# EGEE Middleware

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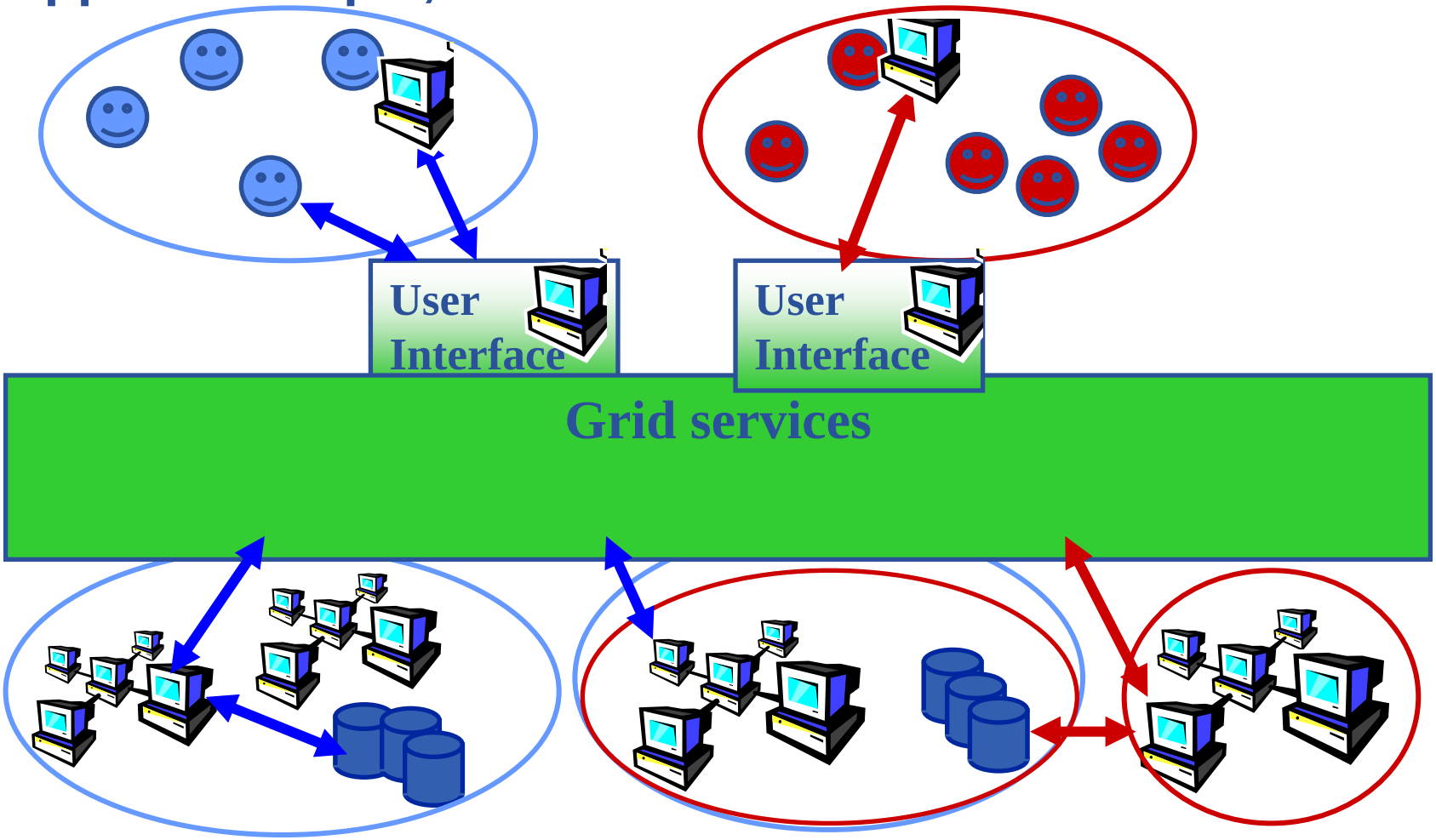
# Contents

- Short review of concepts
- Requirements of the applications communities
- Overview of the main grid services
- A closer look

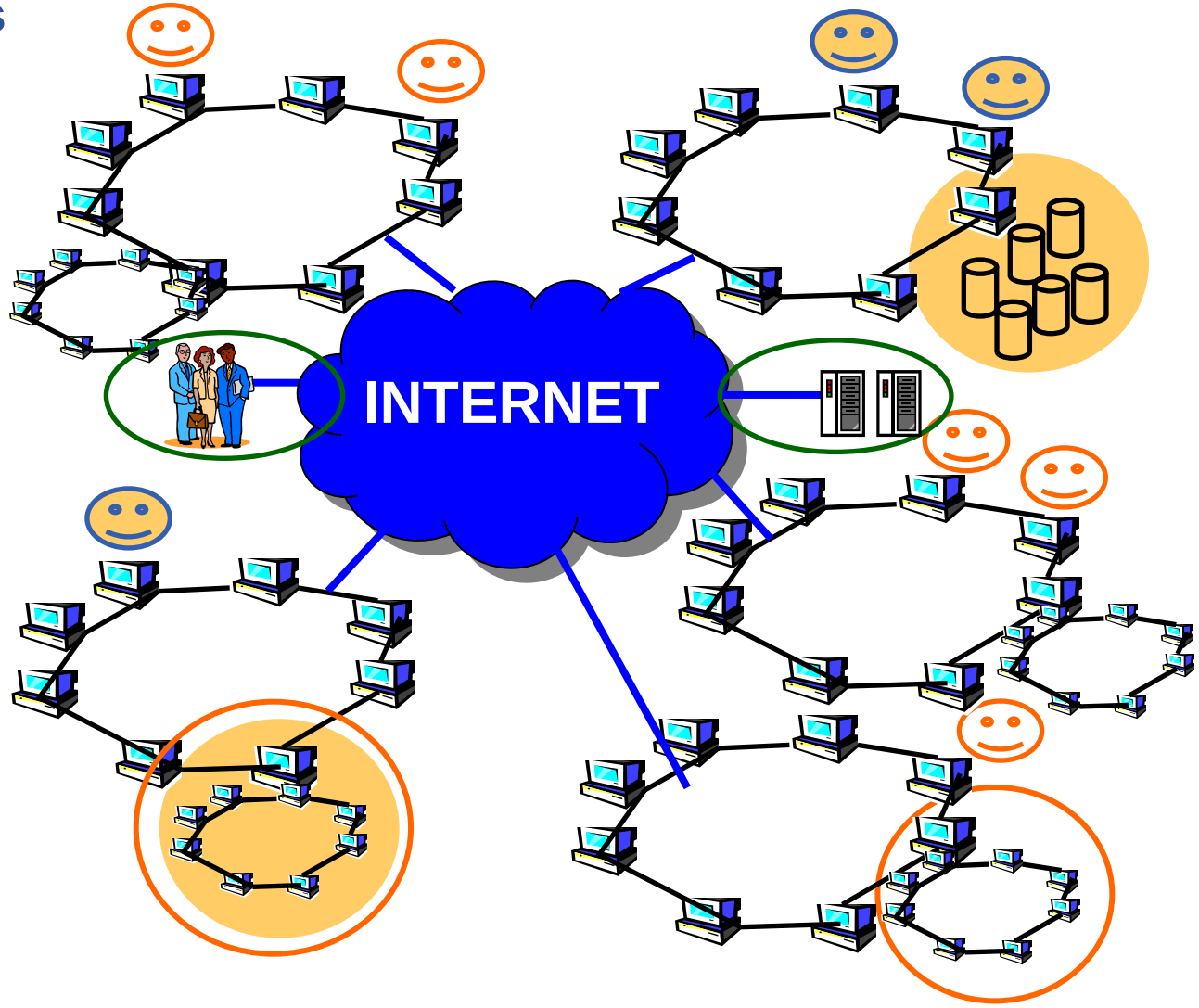
# A multi-VO Grid

- **EGEE is establishing a production grid service to support multiple, diverse VO's**

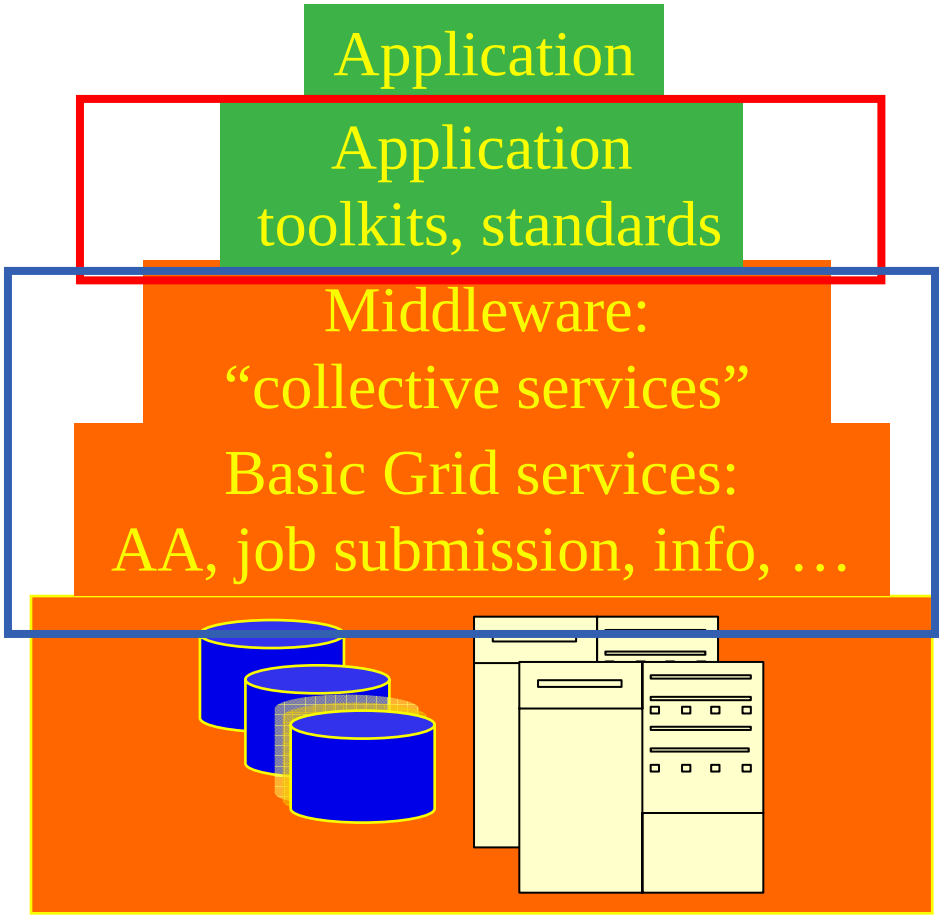


# A grid

- **Grid middleware runs on each shared resource to provide**
  - Data services
  - Computation services
  - Single sign-on
- **Users join VO's**
- **Virtual organisation negotiates with sites to agree access to resources**
- **Distributed services (both people and middleware) enable the grid for multiple VOs**



# Empowering VO's



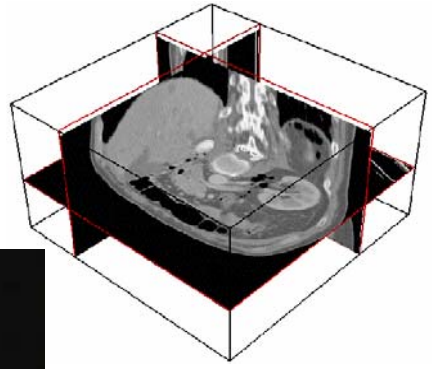

- **Application development environment, portals, workflow**
- **Semantics, ontologies**

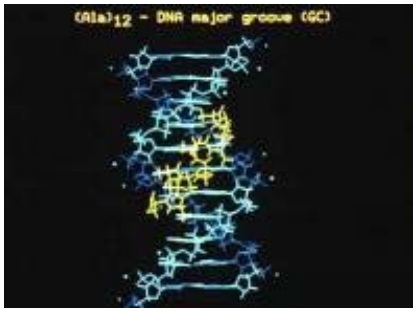
**EGEE middleware:**

- **Grid services for many collaborations**

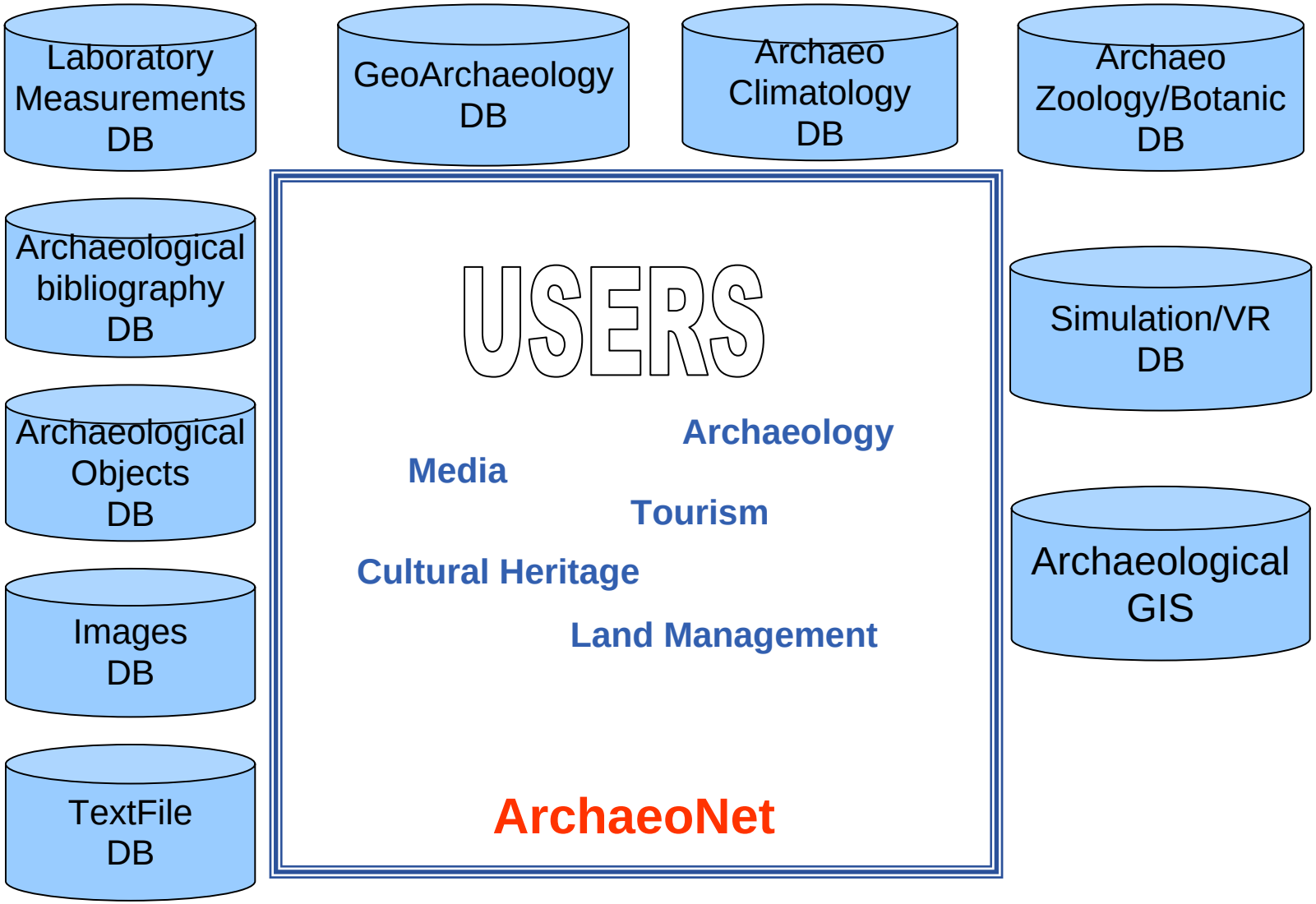
# The initial EGEE applications

- **High-Energy Physics**
  - Provides computing infrastructure
    Large Hadron Collider (LHC)
    LHC Compute Grid (LCG)
  - thousands of processors
    world-wide
  - 1 gigabyte per second achieved
    from CERN to 20 sites
- **Biomedical Applications**
  - Less “centralised” VO’s
    & data flows
  - More sporadic demands
  - Interactive applications needed
  - security & privacy





# The newest VO's plans: Archaeology



# Grid services

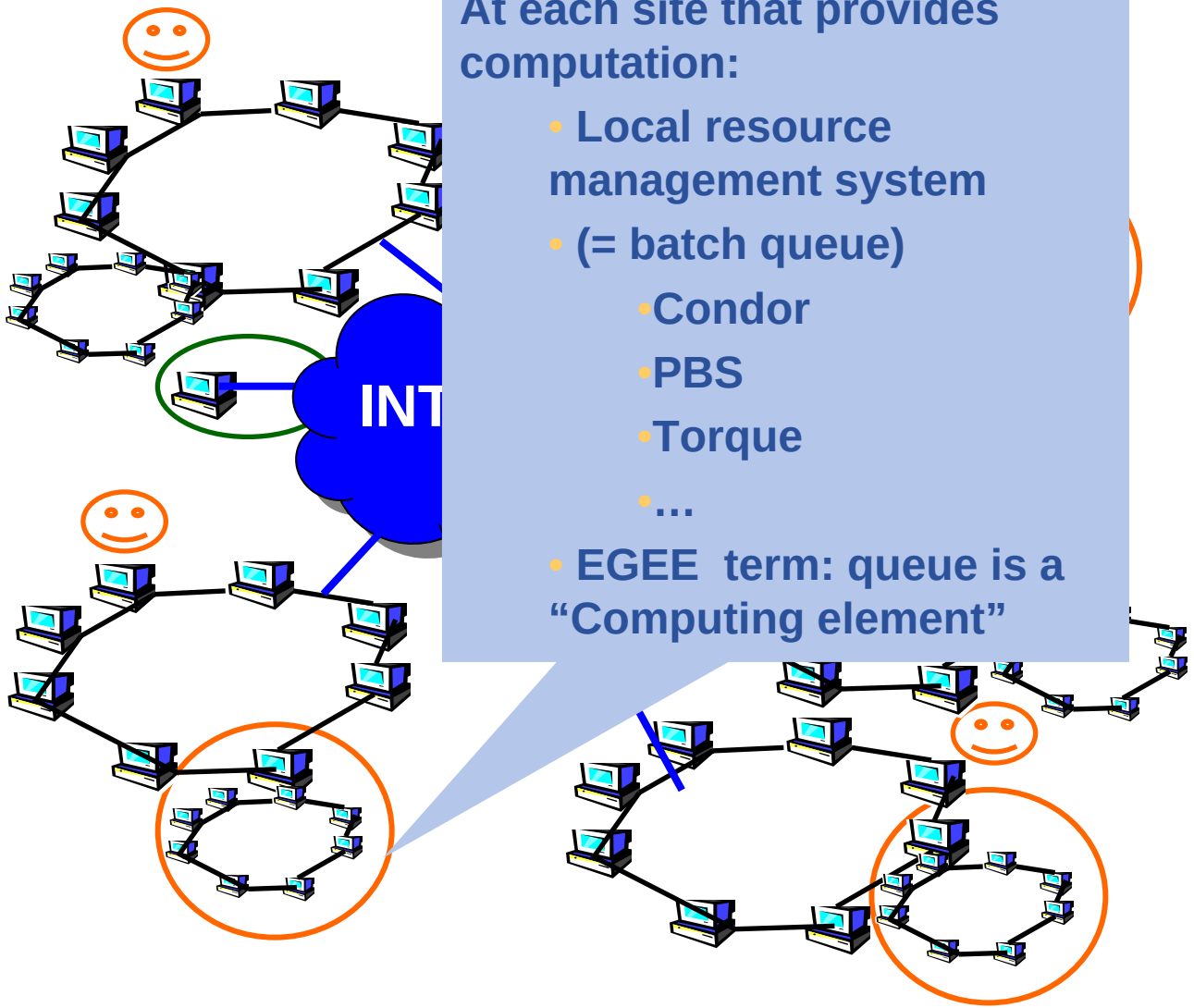
**How can EGEE middleware support collaboration and resource sharing within and between many diverse VO's ?**

# Grid Middleware

- **When using a PC or workstation you**
  - Login with a username and password (“Authentication”)
  - Use rights assigned to you (“Authorisation”)
  - Run jobs
  - Manage files: create them, read/write, list directories
- **When using a Grid you**
  - Login with digital credentials (“Authentication”)
  - Use rights assigned to you (“Authorisation”)
  - Run jobs
  - Manage files: create them, read/write, list directories
- **Middleware that masks**
  - Internet (not a bus) links your services
  - Providers in different admin domains

# Typical current grid

- **Grid middleware runs on each shared resource**
  - Data storage
  - (Usually) batch queues on pools of processors
- **Users join VO's**
- **Virtual organisation negotiates with sites to agree access to resources**
- **Distributed services (both people and middleware) enable the grid, allow single sign-on**




**At each site that provides computation:**

- **Local resource management system**
- **(= batch queue)**
  - **Condor**
  - **PBS**
  - **Torque**
  - **…**
- **EGEE term: queue is a "Computing element"**

# Authorisation, Authentication (AA)

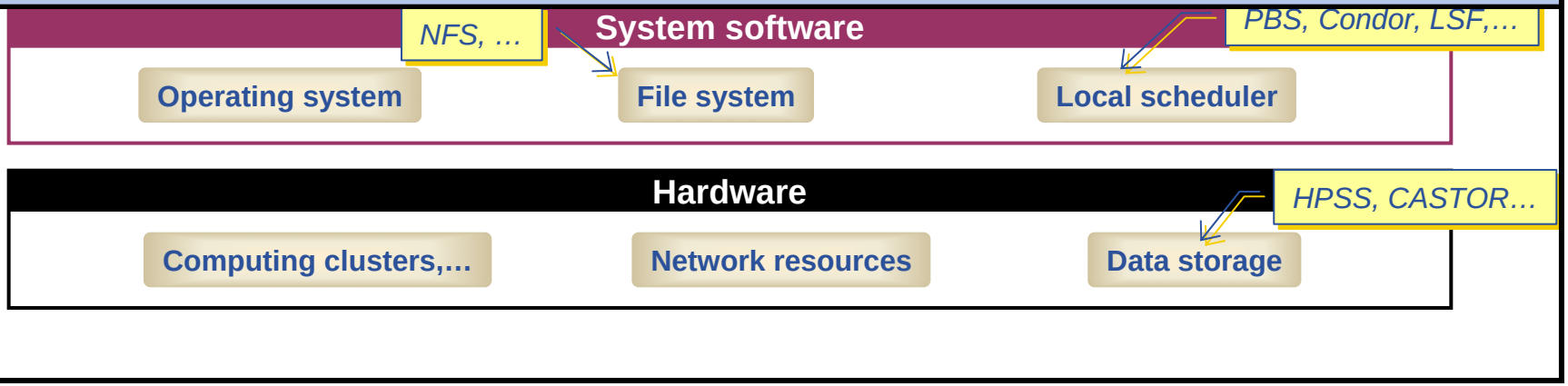
**Users in many locations and organisations**

**Access services (“user interface”) :**
**logon, upload credentials, run m/w**

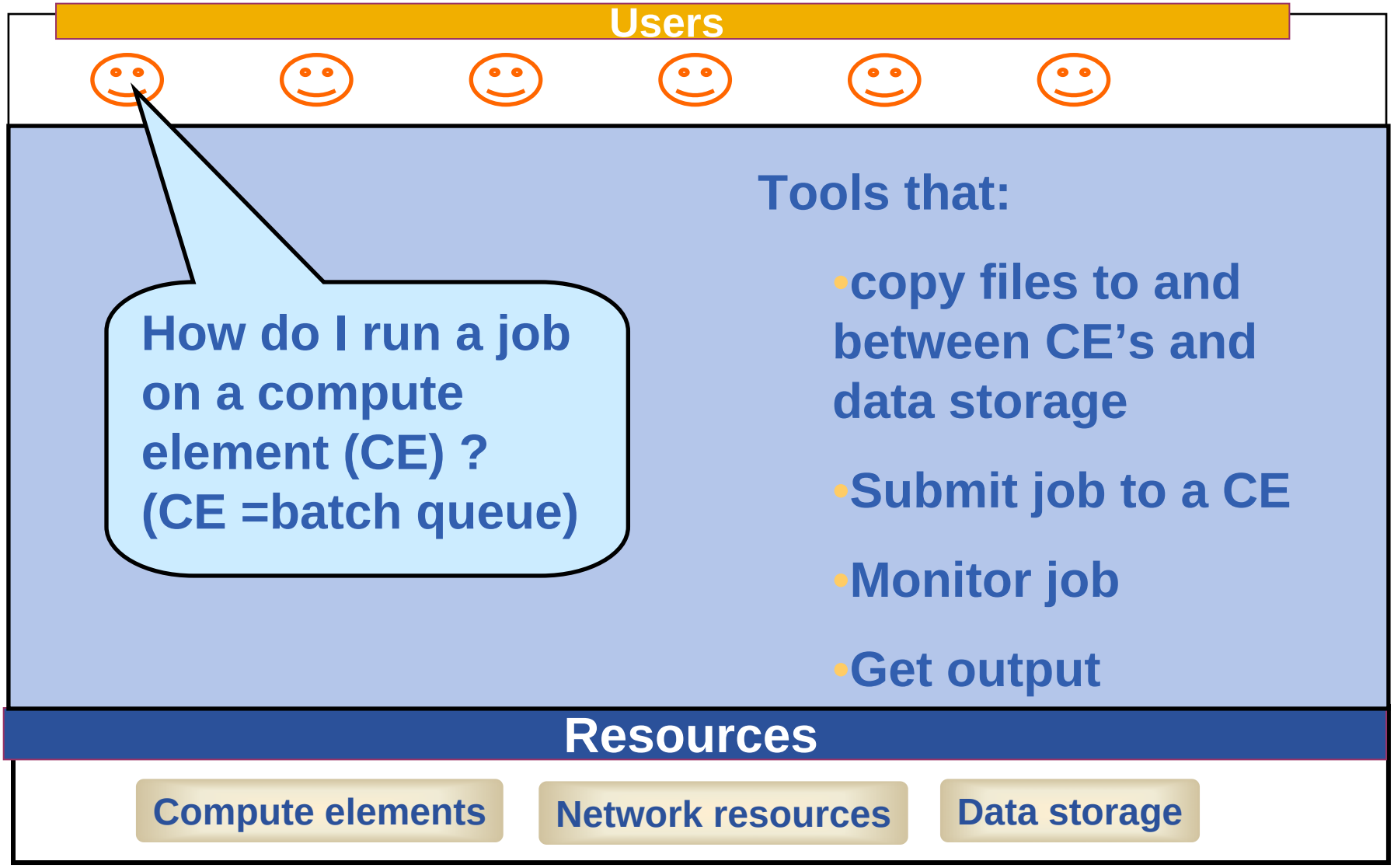
## GRID SERVICES

**Build on Grid Security Infrastructure**

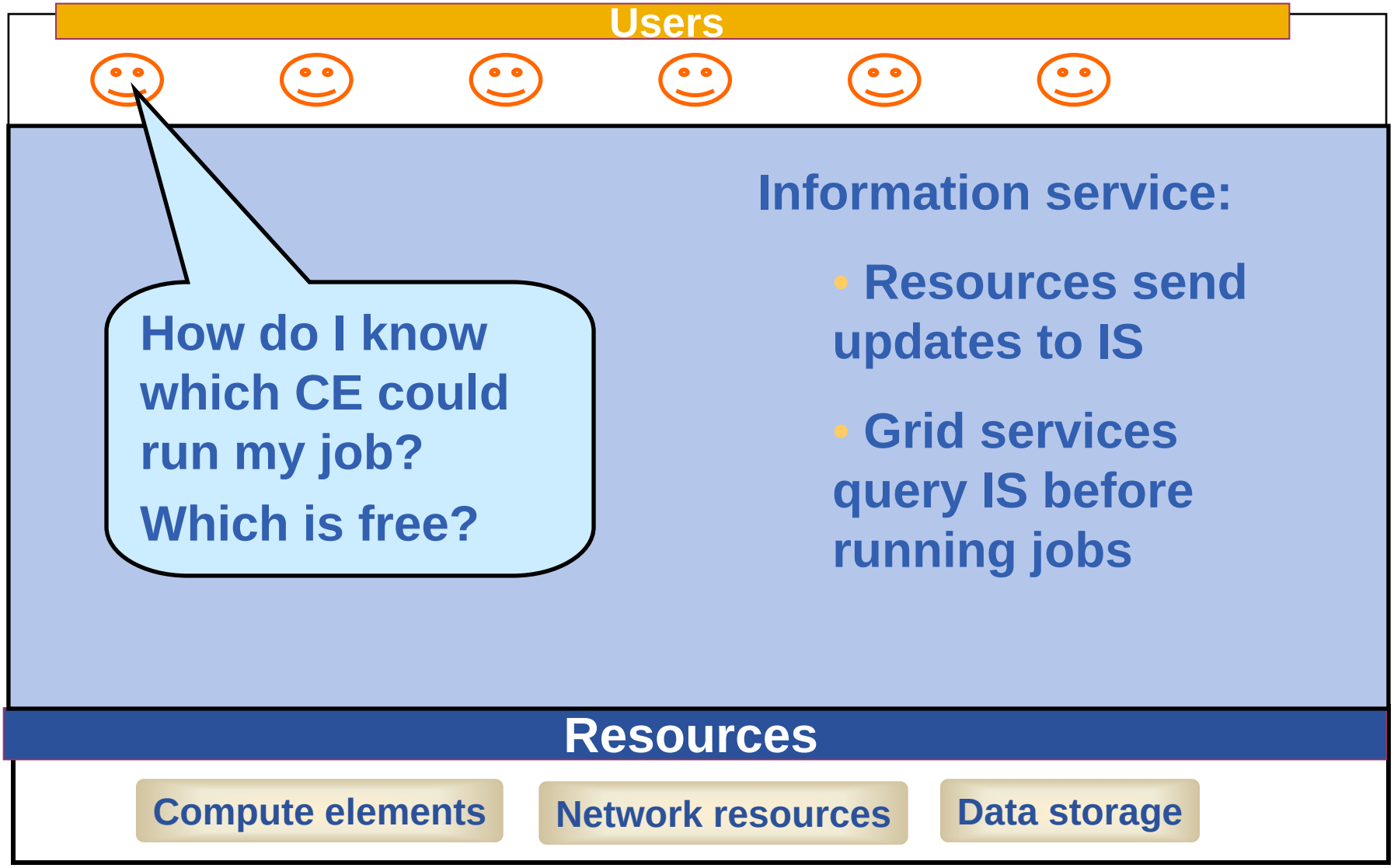
**“Gate keeping”:**
**map user’s credential to local user id / account**



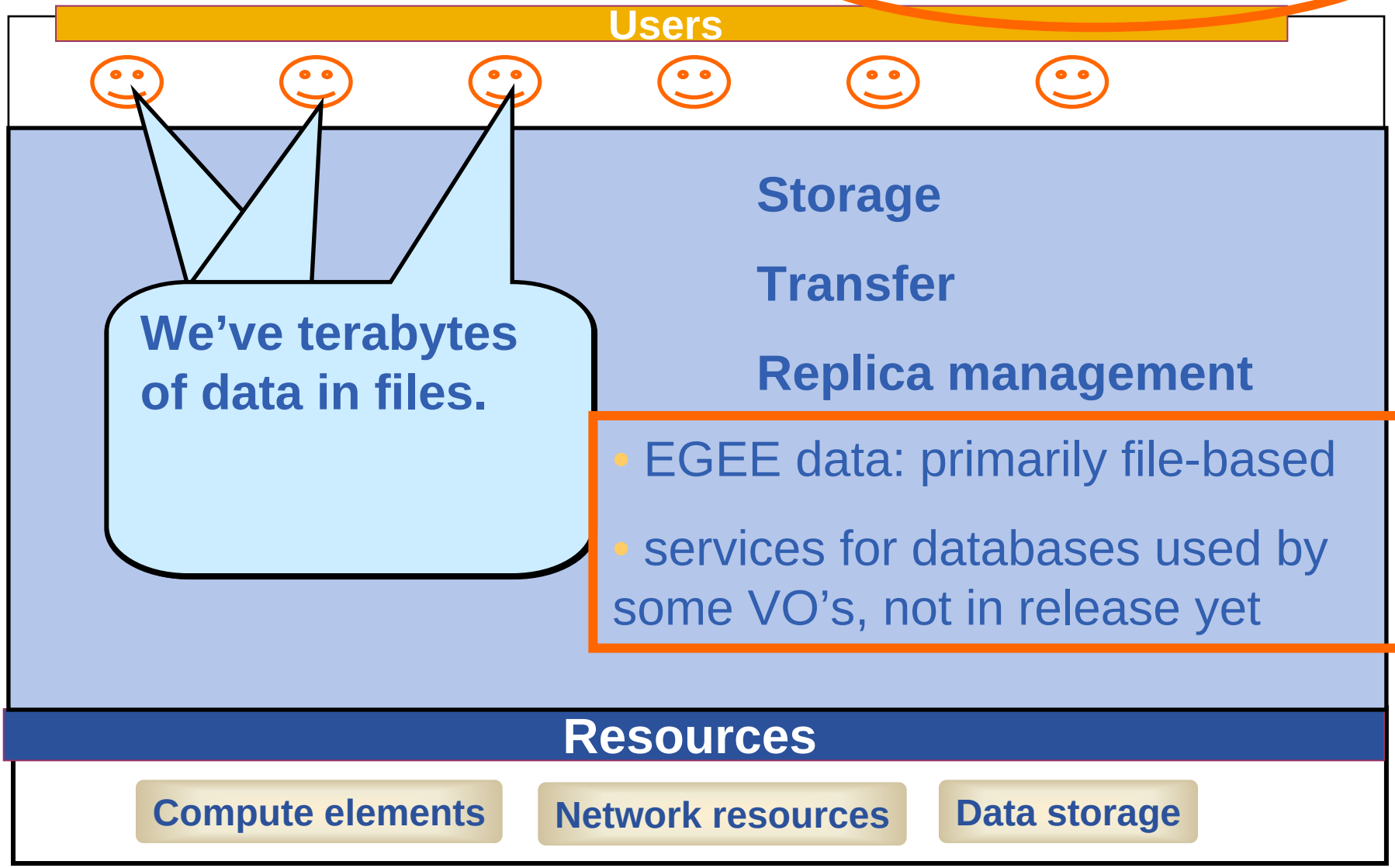
# Basic job submission



# Information service (IS)



# File management



# Globus Toolkit

- **A software toolkit: a modular "bag of technologies"**
  - Made available under liberal open source license
- ***Not* turnkey solutions, but *building blocks* and *tools* for application developers and system integrators**
- **Tools built on Grid Security Infrastructure to include:**
  - Job submission: run a job on a specific remote compute element
  - Information services: So I know which computer to use
  - File transfer: so large data files can be transferred
    - GridFTP: supports multiple channels for one transfer
- **(Most) production grids are (currently) based on the Globus Toolkit release 2**
- **Globus Alliance: http://www.globus.org/**

# Running a job with GT2

- **GT2 *Toolkit***
- **An example of the command line interface:**
  - Job submission – need to know name of a CE to use

**globus-job-submit grid-data.rl.ac.uk/jobmanager-pbs /bin/hostname -f**

**https://grid-data.rl.ac.uk:64001/1415/1110129853/**

**globus-job-status https://grid-data.rl.ac.uk:64001/1415/1110129853/**

**DONE**

**globus-job-get-output https://grid-data.rl.ac.uk:64001/1415/1110129853/**

**grid-data12.rl.ac.uk**

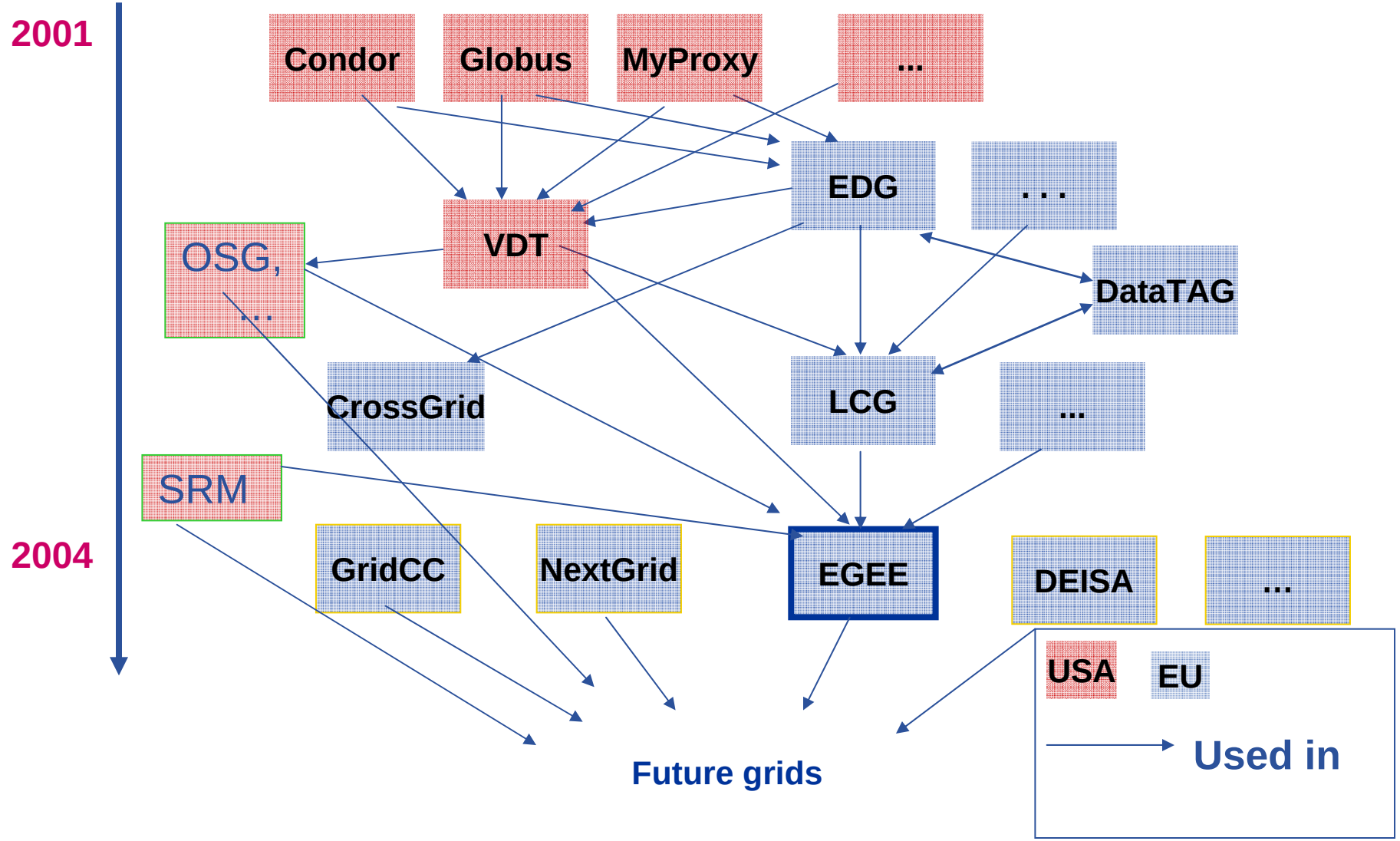
# Building a grid

- **GT2: a toolkit – not a turnkey solution**

- **Need higher level tools including:**
  - **Job submission** to “a grid” not a CE
  - **Data management**
  - **Logging** who’s done what, statistics about jobs,…
  - **Monitoring** whats happening on the grid

- **So EGEE is built on more than GT2 !**

# Parts of the Grid "ecosystem"



# VDT

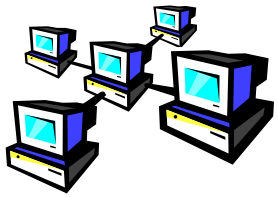
- **“The Virtual Data Toolkit (VDT) is an ensemble of grid middleware that can be easily installed and configured. In our experience, installing grid software is challenging and time consuming. The goal of the VDT is to make it as easy as possible for users to deploy, maintain and use grid middleware.” http://www.cs.wisc.edu/vdt/**

# Main components

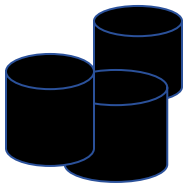
***User Interface (UI)***: The place where users logon to the Grid

***Resource Broker (RB)***: Matches the user requirements with the available resources on the Grid

***Information System***: Characteristics and status of CE and SE
Uses “GLUE schema”

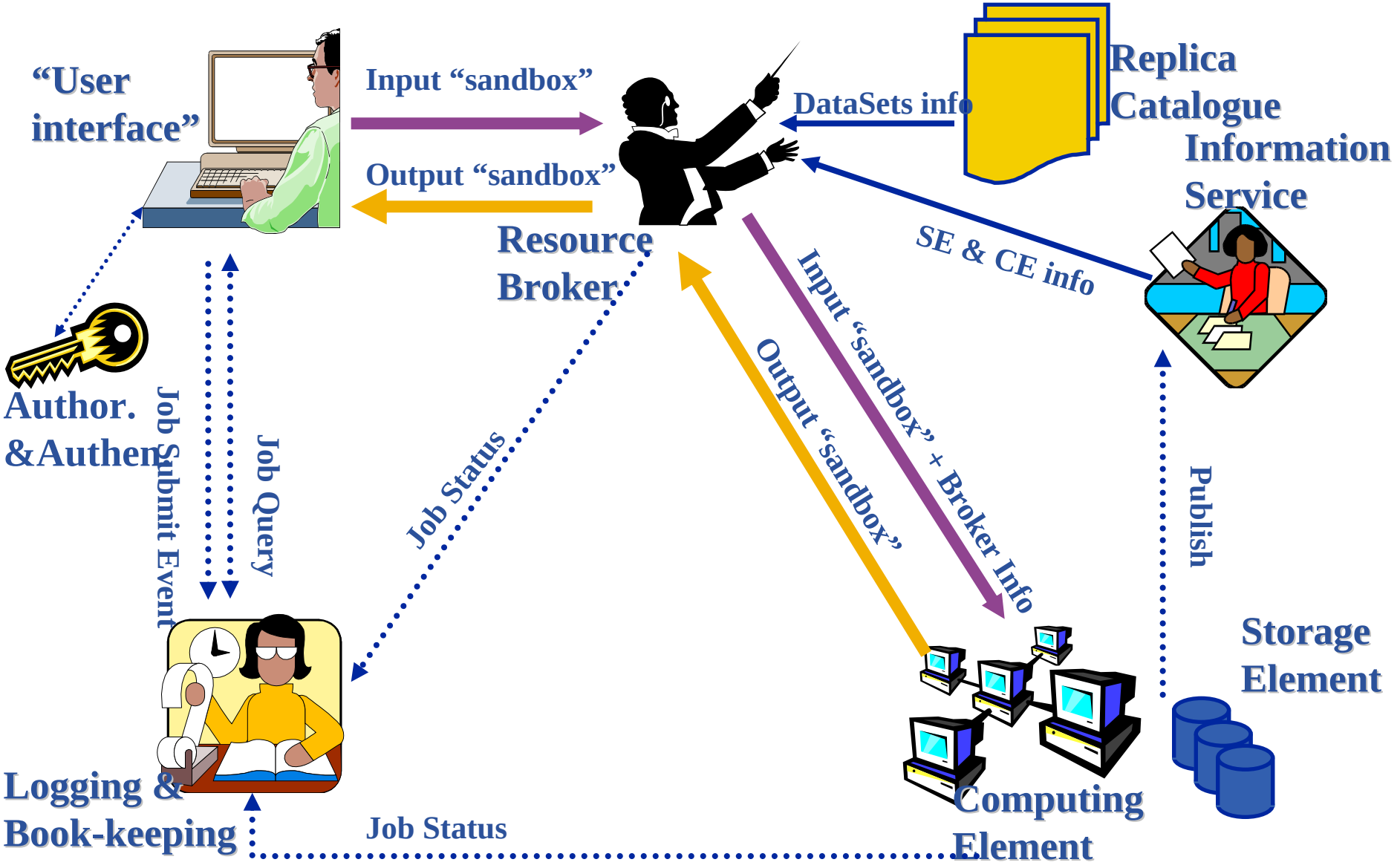


***Computing Element (CE)***: A batch queue on a site’s computers where the user’s job is executed



***Storage Element (SE)***: provides (large-scale) storage for files

# Current production middleware



# Building on basic tools and Information Service

- Submit job to grid via the “resource broker”,
- edg_job_submit *my.jdl*

## Example JDL file

```
Executable = “gridTest”;
StdError = “stderr.log”;
StdOutput = “stdout.log”;
InputSandbox = {“/home/joda/test/gridTest”};
OutputSandbox = {“stderr.log”, “stdout.log”};
…
```

# A closer look at the main EGEE grid services

# 1. Security, Authentication and Authorisation

# Glossary

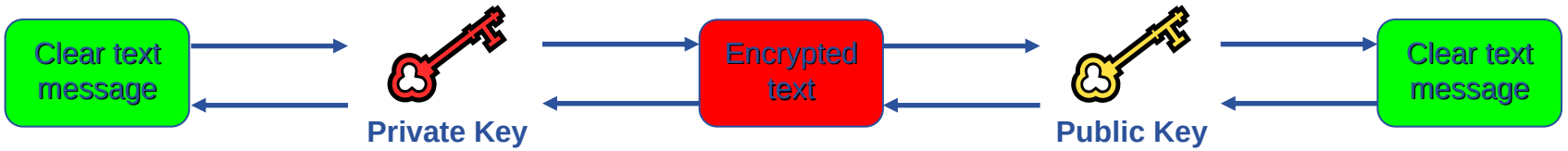
- **Principal**
  - An entity: a user, a program, or a machine
- **Credentials**
  - Some data providing a proof of identity
- **Authentication**
  - Verify the identity of a principal - how the user tells services who they are?
- **Authorization**
  - Map an entity to some set of privileges
- **Confidentiality**
  - Encrypt the message so that only the recipient can understand it
- **Integrity**
  - Ensure that the message has not been altered in the transmission
- **Non-repudiation**
  - Impossibility of denying the authenticity of a digital signature
- **Delegation**
  - Principal delegates authority to a service to act for them, in using another service

# Overview

- **Authentication based on X.509 PKI infrastructure**
  - Trust between Certificate Authorities (CA) and sites, CAs and users is established (offline)
  - CAs issue (long lived) certificates identifying sites and individuals (much like a passport)
    - Commonly used in web browsers to authenticate to sites
  - In order to reduce vulnerability, on the Grid user identification is done by using (short lived) proxies of their certificates
- **Proxies can**
  - Be delegated to a service such that it can act on the user's behalf
  - Include additional attributes (like VO information via the VO Membership Service VOMS)
  - Be stored in an external proxy store (myProxy)
  - Be renewed (in case they are about to expire)

# Use of public and private keys

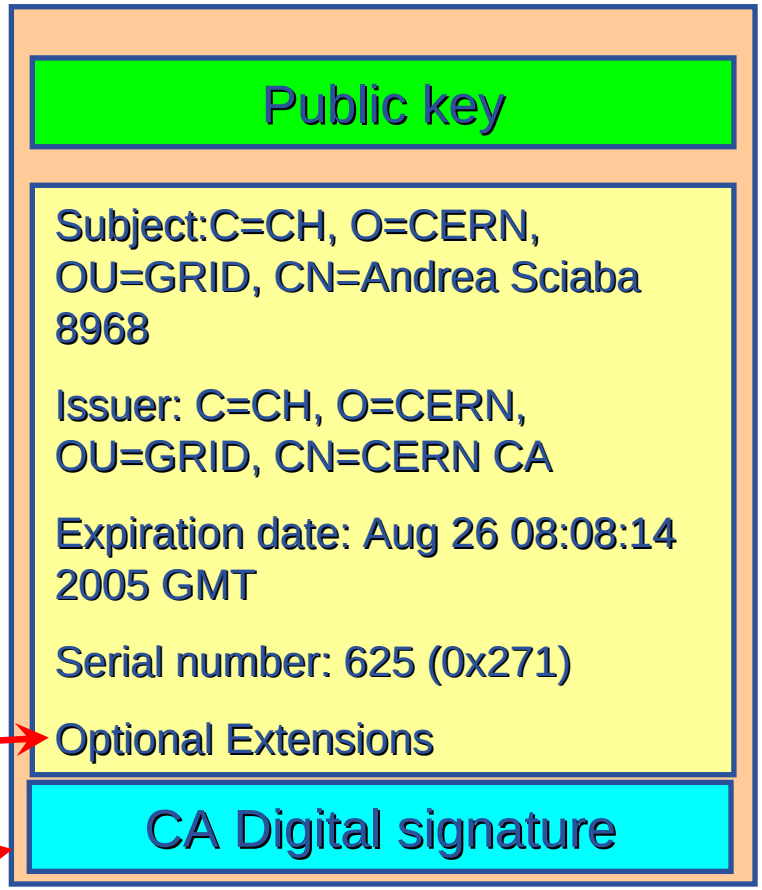
- **Basis for authentication, integrity, confidentiality, non-repudiation**
- **Certificate: held in two parts**
  - Public key + user identity + CA signature
  - Private key: only the owner (should) use this
- **Asymmetric encryption**




- **Digital signatures**
  - A hash derived from the message and encrypted with the signer's private key
  - Signature is checked by decrypting with the signer's public key
- **Public key is trusted only because it is signed by a trusted third party (Certification Authority)**
  - Effect: users and sites can trust each other's identity as expressed in certificates

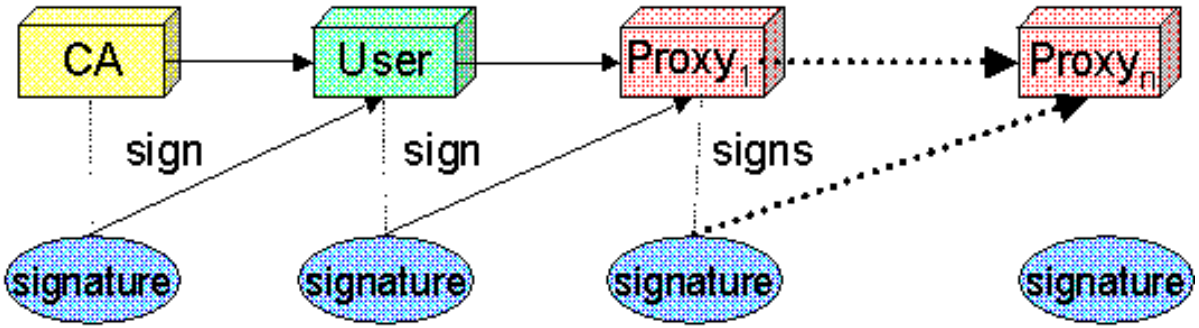
# X.509 Certificates

- **An X.509 Certificate contains:**
  - owner's public key;
  - identity of the owner;
  - info on the CA;
  - time of validity;
  - Serial number;
  - Optional extensions
  - digital signature of the CA



# Grid Security Infrastructure - proxies

- ***de facto* standard for Grid middleware**
- **Based on PKI**
- **To support….**
  - Single sign-on: to a machine on which your certificate is held
  - Delegation: a service can act on behalf of a person
- **….GSI introduces proxy certificates**
  - Short-lived certificates signed with the user's certificate or a proxy
  - Reduces security risk, enables delegation



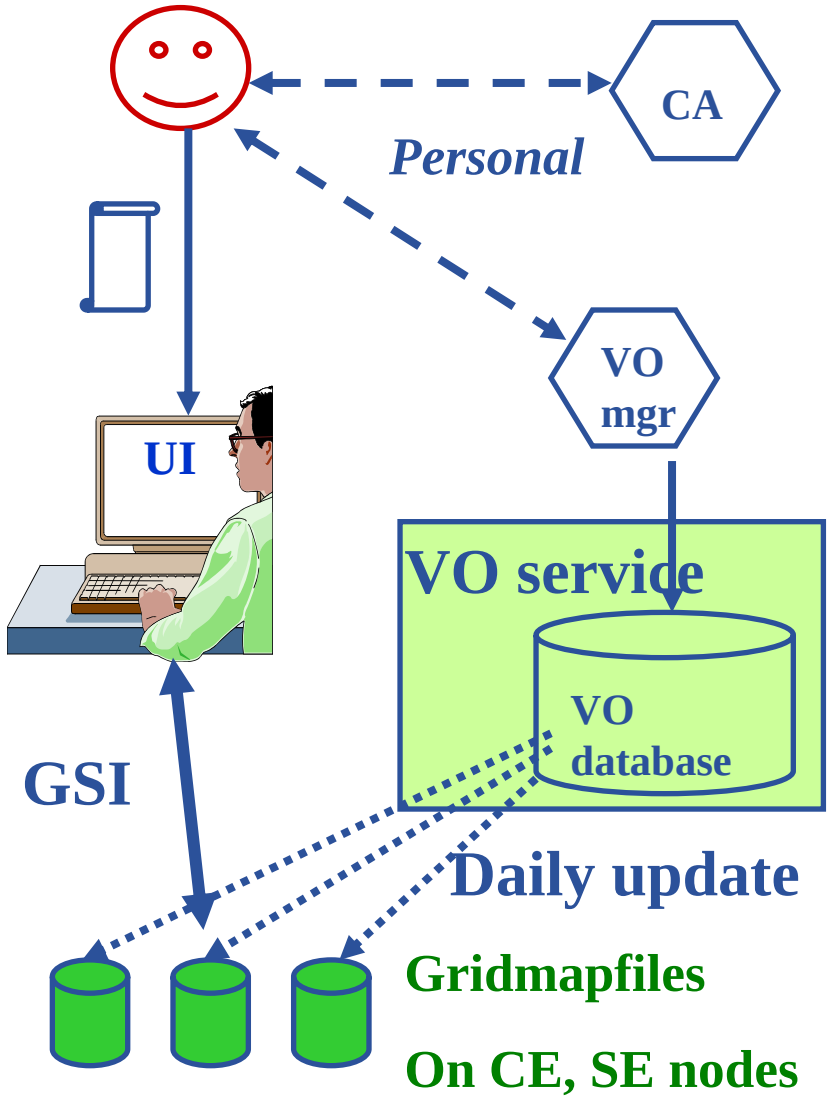
# MyProxy

- **You may need:**
  - To interact with a grid from many machines
    - And you realise that you must NOT, EVER leave your certificate where anyone can find and use it….
  - To use a portal, and delegate to the portal the right to act on your behalf
    - The portal obtains then uses a proxy certificate for you
  - To run jobs that might last longer than the lifetime of a short-lived proxy
- **Solution: you can store a long-lived proxy in a "MyProxy server" and derive a proxy certificate when needed.**

# Authentication, Authorisation

- **Authentication**
  - User obtains certificate from Certificate Authority
  - Connects to UI by ssh
  - Downloads certificate
  - **Single logon** – to UI - create proxy
  - then **Grid Security Infrastructure uses proxies to identify users to other machines**
- **Authorisation - currently**
  - User joins Virtual Organisation
  - VO negotiates access to Grid nodes and resources (CE, SE)
  - Authorisation tested by CE, SE:

gridmapfile maps user to local account



# Certificate Authorities

- **“X 509 Digital certificate”**
- ***Certification Authorities* (CAs)**
  - ~one per country; each builds network of “Registration Authorities” (RA) who issue certificates
- ***CAs are mutually recognized* – to enable international collaboration**
  - International Grid Trust Federation http://www.gridpma.org/
- **For Ireland: https://www.cs.tcd.ie/grid-ireland/gi-ca/**
- **CA issues certificates to**
  - Users: you get a Certificate and use it to access a grid
  - Sites providing resources
- **VITAL:**
  - **KEEP YOUR CERTIFICATE SECURE !!!!!**

# Evolution of VO management

## Before VOMS

- **User is authorised as a member of a single VO**
- **All VO members have same rights**
- **Gridmapfiles are updated by VO management software: map the user's DN to a local account**
- **grid-proxy-init**

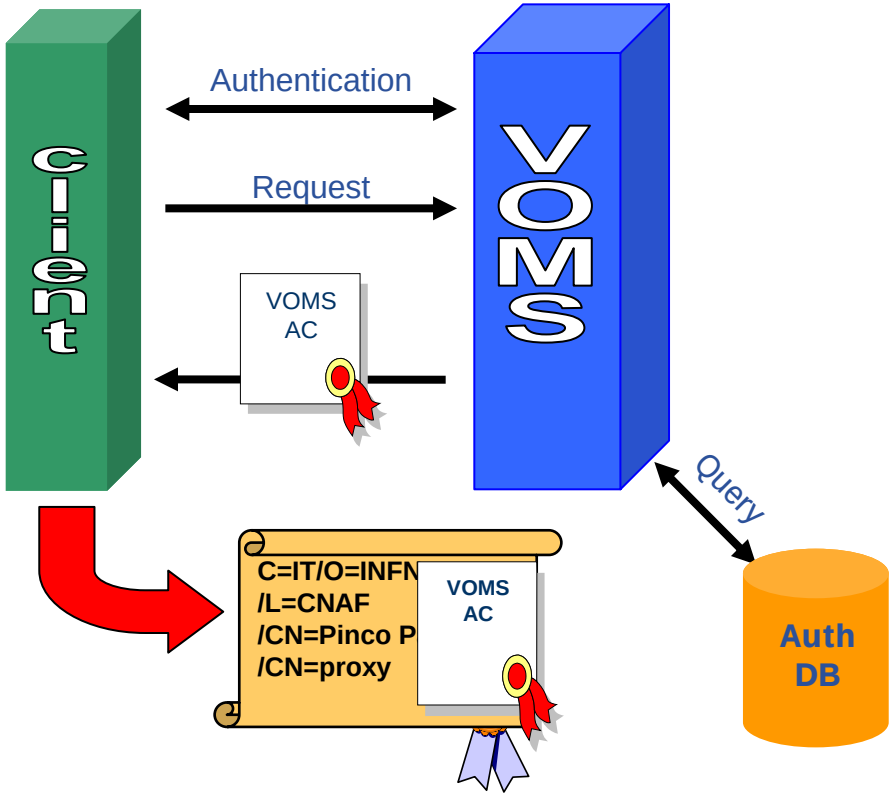
## VOMS

- **User can be in multiple VOs**
  - Aggregate rights
- **VO can have groups**
  - Different rights for each
    - Different groups of experimentalists
    - …
  - Nested groups
- **VO has roles**
  - Assigned to specific purposes
    - E,g. system admin
    - When assume this role
- **Proxy certificate carries the additional attributes**
- **voms-proxy-init**

**VOMS – now in both the production (LCG) and pre-production (gLite) middleware**

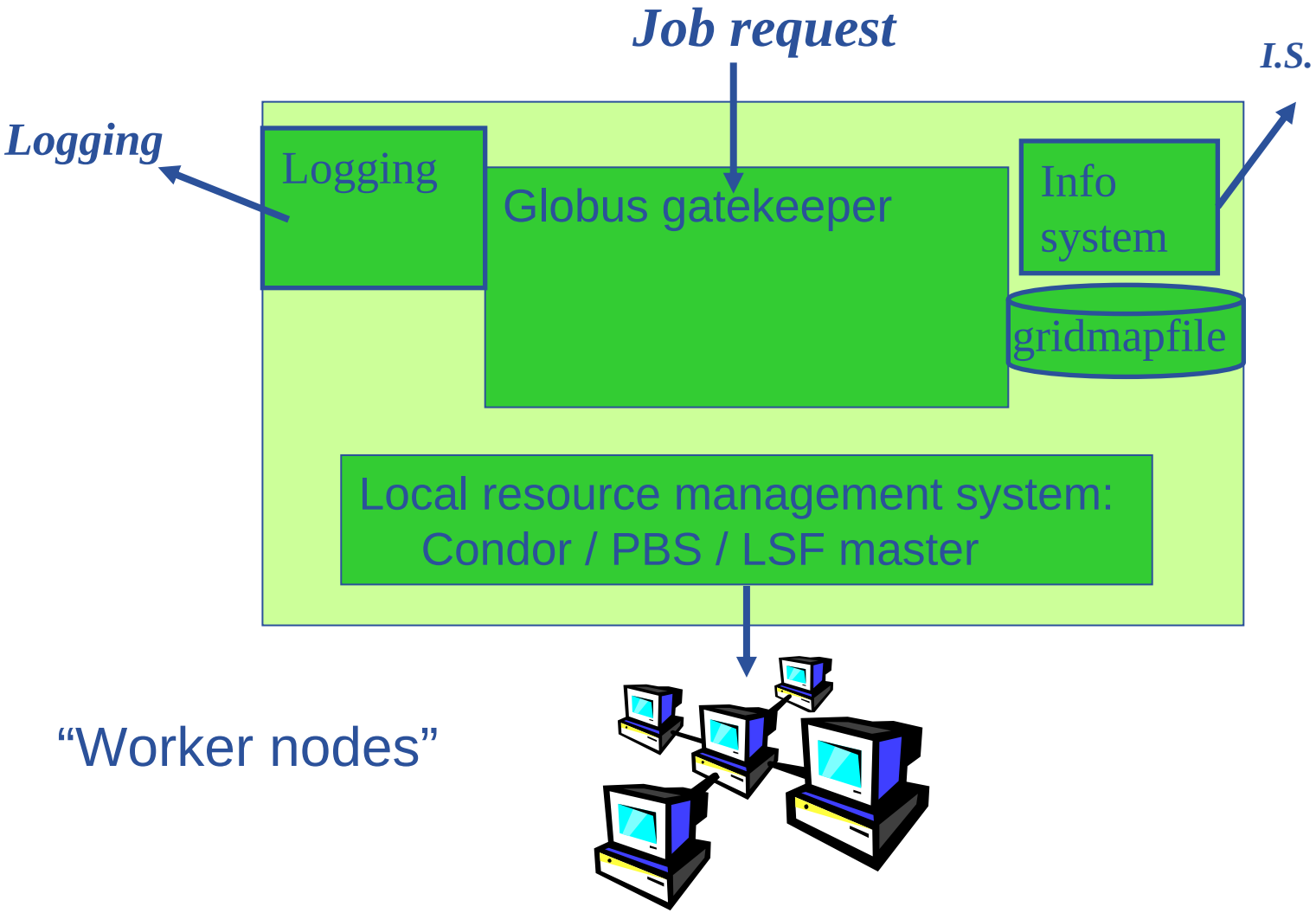
# New - VO Membership Service: VOMS

- **Bare certificates are not enough for defining user capabilities on the Grid**
- **Users belong to VO's, to groups inside a VO and may have special roles**
- **VOMS provides a way to add attributes to a certificate proxy:**
  - mutual authentication of client and server
  - VOMS produces a signed Attribute Certificate (AC)
  - the client produces a new proxy that contains the attributes
- **The attributes are used to provide the user with additional capabilities according to the VO policies.**

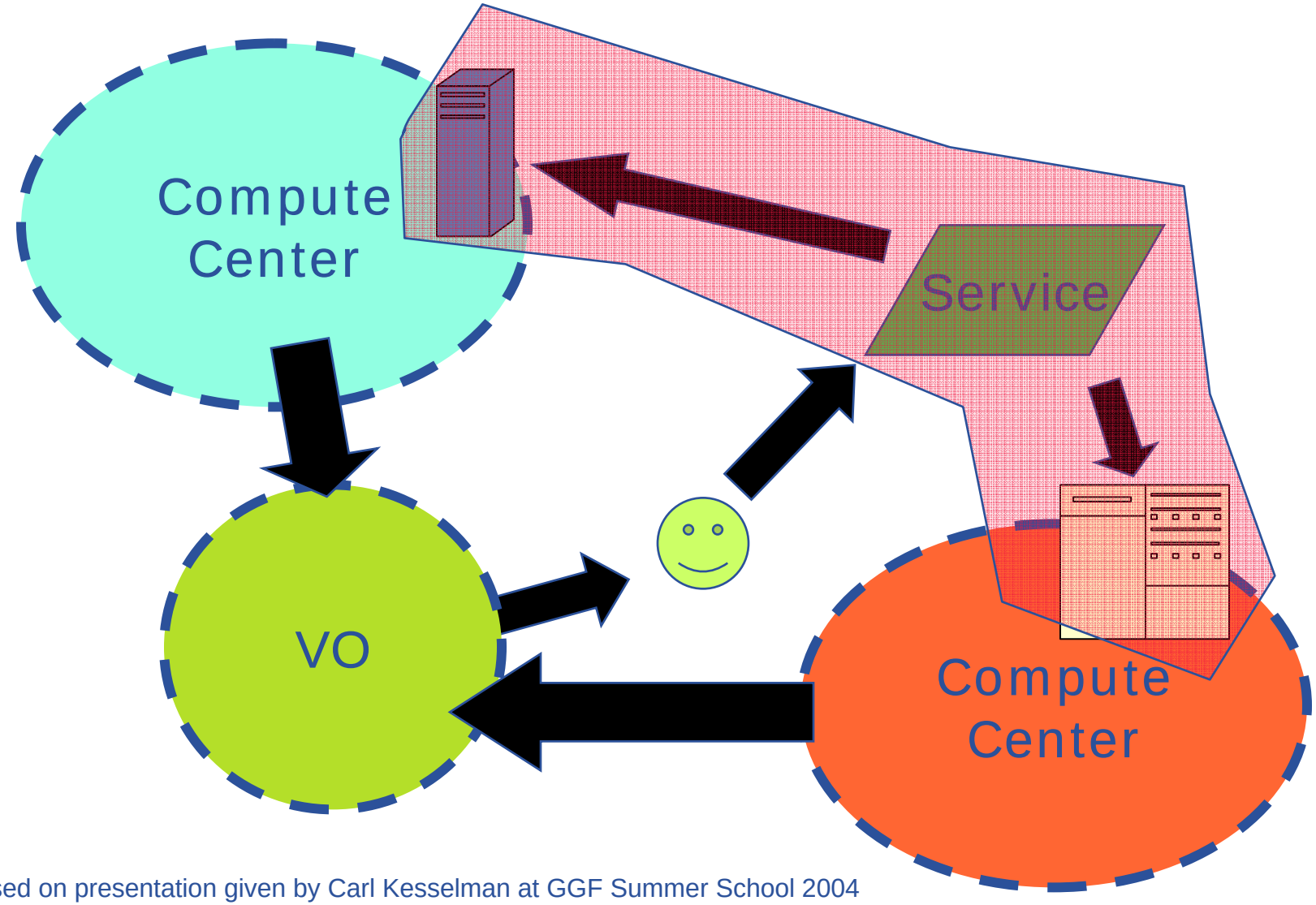



**VOMS – now in both the production (LCG) and pre-production (gLite) middleware**

# "Compute element": An LRMS queue



# Use Delegation to Establish Dynamic Distributed System




slide based on presentation given by Carl Kesselman at GGF Summer School 2004

# A closer look at the main EGEE grid services

# 2. Data services

# Data services in EGEE

- **Files**
  - File Access Pattern:
    - Write once, read-many

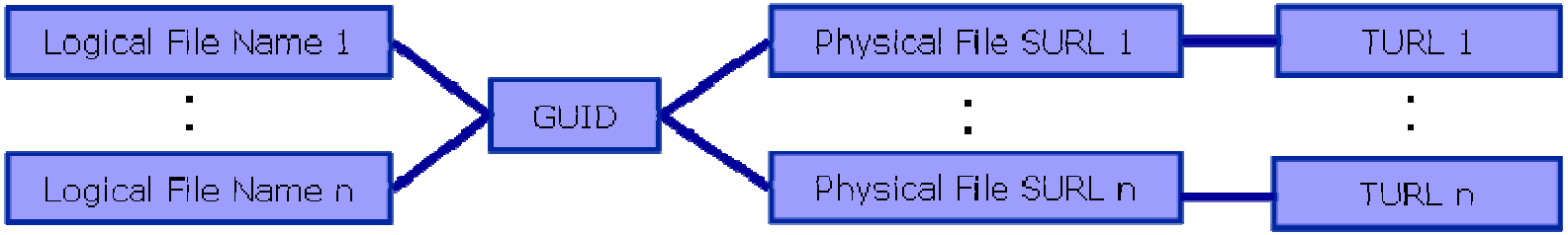
- **3 service types for data**
  - Storage
  - Catalogs
  - Movement

# Storage Element

- **Provides**
  - Storage for files
  - Transfer protocol (gsiFTP)
  - POSIX-like file access
    - Grid File Access Layer (**GFAL**)
      - *API interface*
      - *To read parts of files too big to copy*
- **Two types**
  - “Classic” SE
    - Massive storage system - disk or tape based
  - “SRM” SE
    - SE’s are virtualised by common interface: “SRMv1”
    - SRM = Storage Resource Manager
    - work in progress to migrate to SRMv2

# Name conventions

- **Logical File Name (LFN)**
  - An alias created by a user to refer to some item of data, e.g. "lfn:cms/20030203/run2/track1"
- **Globally Unique Identifier (GUID)**
  - A non-human-readable unique identifier for an item of data, e.g. "guid:f81d4fae-7dec-11d0-a765-00a0c91e6bf6"
- **Site URL (SURL) (or Physical File Name (PFN) or Site FN)**
  - The location of an actual piece of data on a storage system, e.g.
    "srm://pcrd24.cern.ch/flatfiles/cms/output10_1" (SRM)
    "sfn://lxshare0209.cern.ch/data/alice/ntuples.dat" (Classic SE)
- **Transport URL (TURL)**
  - Temporary locator of a replica + access protocol: understood by a SE, e.g.
    "rfio://lxshare0209.cern.ch//data/alice/ntuples.dat"



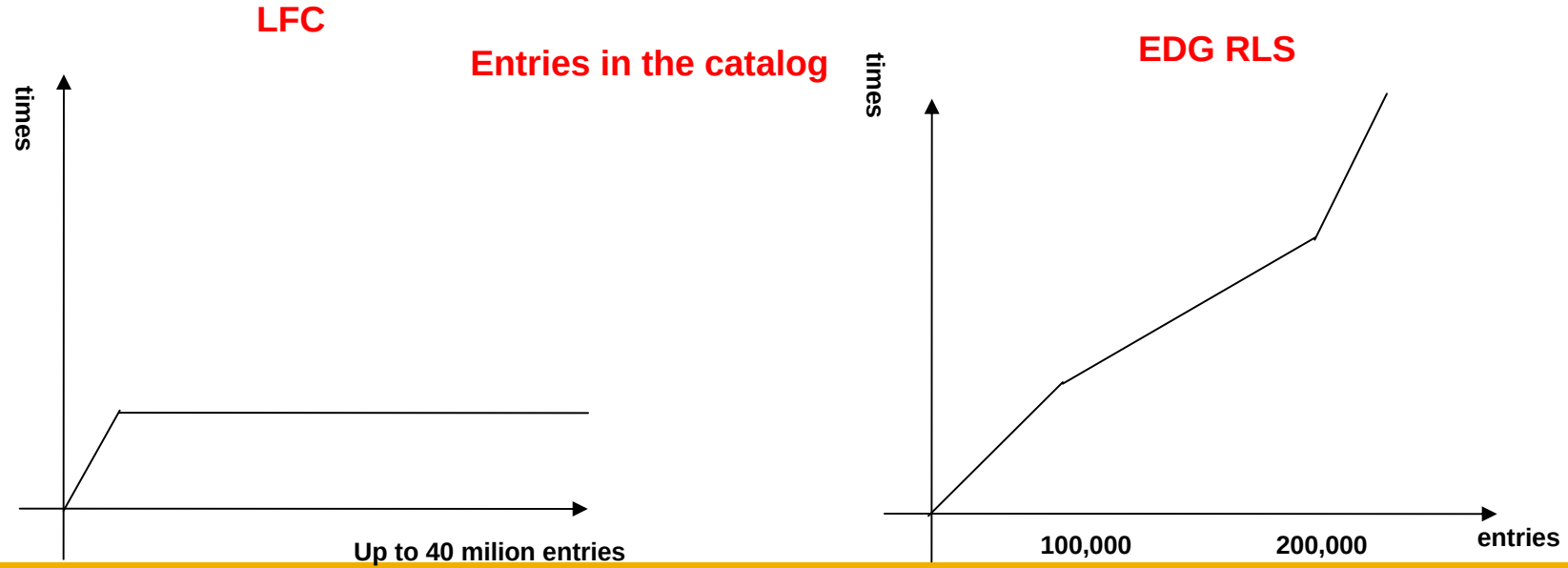
# File Catalogs in LCG

- **File catalogs in LCG:**
  - They keep track of the location of copies (replicas) of files
  - The DM tools and APIs and the WMS interact with them
- **EDG's Replica Location Service (RLS, "old!")**
  - Replica Metadata Catalog (**RMC**) + Local Replica Catalog (**LRC**)
  - Some performance problems
  - Currently on Grid-Ireland
- **New LCG File Catalog (LFC, "current!")**
  - In production
  - Better performance and scalability
  - Provides new features: security, hierarchical namespace, transactions...
- **LFC and lcg-utils commands exist to manage catalog and files on SE's**

# Why LFC exists

- LFC
  - No significant increase in operation times with a large number of entries – insert time or query rate
  - Tested with up to 40 million entries
  - Two previous catalogues combined into one

- Predecessor from EDG (European DataGrid)
  - Individual query time increased rapidity up to 100,000 entries
  - Individual insert time for an individual increased beyond 200,000 entries.



# Requirements

If a site acts as a central catalog for several VOs, it can either have:

- One LFC server, with one DB account containing the entries of all the supported VOs. You should then create one directory per VO.
- Several LFC servers, having each a DB account containing the entries for a given VO.

Both scenarios have consequences on the handling of database backups

- Minimum requirements (First scenario)
  - 2Ghz processor with 1GB of memory (not a hard requirement)
  - Dual power supply
  - Mirrored system disk

# LFC - Description

**The LCG File Catalog fixes the performance and scalability problems of EDG (European Data Grid) file catalogs.**

**Provides**

- **Bulk operations.**
- **Cursors for large queries.**
- **Timeouts and retries for client operations.**

**Added features :**

- **User exposed transaction API.**
- **Hierarchical namespace and namespace operations.**
- **Integrated GSI Authentication and Authorization.**
- **Access Control Lists (Unix Permissions and POSIX ACLs).**
- **Checksums.**

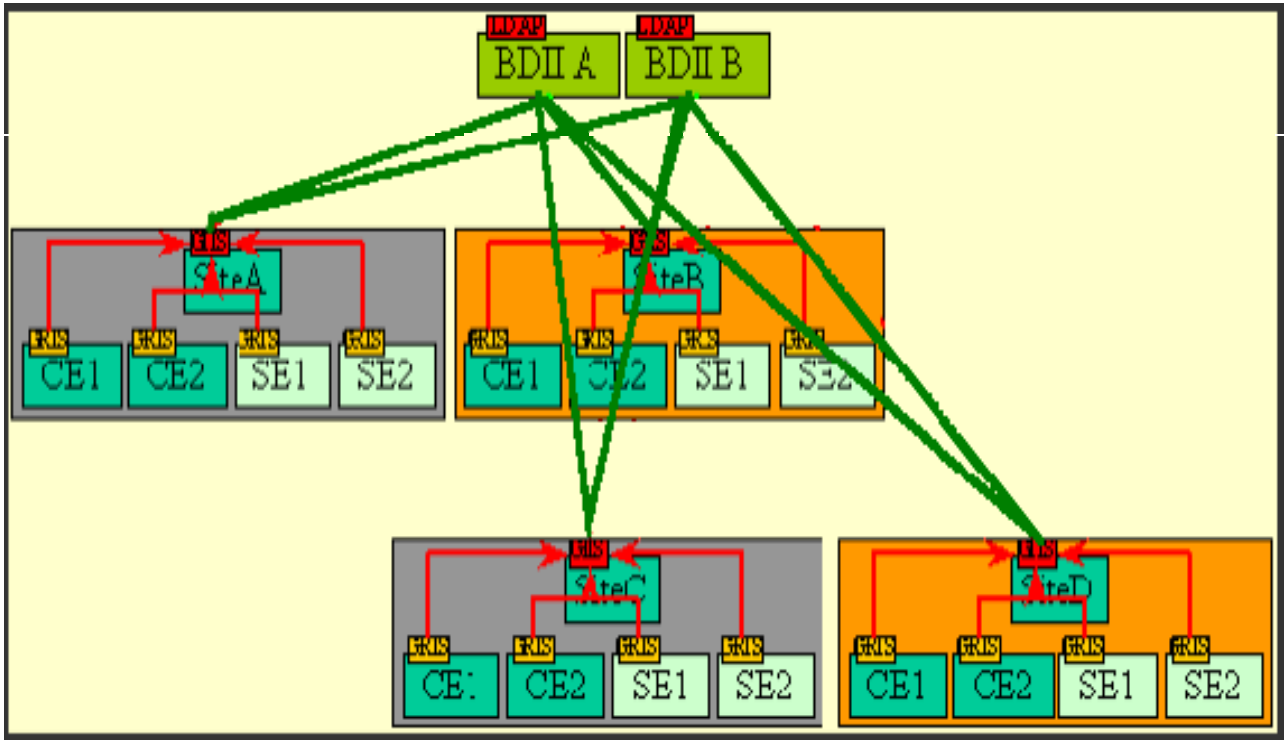
**Supported database backends: Oracle and MySQL**
**GFAL integration and support to lcg-* done by Grid Deployment group**

# A closer look at the main EGEE grid services

# 3. Information services

# 1st Information System: "BDII"

- Users can interrogate BDII servers by 2 sets of commands
  - lcg-infosites
  - lcg-info




- LDAP (Lightweight Directory Access Protocol)
- Glue Schema.

# The 2nd Information System: R-GMA

- **Relational Grid Monitoring Architecture (R-GMA)**
  - Developed as part of the EuropeanDataGrid Project (EDG)
  - Now as part of the EGEE project.
  - Based the Grid Monitoring Architecture (GMA)

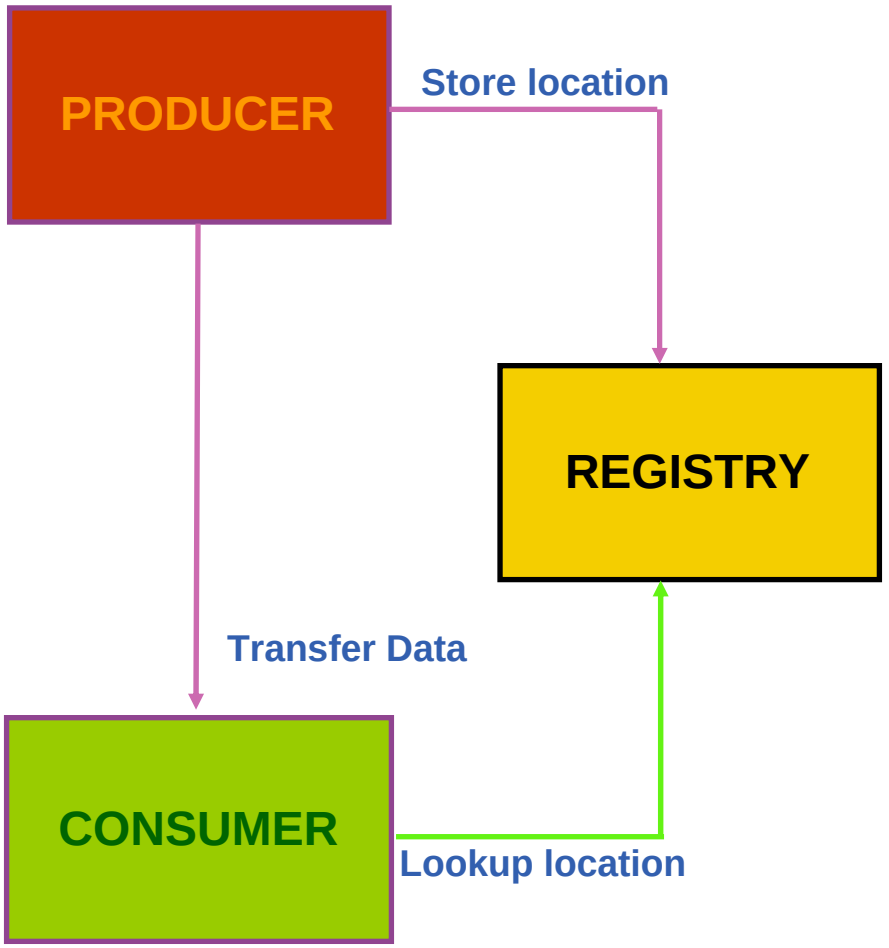
- **Uses a relational data model.**
  - Data are viewed as a table.
  - Data structure defined by the columns.
  - Each entry is a row (tuple).
  - Queried using Structured Query Language (SQL).

| name | ID | birth | Group |
|---|---|---|---|
| Tom | 4 | 1977-08-20 | HR |

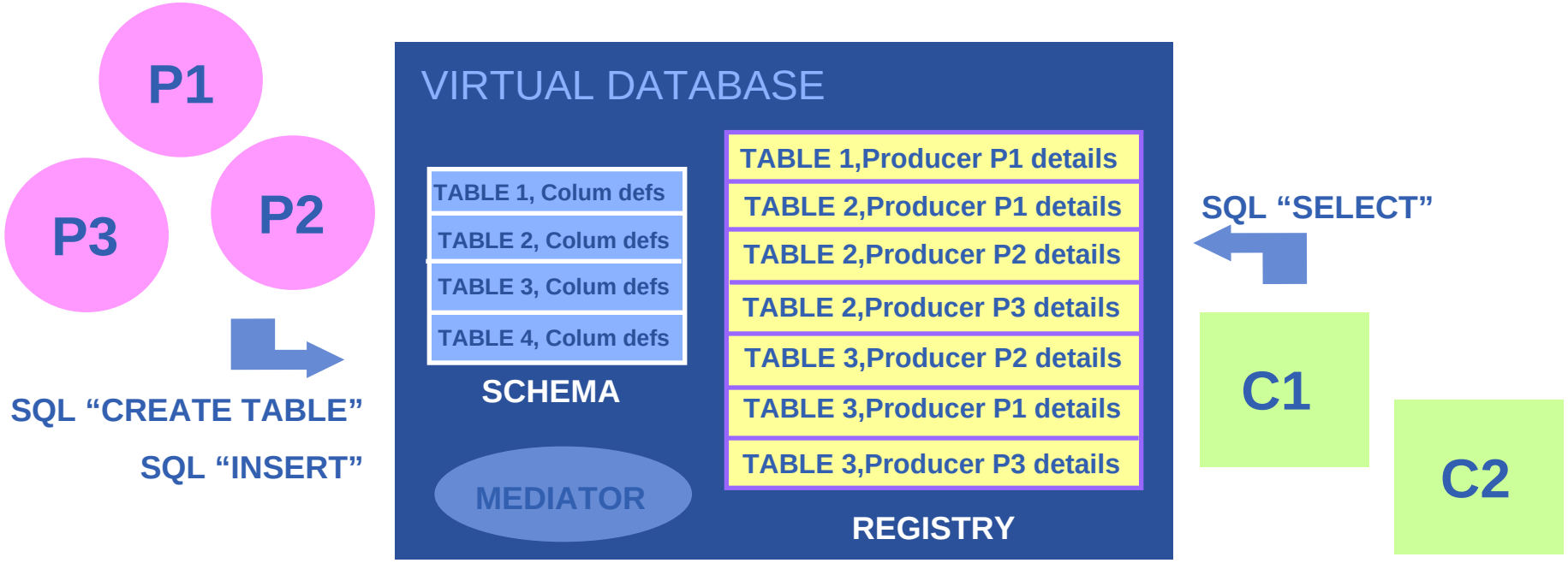
SELECT * FROM people WHERE group='HR'

# Service orientation

- The Producer stores its location (URL) in the Registry.
- The Consumer looks up producer URLs in the Registry.
- The Consumer contacts the Producer to get all the data or the Consumer can listen to the Producer for new data.



# R-GMA




**There is no central repository!!! There is only a "*Virtual Database*".**

**Schema is a list of table definitions: additional tables/schema can be defined by applications**

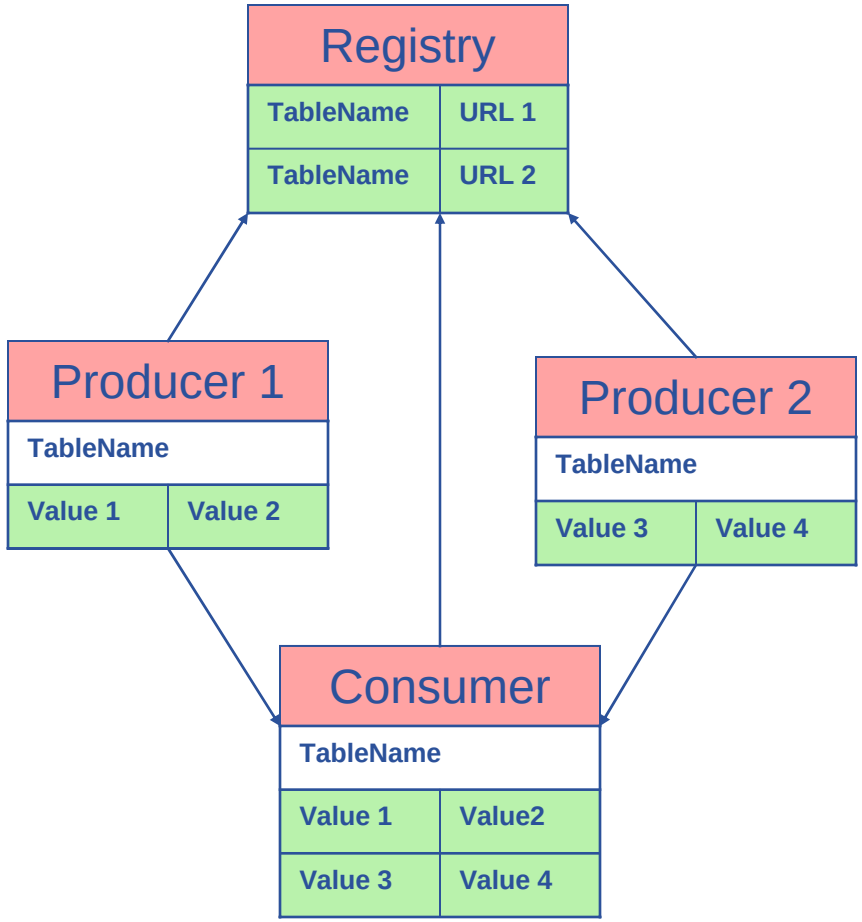
**Registry is a list of data producers with all its details.**

**Producers publish data – from sites, from applications**

**Consumer read data published.**

# Multiple Producers

- The Consumer will get all the URLs that could satisfy the query.
- The Consumer will connect to all the Producers.
- Producers that can satisfy the query will send the tuples to the Consumer.
- The Consumer will merge these tuples to form one result set.

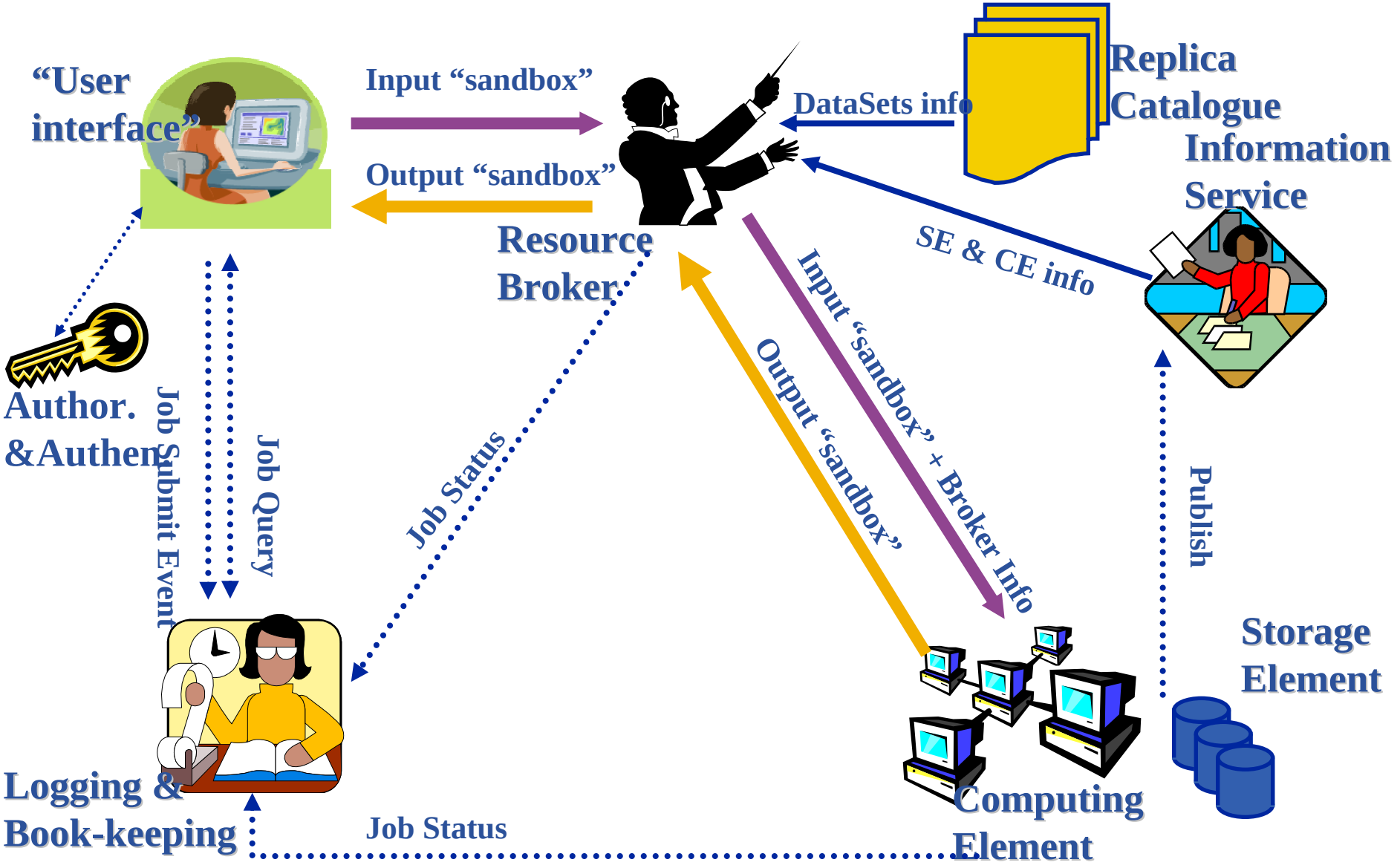


- **Real-time monitor**
  - http://www.hep.ph.ic.ac.uk/e-science/projects/demo/index.html
- **Current status**
  - http://goc.grid-support.ac.uk/gridsite/monitoring/

# A closer look at the main EGEE grid services

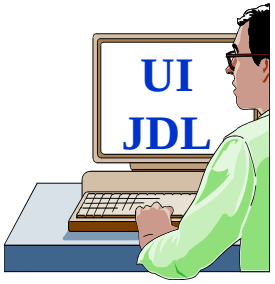
# 4. Job submission

# Current production middleware



# User Interface node

- **The user's interface to the Grid**
- **Command-line interface to**
  - Proxy server
  - Job operations
    - To submit a job
    - Monitor its status
    - Retrieve output
  - Data operations
    - Upload file to SE
    - Create replica
    - Discover replicas
  - Other grid services
- **Also C++ and Java APIs**




- **To run a job user creates a JDL (Job Description Language) file**

# Building on basic tools and Information Service

- Submit job to grid via the “resource broker (RB)”,
- edg_job_submit *my.jdl*

*Returns a “job-id” used to monitor job, retrieve output*

## Example JDL file

```
Executable = “gridTest”;
StdError = “stderr.log”;
StdOutput = “stdout.log”;
InputSandbox = {“/home/joda/test/gridTest”};
OutputSandbox = {“stderr.log”, “stdout.log”};
InputData = “lfn:testbed0-00019”;
DataAccessProtocol = “gridftp”;
Requirements = other.Architecture==“INTEL” && \
               other.OpSys==“LINUX” && other.FreeCpus >=4;
Rank = “other.GlueHostBenchmarkSF00”;
```

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```

lfn: logical file name

RB uses Catalog to find replica locations

# Building on basic tools and Information Service

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               other.OpSys==“LINUX” && other.FreeCpus >=4;
Rank = “other.GlueHostBenchmarkSF00”;
```
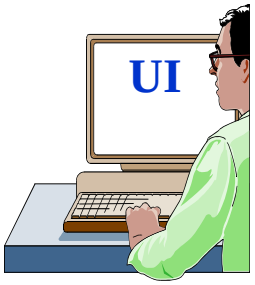

Uses BDII Information System

# Job submission




**RB node**

Network Server

Workload Manager

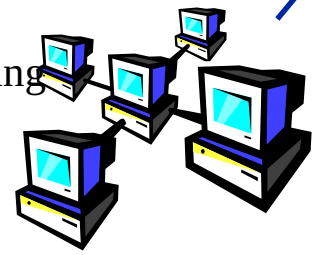
Job Contr. - CondorG

Replica Location Server

Inform. Service

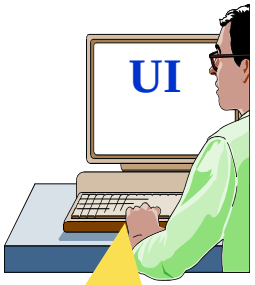
CE characts & status

SE characts & status



Computing Element

Storage Element




UI: allows users to access the functionalities of the WMS
(via command line, GUI, C++ and Java APIs)

RB node

Network Server

Workload Manager

Job Contr. - CondorG

Replica Location Server

Inform. Service

Job Status

submitted

CE characts & status

SE characts & status

Computing Element

Storage Element

edg-job-submit myjob.jdl

Myjob.jdl

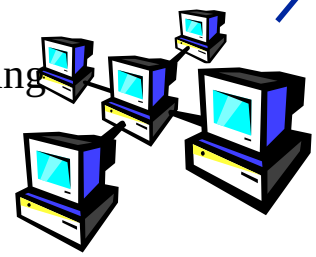
```
JobType = “Normal”;
Executable      = "$(CMS)/exe/sum.exe";
InputSandbox = {"/home/user/WP1testC","/home/file*”,
"/home/user/DATA/*"};
OutputSandbox = {“sim.err”, “test.out”, “sim.log"};
Requirements   = other. GlueHostOperatingSystemName ==
“linux" &&
other. GlueHostOperatingSystemRelease == "Red Hat 7.3“
&& other.GlueCEPolicyMaxCPUTime > 10000;
Rank  = other.GlueCEStateFreeCPUs;
```

Job Statu s

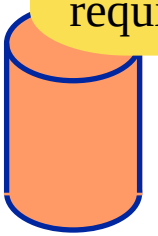
submitted

CE characts & status

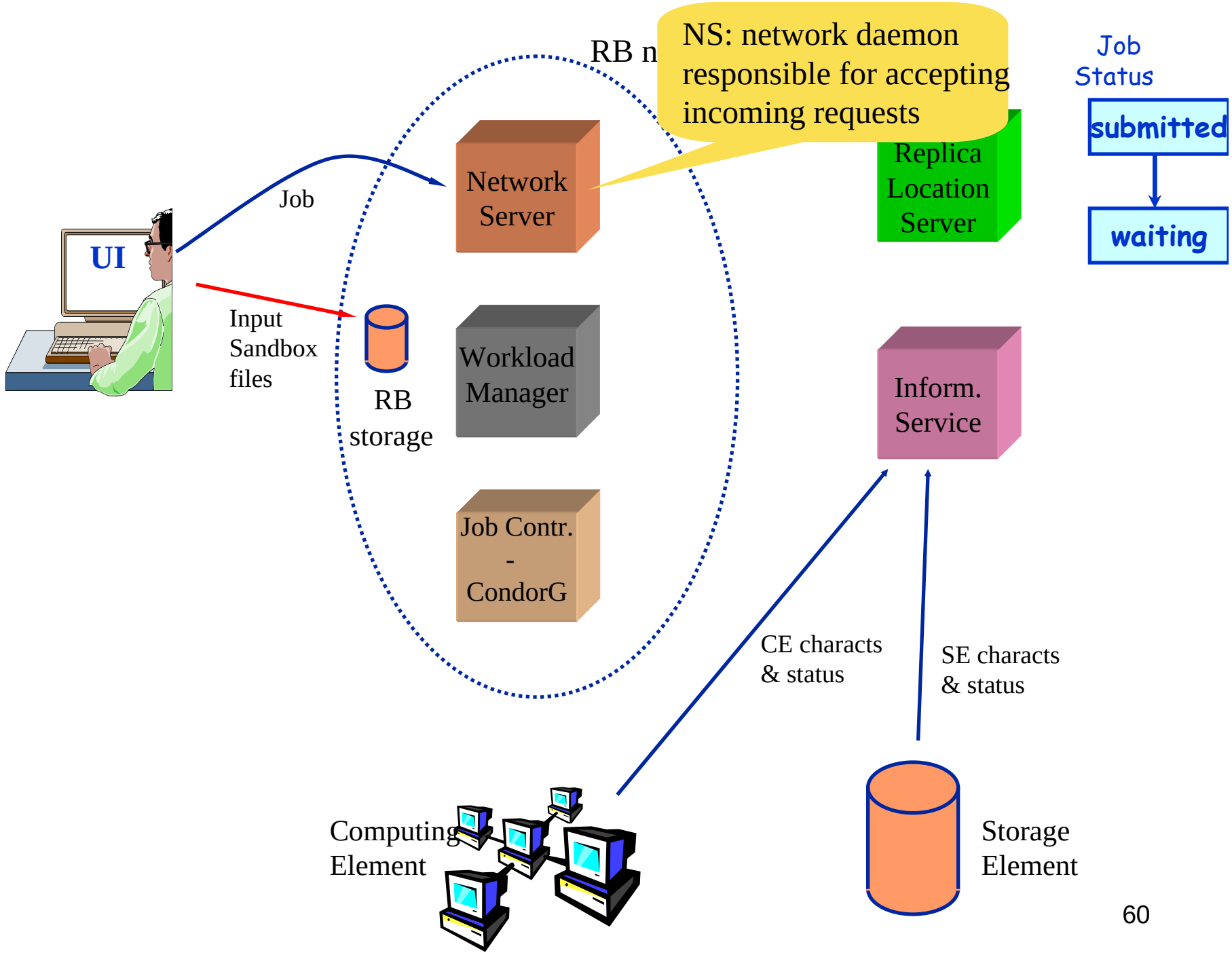
Job Description Languag (JDL) to specify job characteristics and requirements

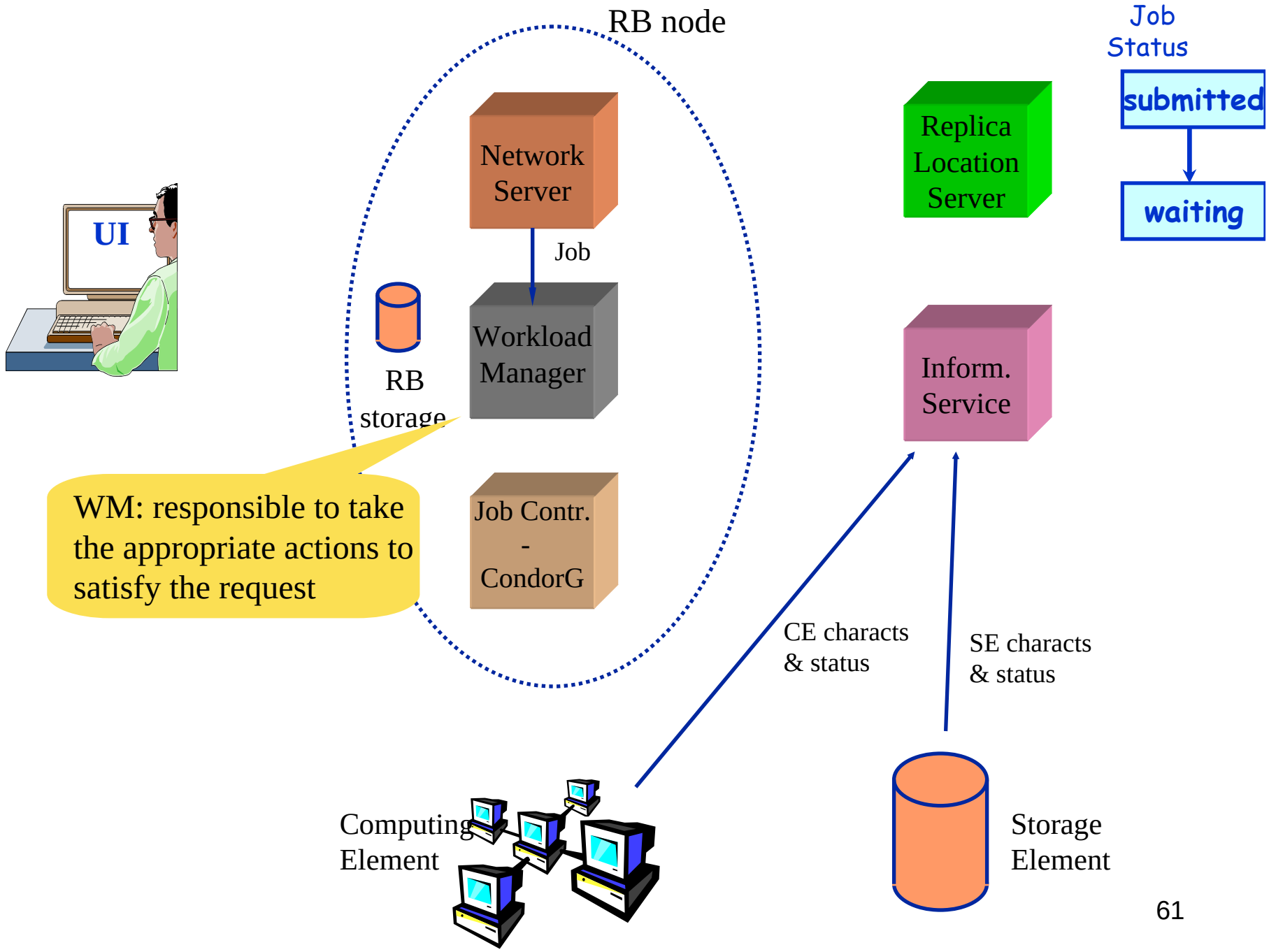


Computing Element

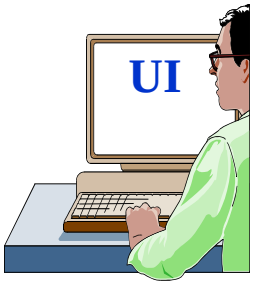


Storage Element


RB n
NS: network daemon responsible for accepting incoming requests
Job Status
submitted
waiting
Job
UI
Network Server
Replica Location Server
Input Sandbox files
RB storage
Workload Manager
Inform. Service
Job Contr. - CondorG
CE characts & status
SE characts & status
Computing Element
Storage Element


RB node
Job Status
submitted
waiting
Network Server
Job
Workload Manager
RB storage
Job Contr. - CondorG
Replica Location Server
Inform. Service
UI
WM: responsible to take the appropriate actions to satisfy the request
CE characts & status
SE characts & status
Computing Element
Storage Element

# Job submission




RB node

Network Server

Match-Maker/ Broker

Workload Manager

RB storage

Where must this job be executed ?

Job Contr. - CondorG

Replica Location Server

Inform. Service

Job Status

submitted

waiting

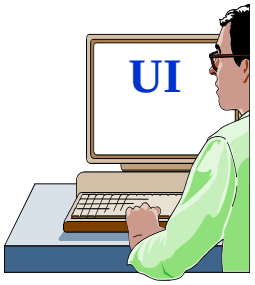
CE characts & status

SE characts & status

Computing Element

Storage Element

# Job submission




RB node

Matchmaker: responsible to find the "best" CE where to submit a job

Match-Maker/ Broker

Workload Manager

RB storage

Job Contr. - CondorG

Replica Location Server

Inform. Service

Job Status

submitted

waiting

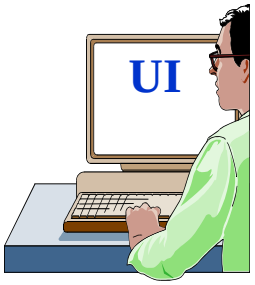
CE characts & status

SE characts & status

Computing Element

Storage Element

# Job submission




RB node

Network Server

Workload Manager

Job Contr. - CondorG

RB storage

Match-Maker/ Broker

Where are (which SEs) the needed data ?

Replica Location Server

Inform. Service

What is the status of the Grid ?

Job Status

submitted

waiting

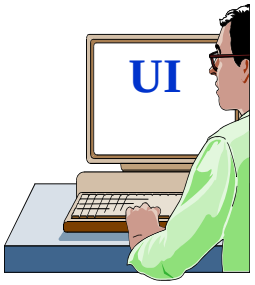
CE characts & status

SE characts & status

Computing Element

Storage Element

# Job submission




RB node

Network Server

Match-Maker/ Broker

Workload Manager

CE choice

RB storage

Job Contr. - CondorG

Replica Location Server

Inform. Service

Job Status

submitted

waiting

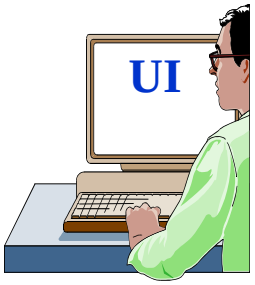
CE characts & status

SE characts & status

Computing Element

Storage Element

# Job submission




RB node

Network Server

Workload Manager

RB storage

Job Contr. - CondorG

Job Adapter

Replica Location Server

Inform. Service

Job Status

submitted

waiting

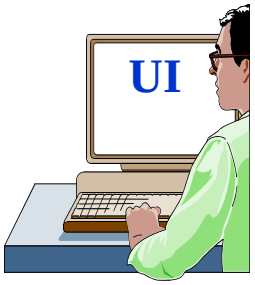
JA: responsible for the final “touches” to the job before performing submission (e.g. creation of wrapper script, etc.)

SE characts & status

Computing Element

Storage Element

# Job submission




RB node

Network Server

RB storage

Workload Manager

Job

Job Contr. - CondorG

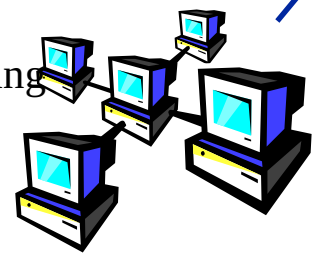
JC: responsible for the actual job management operations (done via CondorG)

Replica Location Server

Inform. Service

CE characts & status

SE characts & status



Computing Element

Storage Element

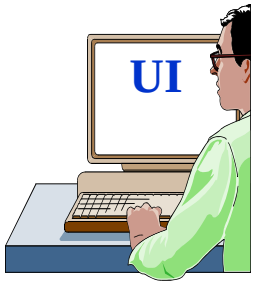
Job Status

submitted

waiting

ready

# Job submission




RB node

Network Server

Workload Manager

RB storage

Job Contr. - CondorG

Replica Location Server

Inform. Service

Job Status

submitted

waiting

ready

scheduled

Input Sandbox files

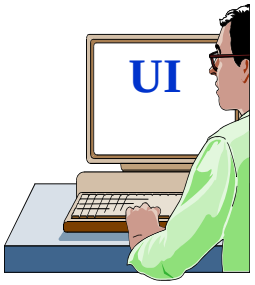
Job

CE characts & status

SE characts & status

Computing Element

Storage Element




RB node

Network Server

Workload Manager

RB storage

Job Contr. - CondorG

Input Sandbox

Replica Location Server

Inform. Service

Job Status

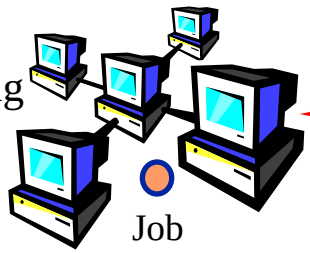
submitted

waiting

ready

scheduled

running

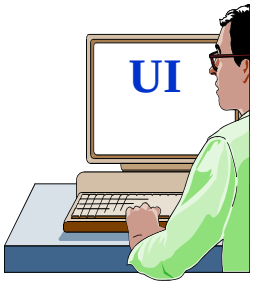


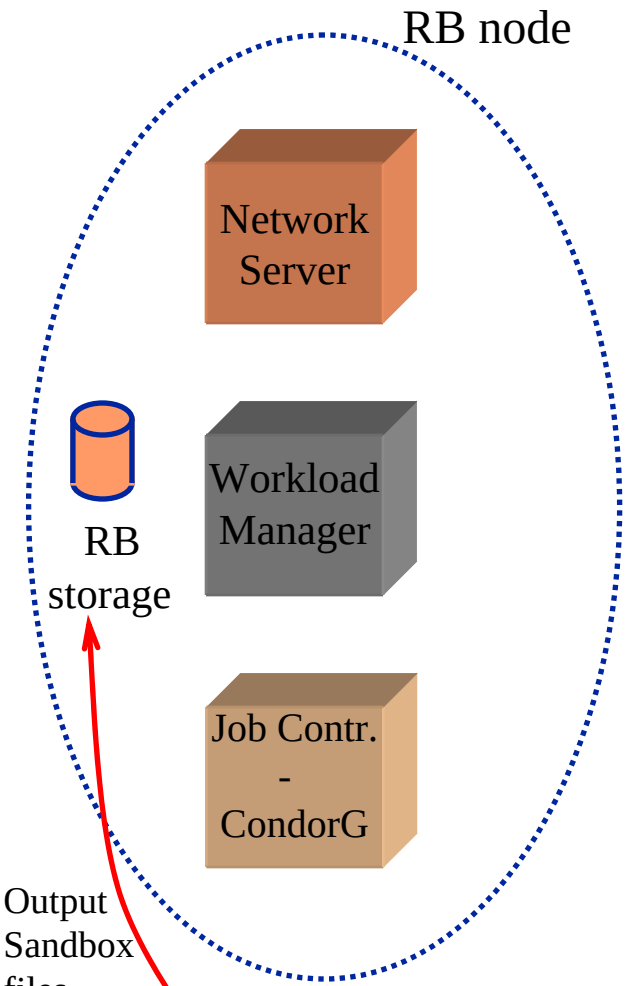
Computing Element

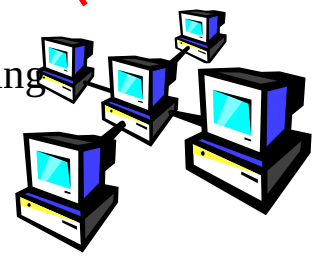
Job

"Grid enabled" data transfers/ accesses

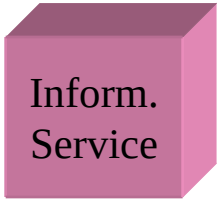
Storage Element

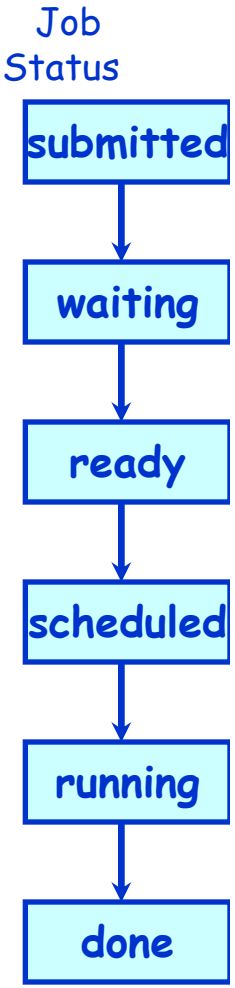

UI

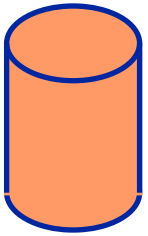

RB node
Network Server
Workload Manager
Job Contr. - CondorG
RB storage
Output Sandbox files

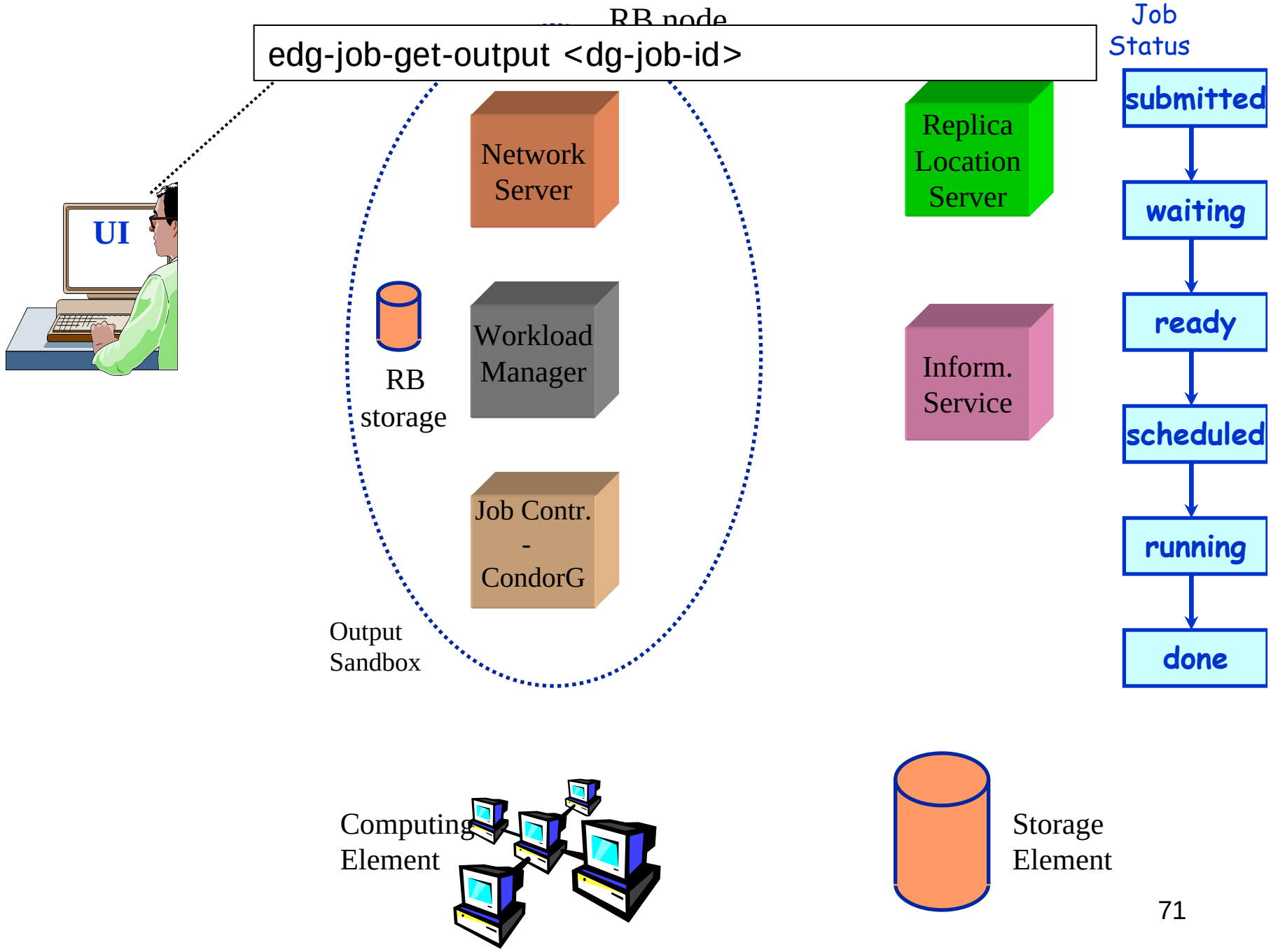

Computing Element

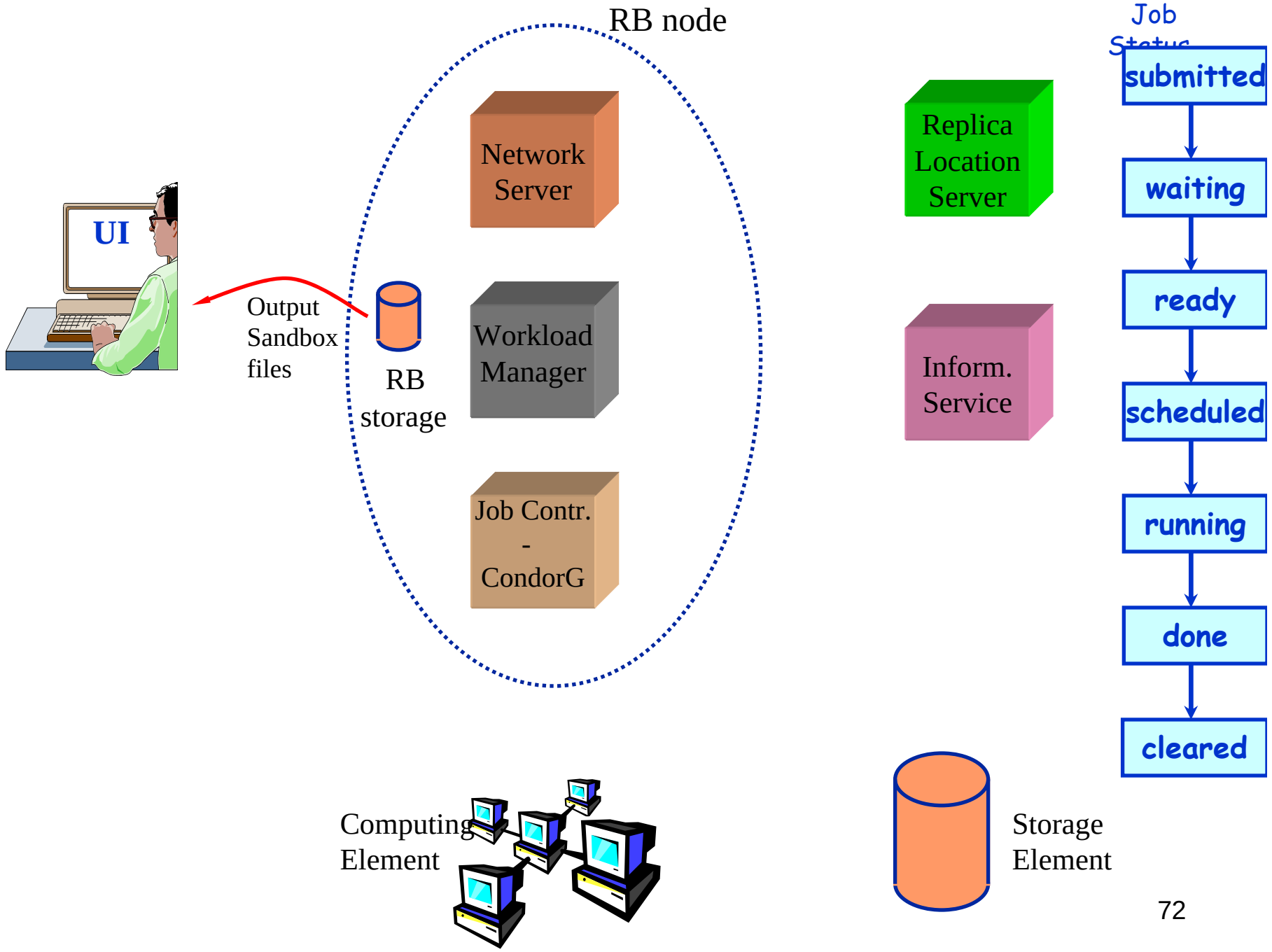

Replica Location Server


Inform. Service

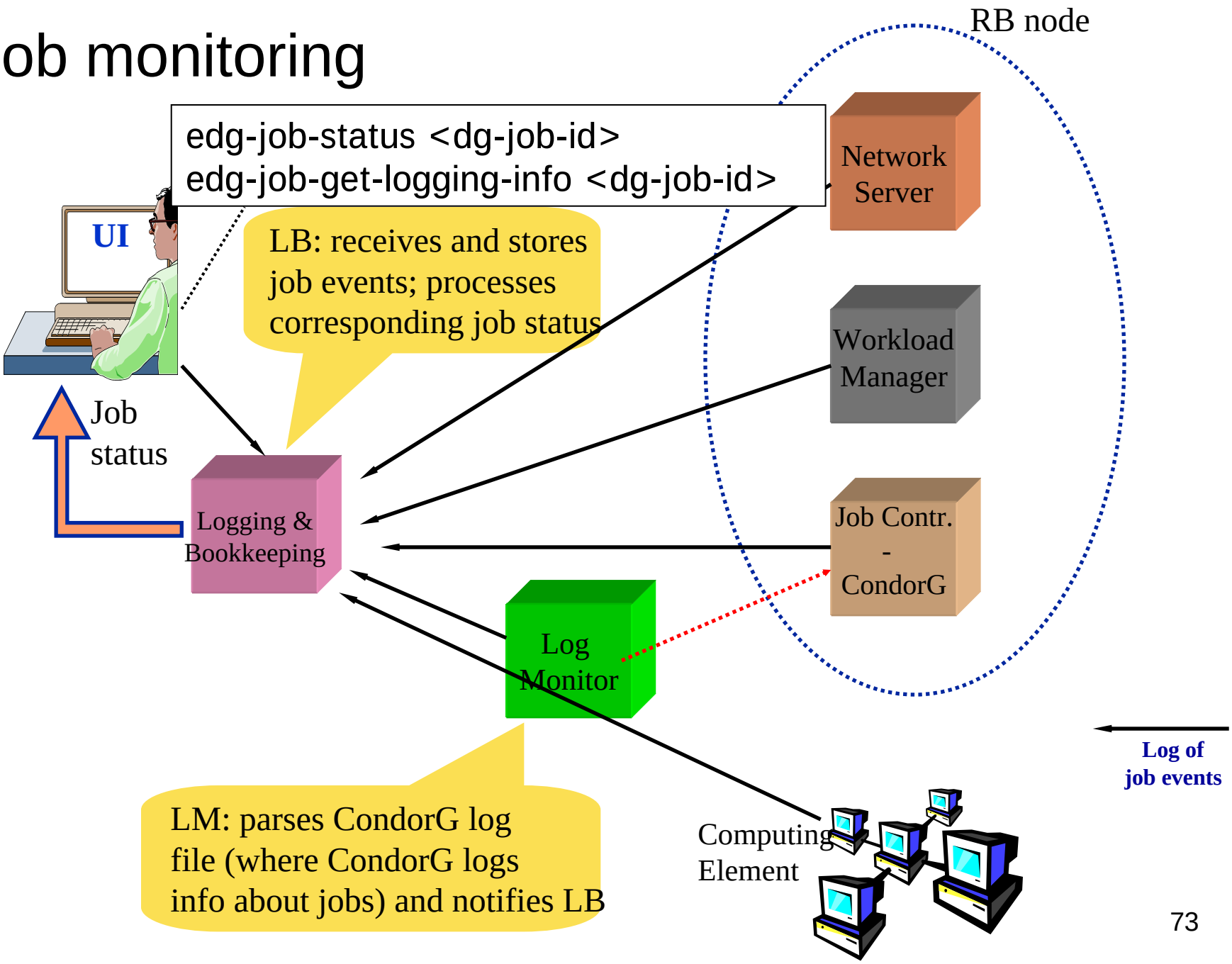

Job Status
submitted
waiting
ready
scheduled
running
done


Storage Element


RB node
edg-job-get-output <dg-job-id>
UI
Network Server
Workload Manager
RB storage
Job Contr. - CondorG
Output Sandbox
Replica Location Server
Inform. Service
Job Status
submitted
waiting
ready
scheduled
running
done
Computing Element
Storage Element

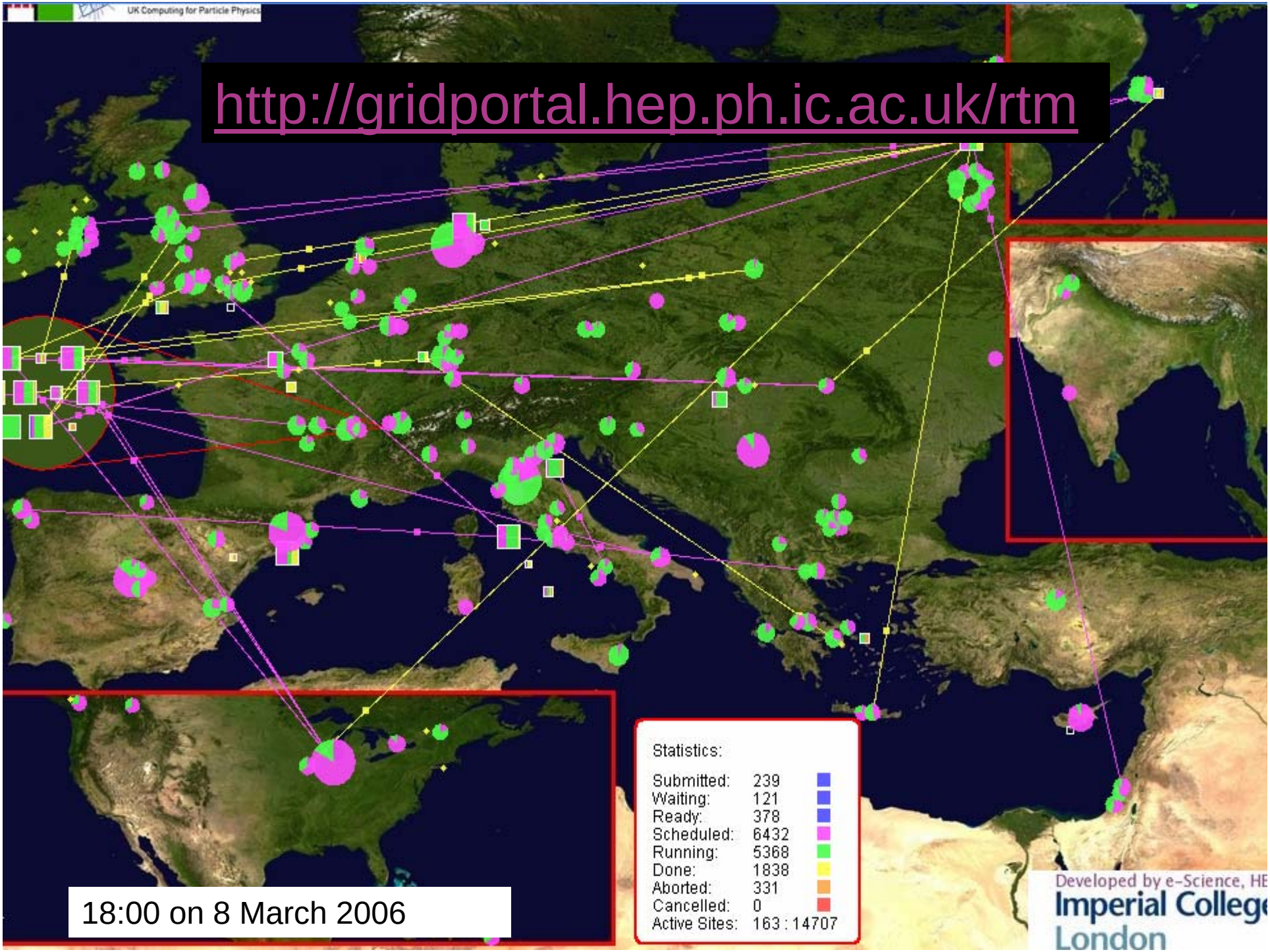

RB node
UI
Output
Sandbox
files
RB
storage
Network
Server
Workload
Manager
Job Contr.
-
CondorG
Replica
Location
Server
Inform.
Service
Job
Status
submitted
waiting
ready
scheduled
running
done
cleared
Computing
Element
Storage
Element

# Job monitoring



# Possible job states

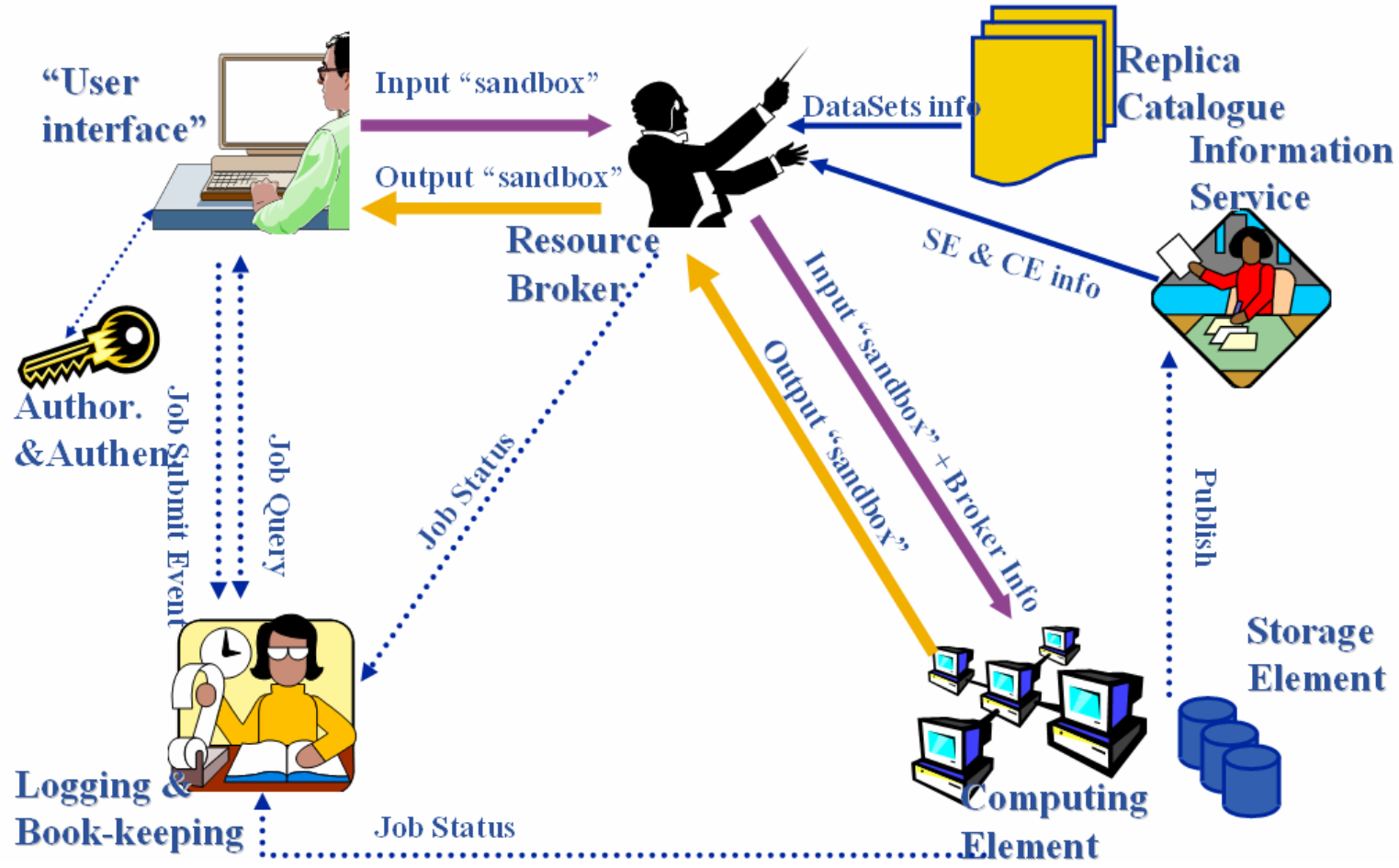
| Flag | Meaning |
|---|---|
| SUBMITTED | **submission logged in the LB** |
| WAIT | **job match making for resources** |
| READY | **job being sent to executing CE** |
| SCHEDULED | **job scheduled in the CE queue manager** |
| RUNNING | **job executing on a WN of the selected CE queue** |
| DONE | **job terminated without grid errors** |
| CLEARED | **job output retrieved** |
| ABORT | **job aborted by middleware, check** *reason* |


UK Computing for Particle Physics
http://gridportal.hep.ph.ic.ac.uk/rtm
Statistics:
Submitted: 239
Waiting: 121
Ready: 378
Scheduled: 6432
Running: 5368
Done: 1838
Aborted: 331
Cancelled: 0
Active Sites: 163 : 14707
18:00 on 8 March 2006
Developed by e-Science, HE
Imperial College
London

# Summary

- **From the rich grid ecosystem emerged the EGEE production middleware**
  - **Built on tools for**
    - Authorisation and authentication
    - Job submission (direct to a Computing Element)
    - File transfer
  - …**with higher level services**
    - Job submission to "a grid" (via resource broker)
    - Data management
    - Information Systems
  - ..**and upon these can be built toolkits and services for new application communities**
    - Workflow
    - Portals …
- **Authorisation and authentication underpin the middleware**
  - resource-sharing across organisations, without centralised control

- **Now its time to begin to use the current production middleware…**



# Further information

- EGEE www.eu-egee.org
- EGEE: 1st user Forum http://egee-intranet.web.cern.ch/egee-intranet/User-Forum

- LCG http://lcg.web.cern.ch/LCG/
- LCG User Guide https://edms.cern.ch/file/454439//LCG-2-UserGuide.pdf

- User Scenario https://edms.cern.ch/file/498081//UserScenario2.pdf

- JDL Attributes http://server11.infn.it/workload-grid/docs/DataGrid-01-TEN-0142-0_2.pdf https://edms.cern.ch/document/590869/1

- Global Grid Forum http://www.gridforum.org/
- Globus Alliance http://www.globus.org/
- VDT http://www.cs.wisc.edu/vdt/

# further Further Information

- VOMS on EGEE: User Guide available at http://glite.web.cern.ch/glite/documentation/default.asp
- VOMS
  - Available at http://infnforge.cnaf.infn.it/voms/
  - Alfieri, Cecchini, Ciaschini, Spataro, dell'Agnello, Fronher, Lorentey, From gridmap-file to VOMS: managing Authorization in a Grid environment
  - Vincenzo Ciaschini, A VOMS Attribute Certificate Profile for Authorization
- GSI
  - Available at www.globus.org
  - A Security Architecture for Computational Grids. I. Foster, C. Kesselman, G. Tsudik, S. Tuecke. *Proc. 5th ACM Conference on Computer and Communications Security Conference*, pp. 83-92, 1998.
  - A National-Scale Authentication Infrastructure. R. Butler, D. Engert, I. Foster, C. Kesselman, S. Tuecke, J. Volmer, V. Welch. *IEEE Computer*, 33(12):60-66, 2000.
- RFC
  - S.Farrell, R.Housley, An internet Attribute Certificate Profile for Authorization, RFC 3281