Overview

- Grid vision
- Grid application domains
- The role of CERN in the Grid research
- Grid Architecture
- Standards and related activities
- Summary

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What is the Grid?

- Name coined by Ian Foster and Carl Kesselman in, “The Grid: blueprint for a new computing infrastructure”
- The name Grid is chosen by analogy with the electric power grid.
  - plug-in to computing power with the same ease as the electrical power grid.
- Distributed computing projects are designed for a specific task. The grid enables a generic framework for certain aspects of distributed computing tasks.
- The aim of a grid is to seamlessly join computing resources into a global system - without centralized control.

Central concepts

- The main concept is the Virtual Organisation (VO).
  - The VO is a group that is organised together for a joint purpose.
    - Eg. A scientific collaboration working towards the same goal.
- The VO requires a security model.
  - In the current implementation X.509 certificates.
- Authentication is achieved via Certificate Authorities (CA).
- Computing resources decide which VOs to support.
- Everything decides which CAs they trust
- The Grid relies on middleware to enable seamless communication between different computing resources.
- There are two separate aspects to grids.
  - Middleware that enables grids to function.
  - Computing policy, Organisation of VOs and CAs.

Grid Projects Worldwide

- NASA Information Power Grid
- DOE Science Grid
- NSF National Virtual Observatory
- NSF GriPhyN
- DOE Particle Physics Data Grid
- NSF TeraGrid
- DOE ASCI Grid
- DOE Earth Systems Grid
- DARPA CoABS Grid
- NEESGrid
- DOH BIRN
- NSF iVDGL

- DataGrid (CERN, ...)
- EuroGrid (Unicore)
- DataTag (CERN,…)
- Astrophysical Virtual Observatory
- GRIP (Globus/Unicore)
- GRIA (Industrial applications)
- GridLab (Cactus Toolkit)
- CrossGrid (Infrastructure Components)
- EGSO (Solar Physics)

- UK e-Science Grid
- Netherlands – VLAM, PolderGrid
- Germany – UNICORE, Grid proposal
- France – Grid funding approved
- Italy – INFN Grid
- Eire – Grid proposals
- Switzerland - Network/Grid proposal
- Hungary – DemoGrid, Grid proposal
- Nordic countries - NorduGrid

Note the difference and overlap between national grid projects, application grid projects, and grid grid projects!

Grid Applications for Science

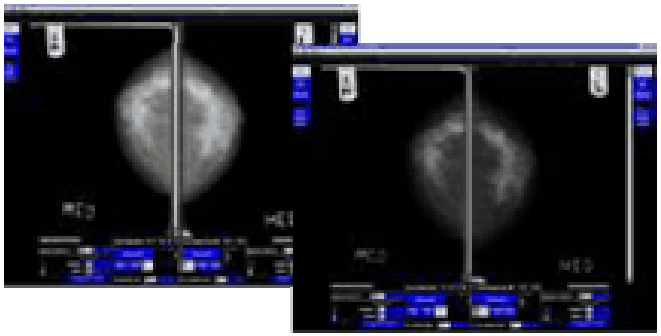
- Medical/Healthcare (imaging, diagnosis and treatment)
- Bioinformatics (study of the human genome and proteome to understand genetic diseases)
- Nanotechnology (design of new materials from the molecular scale)
- Engineering (design optimization, simulation, failure analysis and remote Instrument access and control)
- Natural Resources and the Environment (weather forecasting, earth observation, modeling and prediction of complex systems)

Medical/Healthcare Applications

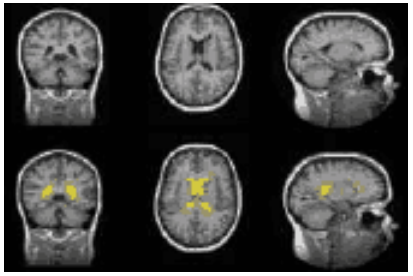
- Digital image archives
- Collaborative virtual environments
- On-line clinical conferences

"The Grid will enable a standardized, distributed digital mammography resource for improving diagnostic confidence"

"The Grid makes it possible to use large collections of images in new, dynamic ways, including medical diagnosis."



"The ability to visualise 3D medical images is key to the diagnosis of pathologies and pre-surgical planning"



Quotes from: http://gridoutreach.org.uk

Bioinformatics

- Capturing the complex and evolving patterns of genetic information, determining the development of an embryo
- Understanding the genetic interactions that underlie the processes of life-form development, disease and evolution.

"Every time a new genome is sequenced the result is compared in a variety of ways with other genomes. Each code is made of 3.5 billion pairs of chemicals…"

Natural Resources/Environment

- Modeling and prediction of earthquakes
- Climate change studies and weather forecast
- Pollution control
- Socio-economic growth planning, financial modeling and performance optimization

"Federations of heterogeneous databases can be exploited through the Grid to solve complex questions about global issues such as biodiversity."

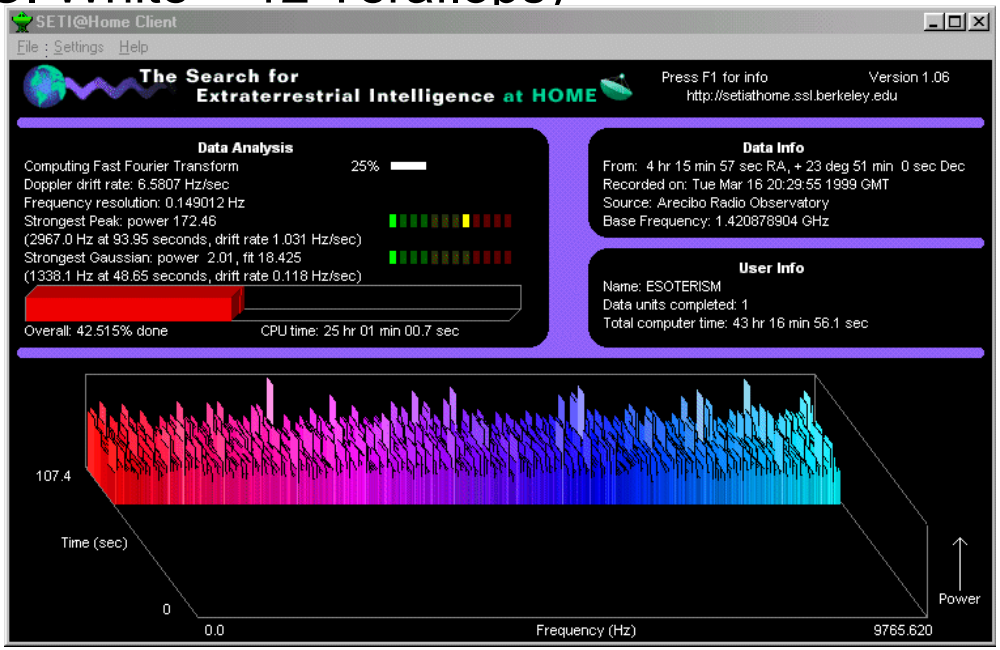
Quotes from: http://gridoutreach.org.uk

Precursors of the Grid

- SETI@home
  - sharing of spare PC processing power to analyse radio signals.
- Napster
  - sharing of data (music) between computers.
- Entropia DCGrid
  - commercial solution for sharing workstations within a company.
- Grid differs from these, since it:
  - Combines resources at major computer centers.
  - Requires dedicated equipment.
  - Uses middleware to monitor and allocate resources.
  - Provides QoS guarantees.

Seti@home

- >1 million years of computer processing time
- >3.5 million have downloaded the screensaver
- >30 Teraflops rating (ASCI White = 12 Teraflops)



The Grid@CERN

The Large Hadron Collider (LHC) is the particle accelerator at CERN.
The Grid is the solution for the LHC computing requirements
CERN is involved in many Grid development efforts worldwide

What is CERN?

- CERN is the world's largest particle physics centre

- Particle physics is about:
  - elementary particles which all matter in the Universe is made of
  - fundamental forces which hold matter together

- Particles physics requires:
  - special tools to create and study new particles

~ 2500 staff scientists (physicists, engineers, ...)
- Some 6500 visiting scientists (half of the world's particle physicists)

They come from 500 universities representing 80 nationalities.

LHC Data

- 40 million collisions per second
- After filtering, 100 collisions of interest per second
- A Megabyte of data digitised for each collision = recording rate of 0.1 Gigabytes/sec
- 10^{10} collisions recorded each year

= 10 Petabytes/year of data

1 Megabyte (1MB)
A digital photo

1 Gigabyte (1GB)
= 1000MB
A DVD movie

1 Terabyte (1TB)
= 1000GB
World annual book production

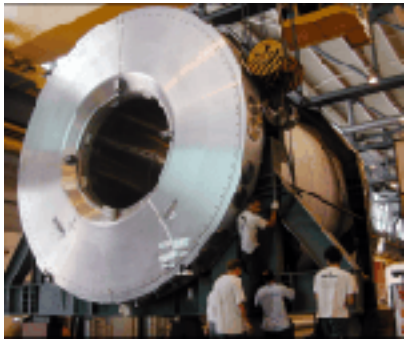
1 Petabyte (1PB)
= 1000TB
Annual production of one LHC experiment

1 Exabyte (1EB)
= 1000 PB
World annual information production

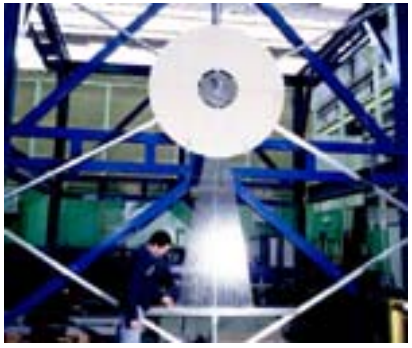
CMS

LHCb

ATLAS

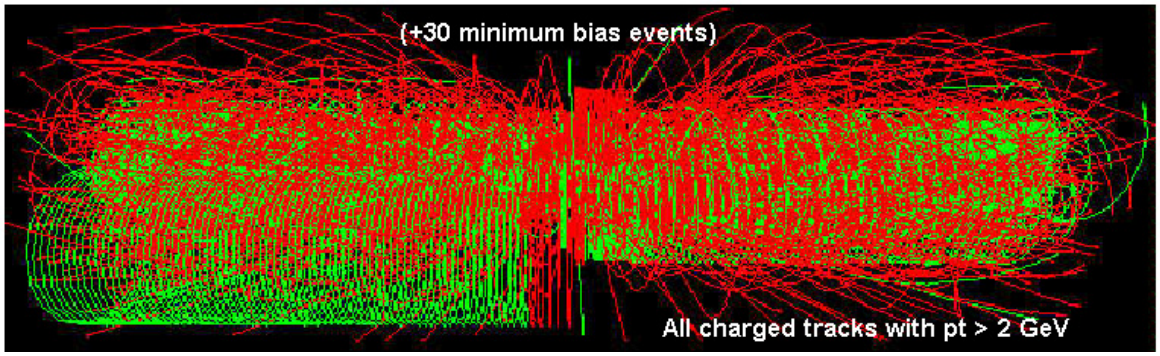


ALICE

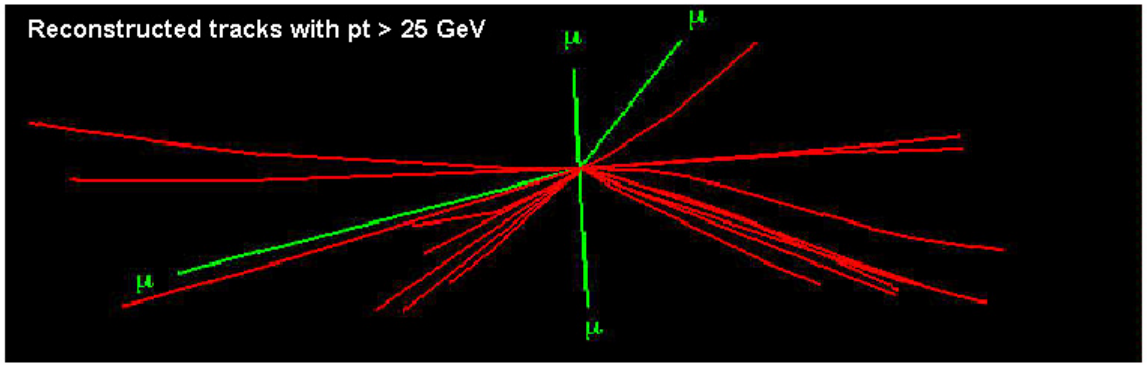


The LHC Data Challenge

Starting from this event…



You are looking for this "signature"



Selectivity: 1 in 10^{13}

Like looking for 1 person in a thousand world populations!

Or for a needle in 20 million haystacks!

Grid Projects @ CERN

- CERN projects:
  LHC Computing Grid (LCG)
- EC funded projects led by CERN:
  European DataGrid (EDG)
  + others
- Industry funded projects:
  CERN openlab for DataGrid applications

LHC Computing Grid (LCG)

Mission:

- Grid deployment project aimed at installing a functioning Grid to help the LHC experiments collect and analyse the data coming from the detectors.

Strategy:

- Integrate thousands of computers at dozens of participating institutes worldwide into a global computing resource.

- Rely on software being developed in advanced grid technology projects, both in Europe and in the USA.

European DataGrid (EDG)

Mission:

- Develop the necessary middleware to run a Grid on a “testbed” involving computer centers in Europe

Key features:

- Largest software development project ever funded by the EU (9.8 million euros)
- Three year phased developments & demos (2001-2003)
- Three application fields: High Energy Physics, Earth Observation and Genomic Exploration

EGEE: Enabling Grids for e-Science in Europe

Mission:

- Deliver 24/7 Grid service to European science; re-engineer and "harden" Grid middleware for production; "market" Grid solutions to different scientific communities

- Be the first international multiscience production Grid facility

Key features:

- 100 million euros/4years

- >400 software engineers + service support

- 70 European partners

DataTAG

Mission:

- Develop advanced networking solutions for transatlantic Grid communications.

Status:

- Recent land speed data transfer record: 1 TeraByte of data transferred in 1hr between SLAC and CERN (equivalent to 200 DVD movies or one CD every 2.3s).

GRACE

Background:

- Today search engines are extremely centralized. In order to index a document they must download it, process it and store its index - all in one central location.

Mission:

- develop a decentralized search engine providing dynamical categorisation of information. Uses Grid technology and semantic tools.

CERN openlab for DataGrid applications

Mission:

- Testbed for Grid software and hardware
- Industry consortium for Grid soft- and hardware research
- Training ground for a new generation of engineers to learn about Grid

Partners:

- CERN
- Intel
- ENTERASYS
- HP
- IBM
- INTEL
- ORACLE

CERN opencluster and data challenges

Example

GB/s storage-to-tape record

1.1 GB/s for hrs, peaks of 1.2 GB/s

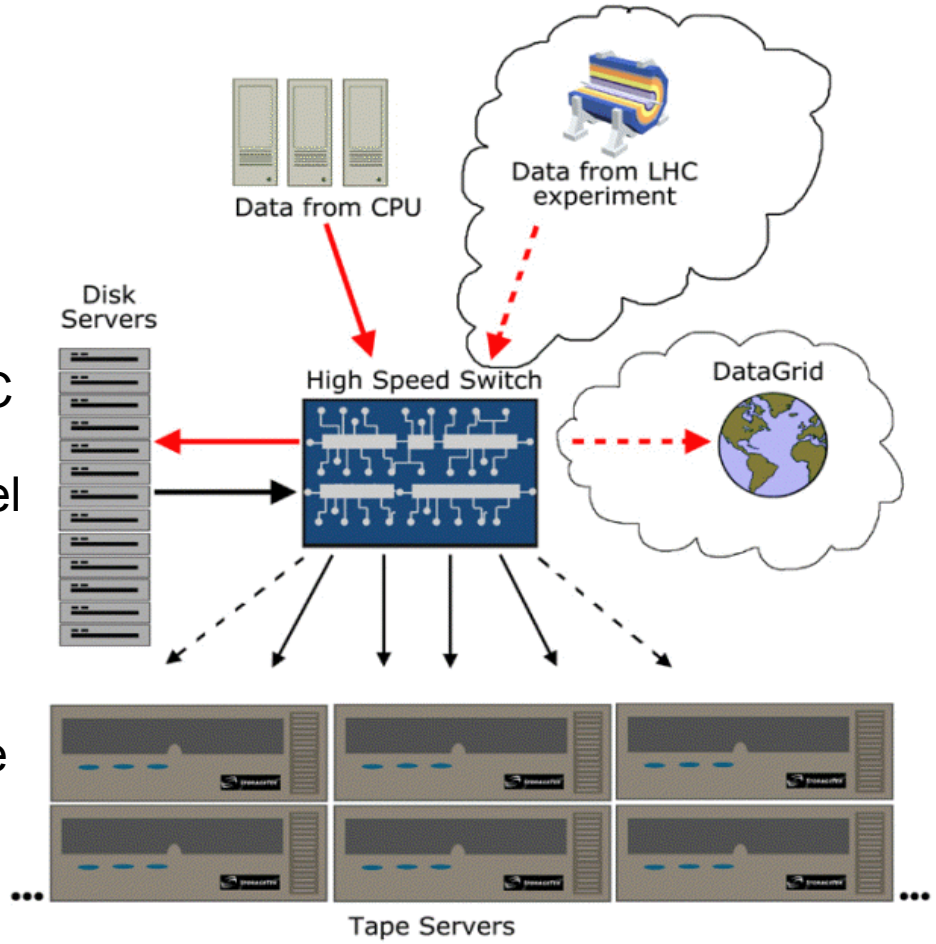
Corresponds to data rates from LHC

45 StorageTek tape drives in parallel

Role of CERN opencluster

Cluster nodes for temporary storage

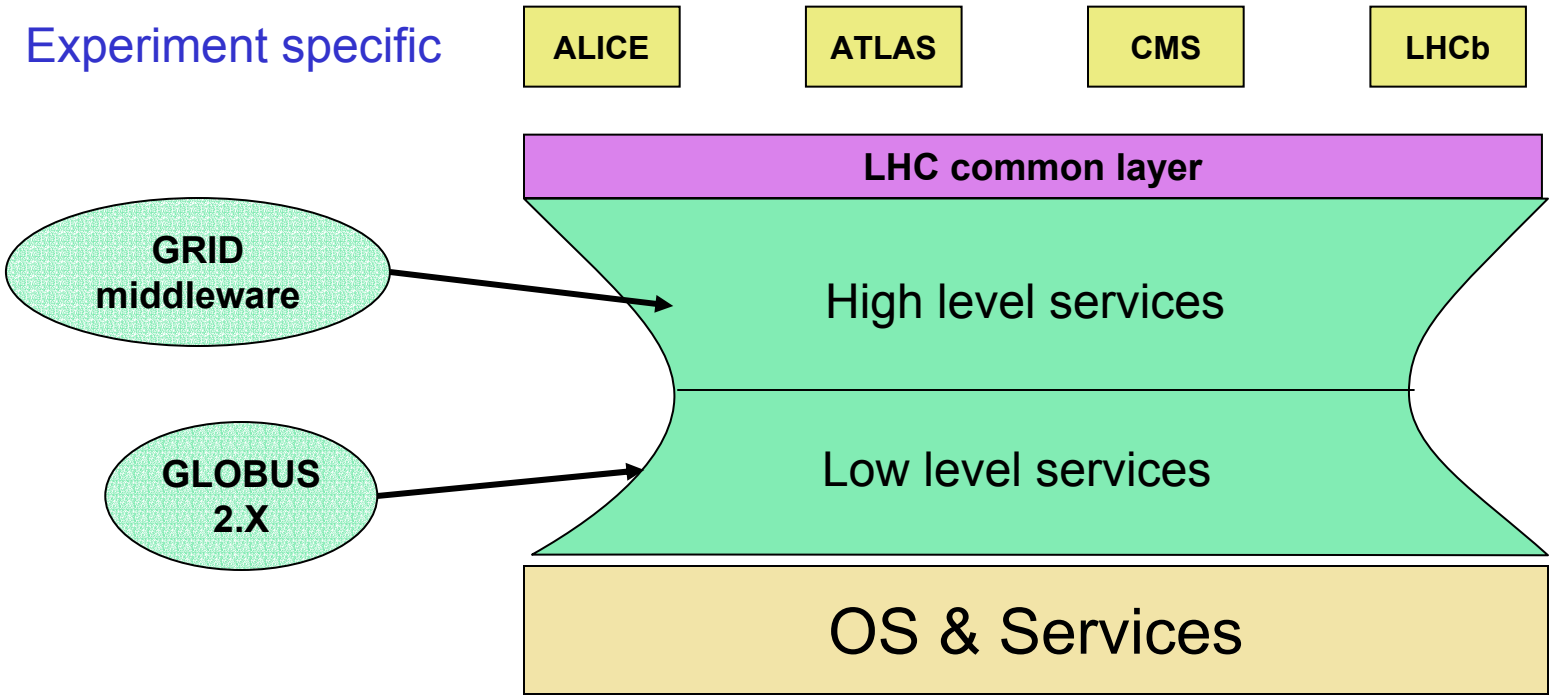
Cluster switch plays central role



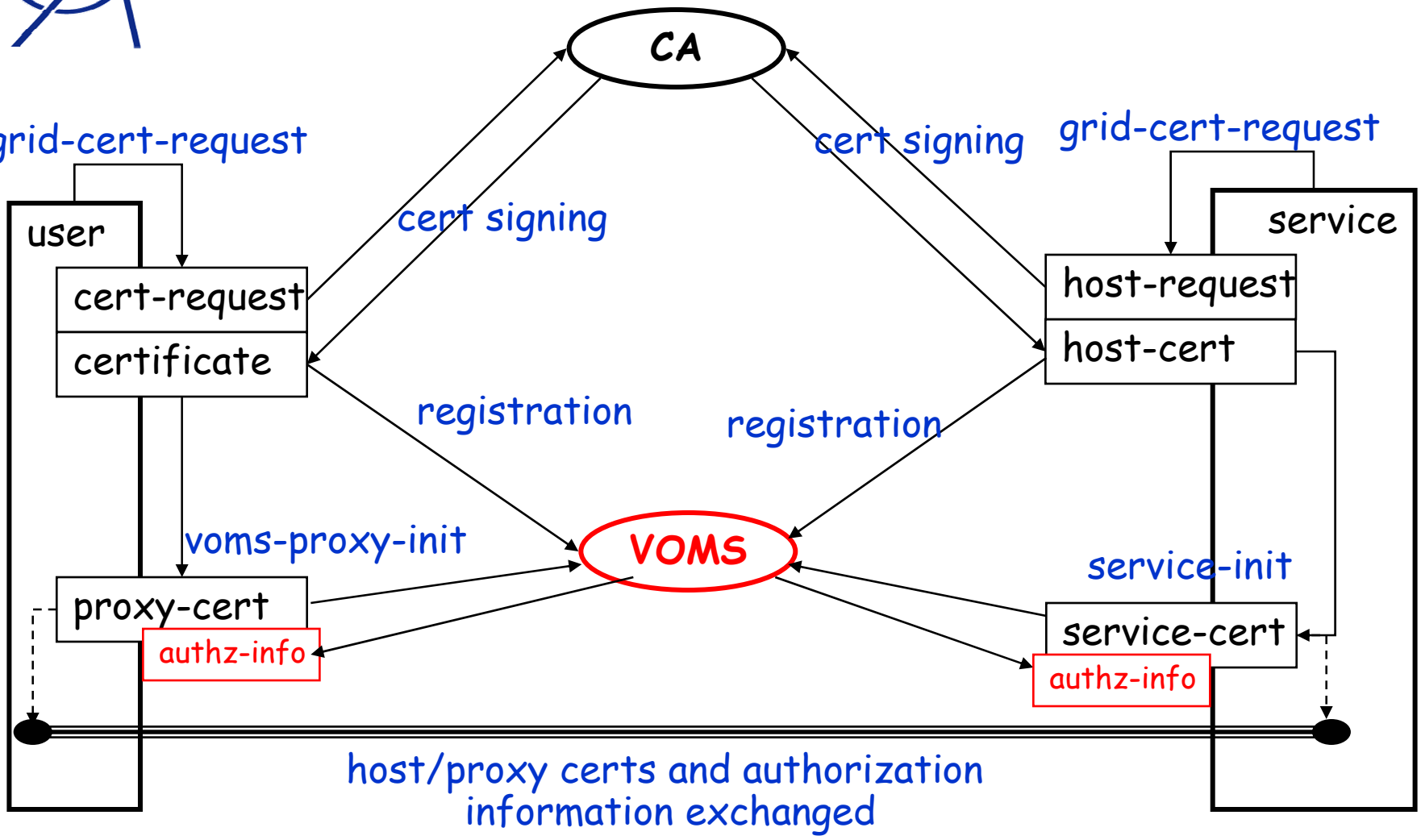
Globus

- Defacto standard of grid computing
  - De facto standardization
    - Features in implementation become standard
    - Problematic when goals of projects are partially orthogonal.
- Globus provides basic Grid services
  - Resource access (GRAM protocol).
  - Data transfer (GridFTP – 3rd party copy).
  - Security (GSI infrastructure).
  - Information system (MDS).
- Most grid projects based on Globus
  - Standards used tend to change between versions.

Hourglass Model



Grid Security



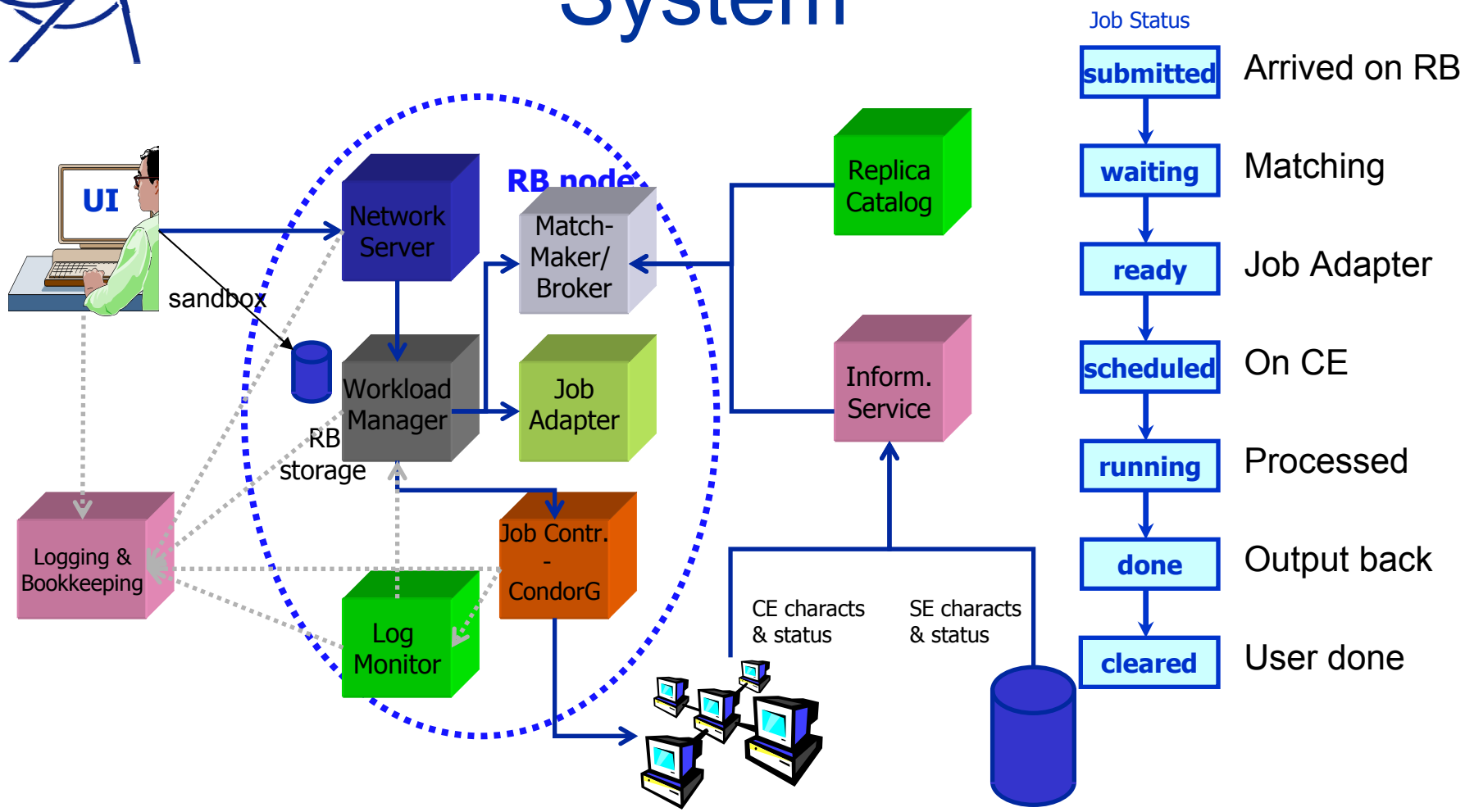
Information System

- Information about resources
  - status, access, parameters, etc.
- Globus Meta-Data Directory Service
  - Based on LDAP.
  - Ldif information model.
  - Hierarchical deployment model.
  - Has not proved itself in projects CERN is involved in.
- LCG uses their own version
  - openLDAP database with perl wrapper.
  - Works well in a production environment.
  - Current Glue Schema is not adequate.

Data Management

- GridFTP used for data transfer
  - Version of parallel ftp with GSI security (gsiftp).
- SRM (Storage Resource Manager
  - Storage interface.
- RLS (Replica Location Service)
  - Keeps track of where files are.
  - Mappings between logical file name and GUID.
- EDG-RM, (Replica Manager)
  - moving files, creating replications.
  - Uses basic tools and RLS.
- GFAL (GRID File Access Lib)
  - Transparent access to files by user via.

WorkLoad Management System



Failed jobs are resubmitted

LHC Grid Building Blocks

UI

- User Interface.
  - Client tools for job submittion, data management and proxy generation etc.

CE

- Computing Element.
  - Grid interface to a computing batch system.

WN

- Worker Node.
  - Batch system worker.
  - Requires grid client tools.

SE

- Storage Element.
  - Grid interface to mass or distributed storage

LHC Grid Building Blocks

RB Resource Broker

– Service of distributing grid jobs.

BDII BDII

– Grid information service.

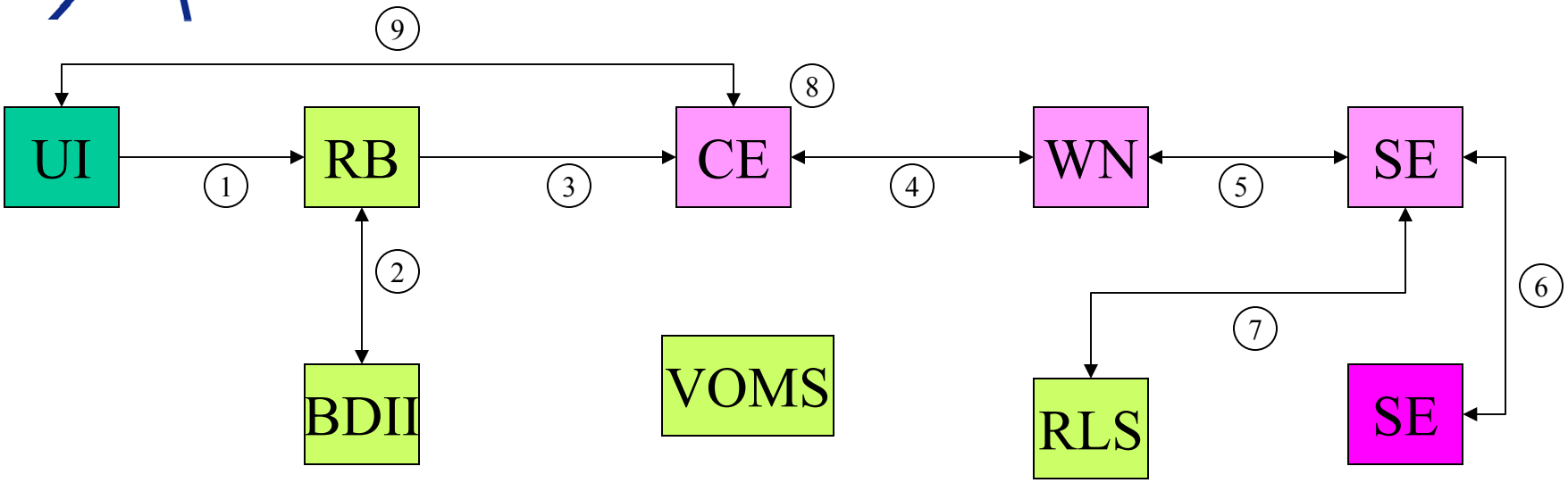
RLS RLS

– Replica location service.

VOMS VOMS

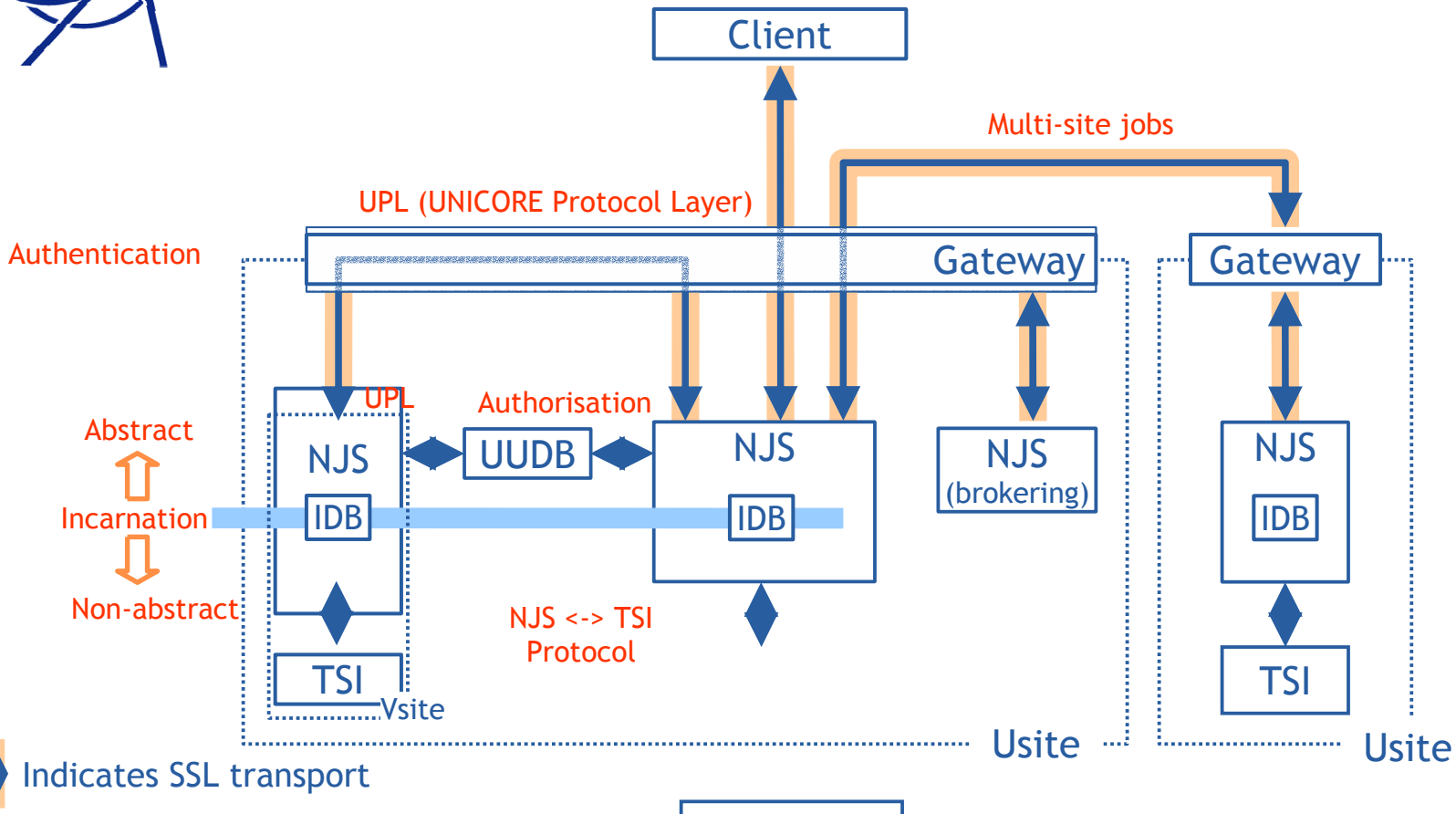
– Virtual organisation membership service.

LHC Grid Deployment



1. A Job is submitted from the UI to the RB.
2. The RB queries BDII to find CEs that could run the job.
3. RB Sends job to a CE.
4. Batch system on CE sends job to WN and executes it.
5. WN asks for a file from SE.
6. SE looks in the Replica catalogue for the location of the file.
7. SE copies the file from remote SE to itself so that the WN can read it.
8. When the worker node finishes the job, new files could have been written to the SE and results will be sent back to the CE via the batch system.
9. The UI will periodically query the CE to find the status of the job and retrieve the output when the job has finished.
10. Everything uses VOMS and the X.509 security model

Unicore


Client
Multi-site jobs
UPL (UNICORE Protocol Layer)
Authentication
Gateway
Gateway
UPL
Authorisation
Abstract
NJS
UUDB
NJS
NJS
(brokering)
NJS
Incarnation
IDB
IDB
IDB
Non-abstract
NJS <-> TSI
Protocol
TSI
TSI
Vsite
Usite
Usite
Indicates SSL transport
TSI
TSI – Target System Interface
NJS – Network Job Supervisor
IDB – Incarnation Database
UUDB – UNICORE User Database
Usite – UNICORE site

Examples of Standards Relevant to Grids

OASIS

- WS-Security, SAML,…

IETF

- HTTP
- FTP
  - GridFTP extension being prepared.
- IPv6

ITU

- X.509
  - The proxy-extension proposal is of especially keen interest!

W3C

- XML
- Web ontologies

Related Activities

OSDL Carrier Grade Linux

- Similar goals in self-management, security, monitoring…

OMA

- Web service interfaces converging point.
- Heterogeneous platforms.

Liberty Alliance

- Federated Iidentity management vs. Virtual Organization.

BOINC

- Generic middleware project for “public resource computing”
- Grid and BOINC possibly complementary technologies

Grid related Initiatives

Global Grid Forum

- Forum for Grid developers from all over the world
- Standards preparation
- Frequent meetings (3 times/year)
- Several working and research groups

eInfrastructures

- EU initiative to coordinate policies and administrative policies
  - Participation from major 6th framework projects: EGEE, DEISA, SEEGRID, GEANT2.
  - Standardization, policies and network global aspects

GRIDSTART project

- Umbrella project for 5th framework EU funded Grid projects
- Technical working groups with European emphasis

Global Grid Forum in Detail

- Modeled after the IETF
- Not-for-profit Corporation
- Not a standardization organization, but produces standard drafts
- 7 research areas with a total of 42 groups (research or working)
  - Applications and Programming environments
  - Architecture
  - Data
  - Information Systems and Performance
  - Peer-to-Peer
  - Scheduling and Resource Management
  - Security
- A truly global community, not just US or Europe!

Conclusions

- There are several different Grid projects in the world
  - CERN is a major European and worldwide center of this research and development area
- Challenges are strongly related to standardization work
  - Interoperability between Grid projects requires this
- Contacts between research, science and industry are needed
  - Science alone can not support the infrastructure in the future!

Contacts, additional information

- Global Grid Forum
  - http://www.ggf.org/
- eInfrastructures initiative
  - http://www.einfrastructures.org/
- EGEE project
  - http://www.eu-egee.org/
- GRIDSTART project
  - http://www.gridstart.org/
  - Contact for standardization related work:
    - Dietmar Erwin (d.erwin@fz-juelich.de)
- CERN IT department
  - http://www.cern.ch/it/ (under “Major Projects”)
- Globus Toolkit
  - http://www.globus.org/
- UNICORE
  - http://www.unicore.org/