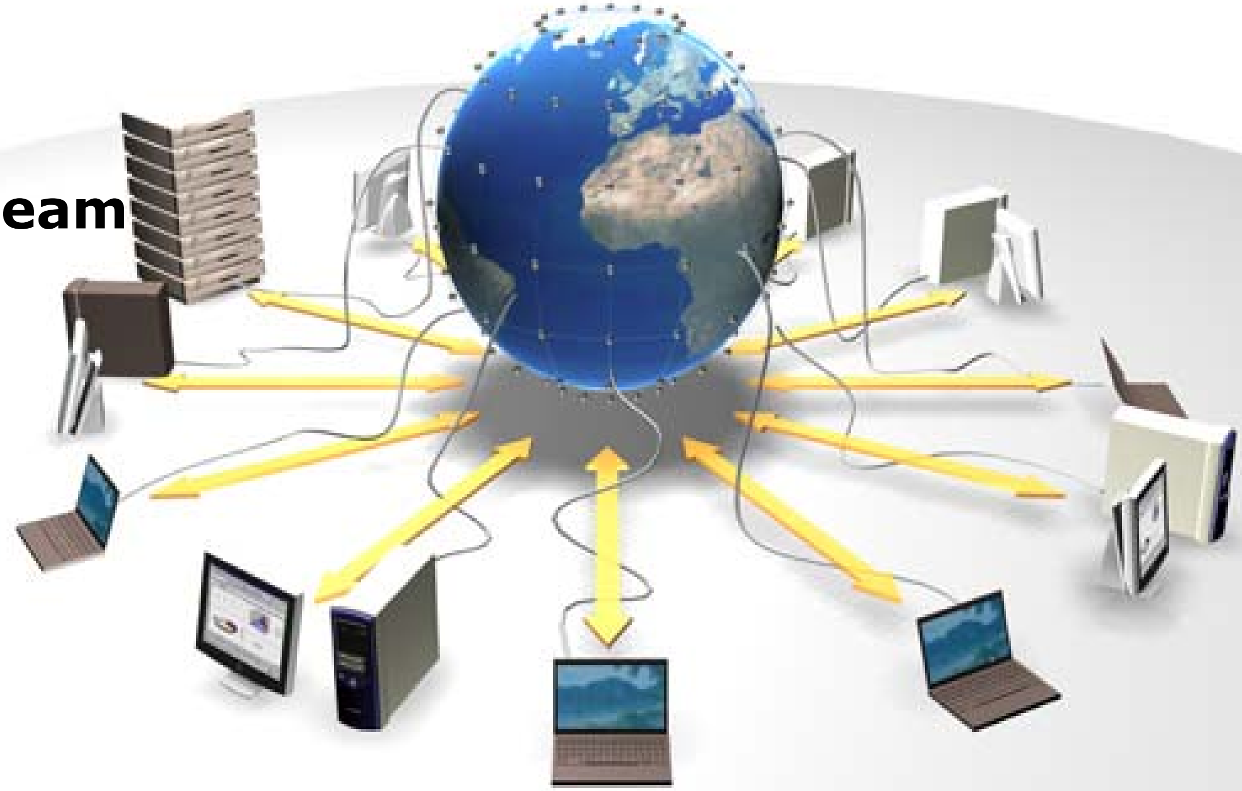
Introduction to Grid computing and overview of the European Data Grid Project

The European DataGrid Project Team



http://www.eu-datagrid.org

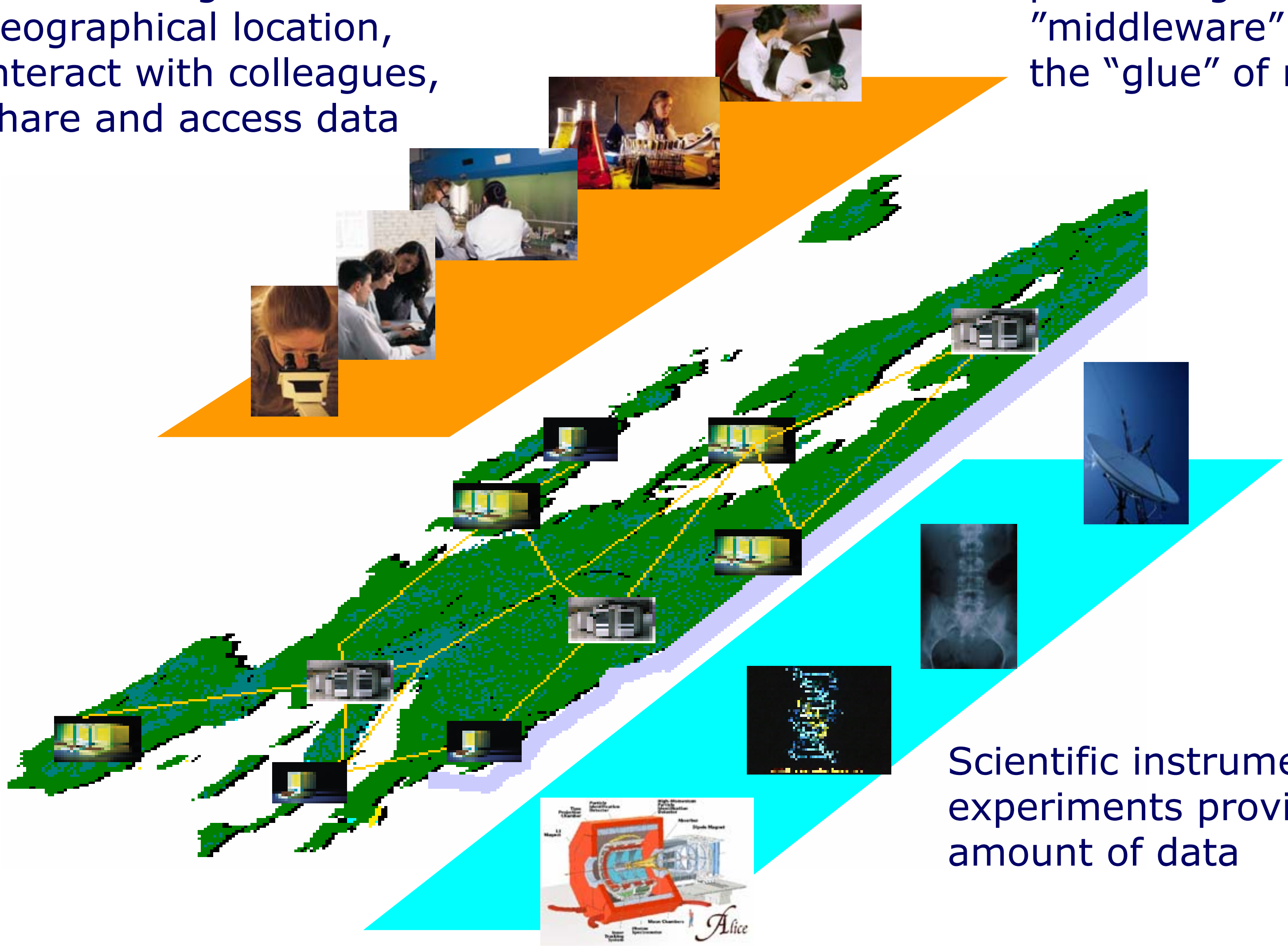
Overview

- What is Grid computing ?
- What is a Grid ?
- Why Grids ?
- Grid projects world wide
- The European Data Grid
  - Overview of EDG goals and organization
  - Overview of the EDG middleware components

The Grid Vision

Researchers perform their activities regardless geographical location, interact with colleagues, share and access data

The Grid: networked data processing centres and ”middleware” software as the “glue” of resources.



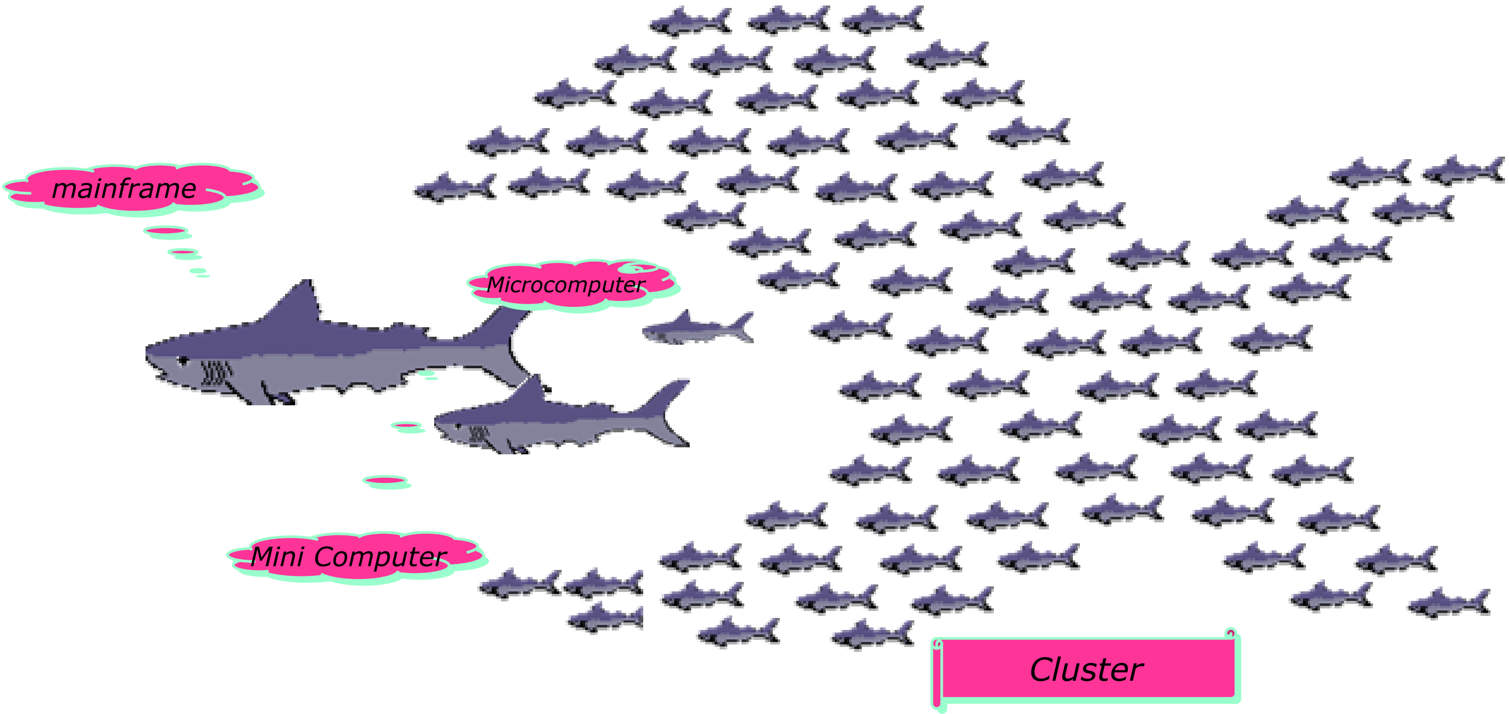
Scientific instruments and experiments provide huge amount of data

What is Grid computing :

- **coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organizations**. [I.Foster]
  - A VO is a **collection of users** sharing similar needs and requirements in their access to processing, data and distributed resources and pursuing similar goals.
- Key concept :
  - **ability to negotiate resource-sharing arrangements among a set of participating parties (providers and consumers) and then to use the resulting resource pool for some purpose** [I.Foster]

The Grid distributed computing idea 1/2

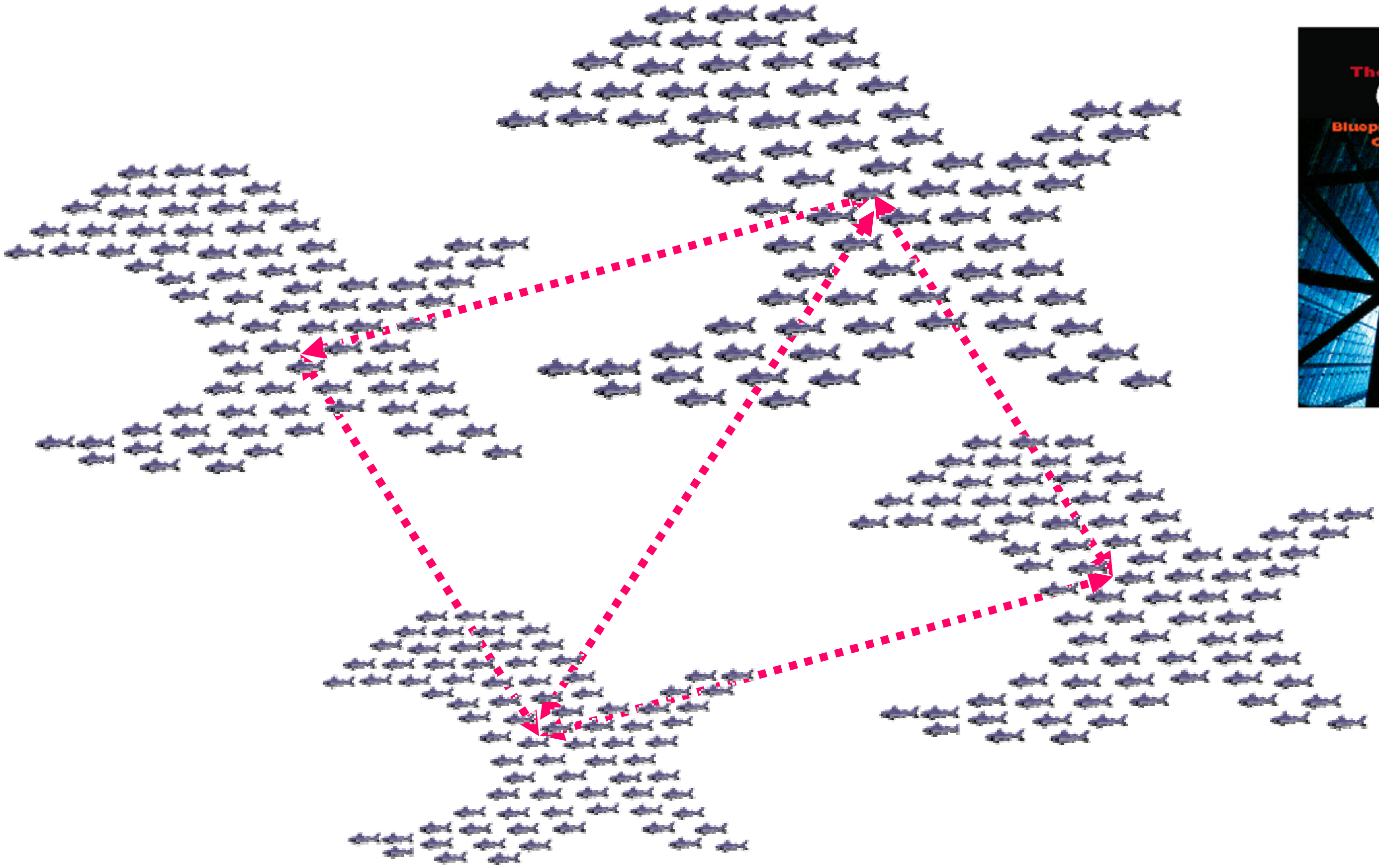
Once upon a time……..

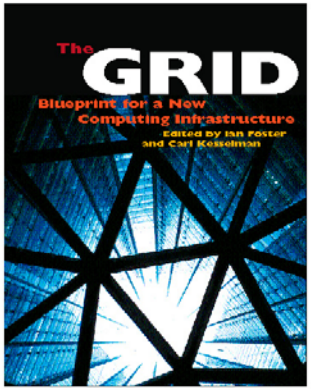


(by Christophe Jacquet)

The Grid distributed computing idea 2/2

…and today





The GRID
Blueprint for a New Computing Infrastructure
Edited by Ian Foster and Carl Kesselman

(by Christophe Jacquet)

Differences between Grids and distributed applications

- **Distributed applications** already exist, but they tend to be **specialised systems** intended for a single purpose or user group
- Grids go further and take into account:
  - Different kinds of **resources**
    - Not always the same hardware, data and applications
  - Different kinds of **interactions**
    - User groups or applications want to interact with Grids in different ways
  - **Dynamic nature**
    - Resources and users added/removed/changed frequently

Main Services of a Grid architecture

- Service providers
  - Publish the availability of their services via information systems
  - Such services may *come-and-go or change* dynamically
  - E.g. a testbed site that offers *x* CPUs and *y* GB of storage
- Service brokers
  - Register and categorize published services and provide search capabilities
  - E.g. 1) **EDG Resource Broker** selects the best site for a "job"
    2) **Catalogues** of data held at each testbed site
- Service requesters
  - **Single sign-on**: log into the grid once
  - Use brokering services to find a needed service and employ it
  - E.g. CMS physicists submit a simulation job that needs 12 CPUs for 6 hours and 15 GB which gets scheduled, via the Resource Broker, on the CERN testbed site

Grid security

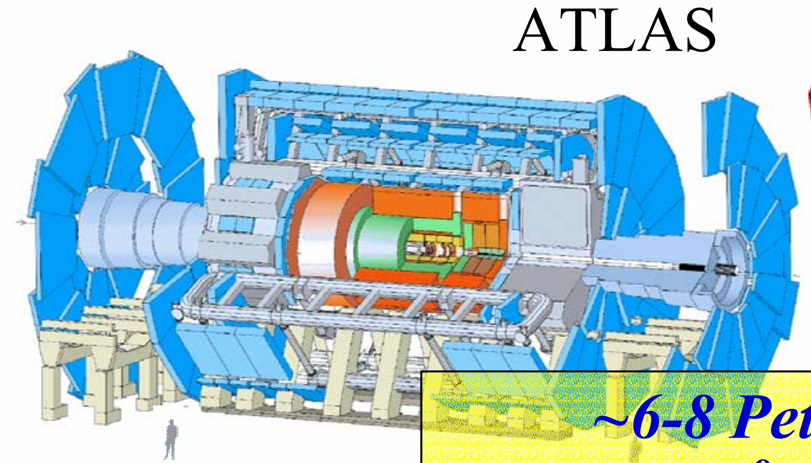
- Resource providers are essentially “opening themselves up” to itinerant users
- **Secure access** to resources is **required**
  - X.509 Public Key Infrastructure
- User’s identity has to be certified by (mutually recognized) national **Certification Authorities** (CAs)
- Resources (node machines) have to be certified by CAs
- **Temporary delegation** from users to processes to be executed “in user’s name” (proxy certificates)
- Common **agreed policies** for accessing resource and handling user’s rights across different domains within Virtual Organizations

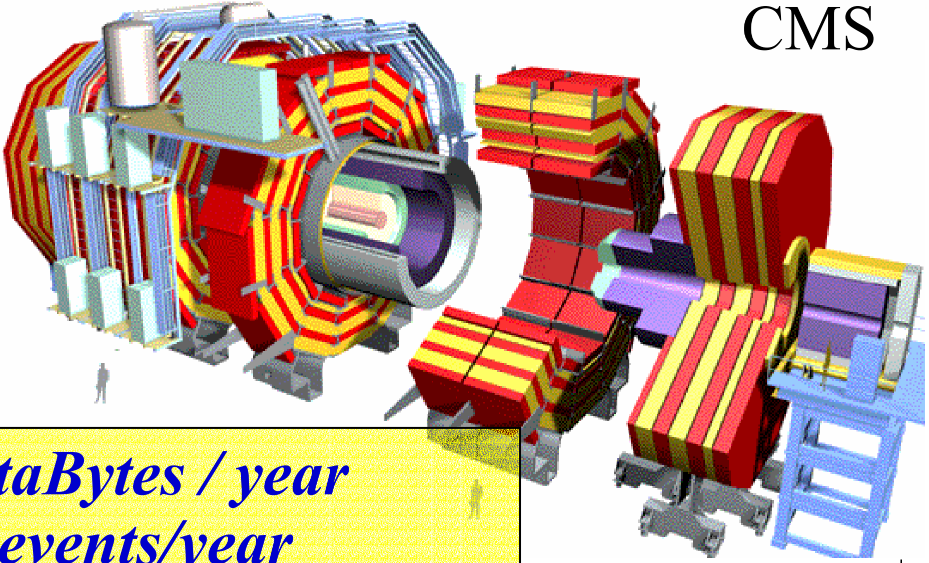
Why Grids

- **Scale** of the problems
  - frontier research in many different fields today requires world-wide collaborations (i.e. multi-domain access to distributed resources)
- Grids provide access to **large data processing power** and **huge data storage possibilities**
  - As the Grid grows its usefulness increases (more resources available)
- Large communities of possible Grid users :
  - High Energy Physics
  - Environmental studies: Earthquakes forecast, geologic and climate changes, ozone monitoring
  - Biology, Genetics, Earth Observation
  - Astrophysics,
  - New composite materials research
  - Astronautics, etc.

High Energy Physics

The LHC Detectors

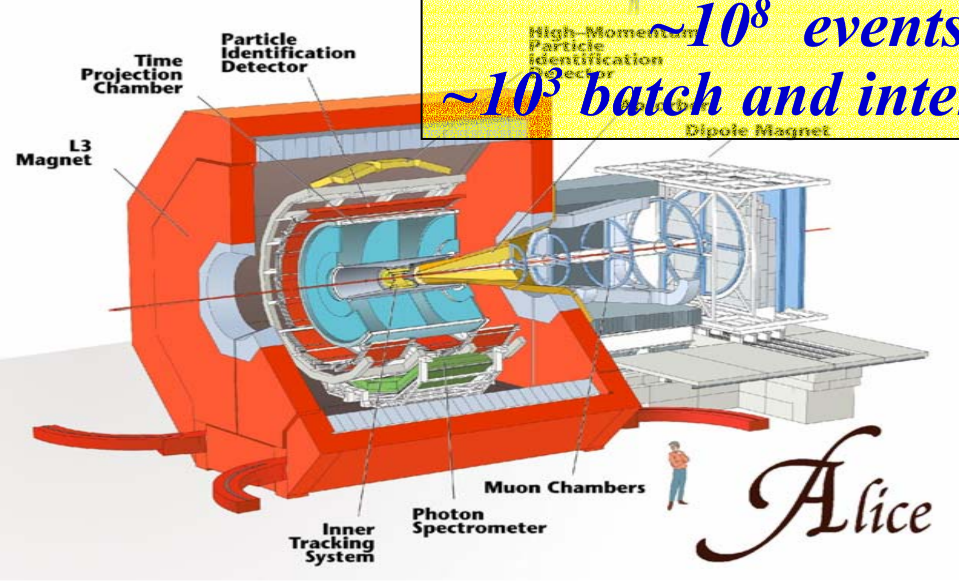


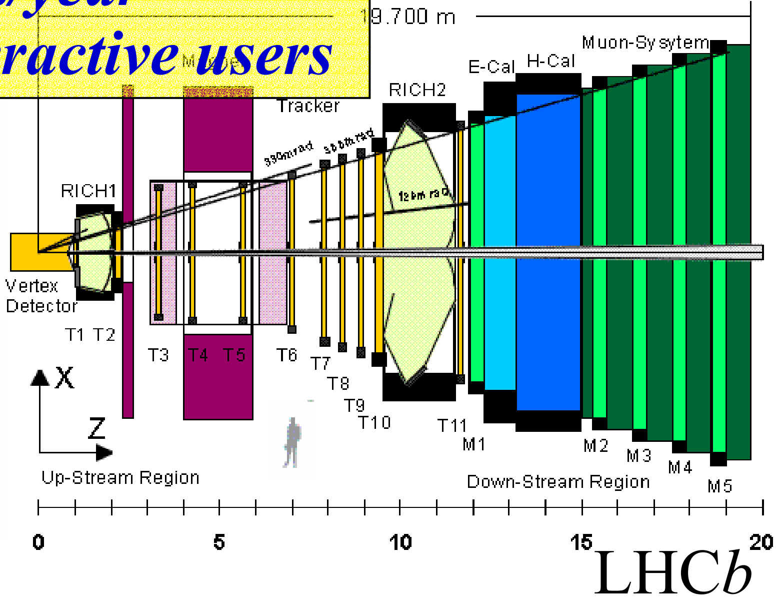


~6-8 PetaBytes / year

~10^8 events/year

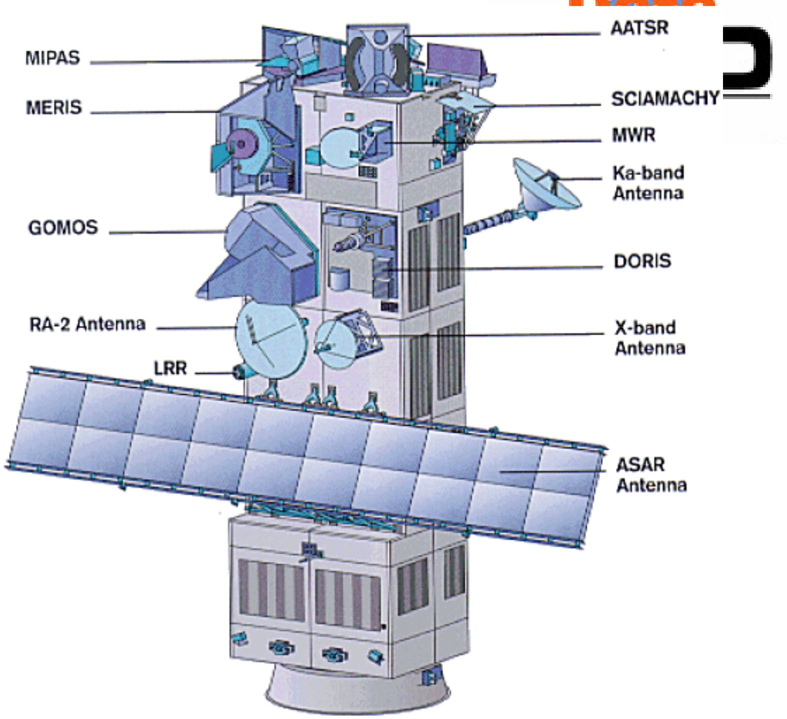
~10^3 batch and interactive users





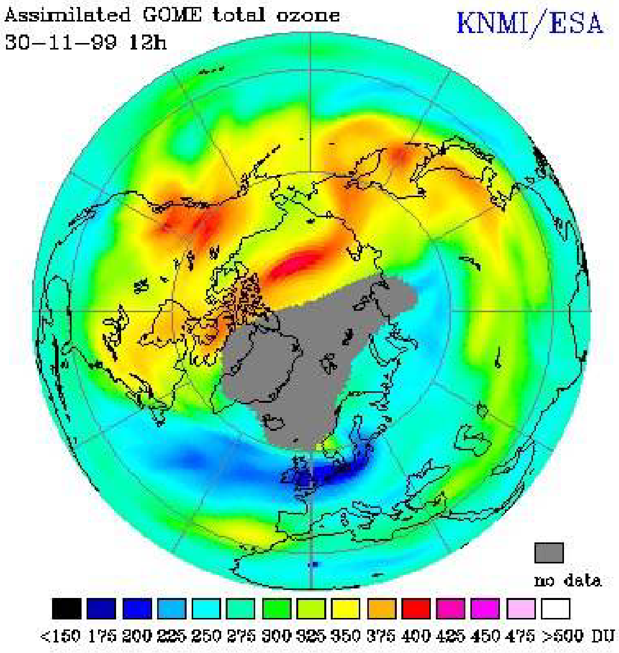
Federico.carminati , EU review presentation

Earth Observation



ESA missions:

- **about 100 Gbytes of data per day (ERS 1/2)**
- **500 Gbytes, for the next ENVISAT mission (2002).**


Assimilated GOME total ozone
30-11-99 12h
KNMI/ESA
no data
<150 175 200 225 250 275 300 325 350 375 400 425 450 475 >500 DU

DataGrid contribute to EO:

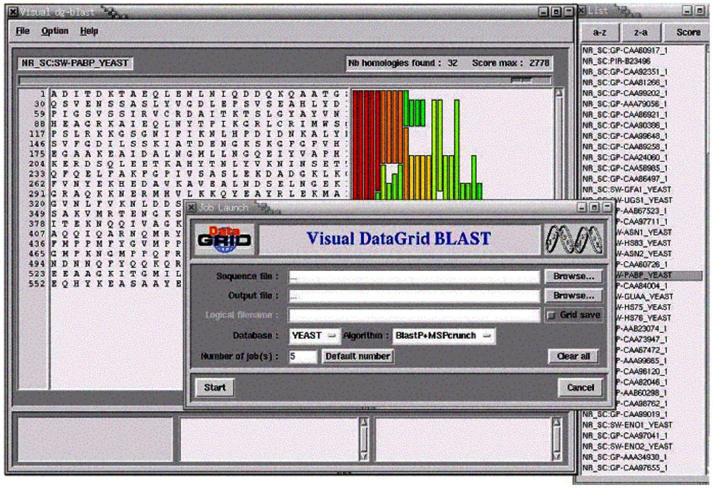
- **enhance the ability to access high level products**
- **allow reprocessing of large historical archives**
- **improve Earth science complex applications (data fusion, data mining, modelling …)**

Source: L. Fusco, June 2001

Federico.Carminati , EU review presentation, 1 March 2002

Biology – BioInformatics

- Bio-informatics
  - **Phylogenetics**
  - **Search for primers**
  - **Statistical genetics**
  - **Bio-informatics web portal**
  - **Parasitology**
  - **Data-mining on DNA chips**
  - **Geometrical protein comparison**
- Medical imaging
  - **MR image simulation**
  - **Medical data and metadata management**
  - **Mammographies analysis**
  - **Simulation platform for PET/SPECT**



NR_SC:SW-PABP_YEAST

Nb homologies found : 32   Score max : 2778

```
  1 A D I T D K T A E Q L E N L N I Q D D Q K Q A A T G
 30 Q S V E N S S A S L Y V G D L E P S V S E A H L Y D
 59 P I G S V S S I R V C R D A I T K T S L G Y A Y V N
 88 H E A G R K A I E Q L N Y T P I K G R L C R I M W S
117 P S L R K K G S G N I F I K N L H P D I D N K A L Y
146 S V F G D I L S S K I A T D E N G K S K G F G F V H
175 E G A A K E A I D A L N G M L L N G Q E I Y V A P H
204 K E R D S Q L E E T K A H Y T N L Y V K N I N S E T
233 Q F Q E L F A K F G P I V S A S L E K D A D G K L K
262 F V N Y E K H E D A V K A V E A L N D S E L N G E K
291 G R A Q K K N E R M H V L K K Q Y E A Y R L E K M A
320 G V N L F V K N L D D S
349 S A K V M R T E N G K S
378 I T E K N Q Q I V A G K
407 A Q Q I Q A R N Q M R Y
436 F M P P M F Y G V M P P
465 G M P K N G M P P Q F R
494 N D N N Q F Y Q Q K Q R
523 E E A A G K I T G M I L
552 E Q H Y K E A S A A Y E
```

```
NR_SC:GP-CAA60917_1
NR_SC:PIR-B23496
NR_SC:GP-CAA92351_1
NR_SC:GP-CAA81266_1
NR_SC:GP-CAA99202_1
NR_SC:GP-AAA79056_1
NR_SC:GP-CAA86921_1
NR_SC:GP-CAA90386_1
NR_SC:GP-CAA99648_1
NR_SC:GP-CAA89258_1
NR_SC:GP-CAA24060_1
NR_SC:GP-CAA58985_1
NR_SC:GP-CAA86497_1
NR_SC:SW-GFA1_YEAST
W-UGS1_YEAST
P-AAB67523_1
P-CAA97711_1
W-ASN1_YEAST
W-HS83_YEAST
W-ASN2_YEAST
P-CAA60726_1
W-PABP_YEAST
P-CAA84004_1
W-GUAA_YEAST
W-HS75_YEAST
W-HS76_YEAST
P-AAB23074_1
P-CAA73947_1
P-CAA67472_1
P-AAA99665_1
P-CAA96120_1
P-CAA82046_1
P-AAB60298_1
P-CAA98762_1
NR_SC:GP-CAA99019_1
NR_SC:SW-ENO1_YEAST
NR_SC:GP-CAA97041_1
NR_SC:SW-ENO2_YEAST
NR_SC:GP-AAA34930_1
NR_SC:GP-CAA97655_1
```

Visual DataGrid BLAST

Sequence file : ...

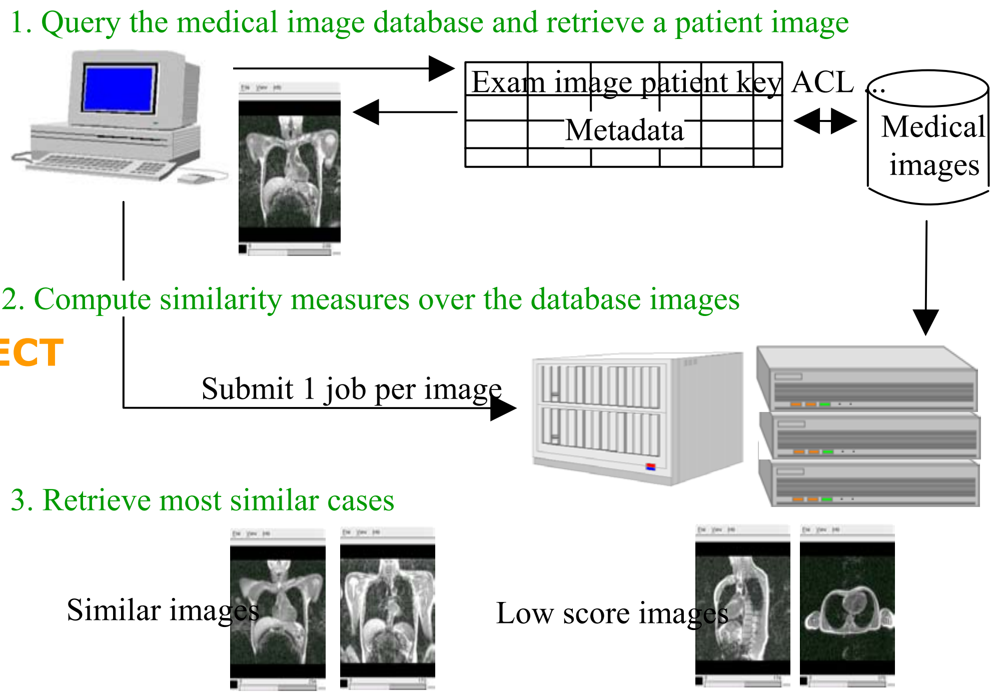
Output file : ...

Logical filename :

Database : YEAST

Algorithm : BlastP+MSPcrunch

Number of job(s) : 5


1. Query the medical image database and retrieve a patient image

Exam	image	patient	key	ACL	...
Metadata					

Medical images

2. Compute similarity measures over the database images

Submit 1 job per image

3. Retrieve most similar cases

Similar images

Low score images

🟩	Applications deployed
🟧	Applications tested on EDG
🟥	Applications under preparation

Major existing Grid projects (1/2)

◆ **Europe-based projects**:

- **European DataGrid (EDG) : 2001-2003** **www.edg.org**
- **LHC Computing GRID (LCG): 2002-2008 -….** **cern.ch/lcg**
- **CrossGrid : 2002-2005 www.crossgrid.org**
- **DataTAG : 2002-2003 www.datatag.org**
- **GridLab : 2002-2004** **www.gridlab.org**
- **EGEE : 2004-2007 ?** **www.cern.ch/egee**

European National Projects:

- **INFNGRID, UK-GridPP, NorduGrid(Nordic test bed for wide area computing)…**

Major existing Grid projects (2/2)

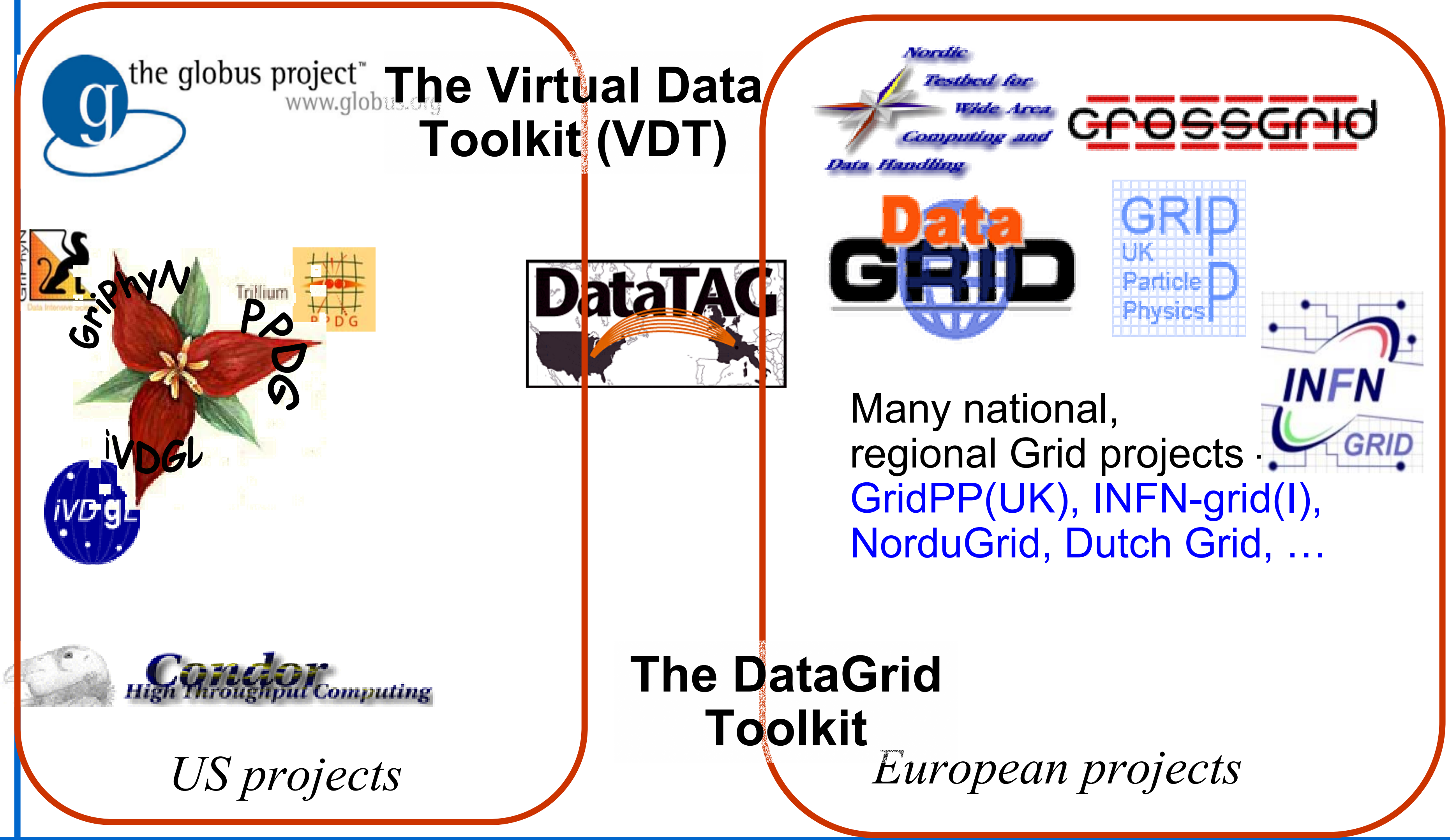
US projects:

- GriPhyN HEP www.griphyn.org
- PPDG HEP www.ppdg.net
- iVDGL (joint GriPhyN, PPDG) www.ivdgl.or
- TERAGRID (NSF) www.teragrid.org
  - IBM, Intel Qwest ,Myricom, Sun Microsystems, Oracle.
- National Middleware Initiative (NSF NMI) www.nsf-middleware.org
- ESG www.earthsystemgrid.org
- NEESgrid virtual lab earthquake engineering www.neesgrid.org
- BIRN biomedical informatics research network birn.ncrr.nih.gov/birn/

Asia-based projects:

- ApGRID www.apgrid.org
- TWGRID www.twgrid.org
- Many Grid projects in : Korea, Japan, China, Australia

Major US & European Grid Projects, many with strong HEP participation



The Virtual Data Toolkit (VDT)

Many national, regional Grid projects -- GridPP(UK), INFN-grid(I), NorduGrid, Dutch Grid, …

The DataGrid Toolkit

US projects

European projects

The European Data Grid Project

- To build on the emerging Grid technology to develop a sustainable computing model for effective share of computing resources and data
- Start : Jan 1, 2001 End : Dec 31, 2003
- Specific project objectives:
  - Middleware for fabric & Grid management (mostly funded by the EU)
  - Large scale testbed (mostly funded by the partners)
  - Production quality demonstrations (partially funded by the EU)
- To collaborate with and complement other European and US projects
- Contribute to Open Standards and international bodies:
  - Co-founder of Global Grid Forum and host of GGF1 and GGF3
  - Industry and Research Forum for dissemination of project results

The EDG Main Partners

- CERN – International (Switzerland/France)
- CNRS - France
- ESA/ESRIN – International (Italy)
- INFN - Italy
- NIKHEF – The Netherlands
- PPARC - UK

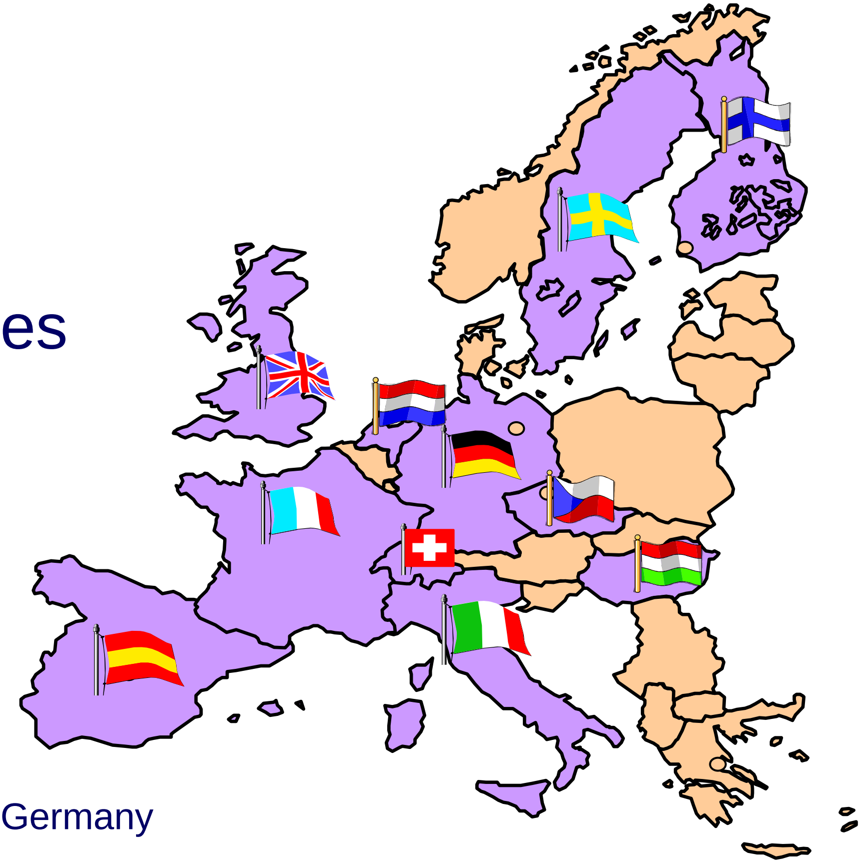
EDG Assistant Partners

Industrial Partners

- •Datamat (Italy)
- •IBM-UK (UK)
- •CS-SI (France)

Research and Academic Institutes

- •CESNET (Czech Republic)
- •Commissariat à l'énergie atomique (CEA) – France
- •Computer and Automation Research Institute, Hungarian Academy of Sciences (MTA SZTAKI)
- •Consiglio Nazionale delle Ricerche (Italy)
- •Helsinki Institute of Physics – Finland
- •Institut de Fisica d'Altes Energies (IFAE) - Spain
- •Istituto Trentino di Cultura (IRST) – Italy
- •Konrad-Zuse-Zentrum für Informationstechnik Berlin - Germany
- •Royal Netherlands Meteorological Institute (KNMI)
- •Ruprecht-Karls-Universität Heidelberg - Germany
- •Stichting Academisch Rekencentrum Amsterdam (SARA) – Netherlands
- •Swedish Research Council - Sweden



EDG overview:
Middleware release schedule

- Release schedule
  - **testbed 1:** late 2001
  - **testbed 2:** early 2003
  - **testbed 3:** end 2003
  - Incremental releases between these major dates
- Each **release** includes
  - feedback on use of previous release by application groups
  - planned improvements/extension by middle-ware groups
- **Application groups** (HEP, EO, Bio-Info) are using existing software and testbed to explore how they can best exploit grids

Current Project Status

- EDG currently provides a set of middleware services
  - Job & Data Management
  - Grid & Network monitoring
  - Security, Authentication & Authorization tools
  - Fabric Management
- EDG release 2.0 currently deployed to the EDG-Testbeds
  - GNU/Linux RedHat 7.3 on Intel PCs ~15 sites in application testbed actively used by application groups
    - Core sites CERN(CH), RAL(UK), NIKHEF(NL), CNAF(I), CC-Lyon(F)
  - EDG sw also deployed at total of ~40 sites via CrossGrid, DataTAG and national grid projects
- Final release 2.1 will be out soon
- Many applications ported to EDG testbeds and actively being used
- Intense middleware development continuously going-on

DataGrid in Numbers

People

>350 registered users

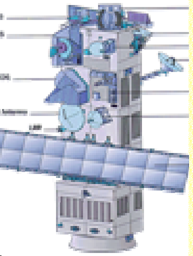
12 Virtual Organisations

16 Certificate Authorities

>500 people trained

278 man-years of effort

100 years funded



Testbeds

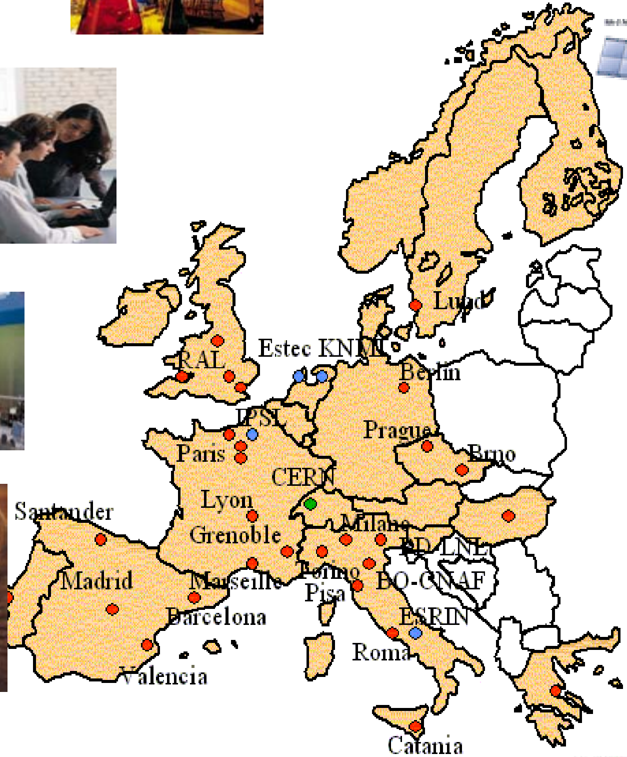
>15 regular sites

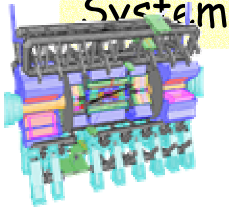
>10'000s jobs submitted

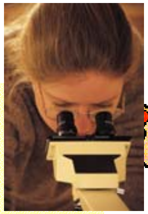
>1000 CPUs

>5 TeraBytes disk

3 Mass Storage Systems





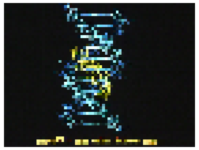


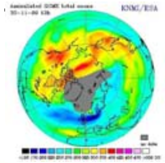
Software

50 use cases

18 software releases

>300K lines of code





GEANT

Scientific applications

5 Earth Obs institutes

9 bio-informatics apps

6 HEP experiments

EDG structure : work packages

- The EDG collaboration is structured in 12 Work Packages:

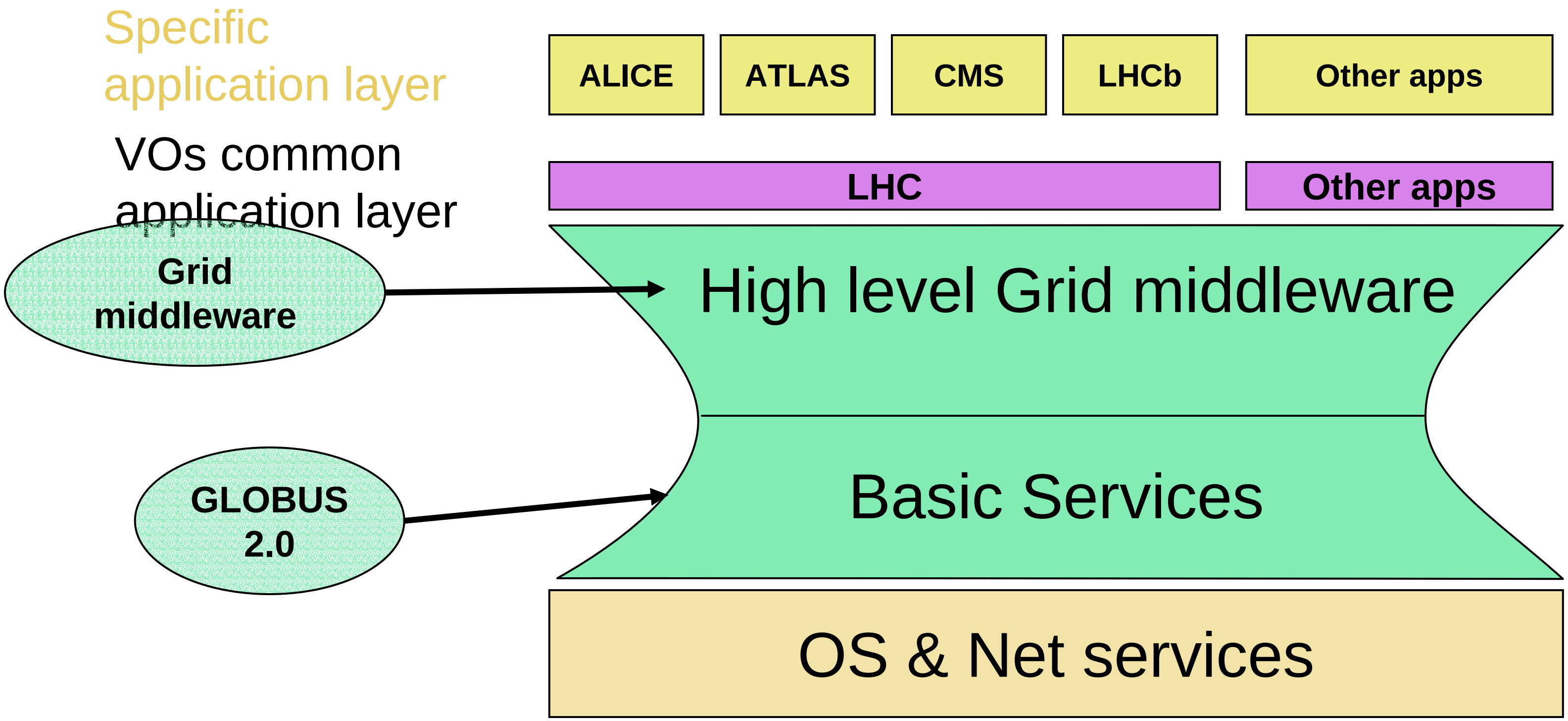
  - WP1: Work Load Management System
  - WP2: Data Management
  - WP3: Grid Monitoring / Grid Information Systems
  - WP4: Fabric Management
  - WP5: Storage Element
  - WP6: *Testbed and demonstrators*
  - WP7: Network Monitoring
  - WP8: High Energy Physics Applications
  - WP9: Earth Observation
  - WP10: Biology
  - WP11: Dissemination
  - WP12: Management

}

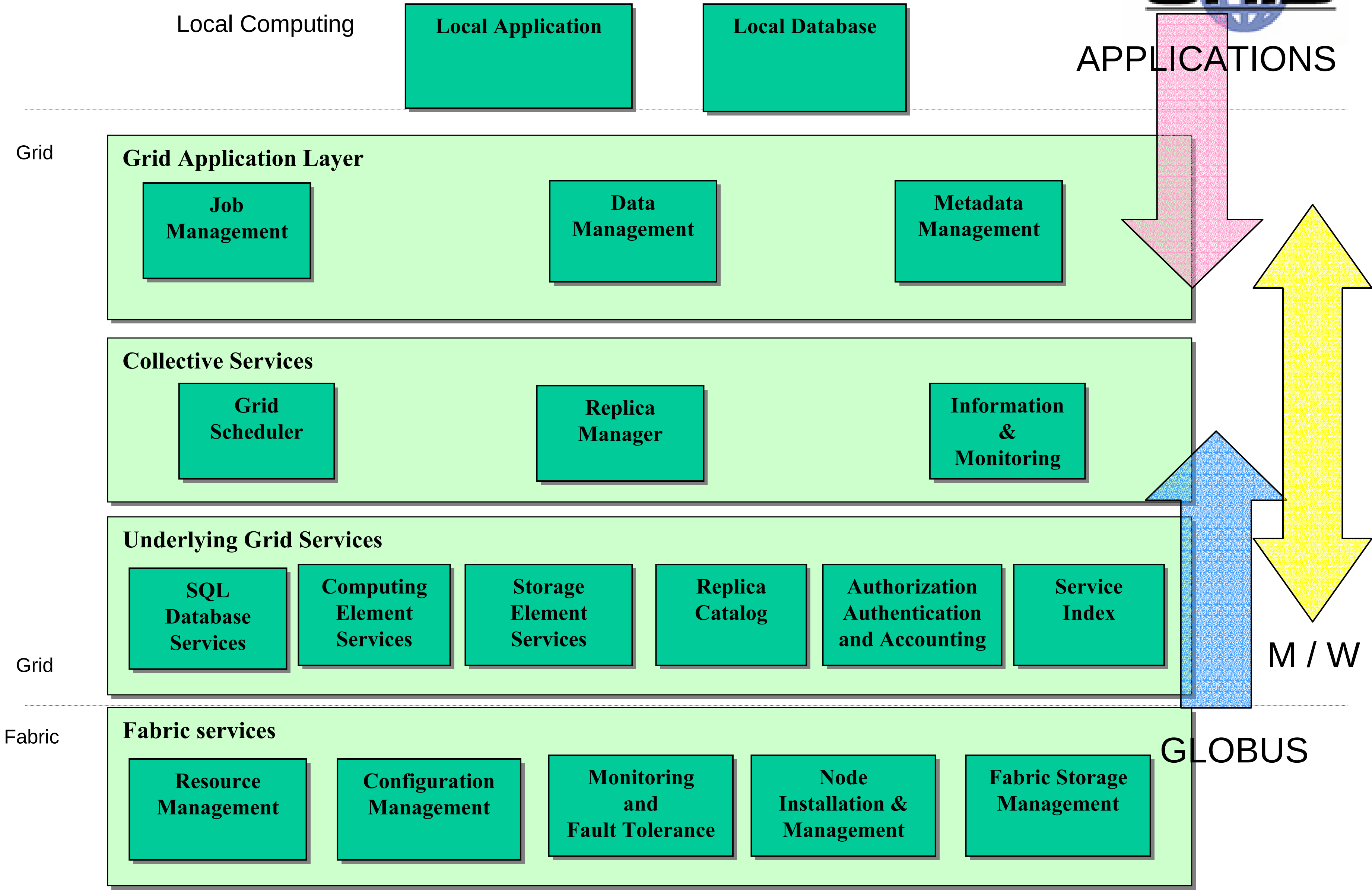
Applications

EDG Globus-based middleware architecture

- Current EDG architectural functional blocks:
  - **Basic Services** (authentication, authorization, Replica Catalog , secure file transfer, Info Providers) rely on Globus 2.0
  - **Higher level EDG middleware.** (developed within EDG)
  - **Applications** (HEP,BIO,EO)



EDG middleware Grid architecture



Local Computing

Local Application

Local Database

APPLICATIONS

Grid

Grid Application Layer

Job Management

Data Management

Metadata Management

Collective Services

Grid Scheduler

Replica Manager

Information & Monitoring

Underlying Grid Services

SQL Database Services

Computing Element Services

Storage Element Services

Replica Catalog

Authorization Authentication and Accounting

Service Index

Grid

M / W

Fabric

Fabric services

Resource Management

Configuration Management

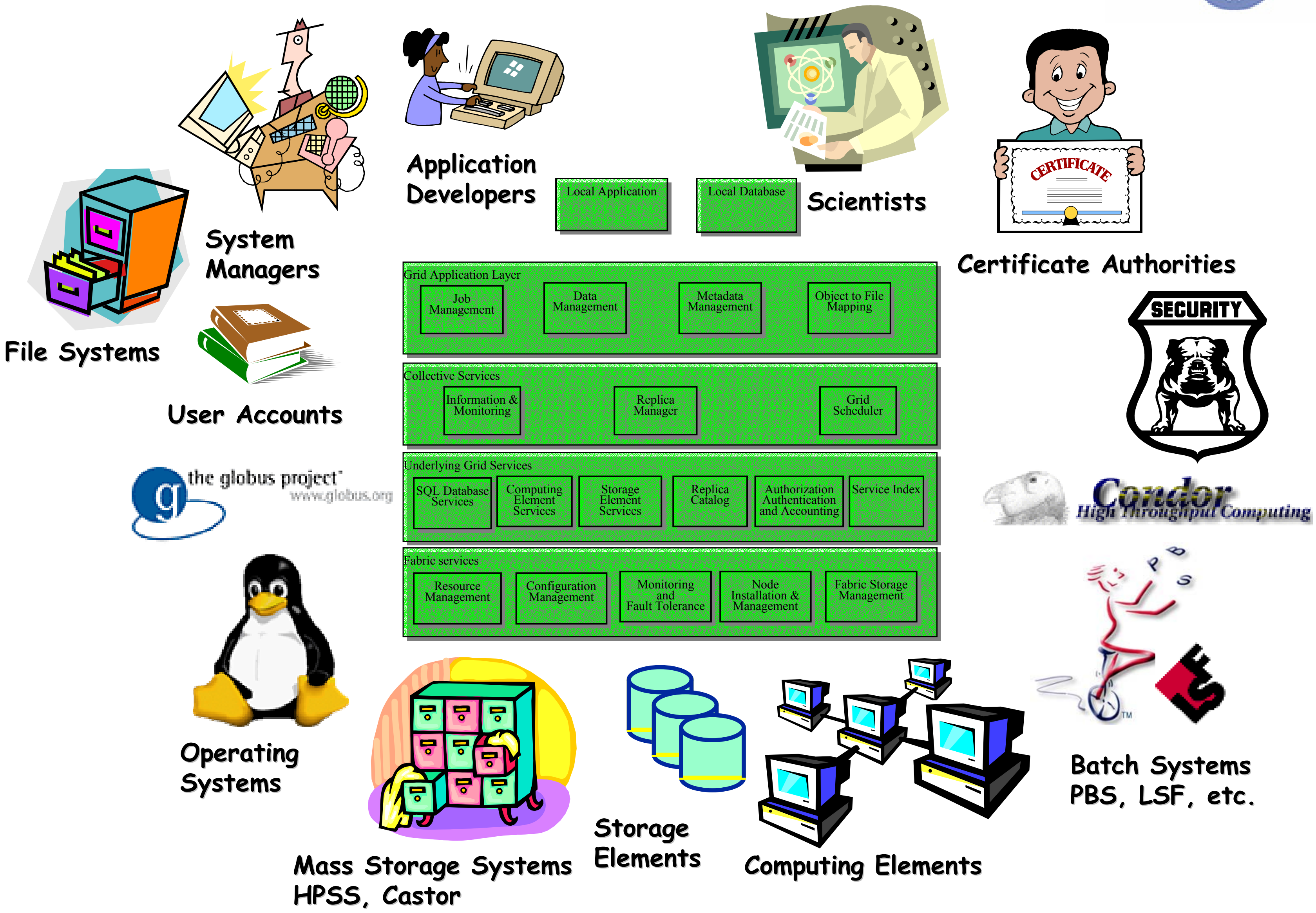
Monitoring and Fault Tolerance

Node Installation & Management

Fabric Storage Management

GLOBUS

EDG Interfaces



System Managers

Application Developers

Local Application

Local Database

Scientists

Certificate Authorities

File Systems

User Accounts

Grid Application Layer

Job Management

Data Management

Metadata Management

Object to File Mapping

Collective Services

Information & Monitoring

Replica Manager

Grid Scheduler

Underlying Grid Services

SQL Database Services

Computing Element Services

Storage Element Services

Replica Catalog

Authorization Authentication and Accounting

Service Index

Fabric services

Resource Management

Configuration Management

Monitoring and Fault Tolerance

Node Installation & Management

Fabric Storage Management

Operating Systems

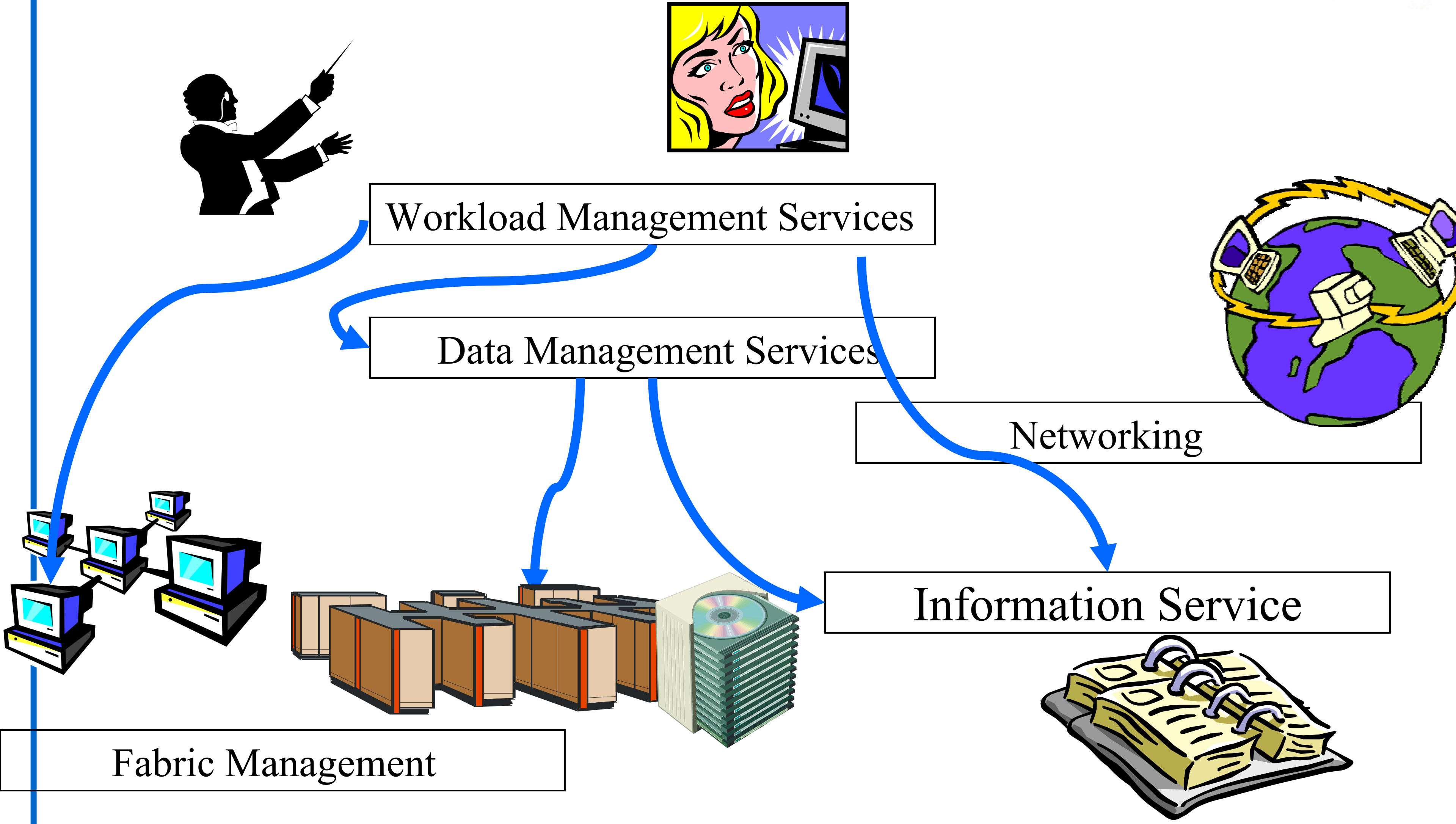
Mass Storage Systems HPSS, Castor

Storage Elements

Computing Elements

Batch Systems PBS, LSF, etc.

EDG Tutorial Overview



Workload Management Services

Data Management Services

Networking

Information Service

Fabric Management

EDG : reference web sites

- EDG web site
  - http://www.edg.org
- Source for all required software :
  - http://datagrid.in2p3.fr
- EDG testbed web site
  - http://marianne.in2p3.fr
- Dissemination Testbed (GriDis)
  - **http://web.datagrid.cnr.it/GriDis/GriDisWP1.html**
- EDG users guide
  - http://marianne.in2p3.fr/datagrid/documentation/EDG-Users-Guide.html
- EDG tutorials web site
  - http://cern.ch/edg-tutorials