

# What is Grid Computing?

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- **Introduction to**
  - e-Research and e-Science
  - Grids
  - e-Infrastructure
- **Grid concepts**
- **Grids - Where are we now?**

*‘e-Science is about global collaboration in key areas of science, and the next generation of infrastructure that will enable it.’*

John Taylor

Director General of Research Councils

Office of Science and Technology

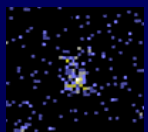
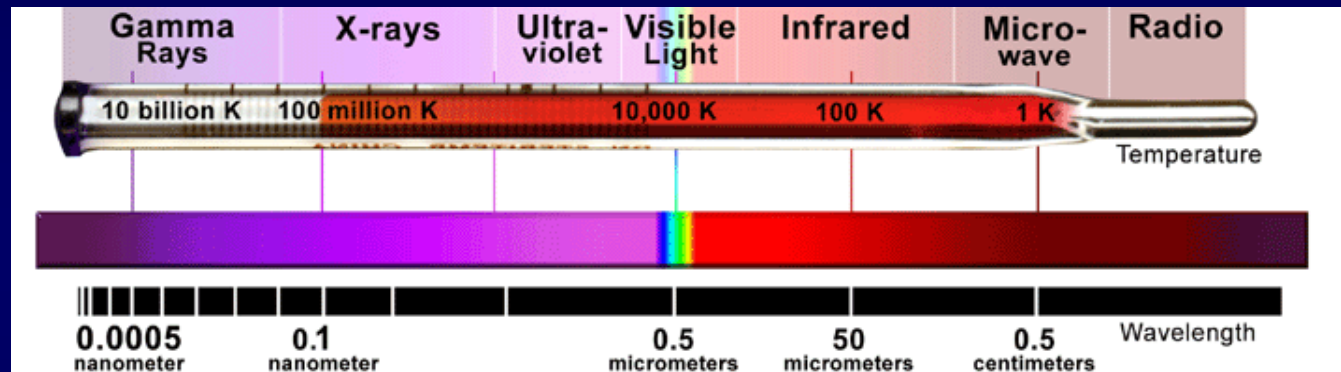
*‘e-Science is about global collaboration in key areas of science, and the **next generation of infrastructure** that will enable it.’*

## **Networks + Grids**

- *Networks connect resources*
- *Grids enable “virtual computing”*

# Virtual Observatories

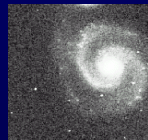
Observations made across entire electromagnetic spectrum



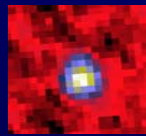
*ROSAT ~keV*



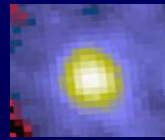
*DSS Optical*



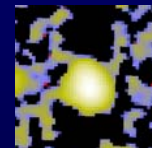
*2MASS 2μ*



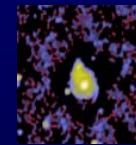
*IRAS 25μ*



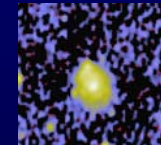
*IRAS 100μ*



*GB 6cm*



*NVSS 20cm*



*WENSS 92cm*

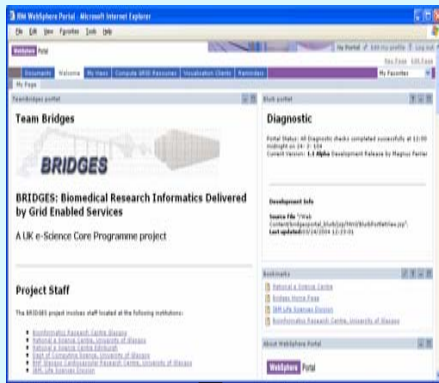
⇒ e.g. different views of a local galaxy

Need all of them to understand physics fully

Databases are located throughout the world

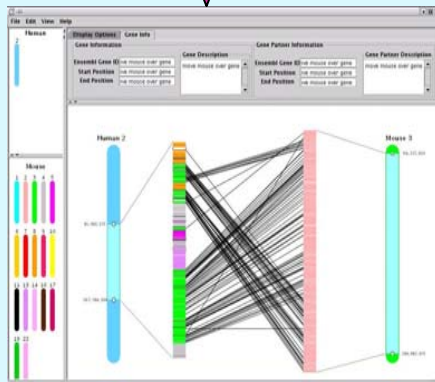
# Biomedical Research Informatics Delivered by Grid Enabled Services

VO Authorisation



Synteny  
Grid  
Service

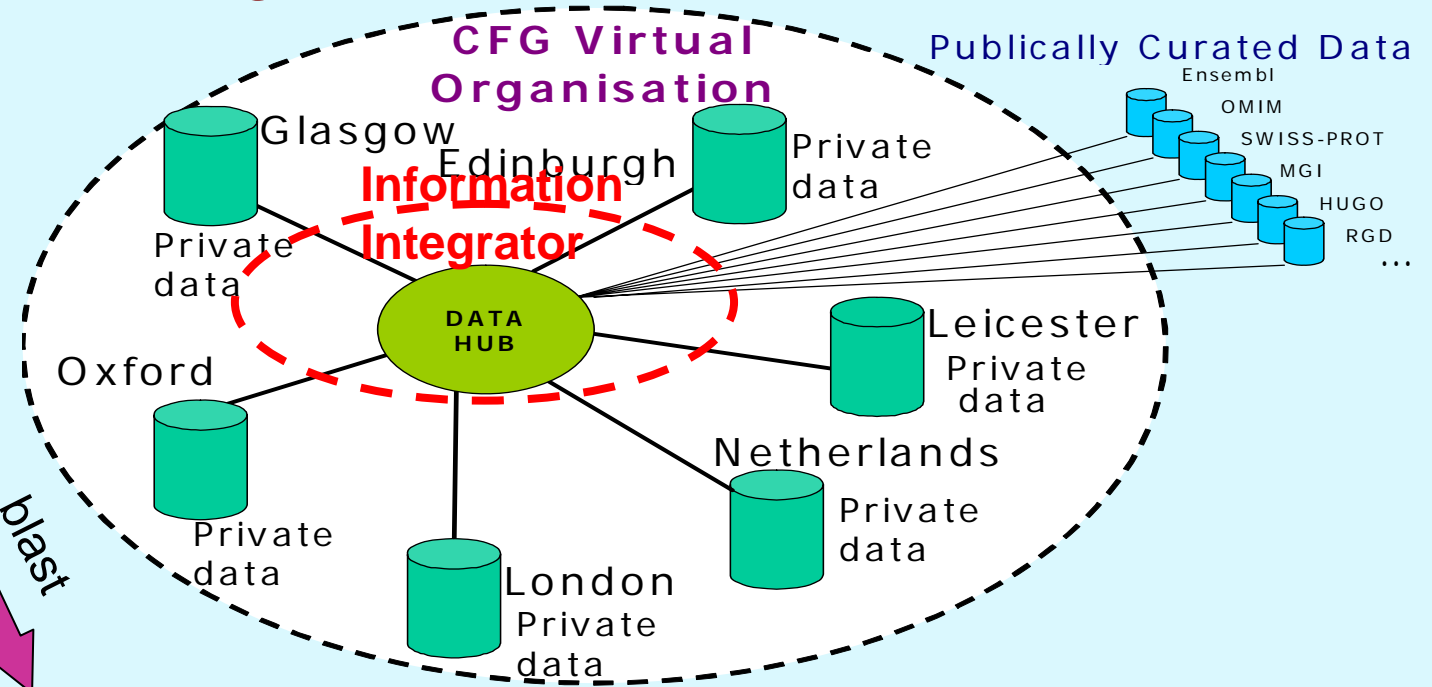
blast



+

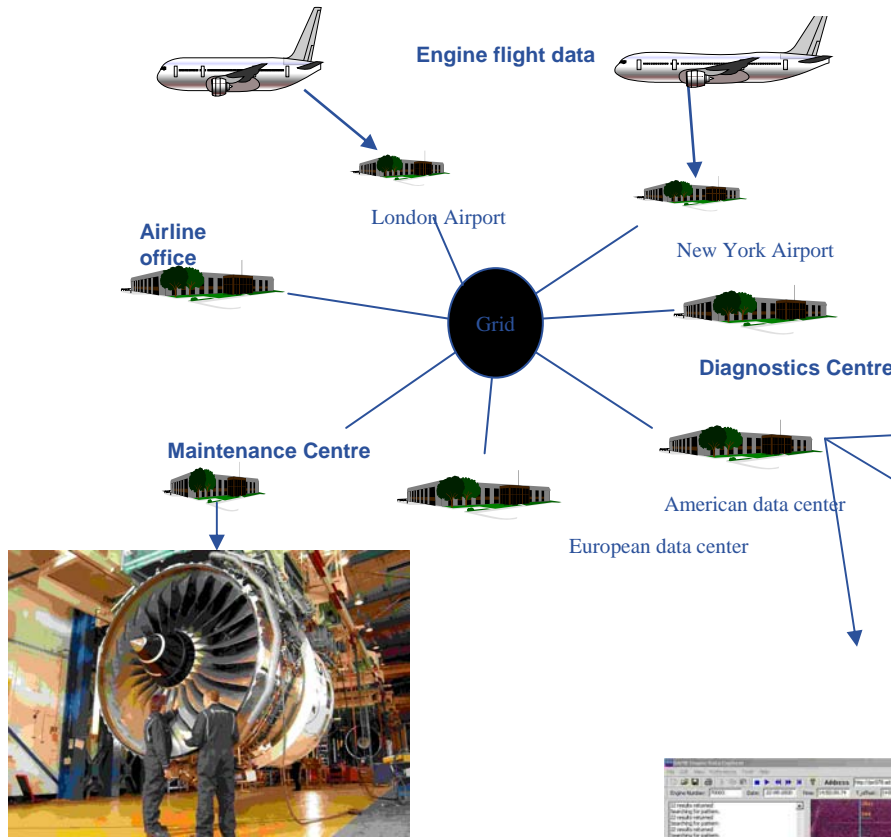


<http://www.brc.dcs.gla.ac.uk/projects/bridges/>





# DAME: Grid based tools and Infrastructure for Aero-Engine Diagnosis and Prognosis



“A Significant factor in the success of the Rolls-Royce campaign to power the Boeing 7E7 with the Trent 1000 was the emphasis on the new aftermarket support service for the engines provided via DS&S. Boeing personnel were shown DAME as an example of the new ways of gathering and processing the large amounts of data that could be retrieved from an advanced aircraft such as the 7E7, and they were very impressed”, DS&S 2004



**Companies:**  
Rolls-Royce  
DS&S  
Cybula

**Universities:**  
York,  
Leeds,  
Sheffield, Oxford

XTO

Engine Model

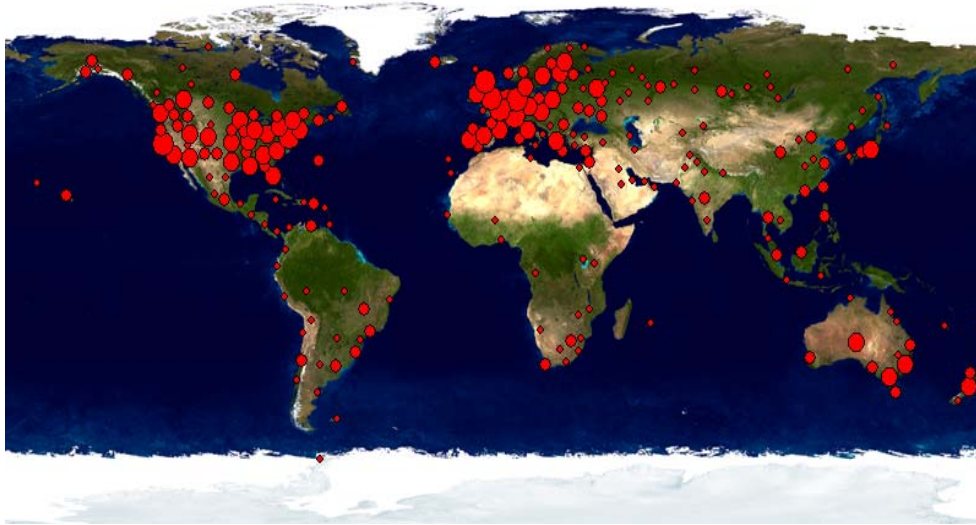
Case Based Reasoning

**Follow-on project: BROADEN**

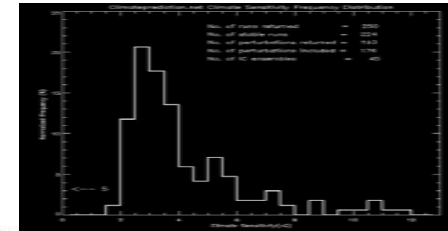
Signal Data Explorer



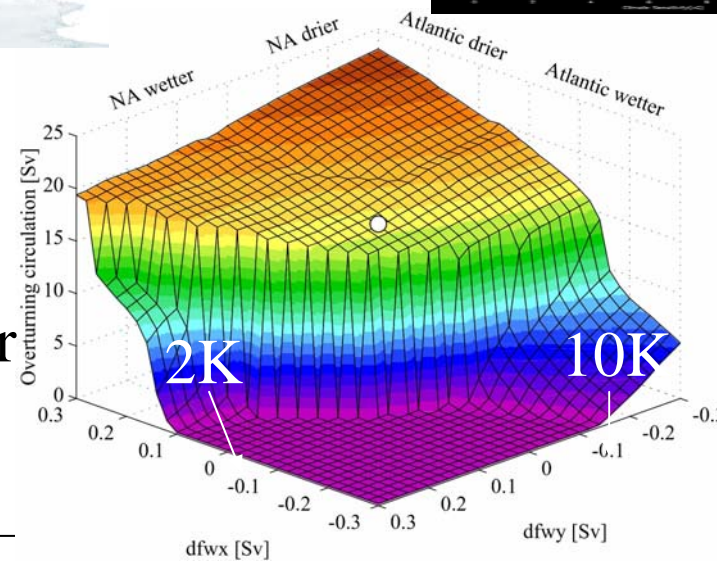
# climateprediction.net and GENIE



- Largest climate model ensemble
- >45,000 users, >1,000,000 model years

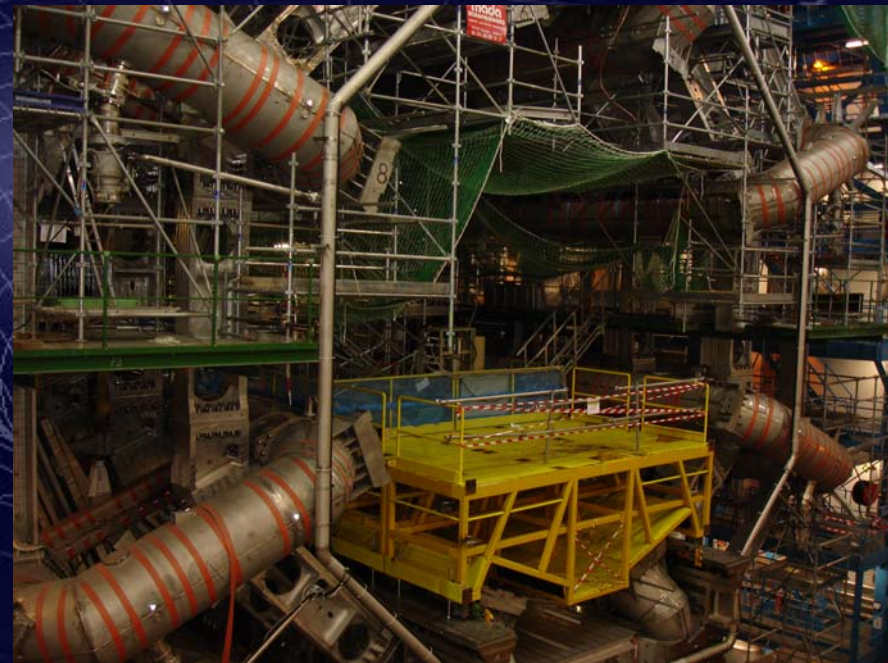


Response of Atlantic circulation to freshwater forcing



PPARC

# UK Grid for Particle Physics



GridPP [www.gridpp.ac.uk](http://www.gridpp.ac.uk)

ATLAS detectors, 2/3/06

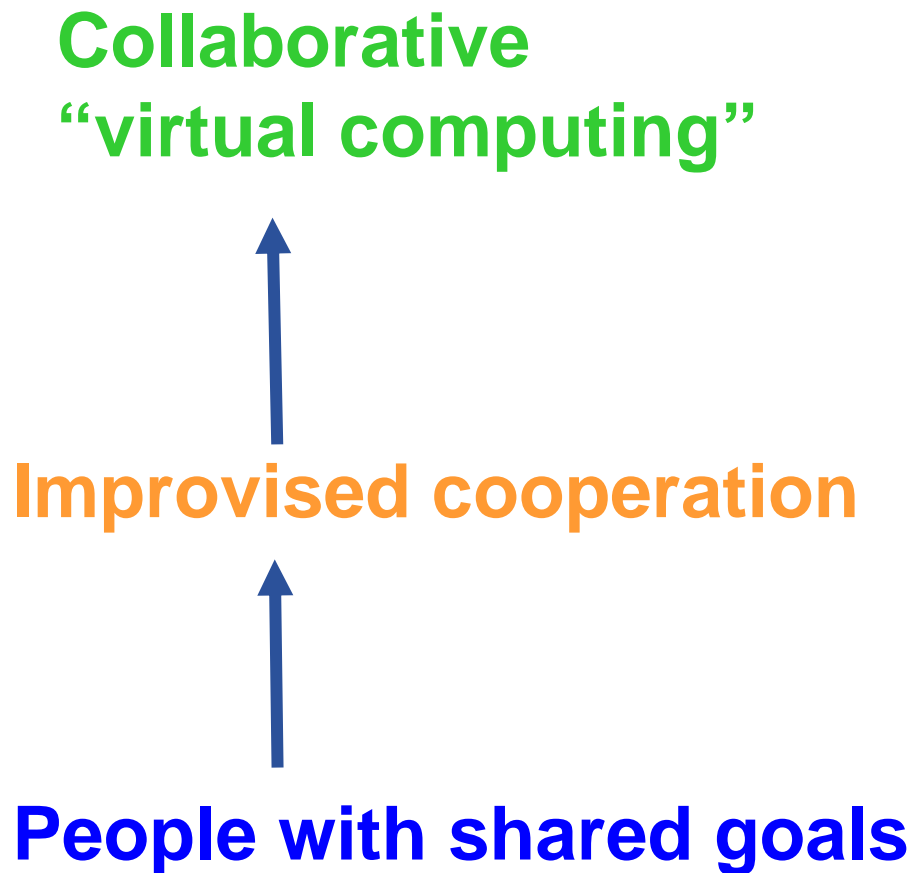
<http://www.accessgrid.org/>

Cameras



Microphones

- **Collaborative research that is made possible by the sharing across the Internet of resources (data, instruments, computation, people's expertise...)**
  - Crosses organisational boundaries
  - Often very compute intensive
  - Often very data intensive
  - Sometimes large-scale collaboration
- **Began with focus in the “big sciences” hence initiatives are often badged as “e-science”**
- **Relevance of “e-science technologies” to new user communities (social science, arts, humanities...) led to the term “e-research”**



Sharing data, computers, software  
Enabled by Grids:

National, regional  
International: EGEE grid

Email  
File exchange  
ssh access to run programs  
Enabled by networks:

national, regional and  
International: GEANT

# Grids: a foundation for e-Research

- enabling a whole-system approach

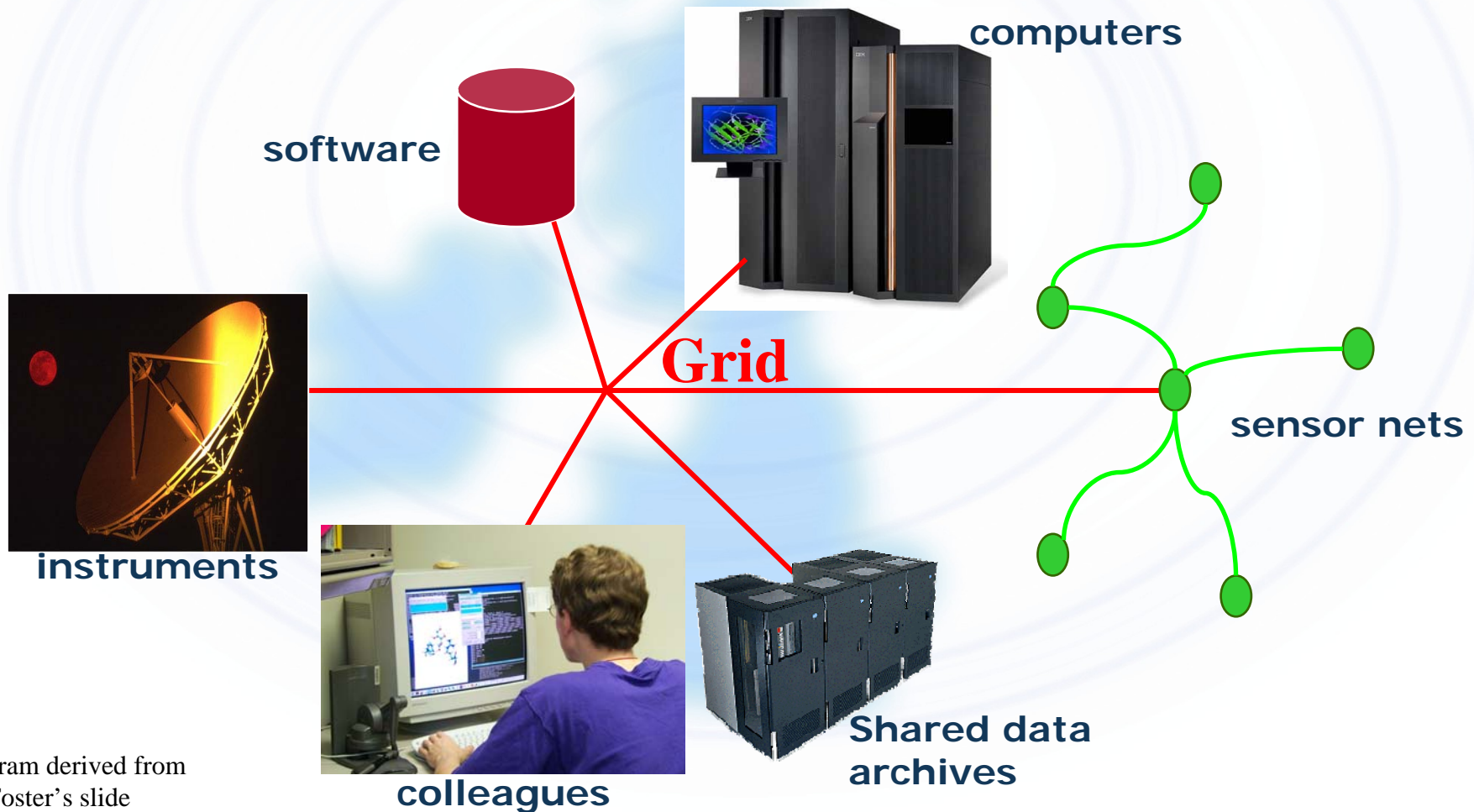
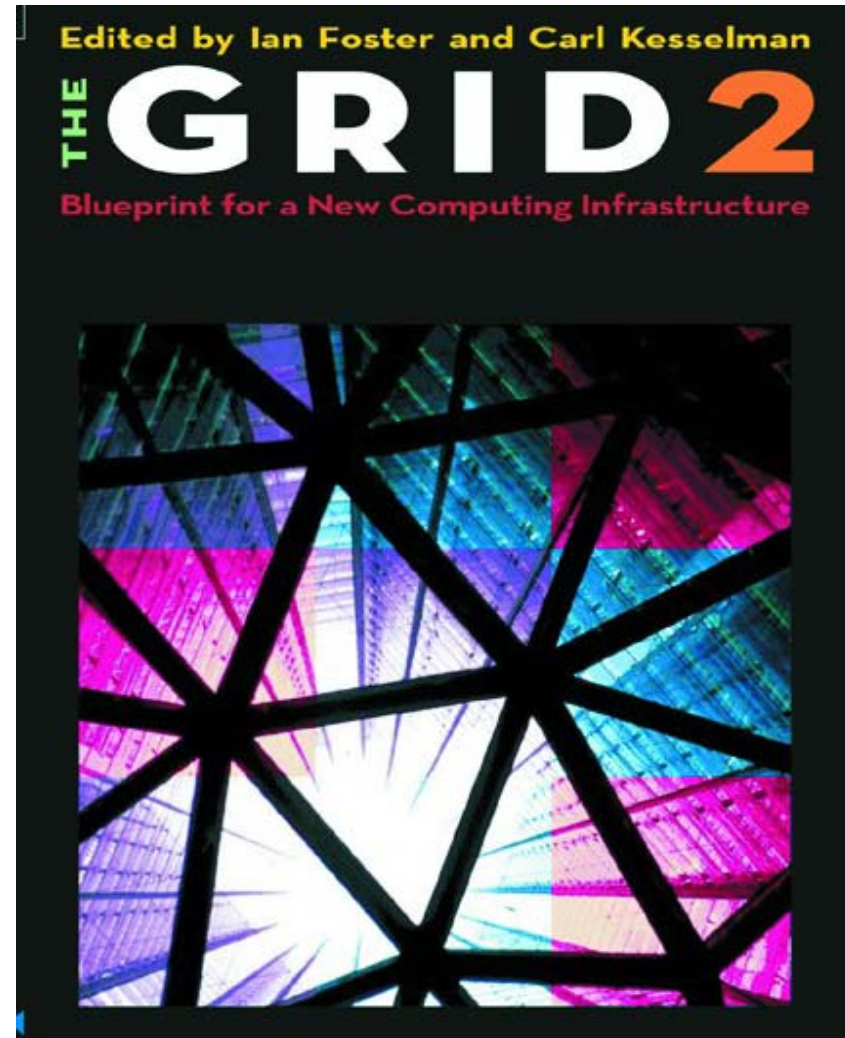
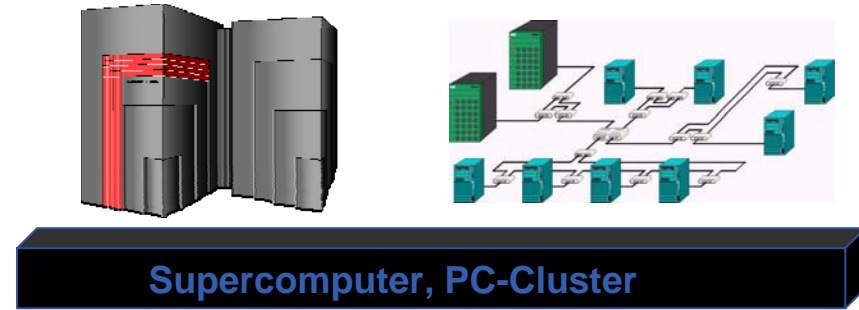
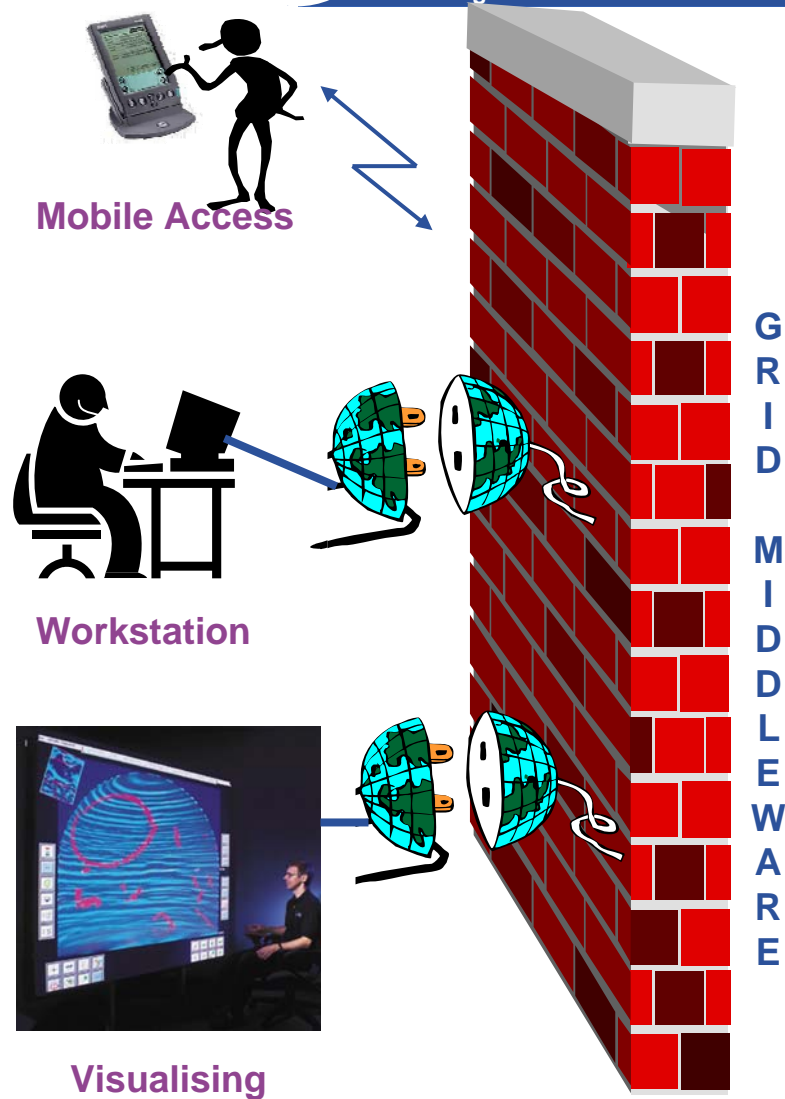


Diagram derived from  
Ian Foster's slide

- The grid vision is of “Virtual computing” (+ information services to locate computation, storage resources)
  - Compare: The web: “virtual documents” (+ search engine to locate them)
  
- **MOTIVATION: collaboration through sharing resources (and expertise) to expand horizons of**
  - Research
  - Commerce – engineering, ...
  - Public service – health, environment,...







- **A shared resource**
  - That enables science, research, engineering, medicine, industry, ...
  - It will improve UK / European / ... productivity
    - Lisbon Accord 2000
    - E-Science Vision SR2000 – John Taylor
  - Commitment by UK government
    - Sections 2.23-2.25
  - Always there
    - c.f. telephones, transport, power, internet

## Science & innovation investment framework 2004 - 2014

July 2004



department for  
education and skills



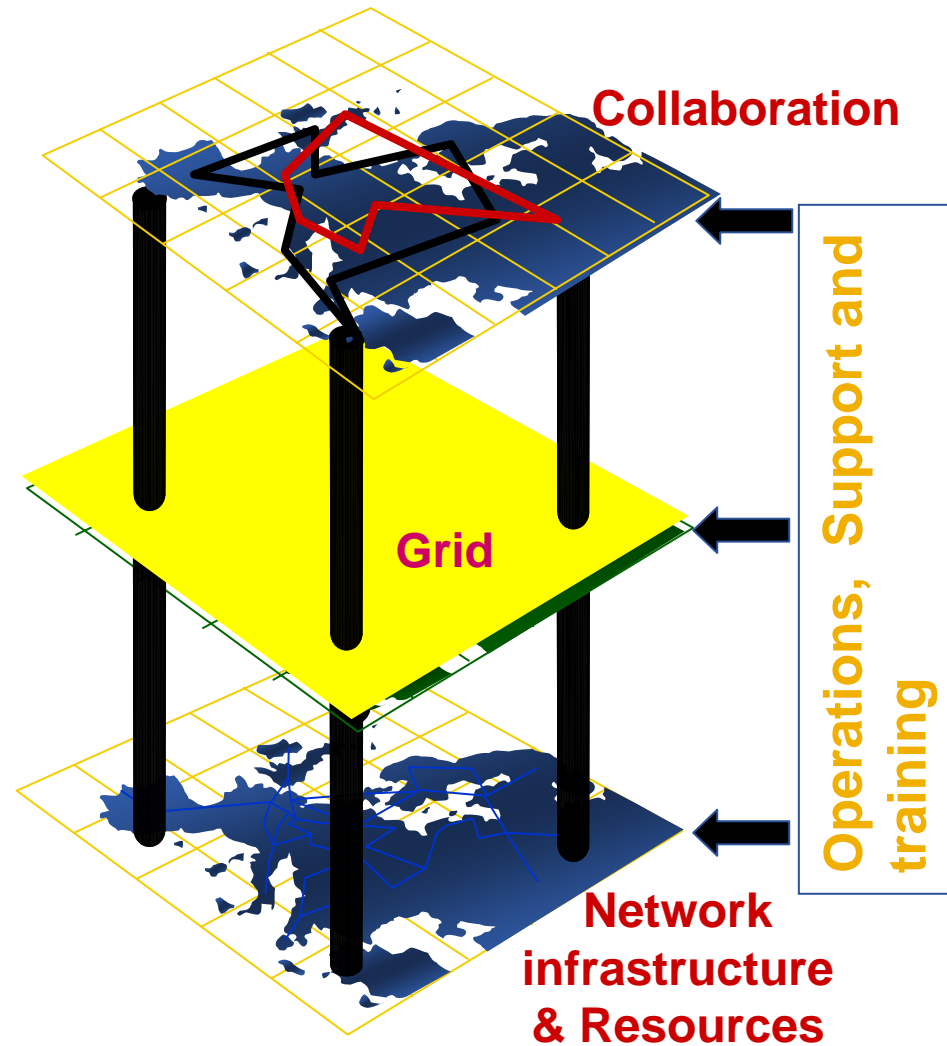

Gordon Brown  
Chancellor of the  
Exchequer

Charles Clarke  
Secretary of State for  
Education and Skills

Patricia Hewitt  
Secretary of State for  
Trade and Industry

# What is e-Infrastructure?

- **Grids:** permit resource sharing across administrative domains
- **Networks:** permit communication across geographical distance
- **Supporting organisations**
  - Operations for grids, networks
- **Resources**
  - Computers
  - Digital libraries
  - Research data
  - Instruments
- **Middleware**
  - Authentication, Authorisation
  - Registries, search engines
  - Toolkits, environments
    - E.g. for collaboration



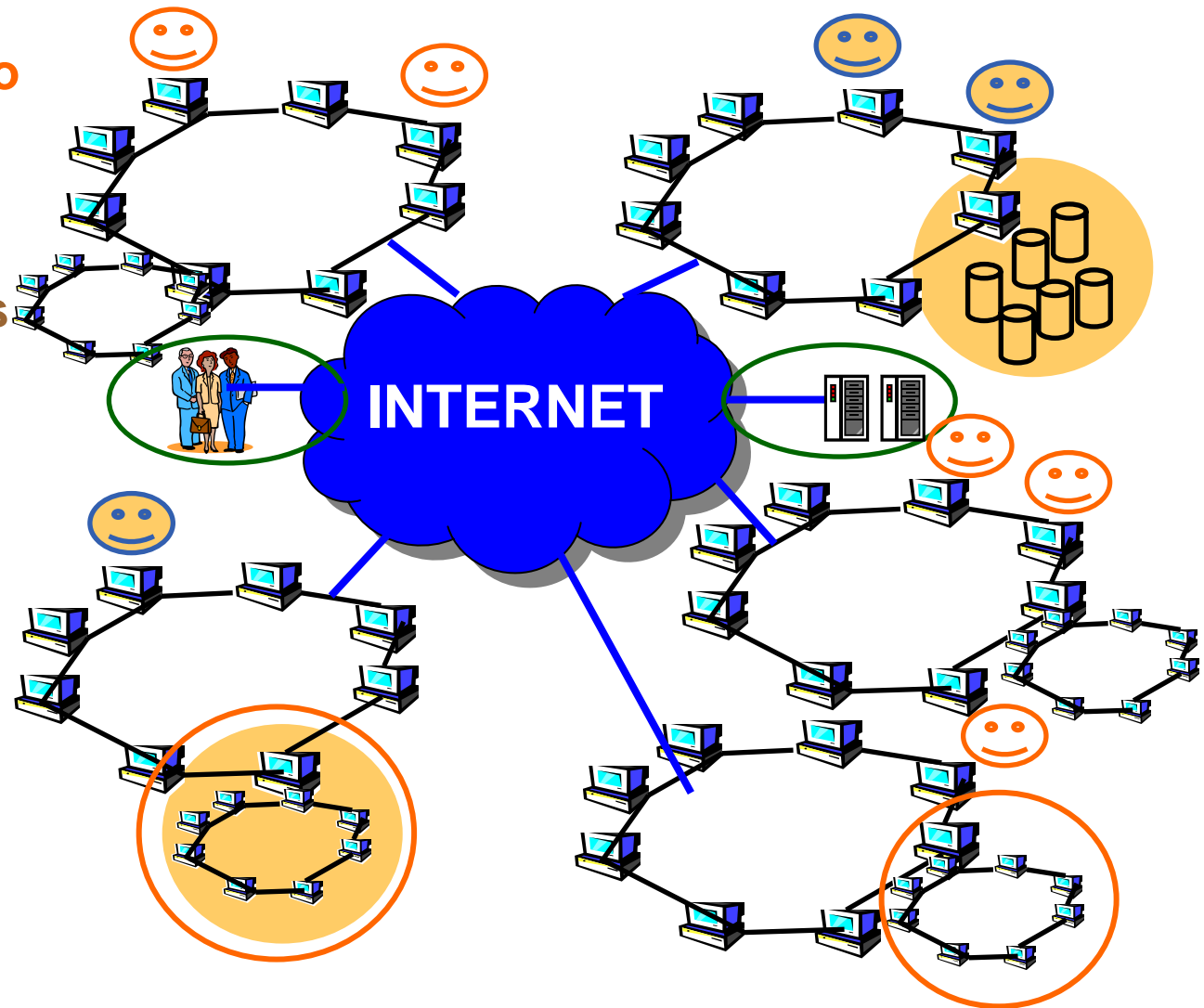
- **Digital technology – exponential growth - e.g. bandwidth**
- **Opportunities for e-Infrastructure to support faster, better, different research**
  - Sharing expertise
    - Support for cooperation and communication
  - Sharing computation services
    - E.g. to serve occasional peaks of high demand for computation (especially trivially parallelisable ones)
  - Sharing data
    - New sensors and instruments
    - Databases
- **Based on an infrastructure that requires and enables multidisciplinary research**
  - Requires: IT + domain specialists
  - Enables: New interdisciplinary research

- **The term “Grid” has become popular!**
  - Sometimes in Industry : “Grids” = clusters
    - Motivations: better use of resources; scope for commercial services
  - Also used to refer to the harvesting of donated, unused compute cycles
    - (SETI@home, Climateprediction.net)
  - These are e-Infrastructure but are not “grids” from the e-Research viewpoint!

# Grid concepts

- **What's a Virtual Organisation?**
  - People in different organisations seeking to cooperate and share resources across their organisational boundaries E.g. A research collaboration
- **Each grid is an infrastructure enabling one or more “virtual organisations” to share and access resources**
- **Key concept: The 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. (Ian Foster)**

- **Virtual organisations negotiate with sites to agree access to resources**
- **Grid middleware runs on each shared resource to provide**
  - Data services
  - Computation services
  - Single sign-on
- **Distributed services (both people and middleware) enable the grid**





**Where computer science meets the application communities!**

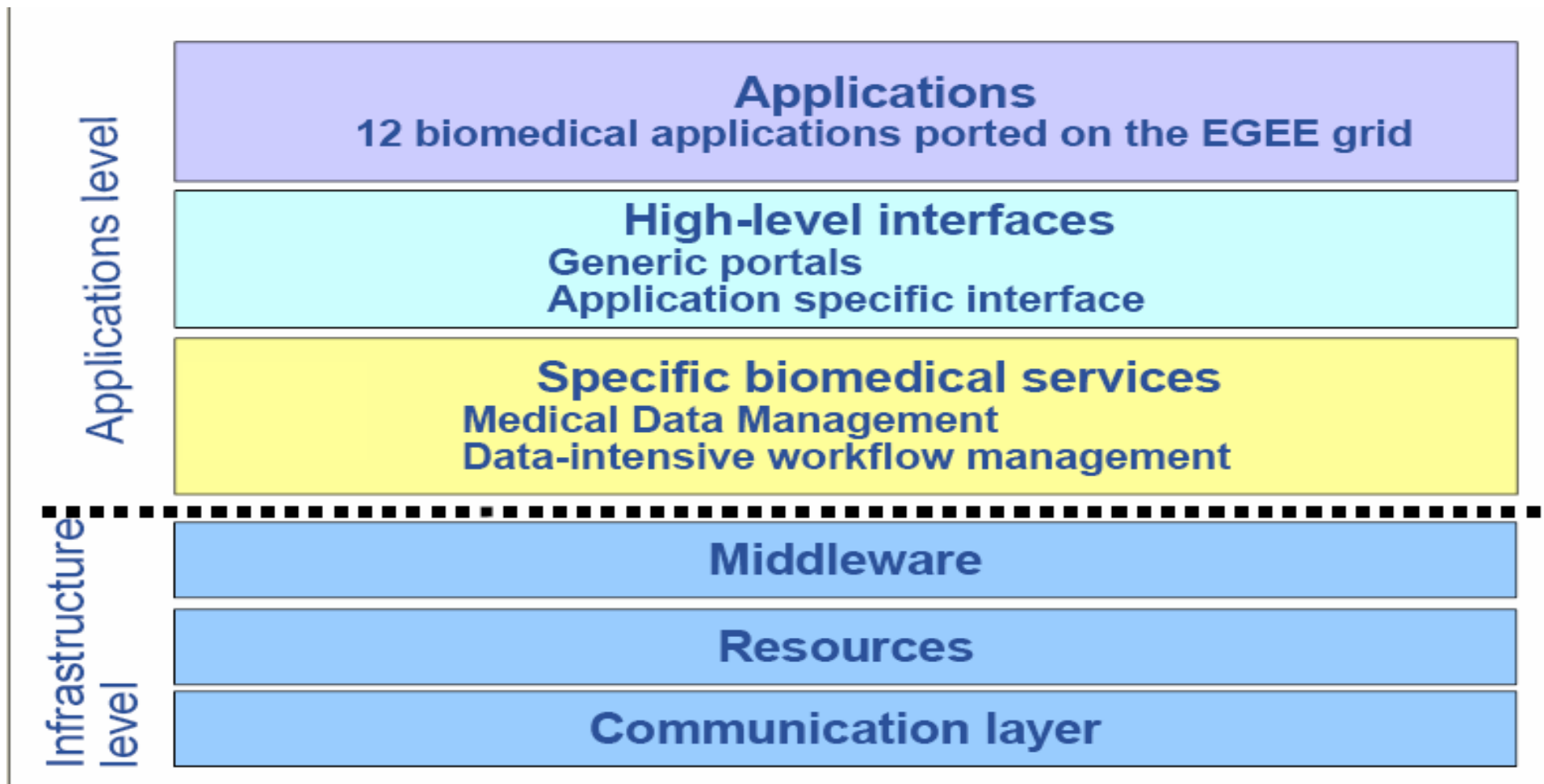
**VO-specific developments:**

- Portals
- Virtual Research Environments
- Semantics, ontologies
- Workflow
- Registries of VO services

**Production grids provide these services.**

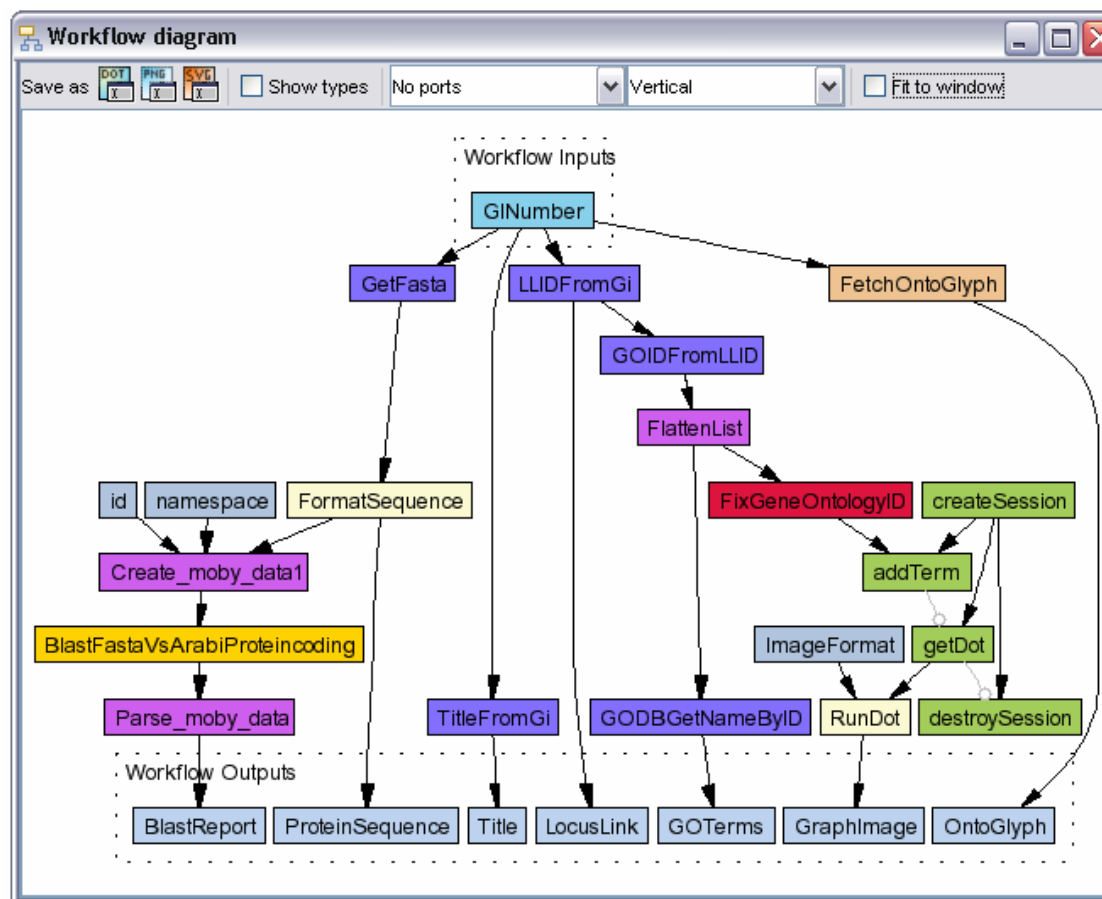


# Example – Biomedical applications



*Biomedical community and the Grid, EGEE User Forum, March 1<sup>st</sup> 2006, I. Magnin*

- Taverna in MyGrid <http://www.mygrid.org.uk/>
- “allows the e-Scientist to describe and enact their experimental processes in a structured, repeatable and verifiable way”
- GUI
- Workflow language
- enactment engine



International instruments,..

National datacentres,  
HPC, instruments

Institutes' data;  
Condor pools,  
clusters

Wider collaboration  
greater resources



International grid (EGEE)

National grids (e.g.  
National Grid Service)

Regional grids (e.g.  
White Rose Grid)

Campus grids

Desktop



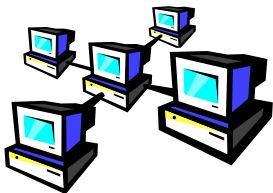
**Access service** How users logon to a Grid



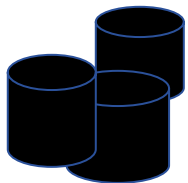
**Resource Broker (RB)**: Service that matches the user's requirements with the available resources on a Grid



**Information System**: Characteristics and status of resources



**Computing Element (CE)**: A batch queue on a site's computers where the user's job is executed



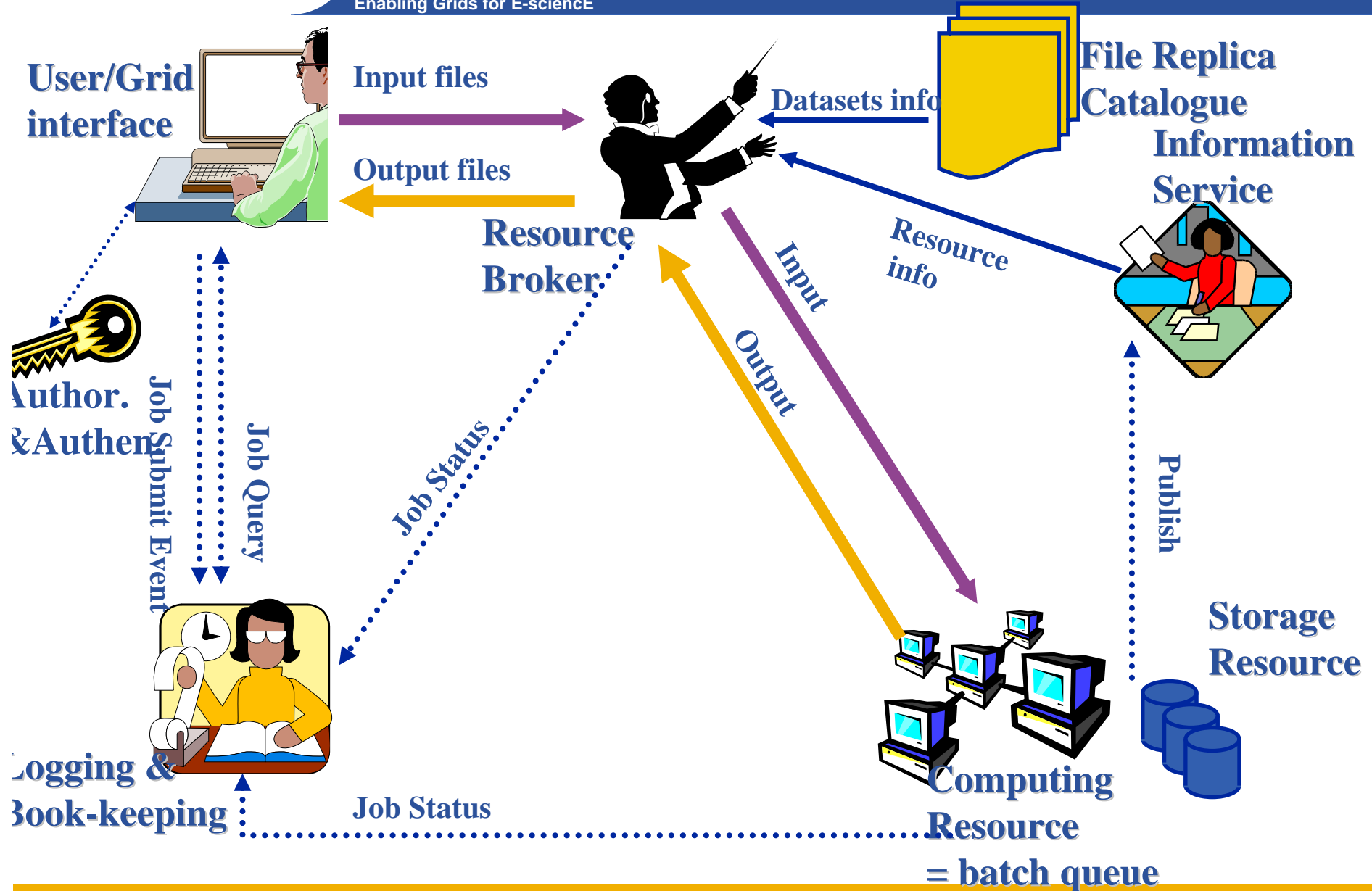
**Storage Element (SE)**: provides (large-scale) storage for files

# Who provides the resources?!

<u>Service</u>	<u>Provider</u>	<u>Note</u>
<u>Access service</u>	User / institute/ VO / grid operations	Computer with client software
<u>Resource Broker (RB)</u>	VO / grid operations	(No NGS-wide RB exists)
<u>Information System:</u>	Grid operations	
<u>Computing Element (CE)</u>	VO / sometimes centralised provision also	Scalability requires that VOs provide resources to match average need
<u>Storage Element (SE)</u>	ditto	ditto

“VO”: virtual organisation

“Grid operations”: funded effort



- **EU-funded project that has established the largest multi-VO production grid in the world!**
- **What's happening now?**  
<http://gridportal.hep.ph.ic.ac.uk/rtm/>
- **What resources are connected?**  
<http://goc.grid-support.ac.uk/gridsite/monitoring/>

- **Providers of resources (computers, databases,...) need risks to be controlled: they are asked to trust users they do not know**
  - They trust a VO
  - The VO trusts its members
- **User's need**
  - single sign-on: to be able to logon to a machine that can pass the user's identity to other resources
  - To trust owners of the resources they are using
- **Build middleware on layer providing:**
  - *Authentication*: know who wants to use resource
  - *Authorisation*: know what the user is allowed to do
  - *Security*: reduce vulnerability, e.g. from outside the firewall
  - *Non-repudiation*: knowing who did what
- **The “Grid Security Infrastructure” middleware is the basis of (most) production grids**



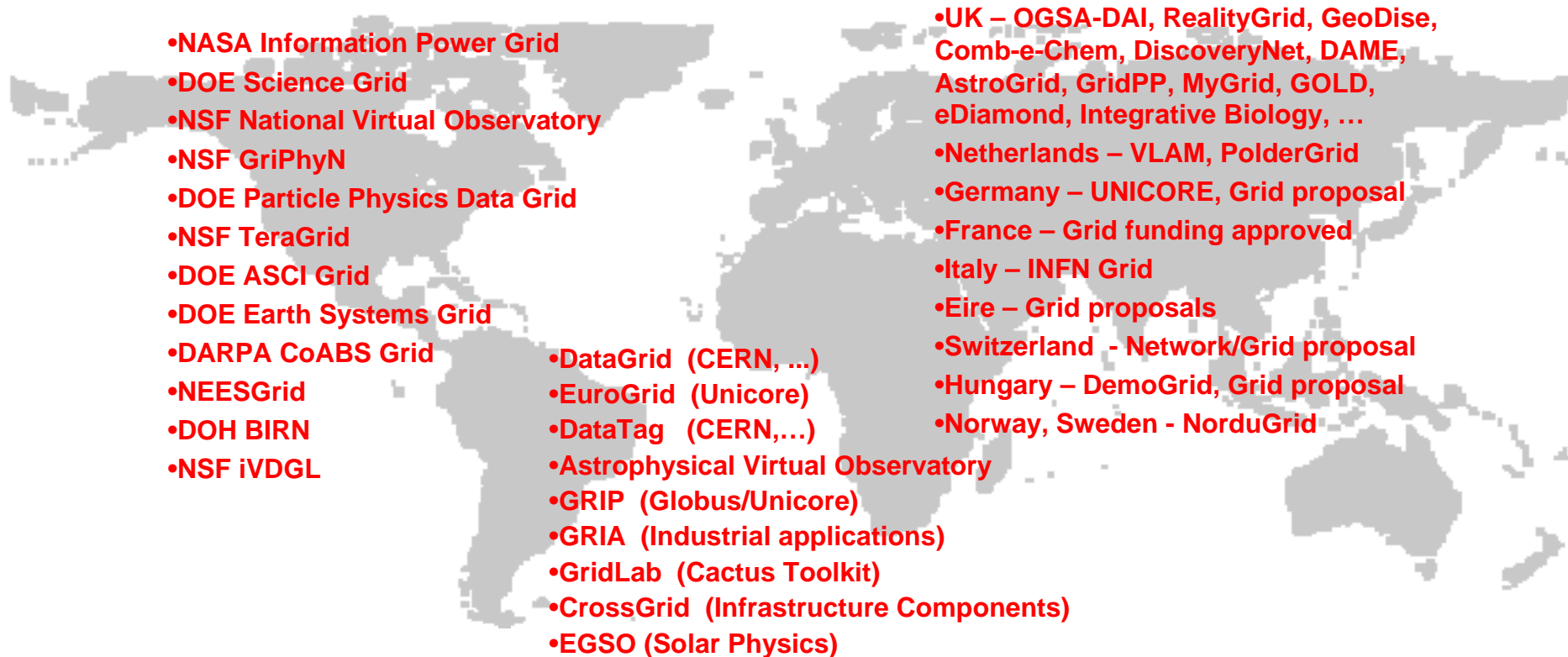
- **Achieved by Certification:**
  - User’s identity has to be certified by one of the national *Certification Authorities* (CAs)
    - mutually recognized <http://www.gridpma.org/>
  - In UK go to <http://www.grid-support.ac.uk/ca/ralist.htm> to find CA’s local “Registration Authorities”
  - Resources are also certified by CAs
- **User**
  - User joins a VO
  - Digital certificate is basis of AA
  - Identity passed to resources you use, where it is mapped to a local account
- ***Policies* express the rights for a Virtual Organization to use resources**



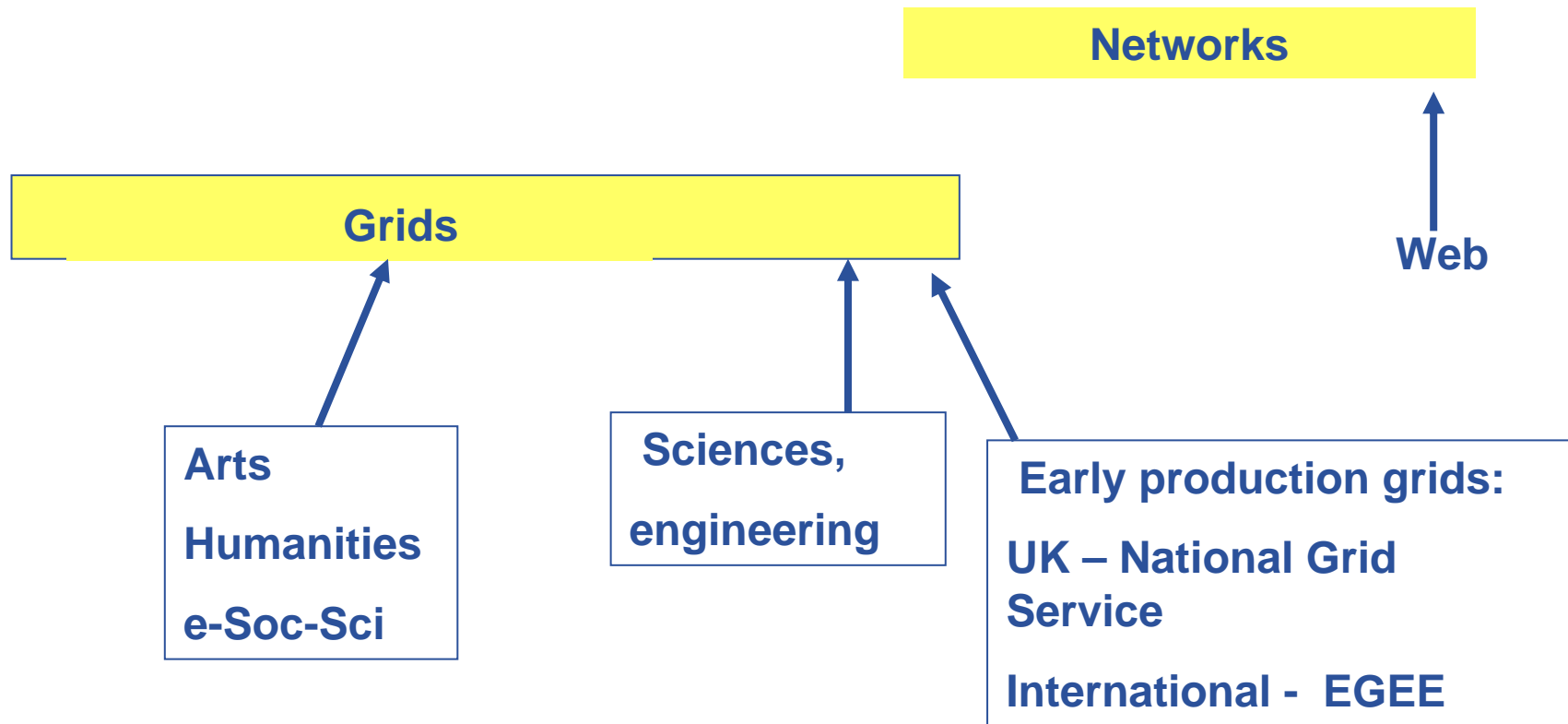
If "The Grid"  
vision leads us  
here...

... then where are  
we now?

## Many Grid development efforts — all over the world

- 
- 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 – OGSA-DAI, RealityGrid, GeoDise, Comb-e-Chem, DiscoveryNet, DAME, AstroGrid, GridPP, MyGrid, GOLD, eDiamond, Integrative Biology, ...
  - 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
  - Norway, Sweden - NorduGrid

- Many key concepts identified and known
- Many grid projects have tested, and benefit from, these
- Major efforts now on establishing:
  - **Production Grids *for multiple VO's***
    - “Production” = Reliable, sustainable, with commitments to quality of service
      - *In Europe, EGEE*
      - *In UK, National Grid Service*
      - *In US, Teragrid and OSG*
    - One stack of middleware that serves many research communities
    - Establishing operational procedures and organisation
  - **Standards** (a slow process)  
(e.g. Open Grid Forum, <http://www.gridforum.org/> )
- **Service orientation** - “*the way to build grids*”

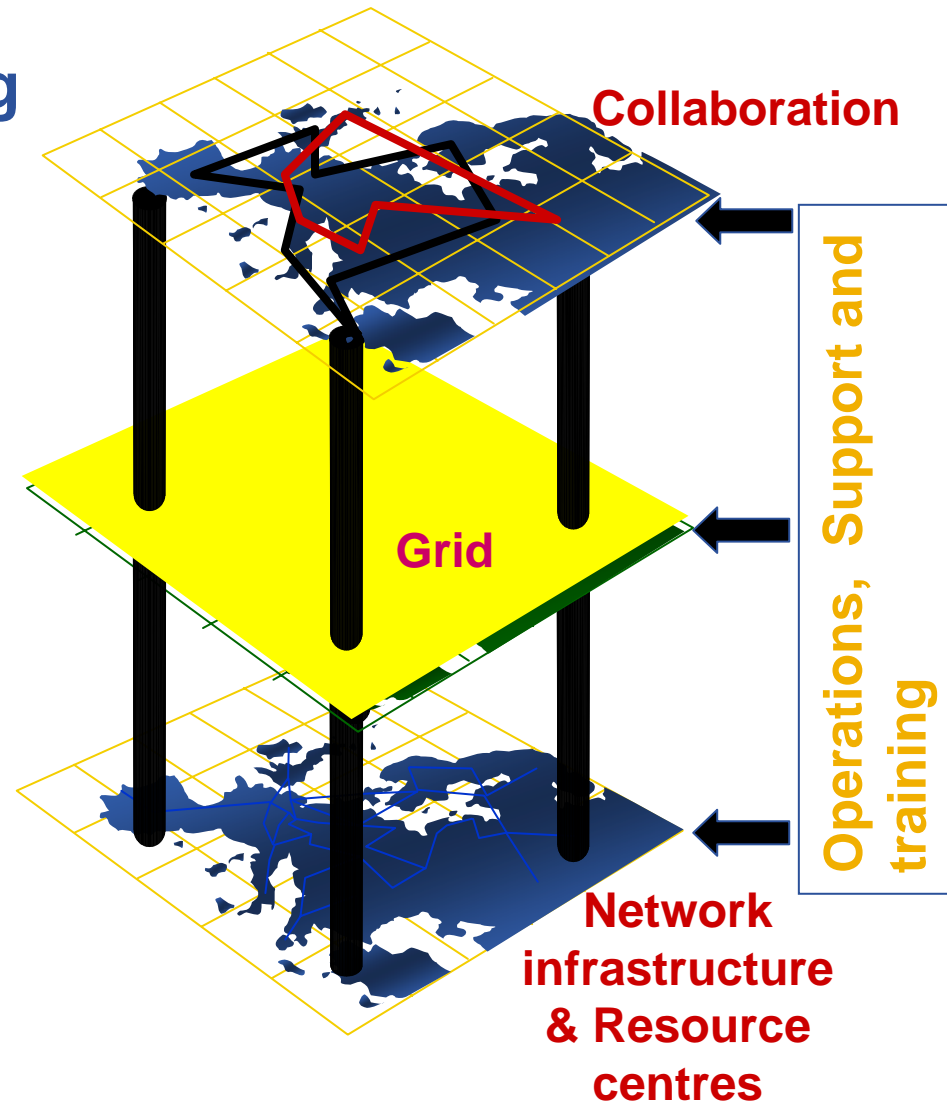


- **Standards are emerging... some near acceptance and some being discarded**
  - Standards bodies:
    - W3C <http://www.w3c.org/>
    - GGF <http://www.ggf.org/>
    - OASIS <http://www.oasis-open.org/home/index.php>
    - IETF <http://www.ietf.org/>
  - For a (slightly outdated) summary see <http://www.innoq.com/soa/ws-standards/poster/>
- **Production grids are based on de-facto standards at present**
  - Inevitably!
  - GT2 especially
  - But locks a grid into one middleware stack unable to benefit from the diverse developments of new services

# National grid initiatives now include...



- **Grids: virtual computing across administrative domains**
  - Data
  - Computation
  - Collaboration
- **Orchestration of services in support of**
  - Research, diagnostics, engineering, public service,...
  - Resource utilisation and sharing





- **Open Grid Forum** <http://www.ogf.org/>
- **National e-Science Centre** <http://www.nesc.ac.uk>
- **UK All Hands Meeting** <http://www.allhands.org.uk/>
- **National Grid Service** <http://www.ngs.ac.uk>
- **EGEE** [www.eu-egee.org](http://www.eu-egee.org)
- **The Grid Cafe** [www.gridcafe.or](http://www.gridcafe.or)
  
- **The Grid Core Technologies, Maozhen Li and Mark Baker, Wiley, 2005**