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2068-21

Advanced School in High Performance and GRID Computing - Concepts and Applications

30 November - 11 December, 2009

Introduction to GRID Computing

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Introduction to GRID Computing

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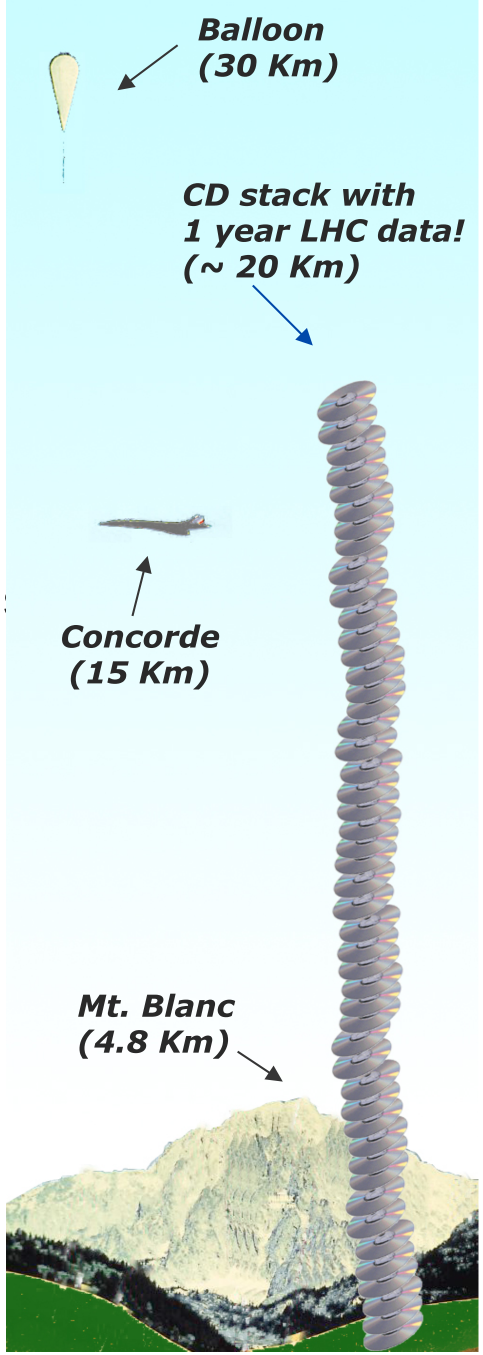
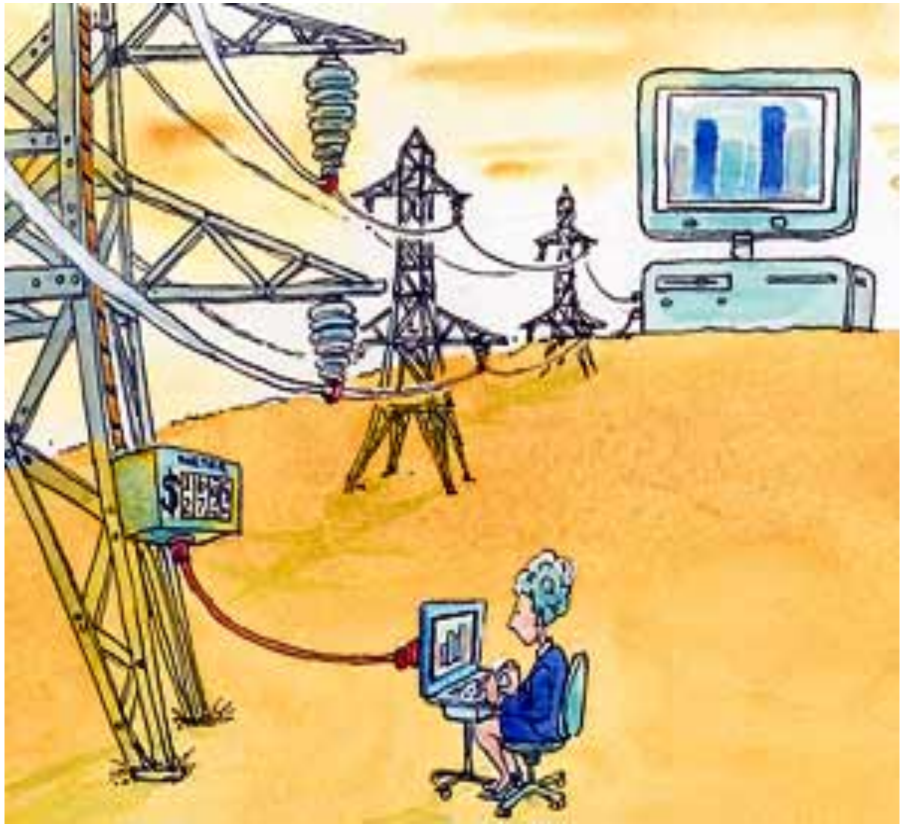
Motivation

- **Why the Grid?**
- Science is becoming increasingly digital and needs to deal with increasing amounts of data
- Particle Physics and other disciplines
  - Large amount of data produced
  - Large worldwide organized collaboration
  - e.g. Large Hadron Collider (LHC) at CERN
    - 40 million collisions per second
    - ~10 petabytes/year (~10 Million GBytes)



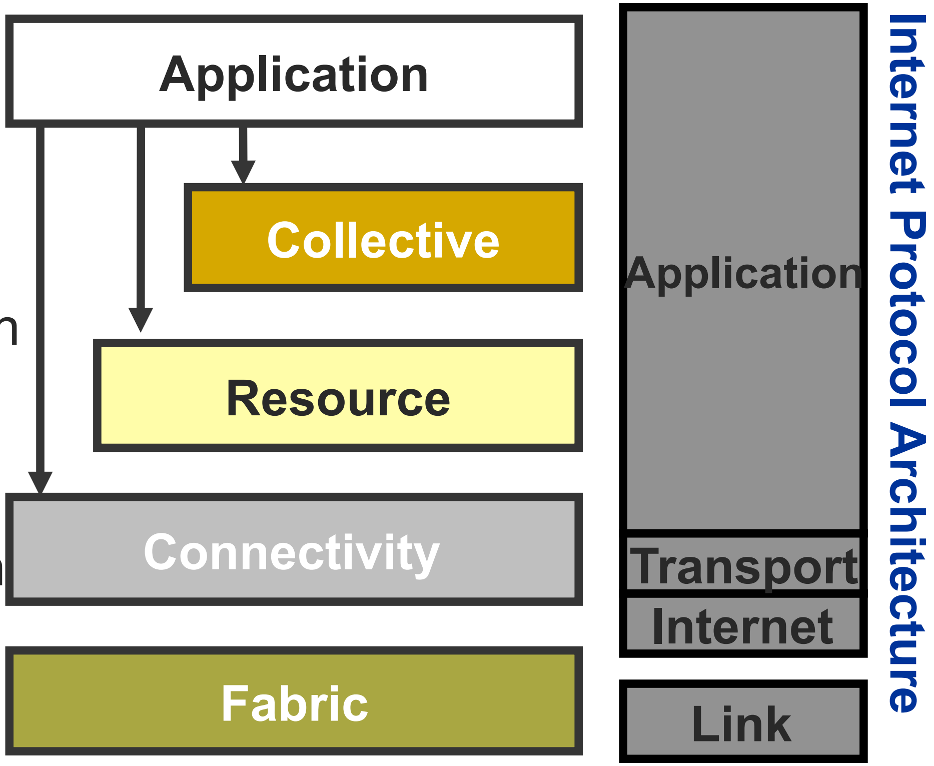
The solution: The Grid

… securely share distributed resources (computation, storage, etc) so that users can collaborate within Virtual Organisations (VO)



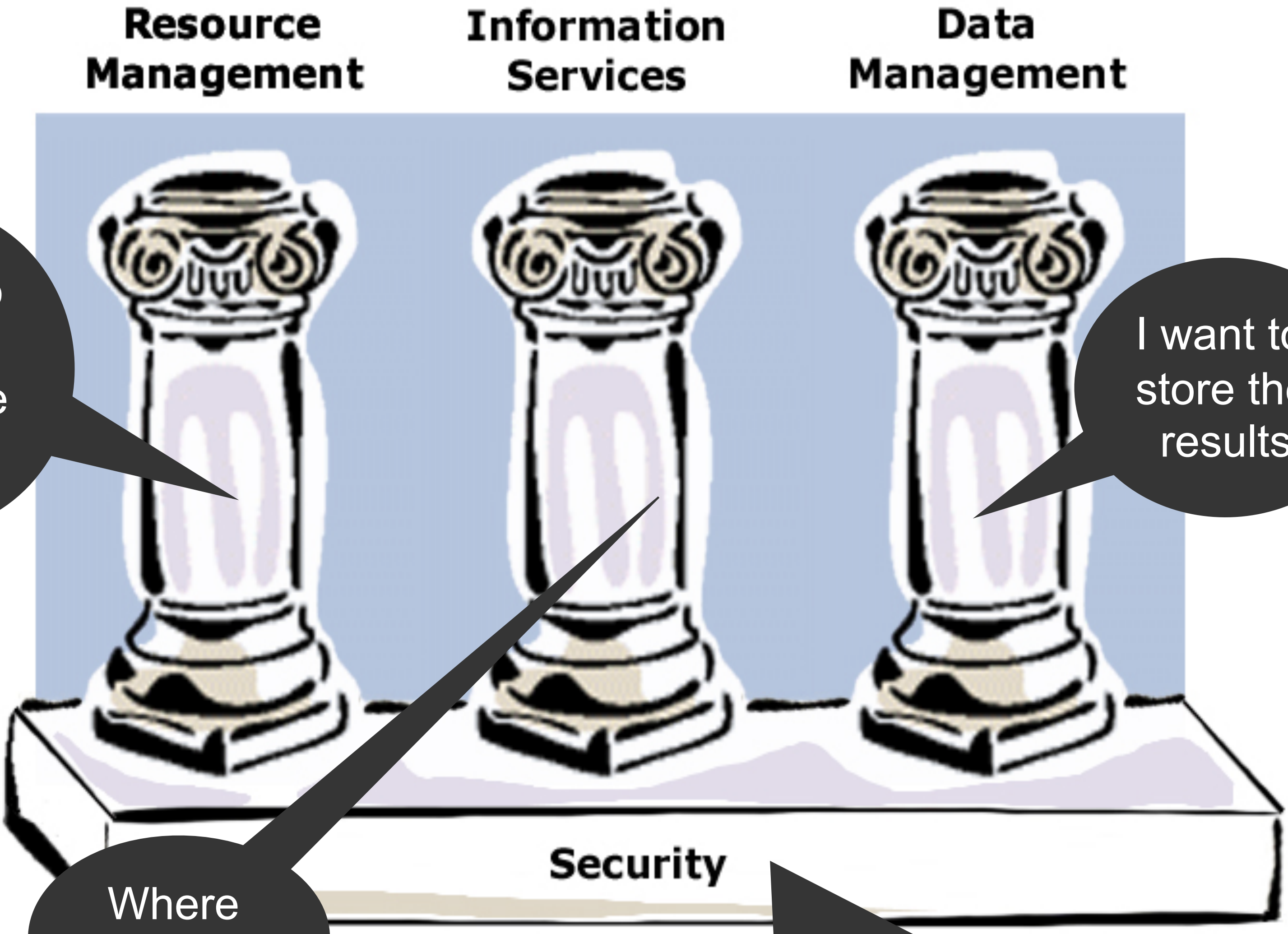
The Grid stack

- Application layer
  - Grid programs
- Collective layer
  - Resource Co-allocation
  - Data Management
- Resource layer
  - Resource Managemen
  - Information Services
  - Data Access
- Connectivity layer
  - Grid Security Infrastructure
  - High-performance data transfer protocols
- Fabric layer
  - the hardware: computers (parallel, clusters..), data storage servers



Grid foundations

- Defined by the Globus: http://globus.org



I want to use a resource on the Grid

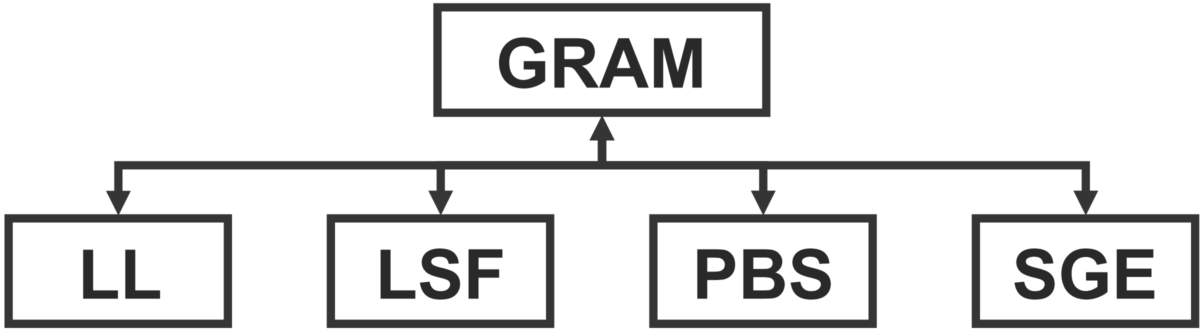
I want to store the results

Where can I find it?

All must be done securely

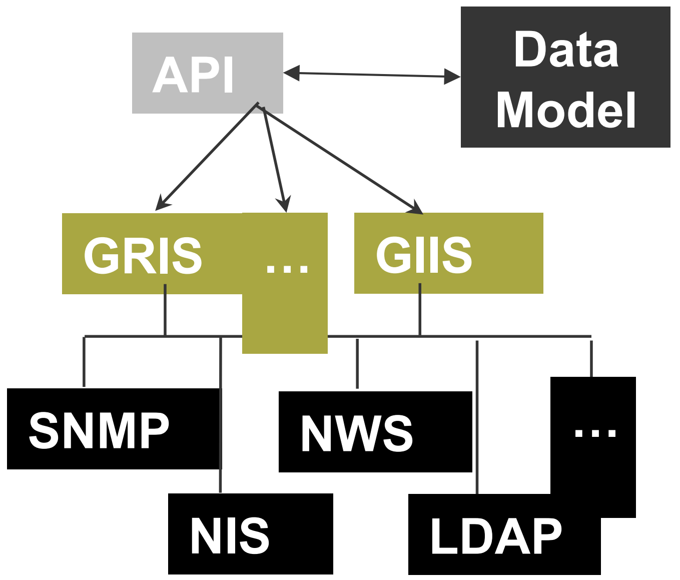
Resource Management

- Everything (or anything) is a resource
  - Physical or logical (single computer, cluster, parallel, data storage, an application...)
  - Defined in terms of **interfaces**, not devices
- Each site must be autonomous (local system administration policy)
- Grid Resource Allocation Manager (GRAM)
  - Defines resource layer protocols and APIs that enable clients to **securely instantiate a Grid computational task** (i.e. a job)
  - Secure remote job submissions
  - Relies on local resource management interfaces



Information Services

- Maintains information about hardware, software, services and people participating in a Virtual Organization
  - Should scale with the Grid´s growth
- “Find a computer with at least 2 free CPUs and with 10GB of free disk space...”

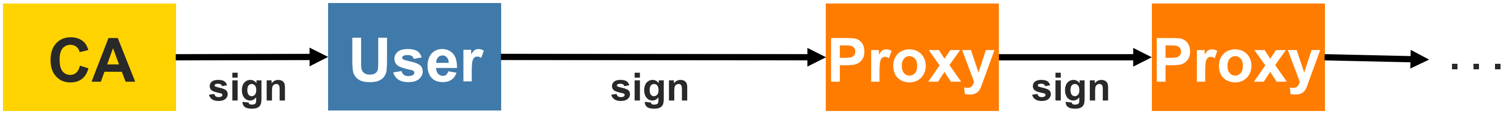


Data Management

- Data access and transfer
  - Simple, automatic multi-protocol file transfer tools: **Integrated with Resource Management service**
    - Move data from/to local machine to remote machine, where the job is executed (staging – stageout)
    - Redirect stdin to a remote location
    - Redirect stdout and stderr to the local computer
    - Pull executable from a remote location
  - To have a secure, high-performance, reliable file transfer over modern WANs: **GridFTP**

Security

- Basic security:
  - **Authentication:** Who we are on the Grid?
  - **Authorization:** Do we have access to a resource/ service?
  - **Protection:** Data integrity and confidentiality
- but, there are thousands of resources over different administration domains...:
  - **Single sign-on**, i.e. give a password once, and be able to access all resources (to which we have access)
- Grid Security Infrastructure (GSI):
  - **Grid credentials:** digital certificate and private key
    - Based on PKI X.509 standard
    - CA signs certificates. Trust relationship
  - **Proxy certificates:** Temporary self-signed certs, allowing single sign-on: Proxy delegation



gLite – **Grid middleware**

- The Grid relies on advanced software – the middleware - which interfaces between resources and the applications
- The GRID middleware
  - Finds convenient places for the application to be executed
  - Optimises use of resources
  - Organises efficient access to data
  - Deals with authentication to the different sites that are used
  - Run the job & monitors progress
  - Transfers the result back to the scientist

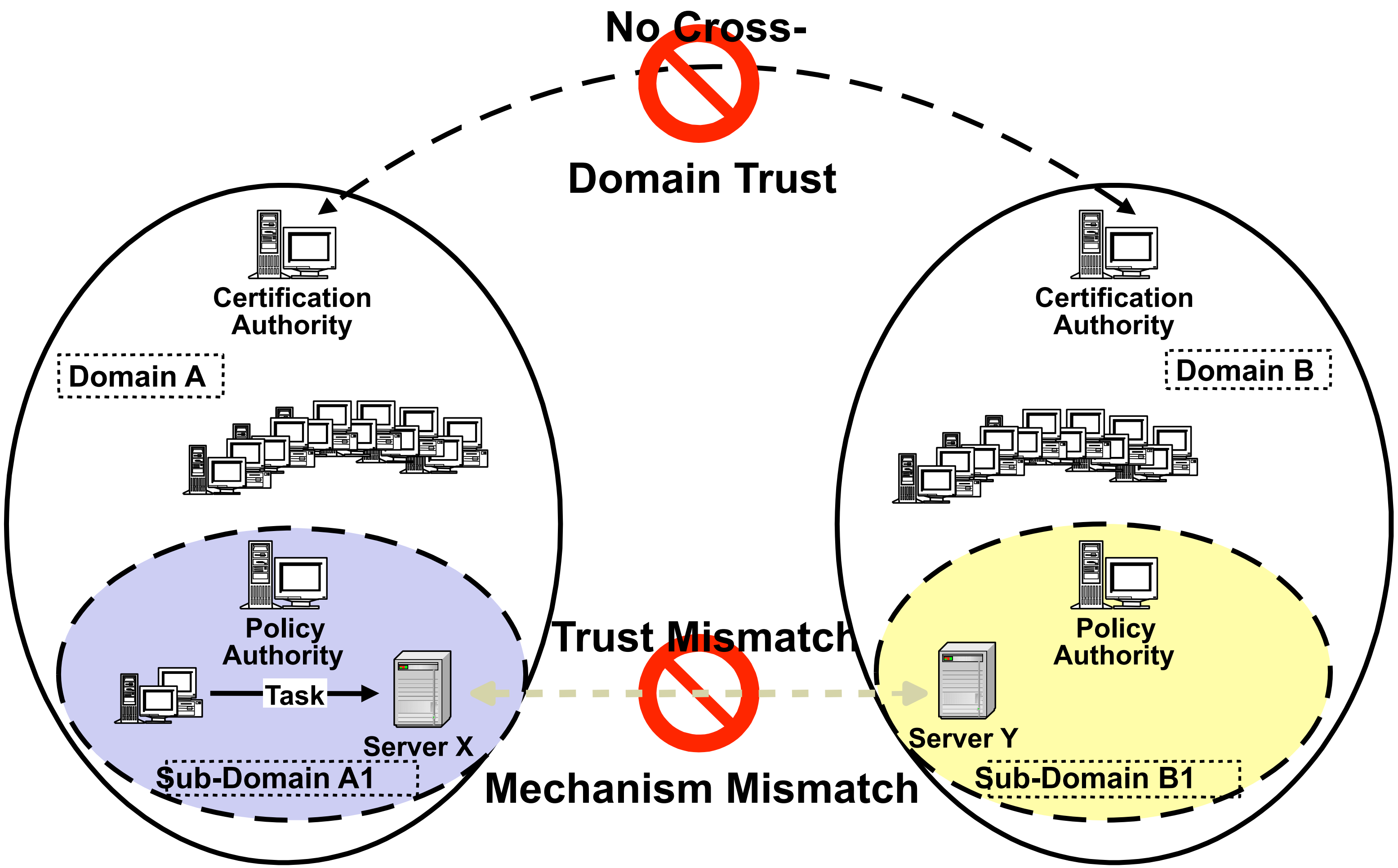
gLite – **Overview**

- First release 2005
- currently gLite 3.1-3.2
- Next generation middleware for grid computing
- Developed from existing components (globus, condor,..)
- Intended to replace present middleware with production quality services
- Interoperability & Co-existence with deployed infrastructure
- Robust: Performance & Fault tolerance
- Open Source license

Set of basic Grid services

- Job submission/management
- File transfer (individual, queued database access)
- Data management (replication, metadata)
- Monitoring/Indexing system information

Multi-institution issues



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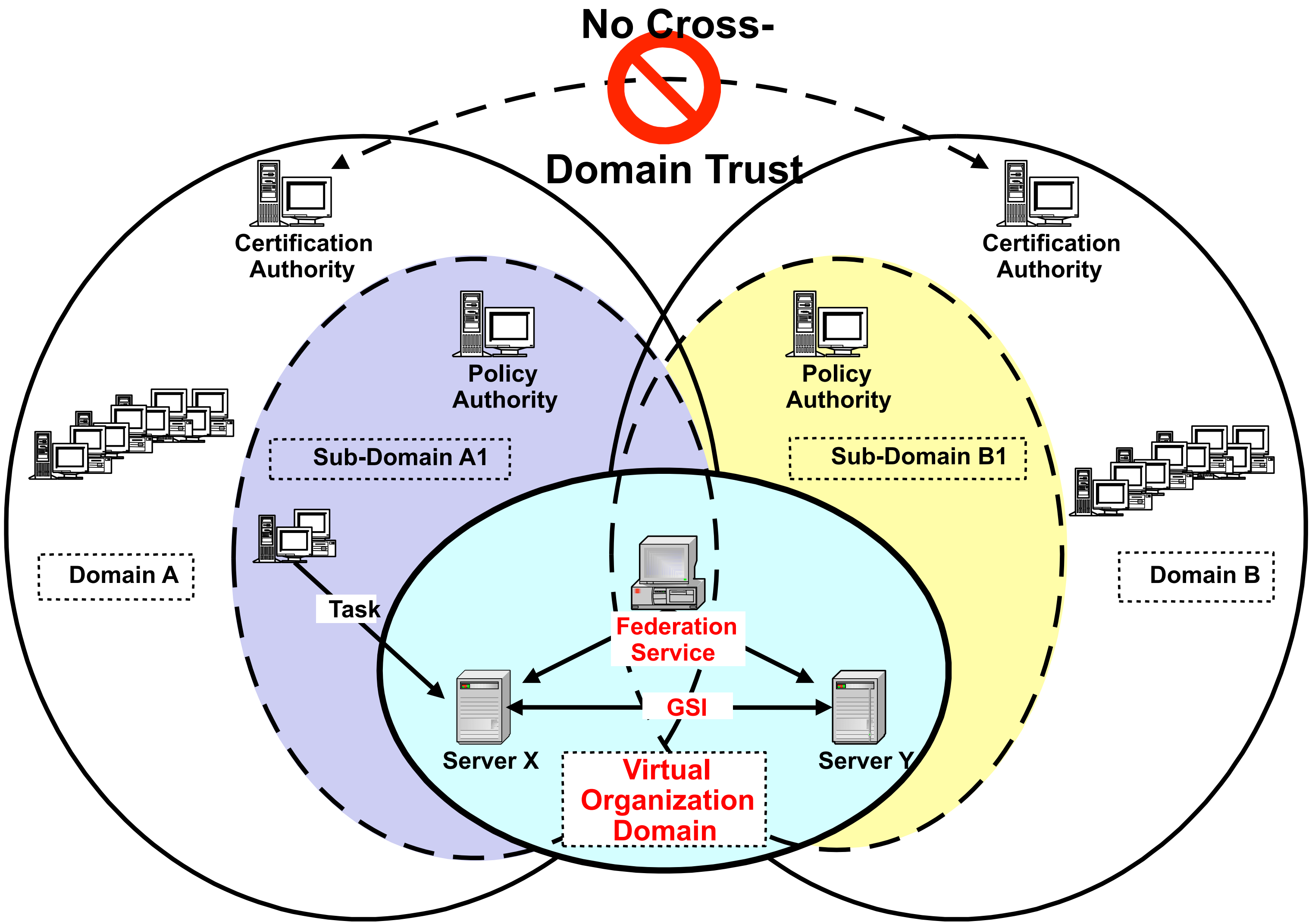
Why Grid security is hard (1)

- Resources being used may be valuable & the problems being solved sensitive
  - Both users and resources need to be careful
- Dynamic formation and management of user groups
  - Large, dynamic, unpredictable…
- Resources and users are often located in distinct administrative domains
  - Cannot assume cross-organizational trust agreements
  - Different mechanisms & credentials

Why Grid security is hard (2)

- Interactions are not just client/server,
  but service-to-service on behalf of user
  - Requires delegation of rights user ➔ service
  - Services may be dynamically instantiated
- Standardization of interfaces to allow for discovery, negotiation and use
- Implementation must be broadly available & applicable
  - Standard, well-tested, well-understood protocols; integrated with wide variety of tools
- Policy from sites, user communities and users need to be combined
  - Varying formats
- Want to hide as much as possible from applications!

Grid solution: use of VOs



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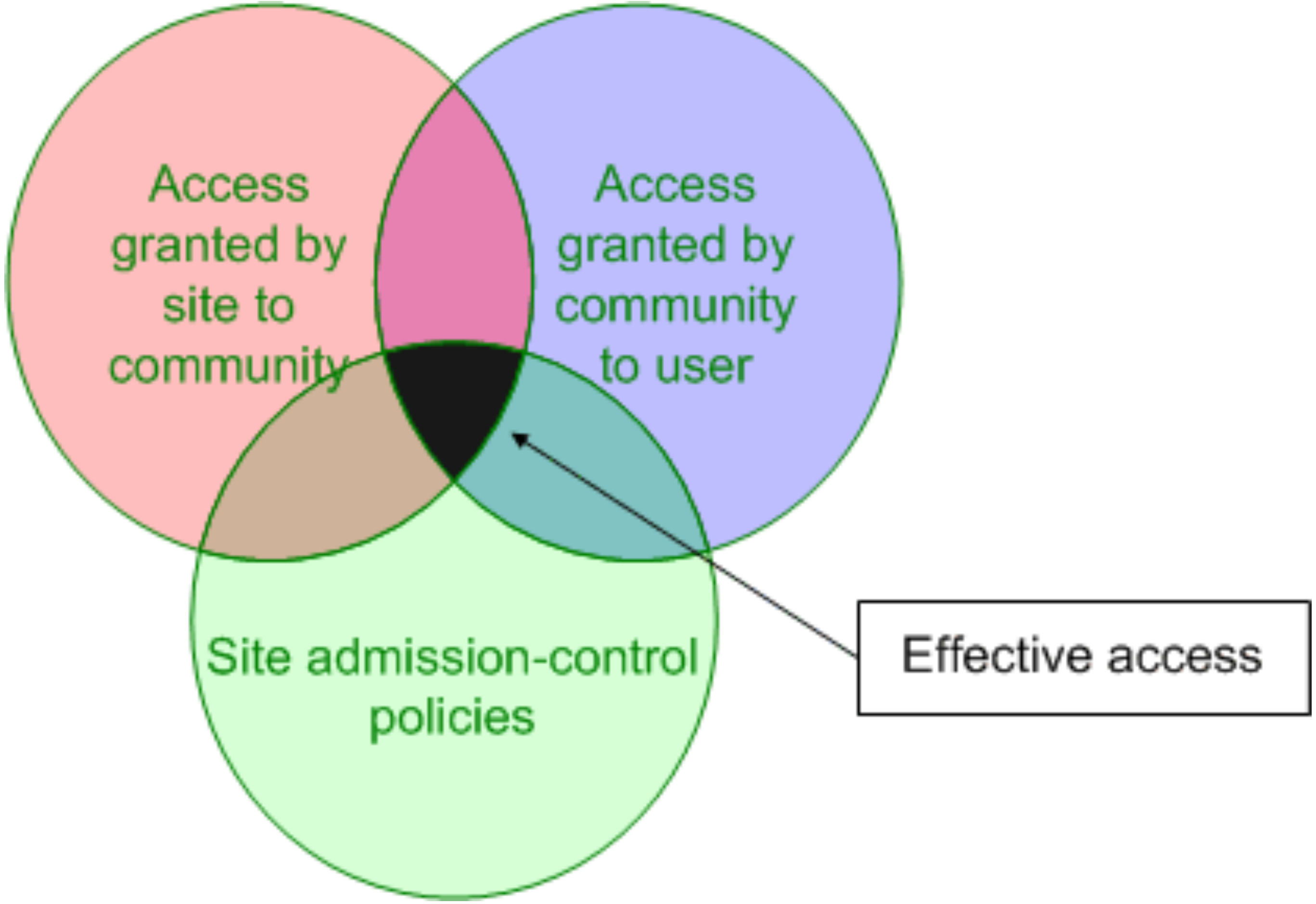
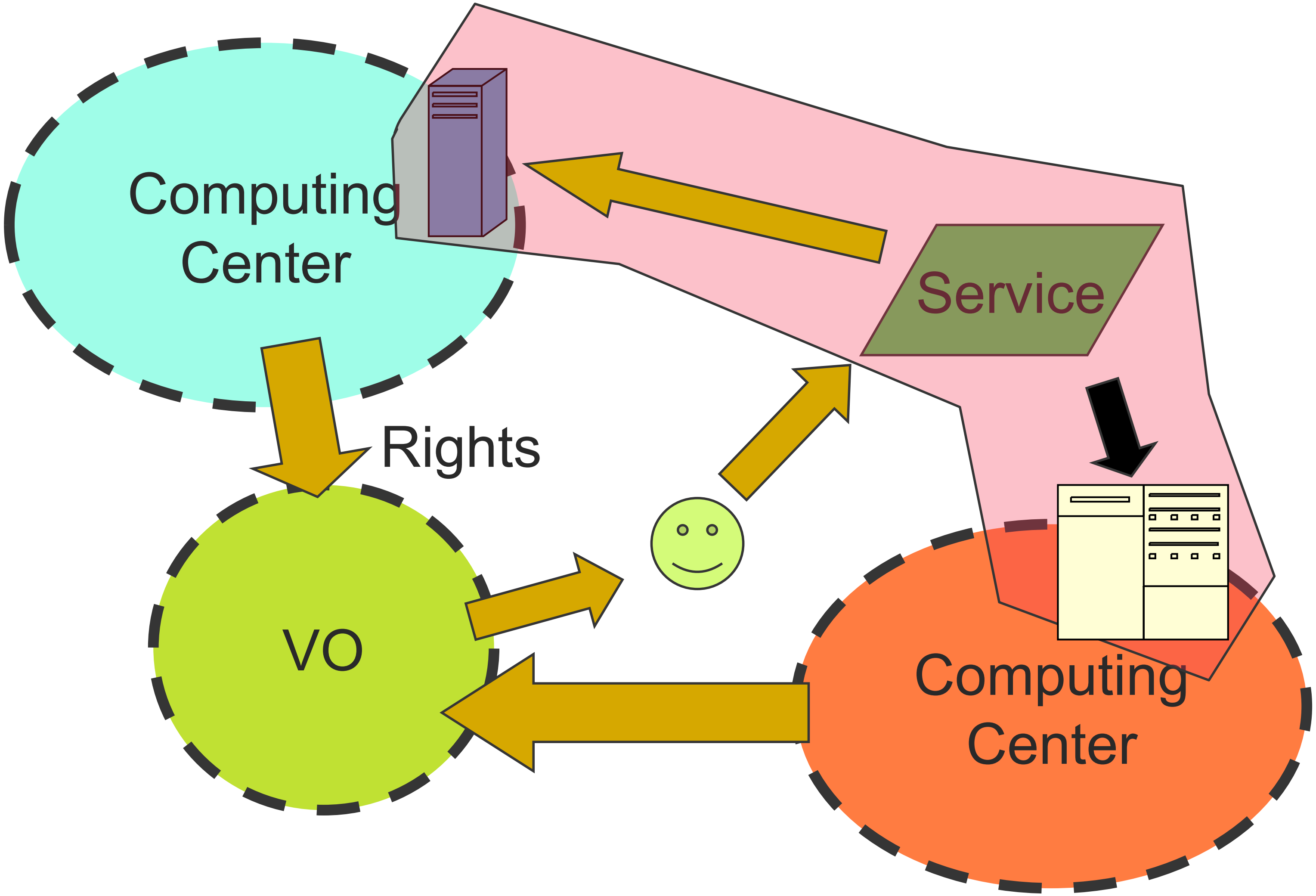
Effective policy governing access within a collaboration


Access granted by site to community
Access granted by community to user
Site admission-control policies
Effective access

Use delegation to establish dynamic distributed system



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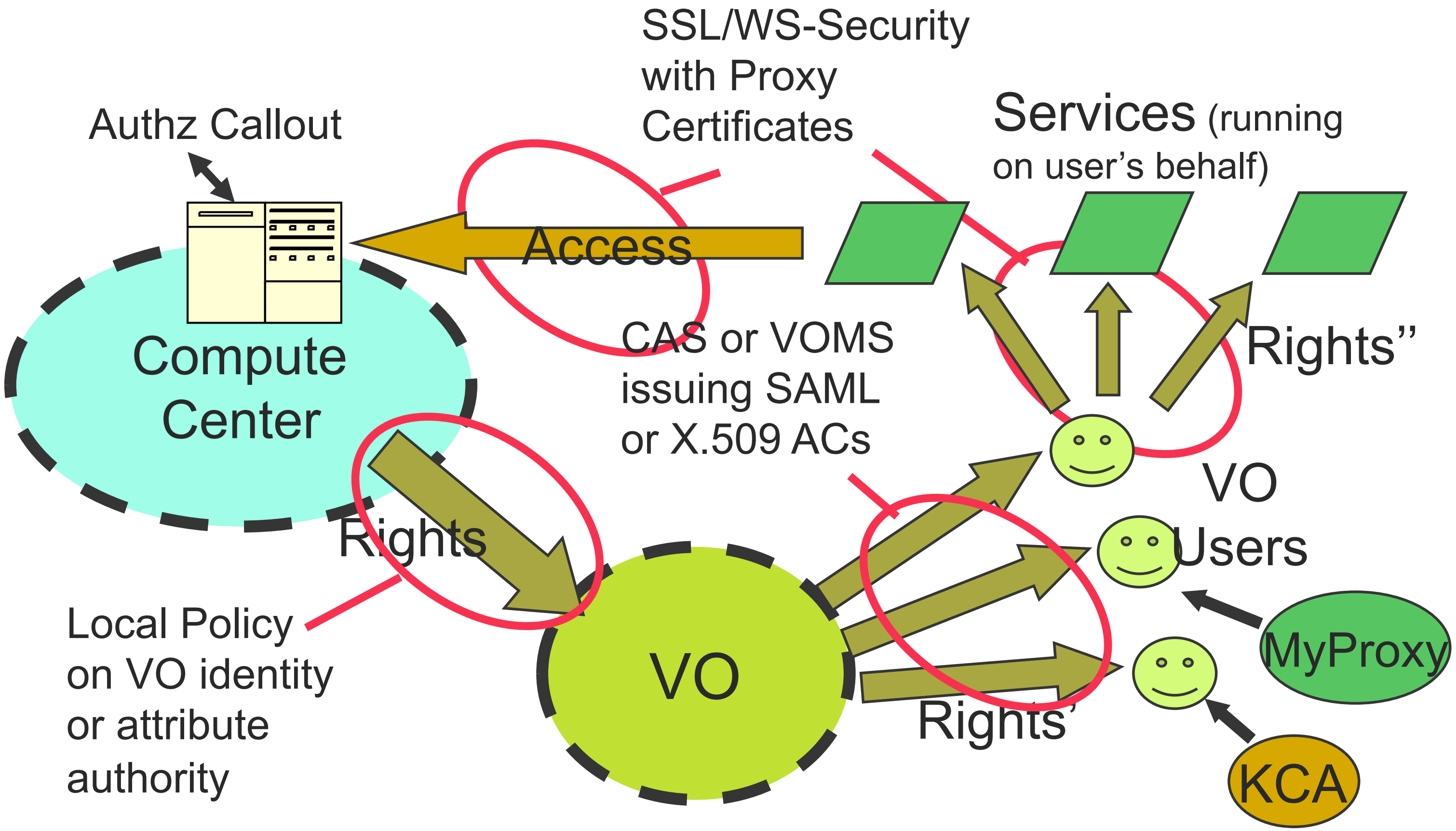
GSI implementation


Authz Callout
SSL/WS-Security with Proxy Certificates
Services (running on user's behalf)
Access
Compute Center
CAS or VOMS issuing SAML or X.509 ACs
Rights''
VO Users
Rights
Local Policy on VO identity or attribute authority
VO
MyProxy
Rights'
KCA

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Grids and VOs (1)

- Virtual organizations (VOs) are groups of Grid users (authenticated through digital certificates)
- VO Management Service (VOMS) serves as a central repository for user authorization information, providing support for sorting users into a general group hierarchy, keeping track of their roles,etc.
- VO Manager, according to VO policies and rules, authorizes authenticated users to become VO members

Grids and VOs (2)

- Resource centers (RCs) may support one or more VOs, and this is how users are authorized to use computing, storage and other Grid resources
- VOMS allows flexible approach to A&A on the Grid

“Logging on” to the Grid

- To run programs, authenticate to Grid:

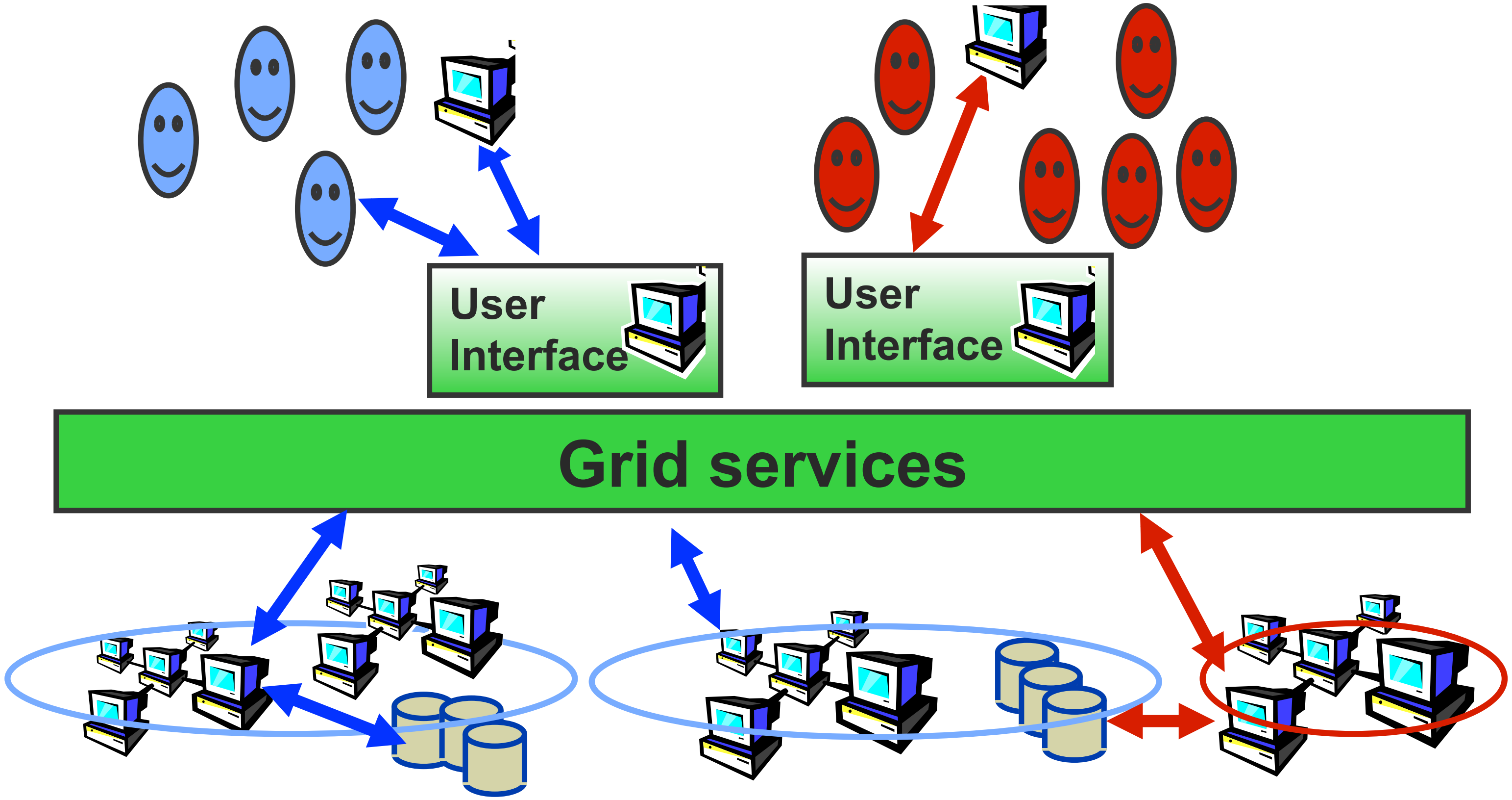
  voms-proxy-init –voms VONAME

  Enter PEM pass phrase: ***************

- Creates a temporary, local, short-lived proxy credential for use by our computations

- Delegation = remote creation of a (second level) proxy credential, which allows remote process to authenticate on behalf of the user

User view of the Grid



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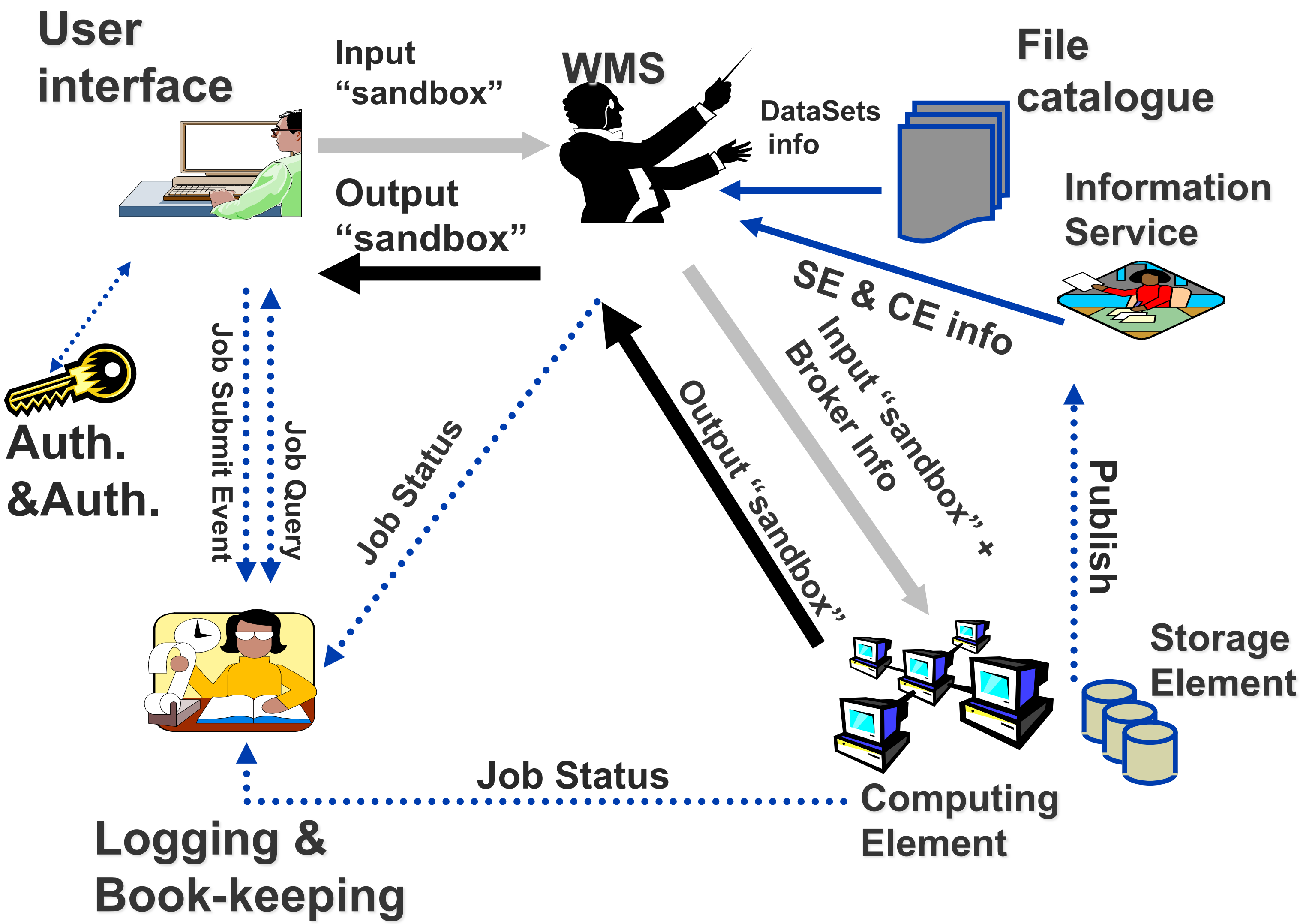
What really happens

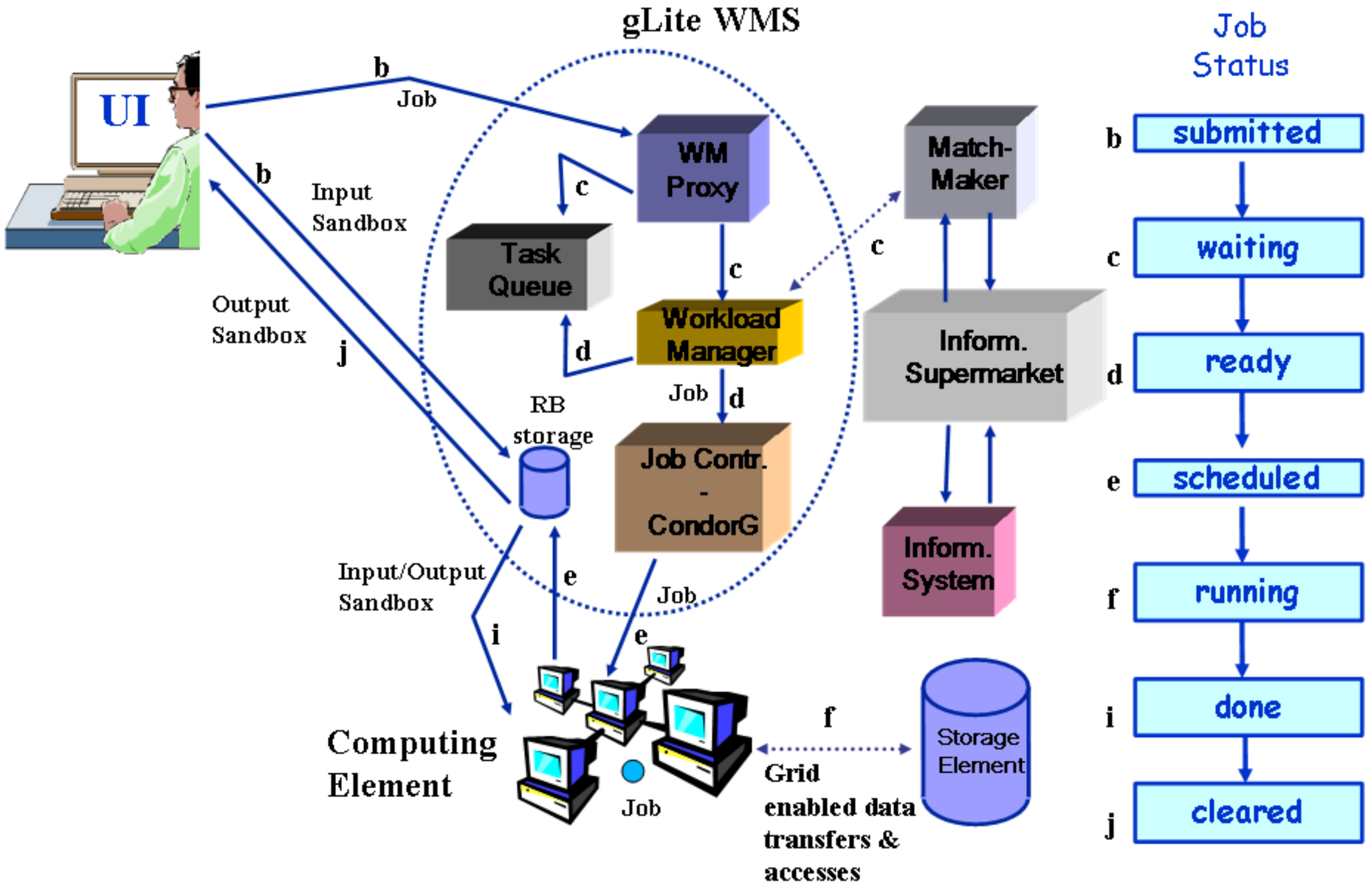


Workload Management System (WMS)

- Distributed scheduling
  - multiple UIs where you can submit your job
  - multiple WMSs from where the job can be sent to a CE
  - multiple CEs where the job can be put in a queuing system

- Distributed resource management
  - multiple information systems that monitor the state of the grid
  - Information from SE, CE, sites

WMS and job states



Authentication and Authorization

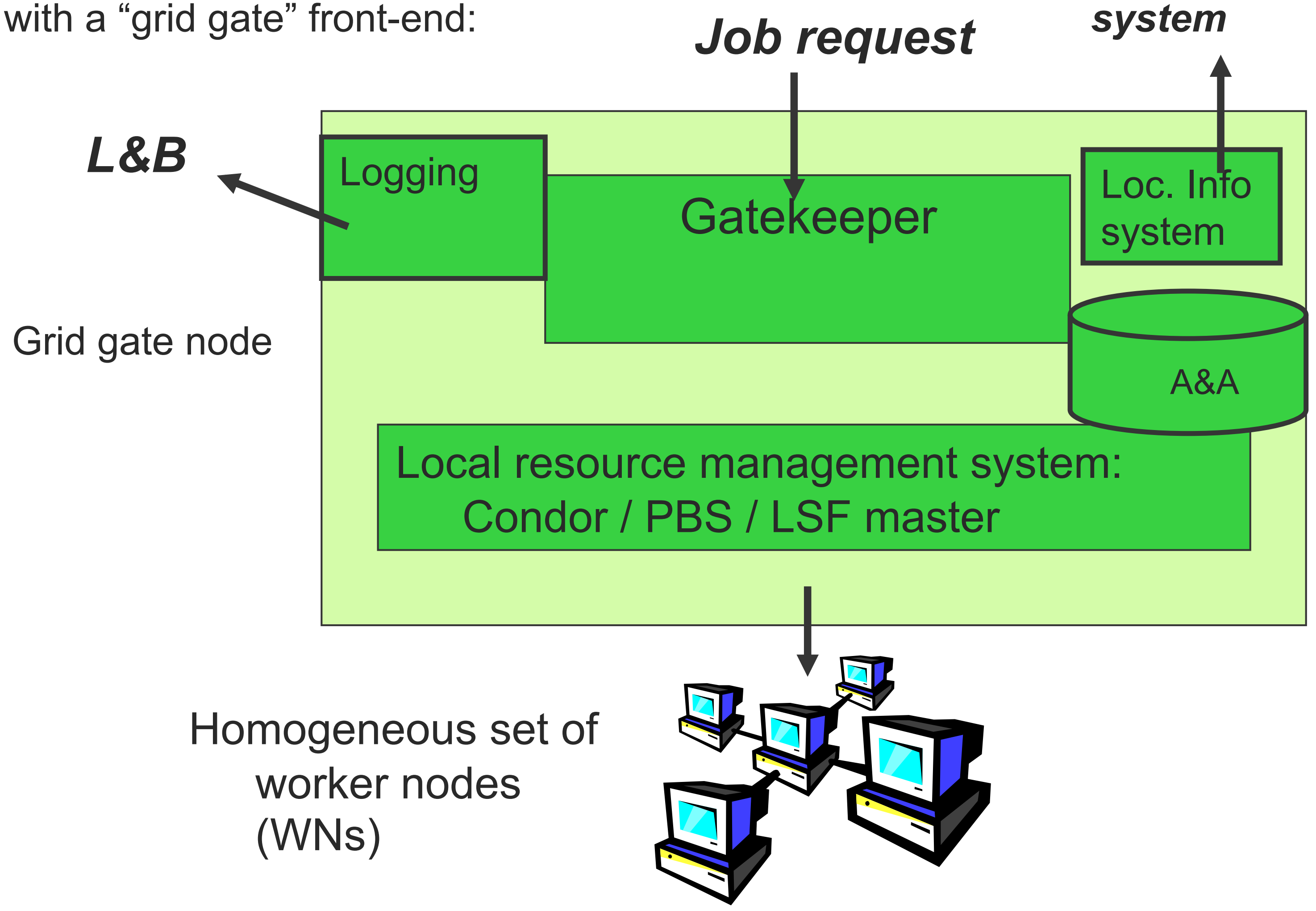
- Authentication
  - User obtains certificate from CA
  - Connects to UI by ssh
  - Downloads certificate
  - Invokes Proxy certificate
  - Single logon – to UI - then Secure Socket Layer with proxy identifies user to other nodes
- Authorization - currently
  - User joins Virtual Organisation
  - VO negotiates access to Grid nodes and resources (CE, SE)
  - Authorization tested by CE, SE: VOMS (or grid-mapfile) maps user to local accounts

User Interface (UI)

- UI is the user's interface to the Grid - Command-line interface to
  - Proxy certificate
  - Job operations
    - To submit a job
    - Monitor its status
    - Retrieve output
  - Data operations
    - Upload file to SE
    - Create replica
    - Discover replicas
  - Other grid services
- To run a job user creates a JDL (Job Description Language) file

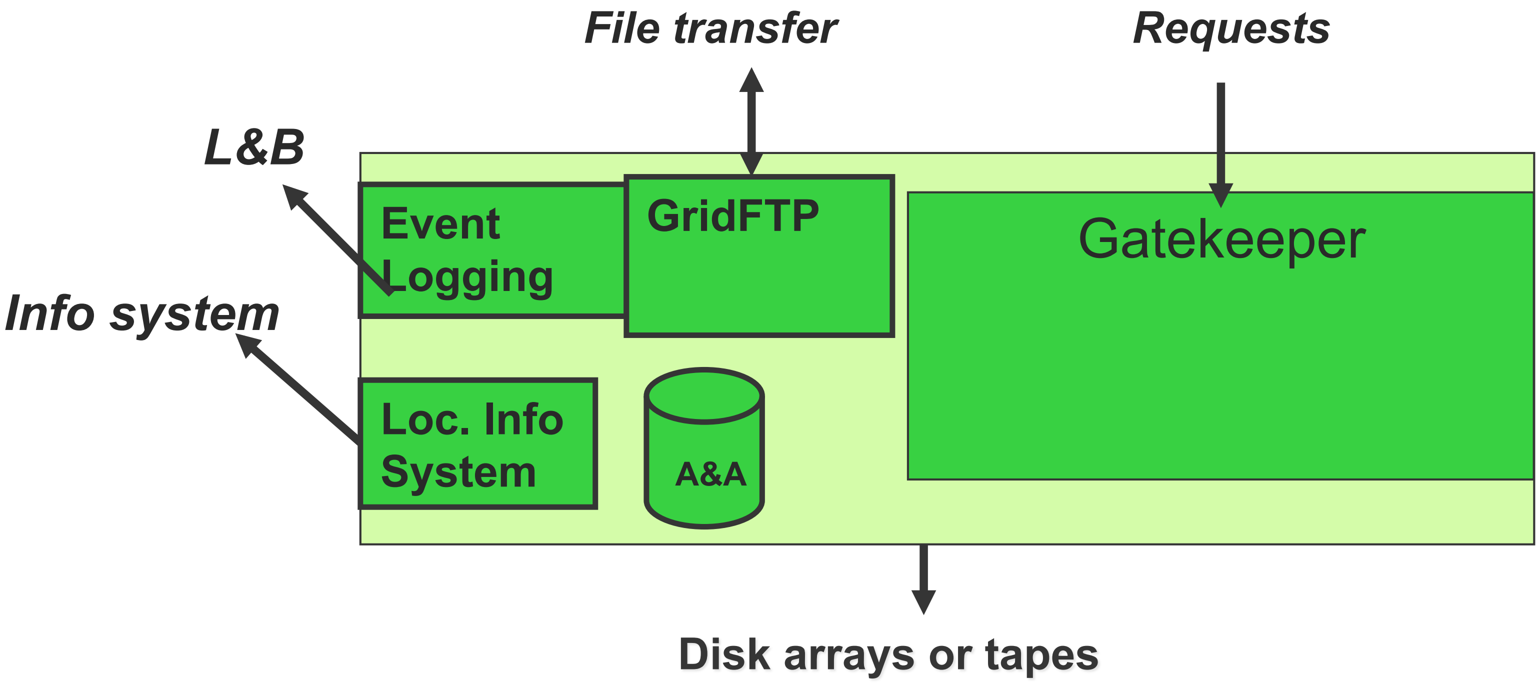
Computing Element (CE)

A CE is a grid batch queue with a "grid gate" front-end:


Job request
Information system
L&B
Logging
Gatekeeper
Loc. Info system
A&A
Grid gate node
Local resource management system: Condor / PBS / LSF master
Homogeneous set of worker nodes (WNs)

Storage Element (SE)

- Storage elements hold files: write once, read many
- Replica files can be held on different SE:
  - “close” to CE; share load on SE
- File Catalogue - what replicas exist for a file and where are they?



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Logging and Bookkeeping

- Who did what and when?
- What is happening to my job?
- Usually runs on the WMS node

Information System

- Receives periodic (~5 min) updates from CE, SE, etc.
- Used by WMS (RB) node to determine resources to be used by a job
- Currently BDII is used

Typical Grid site

- CE + batch system + set of WNs
- SE + set of disk nodes
- MON: accounting and R-GMA
- BDII_site: collects information about all elements
- Additional services (WMS+LB, PX, VOMS, etc.)

Grid in a nutshell

- Grid structure is complicated but hidden from end-users, enabling all the comfort they need
- Users just need to join the VO and obtain certificates: we already have some VOs at hand for you!
- Use of Grid is then just as easy as the use of a typical Linux cluster