



Introduction to gLite Distributed Computing
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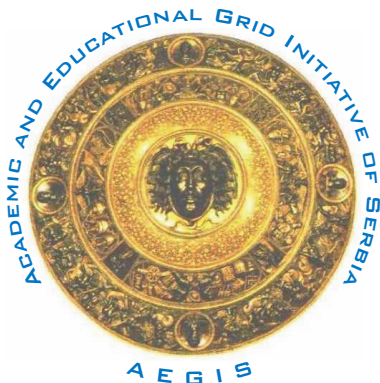
From Cluster Computing to Grid environment

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

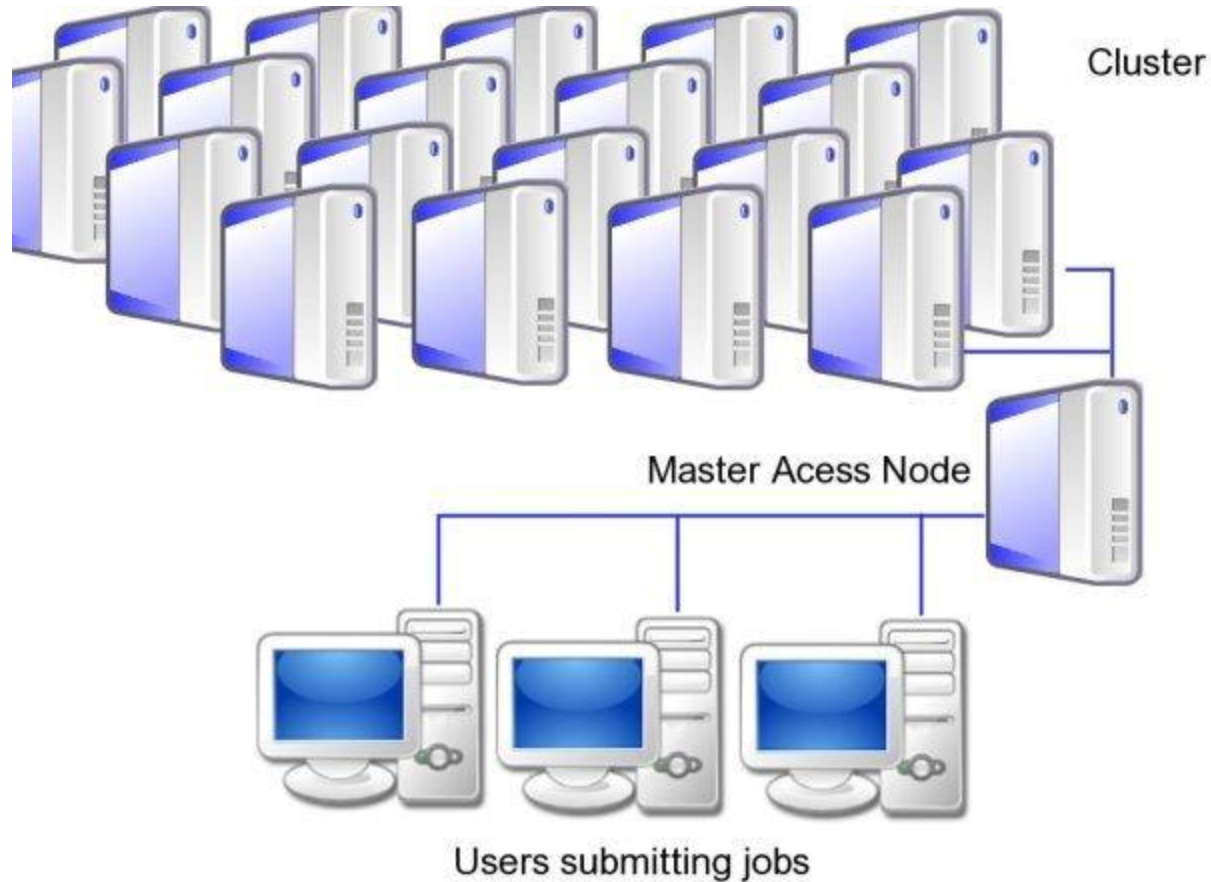
- **Usage of computers in science:**
 - Trivial:
text editing, elementary visualization, special functions, ...
 - Nontrivial:
differential eq., large linear systems, searching combinatorial spaces, statistical data analysis, visualization, ...
 - Advanced:
stochastic simulations, risk assessment in 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**

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

- **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)

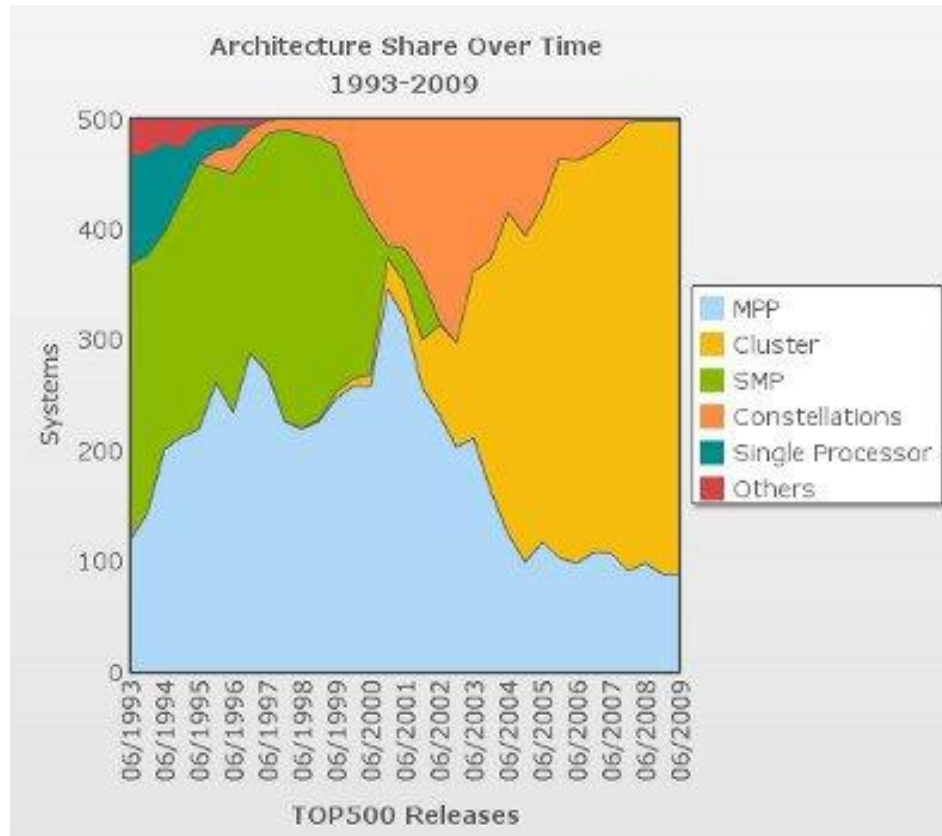
- **Symmetric Multiple Processing (SMP)**
 - two or more processors
 - shared memory
 - examples: UltraSparcII, Alpha ES, Generic Itanium, Opteron, Xeon, ...
- **Non Uniform Memory Access (NUMA)**
 - Solving SMP's scalability issue
 - hybrid memory model
 - examples: SGI Origin/Altix, Alpha GS, HP Superdome

- **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

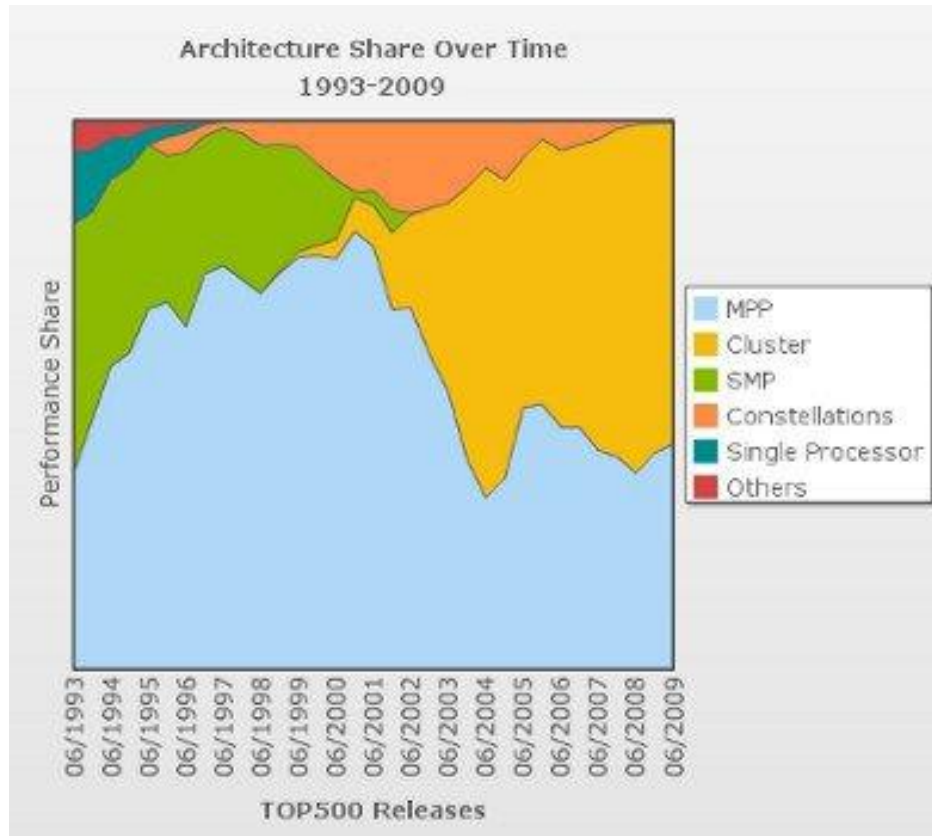


- **1994**
 - T. Sterling & D. Baker
 - NASA Ames Centre
- **High performance parallel computing clusters of inexpensive personal computer hardware**
- **Frontend**
 - Head node with batch software
 - Shared storage –NFS (directory /home)
- **Nodes**
 - Multiple private networks
 - Local storage (/scratch)

- **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

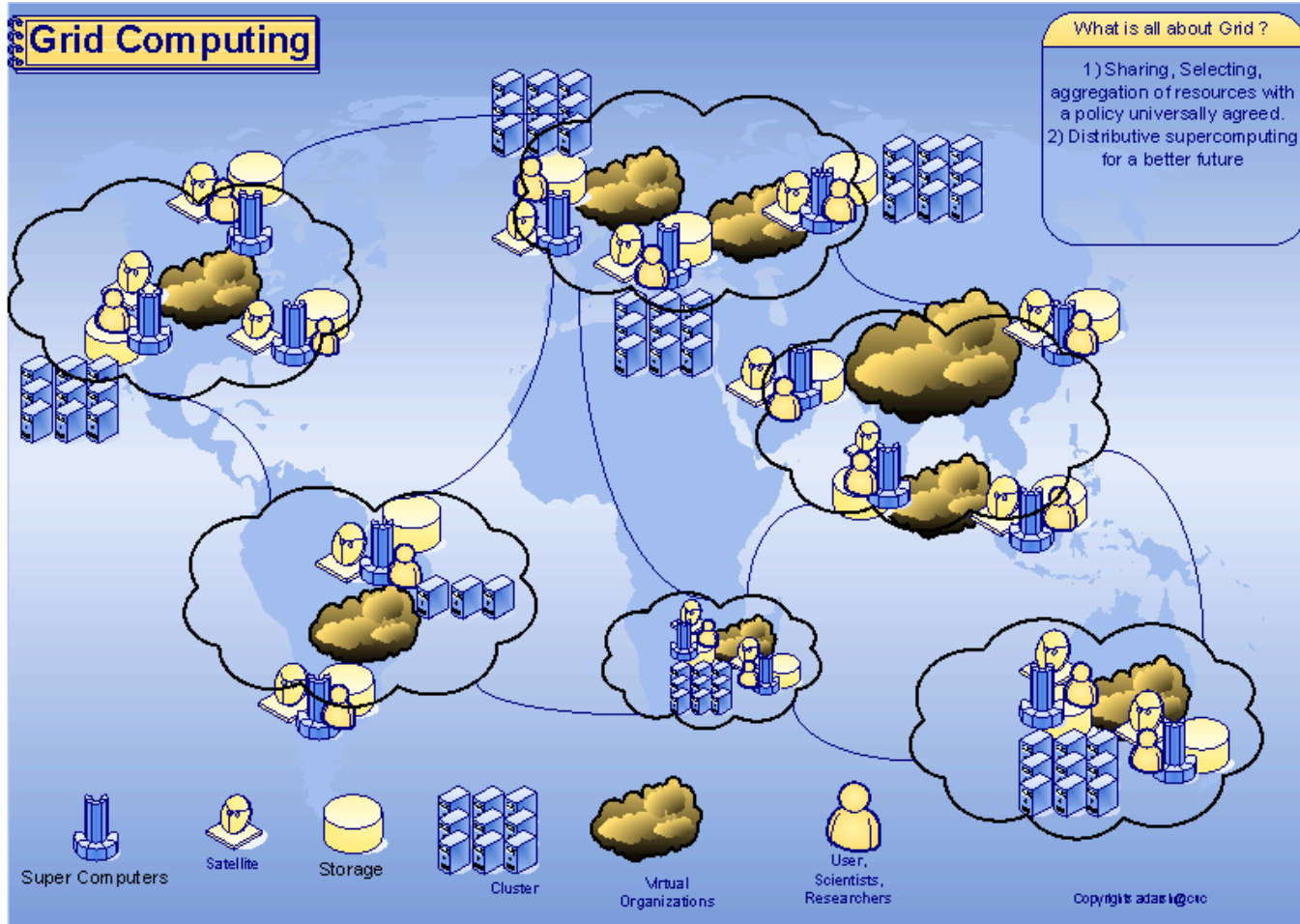


High end architecture change (number of systems)



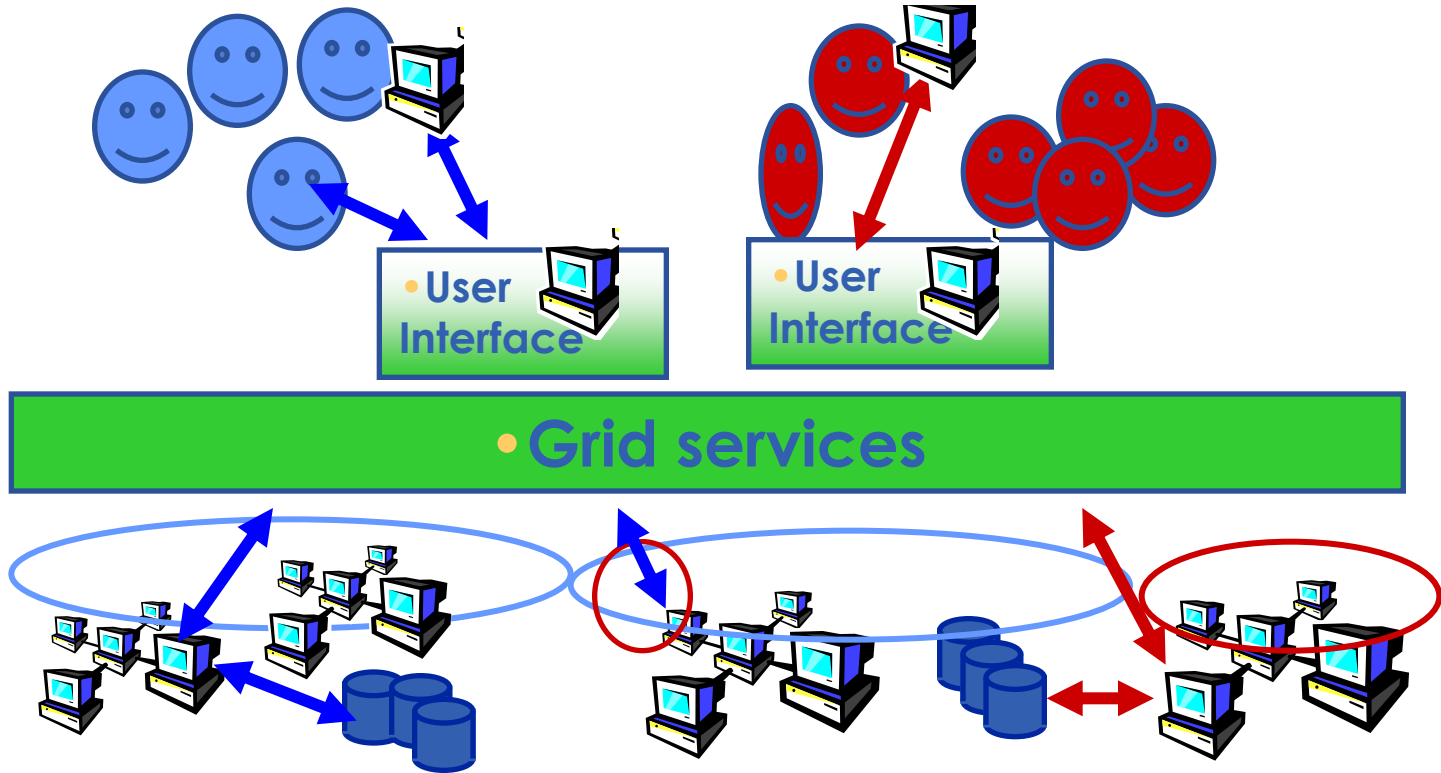
High end architecture change (performance)

- **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**



Grid Computing scheme by Adarsh Patil
 (<http://www.adarshpatil.com/newsite/research.htm>)

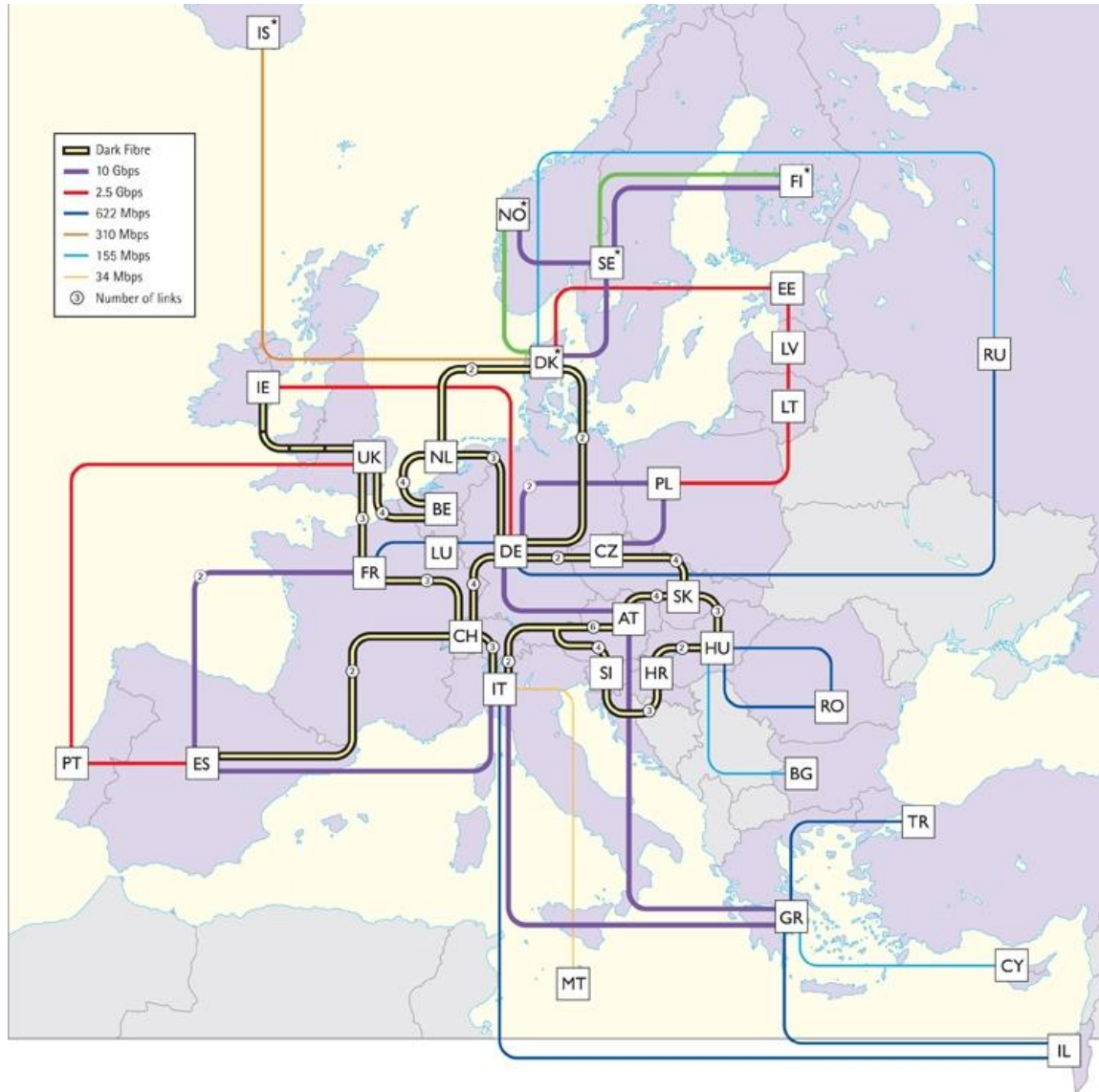
Resource sharing and coordinated problem solving in dynamic, multi-institutional virtual organizations.



- **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

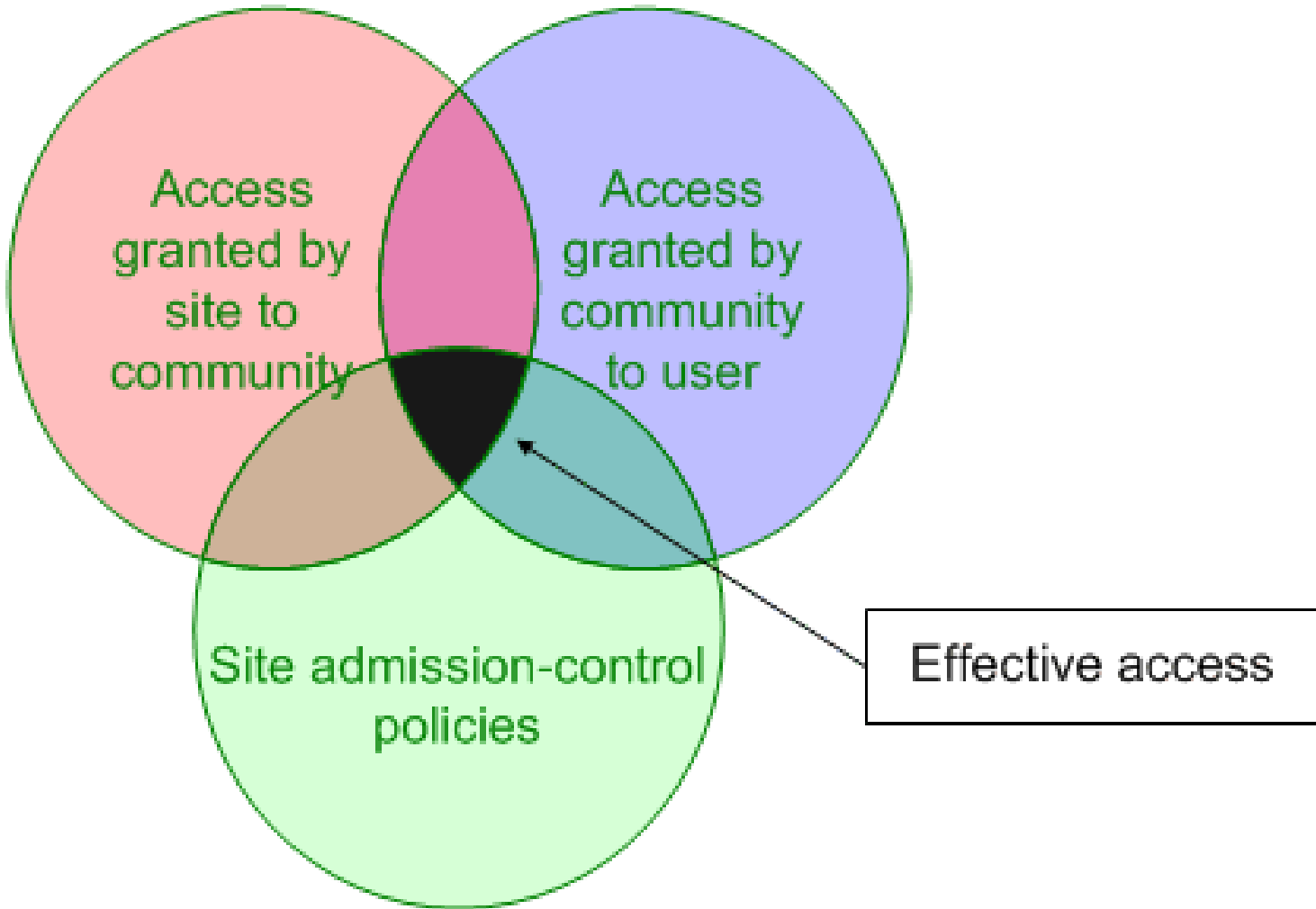
- **The cheapest supercomputers – massively parallel PC clusters**
- **This is possible due to:**
 - Increase in PC processor speed (> Gflop/s)
 - Increase in networking performance (1 Gbs)
 - Availability of stable OS (e.g. Linux)
 - Availability of standard parallel libraries (e.g. MPI)
- **Advantages:**
 - 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

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



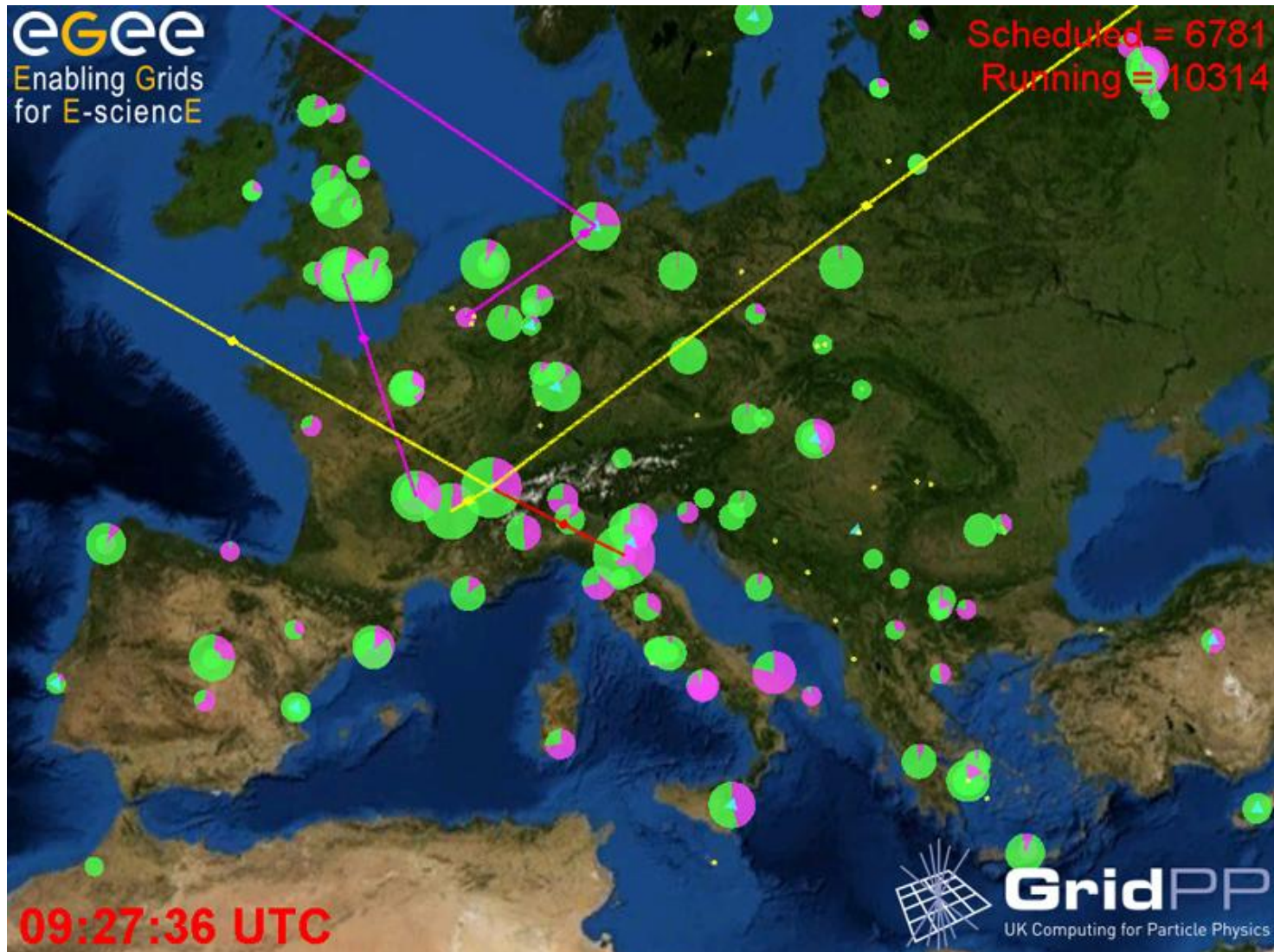
- **Security**
- **Monitoring/Discovery**
- **Computing/Processing Power**
- **Moving and Managing Data**
- **Managing Systems**
- **System Packaging/Distribution**
- **Secure, reliable, on-demand access to data, software, people, and other resources (ideally all via a Web Browser!)**

- **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**

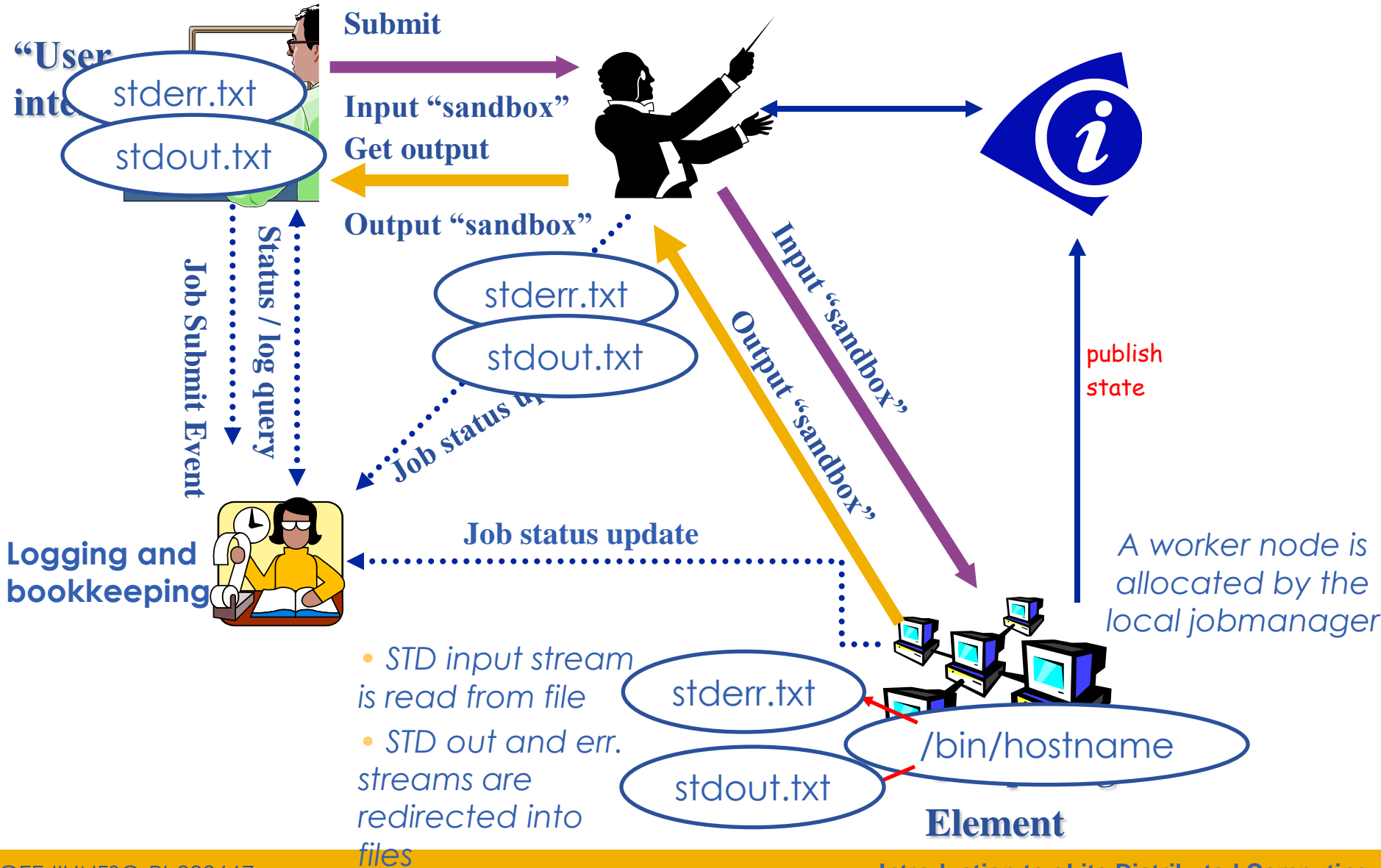


- Enabling Grids for E-scienceE
- NorduGrid
- Open Science Grid
- TeraGrid
- ...





- 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)

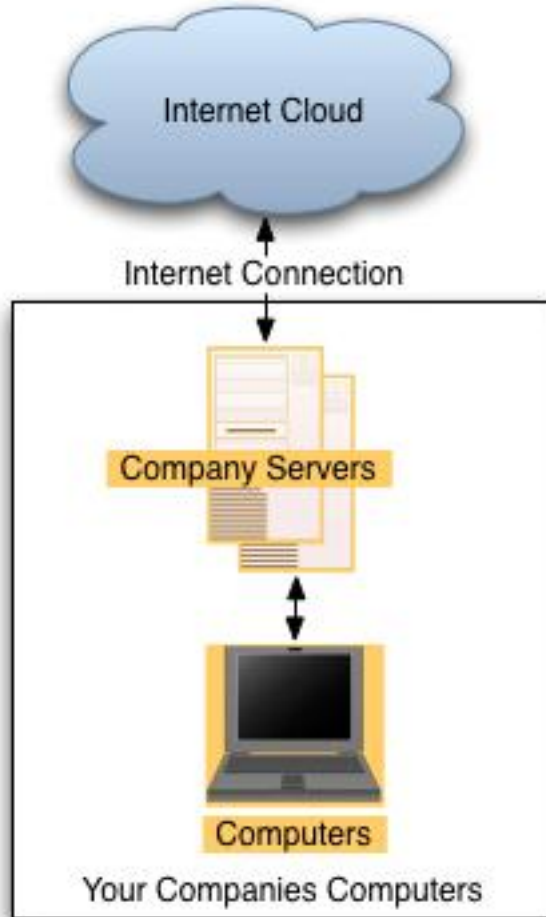


- Even the definition is “cloudy”
- “A computing capability that provides an abstraction between the computing resource and its underlying technical architecture (e.g., servers, storage, networks), enabling convenient, on-demand network access to a shared pool of configurable computing resources that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

- **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**

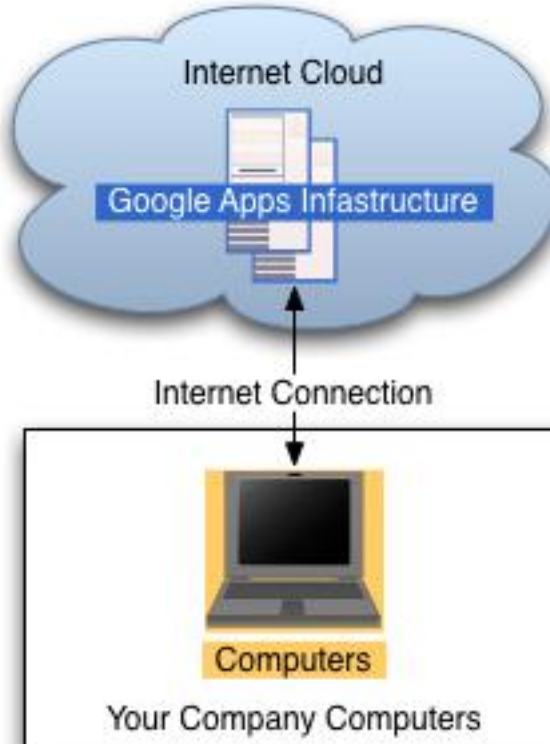
- **Infrastructure-as-a-Service (IaaS)**
 - Virtual server instances with unique IP addresses and blocks of storage on demand (Amazon EC2)
- **Platform-as-a-Service (PaaS)**
 - Set of software and product development tools hosted on the provider's infrastructure (Google App Engine, Microsoft Windows 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)

Current Server Environments

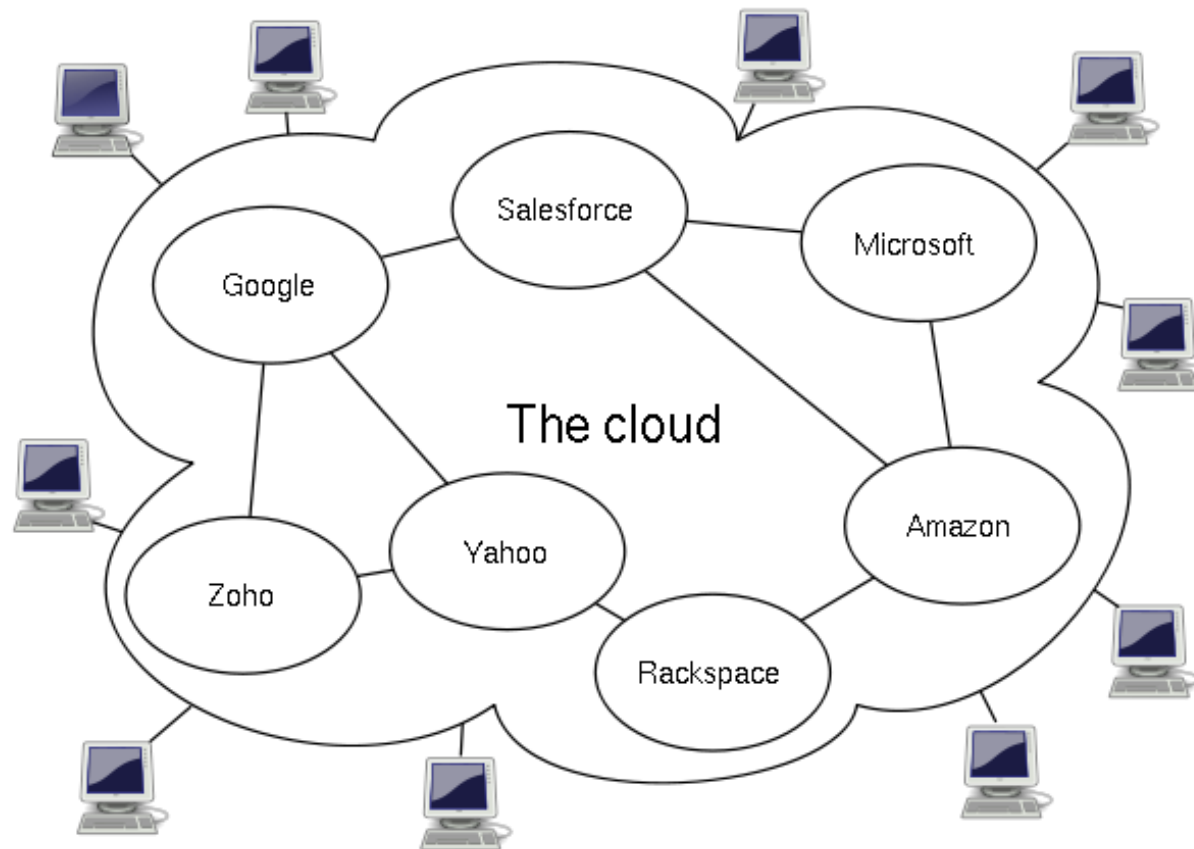


Current server environments are costly and complex to maintain at your company.

Cloud Computing / Software as a Service



Cloud Computing solutions such as Google Apps allows your company to offload management, increase capacity, and reduce cost by leveraging industry experts to provide these systems for you.



- <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