Grid-Computing - eine populäre Einführung

Peter Wegner

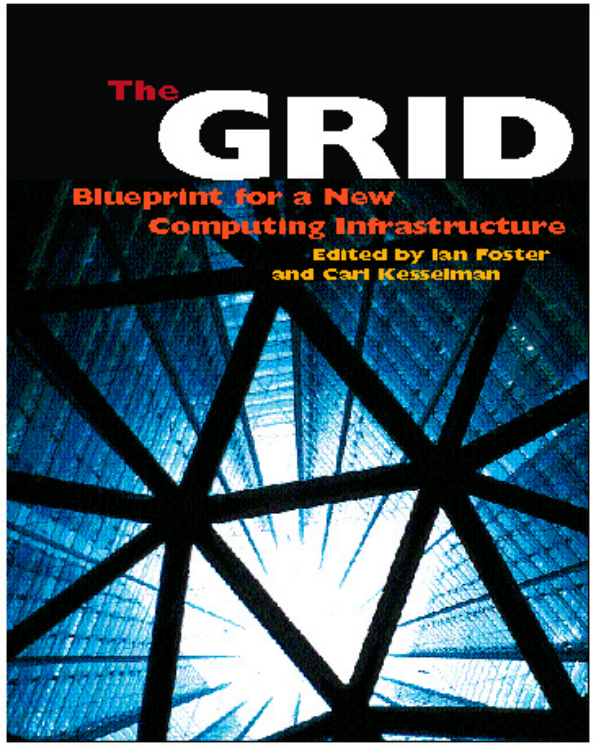
Grid computing – a popular introduction

OUTLINE

Grid Blueprints
Grid Schematics/Components/Genesis
Examples
Middleware – Globus Toolkit
LHC, LCG
Grids@DESY
International Lattice Data Grid
Web pages, demonstration

Grid computing - The Beginning ?

Foster, C. Kesselman *"The Grid: Blueprint for a New Computing Infrastructure"*, Morgan-Kaufman,1999

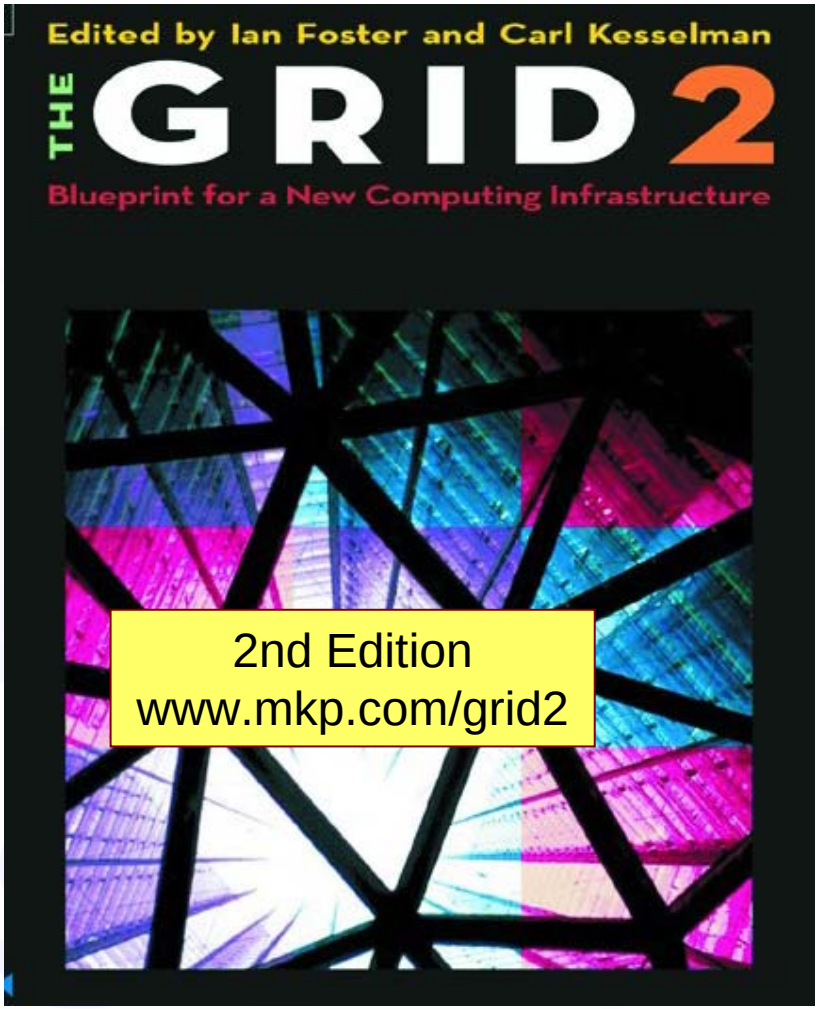


Name: from electrical power Grid

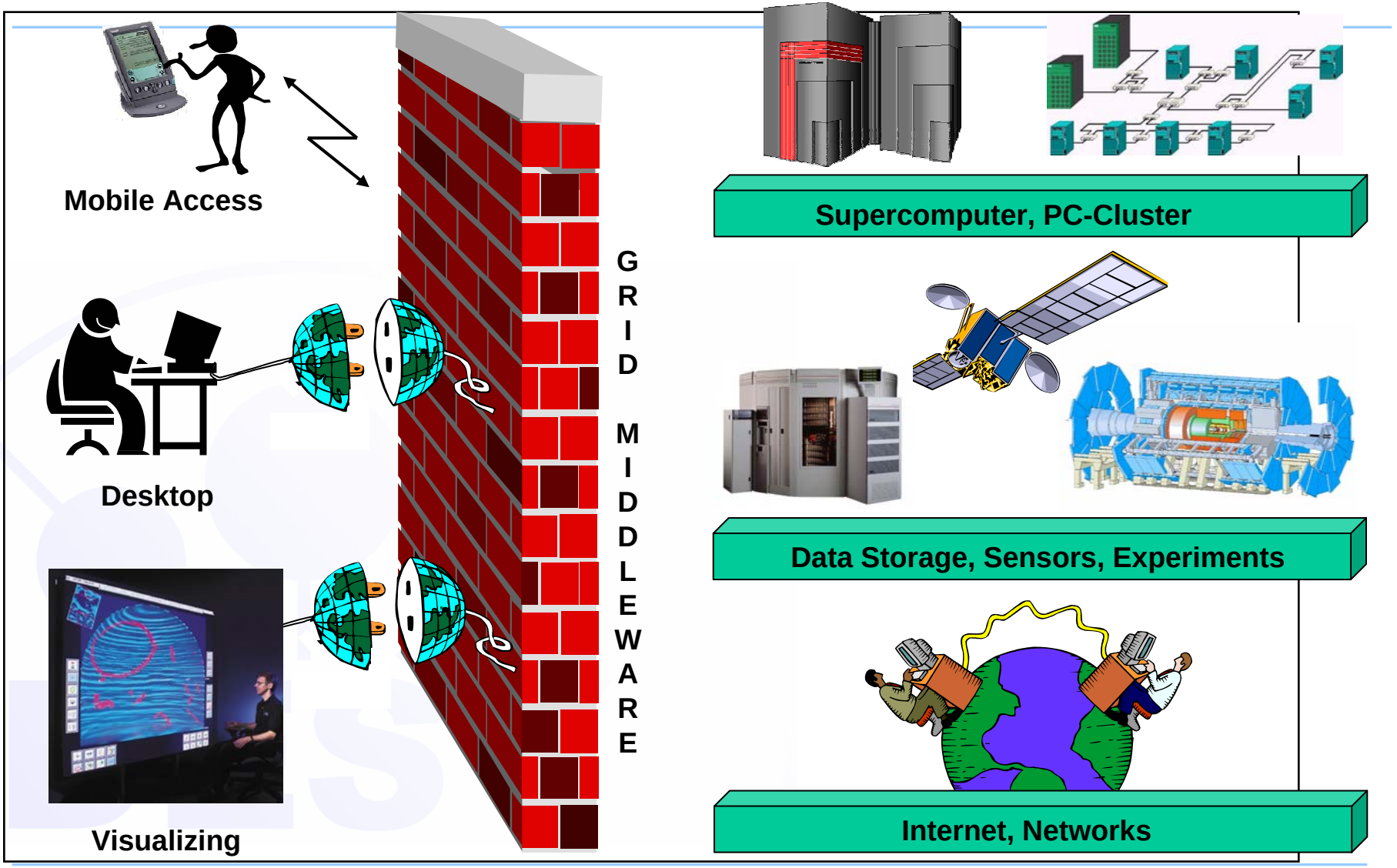
„Beyond the Net lies the Grid. While the Net allows users everywhere to share information, the Grid will allow users to share raw computing power. The goal is to put full supercomputing capabilities into the hands of anyone who needs it while providing for more efficient use of the supercomputers of tomorrow.
The potential benefits to science, government, and business may well be beyond imagination.“

GRID - *"A service for sharing computer power and data storage capacity over the Internet.“*
- CERN (European Organisation for Nuclear Research).

Grid computing - The Beginning – part2



Grid – another schematic view (historical picture)

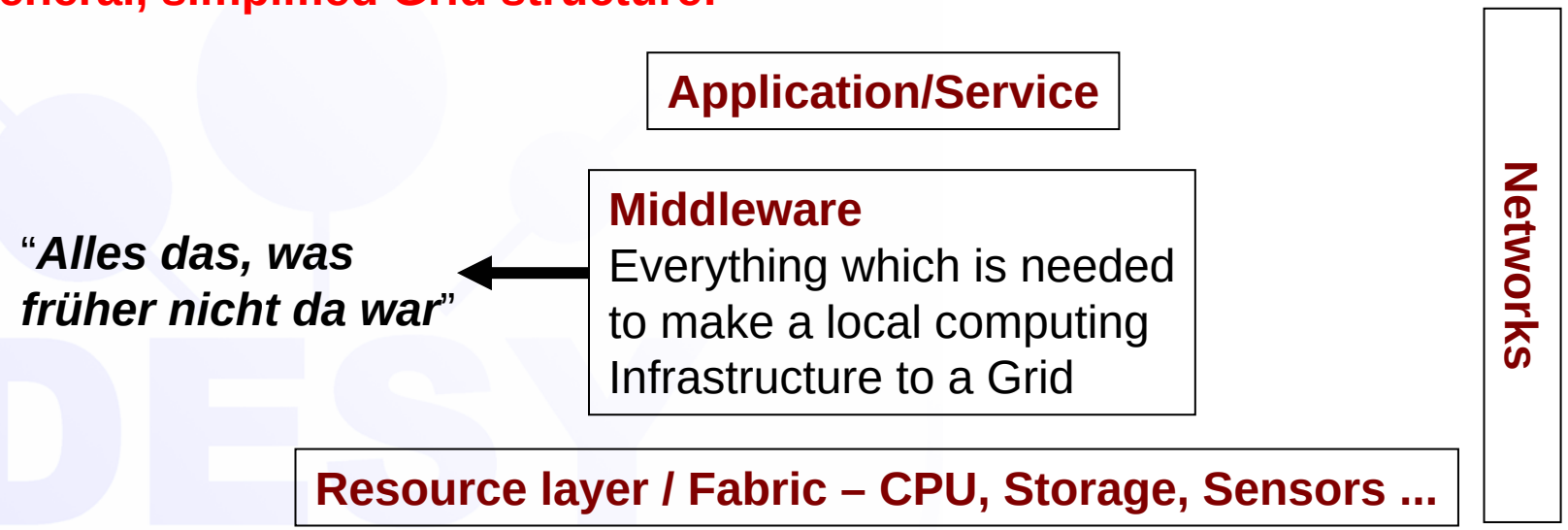


Grid computing – a popular introduction

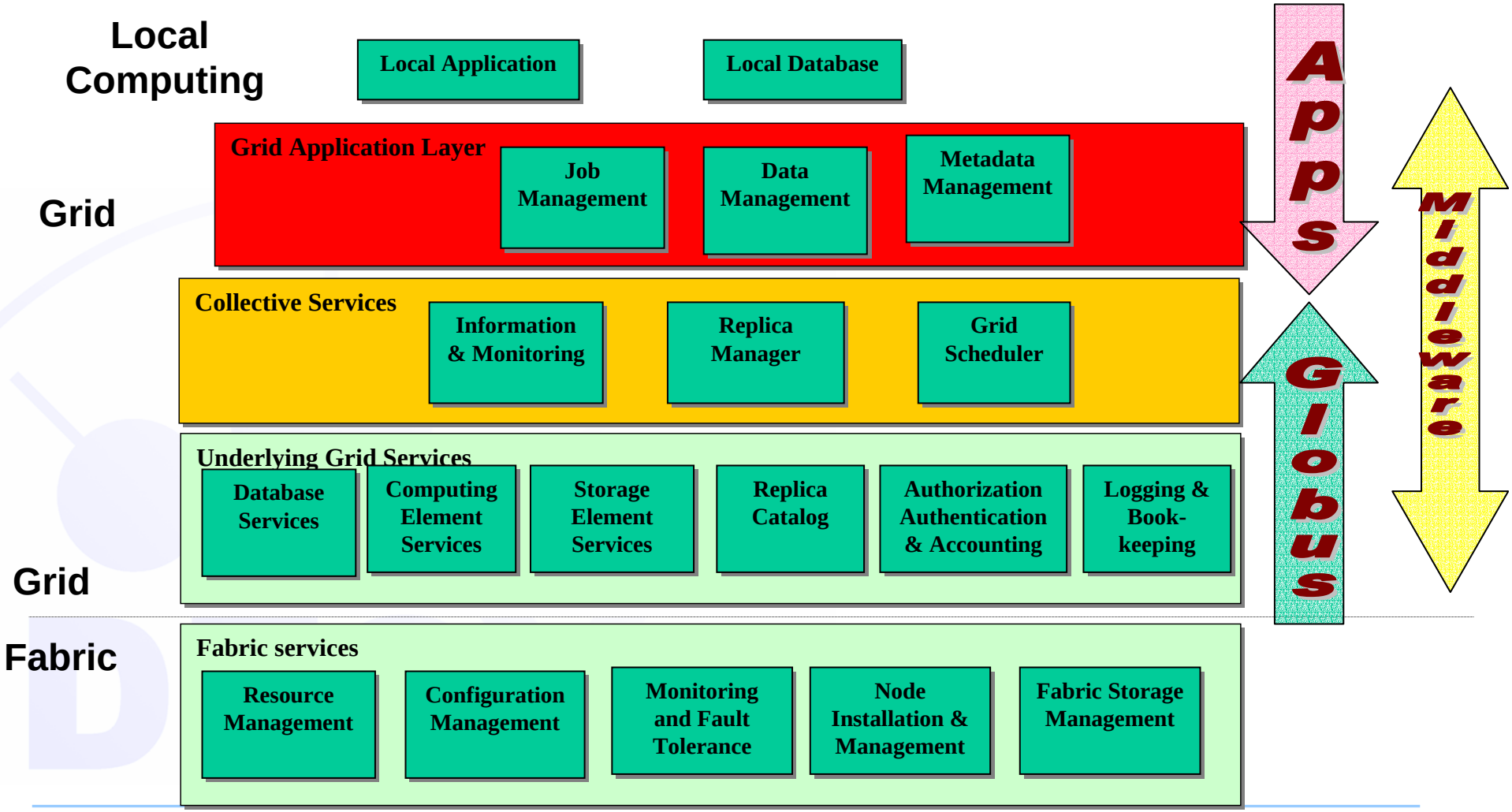
Grid

Globalization of computing resources –
CPU time, Memory, Storage, Software...
and of computing based services
(data access, accounting, billing)
AIM: most efficient global use of global resources

General, simplified Grid structure:



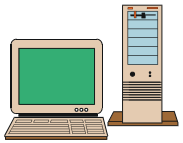
The LCG (LHC Computing Grid, see later) Architecture (Peter Kacsuk)



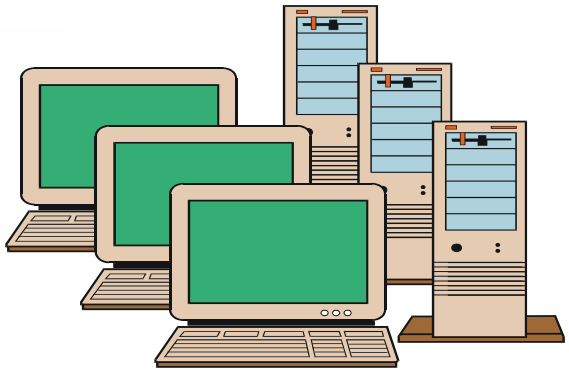
Grid computing – a popular introduction

From Workgroup Servers to Grids, globalization process, local observation

Local workstation, local storage



Workgroup server dedicated to local organizations



Batch on workgroup servers

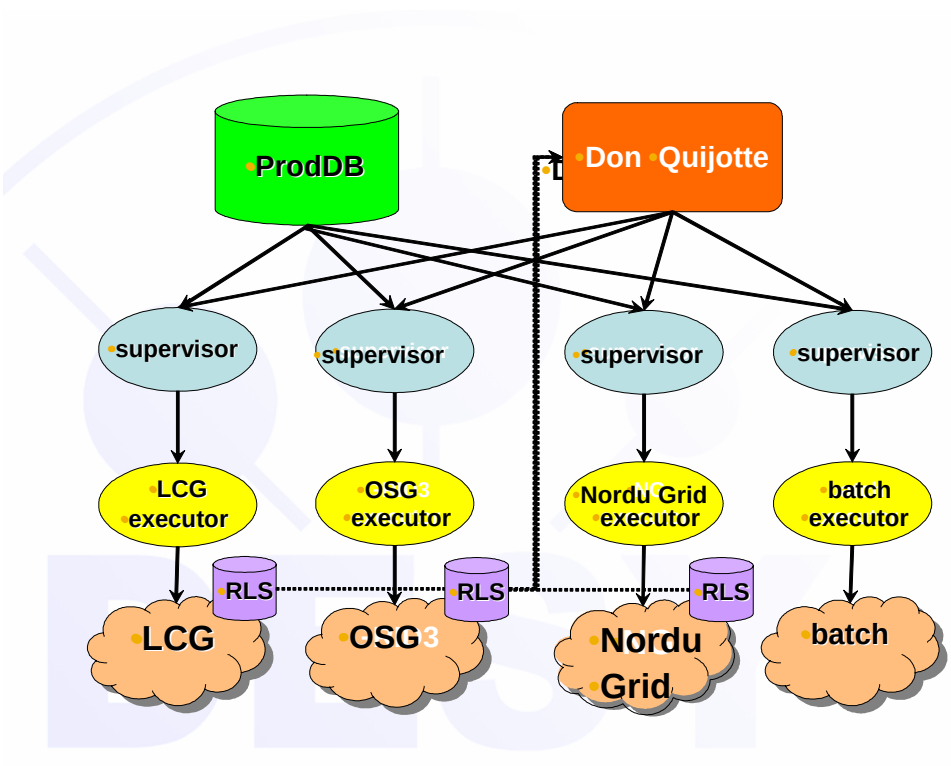
Global batch farm for all local organizations

Grid environment for virtual organizations

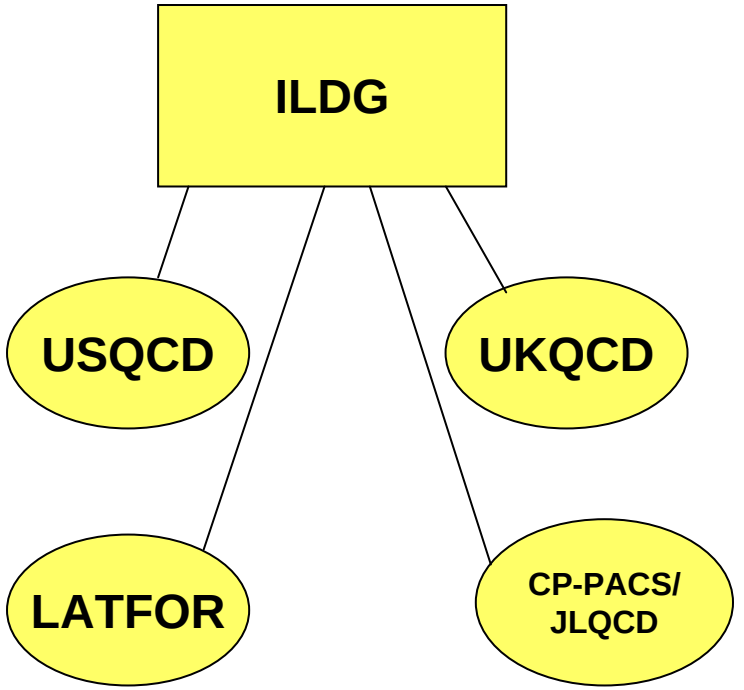
Grids …
(Foster 2005)

Grid computing – Grid-of-Grids examples

LHC Atlas Grid



International Lattice Data Grid

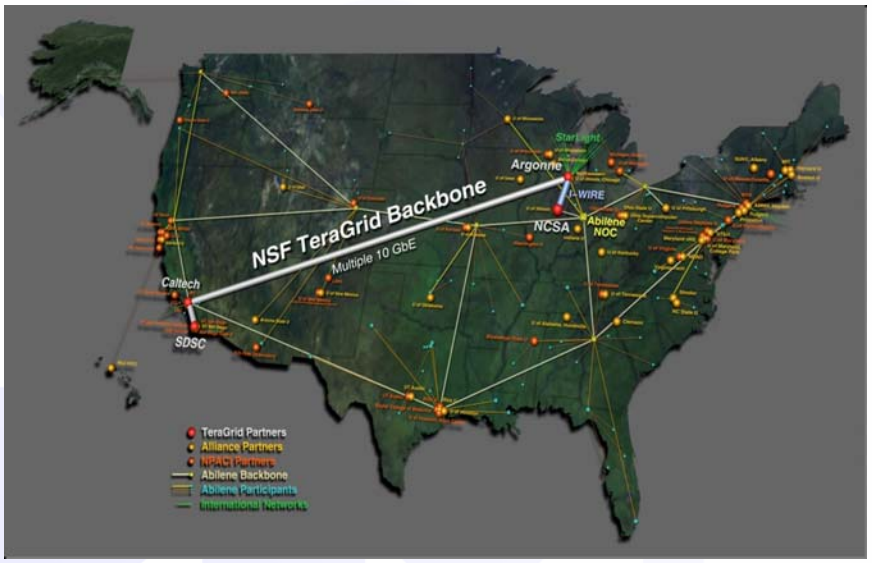


Grid computing – computing Grids

Sun computing Grid:

access to compute power as a utility service over the network for 1$ per CPU hour ...

Terra Grid:



Unicore:

UNICORE

Seamless access to Supercomputer Resources,
FZ Jülich, LRZ, … , EU

Grid computing – examples

Peer-to-Peer Examples (not considered as Grid, but converting):

@home Grids-BOINC (Berkeley Open Infrastructure for Network Computing)

seti@home

scientific experiment that uses Internet-connected computers in the Search for Extraterrestrial Intelligence (SETI)

einstein@home

Program that uses your computer's idle time to search for spinning neutron stars (also called pulsars) using data from the LIGO and GEO gravitational wave detectors

…

LHC@home

SixTrack, which simulates particles traveling around the LHC to study the stability of their orbits

Classical Grid Middleware - Globus toolkit

Key Components

- **GSI (Grid Security Infrastructure)**
  - **Grid security**
    - When requesting a service, the user presents an X.509 certificate, usually a proxy certificate**.**
- **MDS (Monitoring and Discovery Service)**
  - **Interface to system and service information.**
- **GRAM (Grid Resource Allocation Manager)**
  - **Remote job submission and control.**
- **GridFTP**
  - **Secure data transfer.**

Globus Toolkit: Recent History

- **GT2 (2.4 released in 2002)**
  - **GRAM, MDS, GridFTP, GSI.**
- **GT3 (3.2 released mid-2004): *redesign***
  - **OGSA (Open Grid Service Architecture) - OGSI (Open Grid Services Infrastructure) based.**
  - **Introduced “Grid services” as an extension of web services.**
  - **OGSI now abandoned.**
- **GT4 (2005): *redesign***
  - **WSRF (Web service Resource Framework) based.**
  - **Grid standards merged with Web services.**

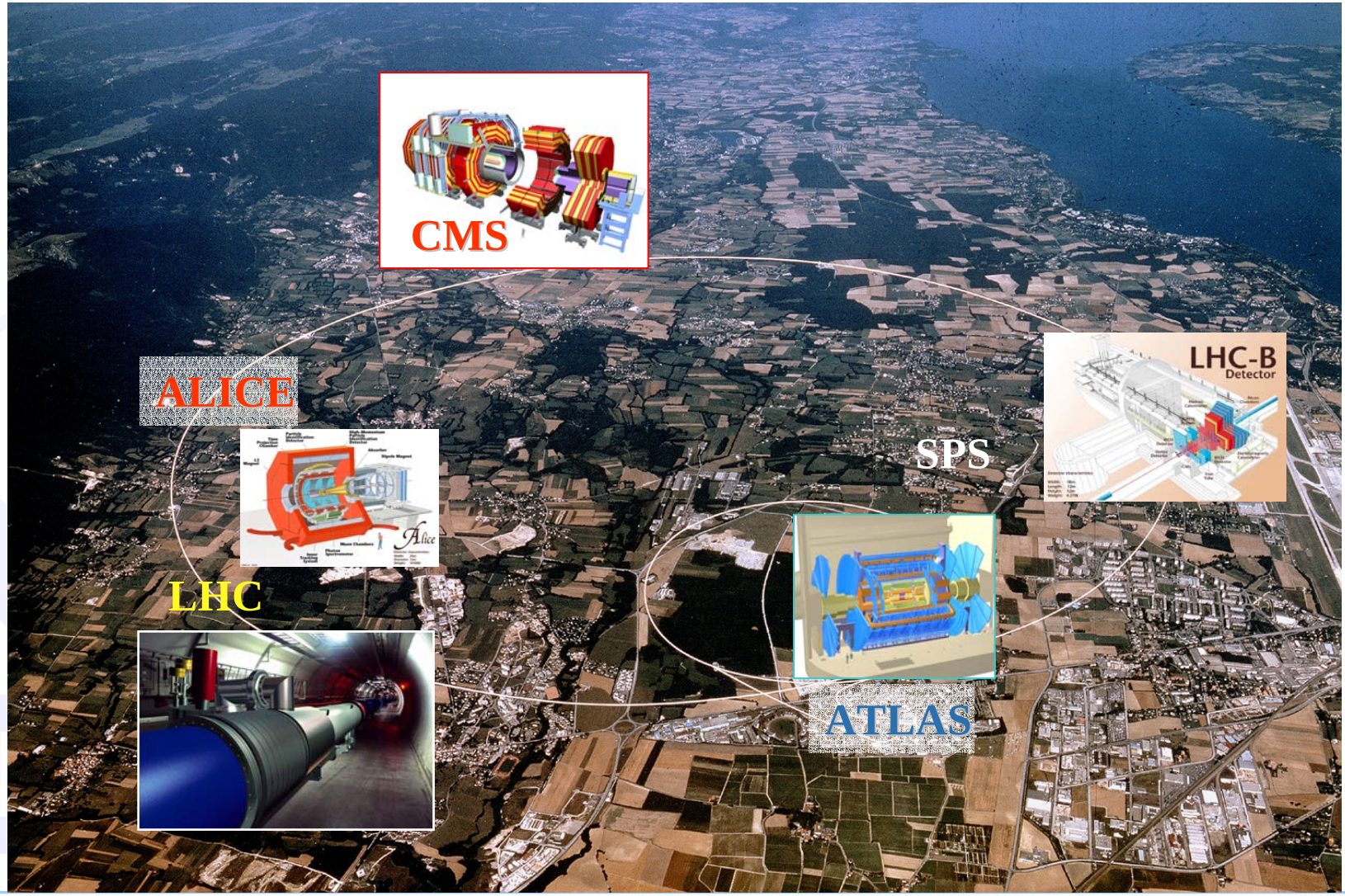
Grid computing – Virtual Organizations

Grid key component
The Virtual Organization (VO)

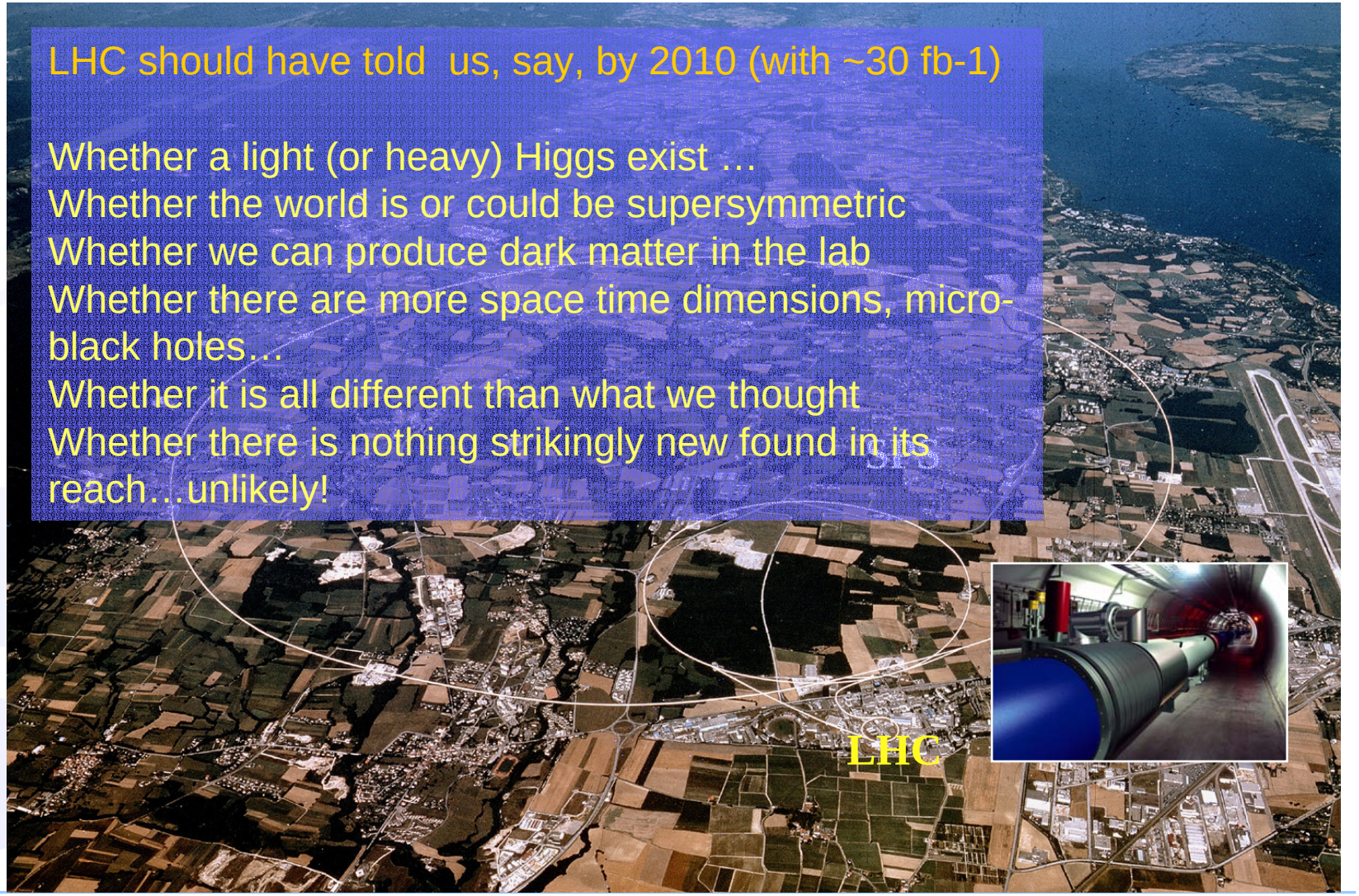
The real and specific problem that underlies the Grid concept is *coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organizations*. The sharing that we are concerned with is not primarily file exchange but rather direct access to computers, software, data, and other resources, …
(Foster et. al "The Anatomy of the Grid")

VOs: A set of collaborators bound together by a project of common interest.
In general, VO members are from different institutions:
application service providers, storage service providers, cycle providers, …, members of an industrial consortium, …, multiyear high energy physics collaborations

CERN Large Hadron Collider (LHC)- Experiments



CERN Large Hadron Collider - Goals



CERN Large Hadron Collider - The Data

Per experiment:

- 40 million collisions per second
- After filtering, 100 collisions of interest per second
- A Megabyte of digitised information for each collision = recording rate of 100 Megabytes/sec
- 1 billion collisions recorded = 1 Petabyte/year

With four experiments, processed data we will accumulate 15 PetaBytes of new data each year

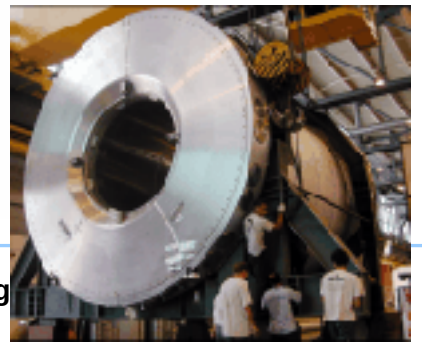
1 Megabyte (1MB)
A digital photo
1 Gigabyte (1GB)
= 1000MB
A DVD movie
1 Terabyte (1TB)
= 1000GB
World annual book production
1 Petabyte (1PB)
= 1000TB
10% of the annual production by LHC experiments
1 Exabyte (1EB)
= 1000 PB
World annual information production

= 1% of

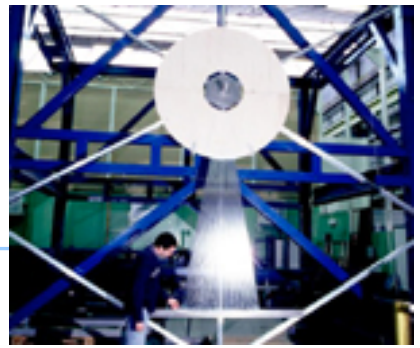
CMS

LHCb

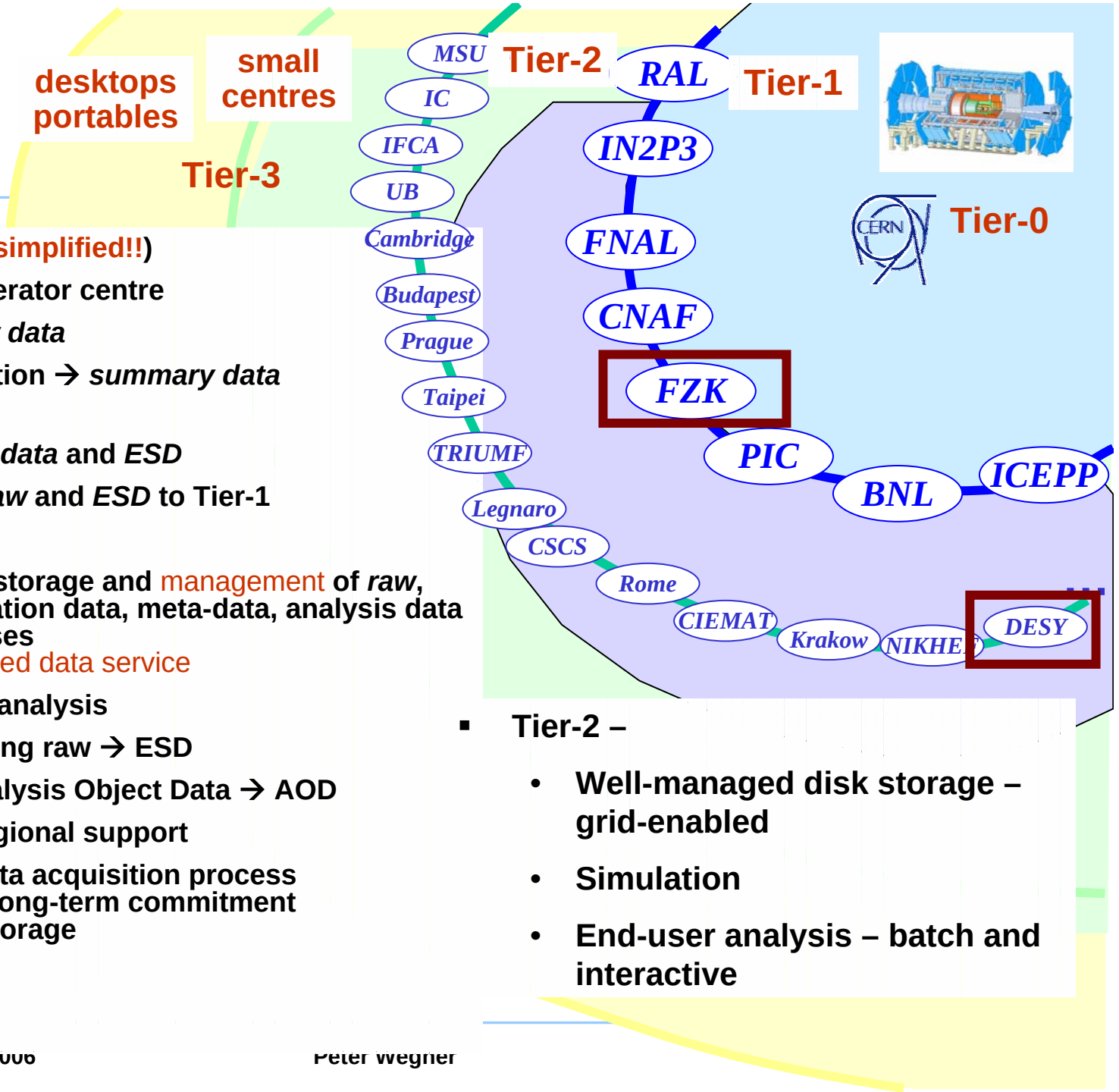
ATLAS



ALICE



LCG Tier structure
(Les Robertson, mod.)



LHC Computing Model (simplified!!)

- **Tier-0 – the accelerator centre**
  - **Filter → *raw data***
  - **Reconstruction → *summary data***
    - **(ESD)**
  - **Record *raw data* and *ESD***
  - **Distribute *raw* and *ESD* to Tier-1**
- **Tier-1 –**
  - **Permanent storage and management of *raw*, *ESD*, calibration data, meta-data, analysis data and databases → grid-enabled data service**
  - **Data-heavy analysis**
  - **Re-processing raw → ESD**
  - **Provide Analysis Object Data → AOD**
  - **National, regional support**

"online" to the data acquisition process high availability, long-term commitment managed mass storage

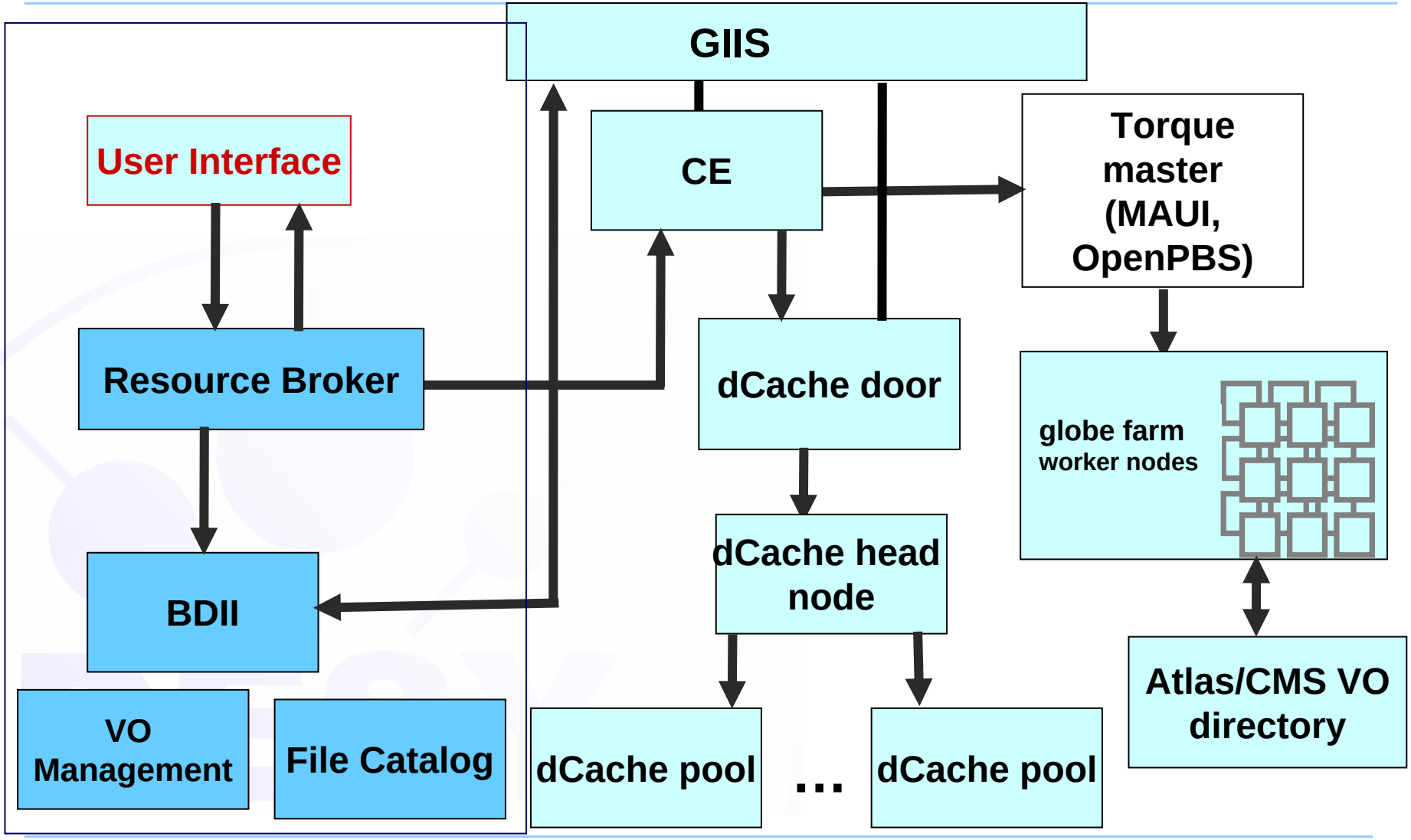
- **Tier-2 –**
  - **Well-managed disk storage – grid-enabled**
  - **Simulation**
  - **End-user analysis – batch and interactive**

Grid computing – LCG

The LCG (LHC Computing Grid) approach – components, items

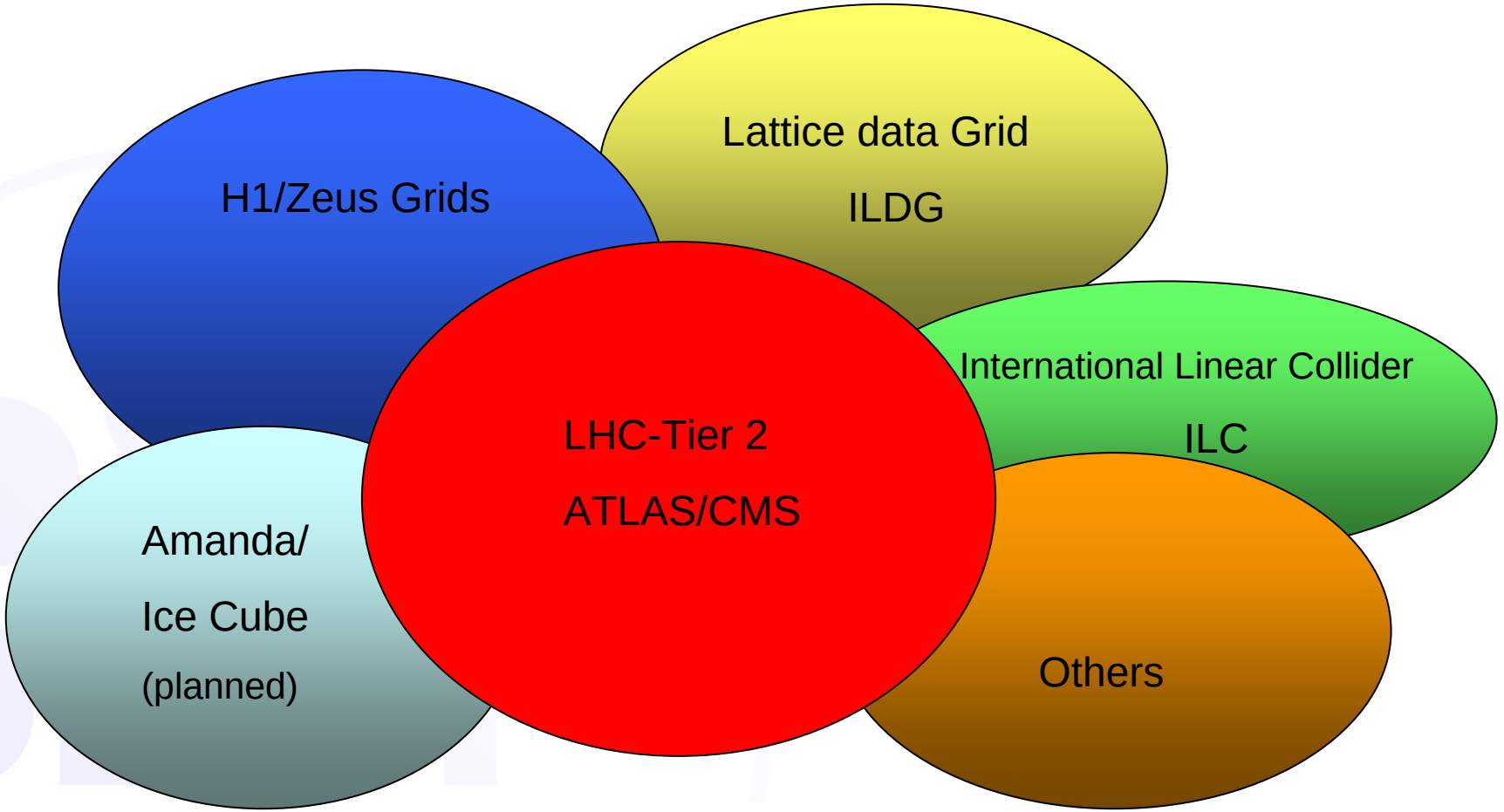
- **Global Resource Management (Resource Broker – RB)**
- **Authentication, Certificates, Globus Security Infrastructure - GSI**
- **Information Services (BDII, site BDII, GIS)**
- **Catalogs (LCG File Catalog – LC)**
- **Computing Element CE**
- **Worker nodes WN**
- **Storage Elements SE**
- **User Interface UI**

DESY Tier2 Services (LCG in action)



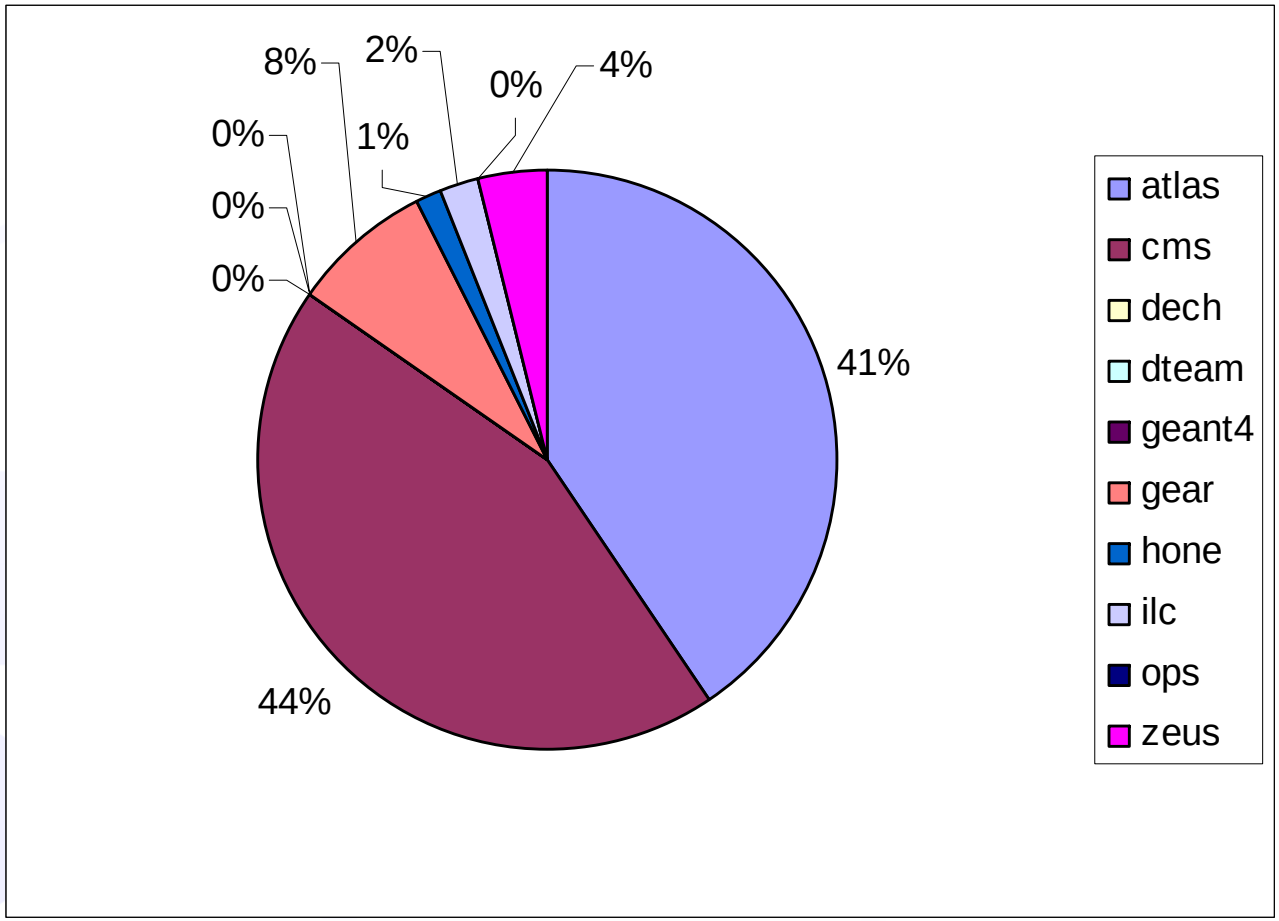
Grids at Desy

Supported Virtual Organizations at DESY



Grid production

Typical CPU time distribution (Zeuthen)



Grid Services

Linux OS: SL3, SL4 32/64 bit

LCG Middleware for all Grids (recently glite 3.0)

- **Central Services**
  - **Certificates (CA – FZ Karlsruhe, DFN)**
  - **Resource Brokers (RB)**
  - **Central VO services for non-LHC VOs (VOMS)**
  - **Information Index (BDII)**
  - **File Catalog (LFC)**

- **Site Services**
  - **Site BDIIs, information services**
  - **Computing Elements**
  - **SRM/dCache based Storage Elements**
  - **VO specific software: VO directory, VO Box (CMS)**

Shared Infrastructure at the Hamburg computer centre

DESY Infrastructure Services (Mail, Web, AFS, Backup, User Registry)

Wide Area Router and Firewall

Wide Area Network (DFN XWin)

DESY LAN

General Computing Environment, Specific to the Tier-2 center

- VO specific Infrastructure Servers
  - Calibr. DB
  - PhEDEx
  - ...
- Install Servers (Quattor)
- Gateways/ Proxies
- Monitoring, Alarming *
- Console Server

Proposed for 2007
- 10Gbps VPN => GridKa
- 1 Gbps shared

CPU Farm für
- Selection
- MC Production
- Digitization
- ...

Network Switch
> 300 GigE, 10GigE

Network Attached Data Servers

Storage Managed by dCache

The Hamburg Tier-2 centre

Status April 2006

Integrated Grid infrastructure, Zeuthen

Grid User

Grid environment

Local environment

Local User

Grid Farm management Torque

Local/global Farm management SUN Gridengine SGE

Global farm worker nodes

Local/global farm

Global/Local Storage

Attempt to combine local and Grid Batch Service

Grid Network Layer - Connectivity

- DESY-HH today has a 1 Gb/s ET XWIN-connection
- Bandwidth will be (according to the needs) at the beginning 300 Mb/s or 600 Mb/s
- Plan to have a 1Gb/s VPN: HH <-> Zeuthen, Autumn 2006
- VPN connection to GridKa Karlsruhe (p2p) (likely 10 Gb/s in 2007)

LHC Grid at DESY (see demonstration)

DESY has decided to join two LHC experiments, ATLAS and CMS
(High Level Trigger, Physics analysis, …, ATLAS Job monitoring under consideration)

In addition

DESY has established a Tier2 joint Hamburg-Zeuthen project for ATLAS and CMS where both experiments are supported at both sites

For CMS the Tier2 is federated with RWTH Aachen

Proposed hardware resources for DESY Tier2, A=Atlas, C=CMS)

	2005	2006	2007	2008	2009
CPU [kSI2k]	100 A 100 C	400 A 400 C	700 A 700 C	700 A 900 C	900 A 1200 C
Disk [TB]	15 A 15 C	100 A 100 C	340 A 200 C	340 A 200 C	570 A 300 C
Tape [TB] (?)	10 A 10 C	50 A 50 C	200 A 100 C	340 A 200 C	570 A 300 C

SI2k - SPECint2000 (from the Standard Performance Evaluation Corporation)

Today – 1CPU: 1 kSI2k … 3 kSI2k

International Lattice Data Grid - ILDG

Lattice Quantum Chromodynamics (LQCD) is the numerical (Monte-Carlo-) simulation of the strong interaction between quarks using discretized space and time.
Computing power requirements: O(10-100) TFlops.
Lattice QCD projects generate large sets of files representing gluon states through a sequence of simulation times.

The International Lattice DataGrid was proposed 2001

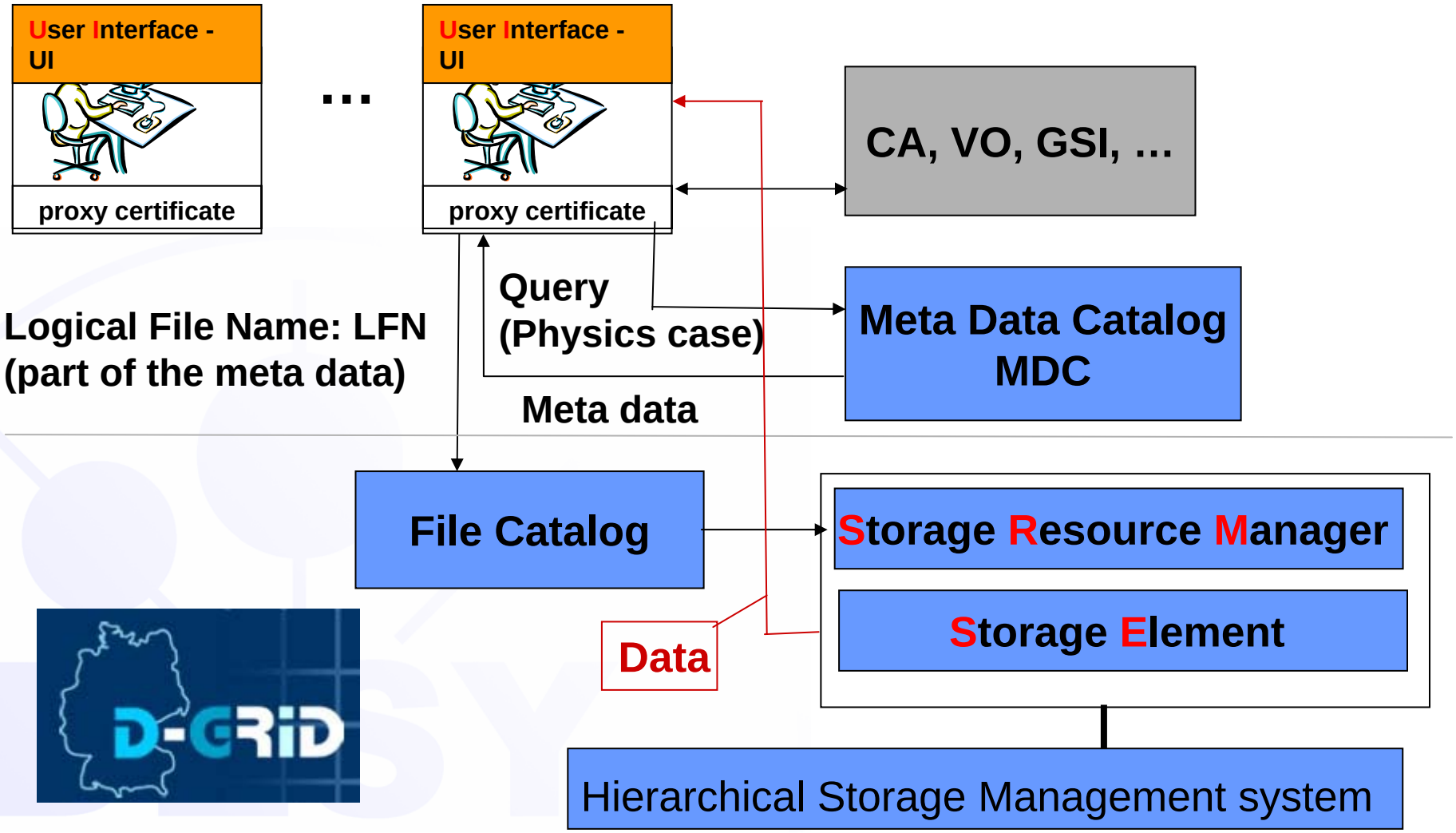
AIM: **Long term storage and global sharing of gauge configurations within a data grid**

→ **Make more efficient use of expensive data**

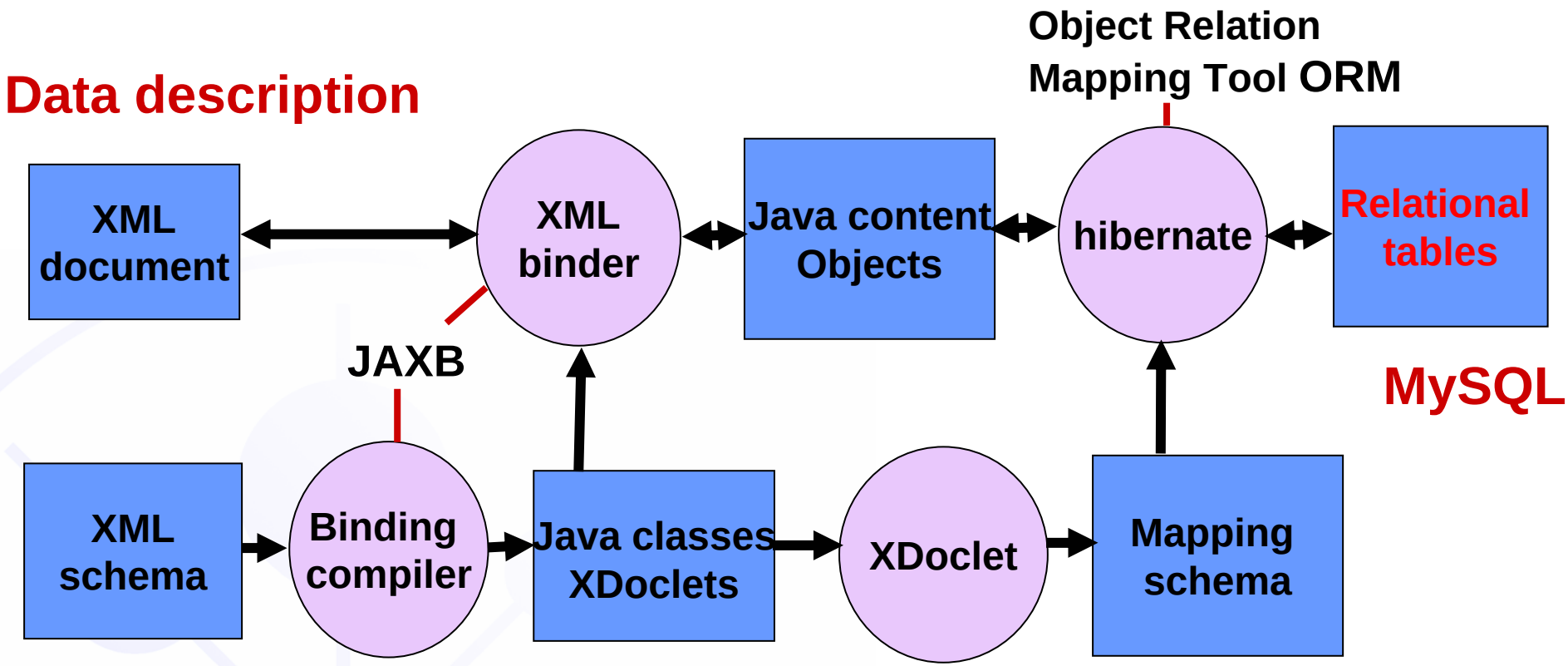
Participants: France, Germany, Italy, Japan, UK, USA, Australia
Working groups: Metadata working group, Middleware working group

http://www.lqcd.org/ildg

International Lattice Data Grid - ILDG



International Lattice Data Grid – ILDG
Metadata catalog implementation



Transforming XML documents into relational tables

The DESY GRID Core-Team (Credits)

- Uwe Ensslin (Operating systems, Tools)
- Michael Ernst (SC3/4, Software Coordination CMS)
- Patrick Fuhrmann (dCache)
- Martin Gasthuber (Fabric, Project Managment)
- Andreas Gellrich (Middleware, VO Managment, Experiment Software)
- Volker Gülzow (Tier2 Project Leader)
- Andreas Haupt (Middleware, Batchsystem)
- David Melkumyan (ILDG – Metadata Catalog)
- Dirk Pleiter (Middleware, ILDG)
- Peter Wegner (Fabric, Batchsystem, Project Managment)
- Stefan Wiesand (Operating systems, Tools)

LCG links

http://gridportal.hep.ph.ic.ac.uk/rtm/embeded_rtm_1024x768.html

GOC monitoring status

http://goc.grid.sinica.edu.tw/gstat/DESY-ZN/

LCG google map

http://goc02.grid-support.ac.uk/googlemaps/lcg.html