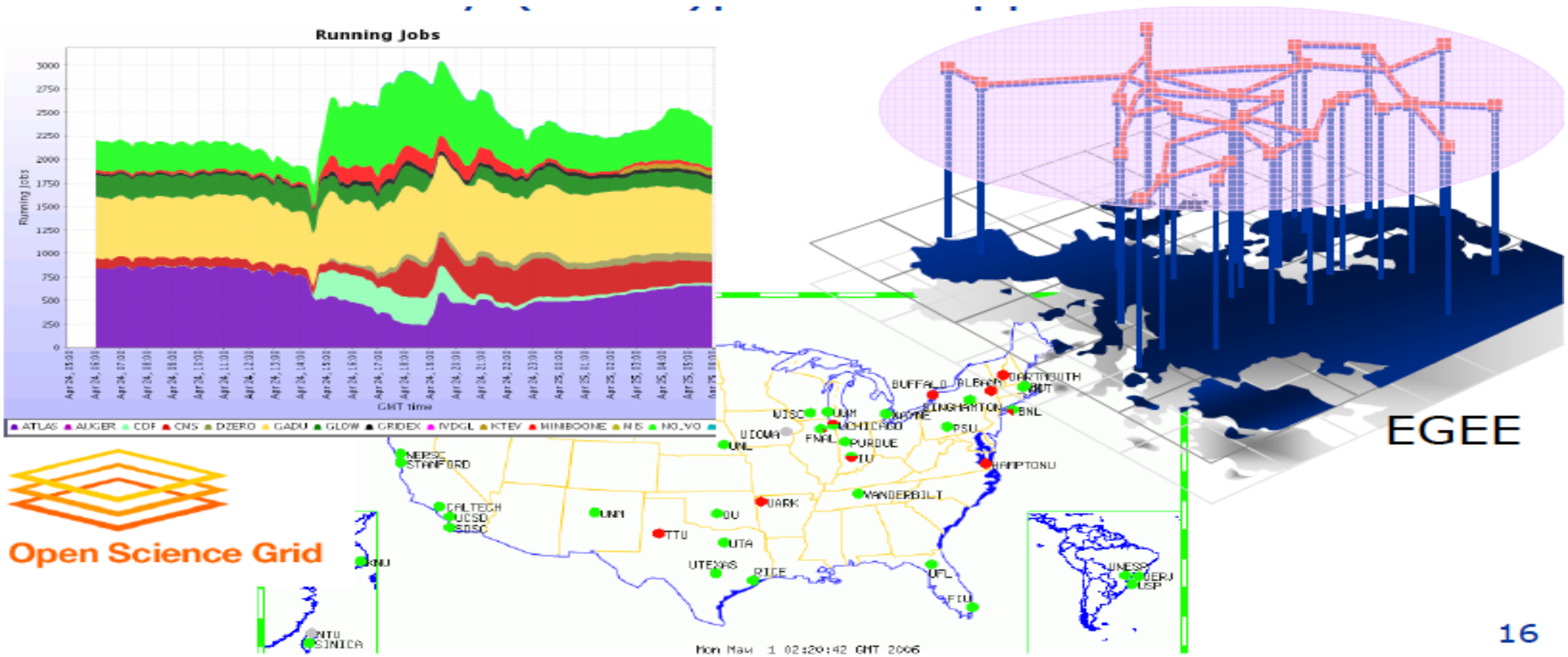
- HPC brings enormous amounts of computing power to bear over relatively short periods of time.
  - HPC is needed for decision-support or applications under sharp time-constraint, such as weather modeling
- HPC applications are:
  - Large in scale and complex in structure.
  - Real time requirements.
  - Ultimately must run on more than one type of HPC system.

HPC/HTC requirements

- HPC/HTC requires a balance of computation and communication among all resources involved.
  - Managing computation,
  - communication,
  - data locality

First Generation of Grids: Batch computing

Focus on aggregation of many resources for massively (data-)parallel applications



Second Generation Grids: Service-Oriented Science

- Empower many more users by enabling
  - On-demand access to **services**
- Grids become an enabling technology for **service oriented science** (or business)
  - Grid infrastructures host **services**
  - Grid technologies used to build **services**

"Service-Oriented Science", *Science*, 2005

Second Generation Grids: Service-Oriented Science (Transient Service Instances)

- Web services address discovery & invocation of persistent services
  - Interface to persistent state of enterprise
- In Grids, must also support transient service instances, created/destroyed dynamically
  - Significant implications for how services are managed, named, discovered, and used

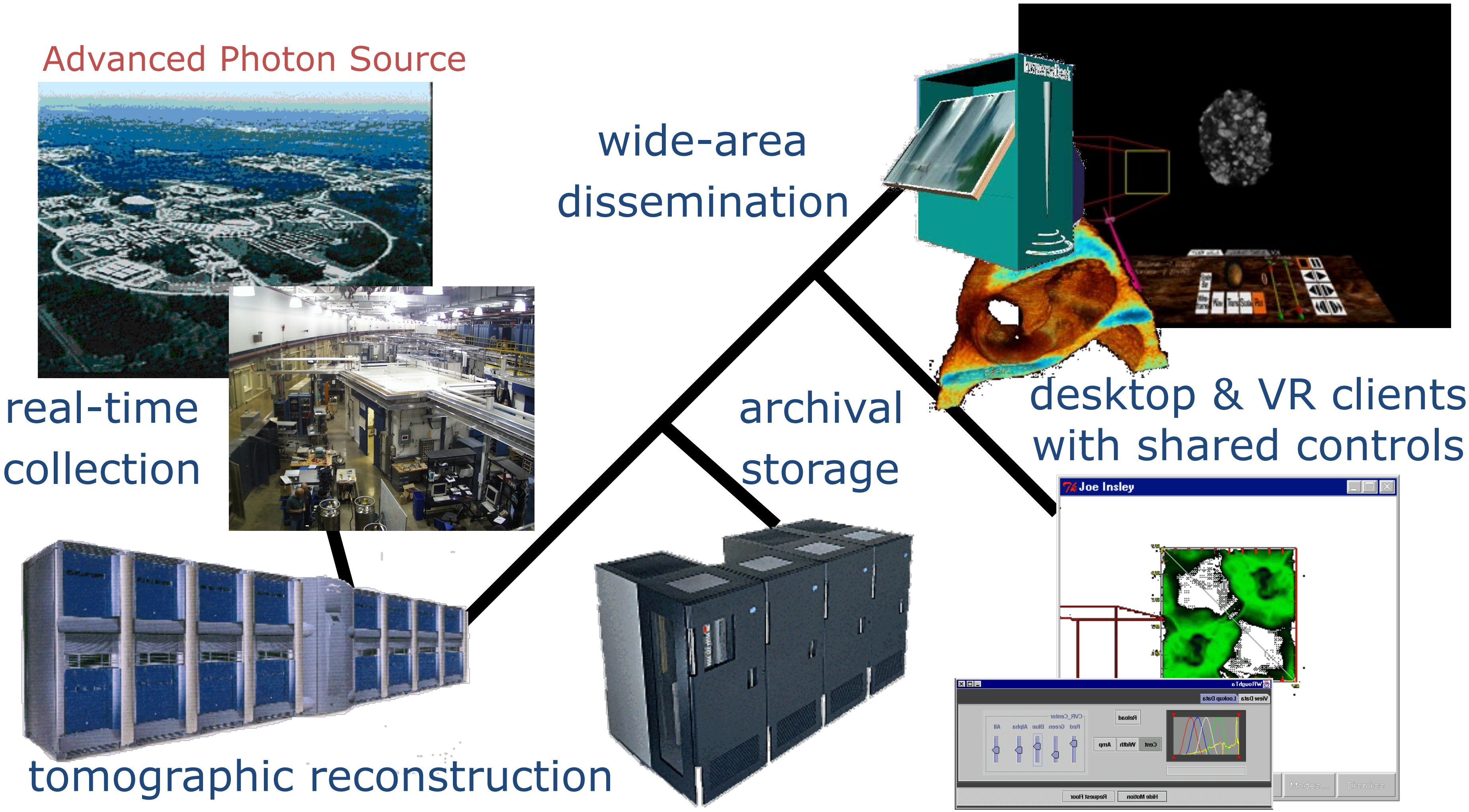
"Globus Toolkit Futures: An Open Grid Services Architecture" Ian Foster et al. Globus Tutorial, Argonne National Laboratory, January 29, 2002

eScience: Applications that needs the Grid

- "eScience promotes innovation in collaborative, computationally or data intensive research across all disciplines, throughout the research lifecycle''

- Nowadays Scientific Applications are
  - CPU intensive
  - Produce/process Huge sets of Data
  - Requires access to *geographically distributed* and *expensive* instruments

Online Access to Scientific Instruments

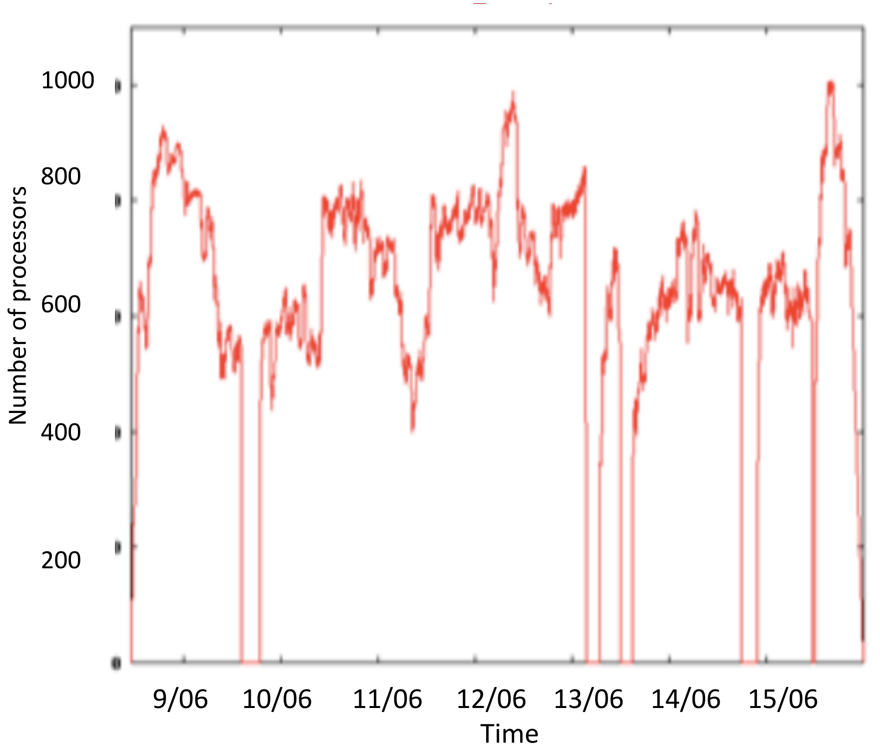


DOE X-ray grand challenge: ANL, USC/ISI, NIST, U.Chicago

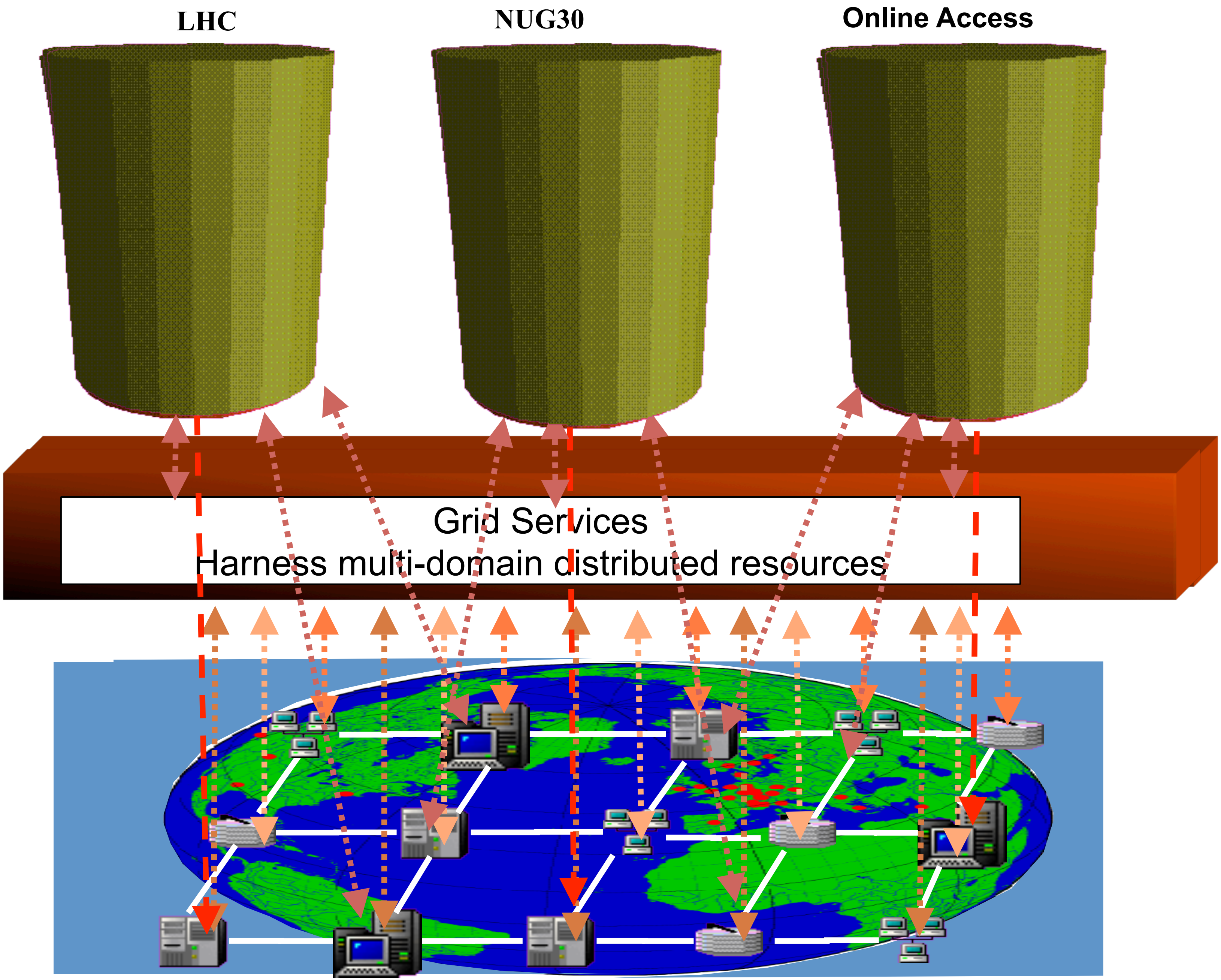
From the Grid tutorials available at : http:.//www.globus.org

CPU intensive Science: Optimization problem NUG30

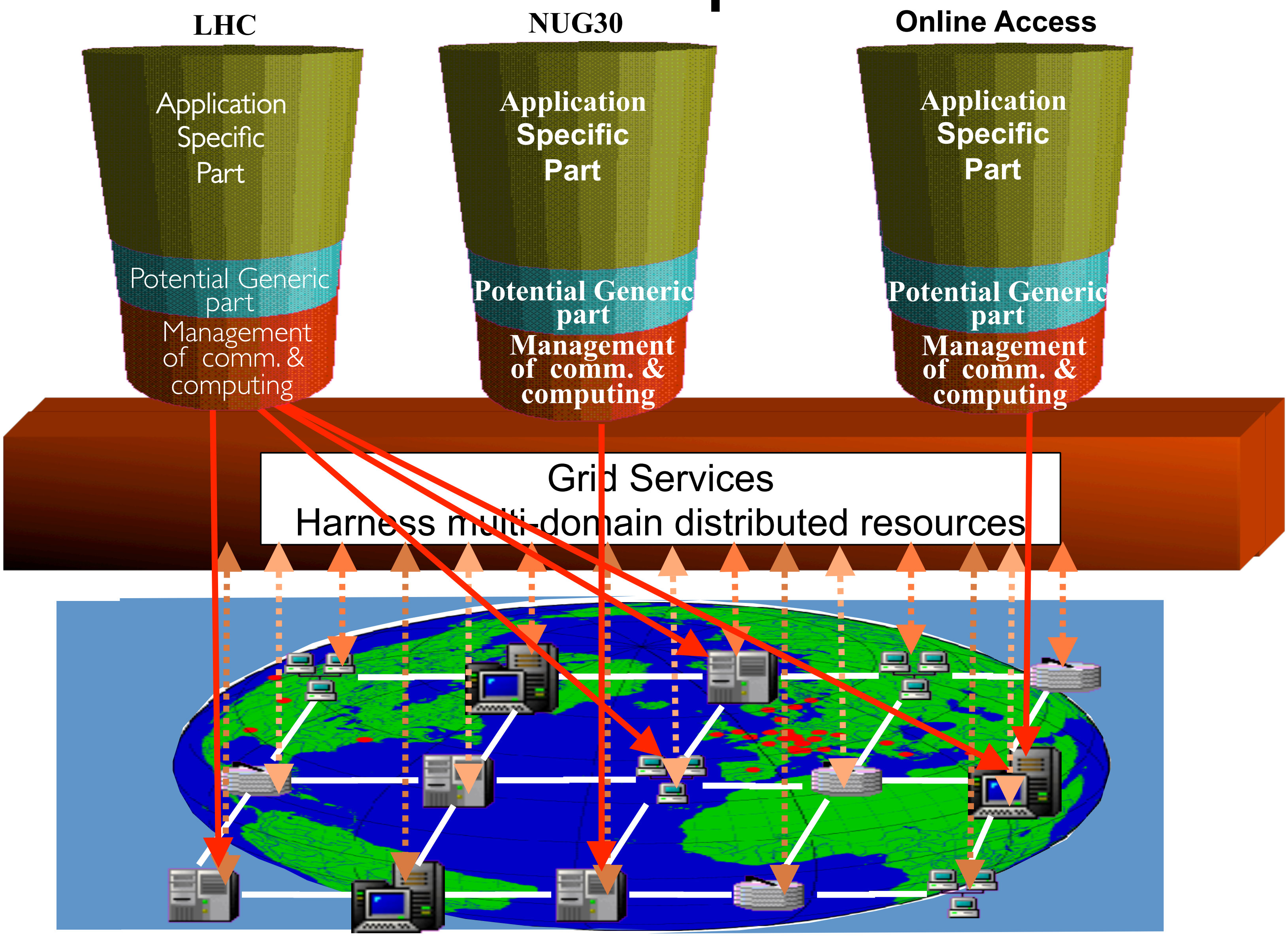
- The problem, a quadratic assignment problem (QAP) known as NUG30
  - given a set of n locations and n facilities, the goal is to assign each facility to a location.
  - There are **n!** possible assignments
- NUG30 proposed in 1968 as a test of computer capabilities, but remained unsolved because of its great complexity.



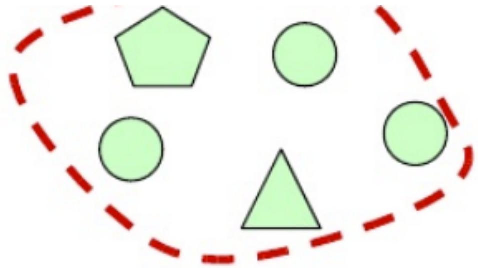
Nug30 Quadratic Assignment Problem Solved by 1,000 https://scout.wisc.edu/archives/r7125


LHC
NUG30
Online Access
Grid Services
Harness multi-domain distributed resources

To solve these problems?



The Grid paradigm

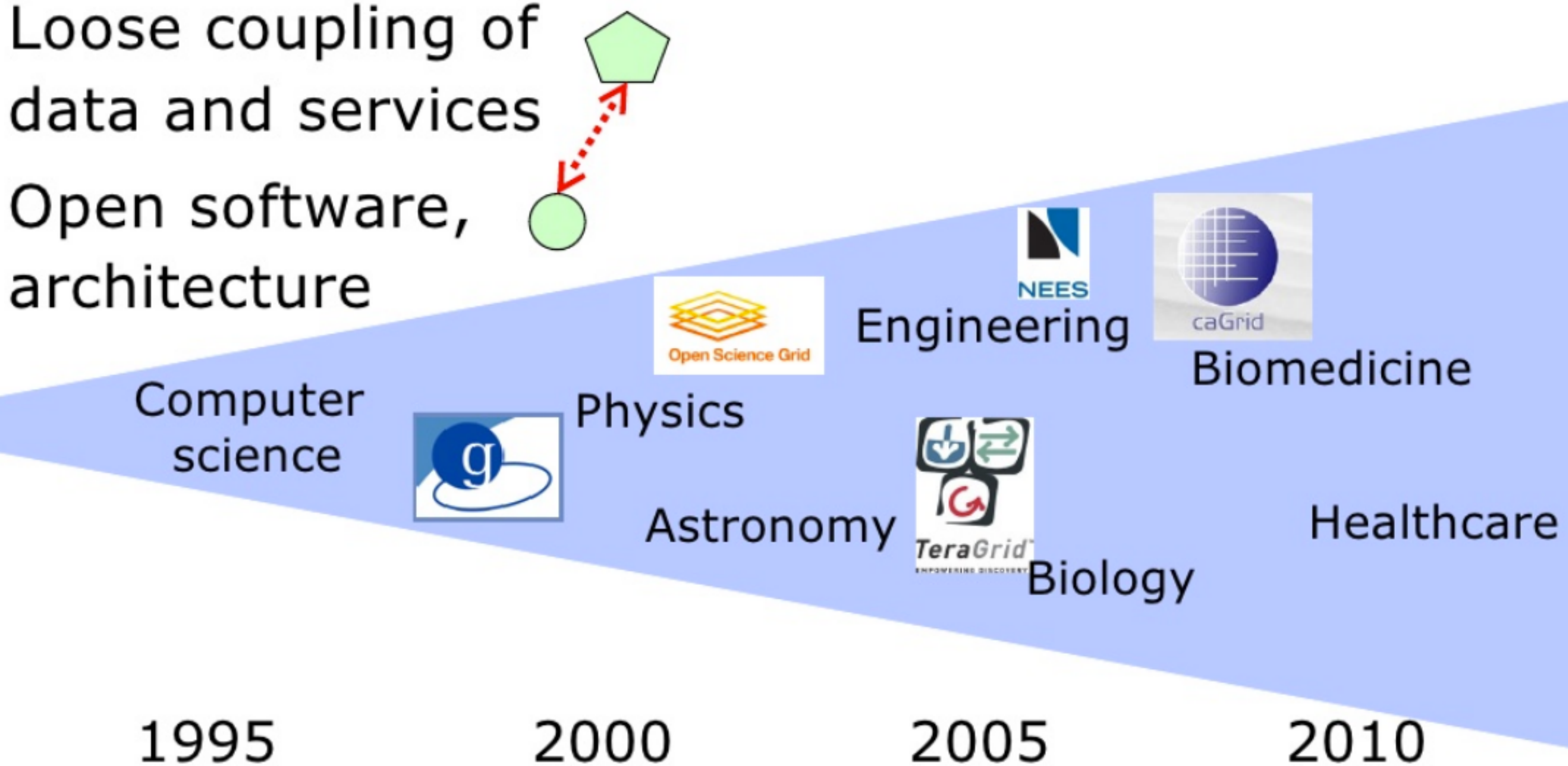


Principles and mechanisms for dynamic VOs

Leverage service oriented architecture (SOA)

Loose coupling of data and services

Open software, architecture



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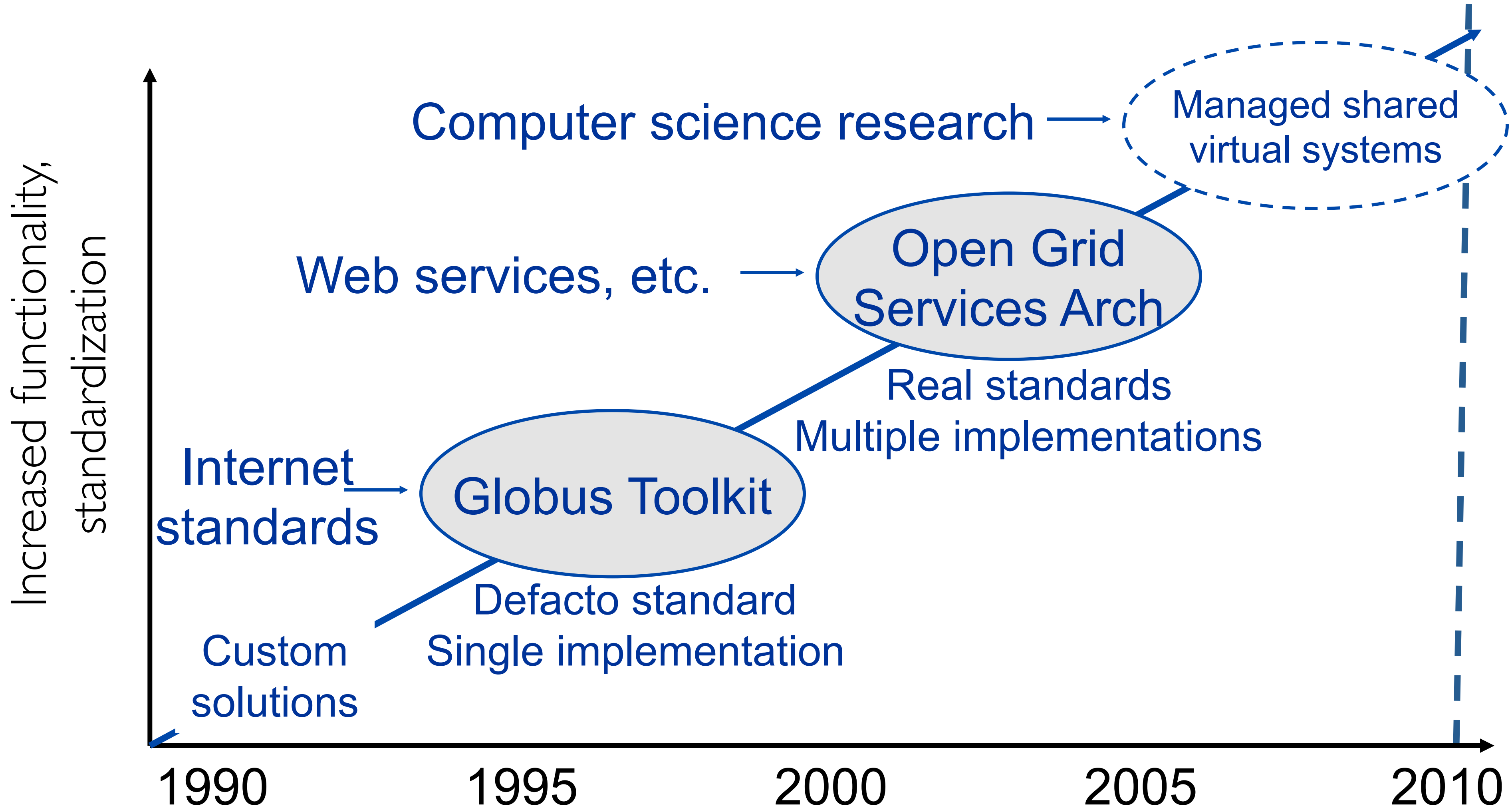
Grid Middleware Definition

- Software toolkit addressing key technical areas
  - Offer a modular "bag of technologies"
  - Enable incremental development of grid-enabled tools and applications
  - Define and standardize grid protocols and APIs
- Focus is on inter-domain issues, not clustering
  - Collaborative resource use spanning multiple organizations
  - Integrates cleanly with intra-domain services
  - Creates a collective service layer

Grid Middleware Definition

- Architecture identifies the fundamental system components, specifies purpose and function of these components, and indicates how these components interact with each other.
- Grid architecture is a protocol architecture, with protocols defining the basic mechanisms by which VO users and resources negotiate, establish, manage and exploit sharing relationships.
- Grid architecture is also a service standard-based open architecture that facilitates extensibility, interoperability, portability and code sharing.

Emergence of Open Grid Standards



"Grid Computing and Scaling Up the Internet" I. Foster, IPv6 Forum, an Diego, 2003

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- Potential Application for Grid computing:
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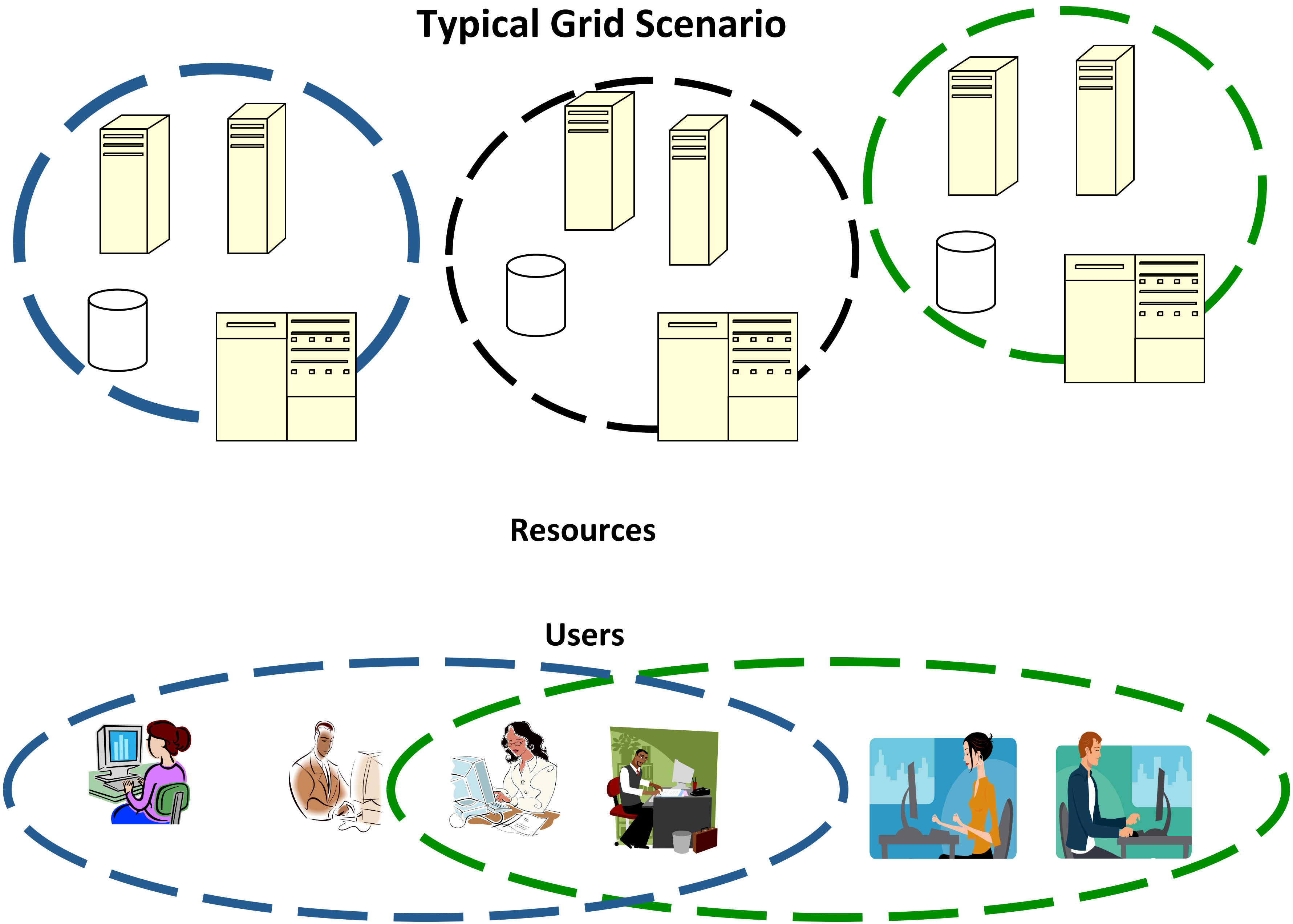
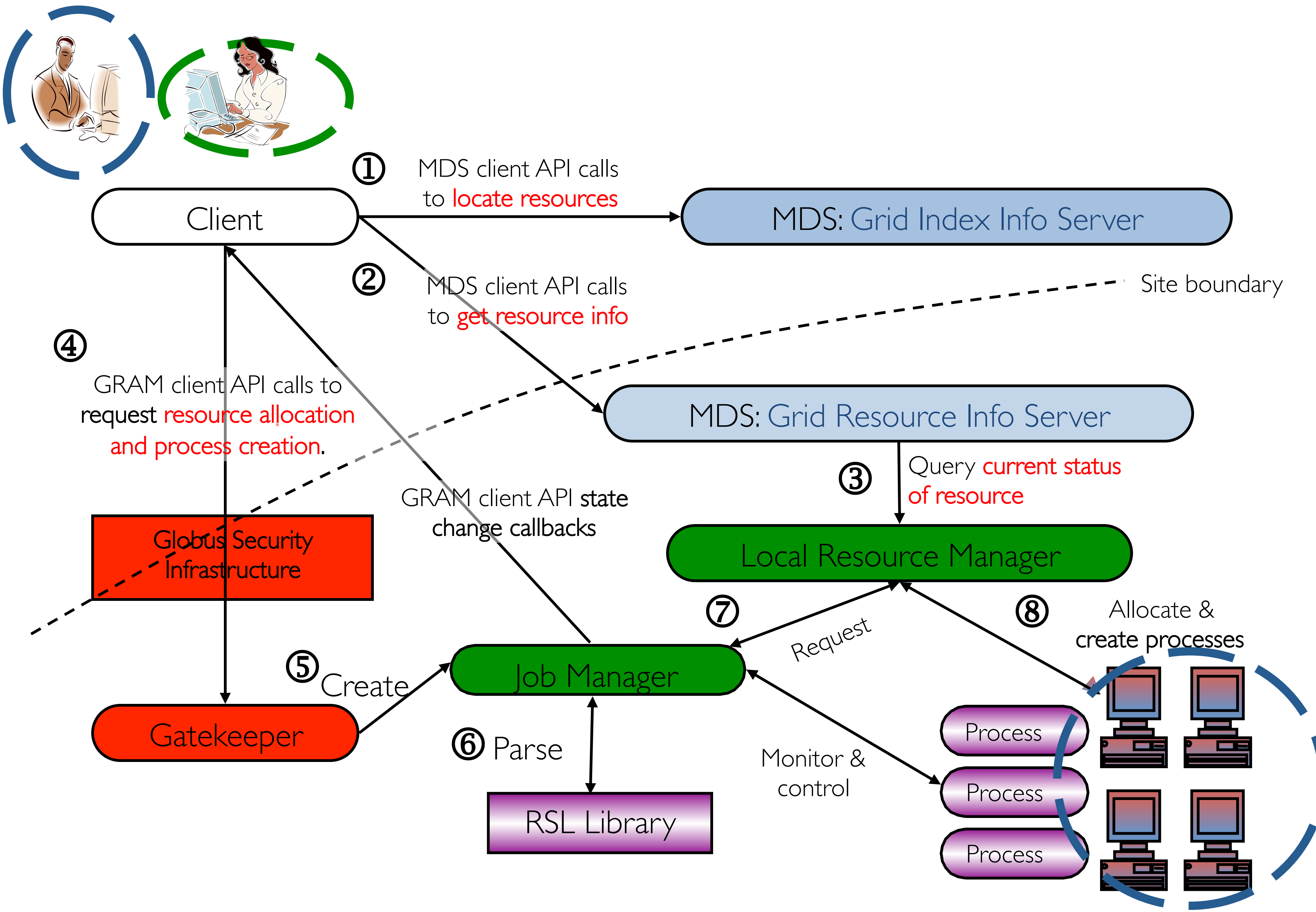
- Example of Services provided by Grid Systems:
  - Authentication, Authorization, Data management, computing resource management

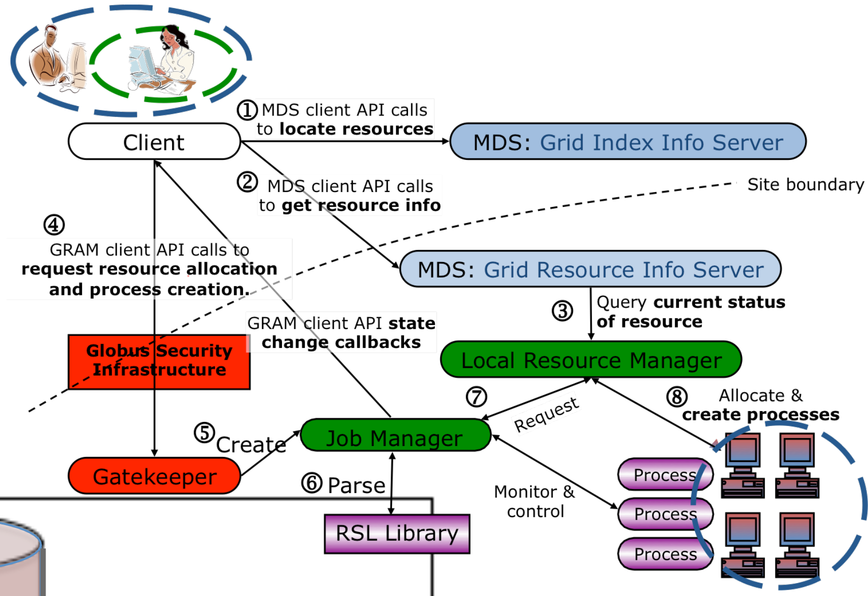

Typical Grid Scenario
Resources
Users



Globus Toolkit 2.0 Components

The Four components of a Grid infrastructure

- Resource Management
- Information services
- Data Management
- Security



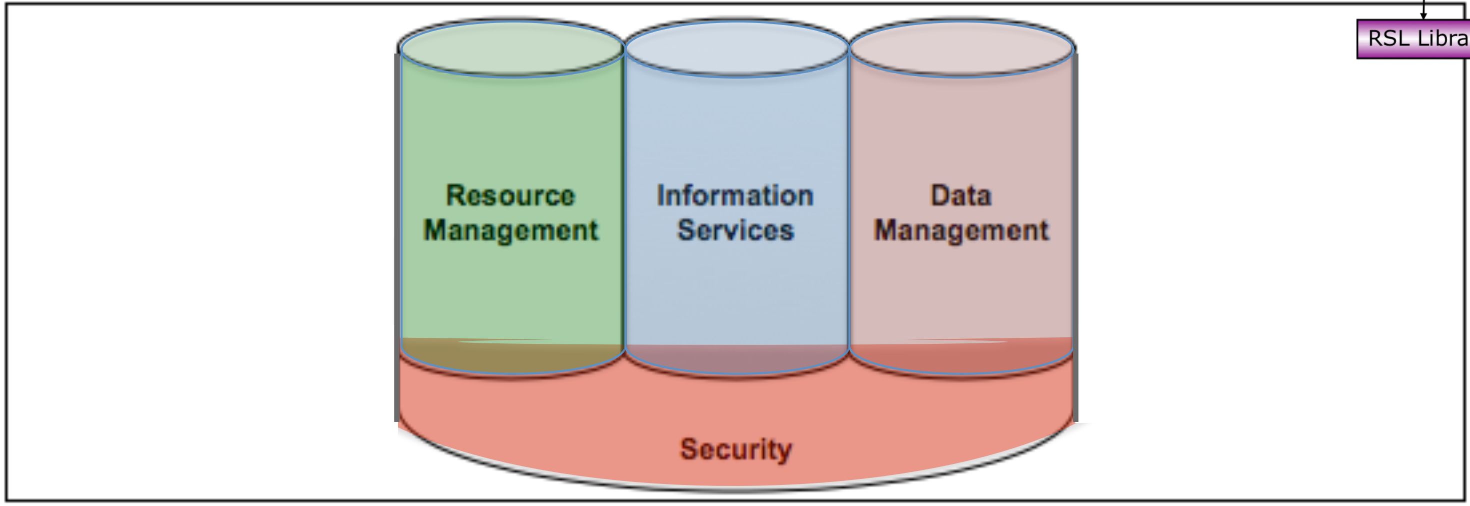
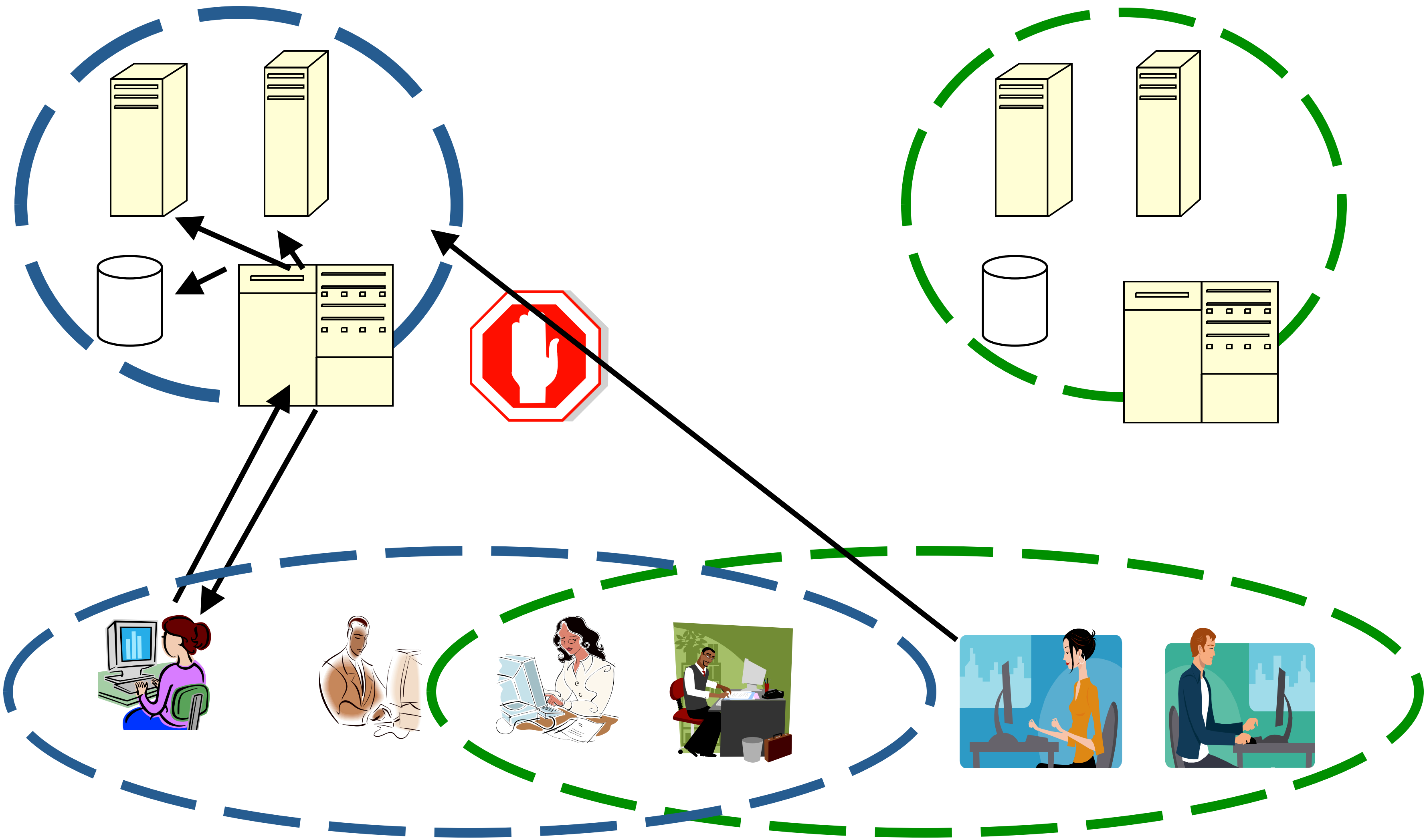


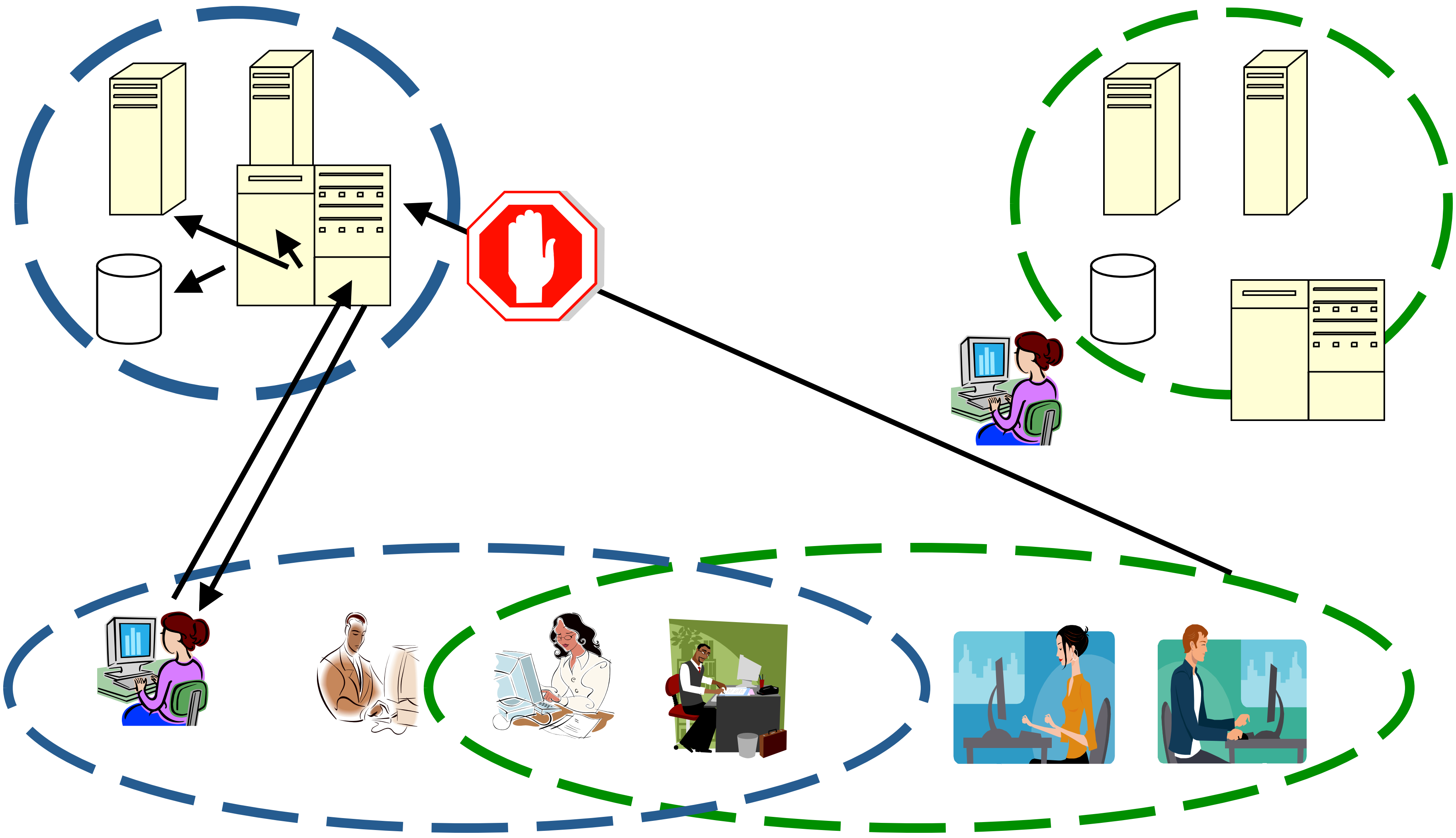
Figure 1-1 Grid computing key areas

Grid Security: Identity



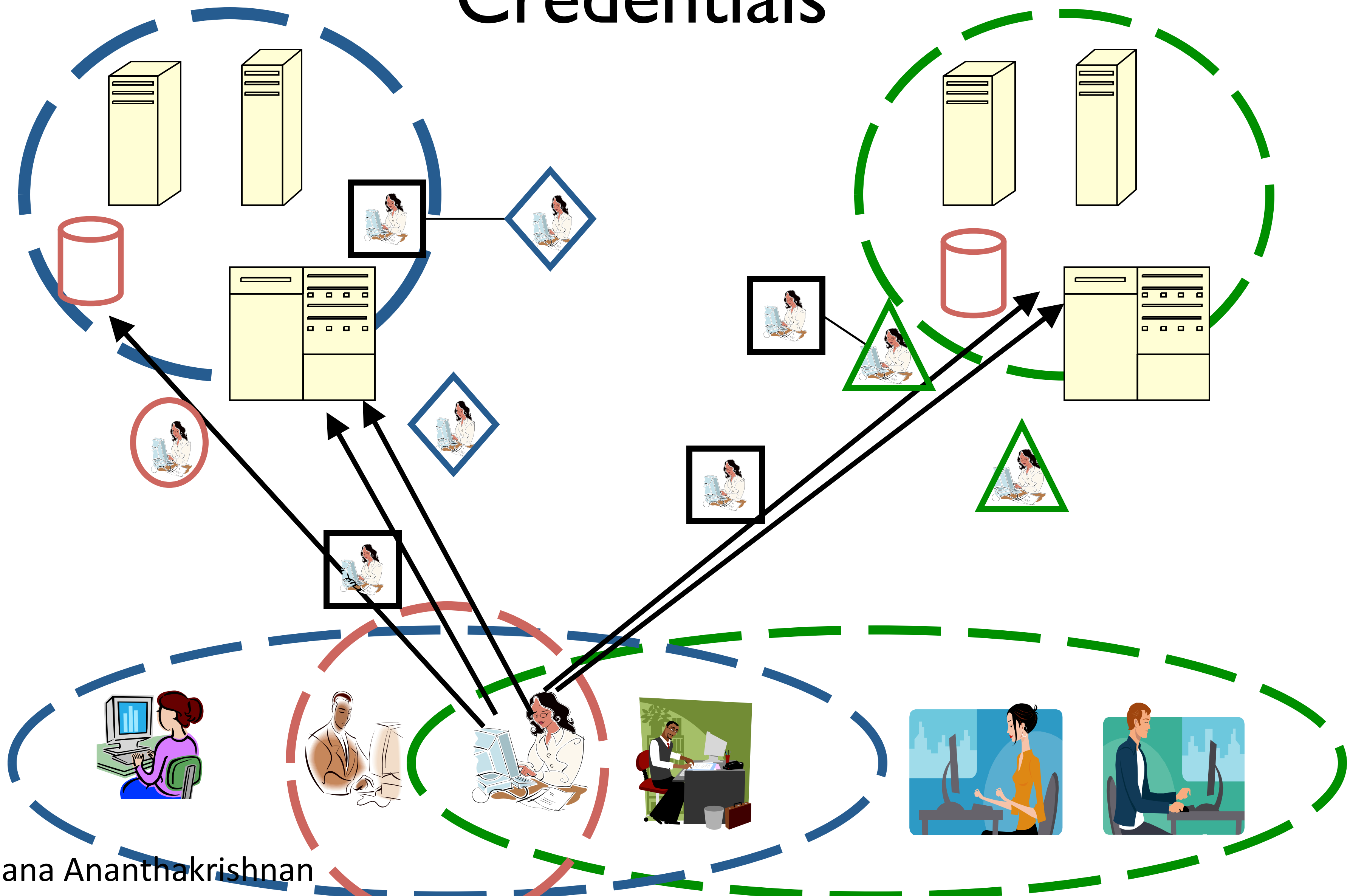
Rachana Ananthakrishnan

Grid Security: Authentication



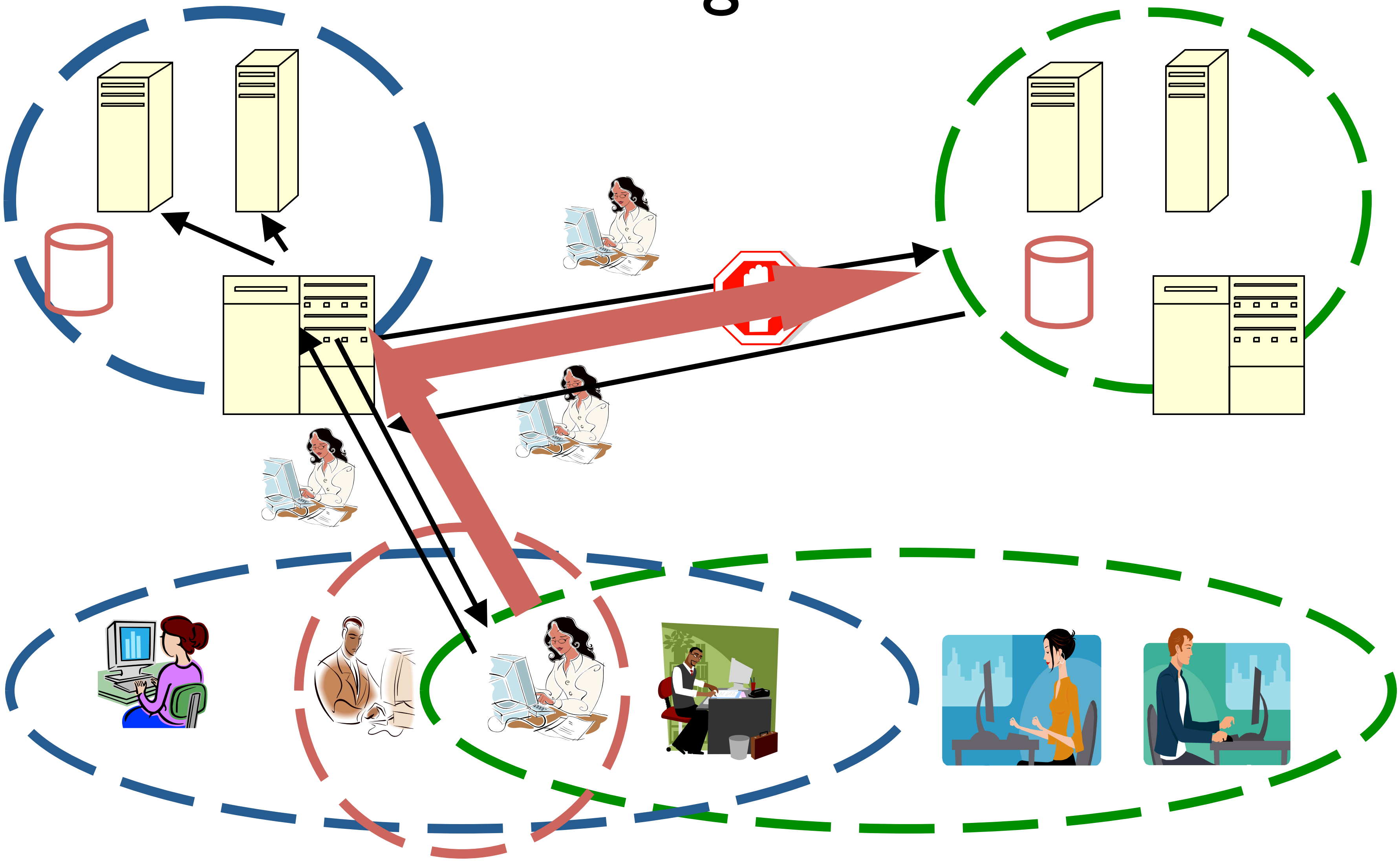
Rachana Ananthakrishnan

Grid Security: Single Sign On Varied Credentials



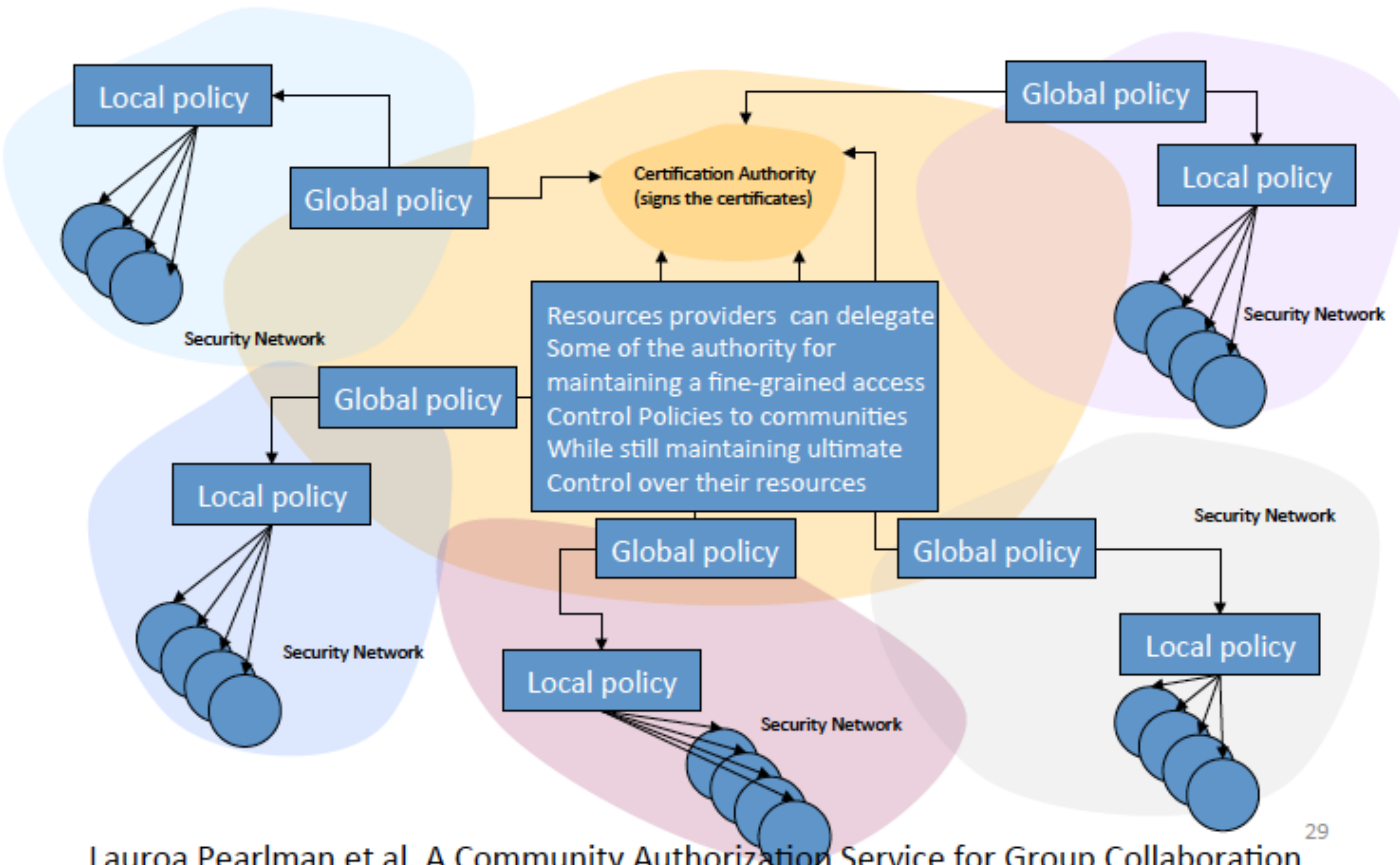
Rachana Ananthakrishnan

Grid Security: Single Sign On Delegation



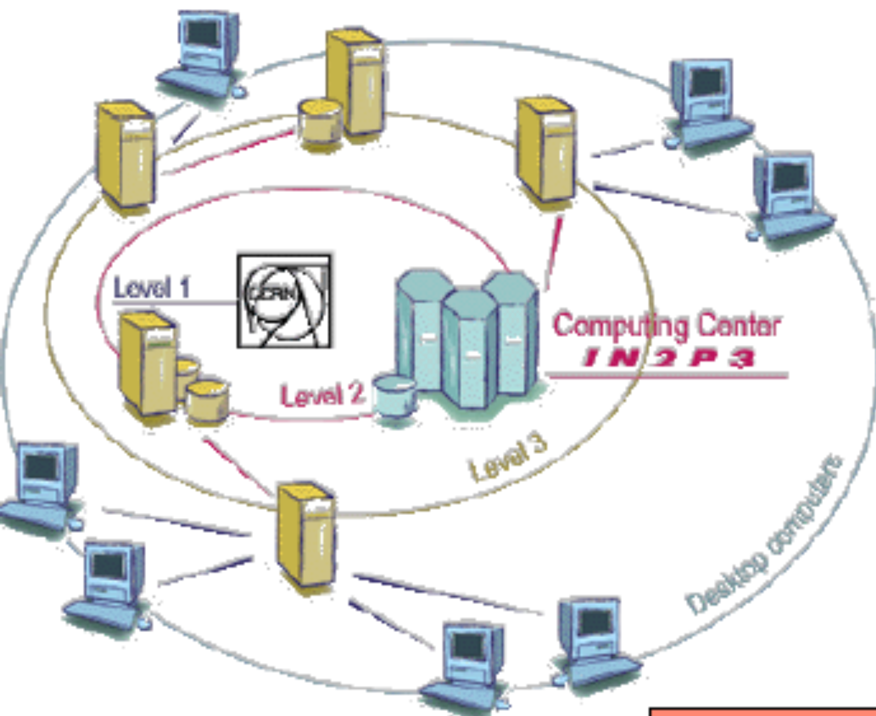
Rachana Ananthakrishnan

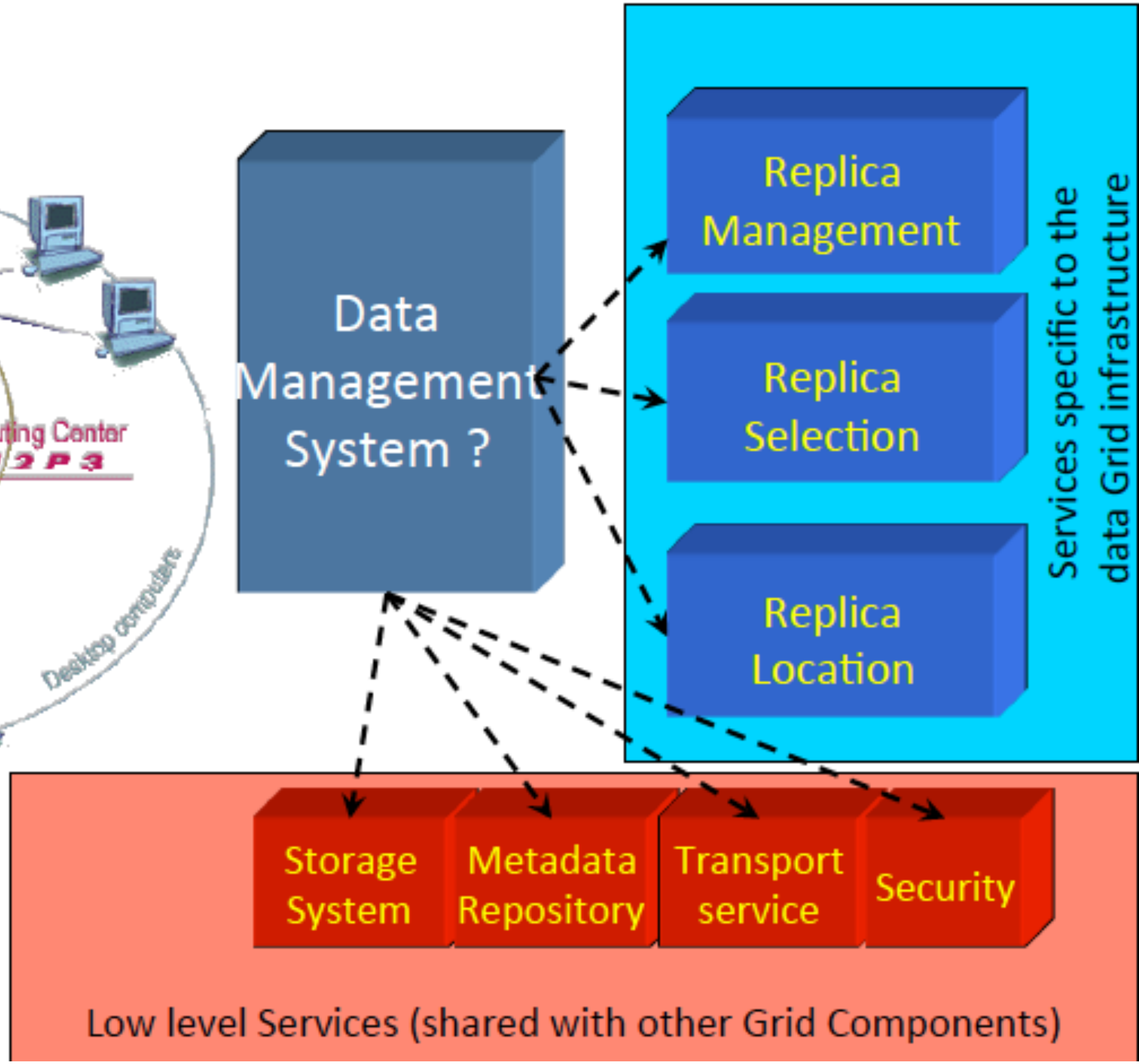
Security cross Grid (V.O.)



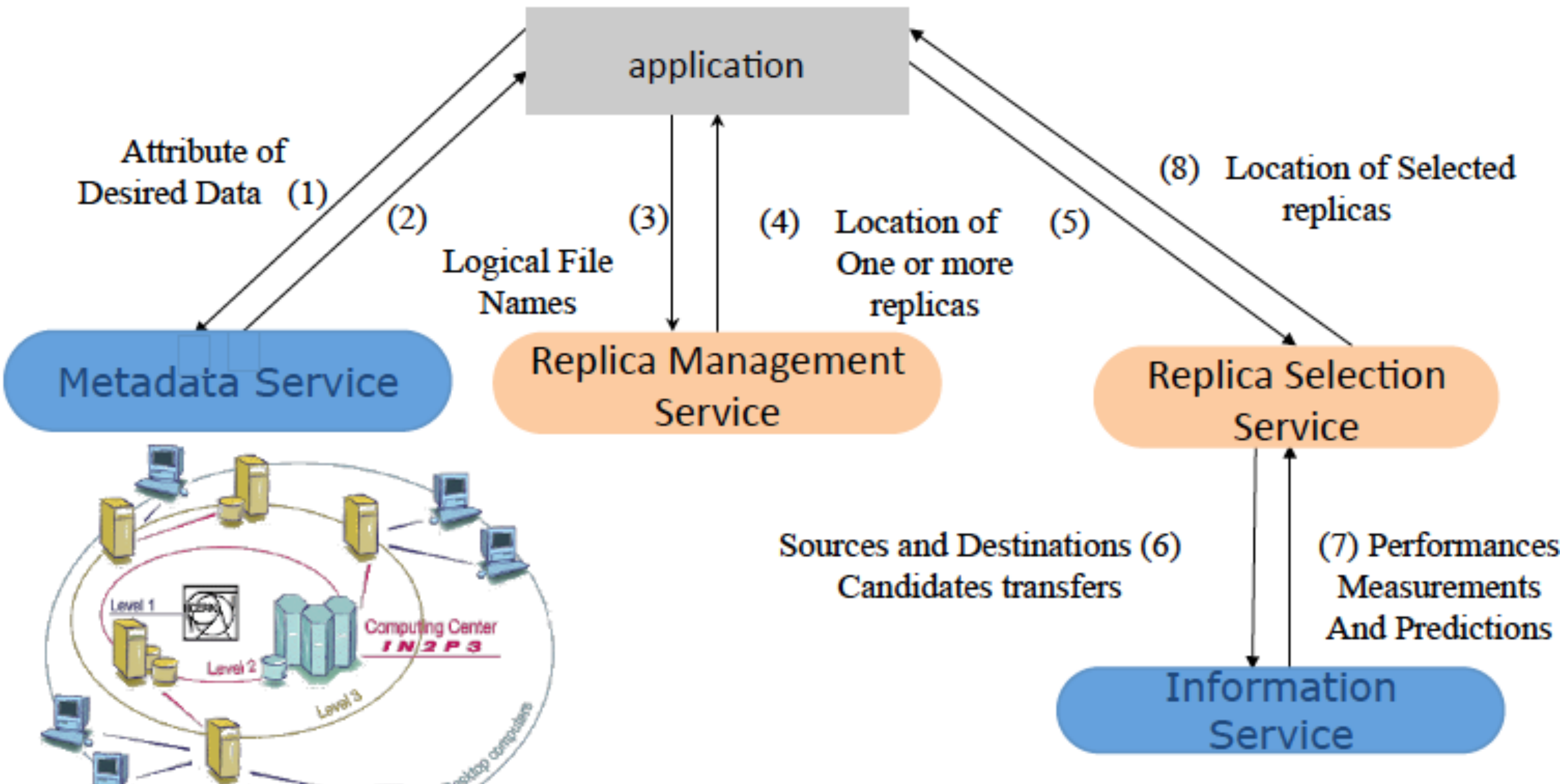
Lauroa Pearlman et al. A Community Authorization Service for Group Collaboration

Grid data management



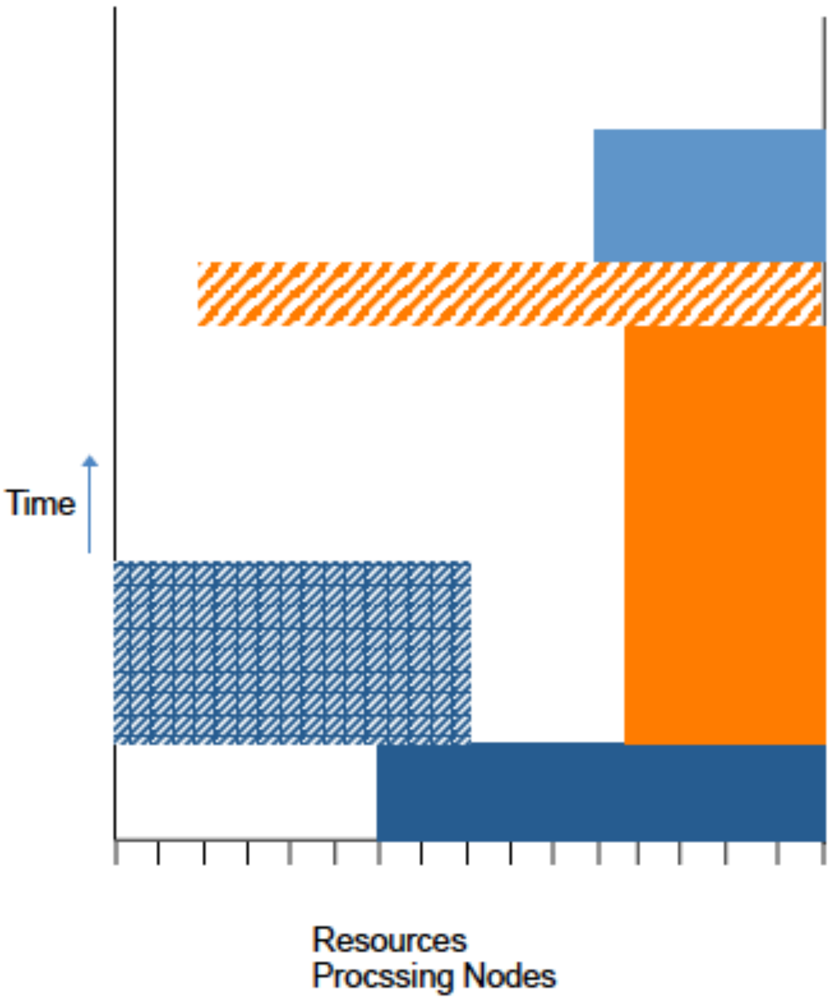


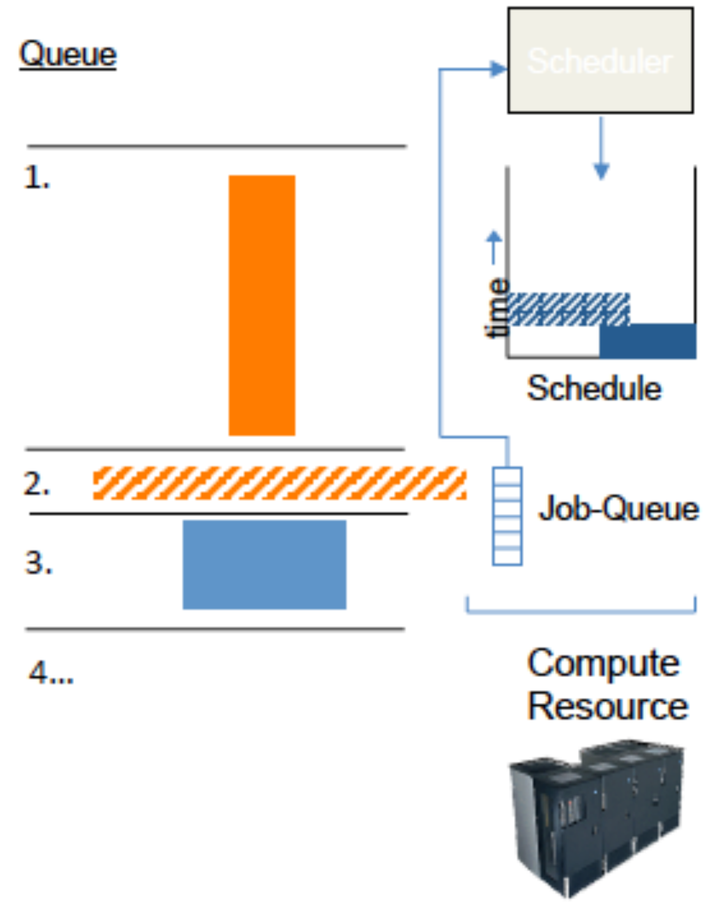
A Data selection scenario



Sudharshan Vazhkudai “Replica Selection in the Globus Data Grid”

Grid Job Scheduling





Grid Programming Issues

- Portability, Interoperability, and Adaptability
- Discovery
- Performance
- Fault Tolerance
- Security

Programming models

- Shared-state models
- Message passing models
- RPC and RMI models
- Hybrid Models
- Peer to Peer Models
- Web Service Models
- …