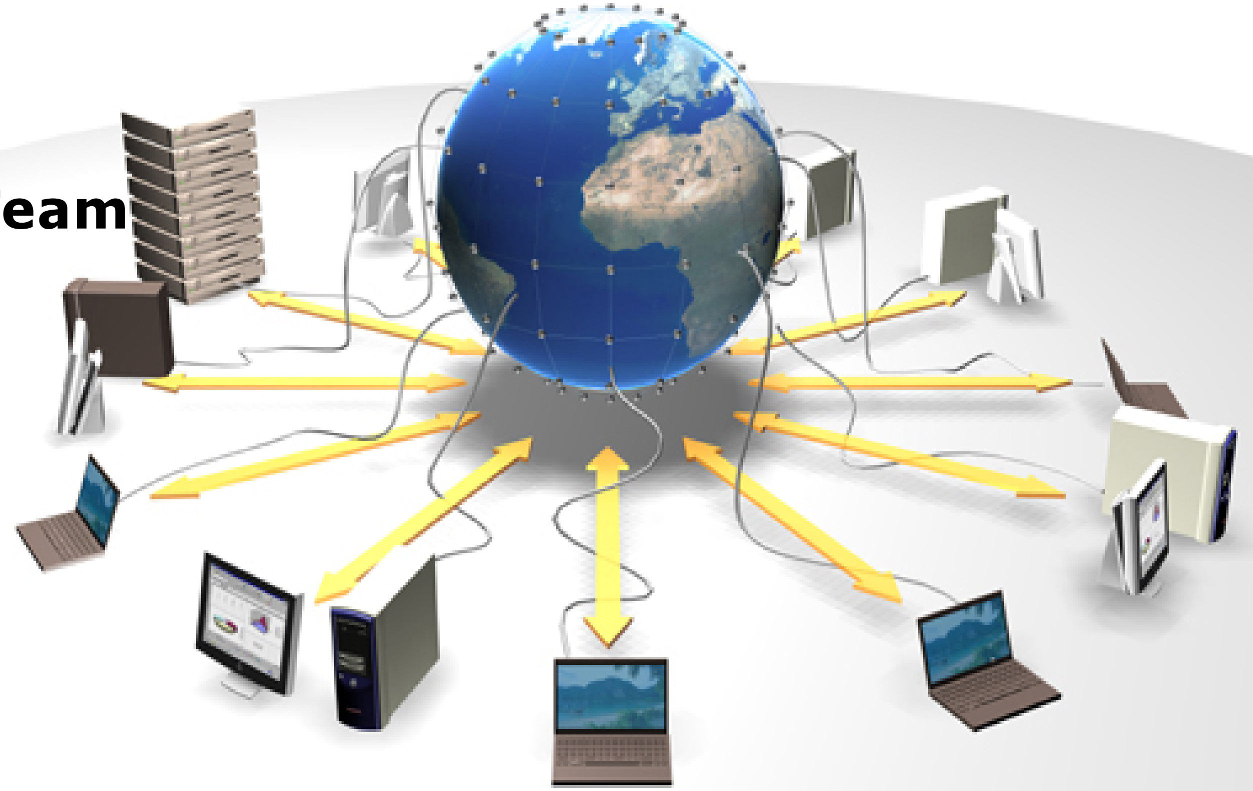
# Introduction to Grid computing and overview of the EU Data Grid Project



**The European DataGrid Project Team**

http://www.eu-datagrid.org

DataGrid is a project funded by the European Union

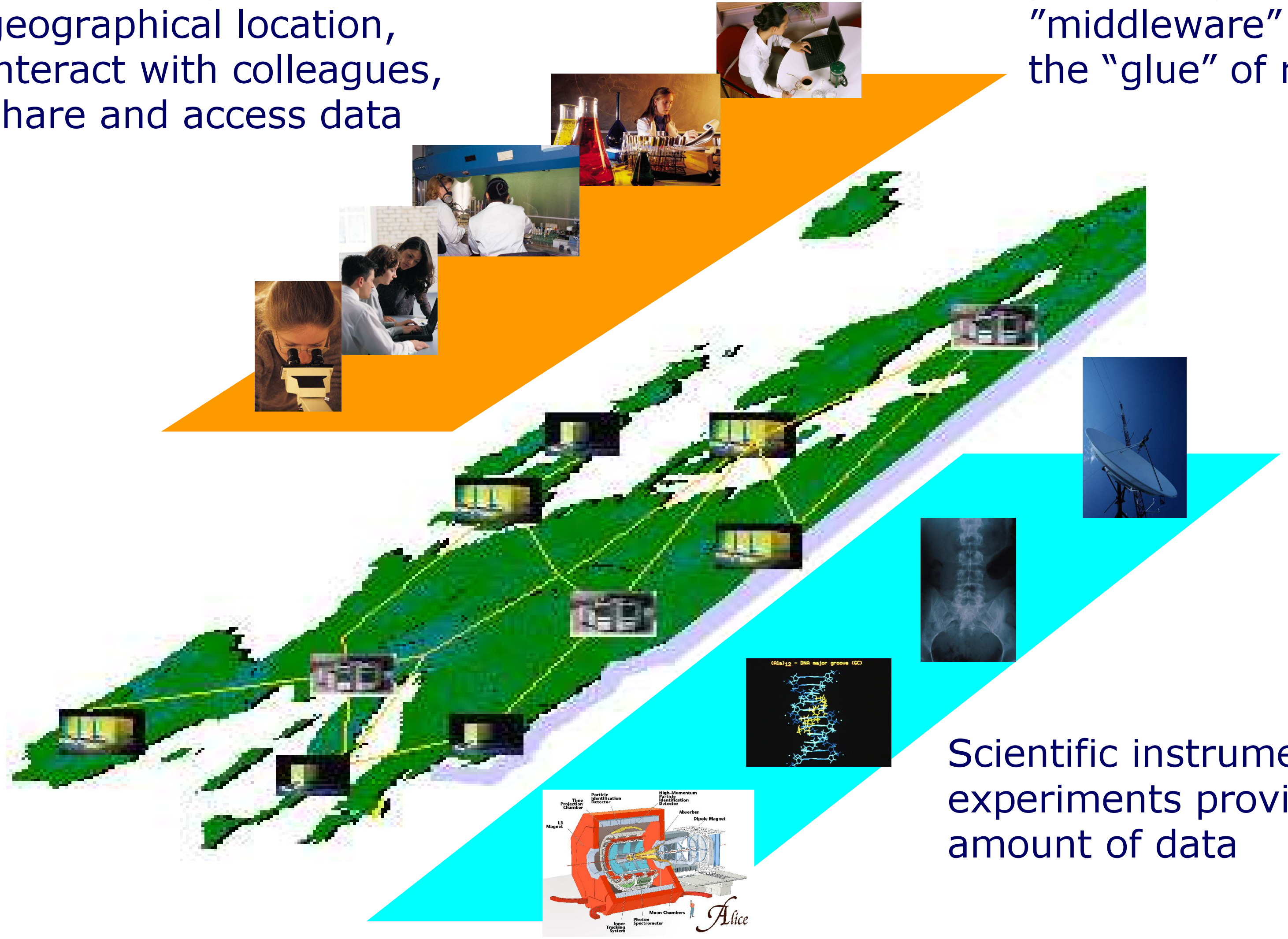
# Overview

- What is Grid computing ?
- What is a Grid ?
- Why Grids ?
- 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.



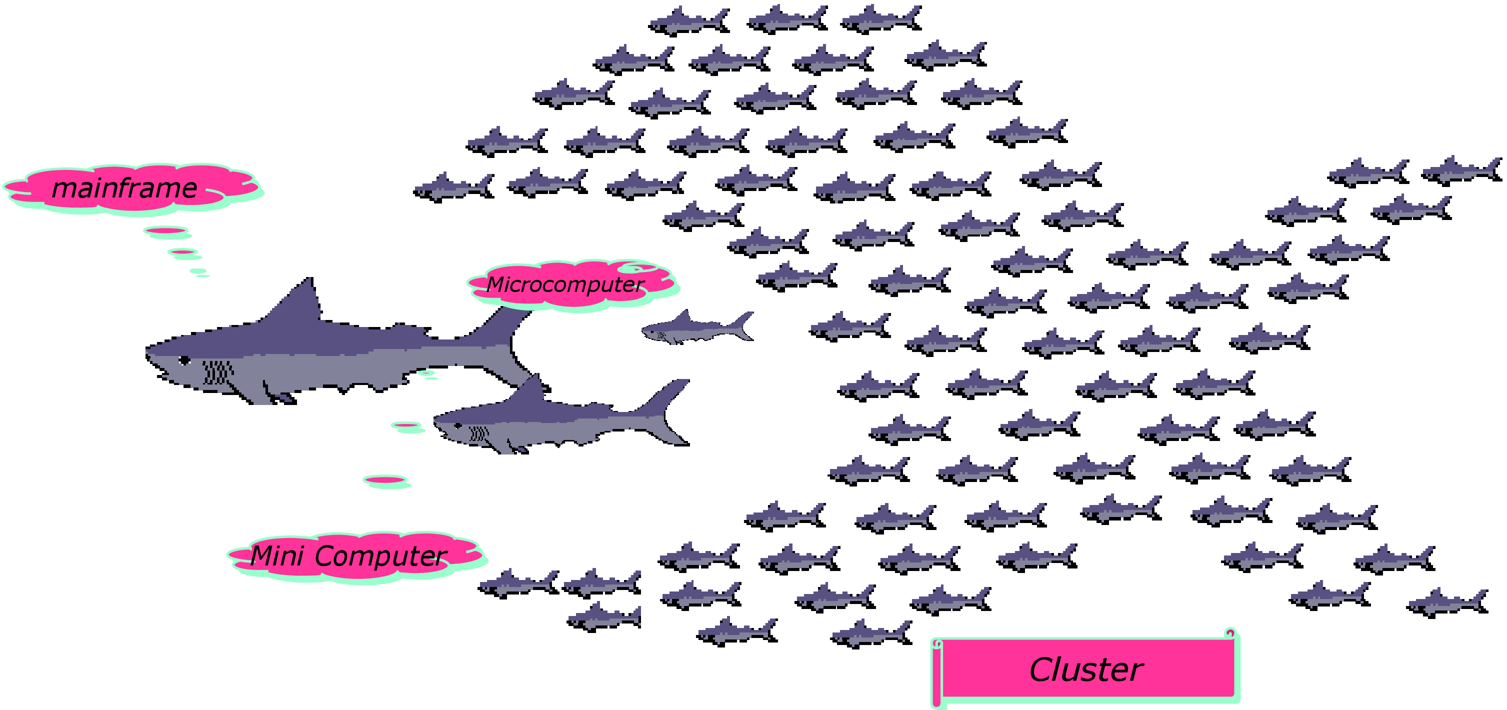
Scientific instruments and experiments provide huge amount of data

# 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

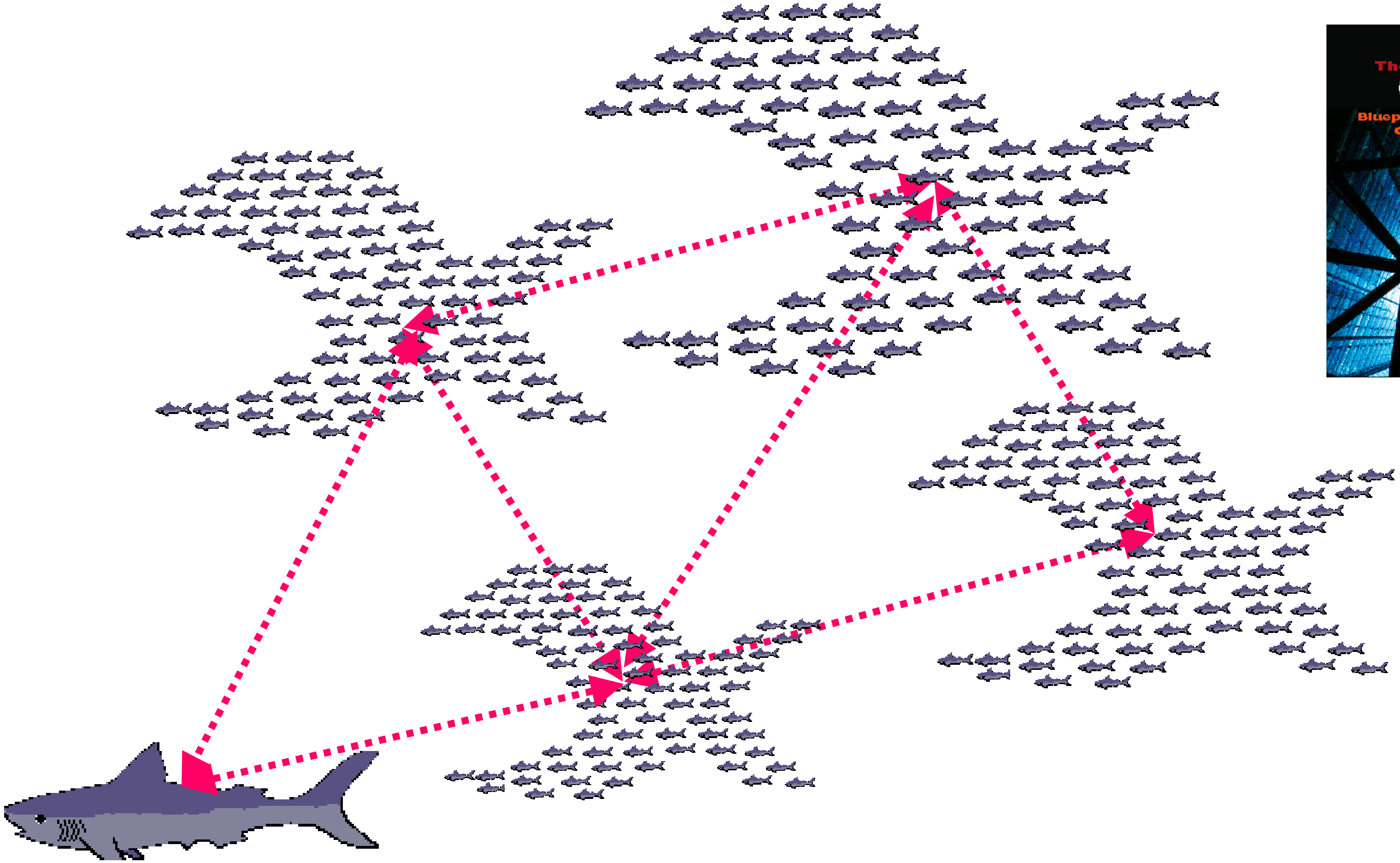
Once upon a time……..

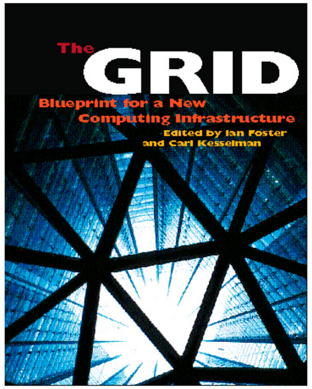

mainframe
Microcomputer
Mini Computer
Cluster

(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

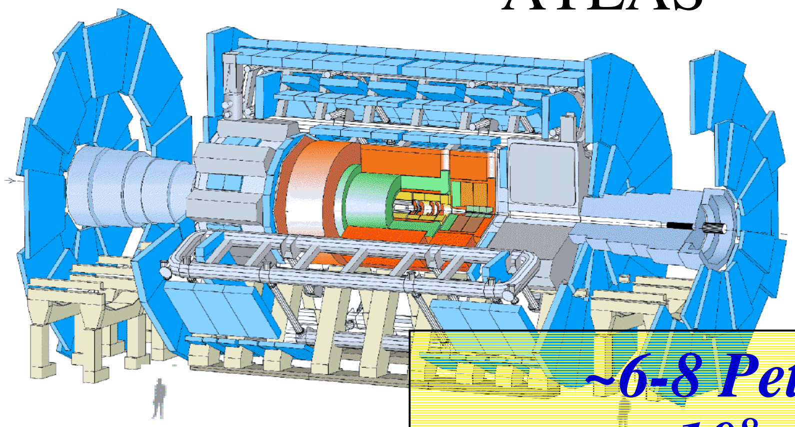
# Why Grids

- **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.

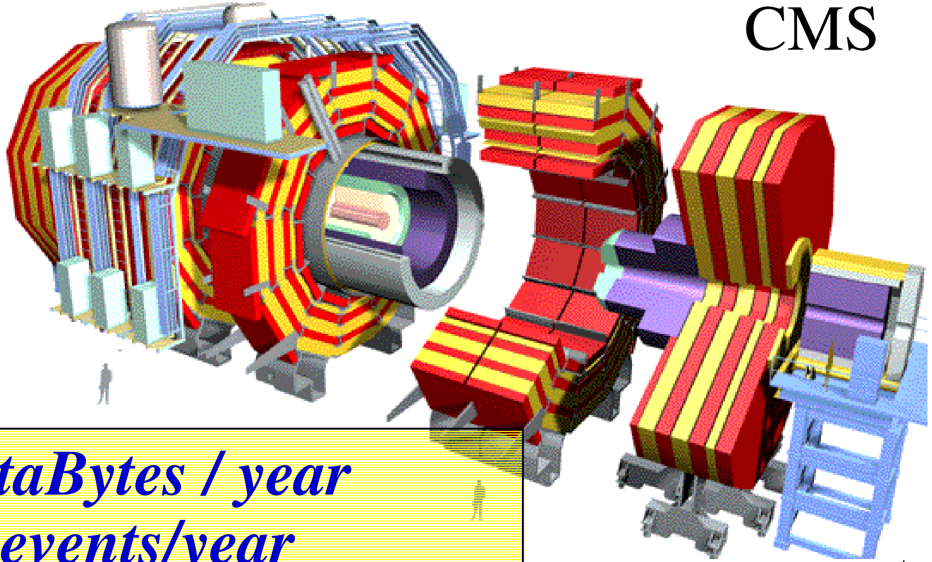
# High Energy Physics

## *The LHC Detectors*

ATLAS



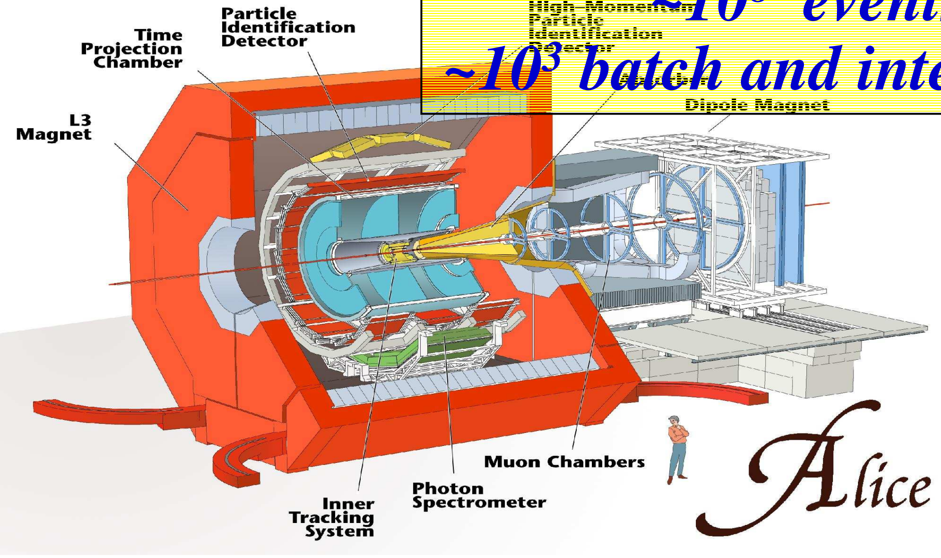
CMS

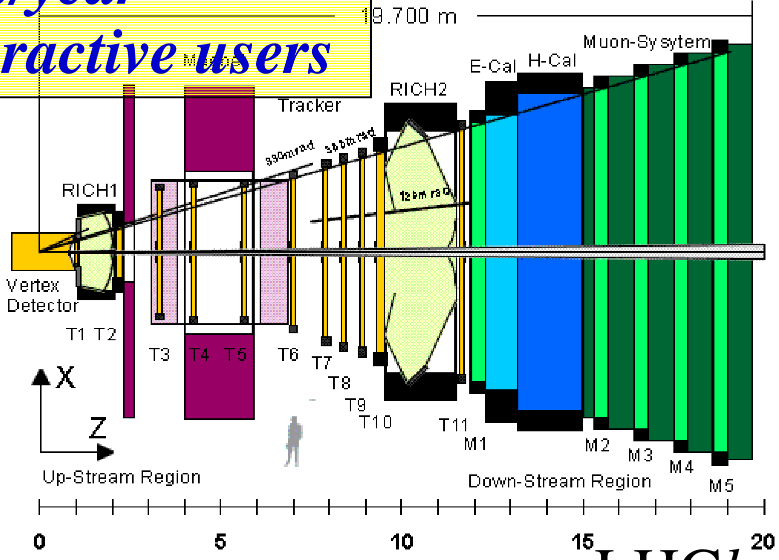


***~6-8 PetaBytes / year***

***~$10^8$ events/year***

***~$10^3$ batch and interactive users***


Time Projection Chamber
Particle Identification Detector
High-Momentum Particle Identification Detector
Dipole Magnet
L3 Magnet
Muon Chambers
Photon Spectrometer
Inner Tracking System
Alice


19.700 m
Muon-Sy sytem
E-Cal
H-Cal
RICH2
Tracker
Magnet
RICH1
Vertex Detector
330mrad
300mrad
120mrad
T1 T2
T3 T4 T5
T6
T7
T8
T9
T10
T11
M1
M2
M3
M4
M5
X
Z
Up-Stream Region
Down-Stream Region
0
5
10
15
20

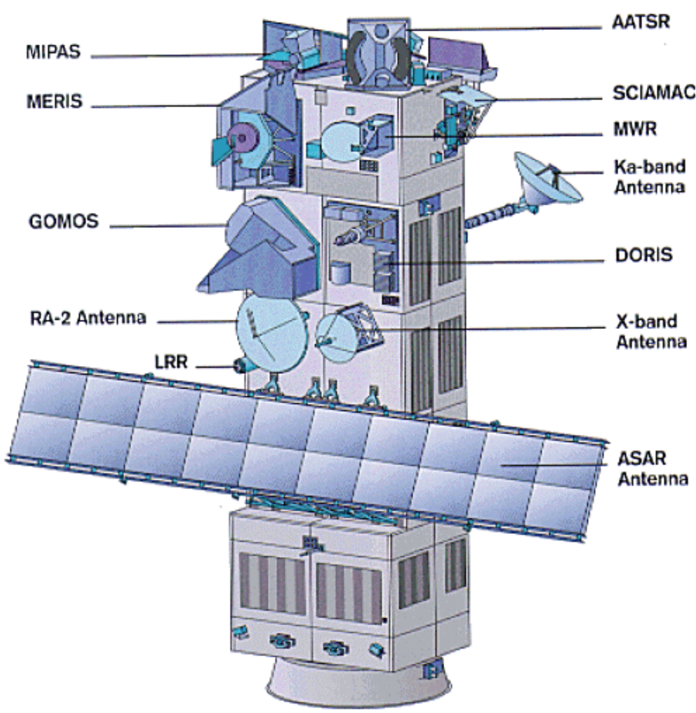
LHC*b*

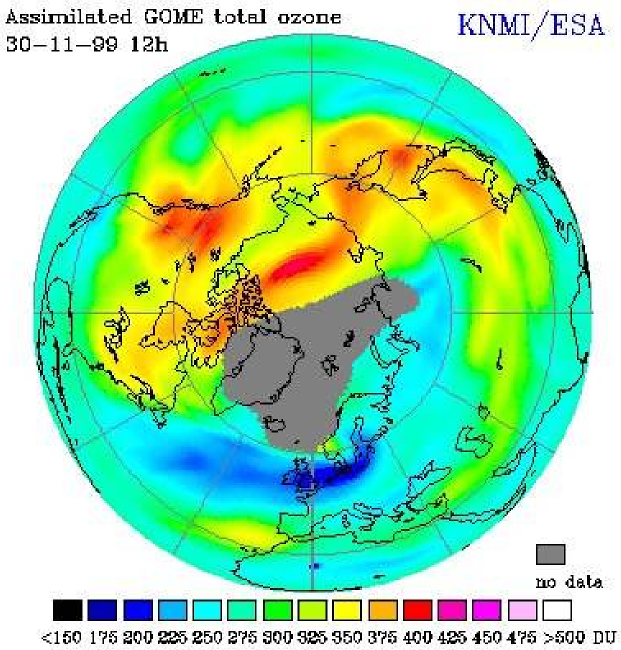
Federico.carminati , EU review presentation

# Earth Observation

**ESA missions:**

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


MIPAS
MERIS
GOMOS
RA-2 Antenna
LRR
AATSR
SCIAMACHY
MWR
Ka-band Antenna
DORIS
X-band Antenna
ASAR Antenna


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 …)**

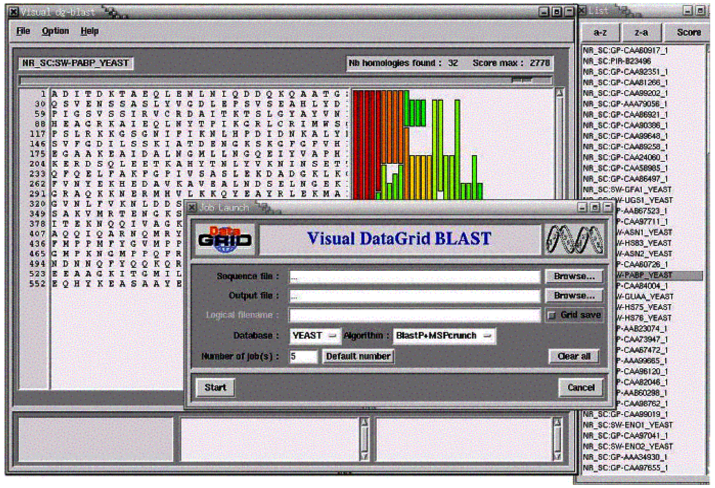
Source: L. Fusco, June 2001

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

| | |
|---|---|
| 🟩 | **Applications deployed** |
| 🟧 | **Applications tested on EDG** |
| 🟥 | **Applications under preparation** |



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 C 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 : ...

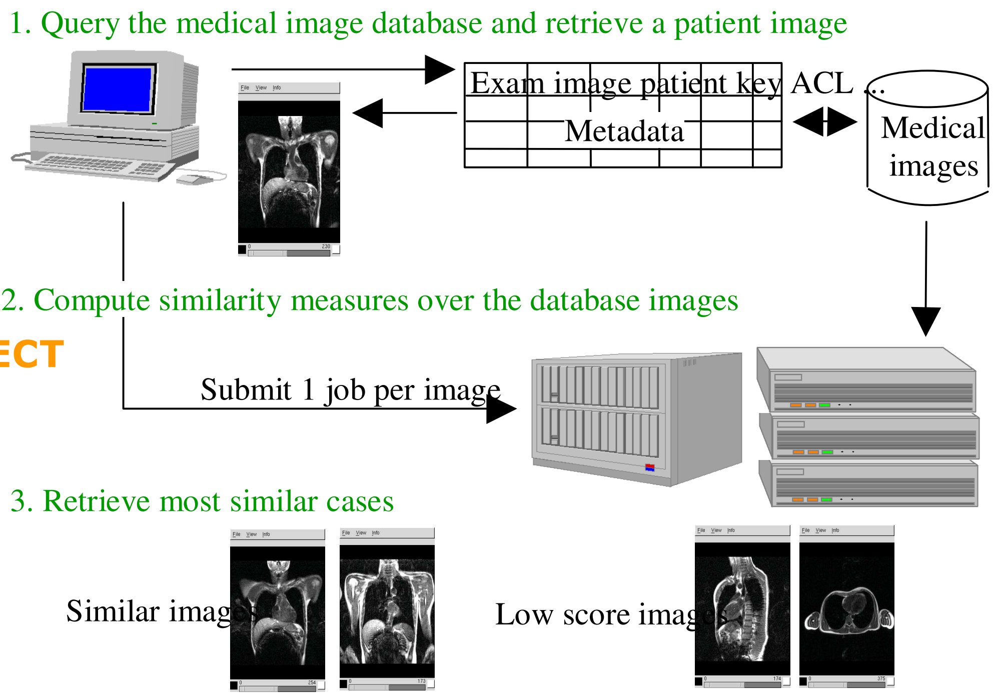
Output file : ...

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

# The EU DataGrid (EDG) Project

- 9.8 M Euros EU (IST) funding over 3 years
- Three year phased developments & demos (2001-2003)
- 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
- Total of 21 partners
  - Research and Academic institutes as well as industrial companies
- Main partners:

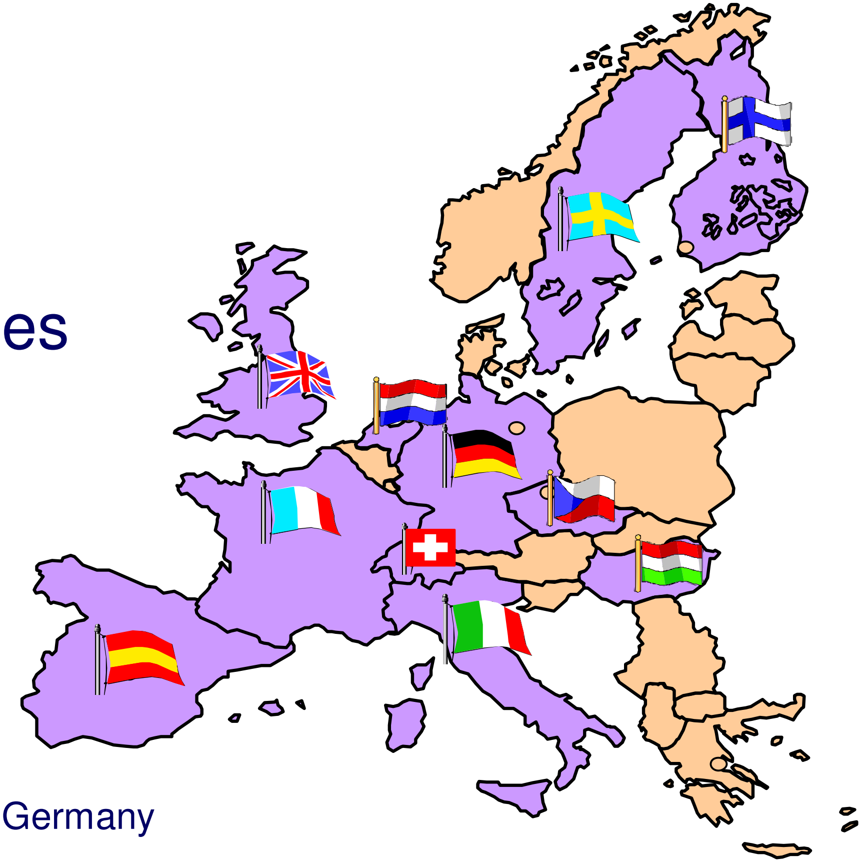
CERN CNRS esa ESRIN PPARC INFN ISTITUTO NAZIONALE DI FISICA NUCLEARE NIKHEF

# 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 structure : work packages

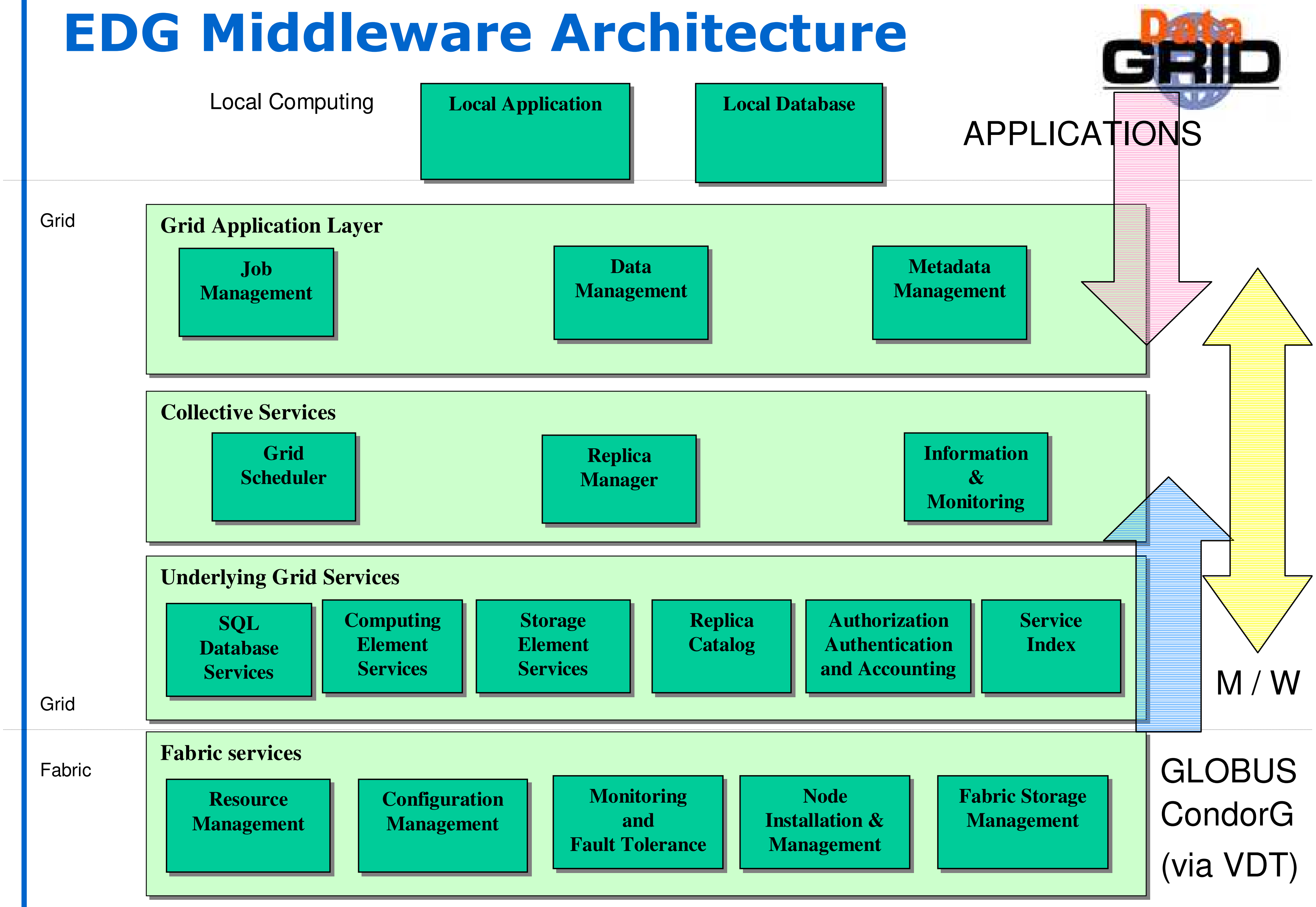
- The EDG collaboration is structured in 12 Work Packages:
  - WP1: Work Load Management System
  - WP2: Data Management
  - WP3: Grid Monitoring / Grid Information Systems
  - WP4: Fabric Management
  - WP5: Storage Element
  - WP6: *Testbed and demonstrators*
  - WP7: Network Monitoring
  - WP8: High Energy Physics Applications
  - WP9: Earth Observation
  - WP10: Biology
  - WP11: Dissemination
  - WP12: Management

} **Applications**

# Project Schedule

- Project started on 1/Jan/2001
- Testbed 0 (early 2001)
  - International test bed 0 infrastructure deployed
    - Globus 1 only - no EDG middleware
- Testbed 1 ( 2002 )
  - First release of EU DataGrid software to defined users within the project:
    - HEP experiments (WP 8), Earth Observation (WP 9), Biomedical applications (WP 10)
- Testbed 2 (End 2002)
  - Builds on Testbed 1 to extend facilities of DataGrid
  - Focus on stability
- EDG very successfully passed its 2nd annual EU review on February 4-5 2003
- Testbed 3 (2003)
  - Advanced functionality; currently being deployed.
- Project stops on 31/Dec/2003

# EDG Middleware 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**

Grid

**Underlying Grid Services**

**SQL Database Services**

**Computing Element Services**

**Storage Element Services**

**Replica Catalog**

**Authorization Authentication and Accounting**

**Service Index**

M / W

Fabric

**Fabric services**

**Resource Management**

**Configuration Management**

**Monitoring and Fault Tolerance**

**Node Installation & Management**

**Fabric Storage Management**

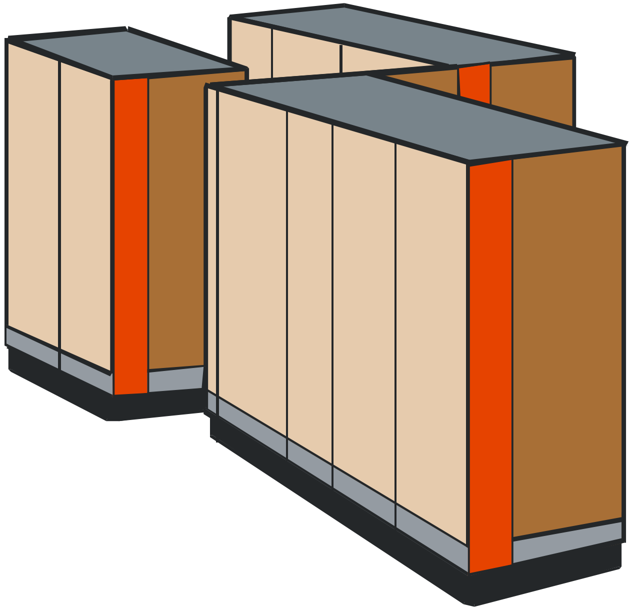
GLOBUS
CondorG
(via VDT)

# The EDG WMS (WP1)

- The user interacts with Grid via a **Workload Management System** (WMS)
- The Goal of WMS is the **distributed scheduling and resource management in a Grid environment**.
- What does it allow Grid users to do?
  - To submit their jobs
  - To execute them on the “best resources”
    - The WMS tries to optimize the usage of resources
  - To get information about their status
  - To retrieve their output

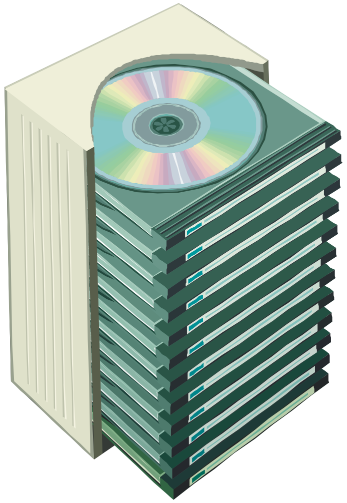
# Computing Element (WP4)

- Is a Grid Job Queue
    - Publishes information about itself
    - Checks the job is permitted
    - Sends it to an an appropriate internal queue



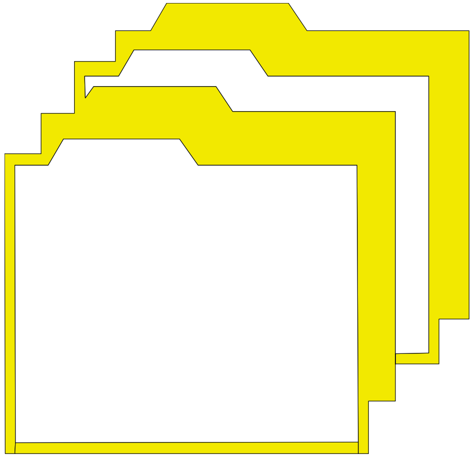
# SRM: Storage Resource Manager (WP5)

- SRM subset implementation
  - A defacto international standard for Storage Resource Management
- Web service uses Java AXIS and EDG security
- Supports multiple VOs
- Functions
  - Writing a file
  - Reading a file



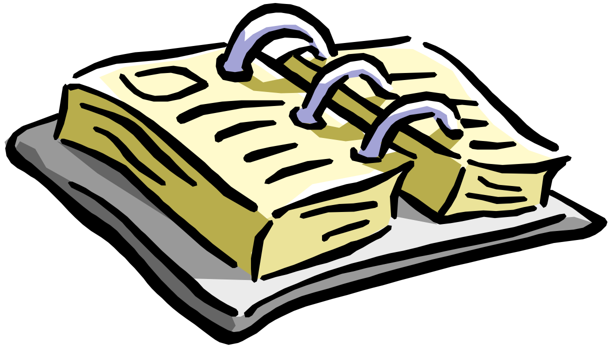
# Replica Manager (WP2)

- High level data management on the Grid
  - Location of data
  - Replication of data
  - Efficient access to data
- Hides the SRM
- Coordinates use of
  - Replica Location Service
  - Replica Metadata Catalog
  - Replica Optimization Service



# Information & Monitoring (WP3)
# R-GMA

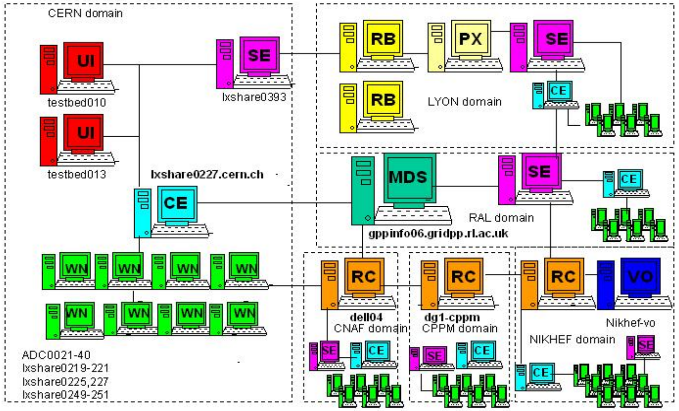
- Relational implementation of GMA from GGF
- Makes use of GLUE schema
- Interoperable with MDS
- Deals with information on
  - The Grid itself
    - Resources and Services (for which the Globus MDS is a common solution)
    - Job status information
  - Grid applications
    - This is information published by user jobs.



# TestBed Integration (WP6)

- Exact definition of RPM lists (components) for the various testbed machine profiles (CE, RB, UI,, WN, IC etc.) – check dependencies
- Perform preliminary centrally (CERN) managed tests on EDG m/w before green light for spread EDG testbed sites deployment
- Provide, update end user documentation for installers/site managers, developers  and end users
- Define EDG release policies, coordinate the integration team staff with the various WorkPackage managers – keep high inter-coordination.
- Set up the Authorization Working Group to manage authorization policies on the testbed

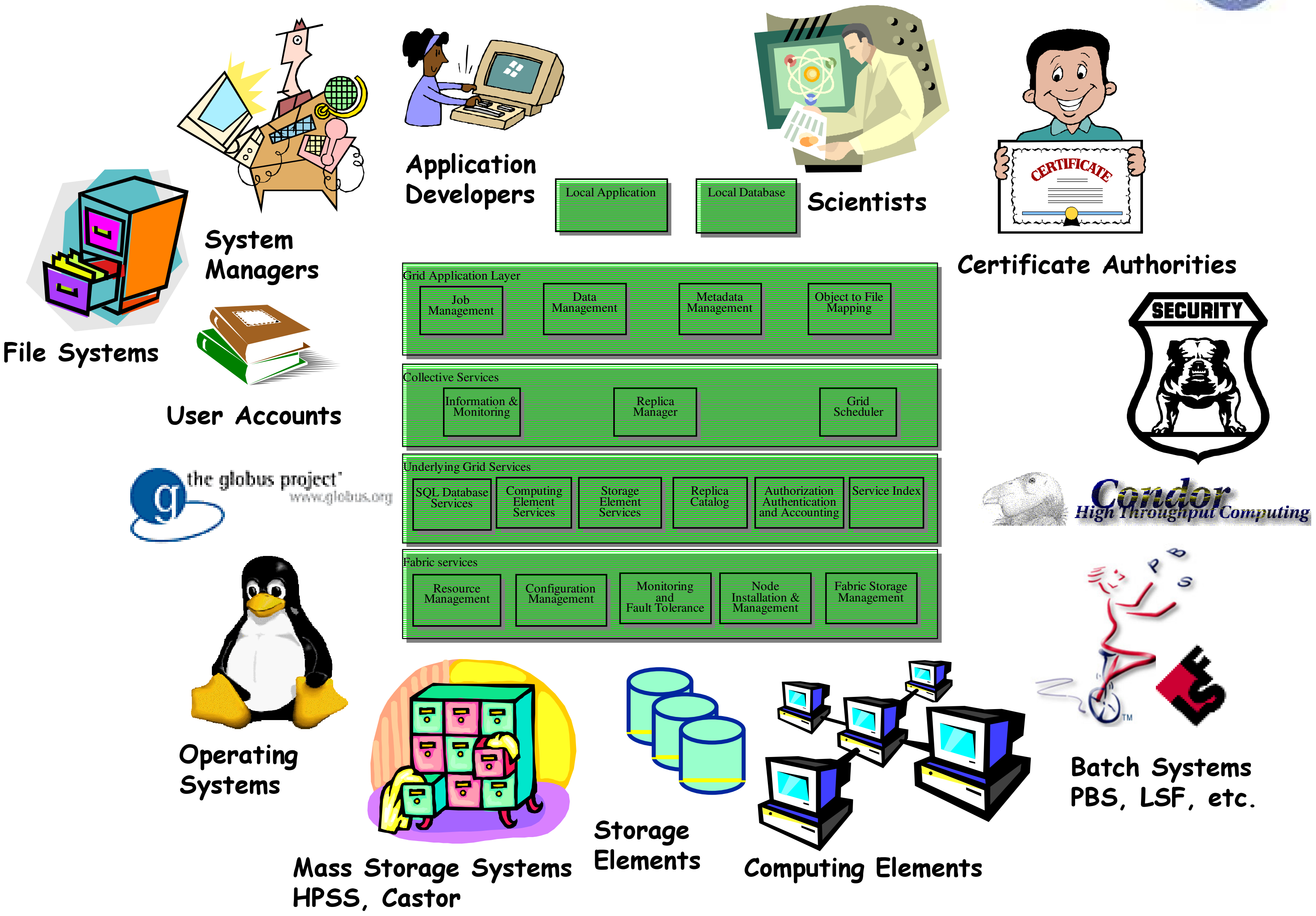
**EDG production testbed  EDG Release EDG 1.4.7**
**CERN** Computing Element site and corresponding spread GRID services


CERN domain
UI
testbed010
UI
testbed013
SE
lxshare0393
lxshare0227.cern.ch
CE
WN
ADC0021-40
lxshare0219-221
lxshare0225,227
lxshare0249-251
RB
PX
SE
RB
LYON domain
CE
MDS
SE
CE
RAL domain
gppinfo06.gridpp.rl.ac.uk
RC
dell04
CNAF domain
SE
CE
RC
dg1-cppm
CPPM domain
SE
CE
RC
VO
Nikhef-vo
NIKHEF domain
SE
CE

# Grid aspects covered by EDG

| | | | |
|---|---|---|---|
| **VOMS** | Provides certificate with VOs, groups and roles | **RGMA: Information & Monitoring** | Provides info on resource utilization & performance |
| **User Interface** | Submit & monitor jobs, retrieve output | **Grid Fabric Management** | Configure, installs & maintains grid sw packages and environ. |
| **Workload Management System** | Manages submission of jobs to Res. Broker, obtains information and retrieves output | **Network performance** | Provides efficient network transport, bandwidth monitoring |
| **Computing Element** | Gatekeeper to a grid computing resource | **Testbed admin.** | Certificate auth.,user reg., usage policy etc. |
| **Storage Resource Manager** | Grid-aware storage area | **Applications** | HEP, EO, Biology |
| **Replica Manager** | Replicates and locates data | | |

# EDG Interfaces



System Managers

File Systems

User Accounts

Application Developers

Local Application

Local Database

Scientists

Certificate Authorities

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.

# DataGrid in Numbers (as of Feb. 2003)

**People**

>350 registered users

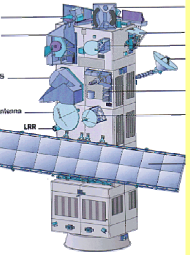
12 Virtual Organisations

16 Certificate Authorities

>200 people trained

278 man-years of effort

100 years funded


MIPAS
MERIS
GOMOS
RA-2 Antenna
LRR

**Testbeds**

>15 regular sites

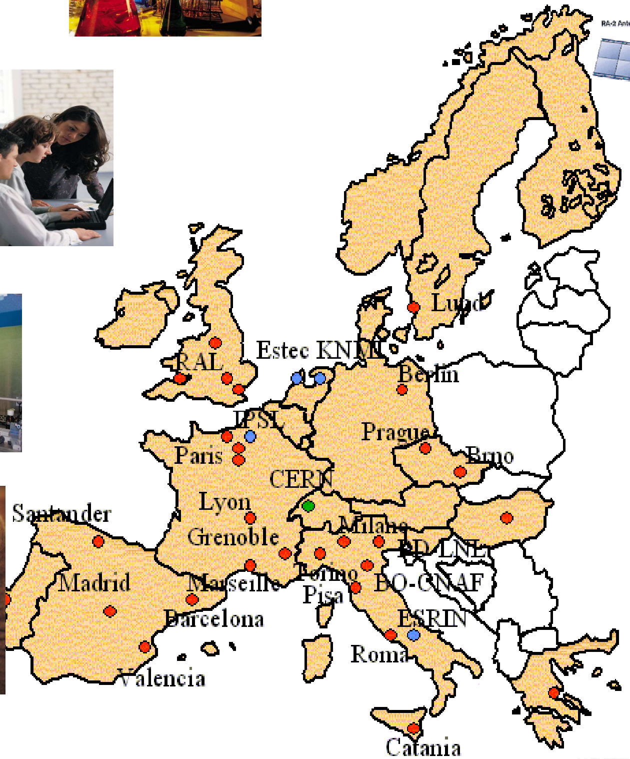
>40 sites using EDG sw

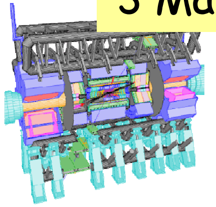
>10'000s jobs submitted

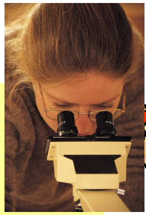
>1000 CPUs

>15 TeraBytes disk

3 Mass Storage Systems


Lund
RAL
Estec
KNMI
Berlin
IPSL
Paris
Prague
Brno
CERN
Lyon
Santander
Grenoble
Milano
PD-LNL
Torino
Madrid
Marseille
BO-CNAF
Pisa
Barcelona
ESRIN
Roma
Valencia
Catania





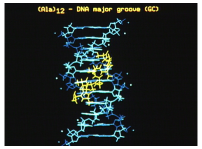
**Software**

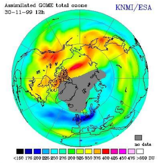
50 use cases

18 software releases

Current release 1.4

>300K lines of code


(Ala)12 - DNA major groove (GC)


Assimilated GOME total ozone
30-11-99 12h
KNMI/ESA

**Scientific applications**

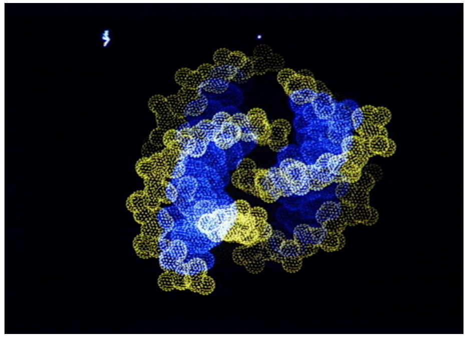
5 Earth Obs institutes

9 bio-informatics apps

6 HEP experiments

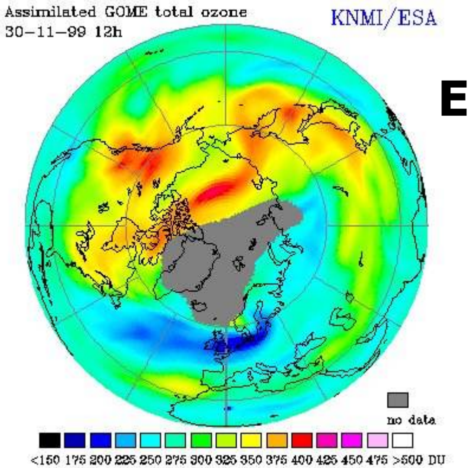
# DataGrid Scientific Applications

***Developing grid middleware to enable large-scale usage by scientific applications***



## Bio-informatics

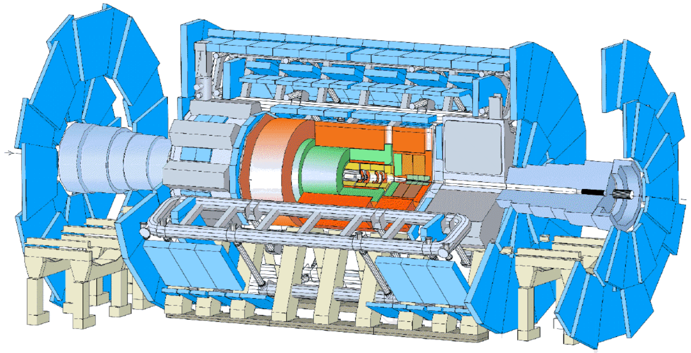
- Data mining on genomic databases (exponential growth)
- Indexing of medical databases (Tb/hospital/year)


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

## Earth Observation

•about 100 Gbytes of data per day (ERS 1/2)

•500 Gbytes, for the ENVISAT mission



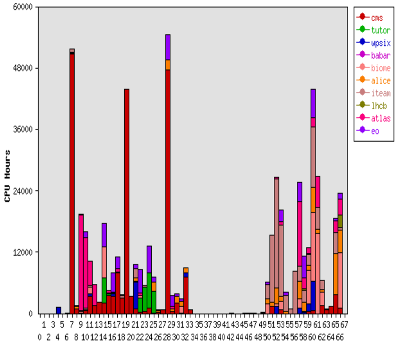
## Particle Physics

- Simulate and reconstruct complex physics phenomena millions of times
- LHC experiments will generate 6-8 PetaBytes/year

# Application Usage of Release 1.4

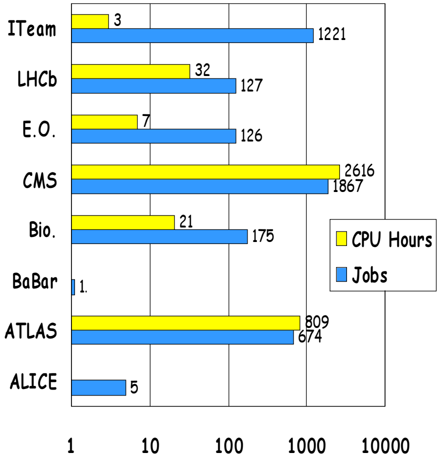
**EDG 1.4 evaluated for review in Feb. 2003**

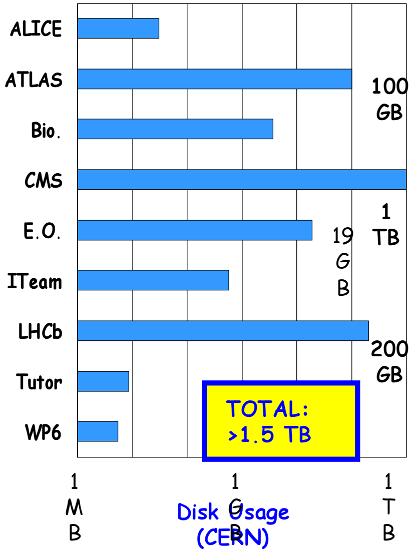
CPU Usage



## Positive Signs:

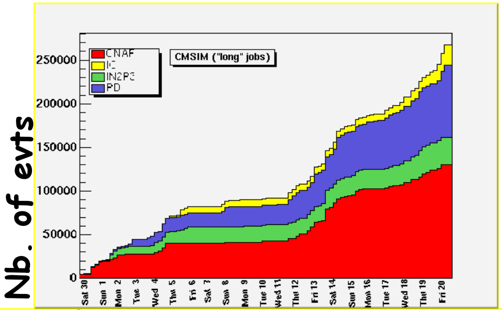
- Large increase in users.
- Many sites interested in joining.
- Pushing real jobs through system.

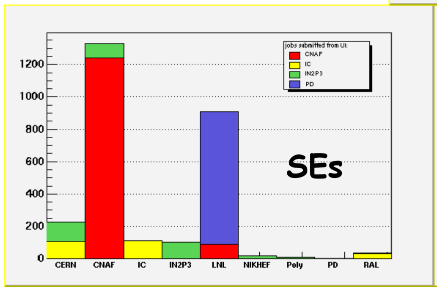


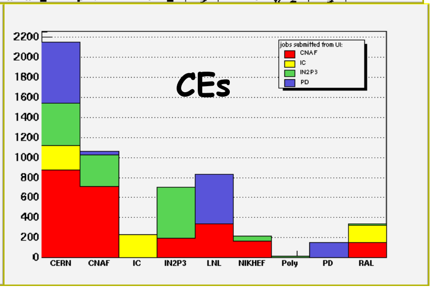


Disk Usage

HEP Simulation







# Release 2.0

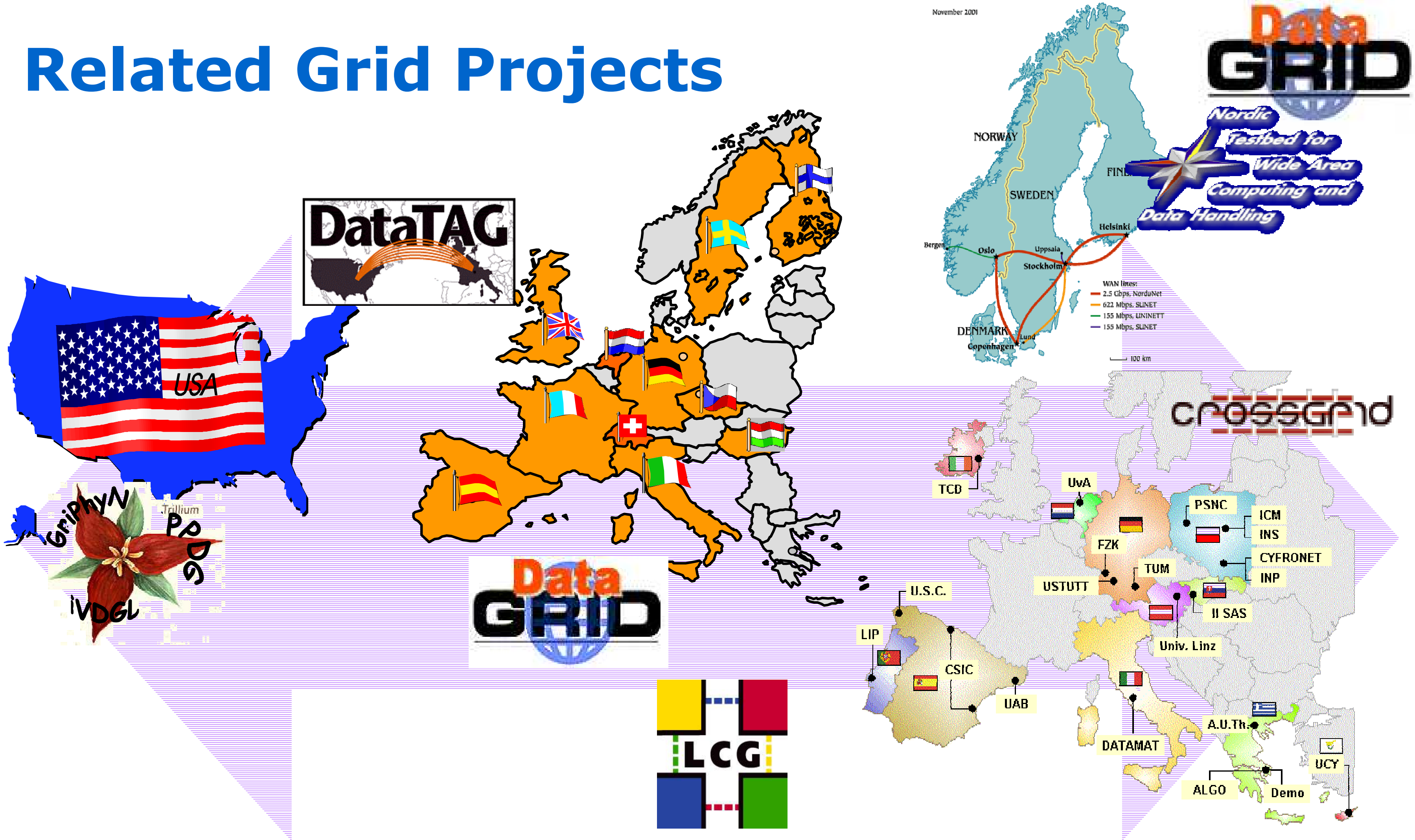
- Major new developments in all middleware areas
- Addre
  - WMS ored
  - Rep
  - Data ed
  - Info scal
  - Unif
  - Fabr
- Provic
- Upgrade underlying software

Being deployed on Application TB now

Tutorial will use 1.4 the first day
- Job submission
- Data management

2.0 will be used second day
- new job submission features
- new data mgmt features
- R-GMA

# Related Grid Projects

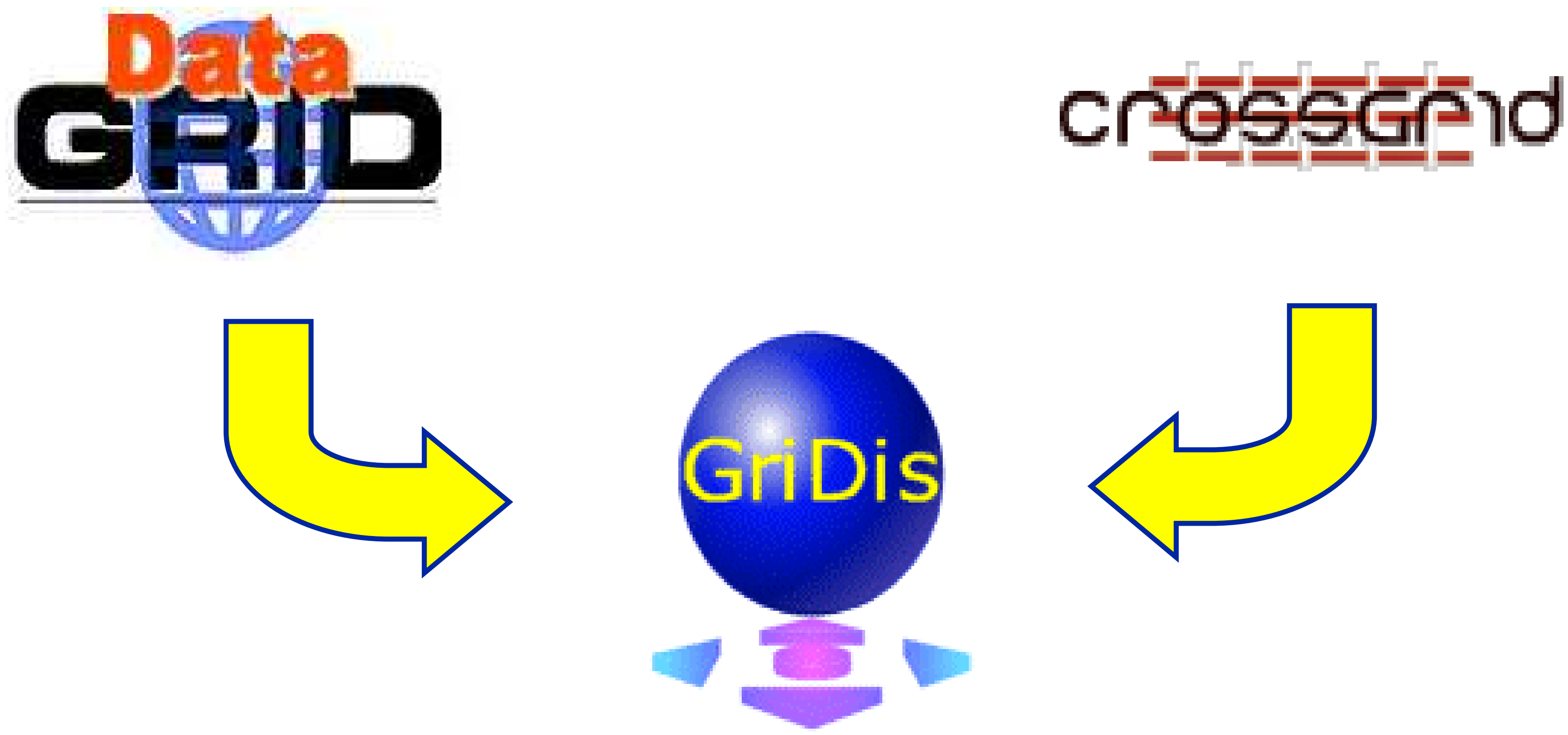

DataTAG
USA
GriPhyN
PPDG
iVDGL
Trillium
DataGRID
LCG
DataGRID
Nordic Testbed for Wide Area Computing and Data Handling
November 2001
NORWAY
SWEDEN
FINL
DENMARK
Bergen
Oslo
Uppsala
Stockholm
Helsinki
Copenhagen
Lund
WAN lines:
2.5 Gbps, NorduNet
622 Mbps, SUNET
155 Mbps, UNINETT
155 Mbps, SUNET
100 km
crossgrid
TCD
UvA
FZK
PSNC
ICM
INS
CYFRONET
INP
USTUTT
TUM
II SAS
Univ. Linz
U.S.C.
LIP
CSIC
UAB
DATAMAT
A.U.Th.
UCY
ALGO
Demo

**Through links with sister projects, there is the potential for a truly global scientific applications grid**

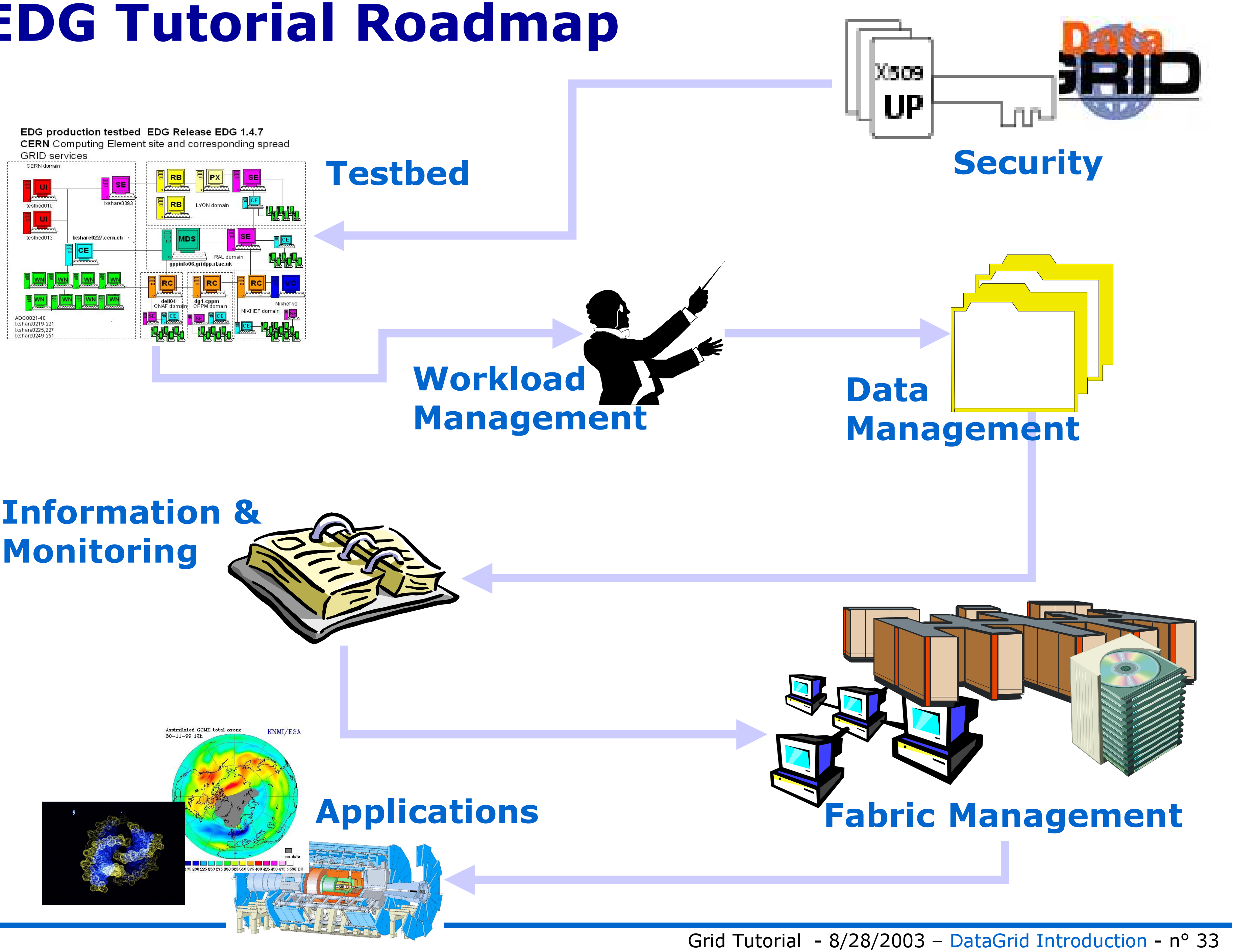
**Demonstrated at IST2002 and SC2002 in November**

# Tutorial Testbed

- EDG dissemination testbed (GriDis)
- Resources from EDG and Crossgrid


Data GRID
crossgrid
GriDis

# EDG Tutorial Roadmap


EDG production testbed EDG Release EDG 1.4.7
CERN Computing Element site and corresponding spread GRID services
CERN domain
UI
testbed010
UI
testbed013
SE
lxshare0393
lxshare0227.cern.ch
CE
WN
ADC0021-40
lxshare0219-221
lxshare0225,227
lxshare0249-251
RB
PX
SE
RB
LYON domain
CE
MDS
SE
CE
RAL domain
gppinfo06.gridpp.rl.ac.uk
RC
dell04
CNAF domain
RC
dg1-cppm
CPPM domain
RC
VO
Nikhef-vo
NIKHEF domain
SE
CE
X509
UP
Data
GRID
Assimilated GOME total ozone
30-11-99 12h
KNMI/ESA
no data

Testbed

Security

Workload Management

Data Management

Information & Monitoring

Applications

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