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Current and Future Grid Infrastructure

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Some material provided by Y. Gil, C. Kesselman and S. Tuecke
Some material obtained from the iVDGL NSF review

The Globus Alliance

- A group of people with a common mission:
  - *"Make Grid computing an everyday reality."*
- Argonne/U.Chicago, USC-ISI, EPCC, & KTH-PDC
  - Led by Ian Foster (Argonne), Carl Kesselman (ISI), Malcolm Atkinson (EPCC), Lennart Johnsson (PDC)
  - Includes researchers, software developers, software architects & designers, systems engineers, & others
  - Collaborations (or at least acquaintances) with most Grid activities in the world
- All activities contribute to our common mission
  - Research
  - Software development (prototypes, reference implns)
    - Globus Toolkit
  - Application and Infrastructure consulting

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Outline

- Grid technologies in Science and Industry
- Developments in Grid Services and Globus Toolkit
  - Convergence with web services
  - The Grid as a resource management problem
- Research activities within the Globus Alliance, a flavor of things to come
  - Pegasus (Planning for Execution in Grids)
    - Large-scale Workflow management on the Grid
  - The Metadata Catalog Service
    - Metadata management on the Grid
- Conclusions

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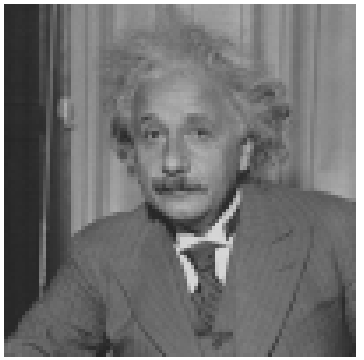
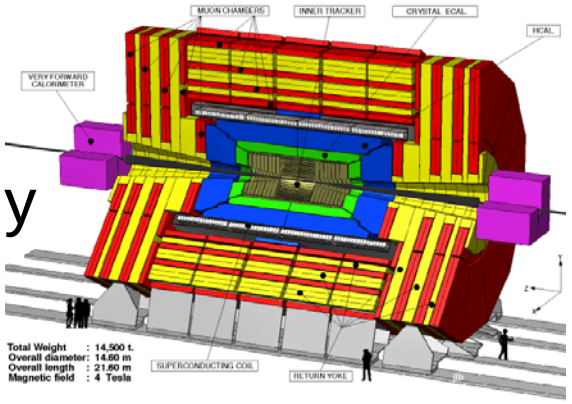
Revolution in Science

- Pre-Internet
  - Theorize &/or experiment, alone or in small teams; publish paper



- Post-Internet
  - Construct and mine large databases of observational or simulation data
  - Develop simulations & analyses
  - Access specialized devices remotely
  - Exchange information within distributed multidisciplinary teams



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Problem Solving in the 21st Century

- Teams organized around common goals
  - Communities: “Virtual organizations”
- With diverse membership & capabilities
  - Heterogeneity is a strength not a weakness
- And geographic and political distribution
  - No location/organization possesses all required skills and resources
- Must adapt as a function of the situation
  - Adjust membership, reallocate responsibilities, renegotiate resources

The Grid: enabling technology

- Infrastructure ("middleware" & "services") for establishing, managing, and evolving multi-organizational federations
  - Dynamic, autonomous, domain independent
  - On-demand, ubiquitous access to computing, data, and services
- Mechanisms for creating and managing workflows within such federations
  - New capabilities constructed dynamically and transparently from distributed services
  - Service-oriented, virtualization

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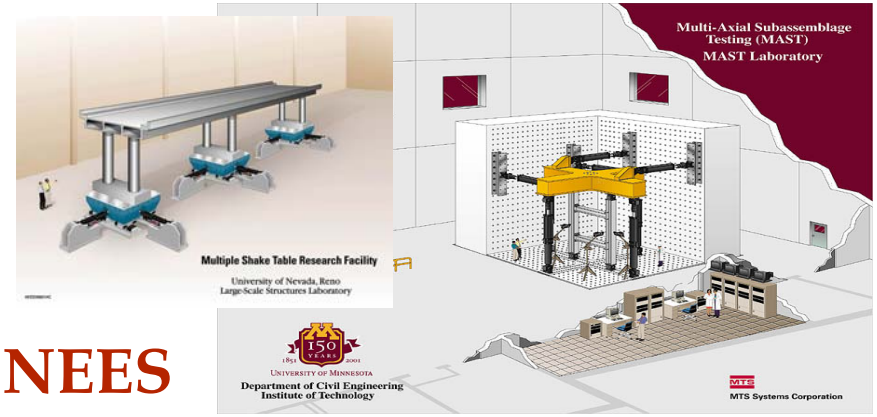
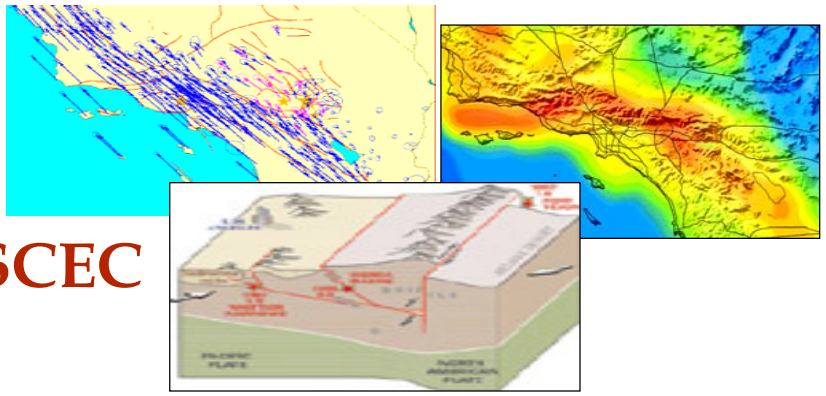
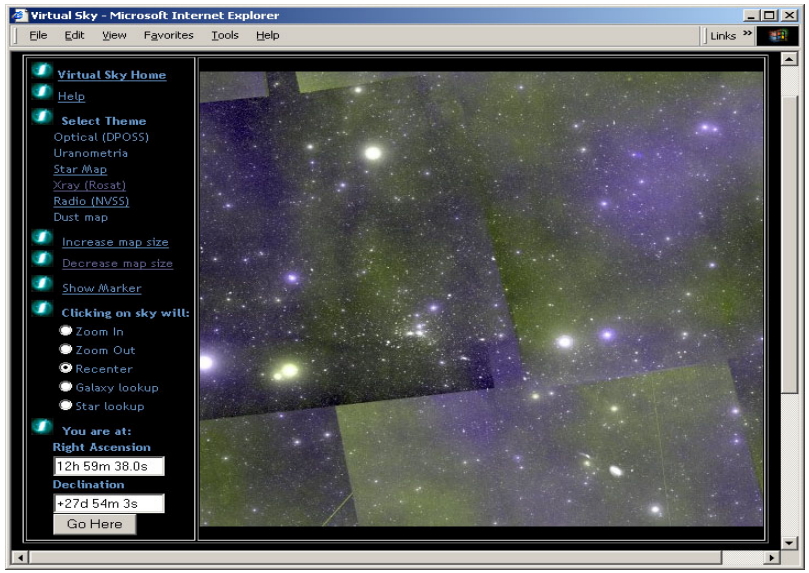
Science is Adopting Grid Technology:



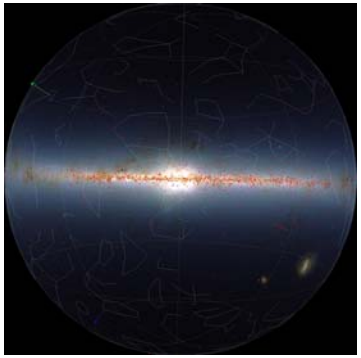
NEES



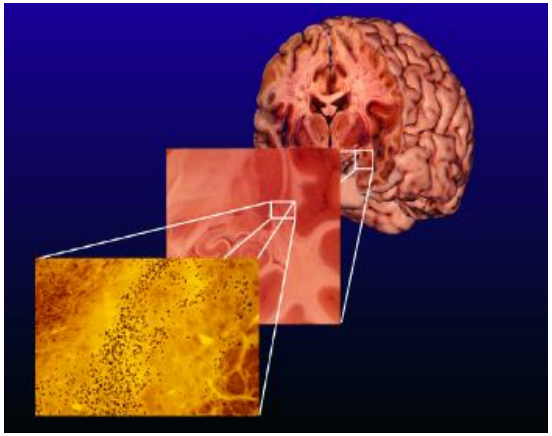
SCEC



NVO



GriPhyN



BIRN

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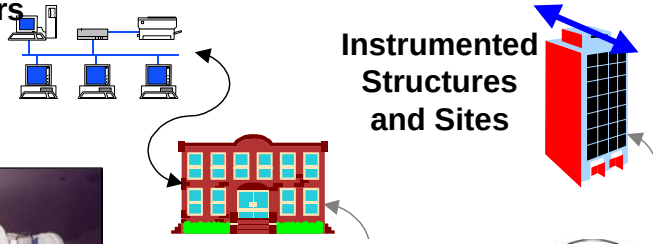
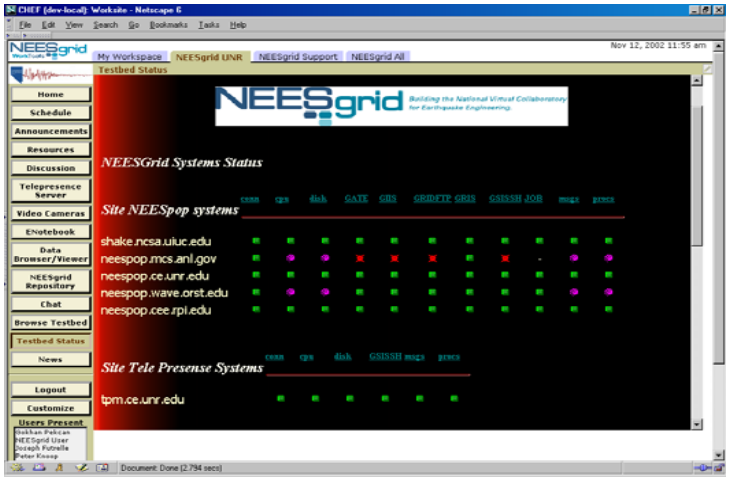
NEESgrid Earthquake Engineering Collaboratory

Focus on remote experimentation

U.Nevada Reno

www.neesgrid.org





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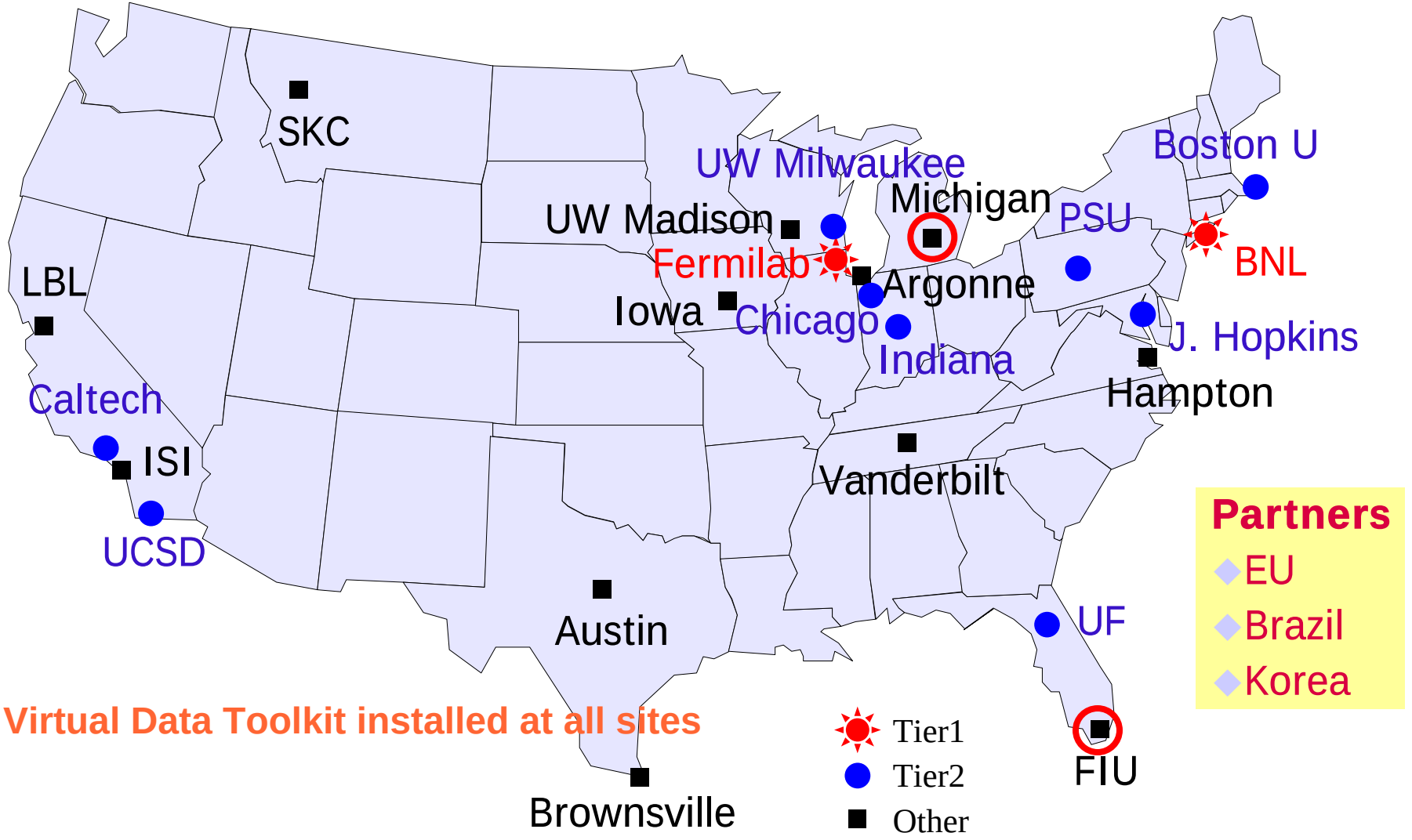
iVDGL Sites (February 2004)
iVDGL supports GriPhyN and PPDG



Partners
- EU
- Brazil
- Korea

Virtual Data Toolkit installed at all sites

Slide by Paul Avery, iVDGL NSF review 2004

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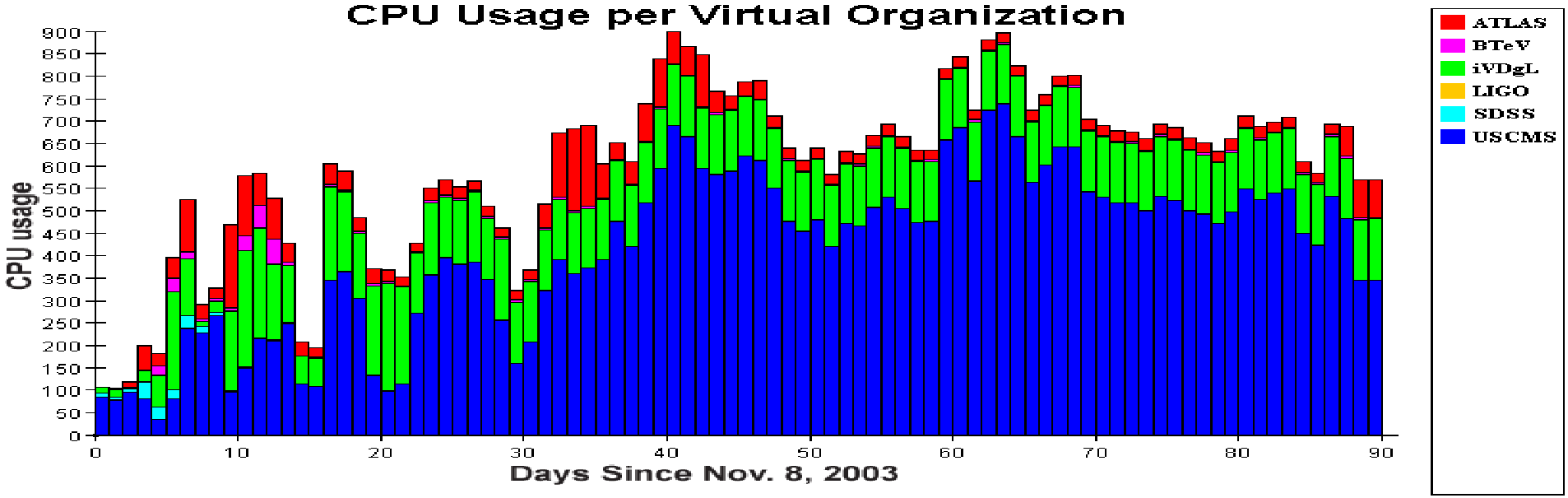
Grid2003: Three Months Usage

- Hardware resources
  - Total of 2762 CPUs
  - Total of 27 sites
    - 27 administrative domains with local policies in effect
    - All across US and Korea
- Running jobs
  - Peak number of jobs 1100



Slide by Paul Avery, iVDGL NSF review 2004

Grid the basic scientific tool

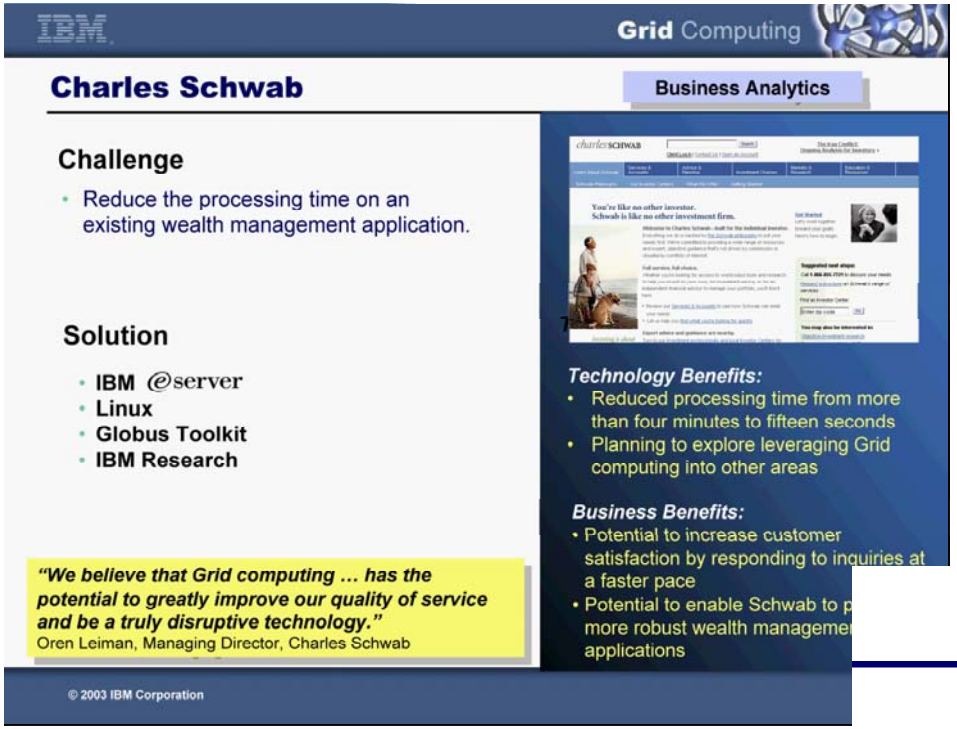
- Proposed infrastructure for University of Texas (provided by IBM)
  - Largest university grid-computing project in the nation
  - Will support more than 50,000 students and 20,000 faculty and staff members
- Grid technology will be used for
  - Simulations
  - data sharing
  - data-intensive calculations
  - genomics investigations; climate modeling; petroleum exploration; and environmental remediation.

eScience is the Initial Motivator …

- New research approaches based on
  - Complex analysis of huge quantities of data
  - Interdisciplinary collaboration
  - Large-scale simulation
  - Smart instrumentation
- Enabled by an infrastructure based on the Globus Toolkit that enables access to, and integration of, resources & services without regard for location

… but eBusiness is catching up rapidly

Industry Adopts Grid Technology



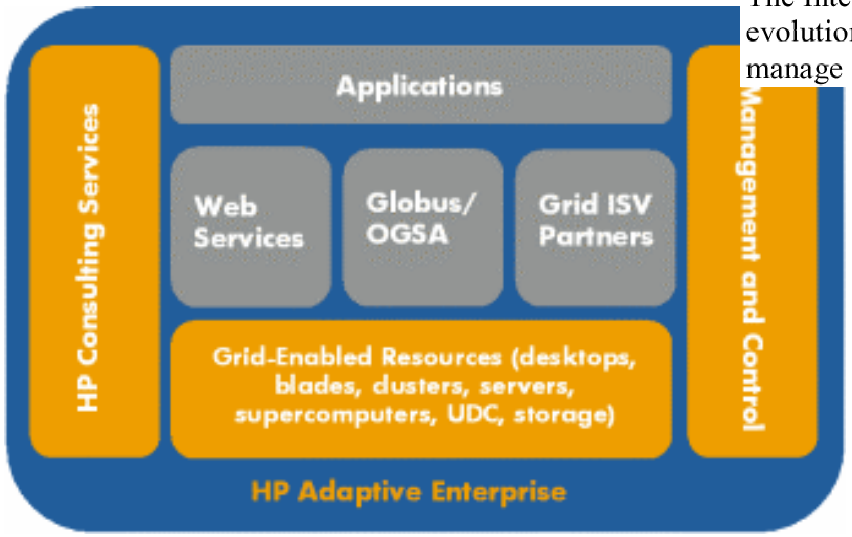
I.B.M. Making a Commitment to Next Phase of the Internet

By STEVE LOHR — The New York Times

I.B.M. is announcing today a new initiative to support and exploit a technology known as grid computing, which the company and much of the computer research community say is the

Merrill Lynch

DataSynapse



Globus Grid Computing—the Next Internet

by John Roy/Steve Milunovich

The Internet was first a network and is now a communications platform. The next evolutionary step could be to a platform for distributed computing. This ability to manage applications and share data over the network is called "grid computing."


COVER STORY

ORACLE DATABASE 10g

THE WORLD'S FIRST

SELF-MANAGING, GRID-READY DATABASE ARRIVES

Oracle's new self-managing database increases performance and availability while enabling commercial grid computing.

BY KELLI WISETH

Ewa Deelman, USC Information Scienc

Grid Solutions in Business Environments

- Financial markets
  - Better market forecasts, risk analysis of stock portfolios
- Life sciences
  - Better drugs faster
- Automotive and aerospace
  - Better collaborative designs in shorter amount of time
- Government
  - Facilitate information sharing and analysis
- Benefits of Grid Solutions:
  - Increase the computation power delivered to businesses
  - Exploit available, underutilized compute and storage resources
  - Enable data sharing and distributed workflow across partners
  - Help with collaborative design

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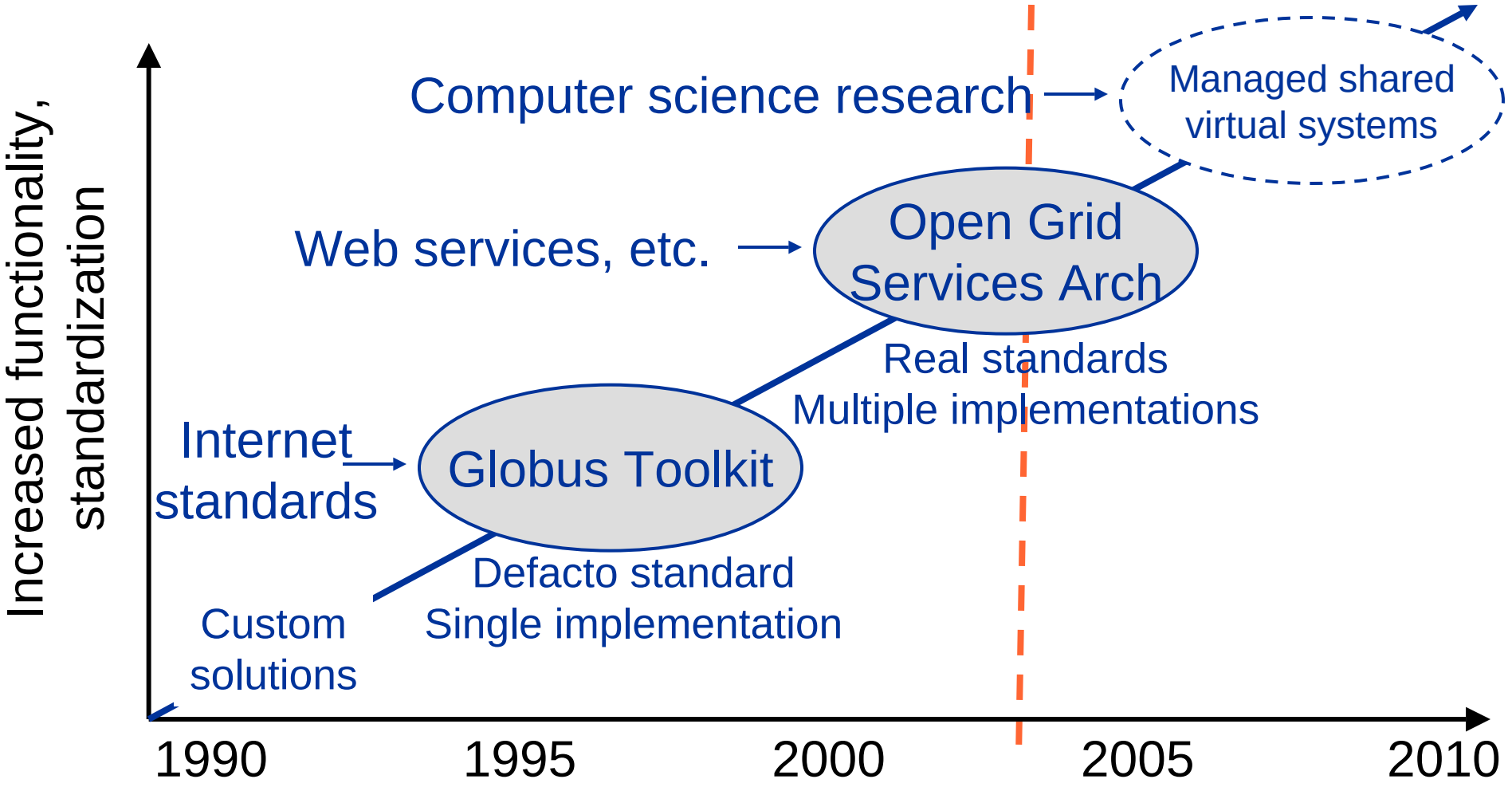
Progress through the Emergence of Open Grid Standards



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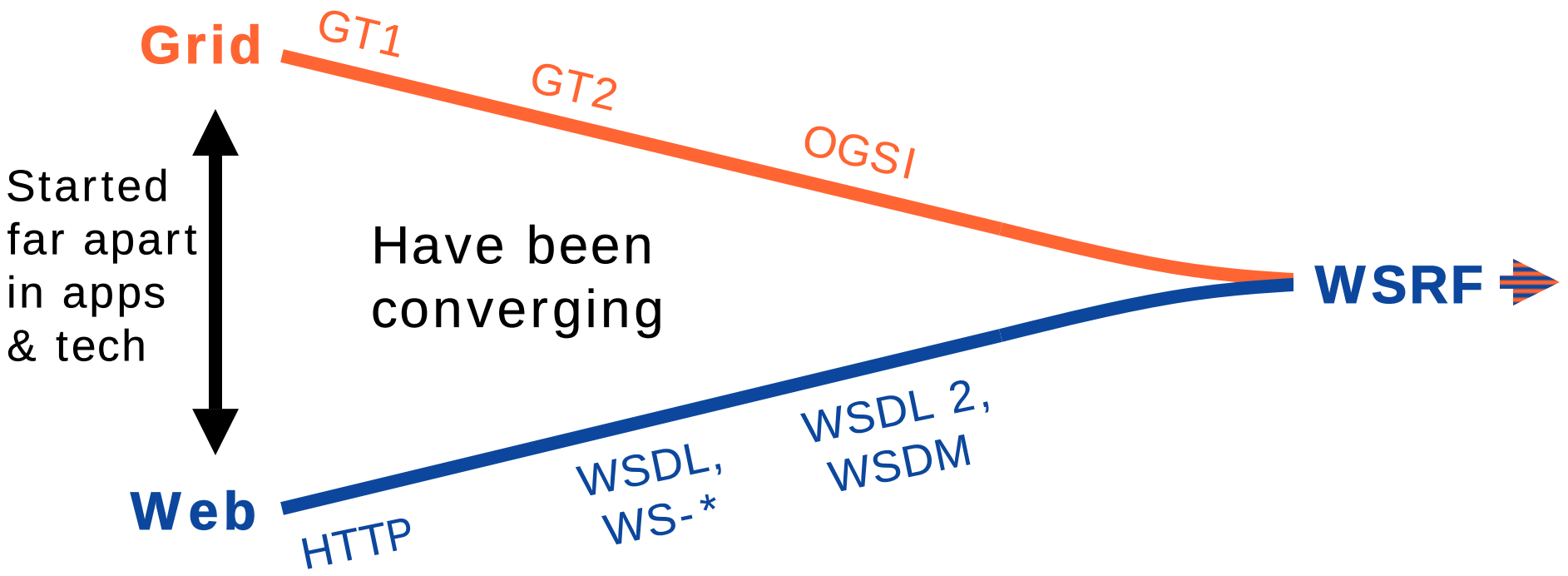
Convergence of Grid and Web Services



The definition of WSRF means that Grid and Web communities can move forward on a common base

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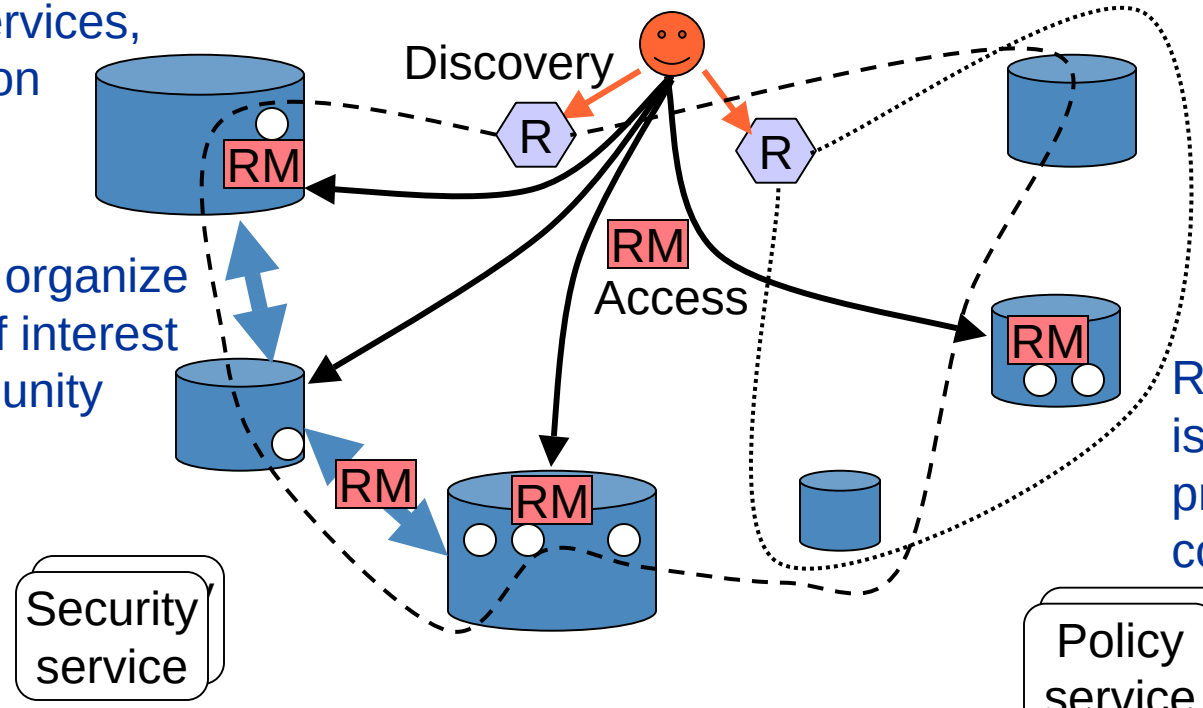
The Grid is about Resource Integration

Many sources of data, services, computation

Registries organize services of interest to a community

Security & policy must underlie access & management decisions

Resource management is needed to ensure progress & arbitrate competing demands



Data integration activities may require access to, & exploration/analysis of, data at many locations

Exploration & analysis may involve complex, multi-step workflows

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How to Build a Grid? Guiding Principles

Grid definition implies that we must be able to

- Talk about resources in uniform ways
  - Ubiquitous Service Oriented Architecture base for modeling resources
- Govern the behavior resources that are not under our control &/or oversubscribed
  - Negotiate agreements among entities
- Exploit commonality across resources so as to reduce integration complexity
  - Factor across multiple resource types

Grids Needs Support for Transient Stateful Services

- Web services address discovery & invocation of persistent services
  - Lack dynamic behavior
- In Grids, must also support transient services, created/destroyed dynamically
  - Interfaces to the states of distributed activities
  - E.g. workflow, video conf., dist. data analysis
- Significant implications for how services are managed, named, discovered, and used
  - In fact, much of our work is concerned with the management of services

Key concepts in OGSI and WSRF

Entity: in OGSI---service, in WSRF---resource

- Naming
  - Every entity has a unique name,
- Lifecycle (basis for fault resilient state management)
  - Entities are dynamically created
  - Entities are destroyed explicitly or via soft state
- Information model (basis for introspection, monitoring, discovery)
  - Attributes associated with entities
  - Operations for querying and setting the attributes
  - Asynchronous notification of changes to attribute set
- Service Groups (basis for registries & collective svcs)
  - Group membership rules & membership management

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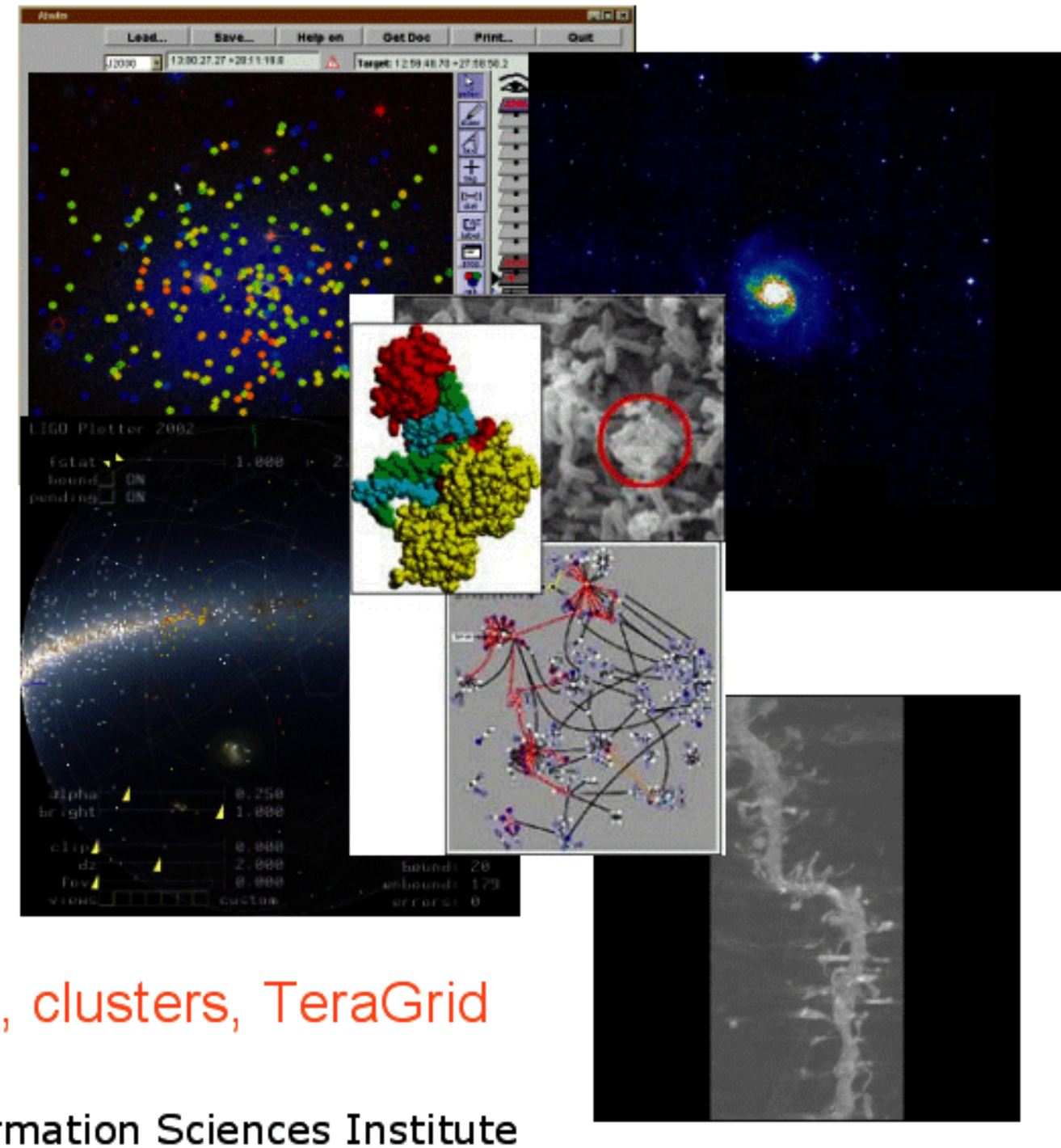
Grid Futures

- Build on standard infrastructure (WSRF)
- Resource management (Service level agreements)
- Large-scale VO management, policy management
- Tele-instrumentation
- Workflow composition, management and planning
  - Pegasus
- High-level data services: metadata, ontologies
  - MCS

Pegasus: scientific workflow management

(work with Y. Gil and dozens of scientists)

- Pulsar search for gravitational-wave physics (NSF-funded GriPhyN)
- Galaxy morphology (NSF-funded NVO) and Montage (NASA)
- Tomography for neural structure reconstruction (NIH)
- High-energy physics – Compact Muon Solenoid (GriPhyN)
- Gene sequencing (PACI Data Quest)



Execution environment: condor pools, clusters, TeraGrid

Pegasus

- Input: a logical workflow that does not indicate locations of the data or the resources used in the computation
- Pegasus
  - Locates the data and executables (possibly replicated)
  - Locates appropriate resources
  - Reduces the workflow where possible (if intermediate data products already exists)
  - Schedules the workflow and hands it off for execution
- Futures: Better performance and reliability

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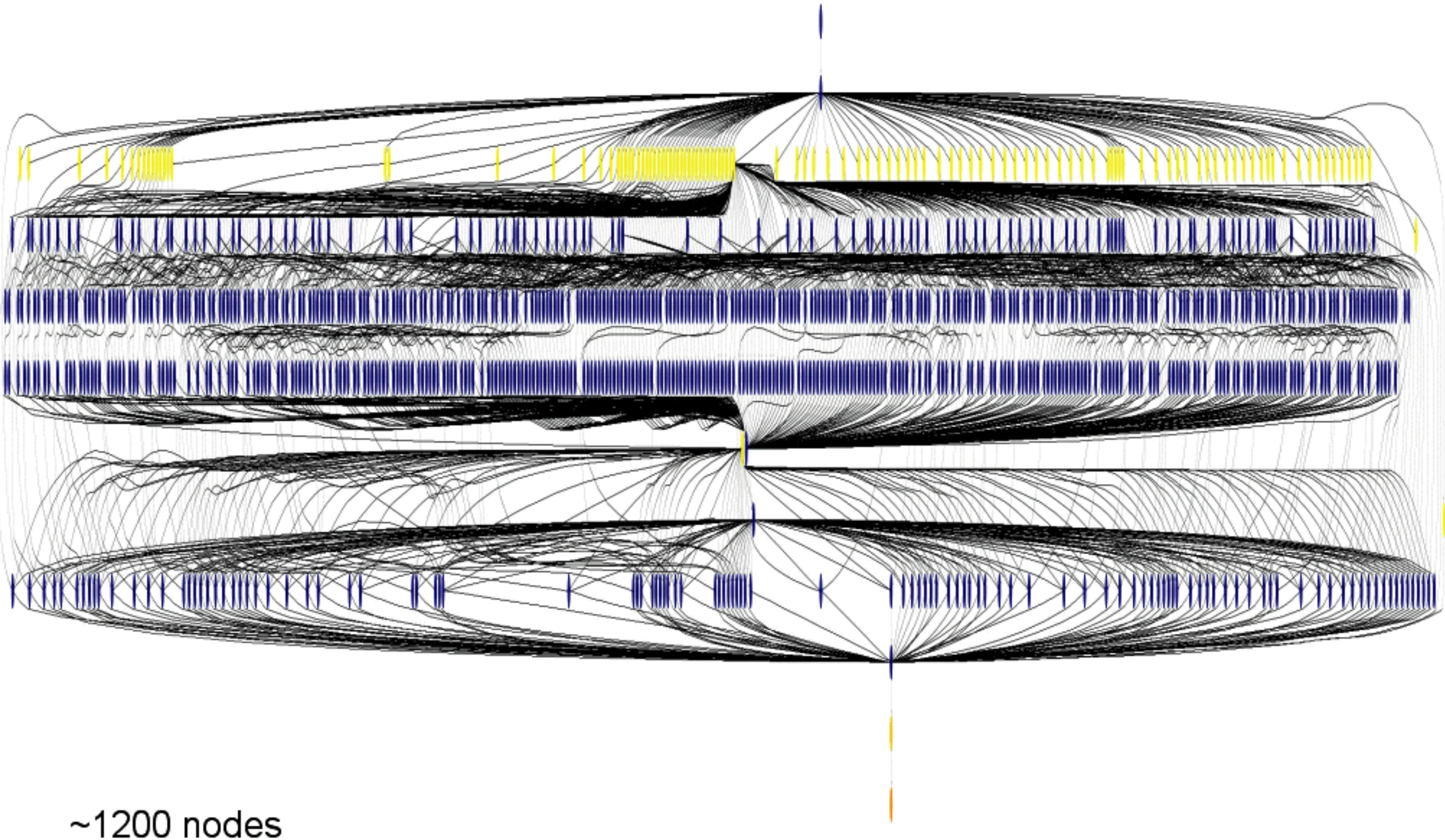
Small Montage Workflow



~1200 nodes

Ewa Deelman, USC Information Sciences Institute

Metadata Catalog Service (MCS)

- Separation between management of metadata and data
- Metadata can be organized and published by a collaboration
- Metadata can be organized and personalized by members of a community
- Metadata and data can be easily discovered through attribute-based queries
- Futures: Exploring issues of metadata federation, use of ontologies, query mediators, query planners

Summary

- Grid: resource sharing, integration, virtualization in network systems
- Grid technologies are used in academia and industry
- Grid and Web standards are merging
- The Globus Toolkit provides the basic grid infrastructure
- Ongoing research in many areas

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For More Information

- Papers and software
  - www.globus.org
  - www.isi.edu/~deelman
  - pegasus.isi.edu
- www.globalgridforum.org