

Grid Computing



Elements of Grid Computing

- Resource sharing
 - Computers, data, storage, sensors, networks, ...
 - Sharing always conditional: issues of trust, policy, negotiation, payment, ...
- Coordinated problem solving
 - Beyond client-server: distributed data analysis, computation, collaboration, ...
- Dynamic, multi-institutional virtual organizations
 - Community overlays on classic org structures
 - Large or small, static or dynamic

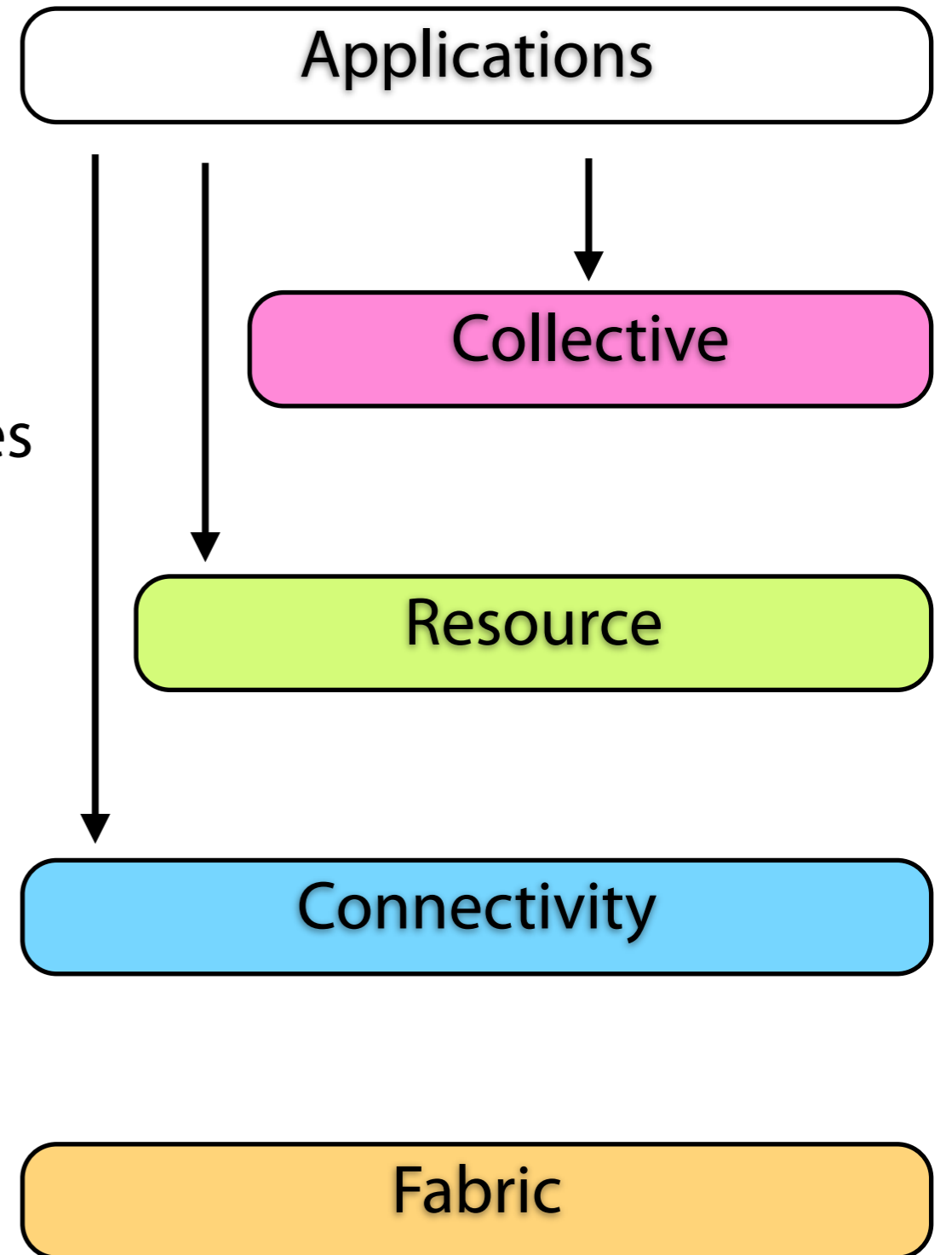
Grid Architecture

“Coordinating multiple resources”:
Ubiquitous infrastructure services,
application-specific distributed services

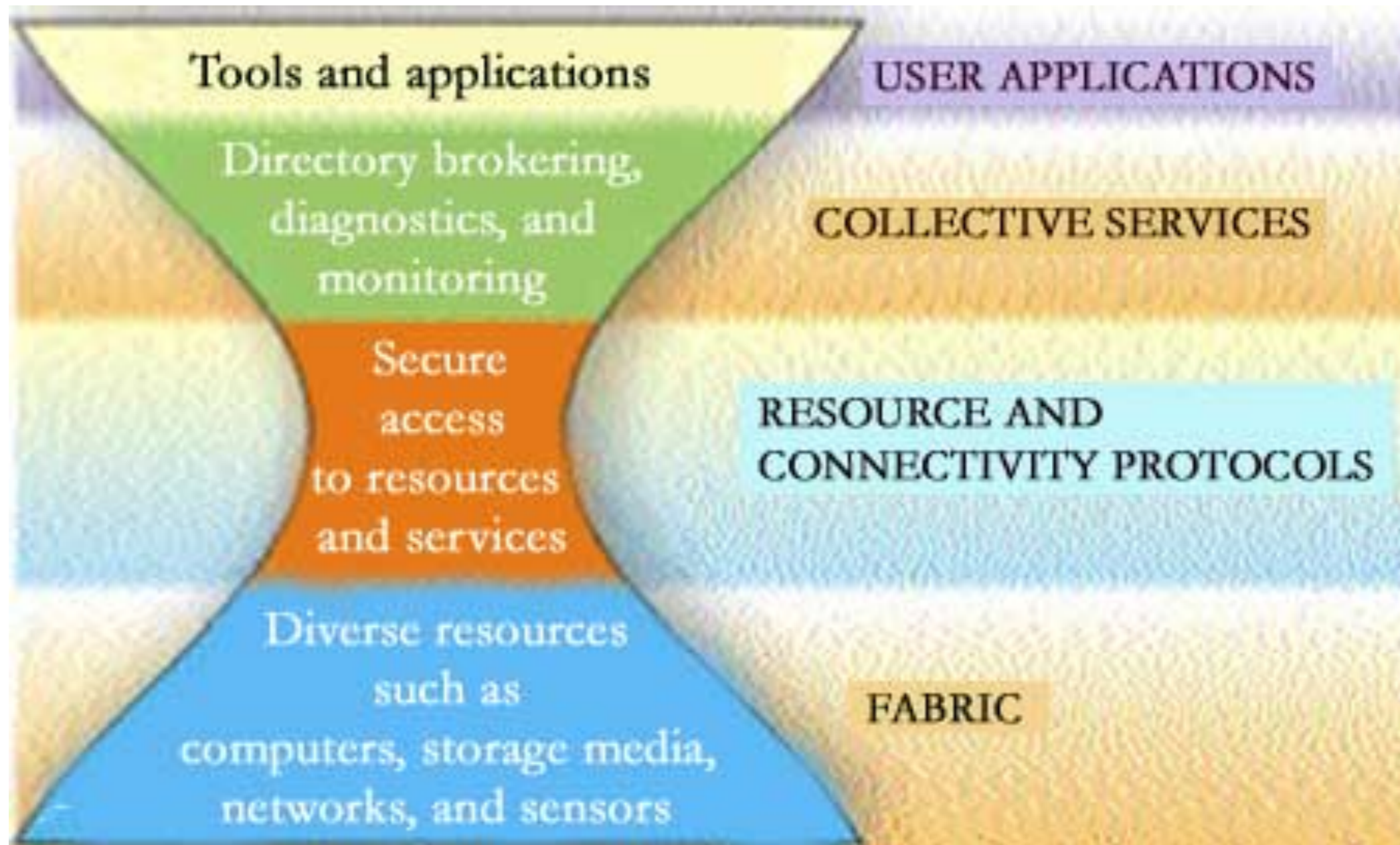
“Sharing single resources”:
Negotiating access, controlling use

“Talking to things”:
Communication (Internet protocols) &
security

“Controlling things locally”:
Access to & control of resources



The Hourglass Model



I. Foster, "The Grid: A New Infrastructure for 21st Century Science," Physics Today, vol. 55, no. 2, pp. 42–47, 2002.

Globus Toolkit

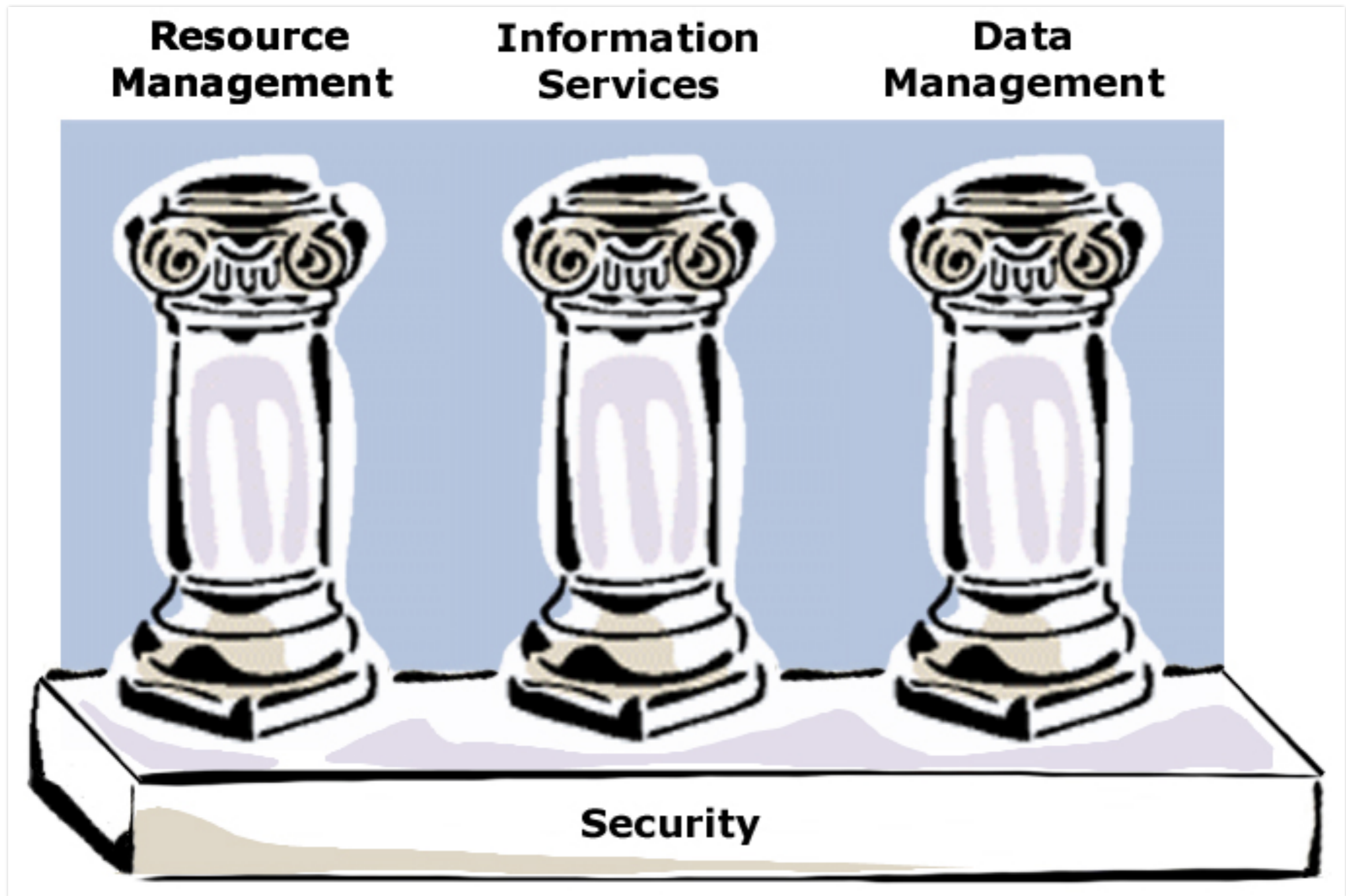
- An example Grid middleware

<http://www.globus.org/toolkit/>

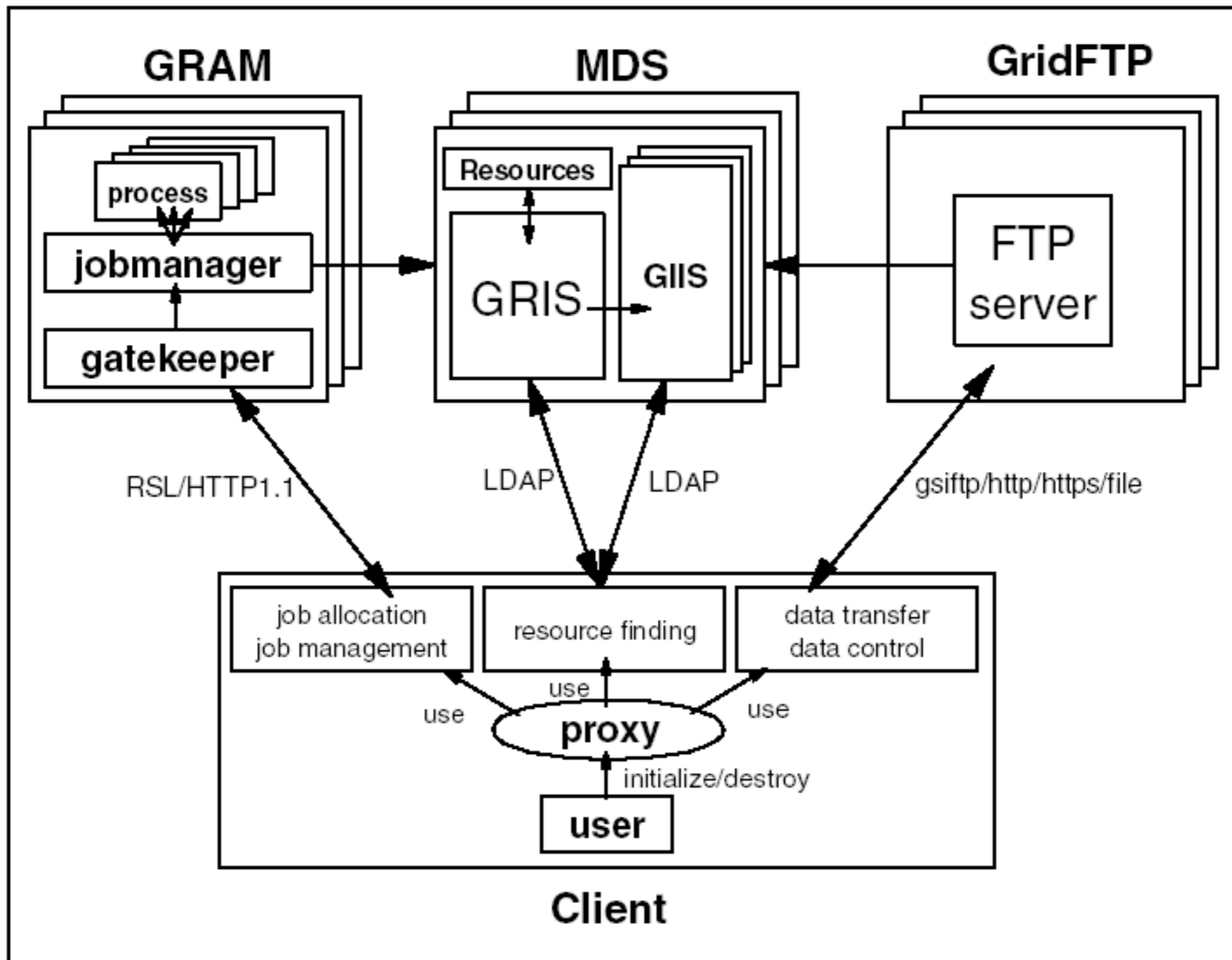
- A software toolkit addressing key technical problems in the development of Grid enabled tools, services, and applications
 - Offer a modular “bag of technologies”
 - Enable incremental development of Grid-enabled tools and applications
 - Implement standard Grid protocols and APIs (the “core” of the hourglass)
 - Is available under liberal open source license
- Now is evolving to Cloud middleware



Key Protocols



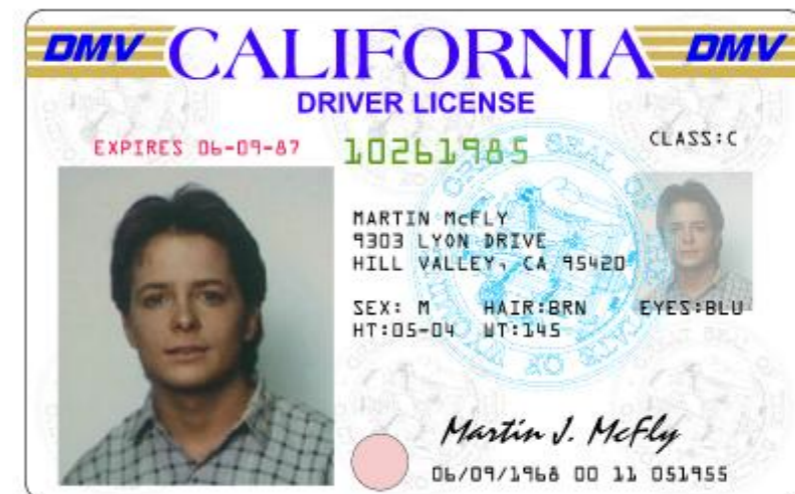
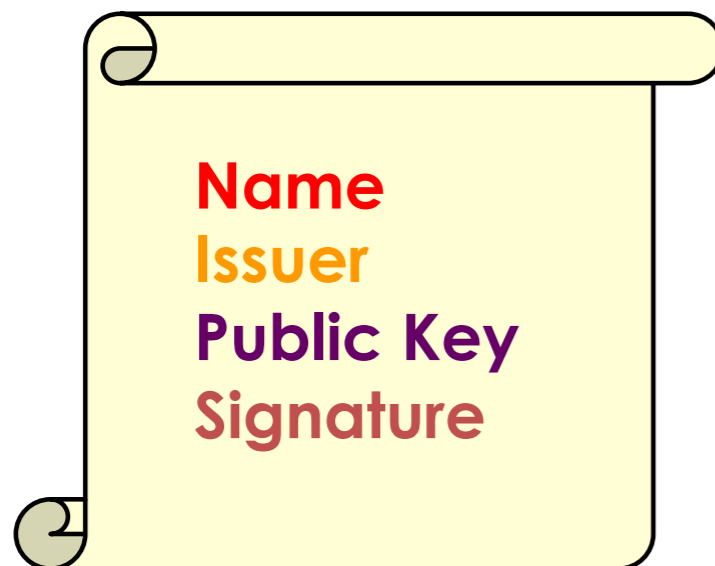
GT2 Protocols and Services



Grid Security

- Resources being used may be valuable & the problems being solved sensitive
- Resources are often located in distinct administrative domains
 - Each resource has own policies & procedures
- Set of resources used by a single computation may be large, dynamic, and unpredictable
 - Not just client/server, requires delegation
- It must be broadly available & applicable
- Standard, well-tested, well-understood protocols; integrated with wide variety of tools

- PKI allows you to know that a given public key belongs to a given user
- PKI builds upon asymmetric encryption:
 - Each entity has two keys: public and private
 - Data encrypted with one key can only be decrypted with the other
 - The private key is known only to the owner
- The public key is given to the world encapsulated in a X.509



Proxies and delegation (GSI extensions) for secure single sign-on

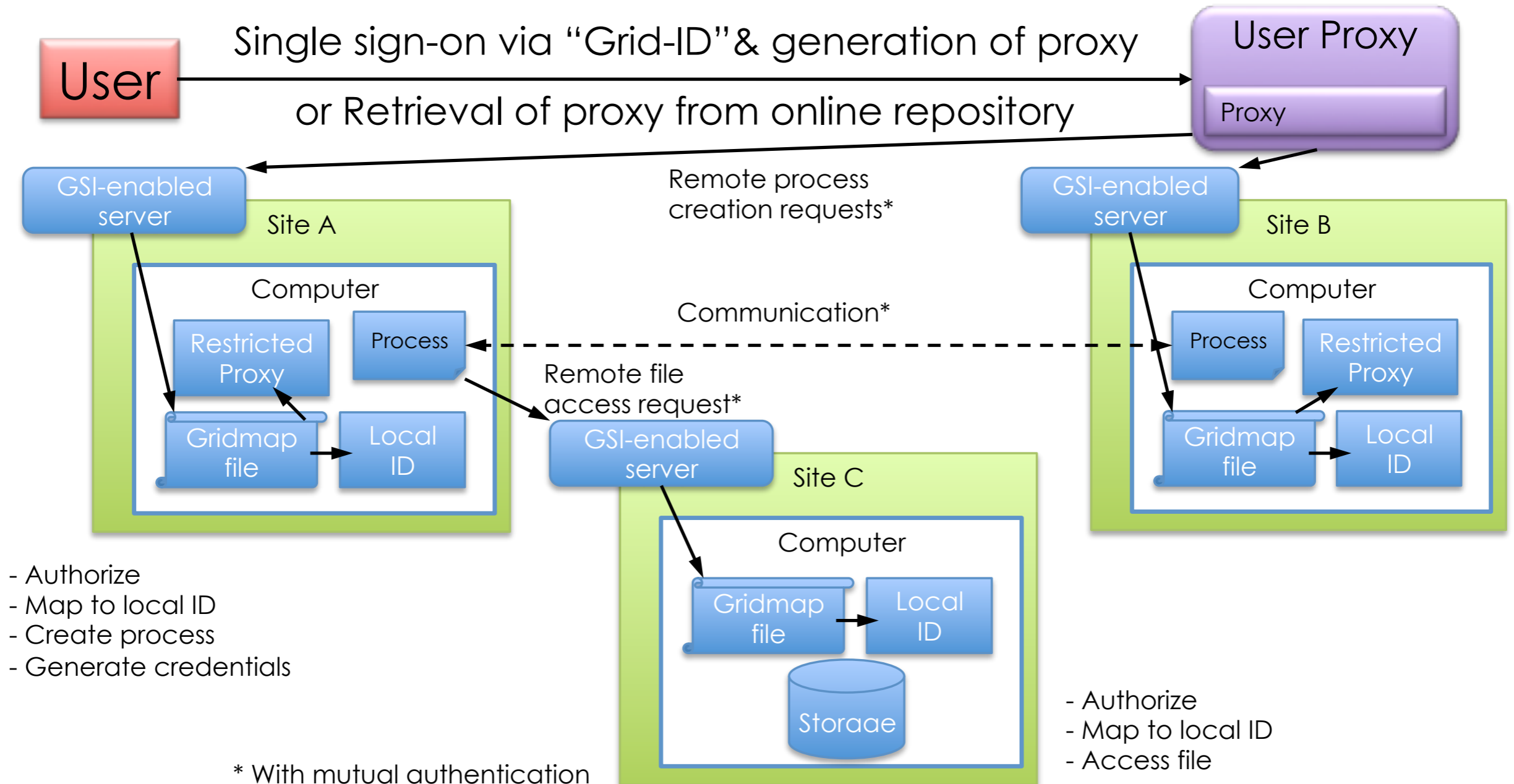


PKI for credentials

SSL for authentication and message protection

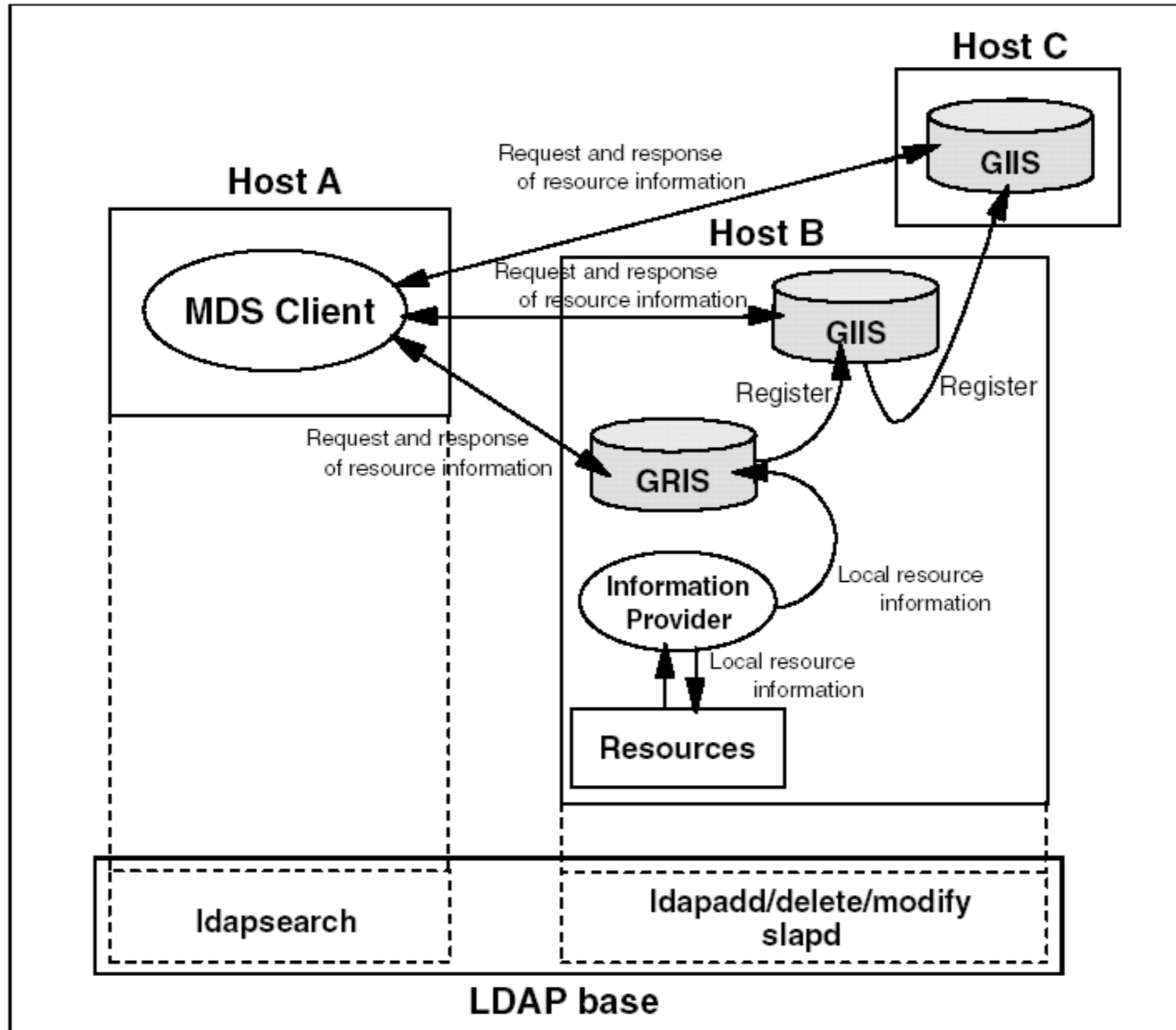
GSI in Action

“Create Processes at A and B that Communicate & Access Files at C”



- Provide access to static and dynamic information regarding system components
- A basis for configuration and adaptation in heterogeneous, dynamic environments
- Resource Description Services
 - Supplies information about a specific resource
- Aggregate Directory Services
 - Supplies collection of information which was gathered from multiple resource description services
 - Customized naming and indexing

MDS Protocols and Services



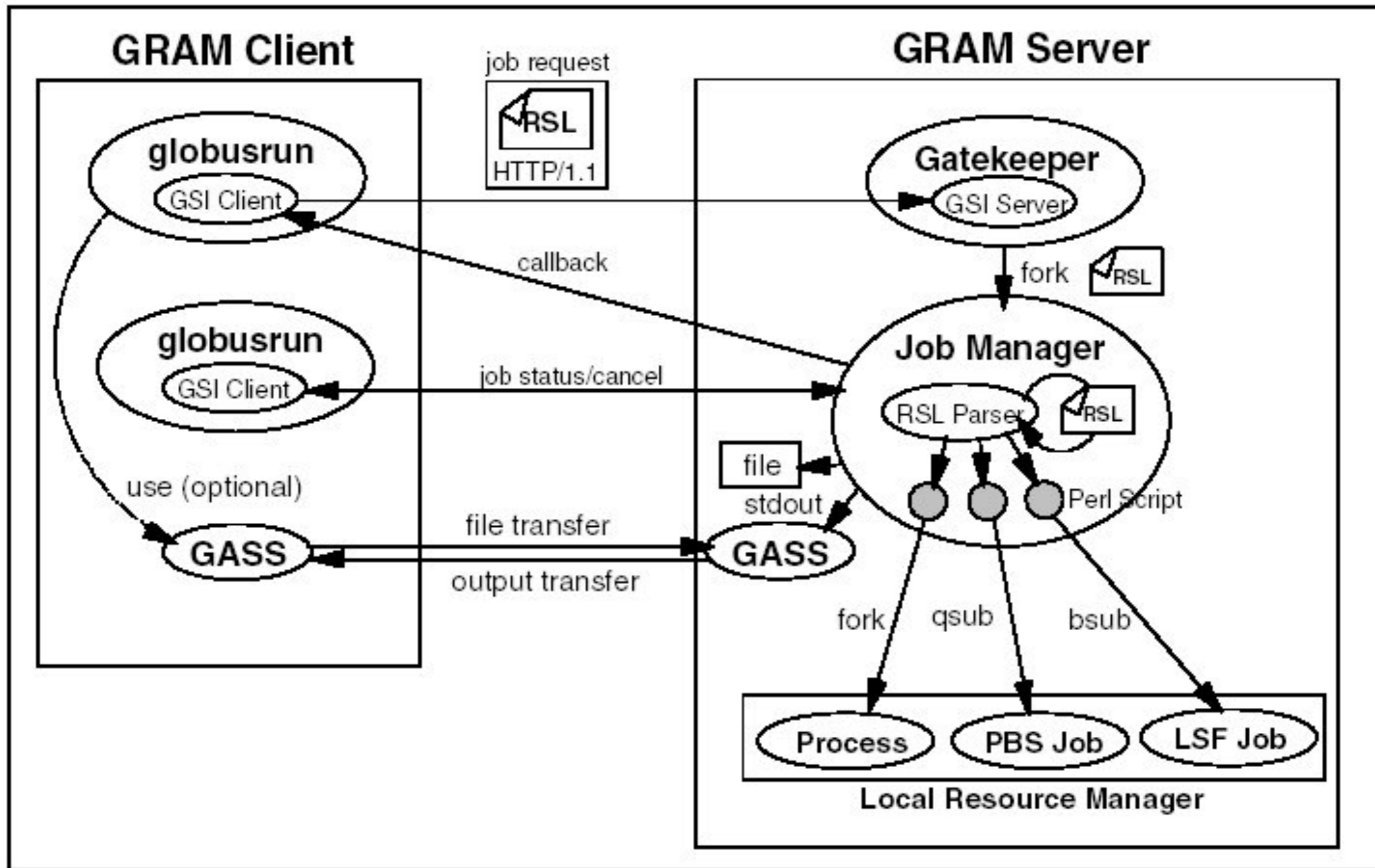
Grid Resource Management

- Grid Resource Management System consists of :
 - Local resource management system (Resource Layer)
 - ▶ Basic resource management unit
 - ▶ Provide a standard interface for using remote resources
 - ▶ Grid Resource Allocation Manager (GRAM)
 - Global resource management system (Collective Layer)
 - ▶ Coordinate all Local resource management system within multiple or distributed Virtual Organizations (VOs)
 - ▶ Provide high-level functionalities to efficiently use all of resources
 - Job Submission
 - Resource Discovery and Selection
 - Scheduling
 - Co-allocation
 - Job Monitoring, etc.
 - ▶ e.g. Meta-scheduler, Resource Broker, etc.

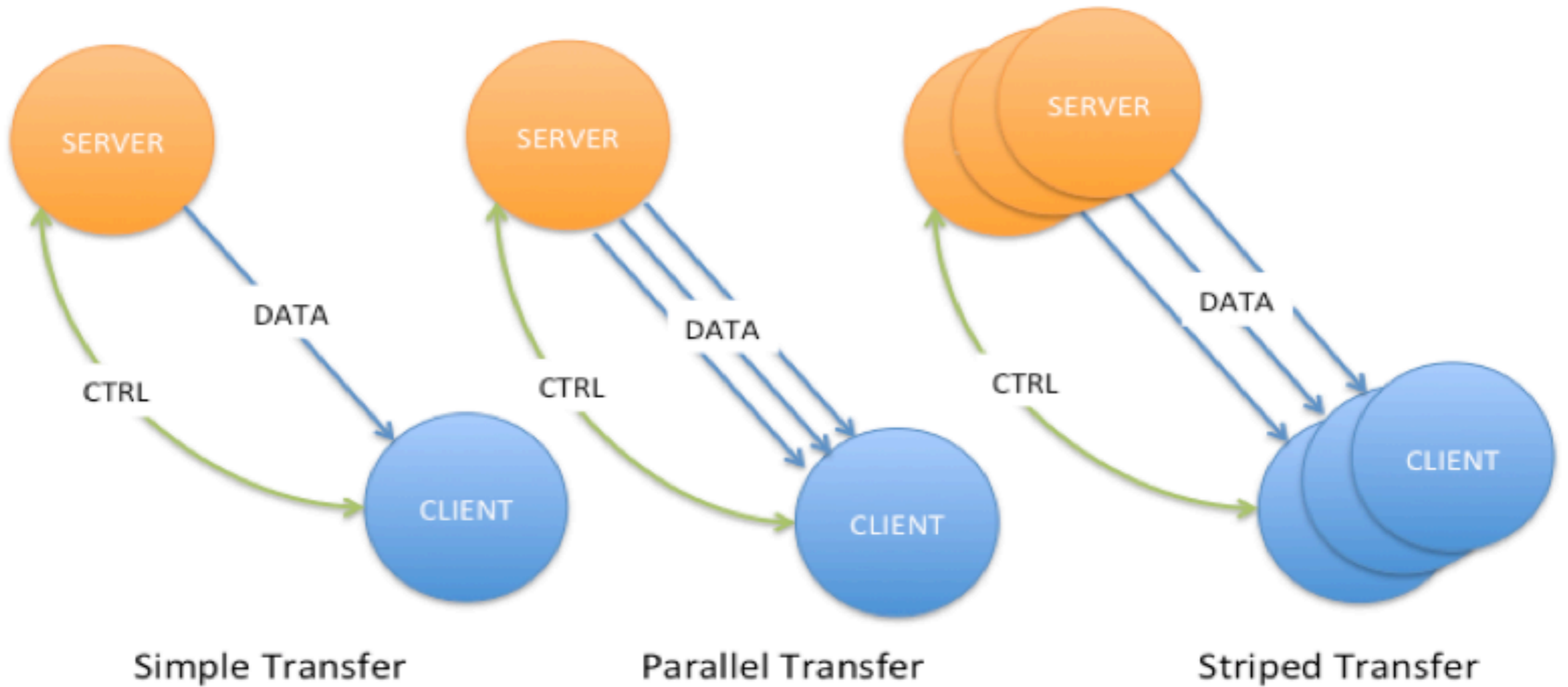
Definitions

- **Resource:** entity able to execute one or more jobs on the behalf of the user
- **Client:** process using GRAM protocol to submit a job request
- **Job:** one or more processes being part of a job request
- **Job request:** a message containing the request and the specification for a job execution on a remote resource. A typical job request specifies:
 - When and where processes should be created
 - How and what processes to create
 - How to execute and terminate processes
- **Gatekeeper:** remote resources service managing incoming job requests (GT2)
- **Job Manager:** service instantiated by the gatekeeper to manage the execution and monitor the job's processes (GT2)

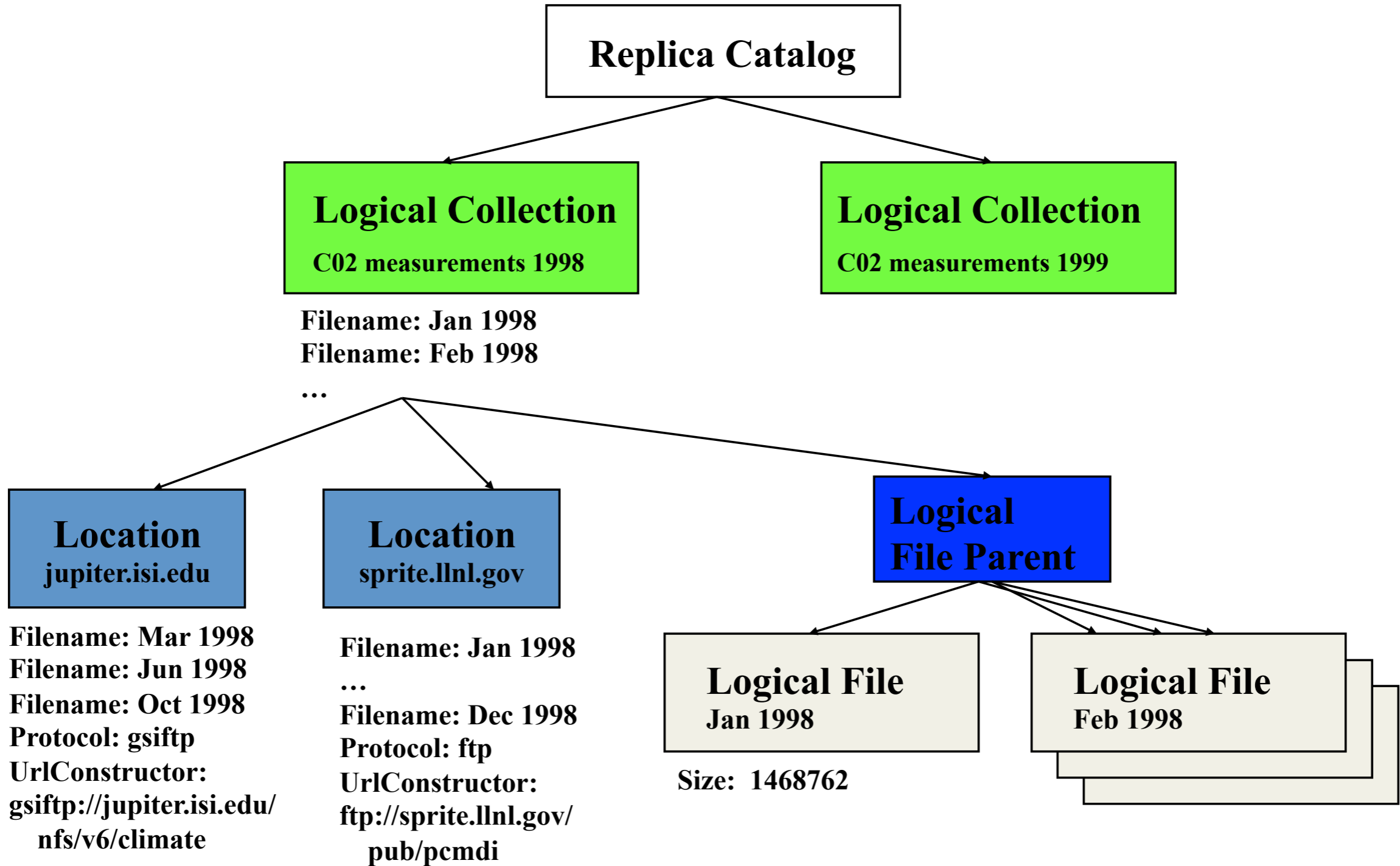
GRAM Protocols and Services



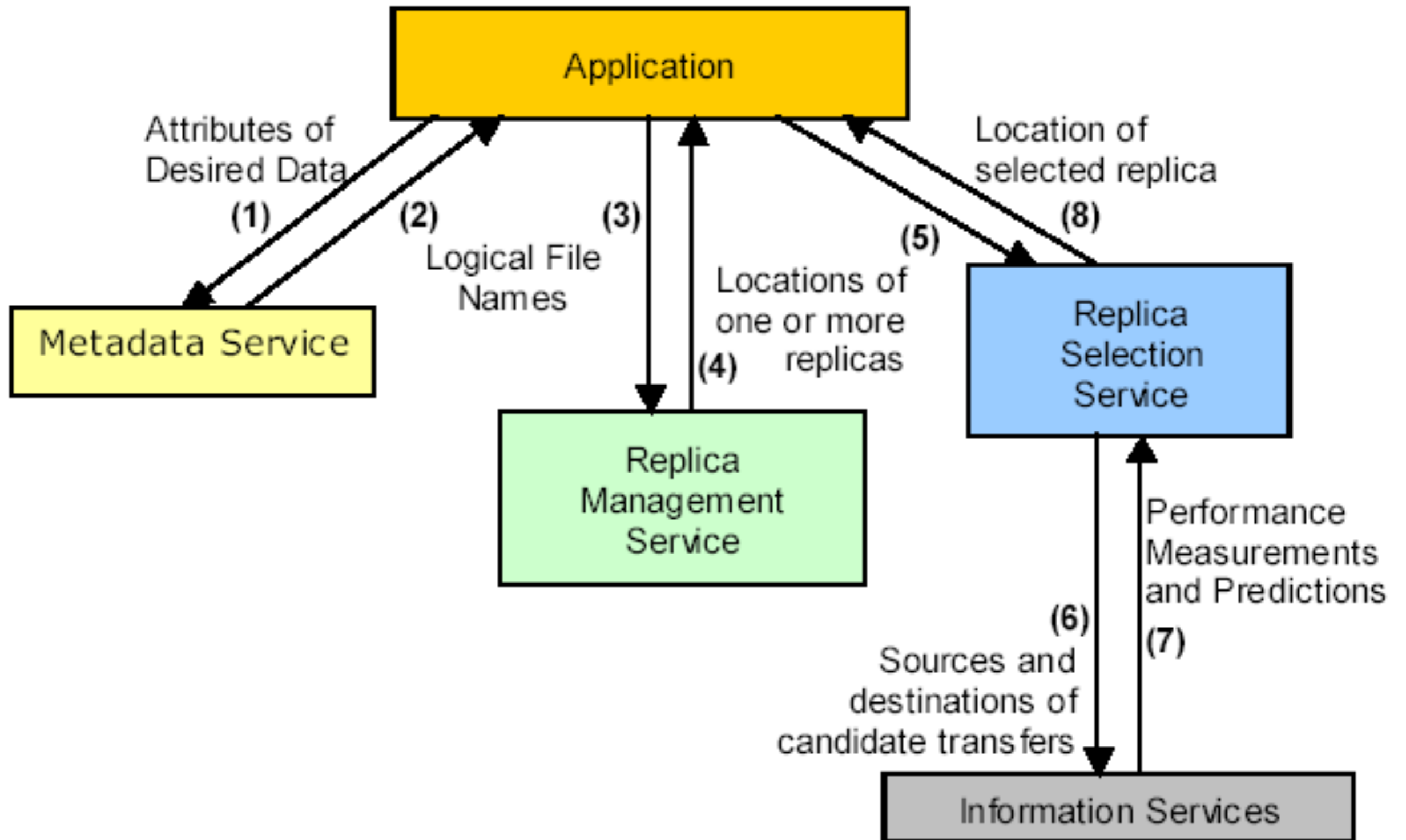
- Data access and transfer
 - **GASS**: Simple multi-protocol tool to transfer 'normal' files; integrated in GRAM
 - **GridFTP**: Reliable and high-performance file transfer protocol for 'big' files in computer networks
- Replica Management
 - **Replica Catalog**: Service to keep updated information on sets of replicated data
 - **Replica Management**: Service to create and manage sets of replicated data



Replica Catalog



Replica Management



Reading Assignments

- C. Kesselman, et al., *The Anatomy of the Grid: Enabling Scalable Virtual Organizations*, International Journal of Supercomputing Applications, pp. 1-25, 2001.

<http://www.globus.org/alliance/publications/papers/anatomy.pdf>

- IBM Redbooks paper, *Fundamentals of Grid Computing*

<http://www.redbooks.ibm.com/redpapers/pdfs/redp3613.pdf>

- IBM Redbooks, *Introduction to Grid Computing*

<http://www.redbooks.ibm.com/redbooks/pdfs/sg246778.pdf>

- Links and additional references provided at:

<http://www.cli.di.unipi.it/doku/doku.php/magistraleinformaticanetworking/cpa/start>