Enabling Grids for E-science in Europe

Information Society Technologies

The Evolution of Grid Technology

Dave Berry, NeSC

EGEE is funded by the European Union under contract IST-2003-508833

The Evolution of Grid Technology

EGEE Training Team

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Acknowledgements

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  - the National e-Science Centre
  - the Condor team
  - the Globus Alliance
  - the EDG training team
  - Roberto Barbera, INFN
- Prepared by Dave Berry, NeSC

Goals of this module

- To give an overview of the history of Grid computing

Enabling Grids for E-science in Europe

Overview

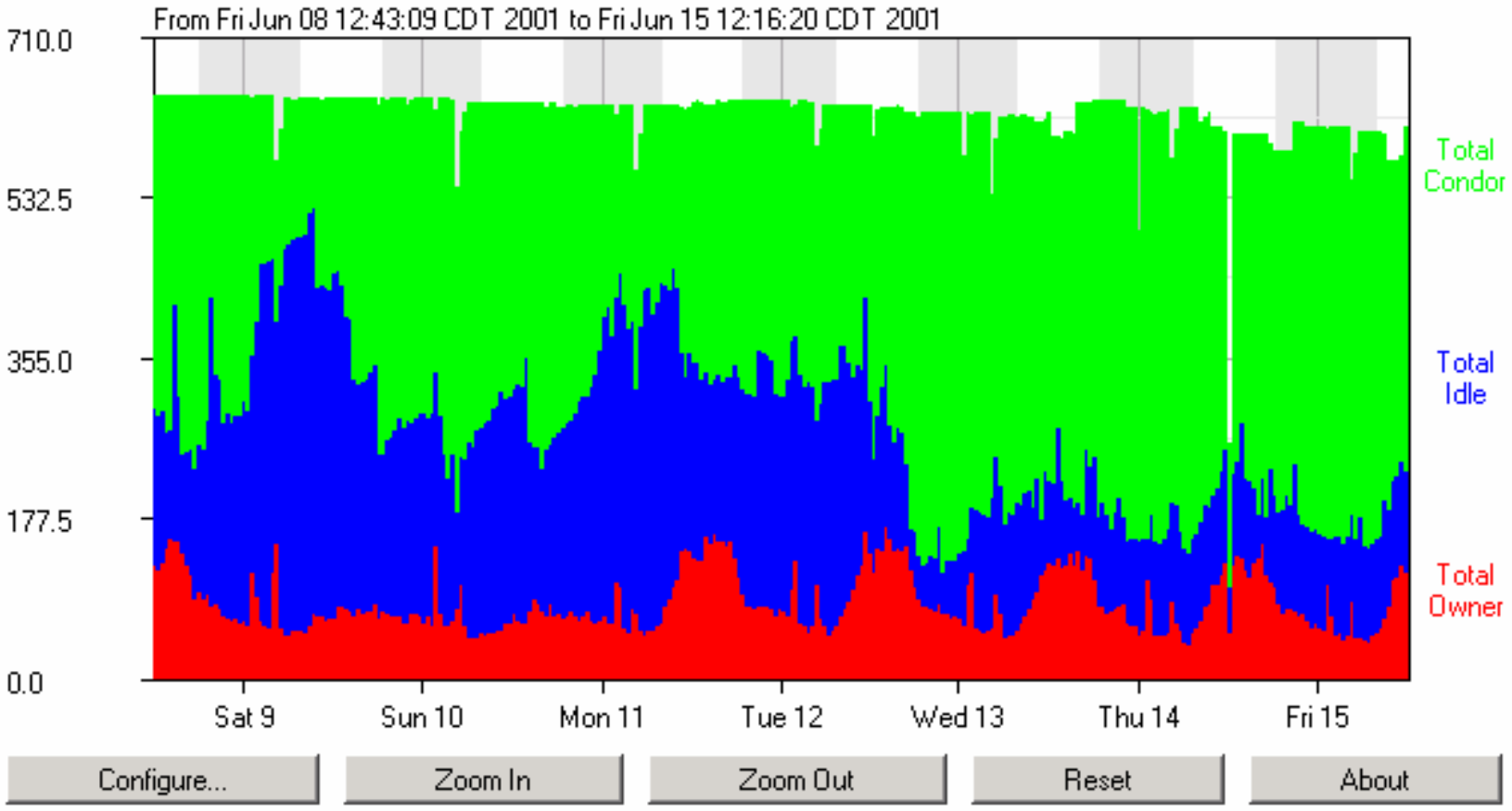
- Some History
  - Cycle stealing
  - Cluster management
  - Data Grids
  - Metacomputing
  - Portals
- The Situation pre-EGEE
- EGEE and LGC
- The Future: OGSA

Enabling Grids for E-science in Europe

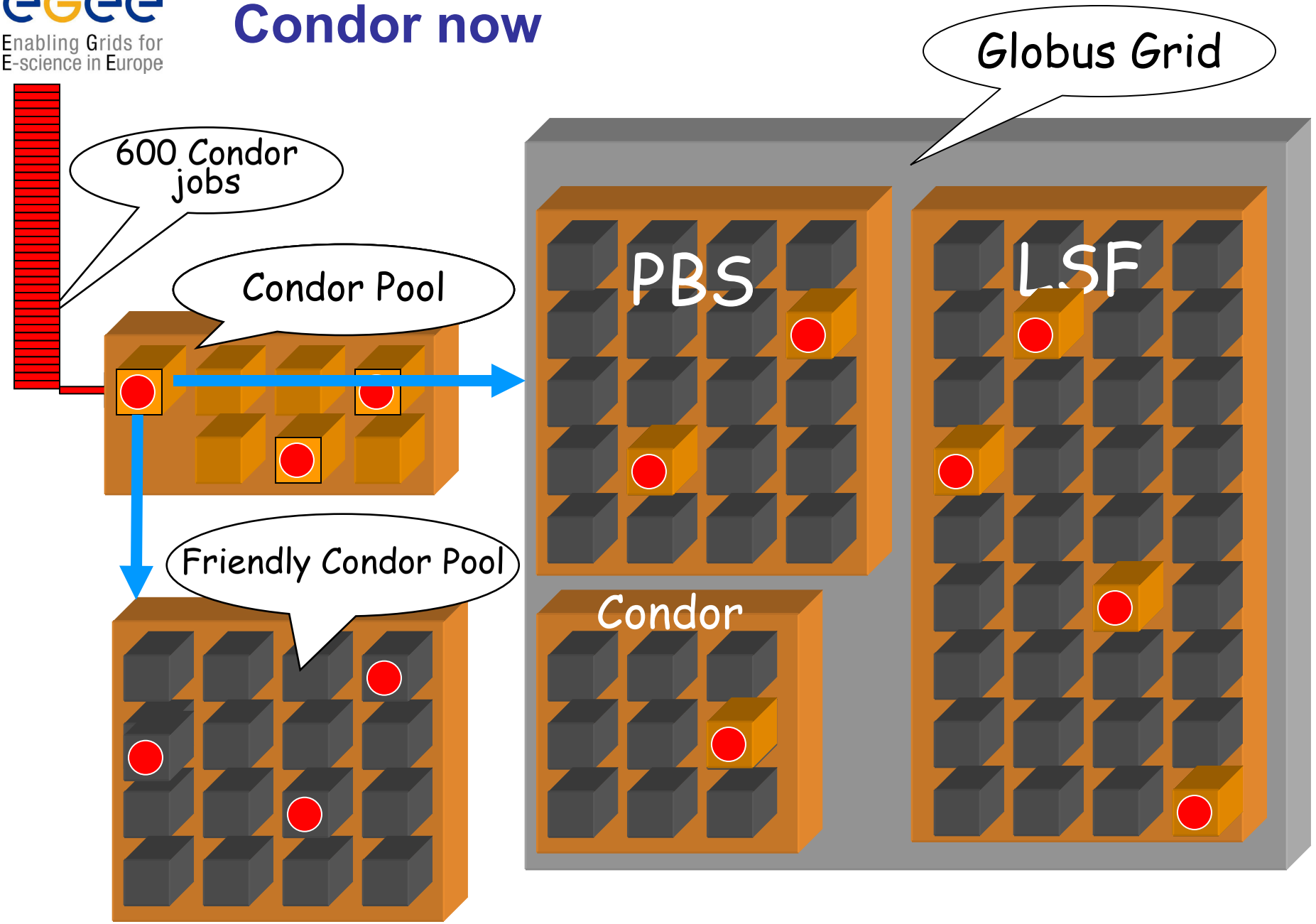
1986 - present: Condor

- "Cycle-stealing"
  - Use idle CPU cycles for productive work
- "High Throughput Computing"
  - Using all available compute power over periods of days, weeks,…
  - "Embarrassingly parallel" problems
- Fault tolerance
  - Algorithms must allow for failure
  - Checkpointing and process migration

CondorView Usage Graph

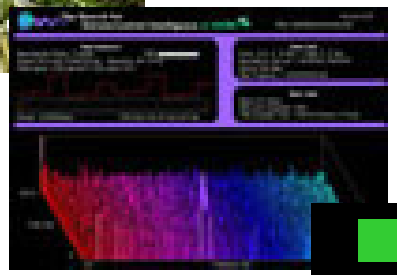


Condor now

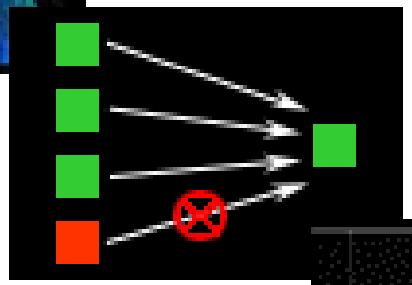

Globus Grid
600 Condor jobs
Condor Pool
Friendly Condor Pool
PBS
LSF
Condor

1997- Present: SETI@Home

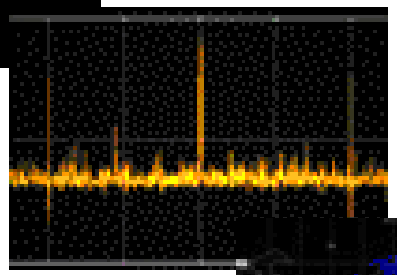
Collect data



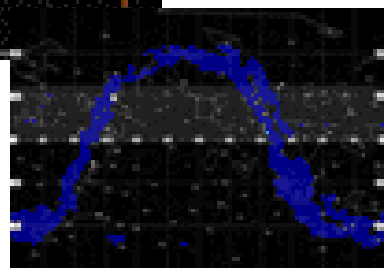
Find candidate signals



Check data integrity



Remove Radio Interference



Identify Final Candidates

1997: Entropia
1999: United Devices

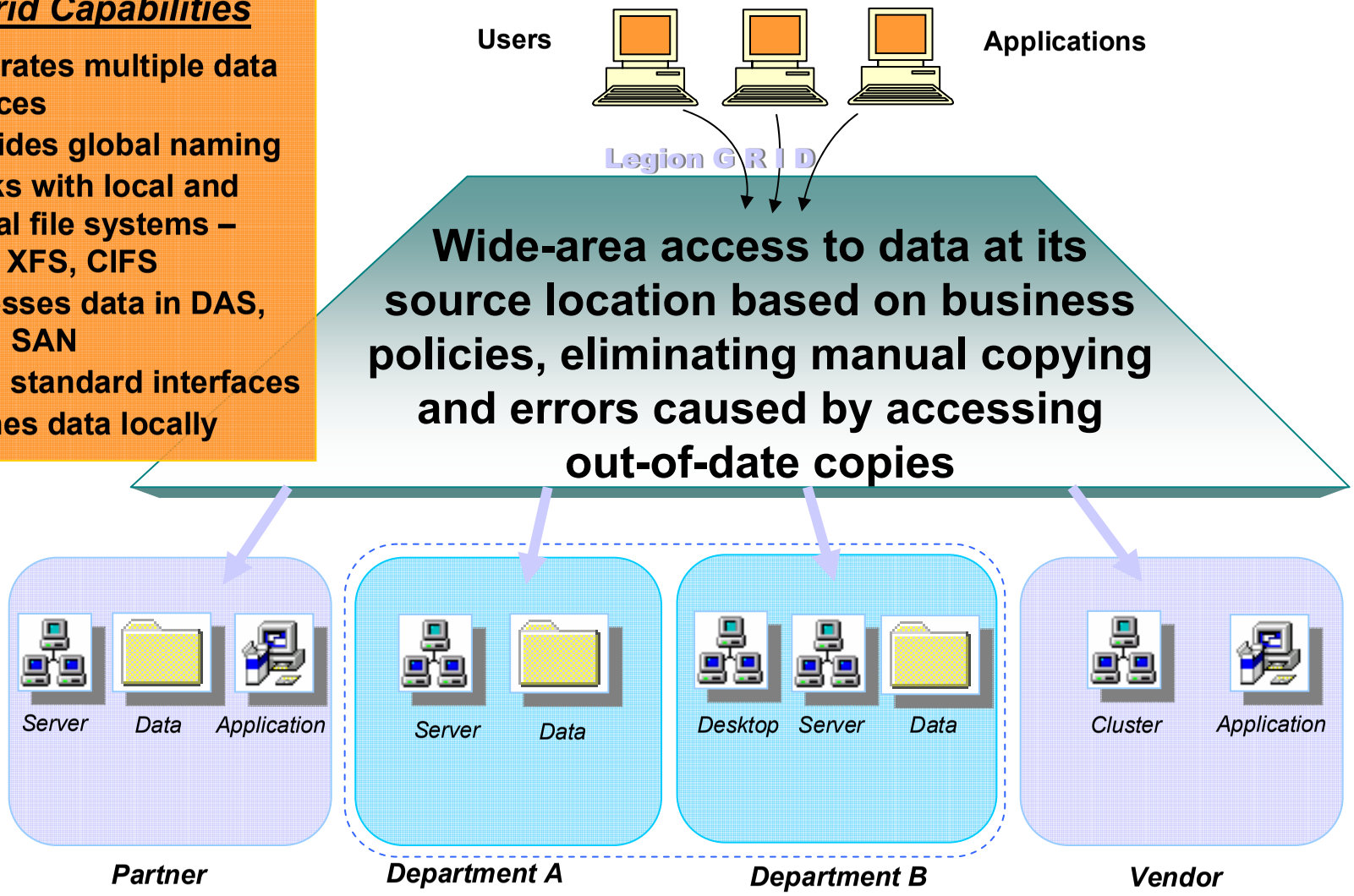
Cluster management

- *Cluster*: off-the-shelf processors linked to provide a high-capacity computing resource
- *Cluster management*: scheduling jobs onto free processors
  - Some similarities to cycle stealing
  - Some solutions based on Condor
- Example systems
  - Platform LSF
  - NASA/Veridian PBS
  - Sun Grid Engine
  - IBM LoadLeveller
  - Nimrod

1995: Legion Data Grid

Data Grid Capabilities

- Federates multiple data sources
- Provides global naming
- Works with local and virtual file systems – NFS, XFS, CIFS
- Accesses data in DAS, NAS, SAN
- Uses standard interfaces
- Caches data locally



More Data Grids

- Storage Resource Broker (SRB)
  - Uniform interface for heterogenous data
  - Distributed data sources
  - Logical files names mapped to physical file names
  - Metadata catalogue
- 2001: Avaki DataGrid
  - Commercial system based on Legion

Metacomputing

- 1993: Linking supercomputer centres
  - Extending parallel computing paradigms
  - Distributed file systems
  - Single sign-on
  - Custom-built, proofs of concept
- USA Gigabit test beds programme
  - Aurora, Blanca, Casa, Nectar and Vistanet
  - Investigating potential network architectures
- 1995: I-WAY (Information Wide-Area Year)
  - Experimental demo project for SuperComputing'95
  - Aggregate 17 sites networked
  - Over 60 applications developed and deployed

Enabling Grids for E-science in Europe

1997- Present: Globus

- A software toolkit addressing certain technical problems in the development of Grid enabled tools, services, and applications
  - Offers a modular “bag of technologies”
  - Implements standard Grid protocols and APIs
  - Made available under liberal open source license
- *Not* turnkey solutions, but *building blocks* and *tools* for application developers and system integrators
  - Some components (e.g., file transfer) go farther than others (e.g., remote job submission) toward end-user relevance

Globus: Key components

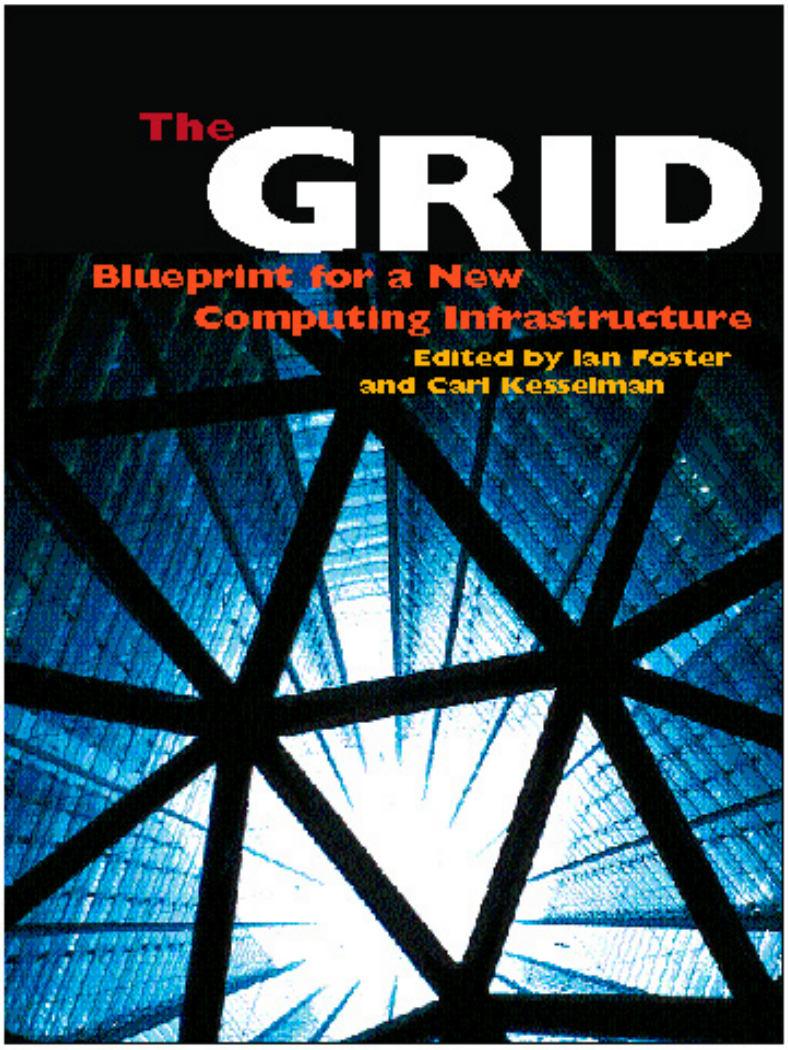
- Grid Security Infrastructure (GSL)
  - X.509 authentication with delegates and single sign-on
- Grid Resource Allocation Mgmt (GRAM)
  - Remote allocation, reservation, monitoring, control of compute resources
- GridFTP protocol (FTP extensions)
  - High-performance data access & transport
- Grid Resource Information Service (GRIS) + Monitoring and Discovery Service (MDS)
  - Access to structure & state information
- XIO
  - TCP, UDP, IP multicast, and file I/O
- Others…

Portals

- Web interfaces to Grid systems
  - Hide complex infrastructure from users
  - NPACI Hotpage
  - SCSD Grid Portal Toolkit
  - Grid Portal Development Kit
  - EDG GENIUS Portal

1998: “The Grid”

- Various Toolkits
  - Distribution
  - Various Protocols
  - FTP
- Security
  - Single Sign on
- Resource Sharing
  - Discovery
  - Process Creation
  - Scheduling
- Portability
  - APIs
- Government Agency Buy in



Enabling Grids for E-science in Europe

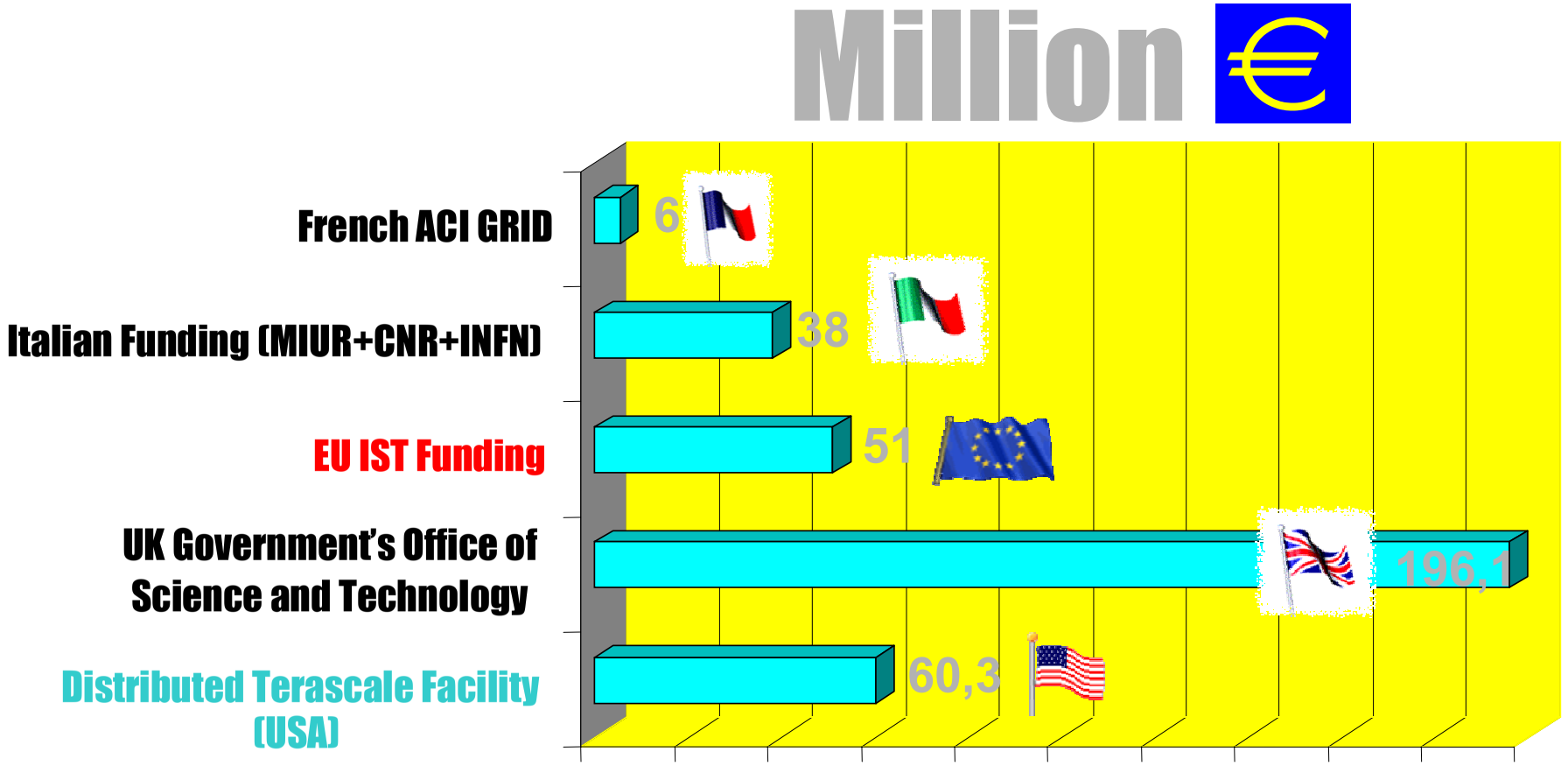
Overview

- Some history
- The situation pre-EGEE
- EGEE and LGC
- The Future: OGSA

Status of "The Grid"

- Hundreds of Grid projects
  - EU Framework funding
  - UK e-Science Programme
  - USA projects
  - Australia, Japan, Singapore, Korea, …
- A handful of Grid infrastructures
  - I.e. Grids supporting multiple applications
  - EDG/LCG
  - UK e-Science Grid
  - USA TeraGrid
  - Others…

2003 Grid investments in EU/US



Future figures:

US Cyber Infrastructure: 1020 M$

Japan (A-P) Grid: ~500 M$

Example: UK GridPP (part of EDG)

17 Universities

Rutherford Appleton Laboratory

European Laboratory for Particle Physics (CERN)

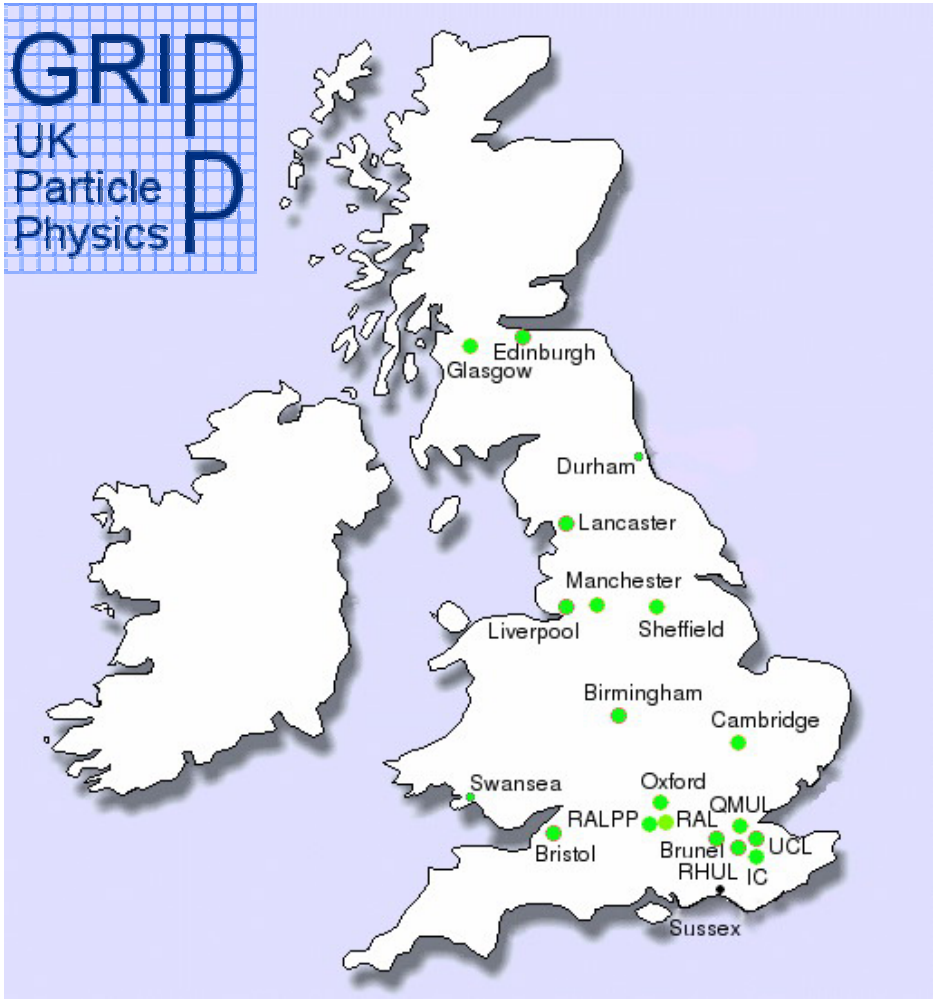
Multiple Projects inc.

- UKQCD
- BaBar
- LHCb

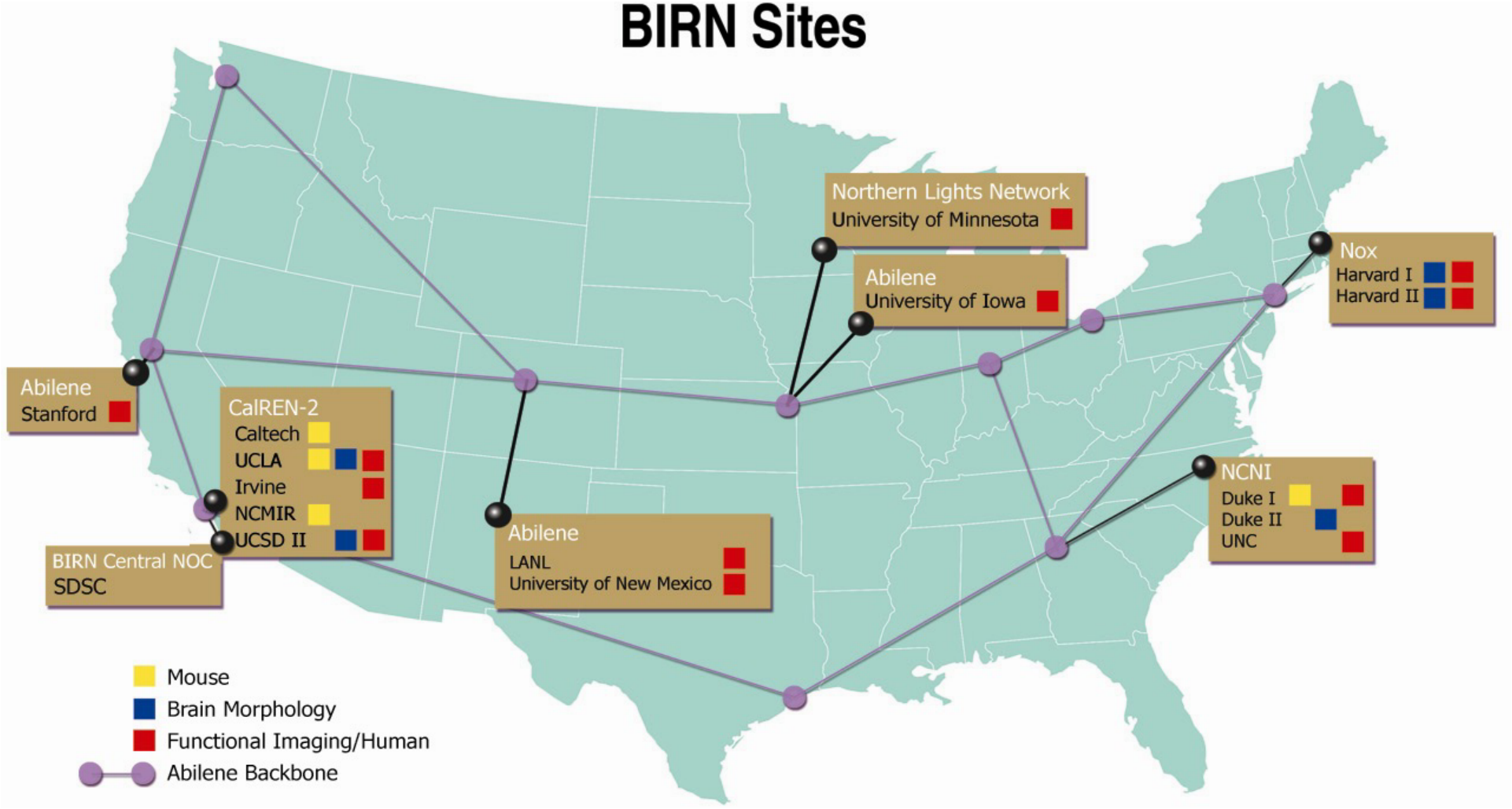
VOMS at Manchester

Resource Broker at IC

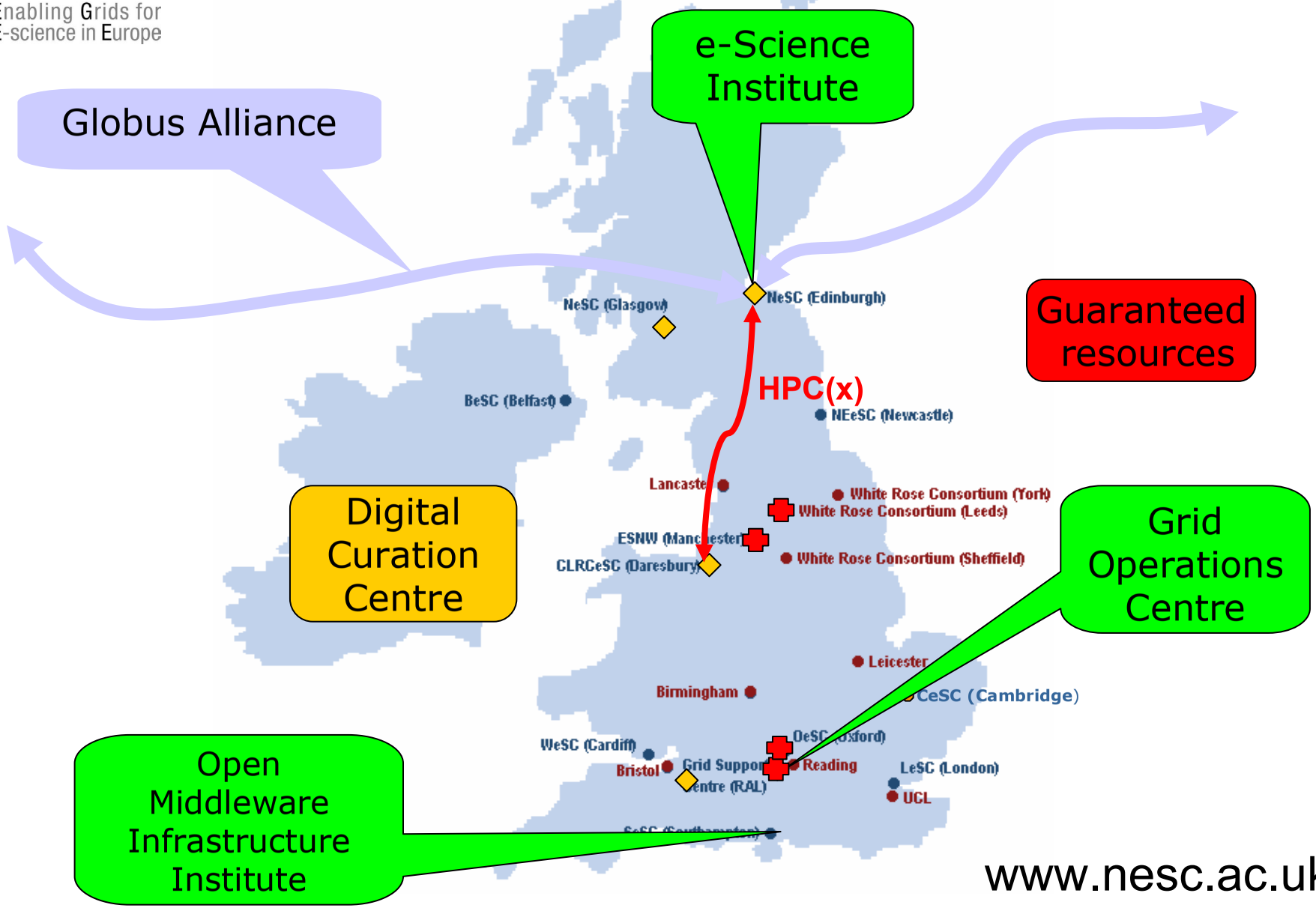
4 Regional Computing Centres



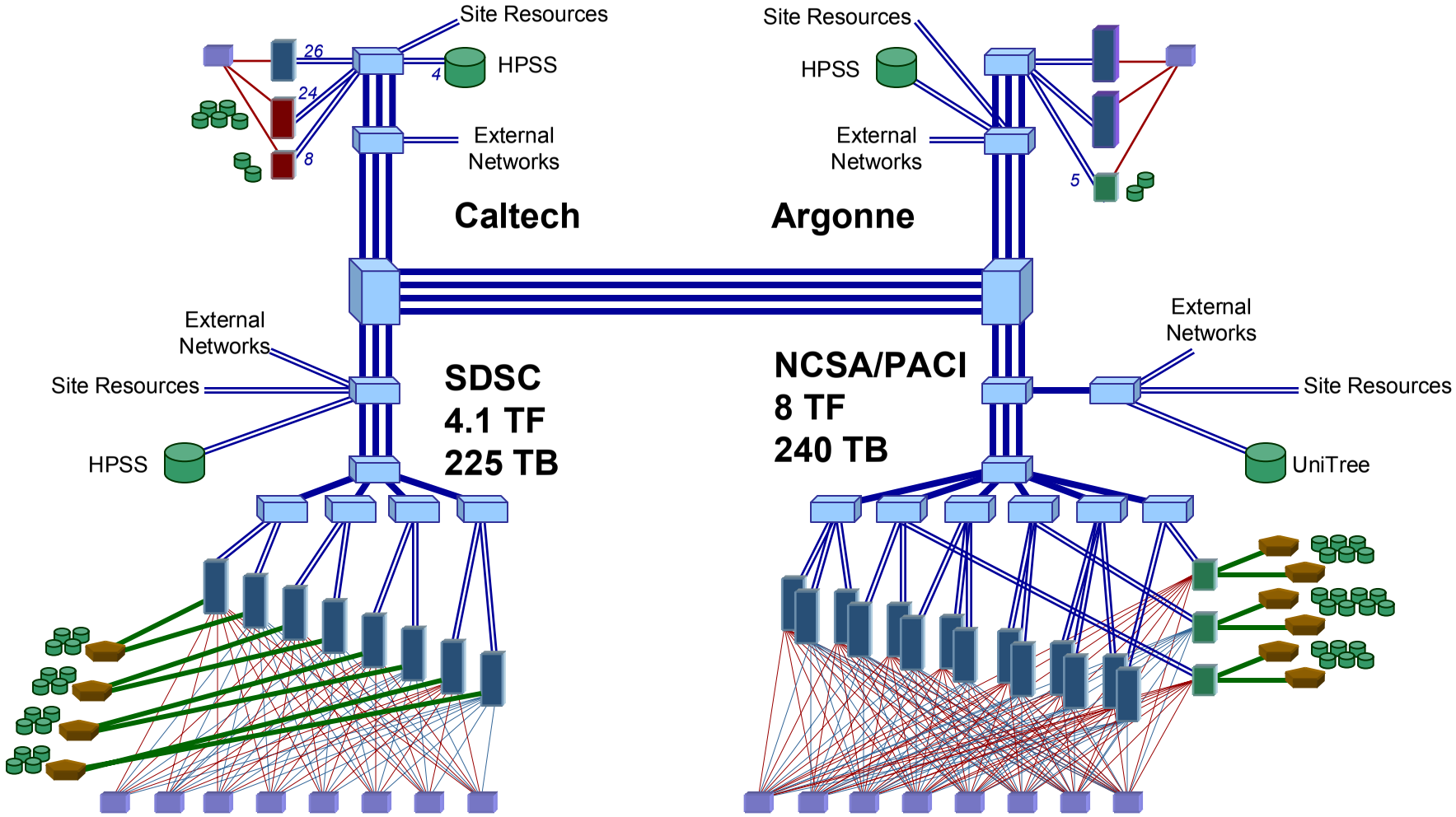
Example: USA Biomedical Informatics Research Network



Example: UK e-Science Grid



2001-2004: TeraGrid (USA)



Major existing Grid projects (1/2)

- **European 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
  - **EUROGRID : 2000-2003** www.eurogrid.org

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

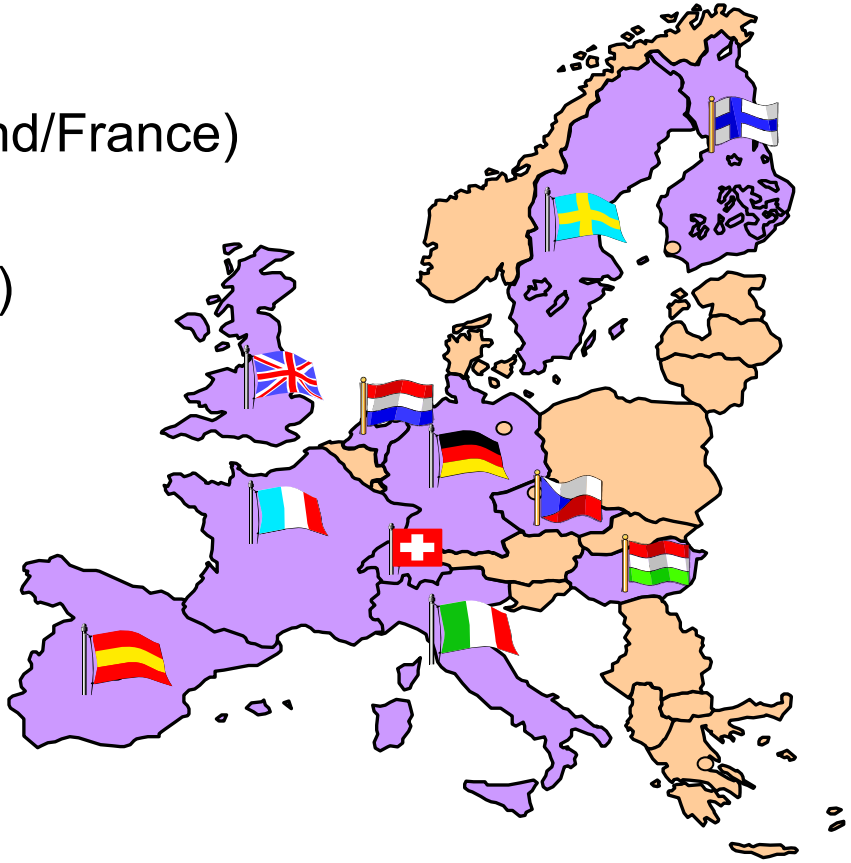
Major existing Grid projects (2/2)

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

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

2001-2003: European Data Grid

- Main Partners
  - CERN – International (Switzerland/France)
  - CNRS - France
  - ESA/ESRIN – International (Italy)
  - INFN - Italy
  - NIKHEF – The Netherlands
  - PPARC - UK
- Industrial Partners
  - Datamat (Italy)
  - IBM-UK (UK)
  - CS-SI (France)



DataGrid in Numbers

People

>350 registered users

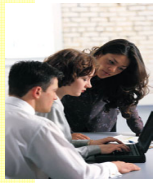
12 Virtual Organisations

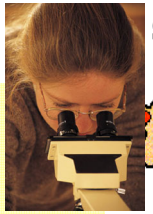
16 Certificate Authorities

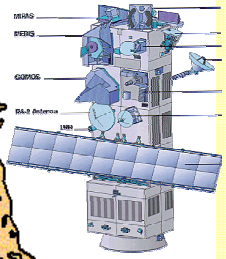
>200 people trained

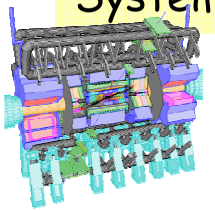
278 man-years of effort

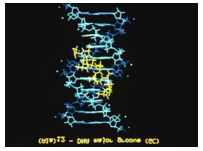
100 years funded

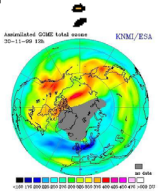












Testbeds

>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

Scientific applications

5 Earth Obs institutes

9 bio-informatics apps

6 HEP experiments

Grid communities

- Established – Co-ordinated communities
  - e.g. HEP, Astronomy
  - Small number of very large data sets
- Emerging – Broader single-discipline communities
  - e.g. BioInformatics, Health, Earth Sciences, Chemistry
  - Large number of separately curated data sources
- Future – Less structured, dynamically created communities?
  - Socio-economic-environmental models
  - Cross-discipline
  - Integration of legacy data and applications
  - Involvement of policy makers and decision takers

Enabling Grids for E-science in Europe

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Enabling Grids for E-science in Europe

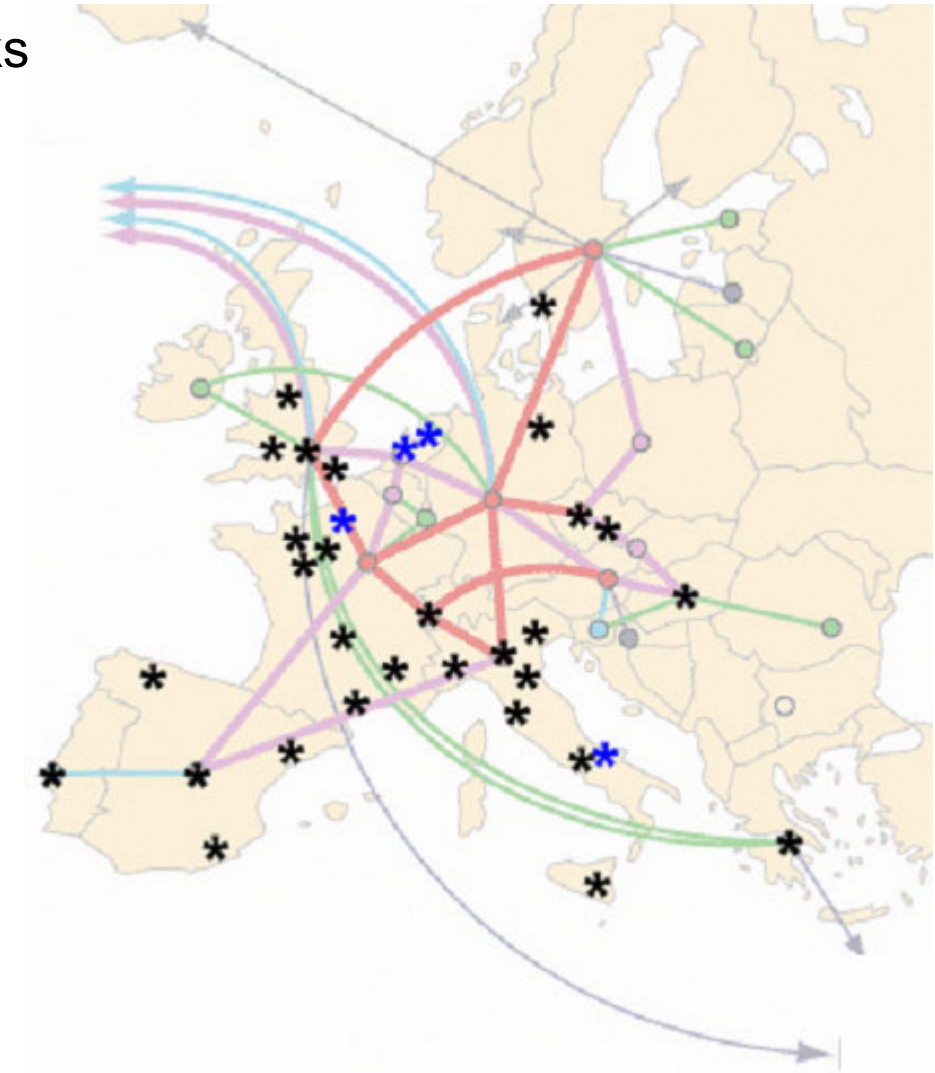
EGEE

- **Goal**
  - Create a European wide production quality Grid
- **Build on**
  - EU and EU member states major investments in Grid Technology
  - International connections (US and AP)
  - Several pioneering prototype results
- **Approach**
  - Bind national and regional Grid infrastructures
  - Procure and deploy robust middleware

The historical analogy

- **EU Geant** ⇒ binds national networks and creates a high performance production network for Europe

- **EGEE** ⇒ will bind national Grid infrastructures - focussing all activities towards establishing a production quality Grid for Europe



The EGEE Consortium

- CERN
- Central Europe (Austria, Czech Republic, Hungary, Poland, Slovakia, Slovenia)
- France
- Germany and Switzerland
- Ireland and UK
- Italy
- Northern Europe (Belgium, Denmark, Estonia, Finland, The Netherlands, Norway, Sweden)
- South-East Europe (Bulgaria, Cyprus, Greece, Israel, Romania)
- South-West Europe (Portugal, Spain)

Total of 70 full partners covering entire EU and beyond
Total budget: ~32 M€

Virtual Data Toolkit

- Condor Group
  - Condor/Condor-G
  - DAGMan
  - Fault Tolerant Shell
  - ClassAds
- Globus Alliance
  - Job submission (GRAM)
  - Information service (MDS)
  - Data transfer (GridFTP)
  - Replica Location (RLS)
- EDG & LCG
  - Make Gridmap
  - Certificate Revocation List Updater
  - GLUE Schema
- ISI & UC
  - Chimera & Pegasus
- NCSA
  - MyProxy
  - GSI OpenSSH
  - UberFTP
- LBL
  - PyGlobus
  - Netlogger
- Caltech
  - MonaLisa
- VDT
  - VDT System Profiler
  - Configuration software
- Others
  - KX509 (U. Mich.)

LHC Computing Grid (LCG)

- Based on VDT
  - EDG Resource Broker
  - Grid File Access library
  - Other extensions
- Homogeneous resources
  - Redhat Linux
- EDG certificate authority
- Operational & network monitoring
  - MDS + GLUE schema, GIIS, Portals
- Virtual organisation management
  - VOMS system

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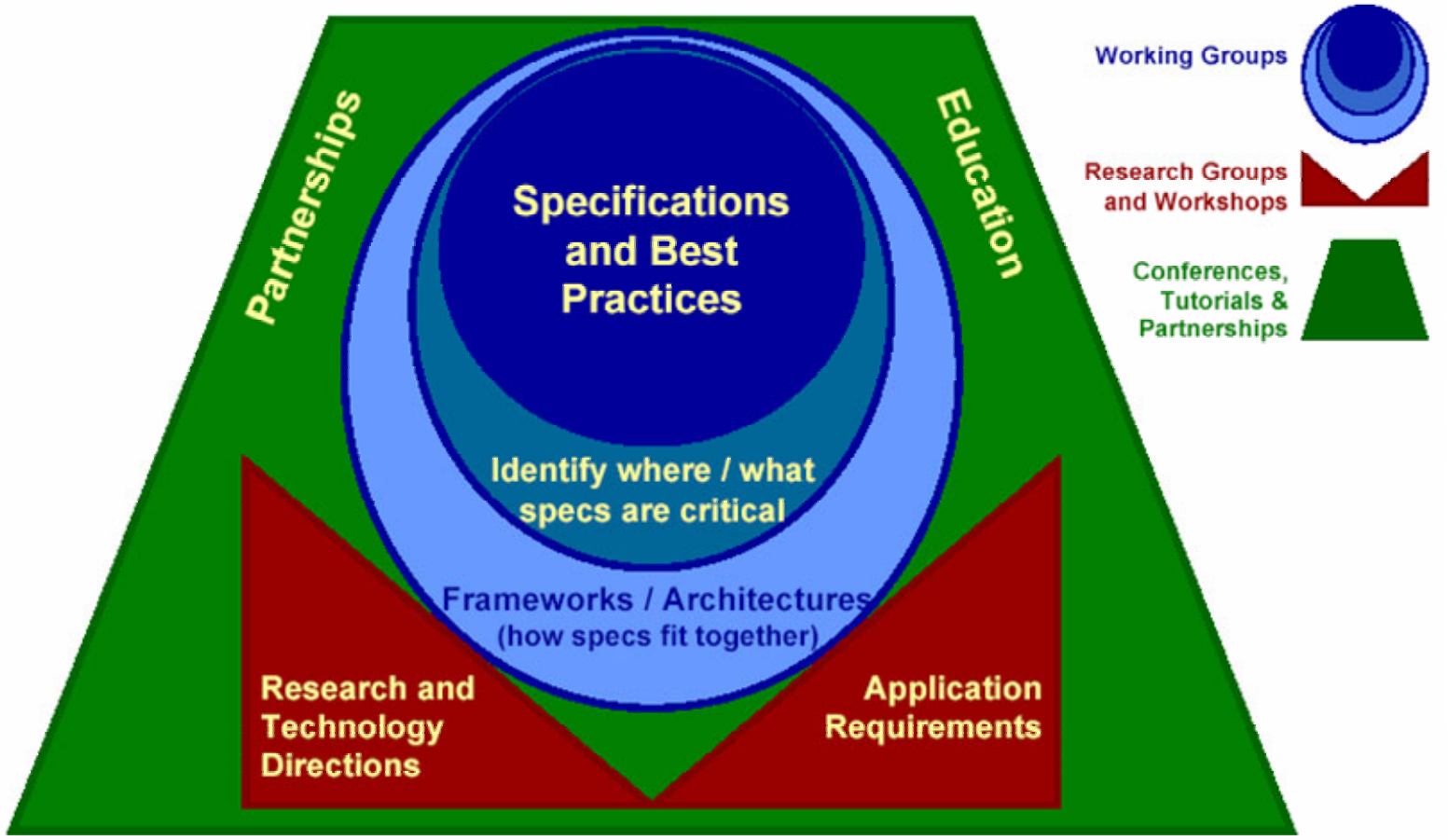
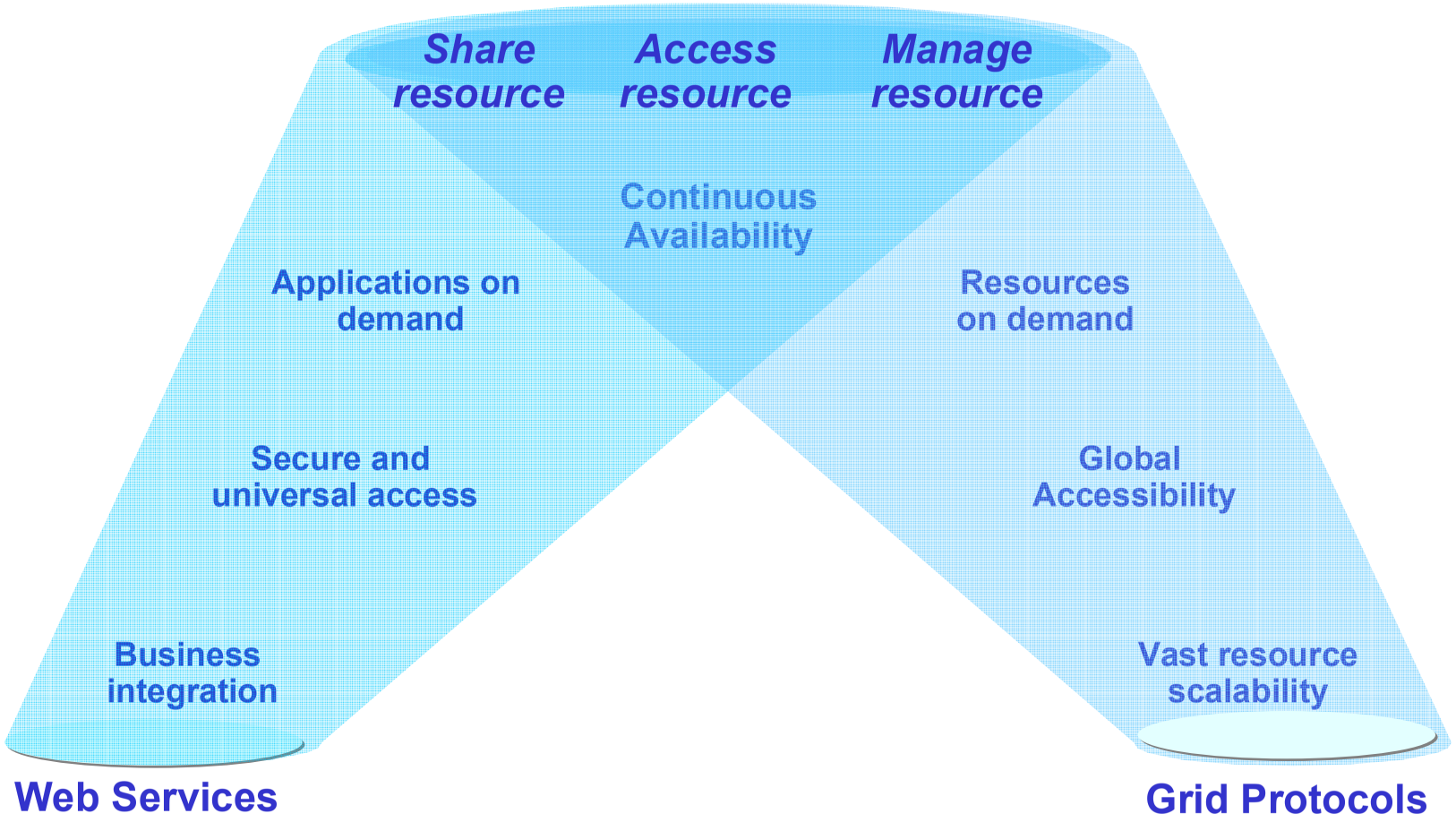
1999 – Present: Global Grid Forum



- Meets 3 times a year to define Grid standards

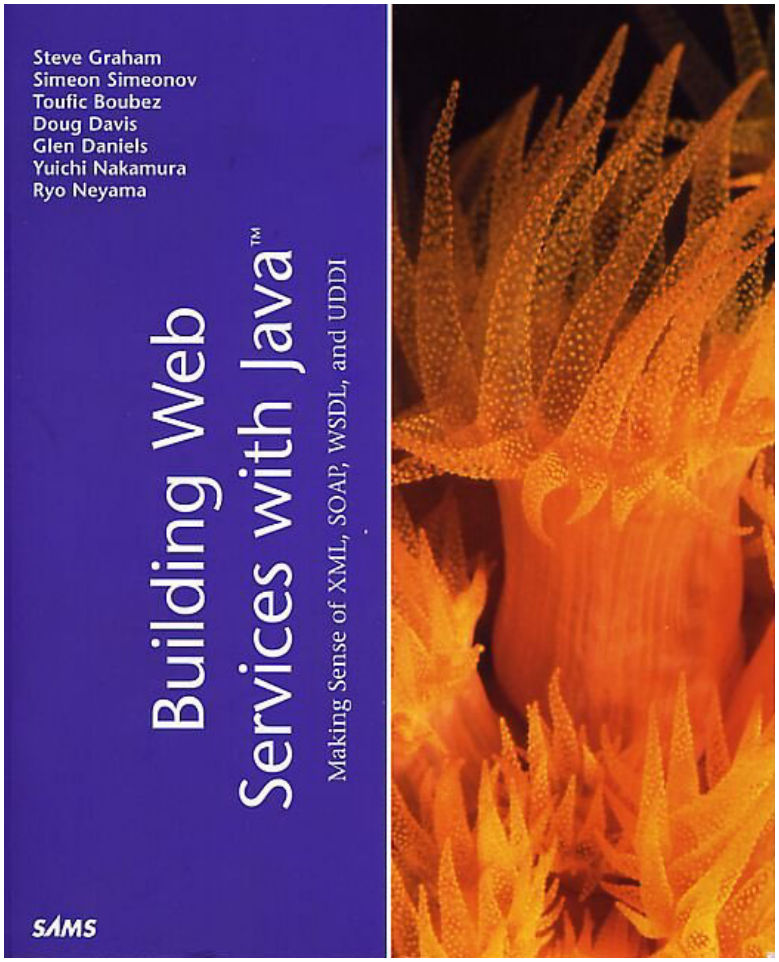
Open Grid Services Architecture



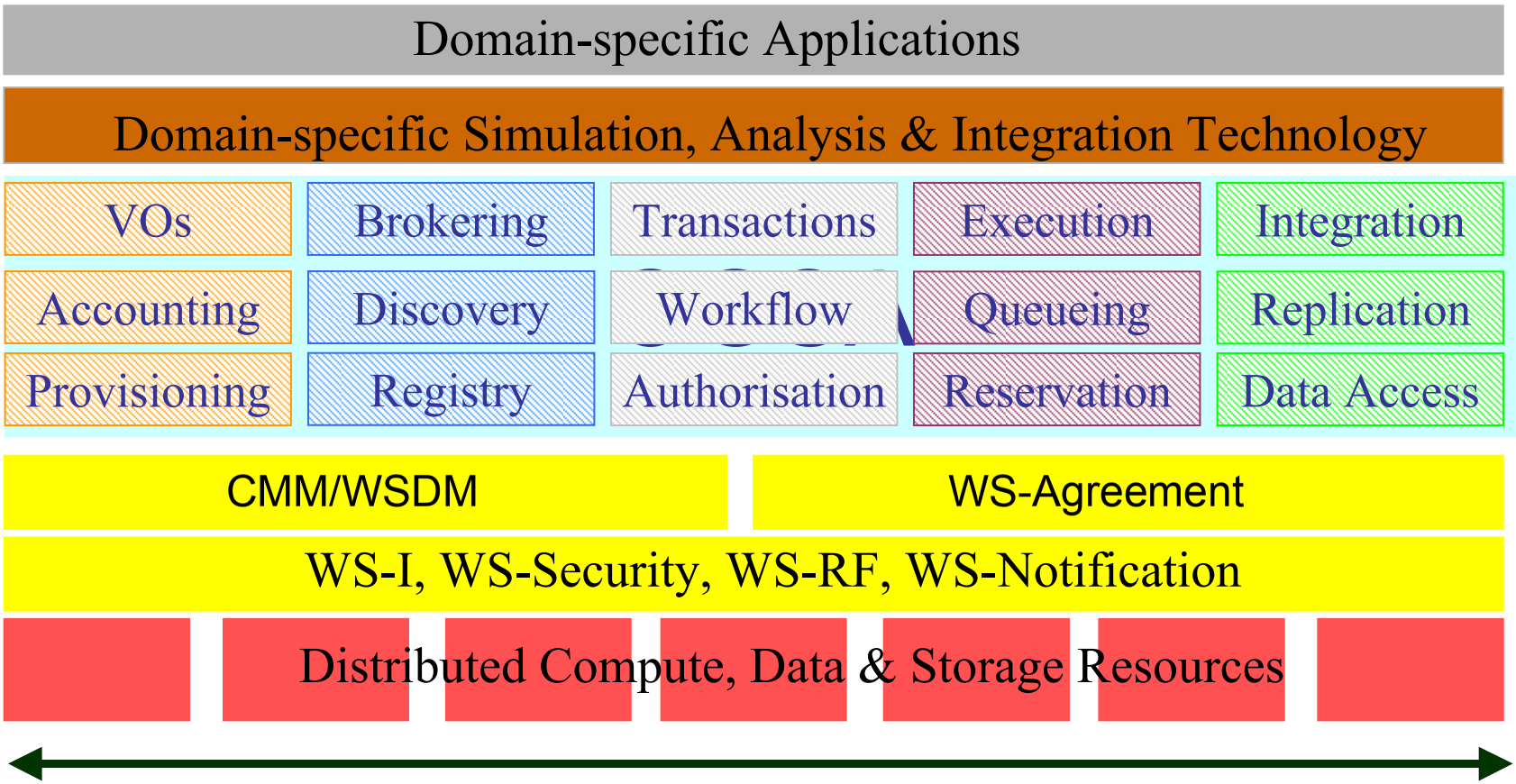
See: “The Physiology Of The Grid”

Web Services

- Description & Discovery
  - WSDL
  - UDDI
- Tools & Platforms
  - Apache axis
  - Websphere, .NET, …
- Invocation
  - SOAP + HTTP
  - …
- Representations
  - XML + Schema



Open Grid Services Architecture



What exists now (roughly) …

Domain-specific Applications

Registry

Data Access

WS-Agreement

WS-I, WS-Security

Distributed Compute, Data & Storage Resources

European Migration to OGSA

- EGEE JRA1 now developing middleware
  - Based on Web Services
  - Pre-production service in 2005
  - Running alongside existing production service
- Later move to WSRF + WS-Notification
  - Globus Toolkit v4
- UK Grid will follow similar strategy
  - Also UNICORE, MS.NETGrid, OGSI::Lite, …
  - Initially running alongside existing GT2-based Grid

Long term prospects

- New architectures
  - EU NextGrid project, and others
- New mechanisms
  - Proof-carrying code?
  - Autonomic computing?
  - More peer-to-peer technologies
  - Better tools
  - New networking technologies
  - …

Enabling Grids for E-science in Europe

Summary

- History:
  - Cycle stealing
  - Cluster management
  - Data Grids
  - Metacomputing
  - Portals
- Current status:
  - Many Grid projects
  - A few Grid Infrastructures
  - EDG, VDT, LCG and EGEE
- The Future:
  - Global Grid Forum
  - OGSA

Enabling Grids for E-science in Europe

Questions?