From Cluster Computing to Grid environment

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Overview

- Usage of computers in science
- Introduction to clusters
- Grid computing paradigm
- Cloud computing

- **Usage of computers in science:**
  - Trivial:
    text editing, elementary visualization, special functions, ...
  - Nontrivial:
    differential eq., large linear systems, searching combinatorial spaces, statistical data analysis, visualization, ...
  - Advanced:
    stochastic simulations, risk assessment in complex systems, dynamics of the systems with many degrees of freedom, calculation of partition functions/functional integrals, ...
- **Why is the use of computation in science growing?**
  - Computational resources are more and more powerful and available (Moore's law)
  - Standard approaches are having problems
    Experiments are more costly, theory more difficult
  - Emergence of new fields/consumers – finance, economy, biology, sociology
- **Emergence of new problems with unprecedented storage and/or processor requirements**

Parallel computing

- **Splitting problem in smaller tasks that are executed concurrently**
- **Why?**
  - Physical limits of hardware components (speed of light, electron speed, …)
  - Performance limits –double frequency <> double performance
  - Large applications –demand too much memory & time
- **Advantages: Increasing speed & optimizing resources utilization**
- **Disadvantages: Complex programming models – difficult development**

Parallel architectures (1)

- **Vector machines**
  - CPU processes multiple data sets
  - shared memory
  - examples: Cray SV, NEC SX, Athlon3/d, Pentium-IV/SSE/SSE2
- **Massively parallel processors (MPP)**
  - large number of CPUs
  - distributed memory
  - examples: ConnectionSystemsCM1 i CM2, GAAP (GeometricArrayParallel Processor)

Parallel architectures (2)

- **Symmetric Multiple Processing (SMP)**
  - two or more processors
  - shared memory
  - examples: UltraSparcII, Alpha ES, Generic Itanium, Opteron, Xeon, …
- **Non Uniform Memory Access (NUMA)**
  - Solving SMP's scalability issue
  - hybrid memory model
  - examples: SGI Origin/Altix, Alpha GS, HP Superdome

Clusters (1)

- **Poor's man supercomputer "…Collection of interconnected stand-alone computers working together as a single, integrated computing resource"– R. Buyya**
- **Cluster consists of:**
  - Nodes
  - Network
  - OS
  - Cluster middleware
- **Standard components**
  - Avoiding expensive proprietary components

Clusters (2)

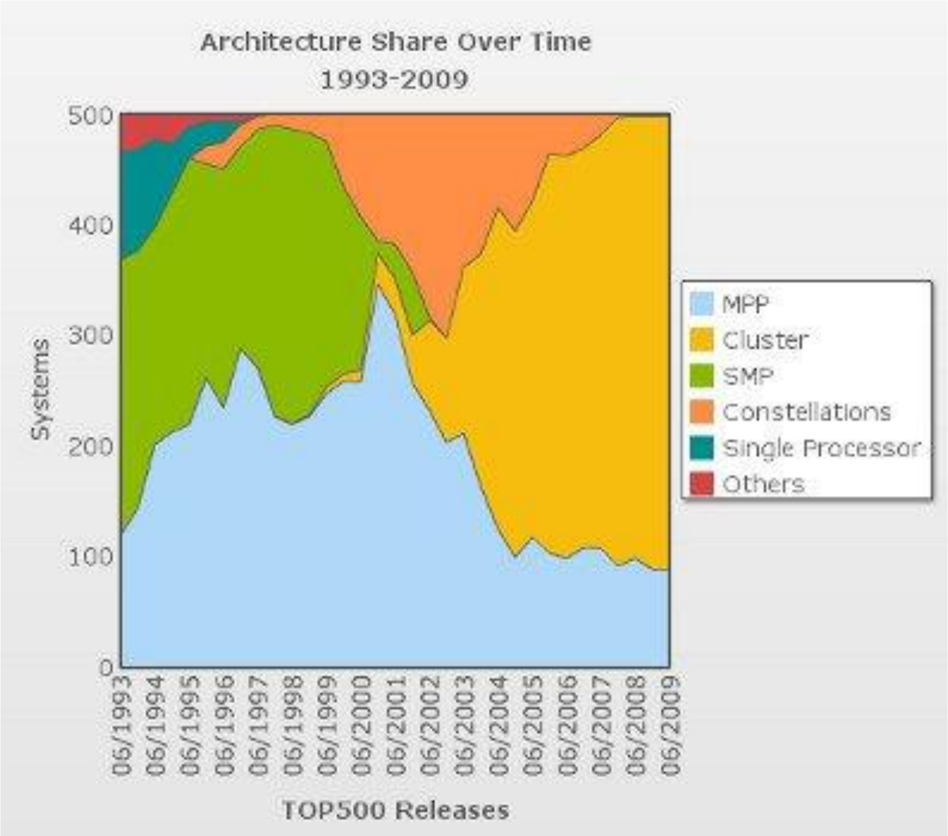
Beowulf clusters

- **1994**
  - T. Sterling & D. Baker
  - NASA Ames Centre
- **High performance parallel computing clusters of inexpensive personal computer hardware**
- **Frontend**
  - Head node with batch software
  - Shared storage –NFS (directory /home)
- **Nodes**
  - Multiple private networks
  - Local storage (/scratch)

Cluster classification

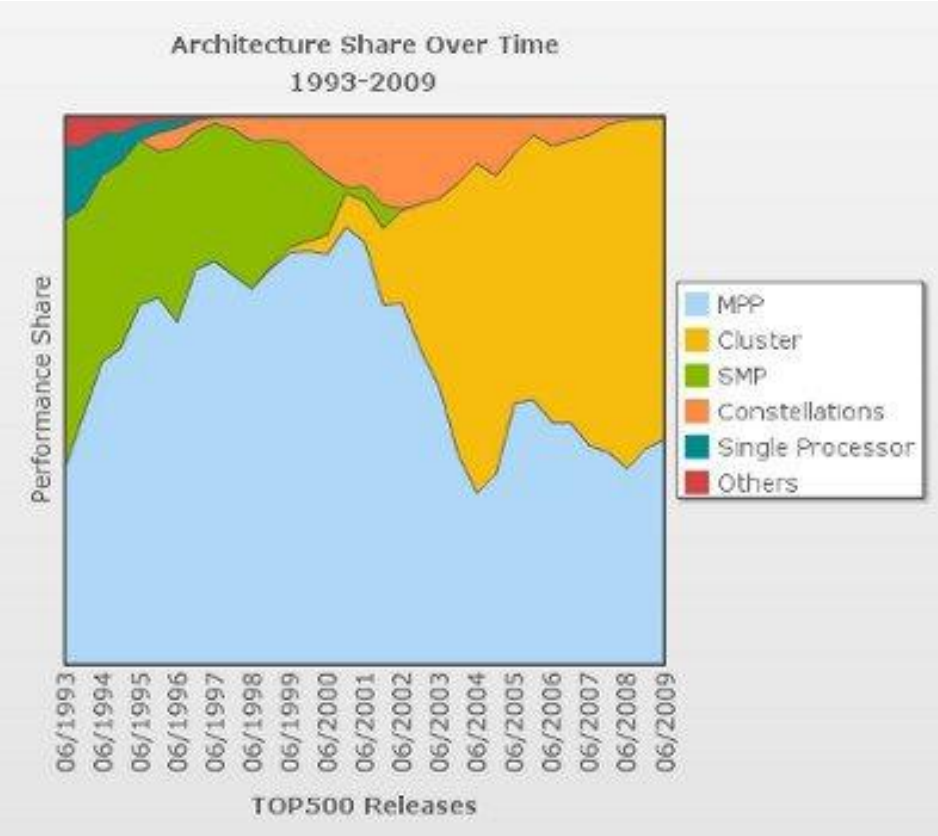
- **High performance clusters (HPC)**
  - Parallel, tightly coupled applications
- **High throughput clusters (HTC)**
  - Large number of independent tasks
- **High availability clusters (HA)**
  - Mission critical applications
- **Load balancing clusters**
  - Web servers, mail servers, …
- **Hybrid clusters**
  - Example: HPC+HA

TOP 500 (1)



High end architecture change (number of systems)

TOP 500 (2)

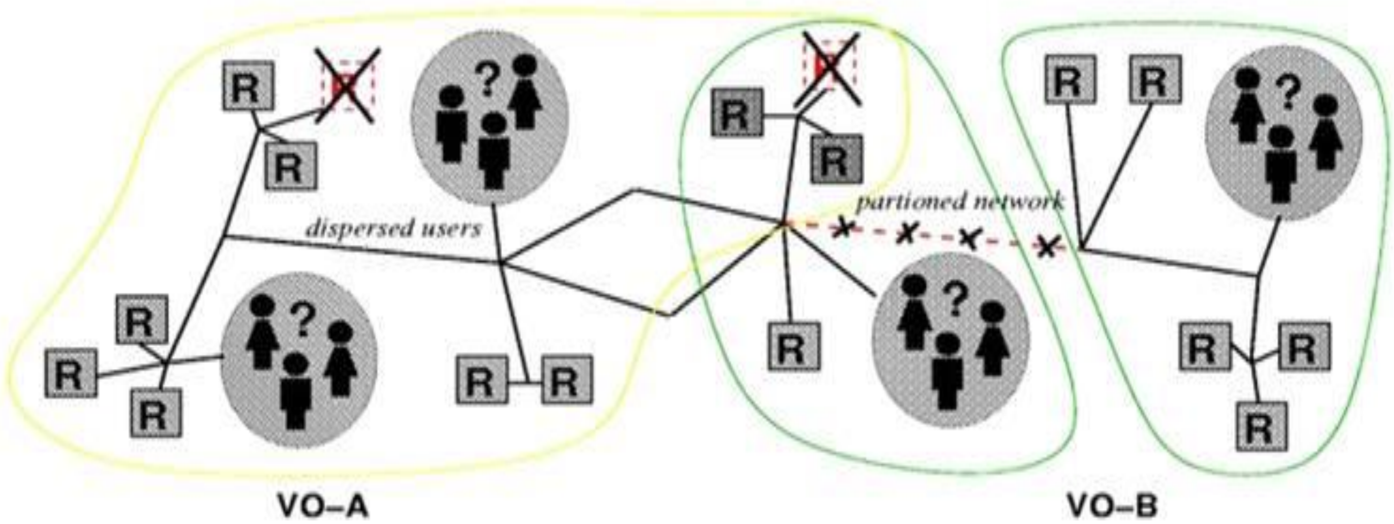


High end architecture change (performance)

From clusters to Grids

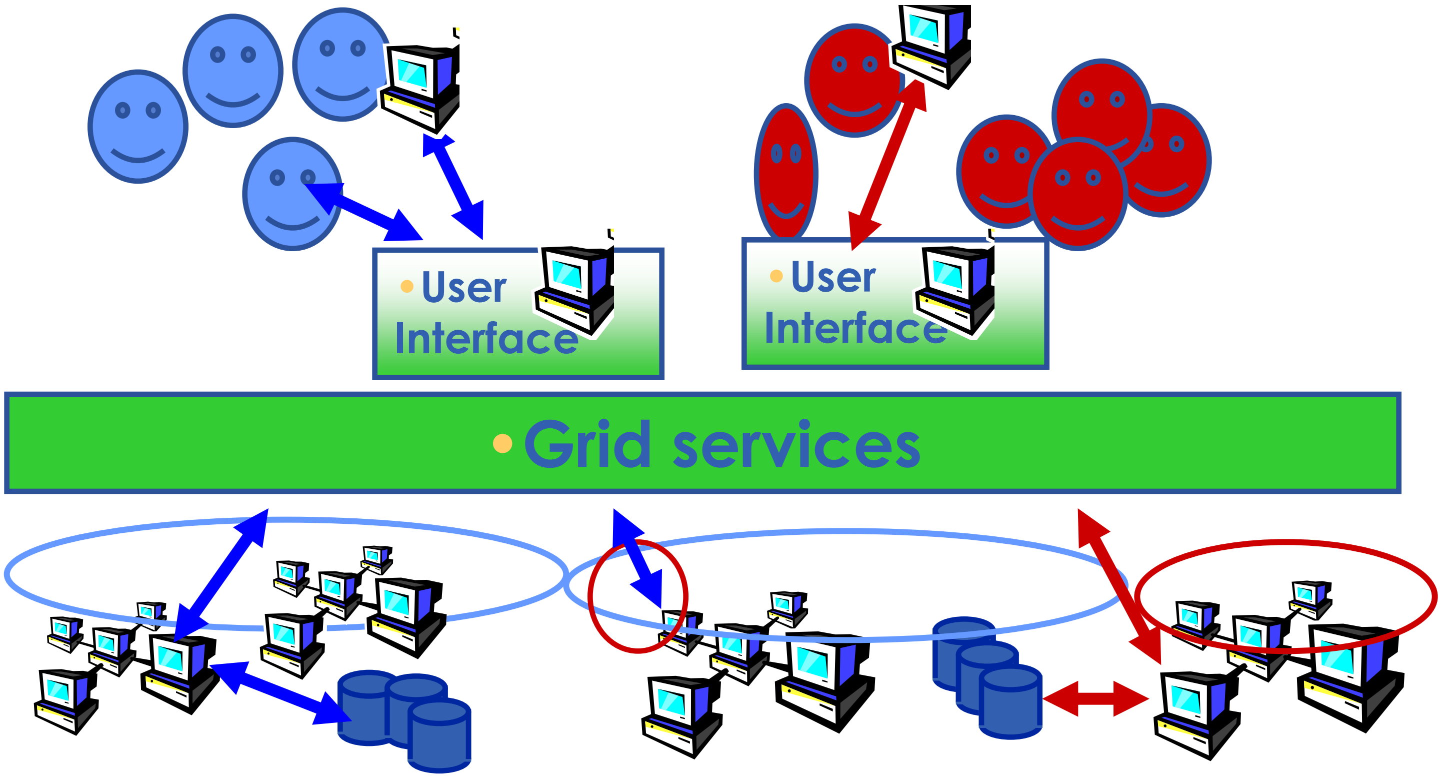
- Problem 1: they cannot be used by end users transparently
- Problem 2: even when access is granted to users to several clusters, they tend to neglect smaller clusters
- Problem 3: distribution of input/output data, sharing of data between clusters
- To overcome such problems, Grid paradigm was introduced

Unifying concept: Grid



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

User view of the Grid



Ingredients for Grid development

- **Supply side**
  - Technology – inexpensive HPC resources (linux clusters)
  - Technology – network infrastructure
  - Financing – domestic, regional, EU, donations from industry
- **Demand side**
  - Need for novel eScience applications
  - Hunger for number crunching power and storage capacity

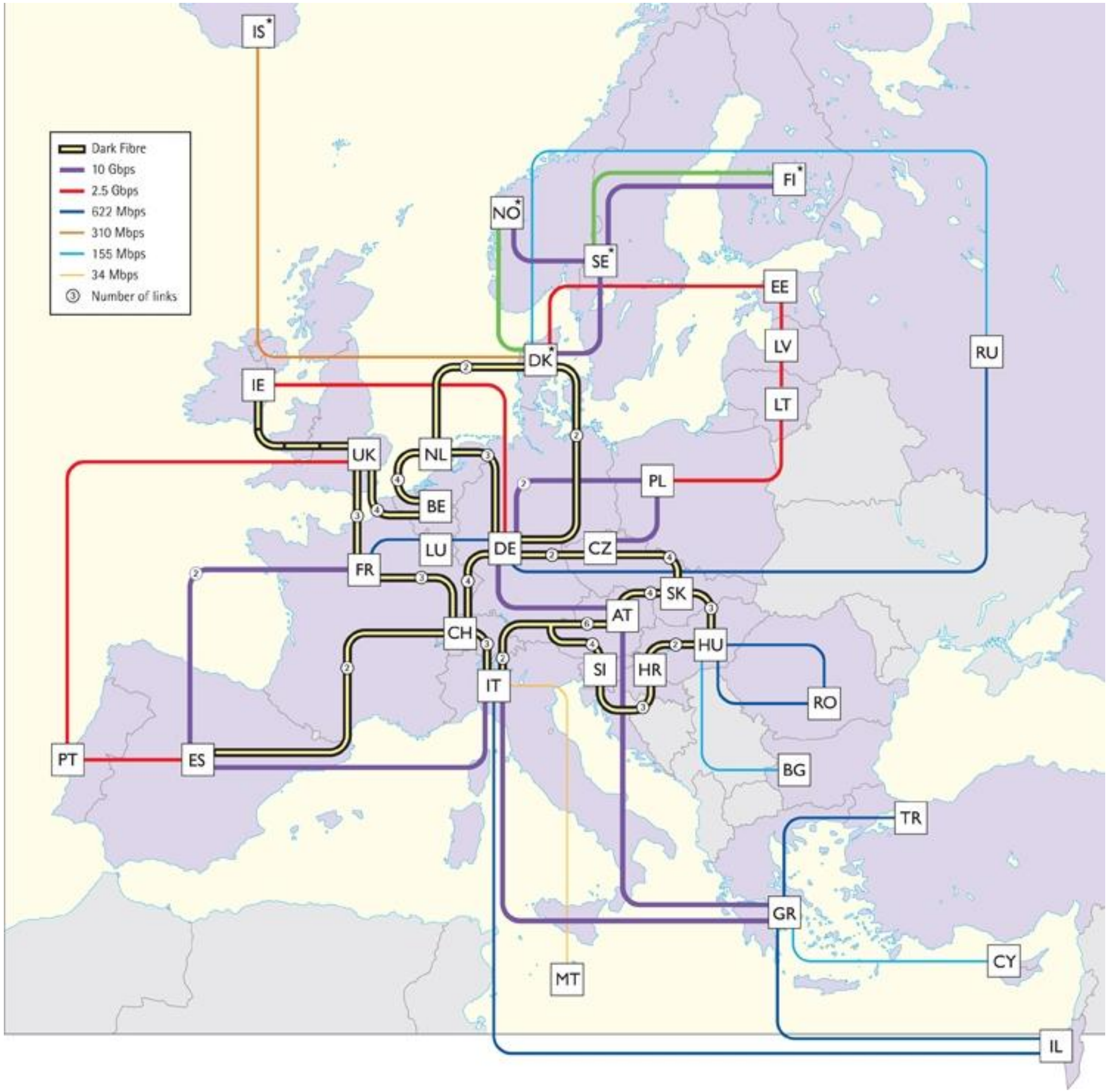
Supply side - clusters

- **The cheapest supercomputers – massively parallel PC clusters**
- **This is possible due to:**
  - Increase in PC processor speed (> Gflop/s)
  - Increase in networking performance (1 Gbs)
  - Availability of stable OS (e.g. Linux)
  - Availability of standard parallel libraries (e.g. MPI)
- **Advantages:**
  - Widespread choice of components/vendors, low price (by factor ~5-10)
  - Long warranty periods, easy servicing
  - Simple upgrade path
- **Disadvantages:**
  - Good knowledge of parallel programming is required
  - Hardware needs to be adjusted to the specific application (network topology)
  - More complex administration

Supply side - network

- **Needed at all scales:**
  - World-wide
  - Pan-European (GEANT2)
  - Regional (SEEREN2, …)
  - National (NREN)
  - Campus-wide (WAN)
  - Building-wide (LAN)

GÉANT2 Pan-European IP R&E network



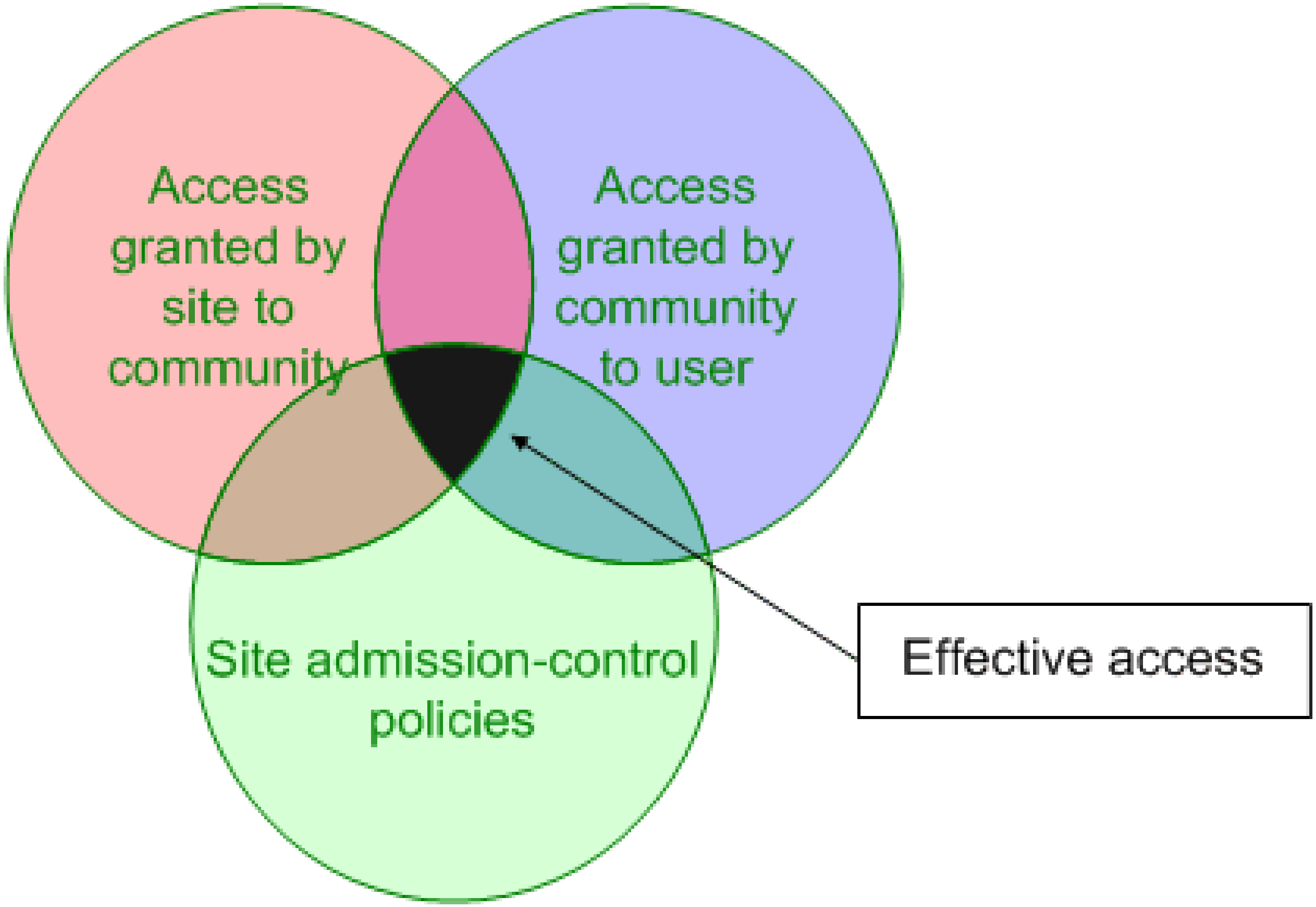
Requirements

- Security
- Monitoring/Discovery
- Computing/Processing Power
- Moving and Managing Data
- Managing Systems
- System Packaging/Distribution
- Secure, reliable, on-demand access to data, software, people, and other resources (ideally all via a Web Browser!)

Grids and VOs

- Virtual organizations (VOs) are groups of Grid users (authenticated through digital certificates)
- VO Management Service (VOMS) serves as a central repository for user authorization information, providing support for sorting users into a general group hierarchy, keeping track of their roles,etc.
- VO Manager, according to VO policies and rules, authorizes authenticated users to become VO members

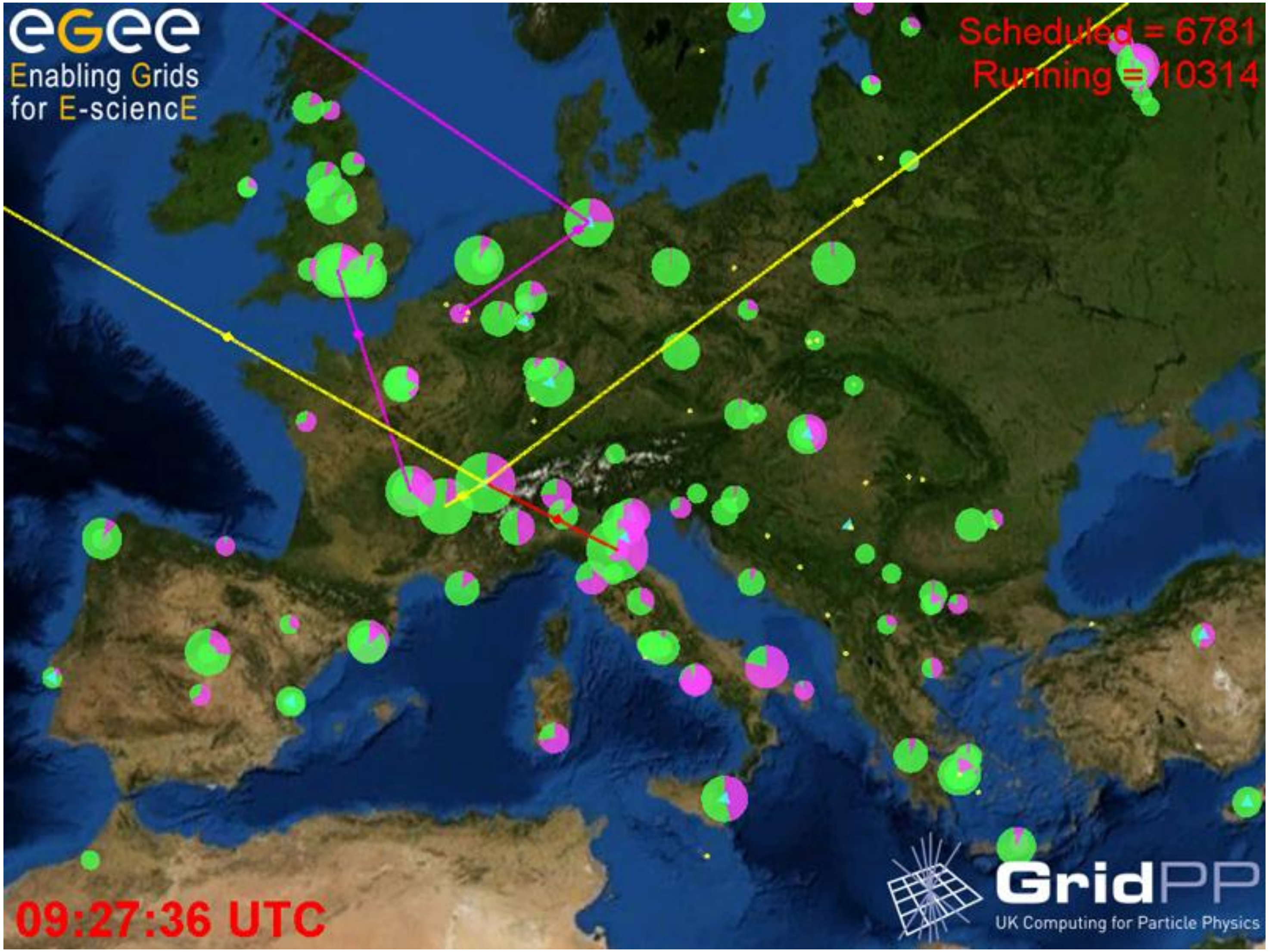
Effective policy governing access within a collaboration



World Grids

- Enabling Grids for E-sciencE
- NorduGrid
- Open Science Grid
- TeraGrid
- …

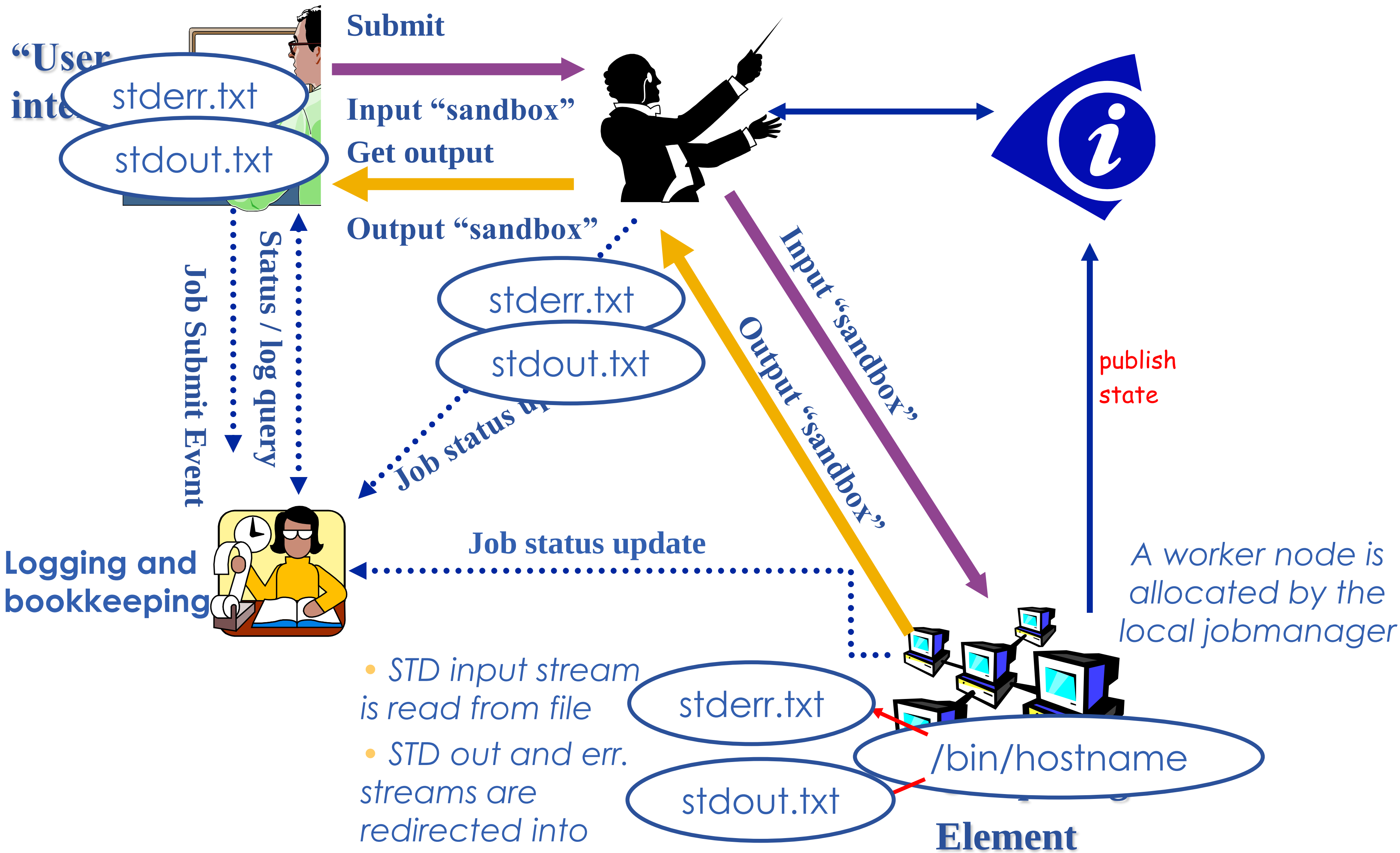
Real Time Monitor of EGEE



What problems Grid addresses

- Too hard to keep track of authentication data (ID/password) across institutions
- Too hard to monitor system and application status across institutions
- Too many ways to submit jobs
- Too many ways to store & access files/data
- Too many ways to keep track of data
- Too easy to leave "dangling" resources lying around (robustness)

Scenario



- *STD input stream is read from file*
- *STD out and err. streams are redirected into files*

Cloud computing (1)

- Even the definition is “cloudy”
- “A computing capability that provides an abstraction between the computing resource and its underlying technical architecture (e.g., servers, storage, networks), enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction.“ - National Institute of Standards and Technology

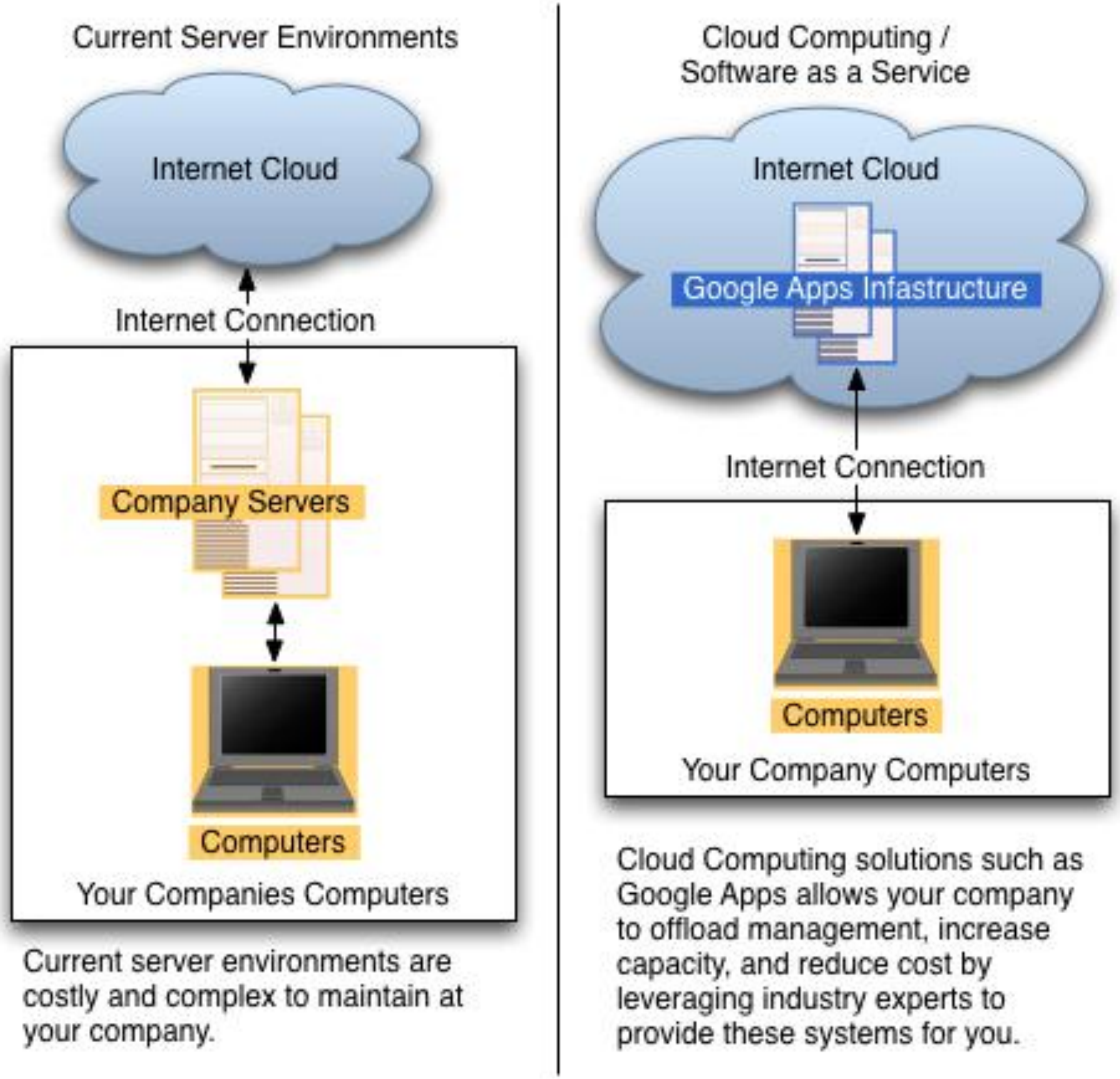
Cloud computing (2)

- A user interacts with the cloud without worrying about how it is implemented
- Commercially based - sold on demand (by the hour)
- Elastic - a user can have as much or as little of a service as they want at any given time
- Service is fully managed by the provider - the consumer needs nothing but a personal computer and Internet access

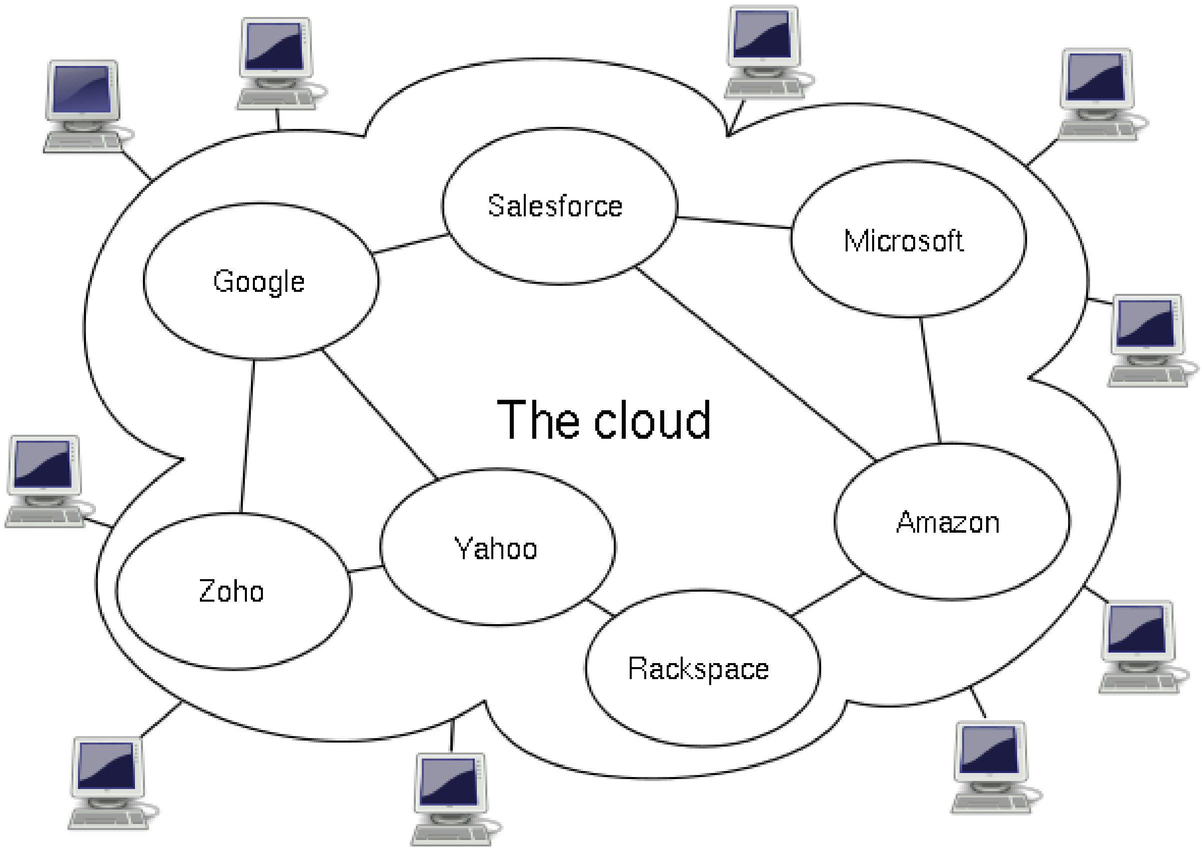
Cloud computing (3)

- **Infrastructure-as-a-Service (IaaS)**
  - Virtual server instances with unique IP addresses and blocks of storage on demand (Amazon EC2)
- **Platform-as-a-Service (PaaS)**
  - Set of software and product development tools hosted on the provider's infrastructure (Google App Engine, Microsoft Windows Azure Platform, Amazon Web Services)
- **Software-as-a-Service (SaaS)**
  - Vendor supplies the hardware infrastructure, the software product and interacts with the user through a front-end portal (anything from Web-based email to inventory control and database processing- GoogleApps)

Cloud computing (4)



Cloud computing (5)



Useful links

- http://www.eu-egee.org/
- http://www.top500.org/
- http://en.wikipedia.org/wiki/Grid_computing/
- http://www.google.com/apps/intl/en/business/index.html
- http://en.wikipedia.org/wiki/Cloud_computing