

# 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

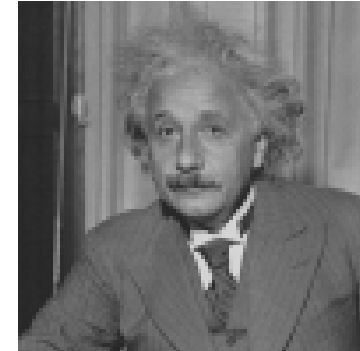
# Outline

- 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

# Revolution in Science

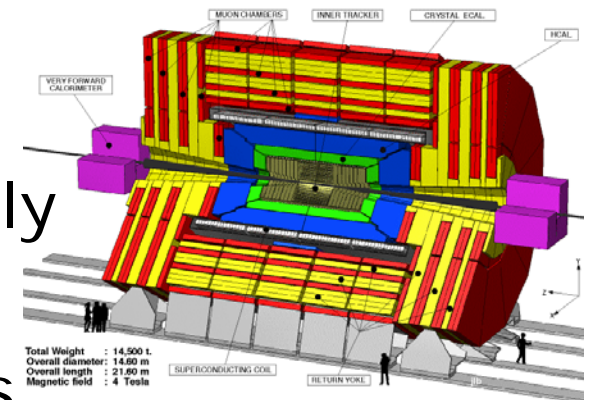
- Pre-Internet

- ◆ 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



# Problem Solving in the 21<sup>st</sup> 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:



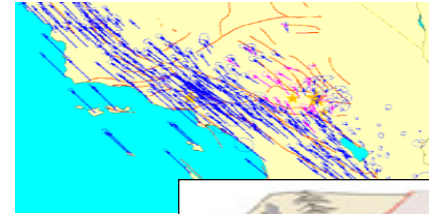
Multiple Shake Table Research Facility  
University of Nevada, Reno  
Large-Scale Structures Laboratory

NEES

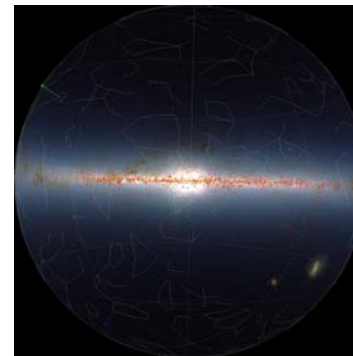
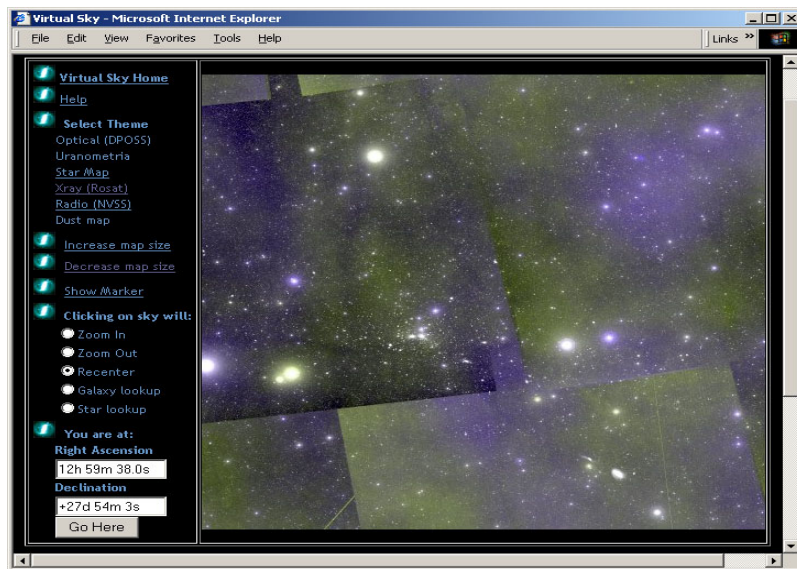
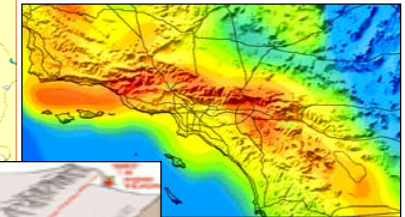


Multi-Axial Subassemblage  
Testing (MAST)  
MAST Laboratory

MTS Systems Corporation

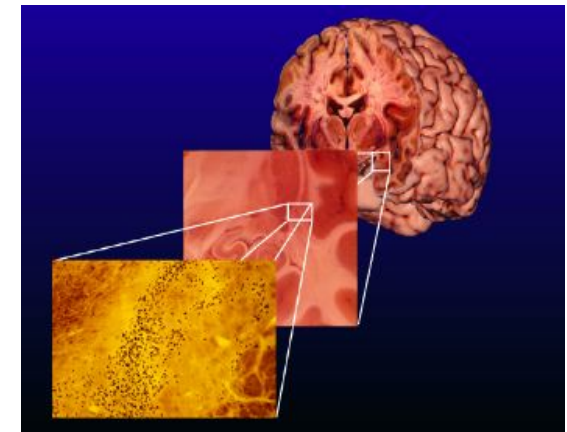


SCEC



GriPhyN

NVO



BIRN



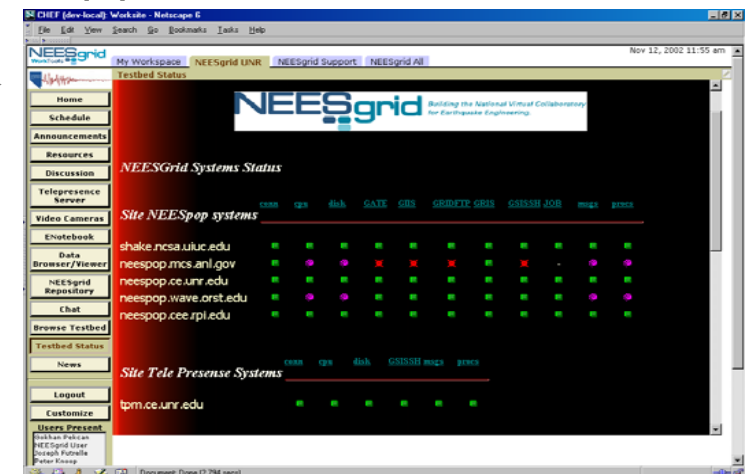
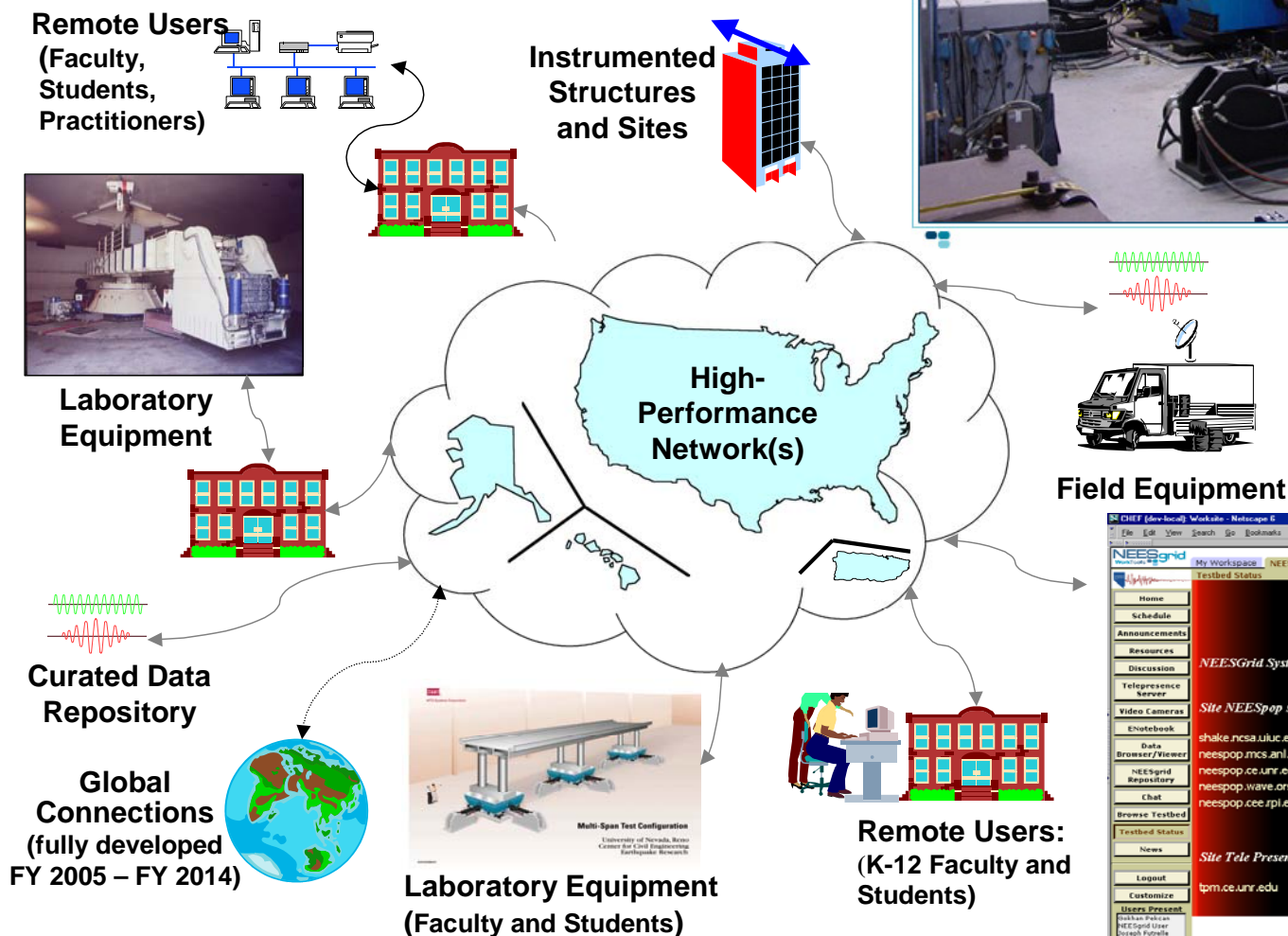
# NEESgrid Earthquake Engineering Collaboratory

Focus on remote experimentation



U.Nevada Reno

[www.neesgrid.org](http://www.neesgrid.org)





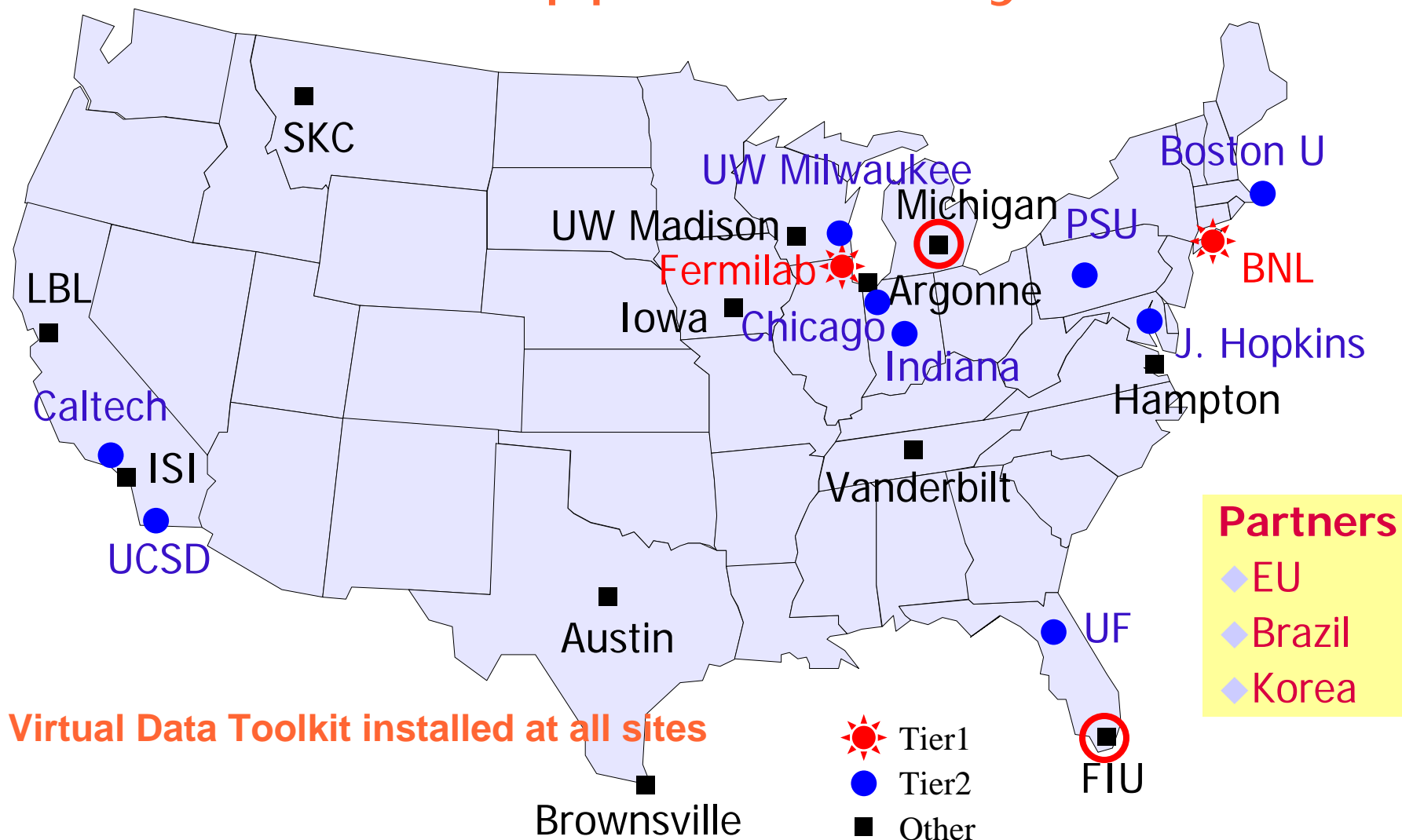


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# iVDGL Sites (February 2004)

## iVDGL supports GriPhyN and PPDG

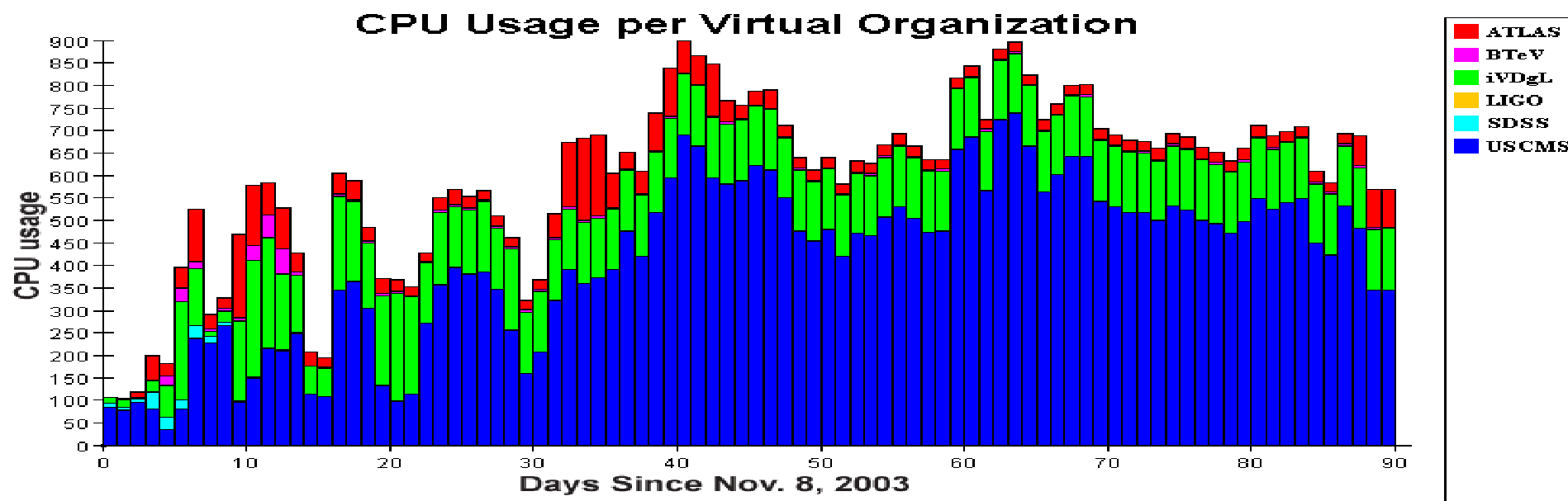


Slide by Paul Avery, iVDGL NSF review 2004

Ewa Deelman, USC Information Sciences Institute

# 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

Ewa Deelman, USC Information Sciences Institute

## 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*

Grid Computing

Charles Schwab

Business Analytics

### Challenge

- Reduce the processing time on an existing wealth management application.

### Solution

- IBM @server
- Linux
- Globus Toolkit
- IBM Research

#### Technology Benefits:

- Reduced processing time from more than four minutes to fifteen seconds
- Planning to explore leveraging Grid computing into other areas

#### Business Benefits:

- Potential to increase customer satisfaction by responding to inquiries at a faster pace
- Potential to enable Schwab to provide more robust wealth management applications

*"We believe that Grid computing ... has the potential to greatly improve our quality of service and be a truly disruptive technology."*

Oren Leiman, Managing Director, Charles Schwab

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# Industry Adopts Grid Technology

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

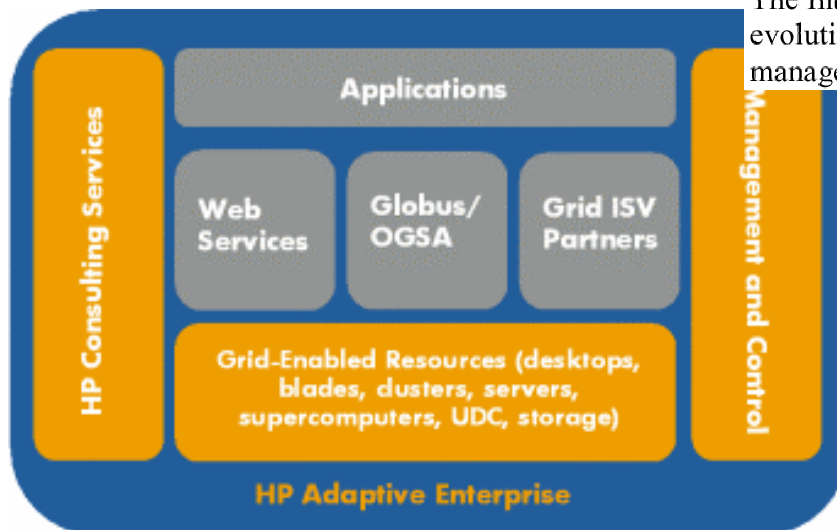
By STEVE LOHR

## 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



## DataSynapse



Ewa Deelman, USC Information Science

## 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 DATABASE10<sup>g</sup>

## 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.

There are trends. And there are trendsetters. In the early to mid-1990s, Oracle forecast the Internet computing paradigm that organizations of every stripe have now woven into the fabric of their businesses. In the process, IT infrastructure has become extremely critical to the enterprise. "Businesses have become more dependent than ever on their IT systems for everything from day-to-day operations to providing service to their customers and clients," says Satish Kumar, director of product management for Database Management at Oracle. "And many new-generation businesses, such as eBay and Amazon, rely completely on their IT infrastructure's being available—if the system goes away, their entire business is in jeopardy."

In short, says Kumar, IT systems have truly become strategic to the enterprise. And that has had a profound impact on the need for availability, scalability, and high performance of IT systems for organizations of all kinds. Downtime, even for much-needed maintenance, is not an option when a global business must run 24/7.

At the same time, says Kumar, there's growing pressure to maintain profitability amid ever-growing competition in a global economy that continues to tighten its belt. The result, he says, is that "organizations must minimize operating expenses across the board—and IT is no exception," says Kumar.

But as IT systems have become more strategic and integral to the core business, they have also become more complex, more difficult to manage, and more costly. Completely able to scale across the board, in terms of time, labor, potential volume, and ability to recover from failure effectively. According to Kumar, these are all reasons why "one of the biggest challenges facing most organizations today is managing a strategic part of the business, so IT systems, more effectively than ever—ensuring the highest performance, scalability, and availability—but at a significantly lower cost than before." These are also some of the reasons that commercial grid computing, enabled in part by cost-effective blade servers, is getting so much attention today. For small incremental costs, organizations can gain more processing power to be used by all data center resources, delivering faster performance and high availability and scaling as needed—but only if the software can effectively take advantage of that architecture.

Clearly, the time is right for software that monitors and manages itself: software that eases management complexity in a cost-effective manner.

BY KELLI WISETH

# 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

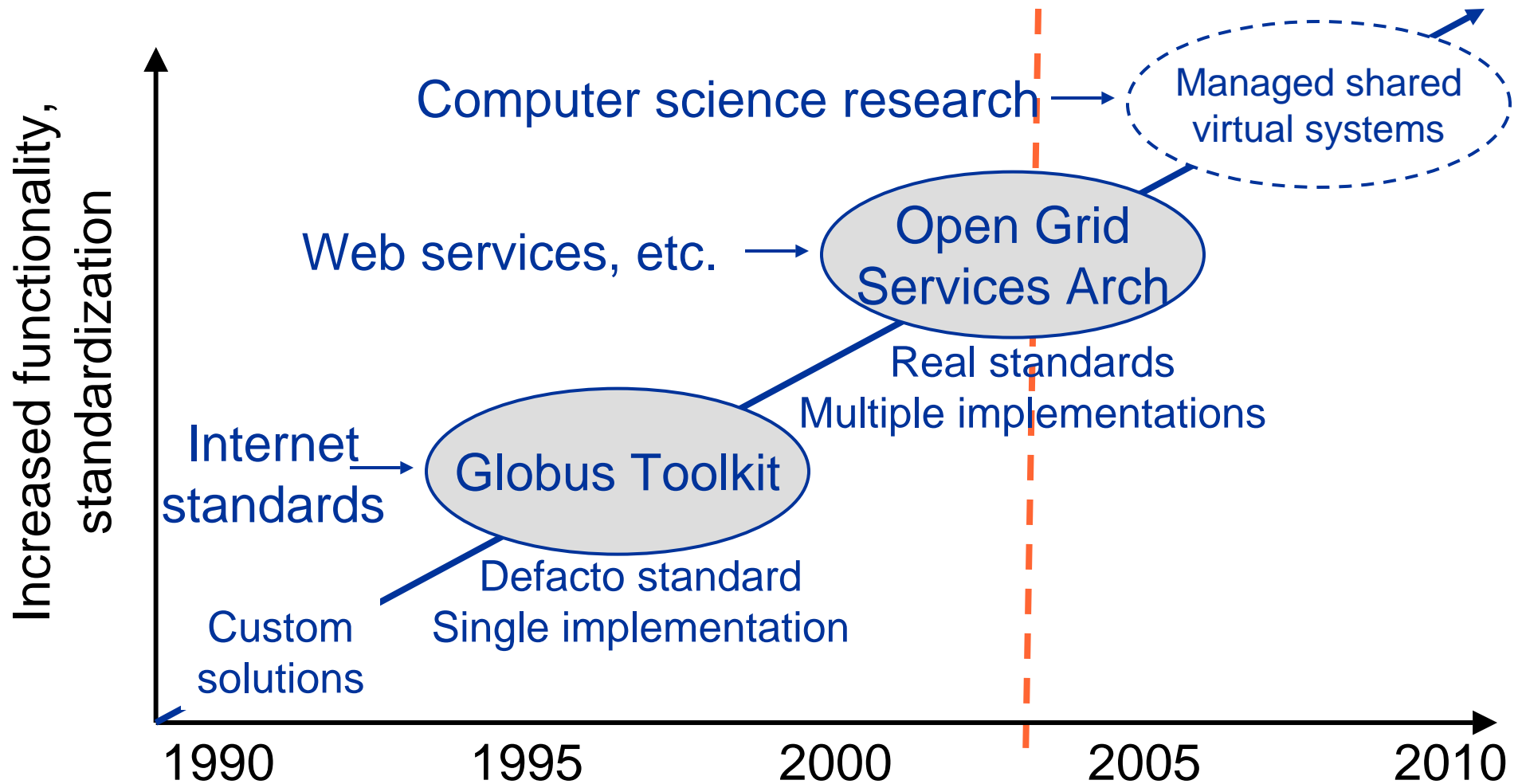




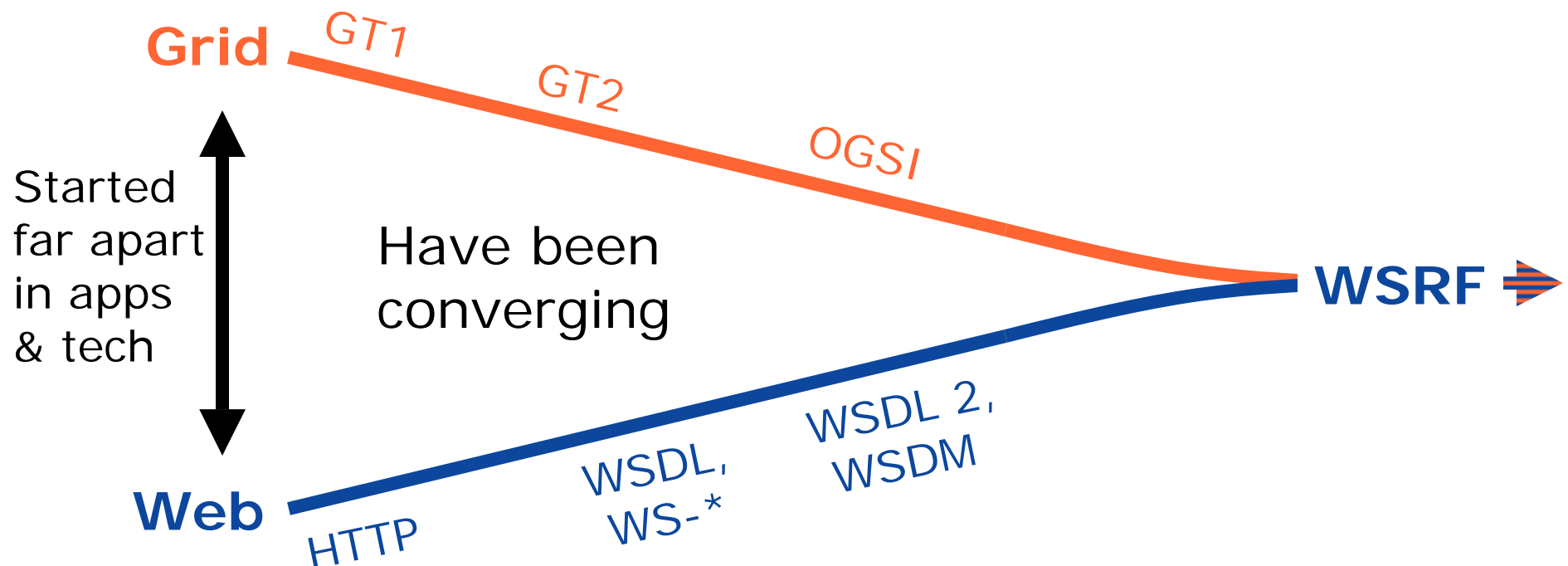
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# Progress through the Emergence of Open Grid Standards



# Convergence of Grid and Web Services



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

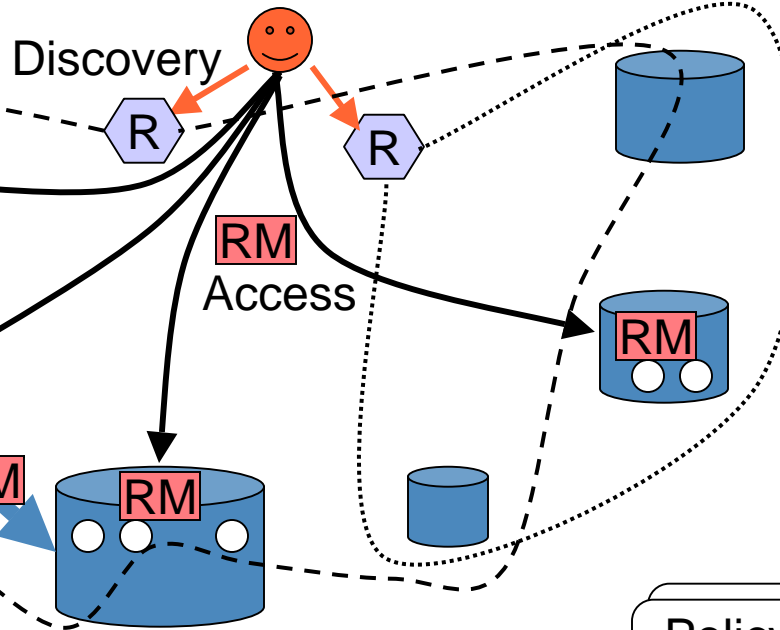
# The Grid is about Resource Integration

Many sources  
of data, services,  
computation

Registries organize  
services of interest  
to a community

Security  
service

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



Security & policy  
must underlie access  
& management  
decisions

Resource management  
is needed to ensure  
progress & arbitrate  
competing demands

Policy  
service

Exploration & analysis  
may involve complex,  
multi-step workflows

## 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



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# 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



# Grid Futures

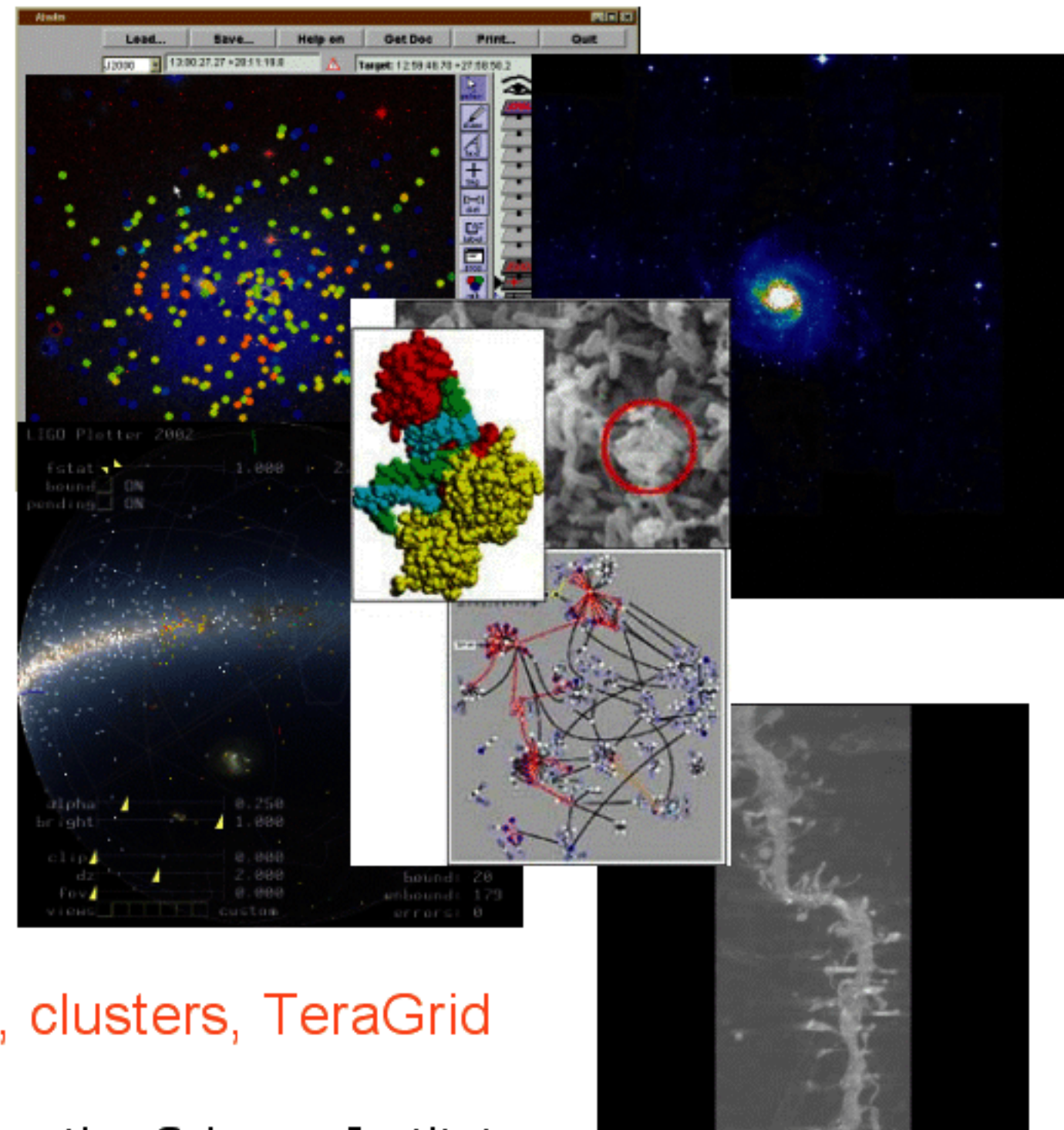
- Build on standard infrastructure (WSRF)
- Resource management (Service level agreements)
- Large-scale VO management, policy management
- Tele-instrumentation
- Workflow composition, management and planning
  - ◆ Pegasus
- High-level data services: metadata, ontologies
  - ◆ MCS



# 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

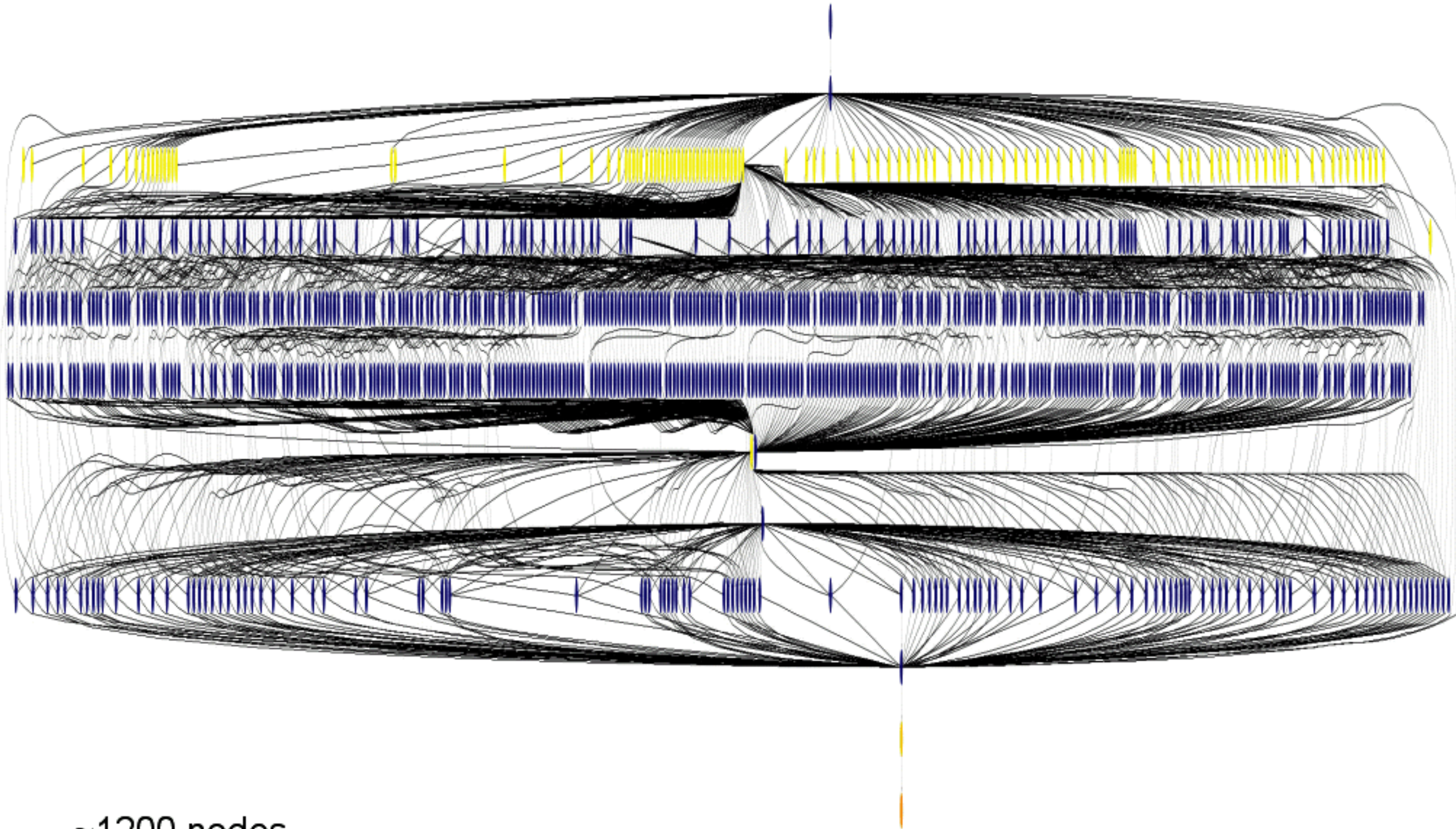
- Input: a logical workflow that does not indicate locations of the data or the resources used in the computation
- Pegasus
  - ◆ Locates the data and executables (possibly replicated)
  - ◆ Locates appropriate resources
  - ◆ Reduces the workflow where possible (if intermediate data products already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





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# Small Montage Workflow



~1200 nodes

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# 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



## For More Information

- Papers and software
  - ◆ [www.globus.org](http://www.globus.org)
  - ◆ [www.isi.edu/~deelman](http://www.isi.edu/~deelman)
  - ◆ [pegasus.isi.edu](http://pegasus.isi.edu)
- [www.globalgridforum.org](http://www.globalgridforum.org)

