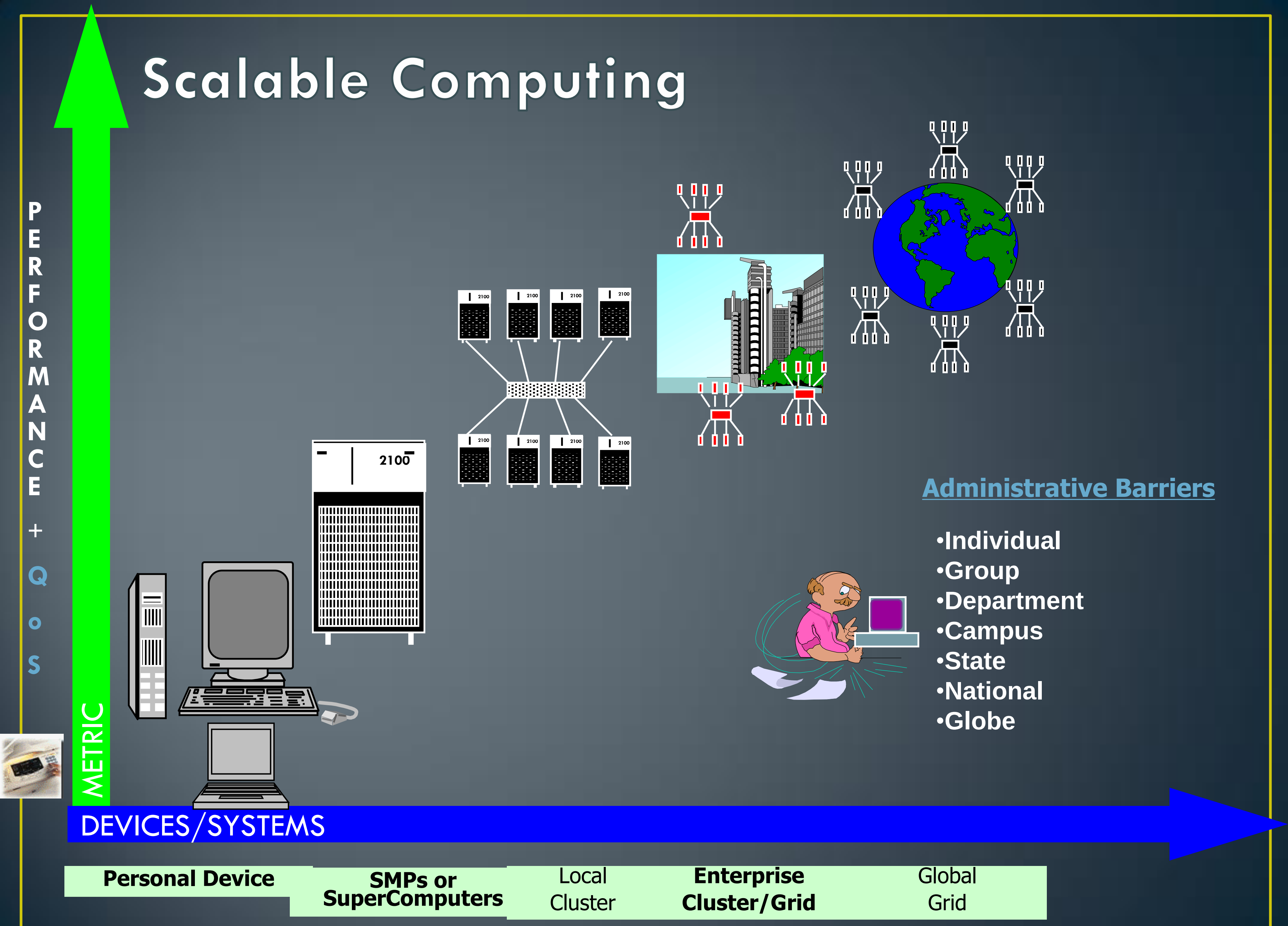
Grid Computing

THANKS TO ALL THE SOURCES FROM WHICH THESE SLIDES ARE PREPARED.

THANK YOU VERY MUCH!

Scalable Computing



Grid Computing

- The term *Grid* comes from an analogy to the Electric Grid
- Grid Computing Is a form of distributed computing
- Execution of large-scale resource intensive applications
- On geographically distributed systems (computing resources).

Formal Definition of Grids

- A grid is a system that:
  - Coordinates resource sharing in a de-centralized manner (i.e., different VOs).
  - Uses standard, open, general purpose protocols and interfaces.
  - Delivers non-trivial qualities of service.
    - Guaranteed bandwidth for application.
    - Guaranteed CPU cycles.
    - Guaranteed latency.

Grid Computing

- Motivation: high performance, improving resources utilization
- Aims to create illusion of a simple, yet powerful computer out of a large number of heterogeneous systems
- Tasks are submitted and distributed on nodes in the grid

Elements of Grid Computing

- Resource sharing
  - Computers, data, storage, sensors, networks, …
  - Sharing always conditional: issues of trust, policy, negotiation, payment, …
- Coordinated problem solving
  - Beyond client-server: distributed data analysis, computation, collaboration, …
- Dynamic, multi-institutional *virtual organizations*
  - Community overlays on classic org structures
  - Large or small, static or dynamic

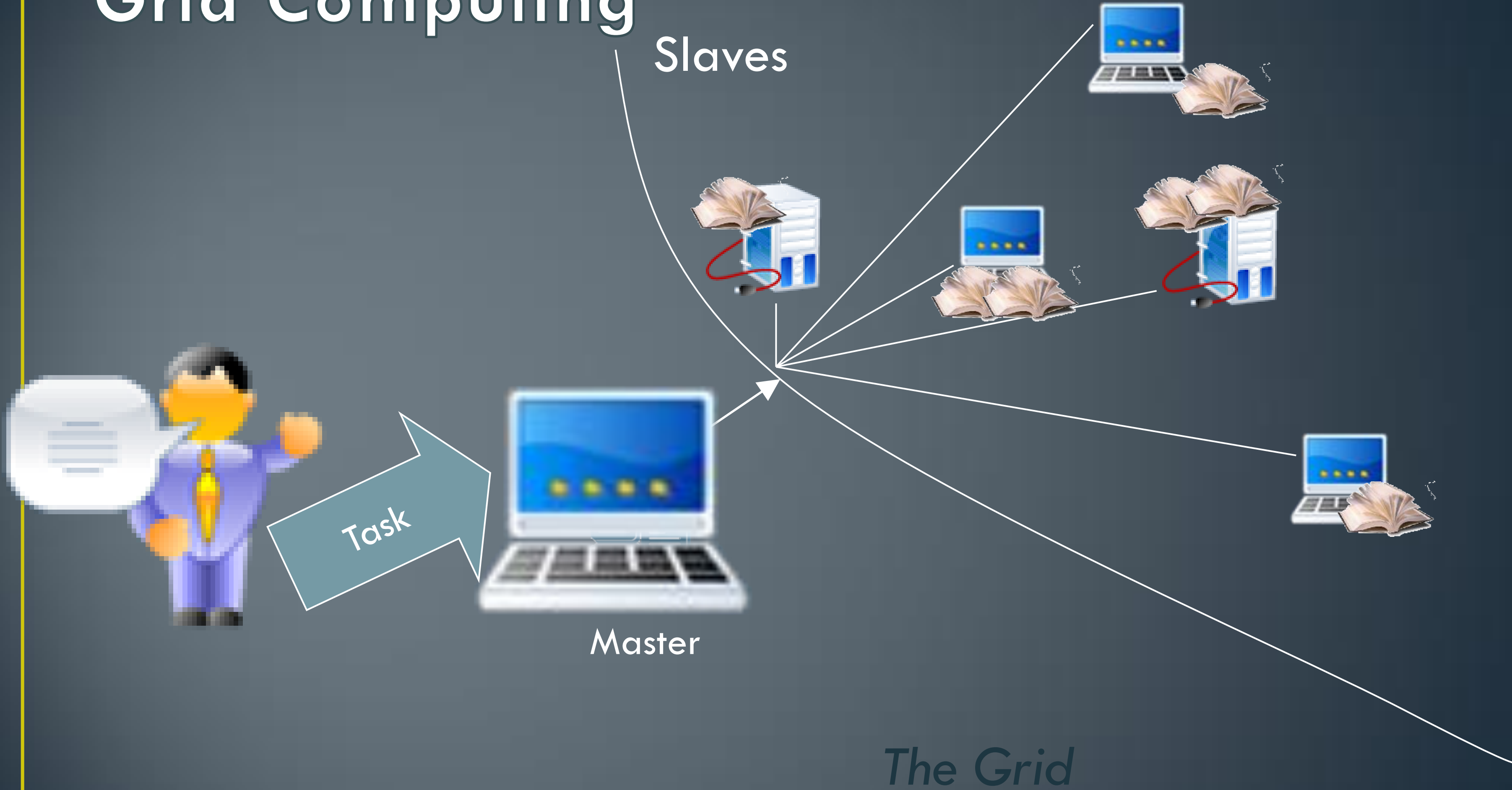
Grid Components and Services

- Communications
- Authentication and Authorization
- Naming Services and local transparency
- Distributed File System
- Resource Management
- Fault Tolerance
- Graphical User Interface

Grid working

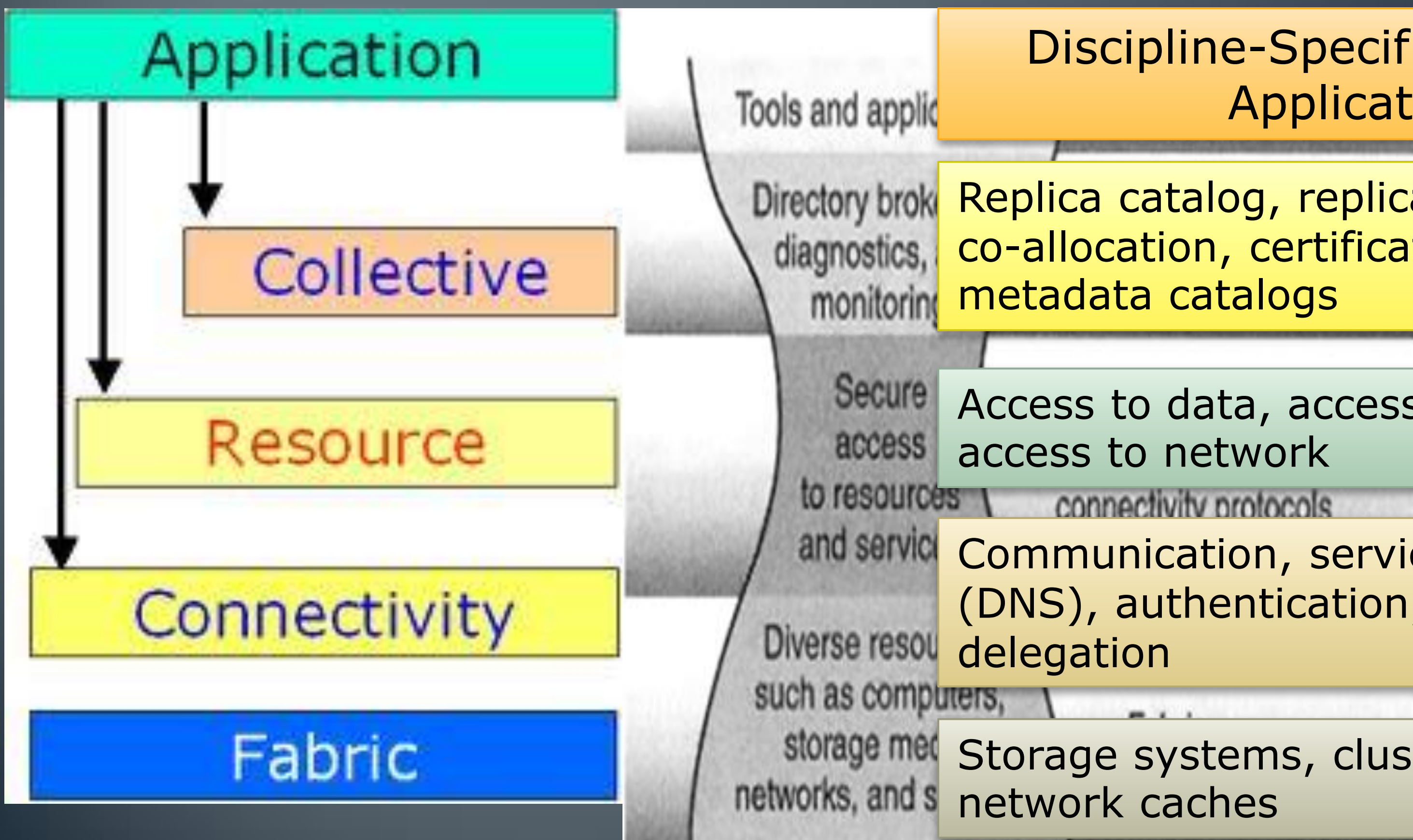
- User submits a job requiring high computation from a low end Work Station
- A server collects requests from similar users and schedules them based on
  - Existing types of resources
  - Their capabilities
  - Current work load
- Submitted jobs are run on the selected computer nodes and results combined later

Grid Computing



Grid Architecture

Basic Grid Protocol Architecture



Discipline-Specific Data Grid Application

Replica catalog, replica management, co-allocation, certificate authorities, metadata catalogs

Access to data, access to computers, access to network

Communication, service discovery (DNS), authentication, authorization, delegation

Storage systems, clusters, networks, network caches

Grid Middleware

- Grids are typically managed by grid ware - a special type of middleware that enable sharing and manage grid components based on user requirements and resource attributes (e.g., capacity, performance)
- Software that connects other software components or applications to provide the following functions:
  - Run applications on suitable available resources
    - Brokering, Scheduling
  - Provide uniform, high-level access to resources
    - Semantic interfaces
    - Web Services, Service Oriented Architectures
  - Address inter-domain issues of security, policy, etc.
    - Federated Identities
  - Provide application-level status monitoring and control

Grid Middleware

- Major functions are:
  - Optimizing use of widely dispersed resources
  - Organizing efficient access to scientific data
  - Authenticating users accessing the resources
  - Arranging interfaces to local site authorization

Grid Systems

Data Grid vs. Computing Grid

- Data Grid:
  - distributed data storage
  - controlled sharing and management of large amounts of distributed data.
- Computing Grid:
  - Parallel execution
  - divide pieces of a program among several computers

$$\underbrace{\text{Data Grid + Computing Grid}}_{\text{Grid Computing}}$$

Data Grid

- A **data grid** is a grid computing system that deals with data — the **controlled sharing and management of large amounts of distributed data.**
- Large datasets can be stored in repositories
- Data grid provide services to distributed data-intensive applications
  - Data replication
  - Data invalidation
  - Data backup
  - Distributed transactions
  - Data affinity/partitioning

Example :

Biomedical informatics Research Network (BIRN),

the Southern California earthquake Center (SCEC).

Computational Grid

- "A computational grid is a hardware and software infrastructure that provides dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities."
- Example : Science Grid (US Department of Energy)

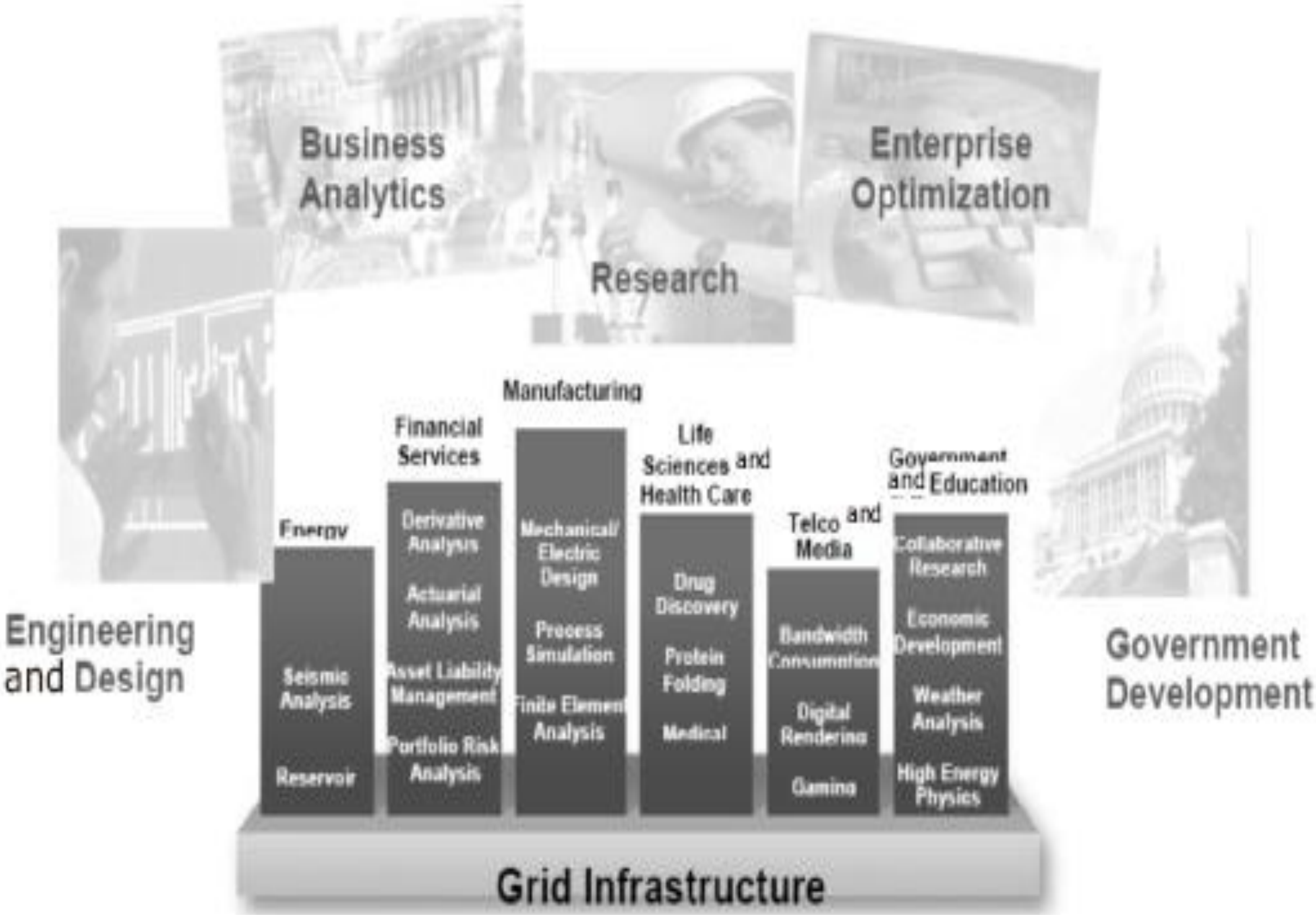
- Characteristics:
  - Made up of clusters of clusters
  - Enable CPU scavenging for better resource utilization
  - provide computational power for compute-intensive jobs
  - Provide instant access on demand

Benefits of Grid Computing

- Exploit Underutilized resources
- Resource load Balancing
- Virtualize resources across an enterprise
  - Data Grids, Compute Grids
- Enable collaboration for virtual organizations

Grid Computing Applications

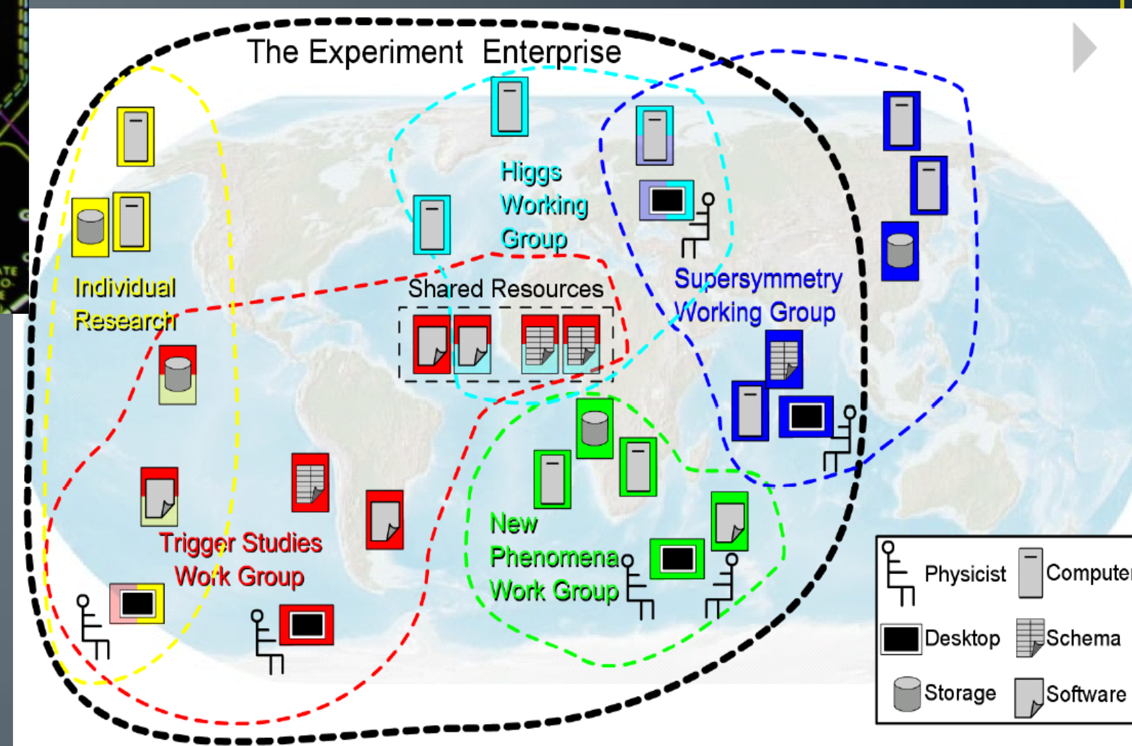
- Distributed computing
- High Throughput
- On-demand
- Data-intensive
- Collaborative

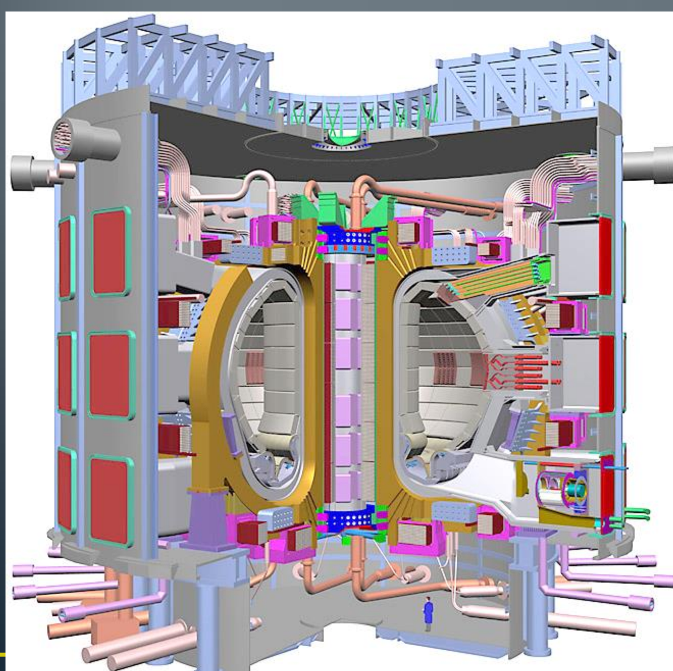


Variety of grid computing applications

Examples

Science Today is a Team Sport!!





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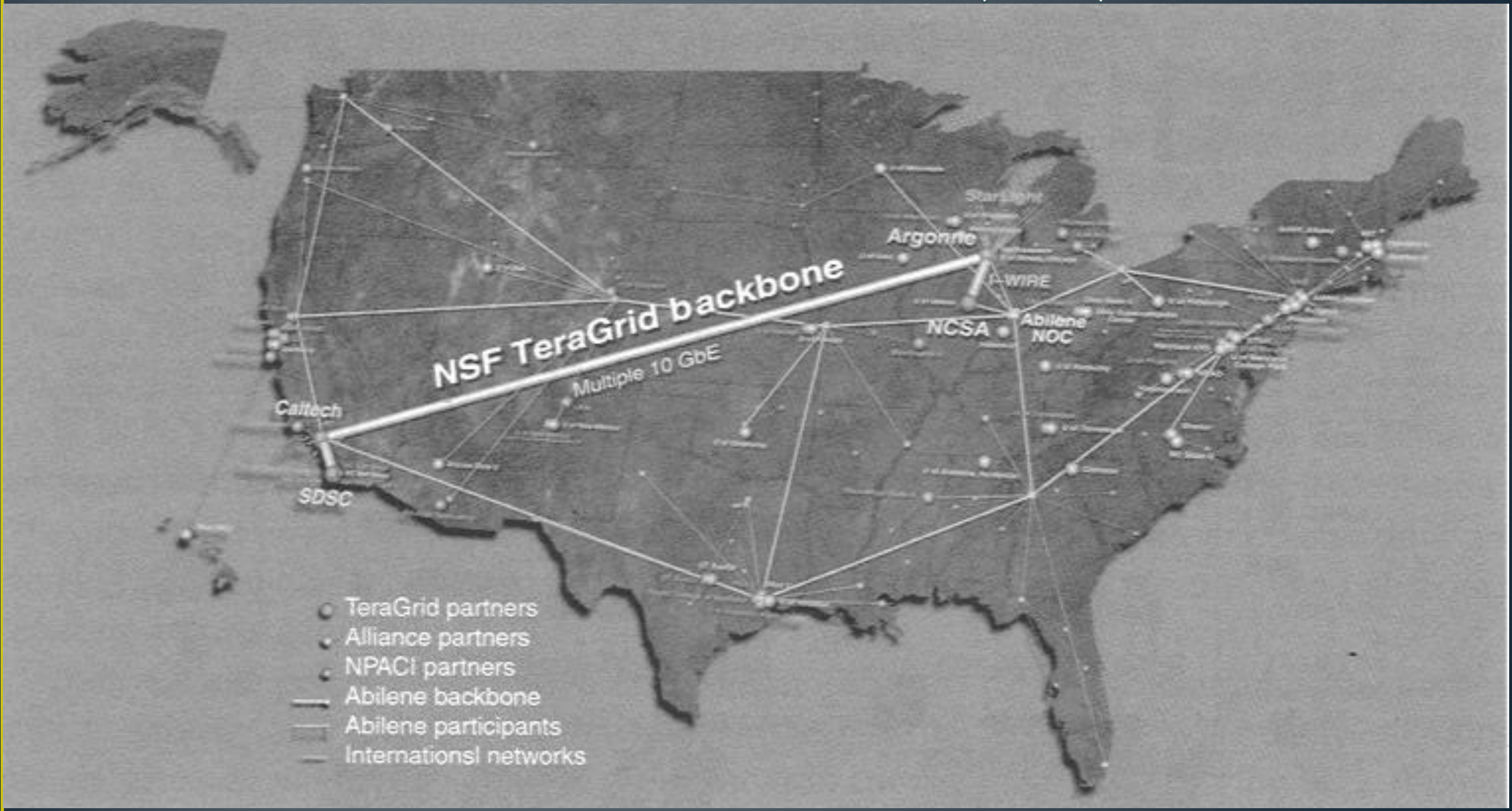
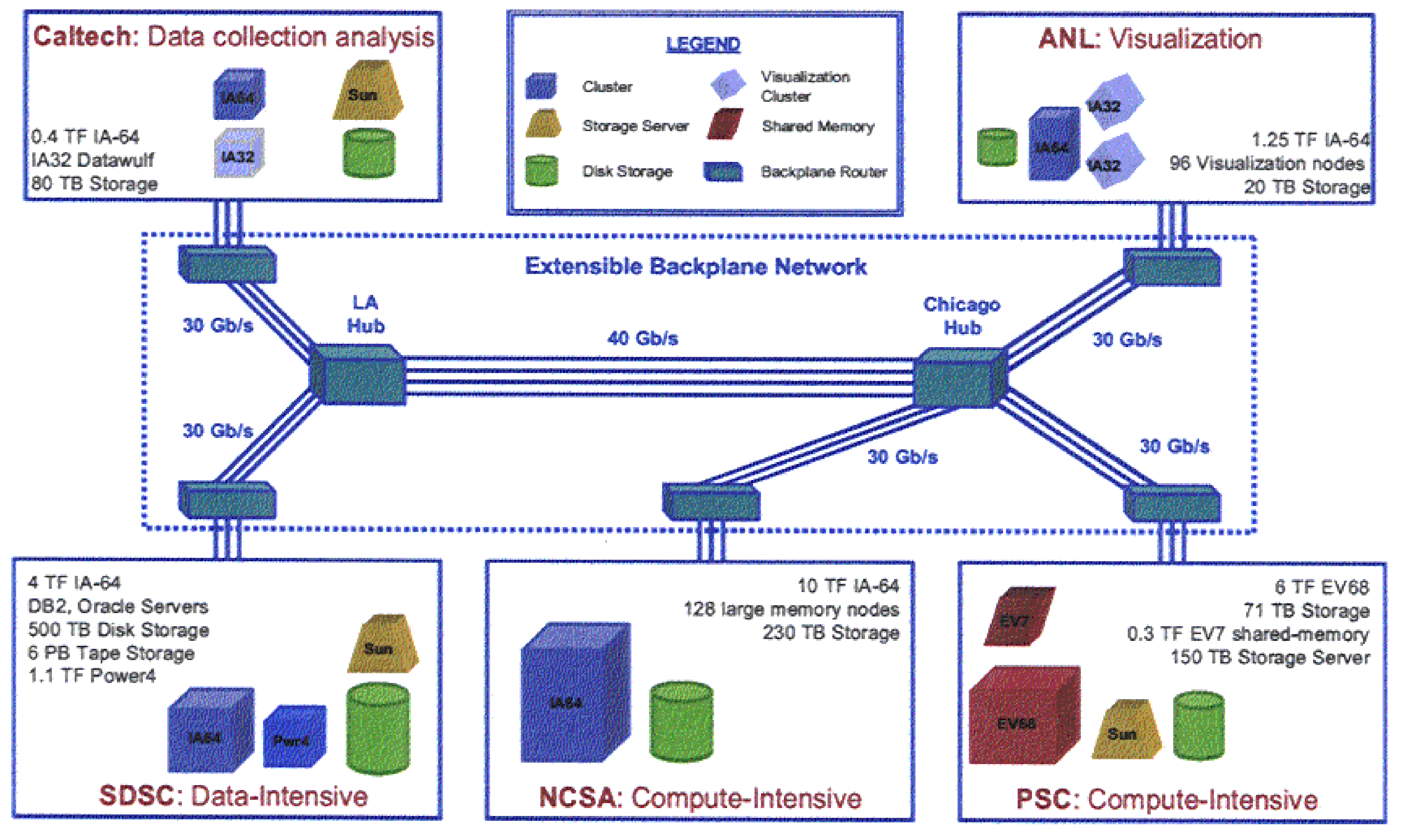
TeraGrid is an Important Project developed by the National Science Foundation (NSF).



Slide obtained from B. Wilkinson, http://sol.cs.wcu.edu/~abw/CS493F04/

TeraGrid



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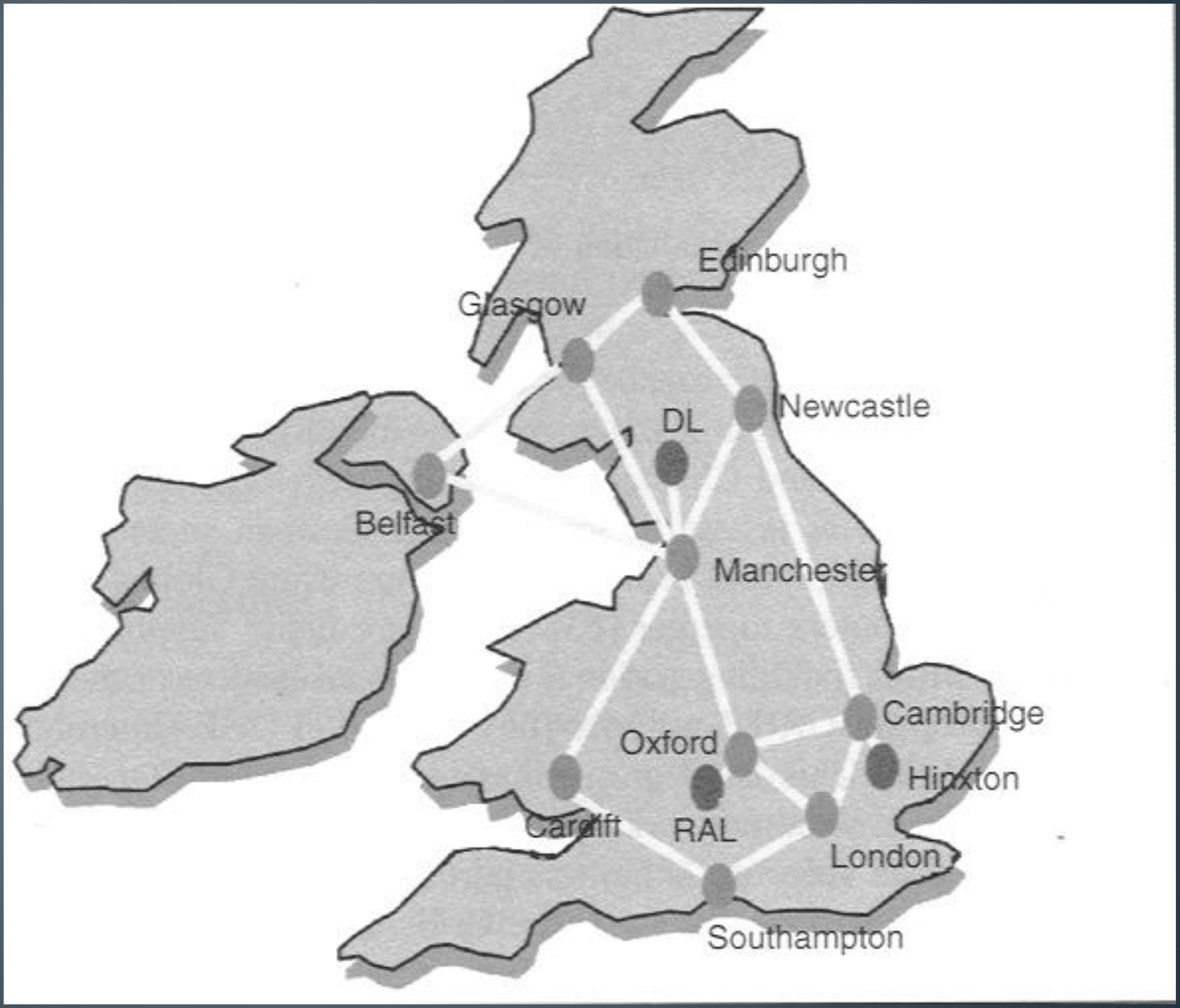
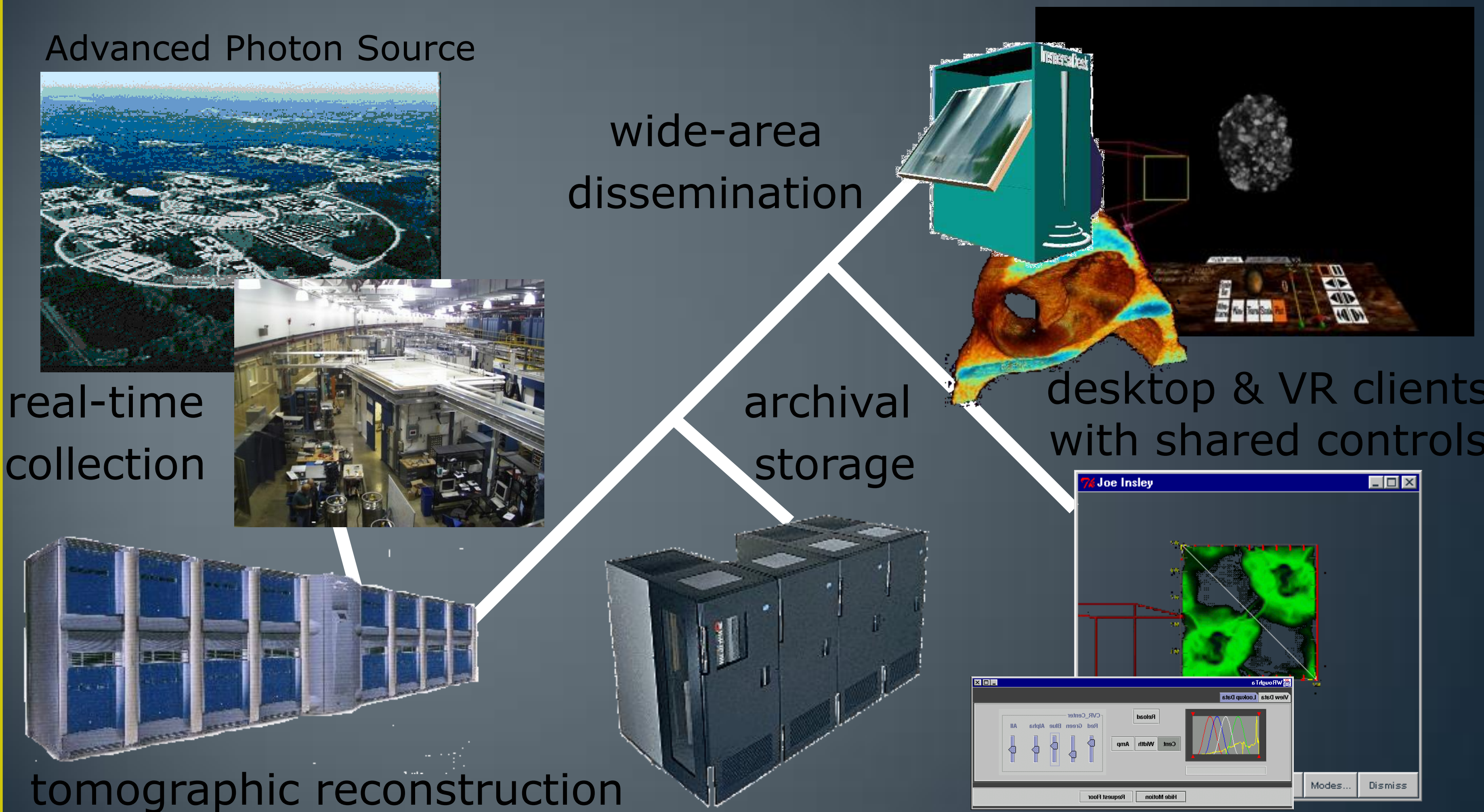
UK e-Science Grid



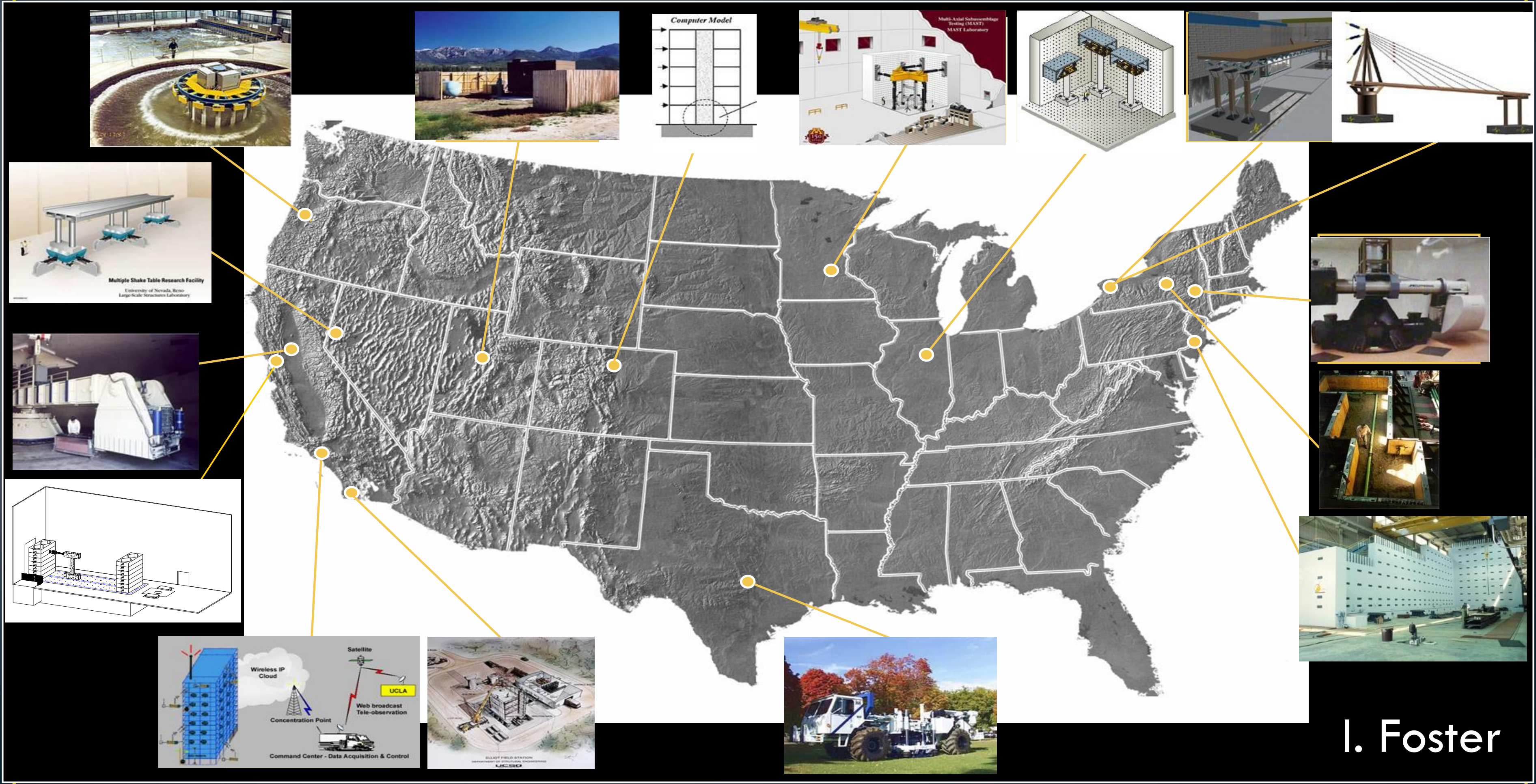
Online Access to Scientific Instruments



DOE X-ray grand challenge: ANL, USC/ISI, NIST, U.Chicago

NSF Network for Earthquake Engineering Simulation (NEES)

Transform our ability to carry out research vital to reducing vulnerability to catastrophic earthquakes



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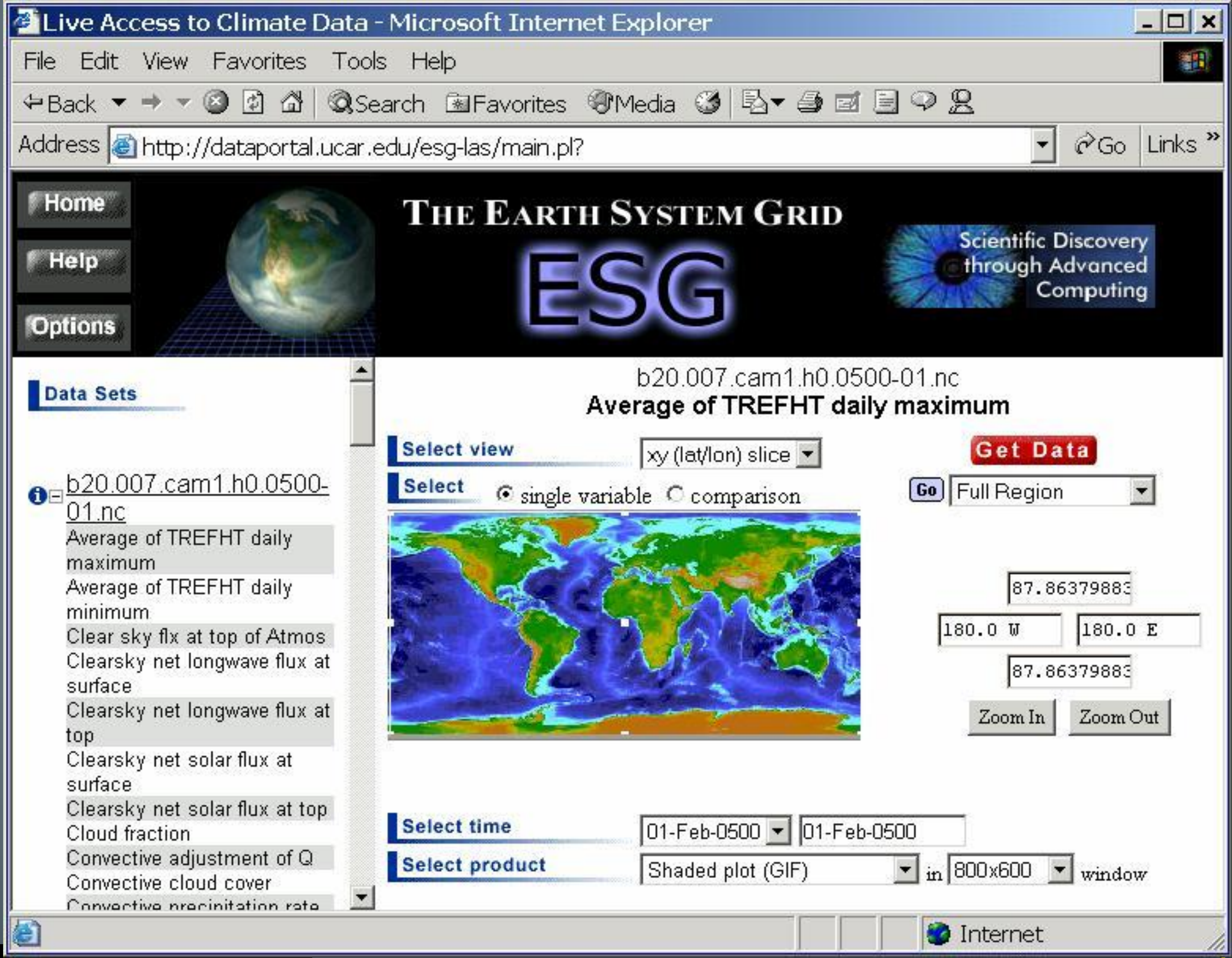
DOE Earth System Grid

<u>Goal</u>: address technical obstacles to the sharing & analysis of high-volume data from advanced earth system models



www.earthsystemgrid.org

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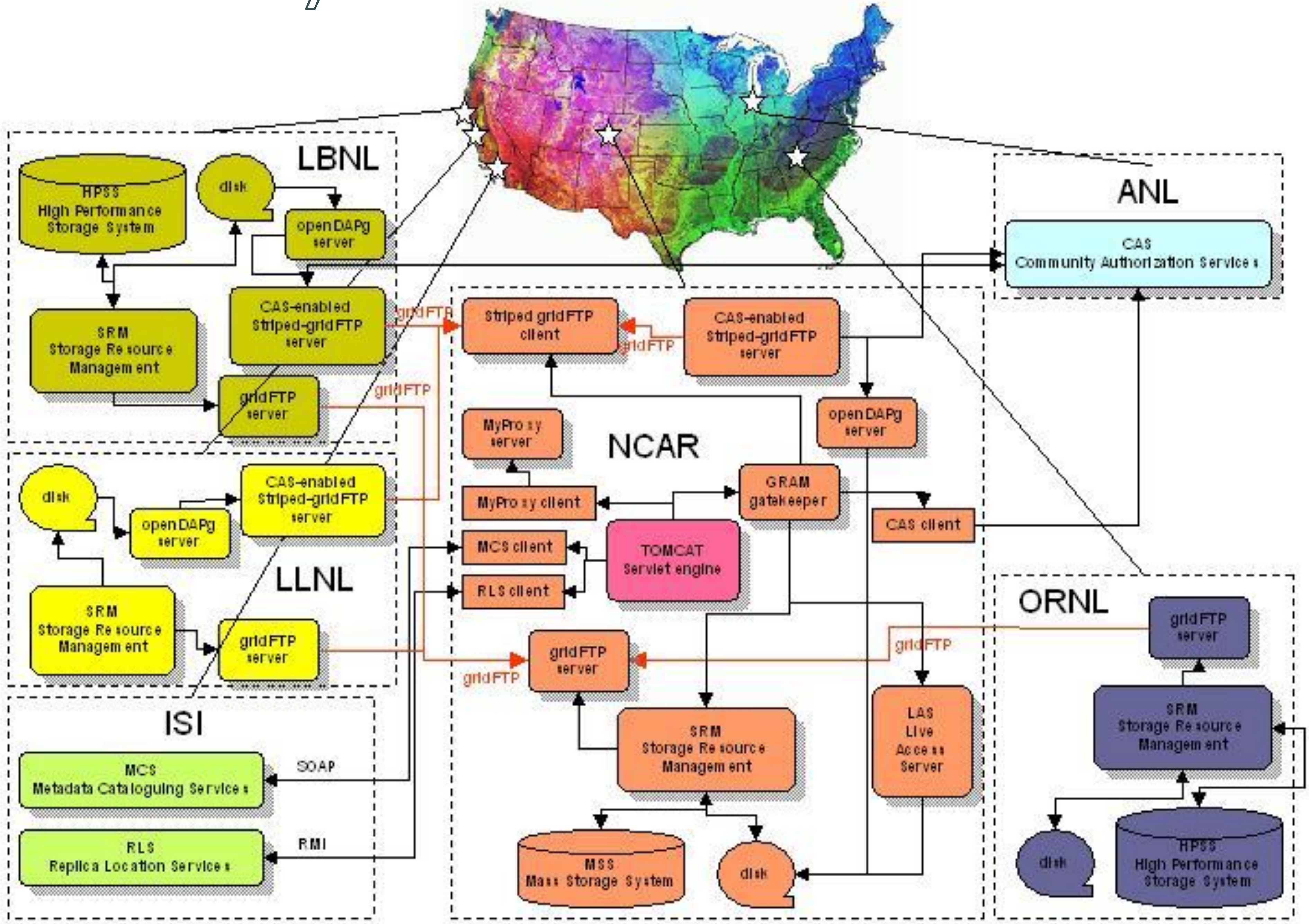
Earth System Grid



Simulation tools

- GridSim – job scheduling
- SimGrid – single client multiserver scheduling
- Bricks – scheduling
- GangSim- Ganglia VO
- OptoSim – Data Grid Simulations
- G3S – Grid Security services Simulator – security services

Middlewares

- Globus –chicago Univ
- Condor – Wisconsin Univ – High throughput computing
- Legion – Virginia Univ – virtual workspaces- collaborative computing
- IBP – Internet back pane – Tennesse Univ – logistical networking
- NetSolve – solving scientific problems in heterogeneous env – high throughput & data intensive

Standards Bodies

The primary standards-setting body is[1]:

- Global Grid Forum (GGF)
  - Started in 1998
  - Meets three times a year, GGF1, GGF2, GGF3 …
  - More than 40 organizations involved and growing …

Others:

- W3C consortium (Worlds Wide Web Consortium)
  - Working on standardization of web-related technologies such as XML
  - See http://www.w3.org
- OASIS (Organization for the Advancement of Structured Information Standards)
- IETF, DMTF

[1] "The Grid Core Technologies" by M. Li and M. Baker, 2005, page 4.

Standards in the Web Services World

- XML introduced (ratified) in 1998
- SOAP ratified in 2000
- Web services developed
- Subsequently, standards have been are continuing to be developed:
  - WSDL
  - WS-* where * refers to names of one of many standards

Standards in the grid computing world

- Open Grid Services Architecture (OGSA)
- First announced at GGF4 in Feb 2002
- OGSA does not give details of implementation.