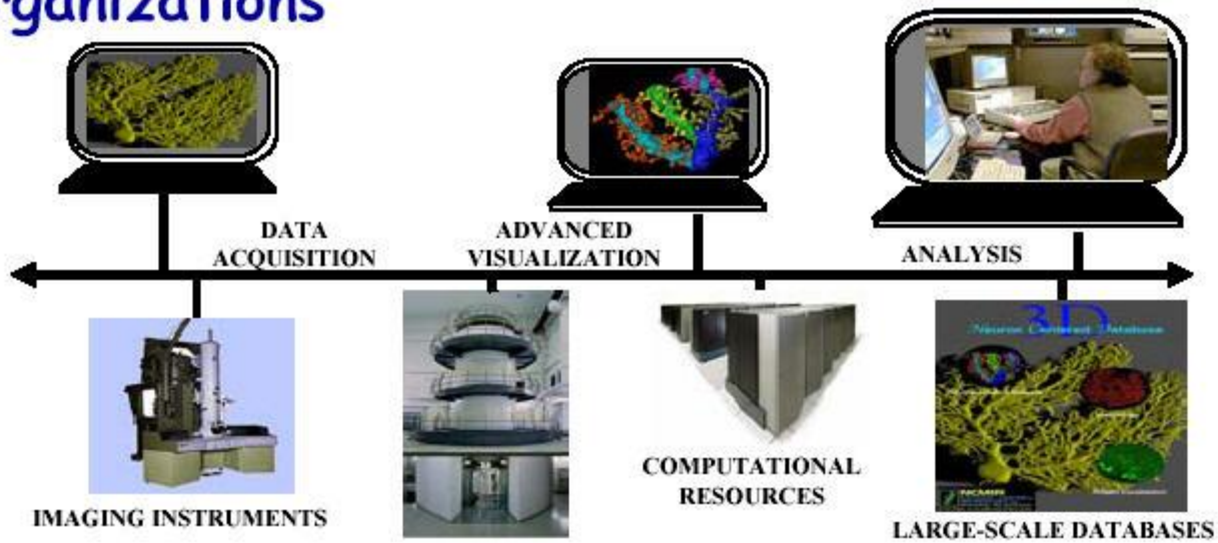
Distributed Systems – Techs
3. Grids

Grid Computing is About …

Resource sharing & coordinated problem solving in dynamic, multi-institutional virtual organizations



"Telescience Grid", Courtesy of Mark Ellisman

Definition

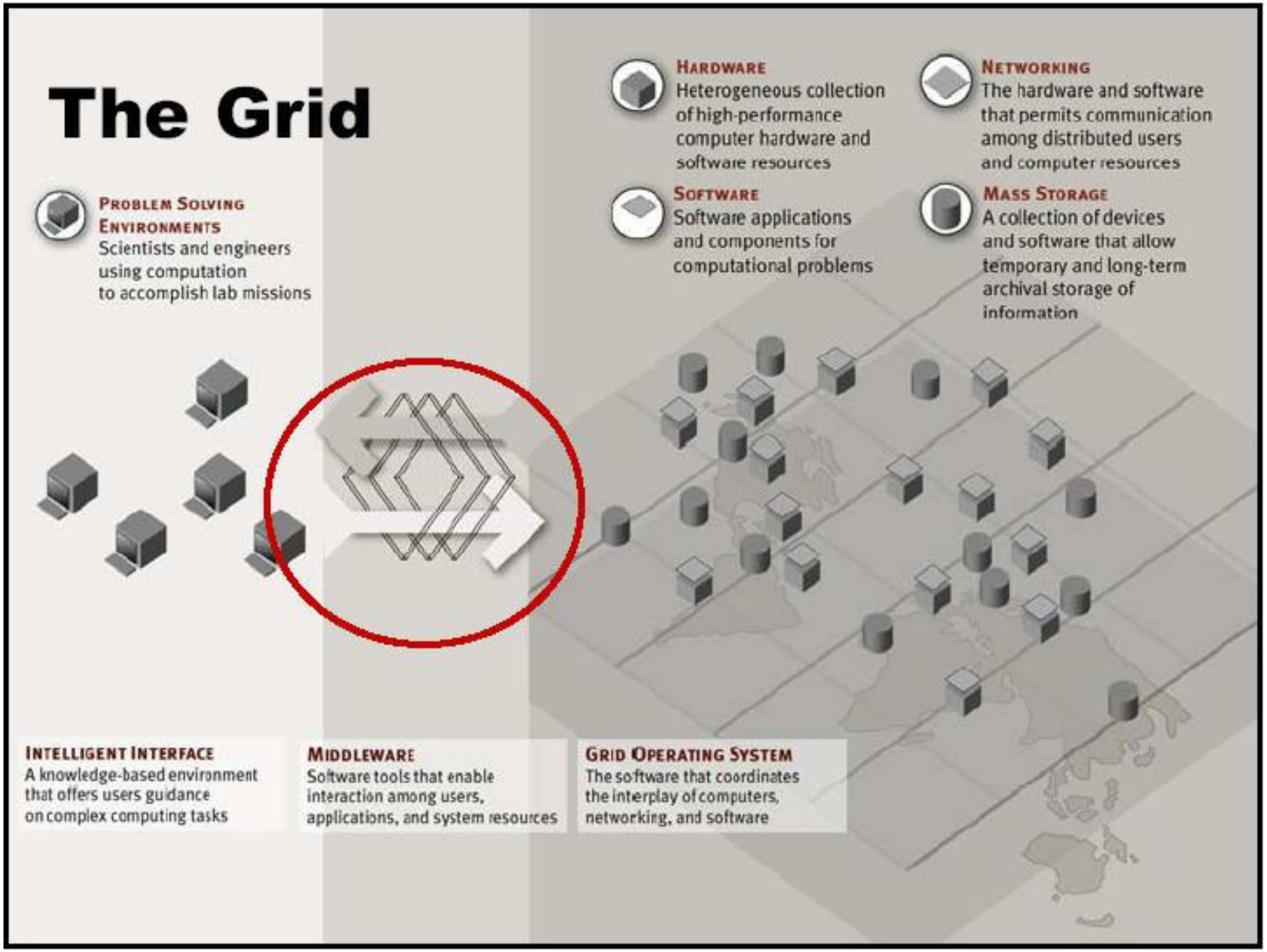
A type of **distributed system** that enables the sharing, selection, & aggregation of geographically distributed resources:

- Computers – PCs, workstations, clusters, supercomputers, laptops, notebooks, mobile devices, PDA, etc;
- Software – e.g., ASPs renting expensive special purpose applications on demand;
- Catalogued data and databases – e.g. transparent access to human genome database;
- Special devices/instruments – e.g., radio telescope – SETI@Home searching for life in galaxy.
- People/collaborators.

depending on their availability, capability, cost, and user QoS requirements

for solving large-scale problems/applications.

thus enabling the creation of "virtual organization" (VOs)


The Grid
Problem Solving Environments
Scientists and engineers using computation to accomplish lab missions
Hardware
Heterogeneous collection of high-performance computer hardware and software resources
Networking
The hardware and software that permits communication among distributed users and computer resources
Software
Software applications and components for computational problems
Mass Storage
A collection of devices and software that allow temporary and long-term archival storage of information
Intelligent Interface
A knowledge-based environment that offers users guidance on complex computing tasks
Middleware
Software tools that enable interaction among users, applications, and system resources
Grid Operating System
The software that coordinates the interplay of computers, networking, and software

Grid‘s main idea

- To treat CPU cycles and software like commodities.
- Enable the coordinated use of geographically distributed resources – *in the absence of central control and existing trust relationships*.
- Computing power is produced much like utilities such as power and water are produced for consumers.
- Users will have access to “power” *on demand*
- “When the Network is as fast as the computer’s internal links, the machine disintegrates across the Net into a set of special purpose appliances” – Gilder Technology Report June 2000

Computational Grids and Electric Power Grids

- **Power Grid analogy**
  – Power producers: machines, software, networks, storage systems
  – Power consumers: user applications
- **Applications draw power from the Grid the way appliances draw electricity from the power utility.**
  – Seamless, High-performance, Ubiquitous, Dependable
- **Why the Computational Grid is like the Electric Power Grid**
  – Electric power is ubiquitous
  – Don’t need to know the source of the power (transformer, generator) or the power company that serves it
- **Why the Computational Grid is different from the Electric Power Grid**
  – Wider spectrum of performance
  – Wider spectrum of services
  – Access governed by more complicated issues: Security, Performance

Alessandro Volta in Paris in 1801 inside French National Institute shows the battery while in the presence of Napoleon I

Fresco by N. Cianfanelli (1841)
(Zoological Section "La Specula" of National History Museum of Florence University)


What ?!?!
This is a mad man...
Oh, mon Dieu !
….and in the future, I imagine a Worldwide Power (Electrical) Grid ……

2002 - 1801 = 201 Years

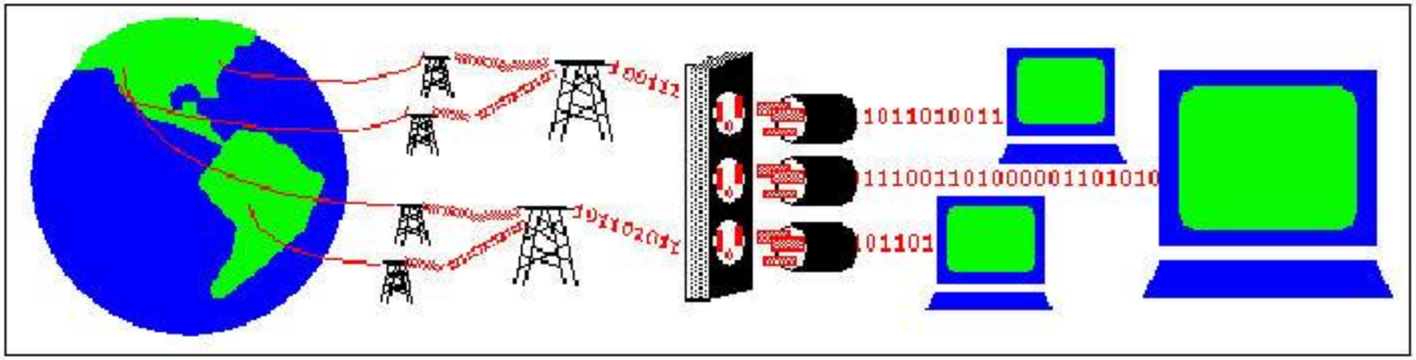
1801

2002

IPG: Analogy to Electric Power Grid

Principal benefits:

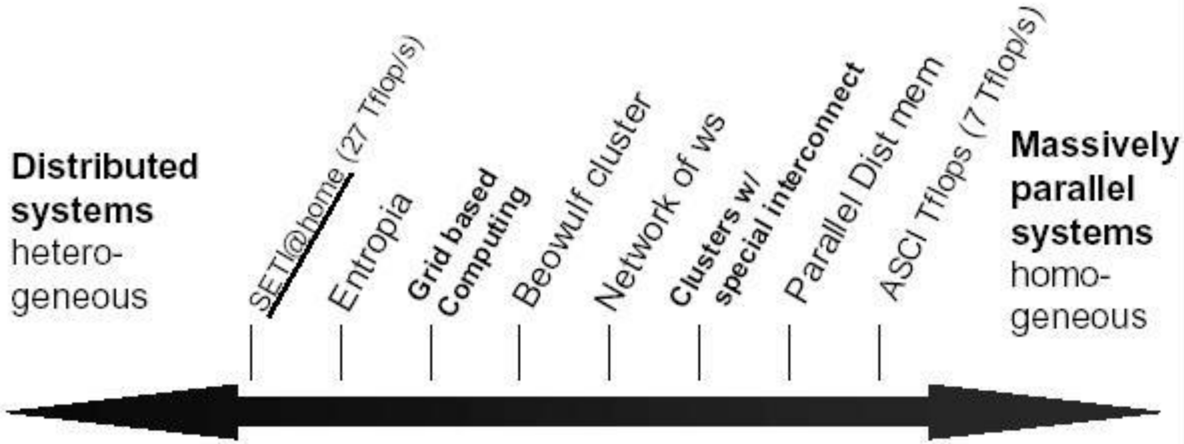
- load sharing/balancing
- fault tolerance, minimum loss-of-service
- economies of scale



Principal risks/challenges:

- possible fault domino effect
- reliance on facilities under other's control
- negotiation of agreements
- standards development and compliance policing

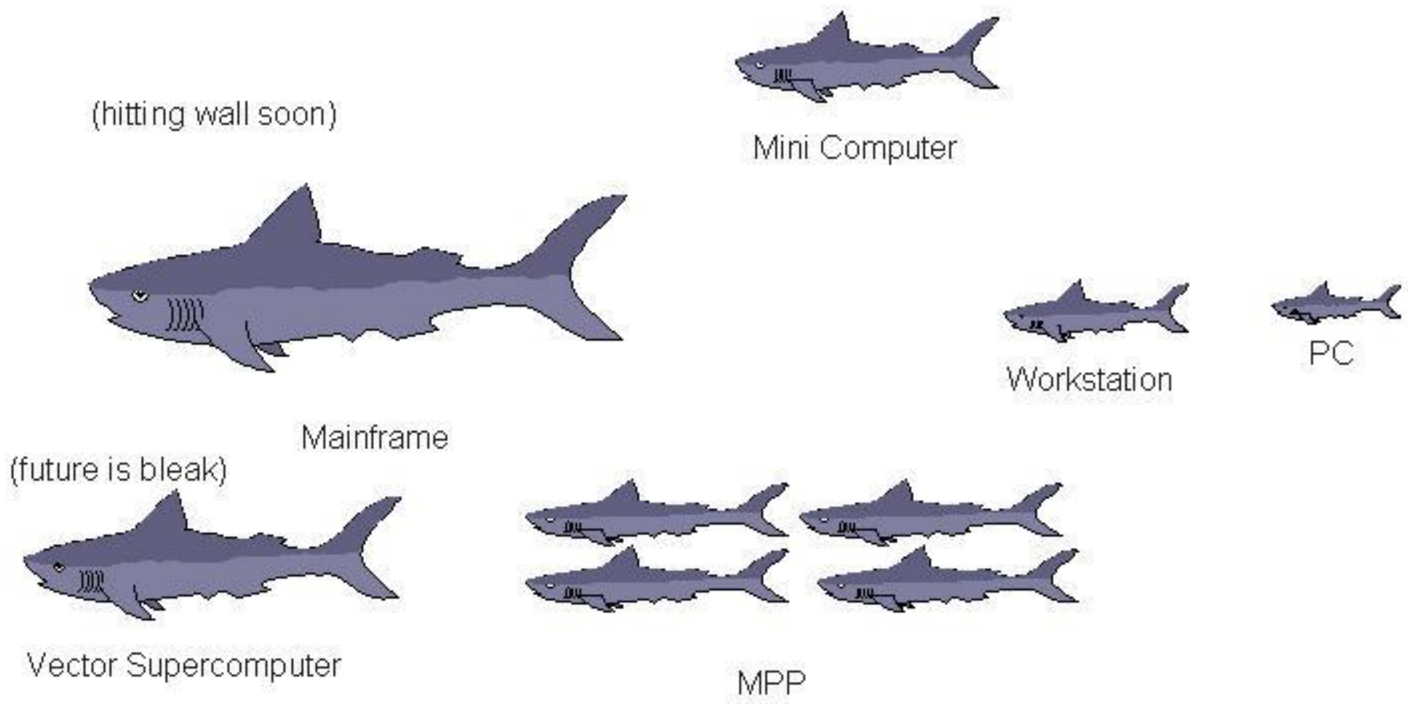
Distributed and Parallel Systems

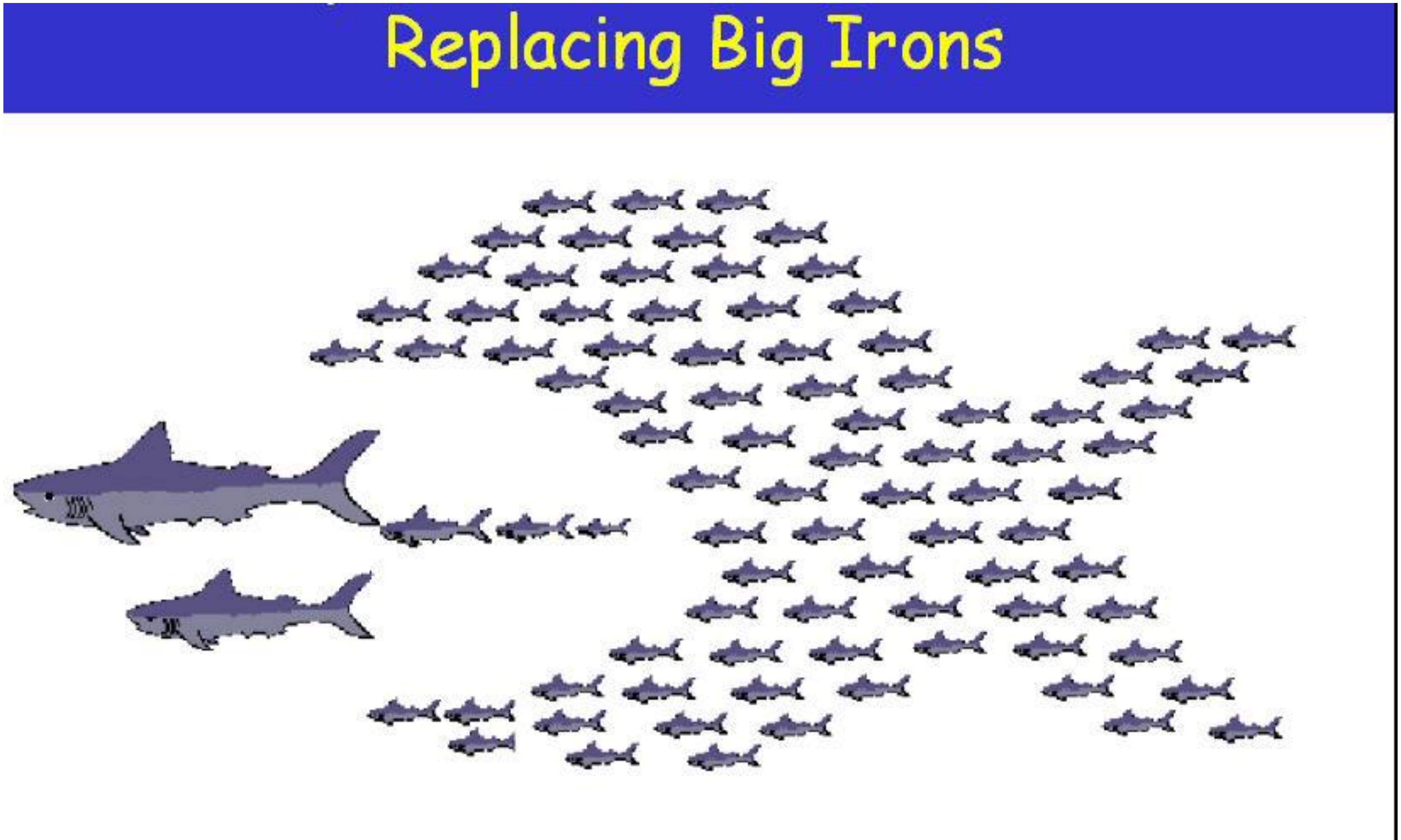


- Gather (unused) resources
- Steal cycles
- System SW manages resources
- System SW adds value
- 10% - 20% overhead is OK
- Resources drive applications
- Time to completion is not critical
- Time-shared

- Bounded set of resources
- Apps grow to consume all cycles
- Application manages resources
- System SW gets in the way
- 5% overhead is maximum
- Apps drive purchase of equipment
- Real-time constraints
- Space-shared

Early 1990 Computer Food Chain




Replacing Big Irons

P2P, Cluster, Internet computing vs. Grid computing

- ***Peer-to-peer*** networks (eg Kazaa) fall within the definition of grid computing (the resource shared is the storage capacity of each node)

  P2P Working Group part of Global Grid Forum
- A ***cluster*** is a resource that can be shared- a grid is a cluster of clusters
- ***Internet computing***: a VO is assembled for a particular project and disbanded once the project is complete -the shared resource is the Internet connected desktop

Grid evolution: 1st generation

Grid Evolution - Metacomputing

- Different Supercomputing Resourses
  - geographically distributed
  - used as a single **powerful** parallel machine (clear, High-Performance orientation)

Metacomputing

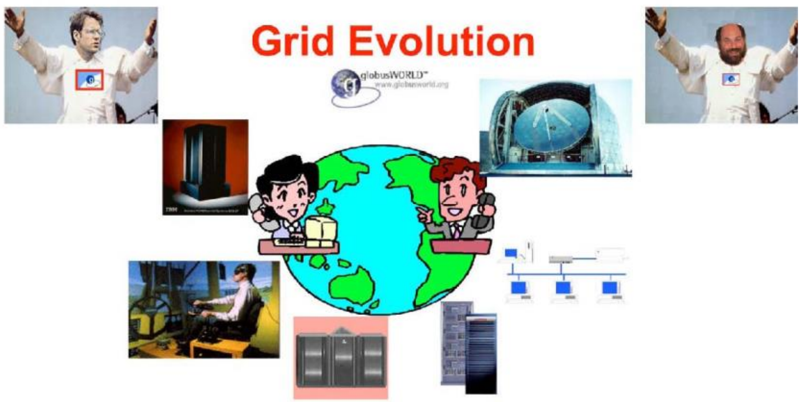
- The word metacomputing was coined to describe this new computational approach

California Institute for Telecommunications and Information Technology

- Reference:
- Larry Smarr & Charles E. Catlett

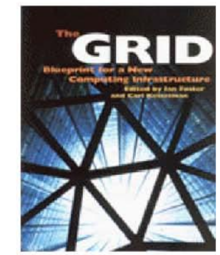
- Metacomputing
  - Communications of the ACM, 35(6):45-52, June 1992

Grid computing: 2nd generation



Grid computing has emerged as an important new field, distinguished from conventional distributed computing by its focus on large-scale resource sharing, innovative applications, and, in some cases, high-performance orientation.

Grid Applications



- Distributed Supercomputing
  - Stellar Dynamics, Ab initio chemistry, ...
- High Throughput
  - Chip design, Parametric studies, ...
- On Demand
  - Medical instrumentation, network-enabled solvers, ...
- Data Intensive
  - Sky survey, Physics data, Data Mining, ...
- Collaborative
  - Collaborative design, data exploration, education, ...

Grid computing: 3rd generation

Grid Evolution

The marriage of the **Web technology** with the **2nd Generation Grid technology** led to new and generic Grid Services

The Physiology of the Grid

An Open Grid Services Architecture for Distributed Systems Integration

I. Foster, C. Kesselman, J. Nick, S. Tuecke, January, 2002

http://www.globus.org/research/papers/ogsa.pdf

OGSA services

- Open Grid Service Architecture,
  - defined by GGF group
  - In ubiquitous Grid platform, there is common need for some essential set of interfaces, behaviors, resource models, and bindings
  - defines the core set of services essential for grid, their functionality and interrelationships
  - Core services: service interaction, management, communication, security
  - Non-core: data, program execution, resource management
- Grid service is a Web service with extensions, which are:
  - Name (handle GSH, reference GSR)
  - Lifetime management (factories, persistent and transient services)
  - State (Service Data)
  - Notification as well as querying

CoreGrid Definition of GRID

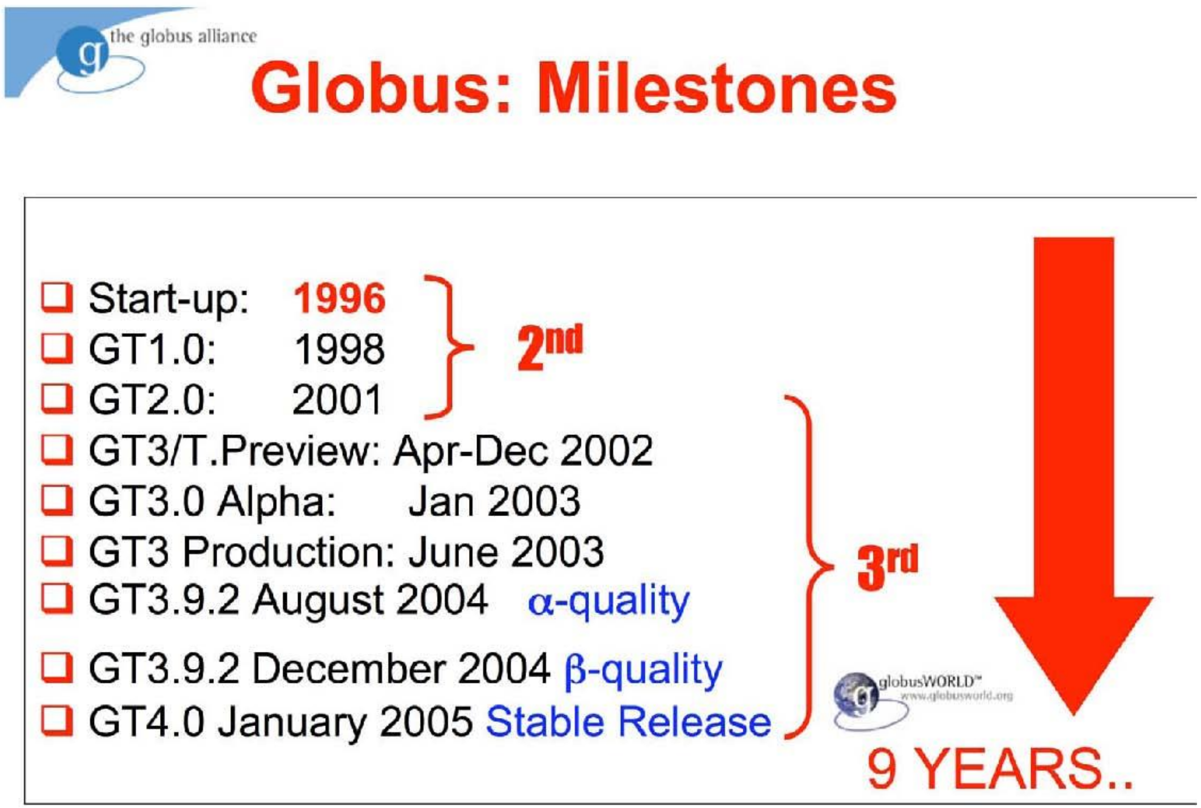
A fully distributed, dynamically reconfigurable, scalable and autonomous infrastructure to provide location independent, pervasive, reliable, secure and efficient access

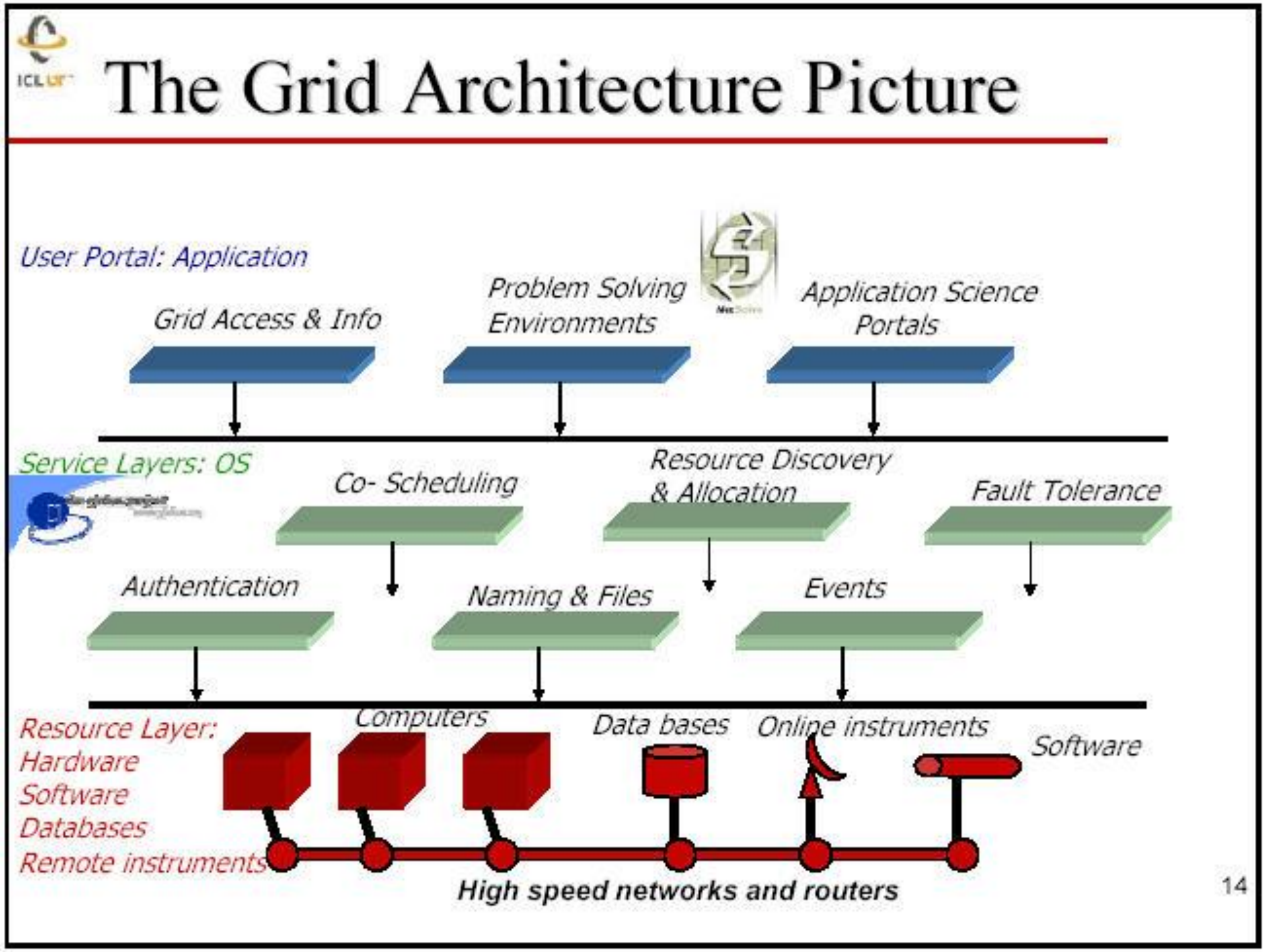
to a coordinated set of services encapsulating and virtualizing resources (computing power, storage, instruments, data, etc.)

in order to generate knowledge.

2006

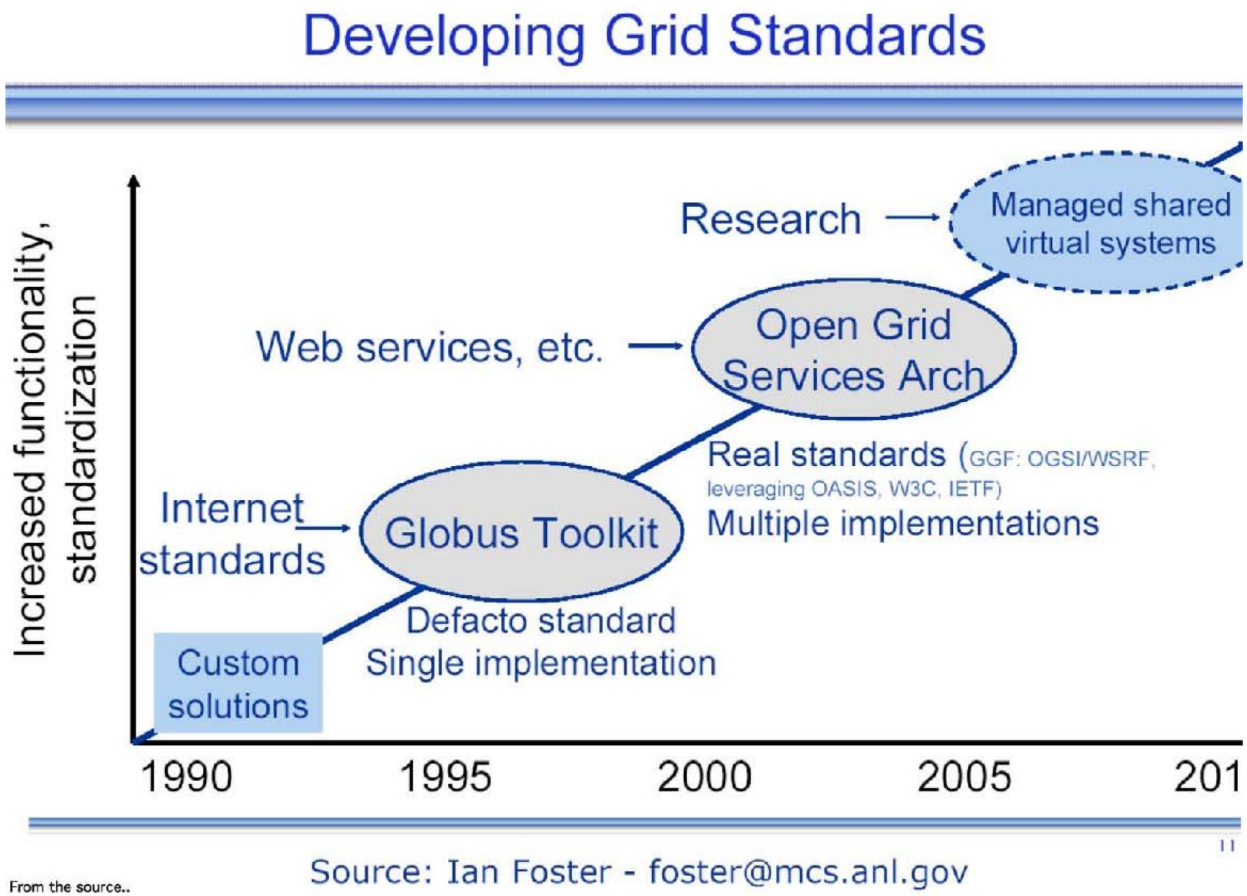
De facto-middleware: Globus Toolkit





The Grid Architecture Picture
User Portal: Application
Grid Access & Info
Problem Solving Environments
Application Science Portals
Service Layers: OS
Co- Scheduling
Resource Discovery & Allocation
Fault Tolerance
Authentication
Naming & Files
Events
Resource Layer:
Hardware
Software
Databases
Remote instruments
Computers
Data bases
Online instruments
Software
High speed networks and routers
14

The future?



From the source..

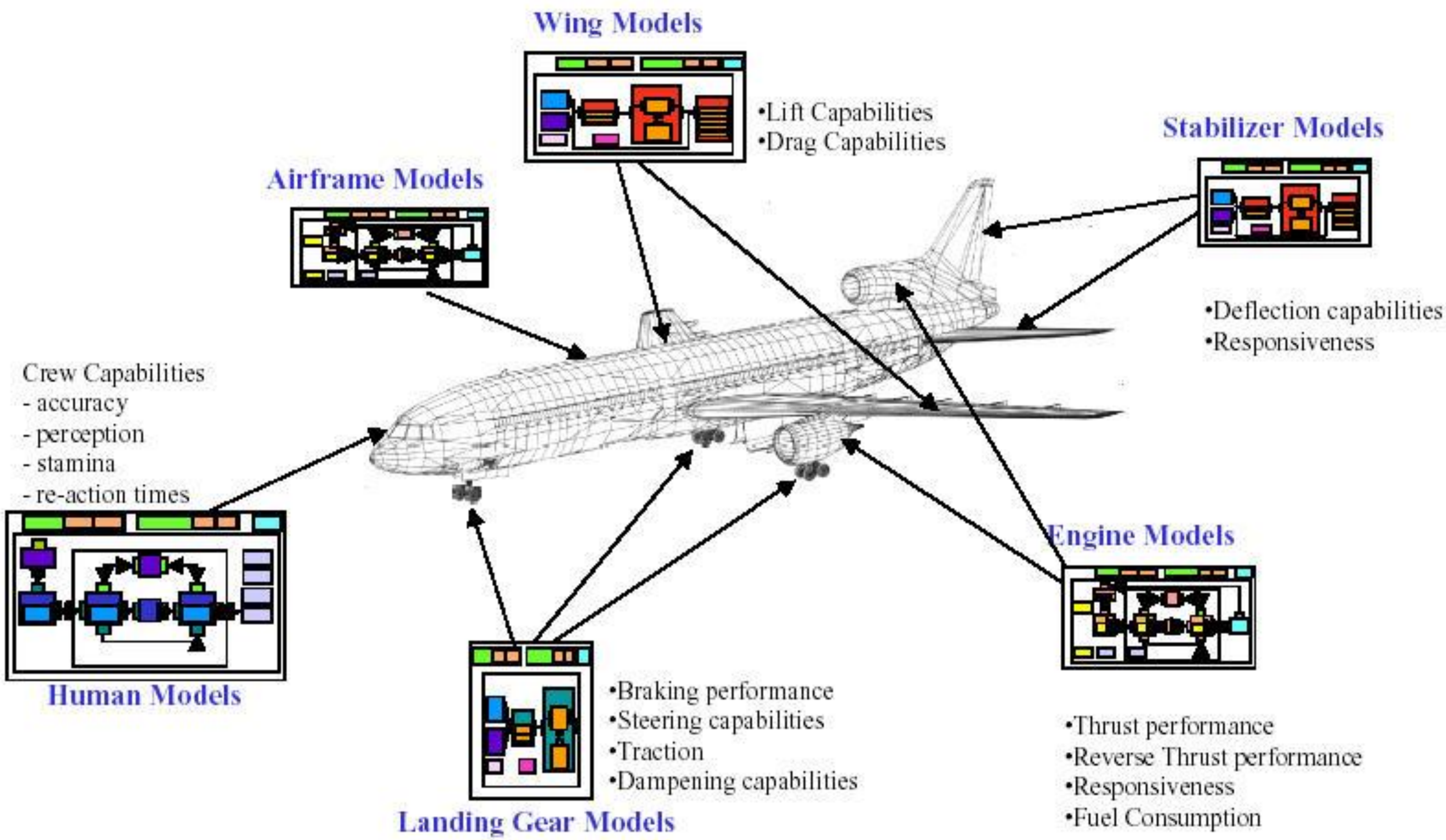
What do users want ?

- Grid Consumers
  - Execute jobs for solving varying problem size and complexity
  - Benefit by selecting and aggregating resources wisely
  - Tradeoff timeframe and cost
- Grid Providers
  - Contribute ("idle") resource for executing consumer jobs
  - Benefit by maximizing resource utilization
  - Tradeoff local requirements & market opportunity

Grid Applications

- ***Distributed HPC (Supercomputing*):**
  - Computational science.
- ***High-Capacity/Throughput Computing***:
  - Large scale simulation/chip design & parameter studies.
- ***Content Sharing (free or paid***)
  - Sharing digital contents among peers (e.g., Napster)
- ***Remote software access/renting services***:
  - Application service provides (ASPs) & Web services.
- ***Data-intensive computing:***
  - Drug Design, Particle Physics, Stock Prediction...
- ***On-demand, real-time computing***:
  - Medical instrumentation & Mission Critical.
- ***Collaborative Computing***:
  - Collaborative design, Data exploration, education.
- ***Service Oriented Computing (SOC):***
  - Towards economic-based Utility Computing: New paradigm, new applications, new industries, and new business.

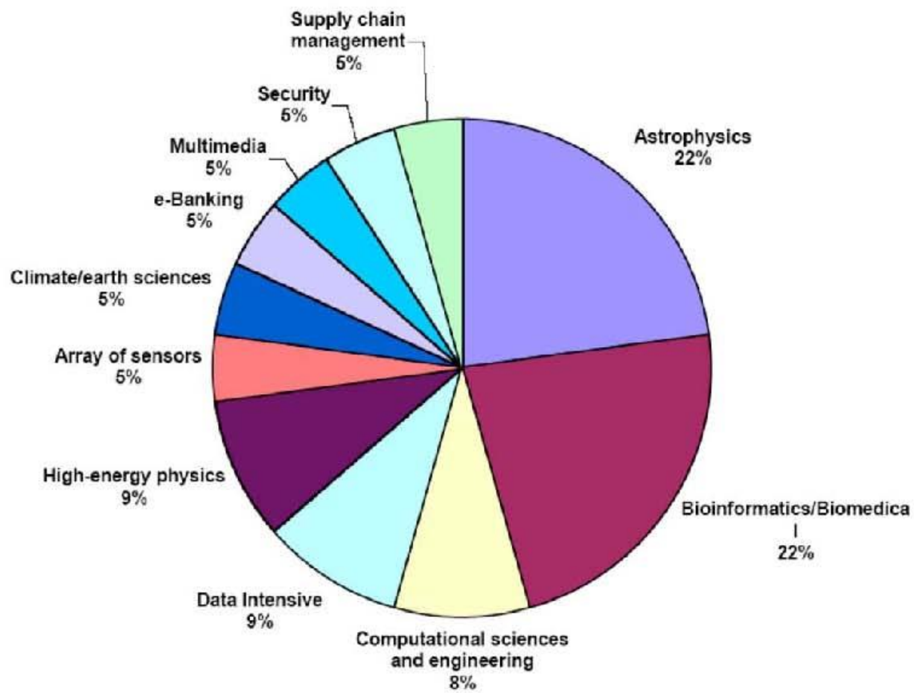
Multi-disciplinary Simulations



Whole system simulations are produced by coupling all of the sub-system simulations

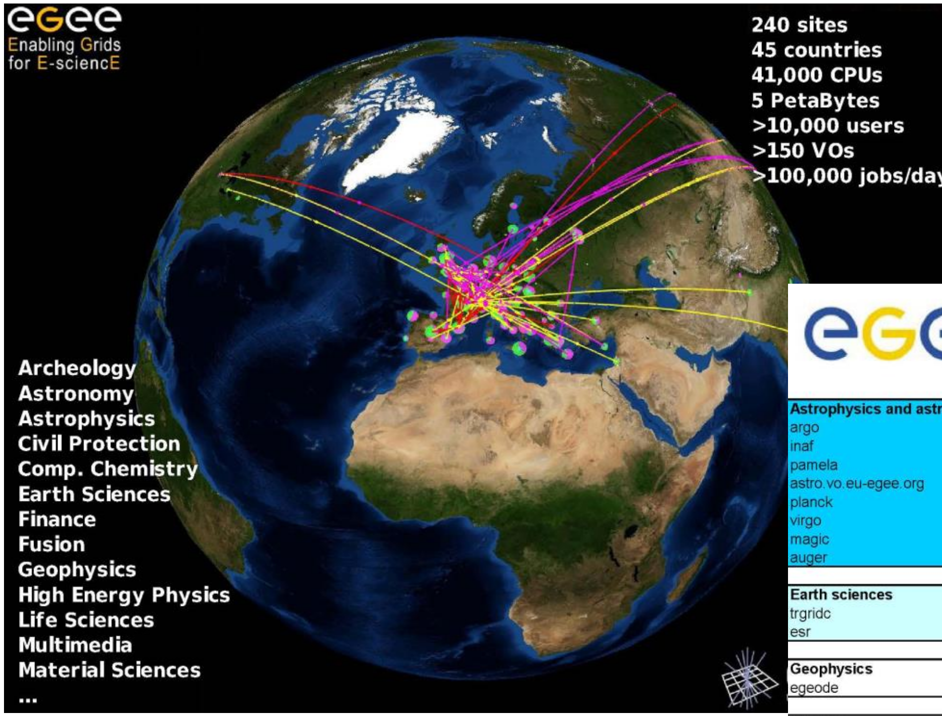
GridCoord Survey

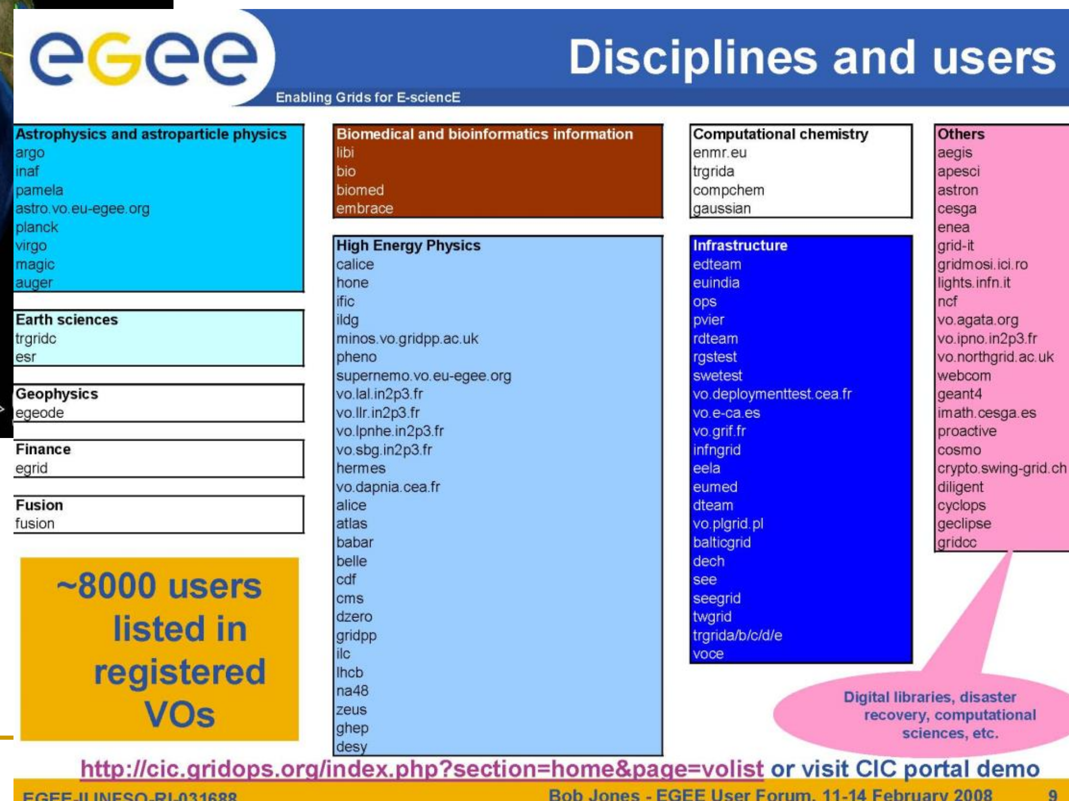
Applications by Topic



From the source...

EGEE – largest European Grid & LHC





EGEE usage

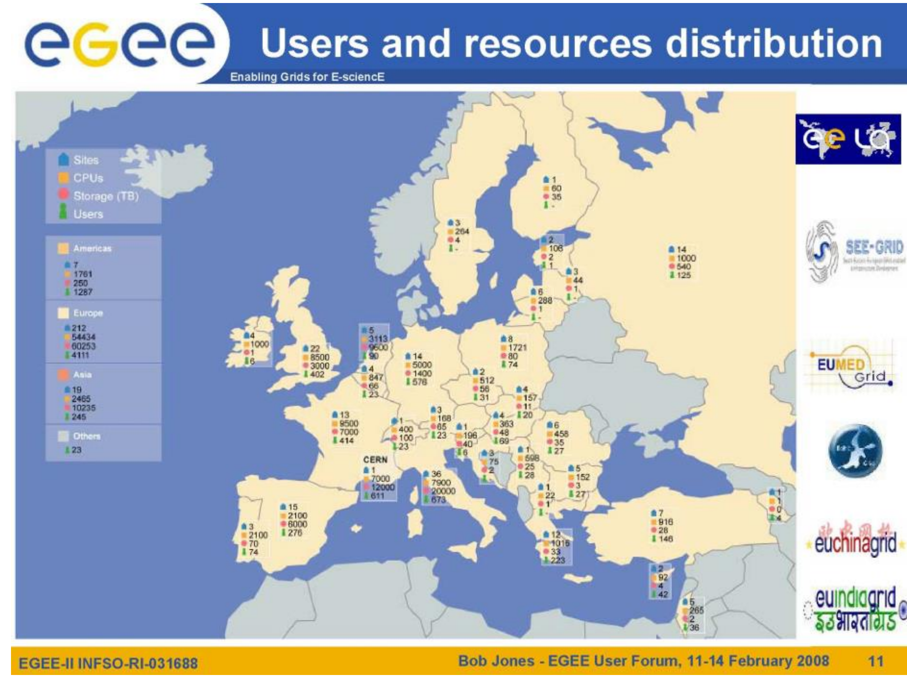
eGee NEWS RELEASE

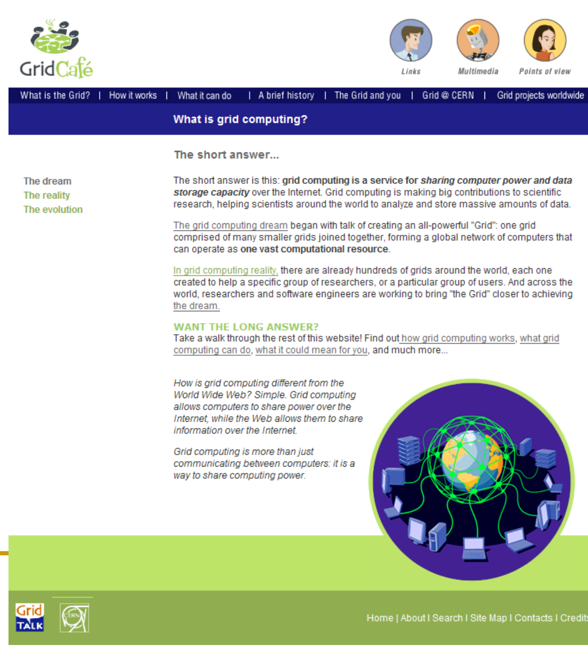
Embargoed until 4 May 2006, 18:00 CCT (10:00 GMT, 12:00 MEST)

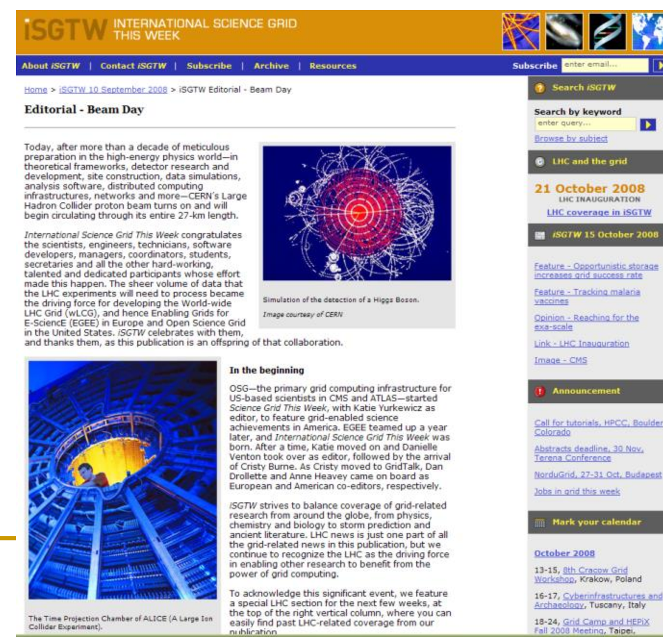
EGEE Grid attacks Avian Flu

During April, a collaboration of Asian and European laboratories has analysed 300,000 possible drug components against the avian flu virus H5N1 using the EGEE Grid infrastructure. The goal was to find potential compounds that can inhibit the activities of an enzyme on the surface of the influenza virus, the so-called neuraminidase, subtype N1. Using the Grid to identify the most promising leads for biological tests could speed up the development process for drugs against the influenza virus.

One of the targets of existing drugs today on the market is viral neuraminidase, an enzyme that helps the virus to proliferate and infect more cells. As this protein is known to evolve into variants if it comes under drug stress, drug resistance becomes a potential concern in case of an influenza pandemic.







RO in EGEE, SEE-Grid & other Grids

seegrid GStat: 21:39:54 04/03/08 GMT - @wgoc01 - Mozilla Firefox

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							sites	countries	totalCPU	freeCPU	runJob	waitJob	seAvail TB	seUsed TB	maxCPU	avgCPU				

Come to: SEE-Grid-SCI training in December 19th, 2008 !!!

Grid Requirements

- Identity & authentication
- Authorization & policy
- Resource discovery
- Resource characterization
- Resource allocation
- (Co-)reservation, workflow
- Distributed algorithms
- Remote data access
- High-speed data transfer
- Performance guarantees
- Monitoring Adaptation
- Intrusion detection
- Resource management
- Accounting & payment
- Fault management
- System evolution
- Etc.

Some Grid Requirements – User Perspective

- Single *allocation*: if any at all
- Single *sign-on*: authentication to any Grid resources authenticates for all others
- Single *compute space*: one scheduler for all Grid resources
- Single *data space*: can address files and data from any Grid resources
- Single *development environment*: Grid tools and libraries that work on all grid resources

The Security Problem

- Resources being used may be extremely valuable & the problems being solved extremely sensitive
- Resources are often located in distinct administrative domains
  – Each resource may have own policies & procedures
- The set of resources used by a single computation may be large, dynamic, and/or unpredictable
  – Not just client/server
- It must be broadly available & applicable
  – Standard, well-tested, well-understood protocols
  – Integration with wide variety of tools

The Resource Management Problem

Enabling secure, controlled remote access to computational resources and management of remote computation

– Authentication and authorization

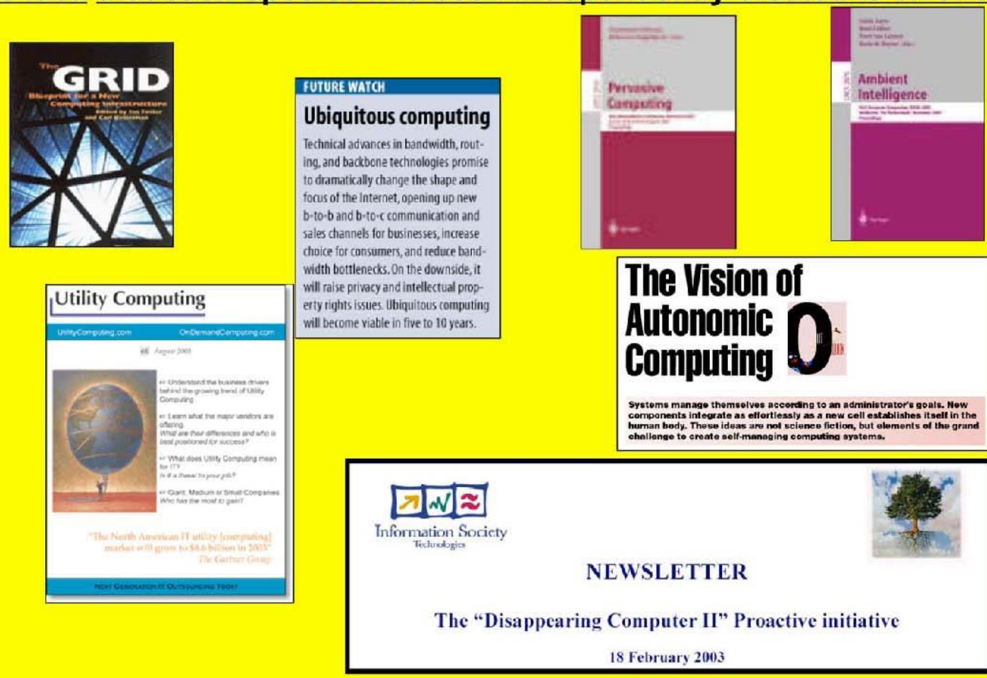
– Resource discovery & characterization

– Reservation and allocation

– Computation monitoring and control

Conclusions

The idea that each species has been independently created is erroneous



Convergence is a need !

The long-awaited technologic convergence of the communications industry.