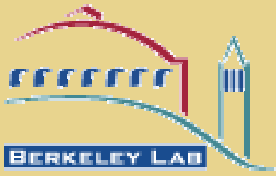


# Particle Physics Data Grid:

How GRID Computing Enhances Remote Collaboration

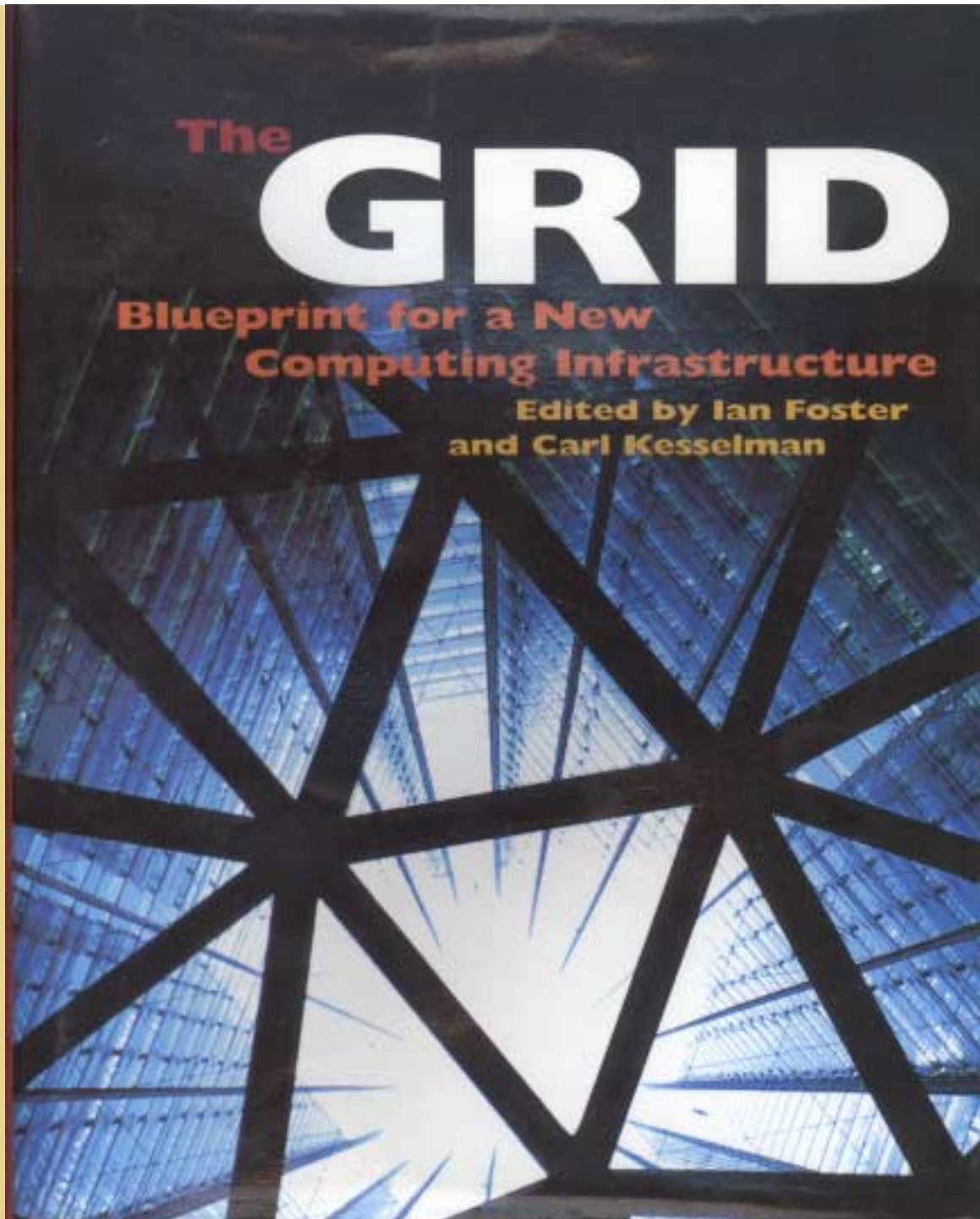
Doug Olson  
Lawrence Berkeley National Laboratory  
November, 2000

[www.ppdg.net](http://www.ppdg.net)



# Outline

- Overview of GRID
- Motivation for Data Grid
- Grid projects for experimental high-energy & nuclear physics
  - PPDG: Particle Physics Data Grid
  - GriPhyN: Grid Physics Network
  - EU DataGrid
- Schedule
- Implementation for STAR
- Resources & Acknowledgements

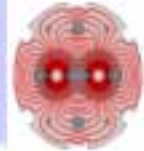


November 1998  
Morgan Kaufmann Publishers;  
ISBN: 1558604758

14-Nov-00



## Grid Services Architecture [\*]



AppIns

A Rich Set of HEP Data-Analysis  
Related Applications

Appln  
Toolkits

Remote  
data  
toolkit

Remote  
comp.  
toolkit

Remote  
viz  
toolkit

Remote  
collab.  
toolkit

Remote  
sensors  
toolkit

*Grid  
Services*

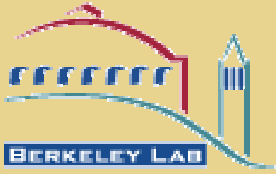
Protocols, authentication, policy, resource  
management, instrumentation, discovery, etc.

Grid  
Fabric

Data stores, networks, computers, display  
devices, ... ; associated local services

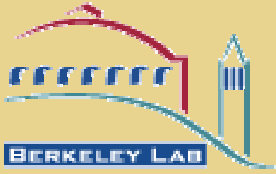
[\*] Adapted from Ian Foster: there are computing grids,  
access (collaborative) grids, data grids, ...





# Definition of GRID

- Ubiquitous and robust high-performance computational resources and intelligent massive storage systems.
- Scientists will have a consistent interface to carrying out calculations, visualization, and data analysis.
- Intelligent middleware will carry the computation to the data or the data to the computation depending upon dynamic load balancing.
- Scientists should be able to spend their time contemplating the content of the data rather than struggling with mechanisms to access it and process it.



# Some Examples of Grids

- NASA Information Power Grid
  - High performance computing for aerospace design and simulation
- NCSA Alliance Access Grid
  - Access to supercomputer resources
- Earth Systems Grid
  - Simulations for climate prediction
- NEESgrid
  - earthquake engineering virtual collaboratory

IPG Engineering and Research - Microsoft Internet Explorer

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Address <http://www.ipg.nasa.gov/> Go Links

## NASA Information Power Grid Engineering and Research Home Page

NASA's Information Power Grid (IPG) is a testbed that provides access to a grid--a widely distributed network of high performance computers, stored data, instruments, and collaboration environments. The IPG is a collaborative effort between NASA Ames, NASA Glenn, and NASA Langley Research Centers, and the NSF PACI programs at SDSC and NCSA, and is funded by the IT/ACNS program at NASA Ames Research Center.

**An IPG Workshop was held September 19th and 20th, 2000.**  
Many of the presentation can be found in PDF and PPT format on the [IPG Workshop Program](#) page.




[High Level Overview of IPG](#) provides an overview of the goals of the IPG and the vision of what is will become.


[Engineering and Research Pages](#) contain information about the work being done to accomplish the goals and milestones of the IPG. [Presentations and Papers](#) on the IPG are also archived at this location. *Some of these pages are restricted to staff working on the project.*

[IPG User Support Pages \(HotPage\)](#) include information necessary to utilize the IPG testbeds. *Some of the information provide in these pages is restricted to those utilizing the resources.*

---



Updated: October 13, 2000  
WebWork: [George Myers](#)  
NASA Responsible Official:  
[William Thigpen](#)



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- Technology
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- NCSA Employment Opportunities
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- Alliance Training Schedule
- Live Web Cam of ACB Expansion

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**NCSA/UIUC  
Faculty Fellows**

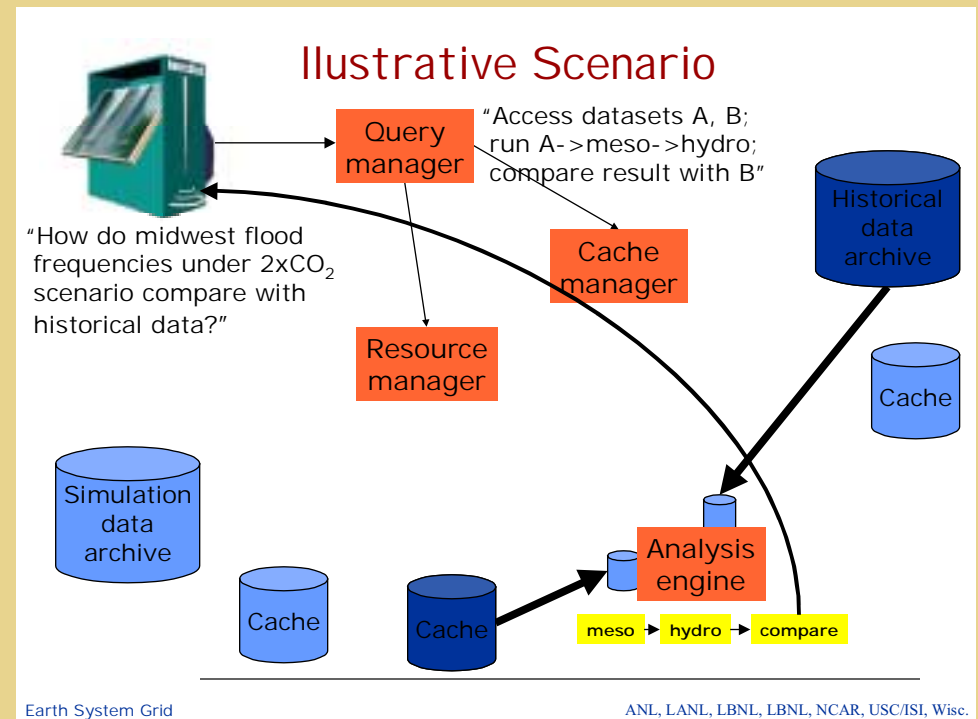
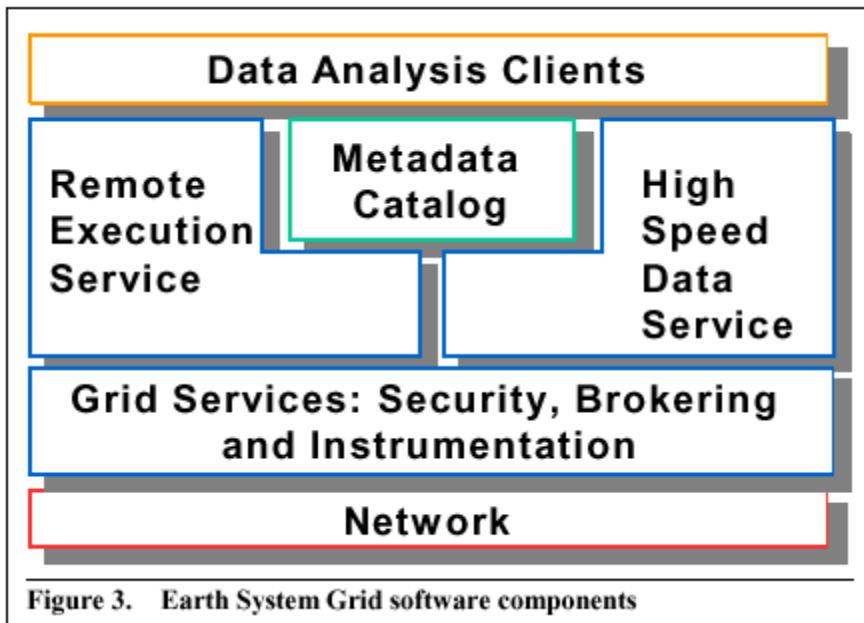
NEWS HEADLINES	EVENTS	FUNDING	BRIEFS
<p><a href="#">NCSA Researchers Report Early Intel Itanium Processor Performance Levels</a> Released 11.08.00</p> <p><a href="#">Entropia Creates Largest Computing Resource Ever Available to Academic Scientists</a></p>	<p><a href="#">Macromedia Dreamweaver Conference 2000</a> November 13-14</p> <p><a href="#">Defense Manufacturing Conference 2000</a> November 27-30</p> <p><a href="#">NCSA/UIUC FY2001 Faculty Fellows Program</a> November 28</p>	<p><a href="#">DARPA Defense Sciences Office</a> Due November 9</p> <p><a href="#">University/Industry Grants From NSF</a> Due November 13</p> <p><a href="#">Astronomy, Astrophysics Fellowships</a> Due November 13</p> <p><a href="#">NSF Postdoctoral Fellowships</a></p>	<p><a href="#">NCSA Mosaic Named Top Product By Network Computing Magazine</a></p> <p><a href="#">Alliance Offers Virtual Tour of the Universe in SC2000 Booth</a></p> <p><a href="#">Former NCSA Faculty Fellows Win Presidential</a></p>

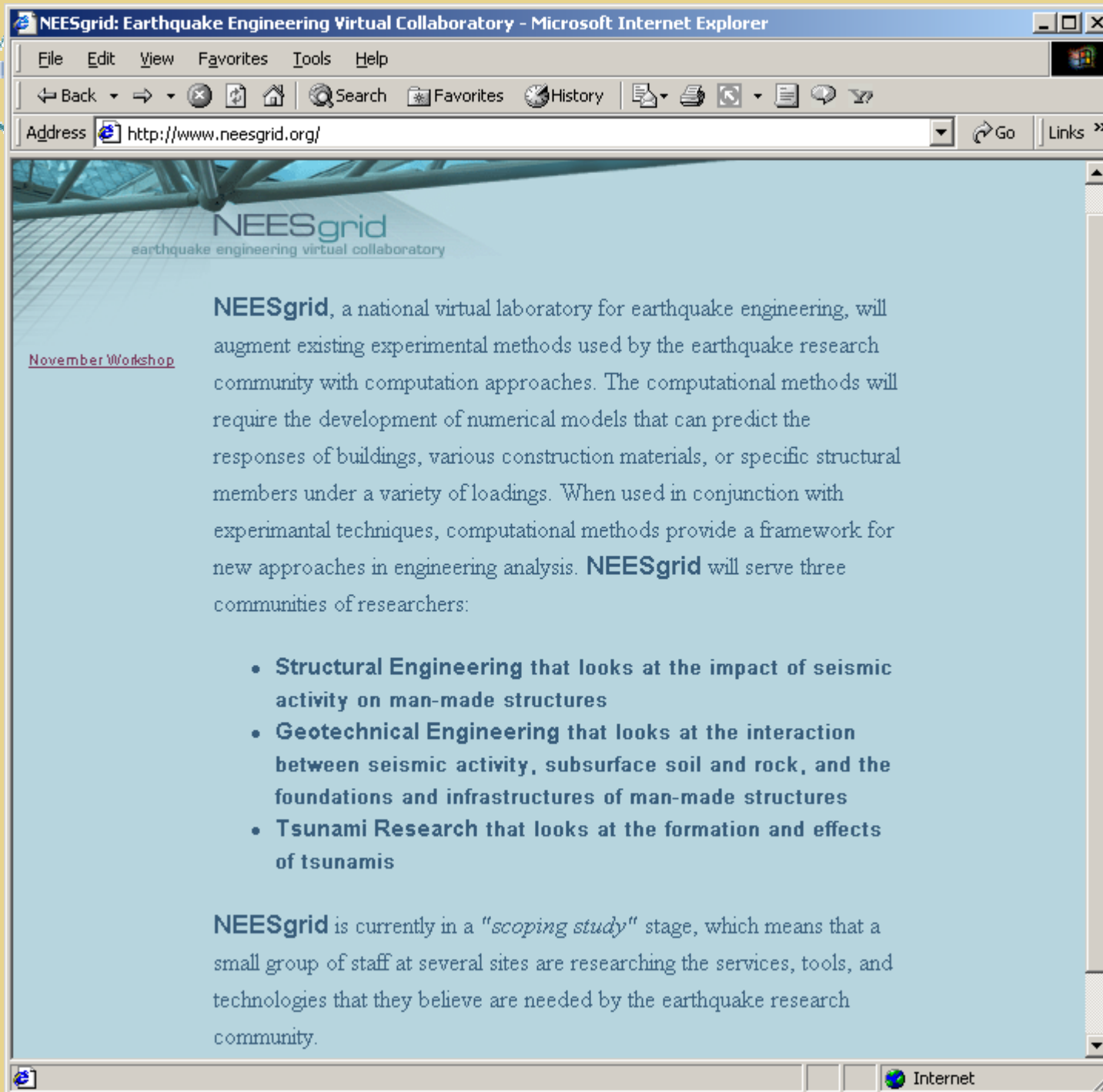
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# Earth Systems Grid





NEESgrid: Earthquake Engineering Virtual Collaboratory - Microsoft Internet Explorer

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**NEESgrid**  
earthquake engineering virtual collaboratory

[November Workshop](#)

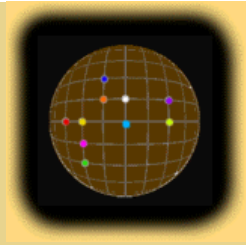
NEESgrid, a national virtual laboratory for earthquake engineering, will augment existing experimental methods used by the earthquake research community with computation approaches. The computational methods will require the development of numerical models that can predict the responses of buildings, various construction materials, or specific structural members under a variety of loadings. When used in conjunction with experimental techniques, computational methods provide a framework for new approaches in engineering analysis. NEESgrid will serve three communities of researchers:

- **Structural Engineering** that looks at the impact of seismic activity on man-made structures
- **Geotechnical Engineering** that looks at the interaction between seismic activity, subsurface soil and rock, and the foundations and infrastructures of man-made structures
- **Tsunami Research** that looks at the formation and effects of tsunamis

NEESgrid is currently in a "scoping study" stage, which means that a small group of staff at several sites are researching the services, tools, and technologies that they believe are needed by the earthquake research community.

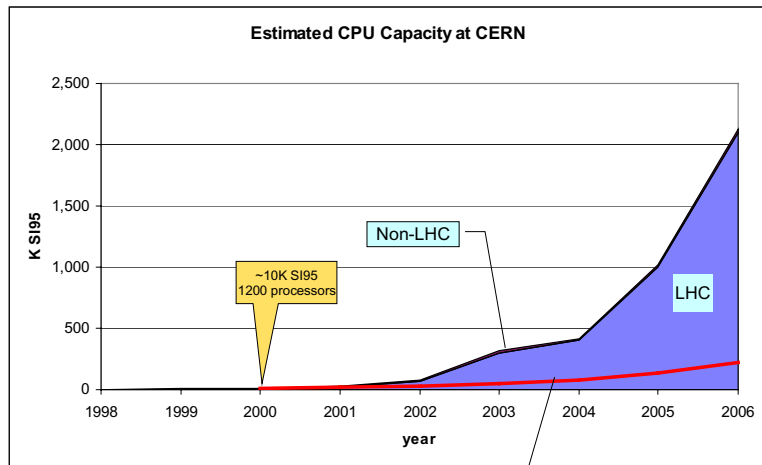
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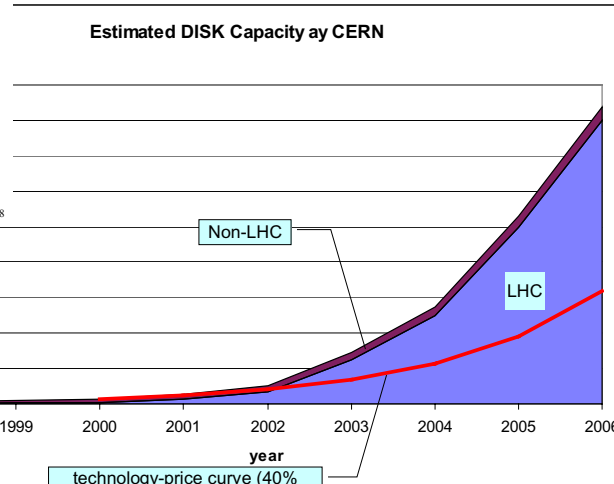
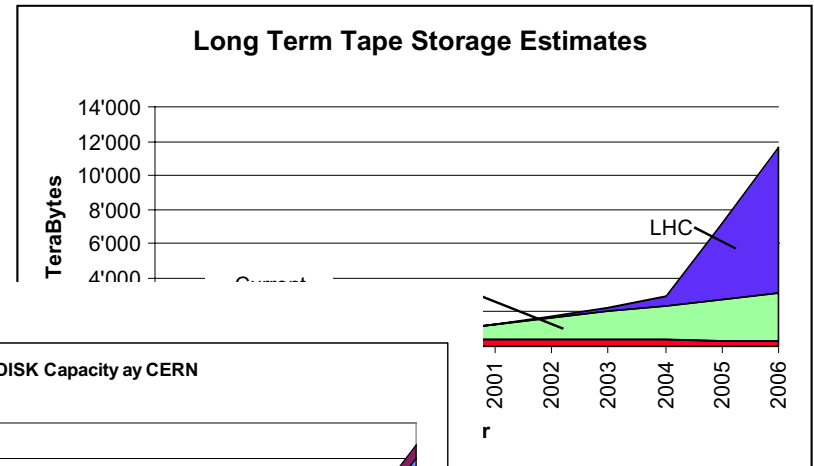
# Motivation for Data Grid I

- HENP experiments are data intensive science



technology-price curve (40% annual price improvement)  
Capacity that can be purchased for the value of the equipment present in 2000

ECFA June 2000



technology-price curve (40% annual price improvement)

ECFA June 2000

F. Gagliardi - CERN/IT 9

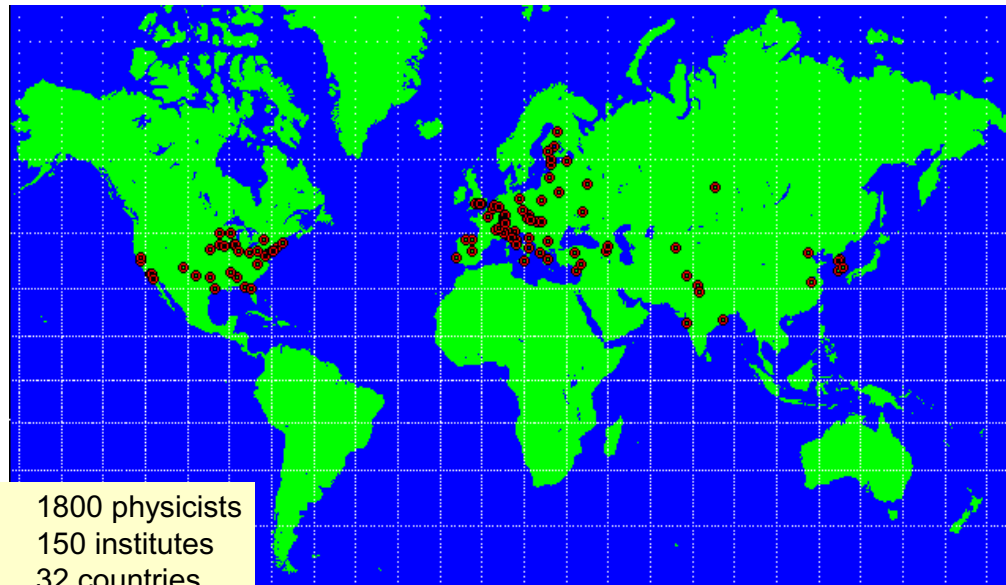
F. Gagliardi - CERN/IT 10



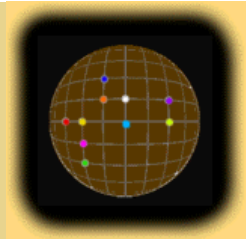
# Motivation for Data Grid II

- Collaborations are distributed worldwide

*World Wide Collaboration*  
⇒ *distributed computing & storage capacity*

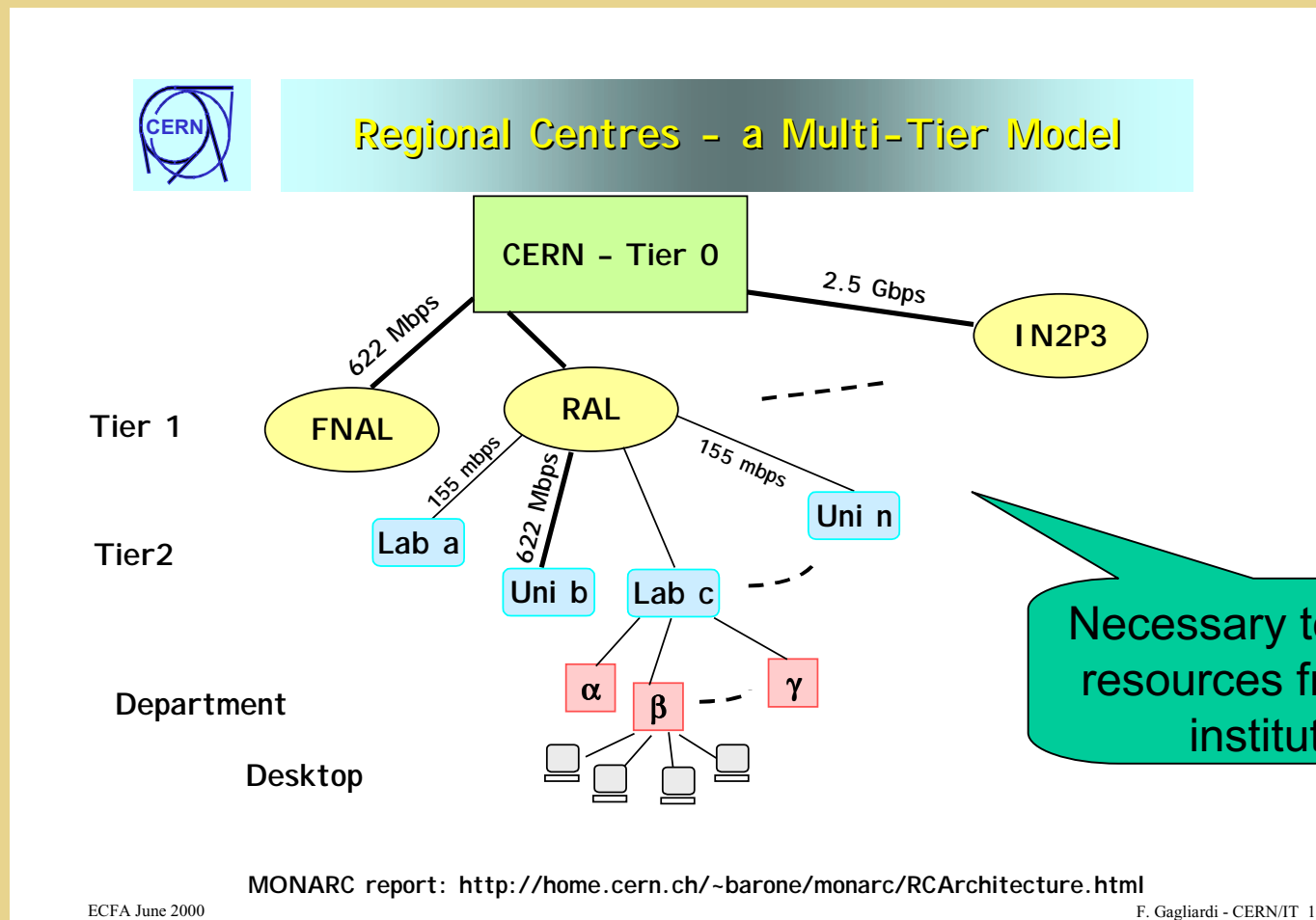


CMS: 1800 physicists  
150 institutes  
32 countries



# Motivation for Data Grid III

- Multi-tier, hierarchical distribution of resources







# Datagrid Projects


- Particle Physics Data Grid
  - <http://www.ppdg.net>
  - U.S. DOE funded datagrid development for particle and nuclear physics
  - ATLAS, BaBar, CMS, D0, STAR, ...
- Grid Physics Network
  - <http://www.griphyn.org>
  - U.S. NSF funded IT research project
  - ATLAS, CMS, LIGO, SDSS
- EU DataGrid
  - <http://grid.web.cern.ch/grid>
  - European Union funding
  - High-energy physics, earth observation, biology

Particle Physics Data Grid - Microsoft Internet Explorer

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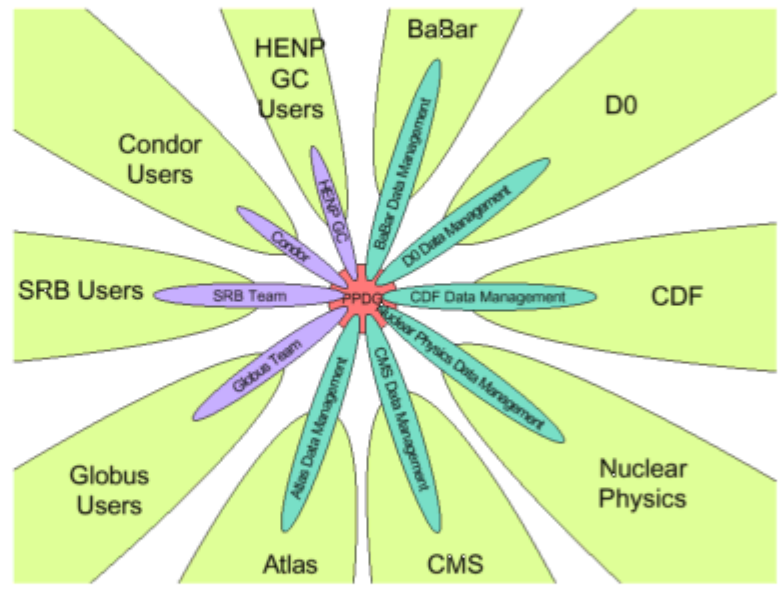
**Related grid activities**

**Acknowledgements**

Notice to Users

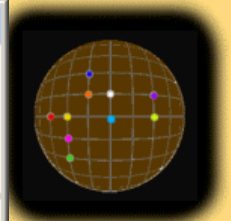
## Particle Physics Data Grid

A collaboration of:  
[ANL](#), [BNL](#), [Caltech](#), [FNAL](#), [JLAB](#), [LBNL](#), [SDSC](#), [SLAC](#), [Wisconsin](#)



The mission of the Particle Physics Data Grid (PPDG) project is to provide a distributed (grid-enabled) data access and management service for the large collaborations of current and future particle and nuclear physics experiments. It is a collaborative effort between physicists and computer scientists at several DOE laboratories and universities. This is accomplished by applying existing grid middleware to current problems and providing feedback to middleware developers on additional features required or shortcomings in the current implementations.

Done Internet





# PPDG Collaborators

*California Institute of Technology* **Harvey B. Newman**, Julian J. Bunn, Koen Holtman, Asad Samar, Takako Hickey, Iosif Legrand, Vladimir Litvin, Philippe Galvez, James C.T. Pool, Roy Williams

*Argonne National Laboratory* **Ian Foster**, Steven Tuecke, **Lawrence Price**, David Malon, Ed May

*Lawrence Berkeley National Laboratory* **Stewart C. Loken**, Ian Hinchcliffe, Doug Olson, Alexandre Vaniachin, **Arie Shoshani**, Andreas Mueller, Alex Sim, John Wu

*Brookhaven National Laboratory* **Bruce Gibbard**, Richard Baker, Torre Wenaus

*Fermi National Laboratory* **Victoria White**, Philip Demar, Donald Petravick  
**Matthias Kasemann**, Ruth Pordes, James Amundson, Rich Wellner, Igor Terekhov, Shahzad Muzaffar

*University of Florida* **Paul Avery**

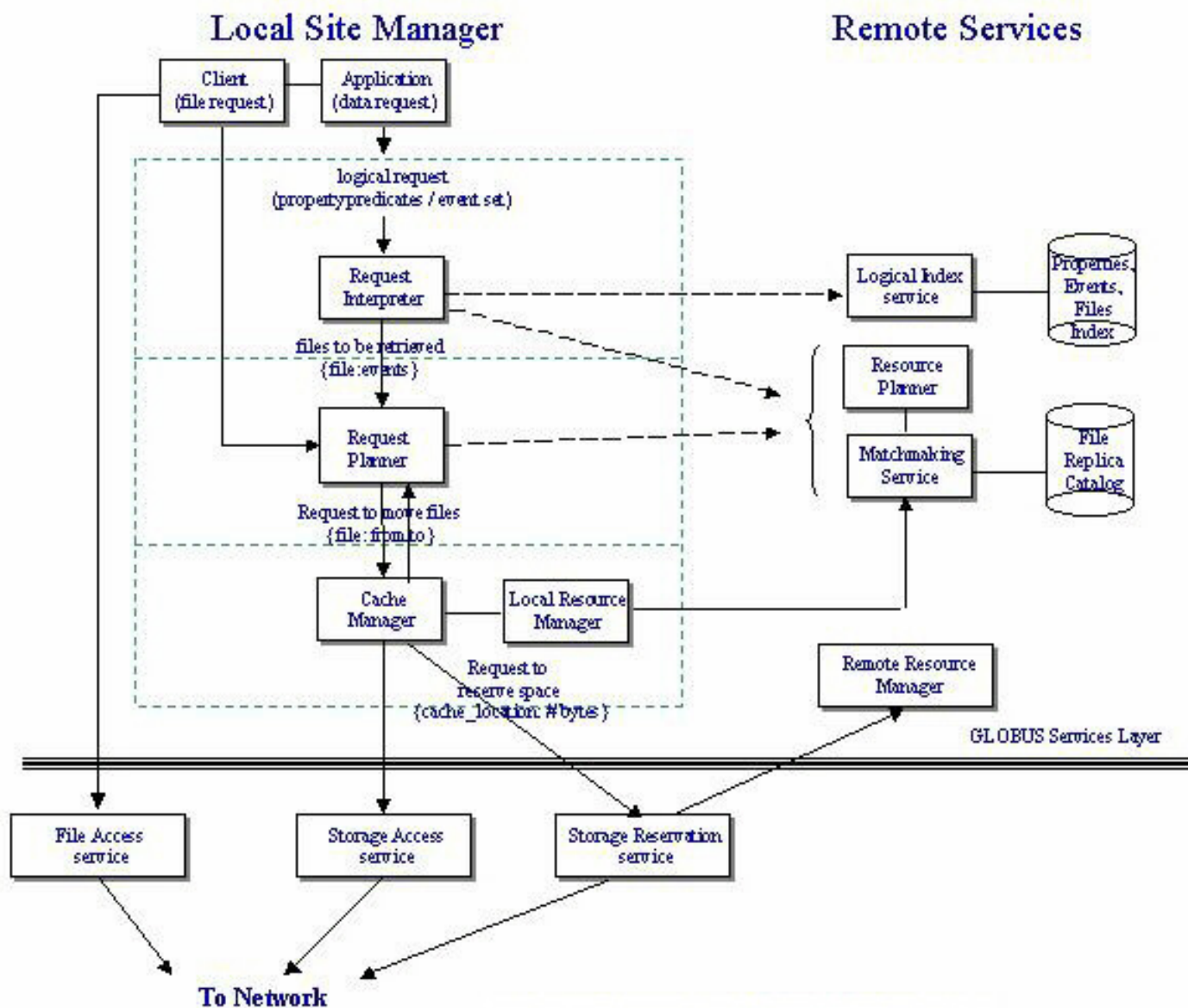
*San Diego Supercomputer Center* **Margaret Simmons**, Reagan Moore

*Stanford Linear Accelerator Center* **Richard P. Mount**, Les Cottrell, Andrew Hanushevsky, David, Millsom, Davide Salomoni

*Thomas Jefferson National Accelerator Facility*

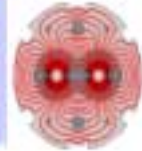
**Chip Watson**, Ian Bird, Jie Chen

*University of Wisconsin* **Miron Livny**





# The Particle Physics Data Grid (PPDG)



**ANL, BNL, Caltech, FNAL, JLAB, LBNL,  
SDSC, SLAC, U.Wisc/CS**



- ◆ **First Round Goal:** Optimized cached read access to 10-100 Gbytes drawn from a total data set of 0.1 to ~1 Petabyte
- ◆ **Matchmaking, Co-Scheduling:** SRB, Condor, Globus services; HRM, NWS

## Multi-Site Cached File Access Service





The GriPhyN Project - Microsoft Internet Explorer


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**GriPhyN**



Data Intensive Science

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**NEWS: Griphyn Project to Lead Way for Ultra-powerful Computer Data Grid**

Press Announcements:

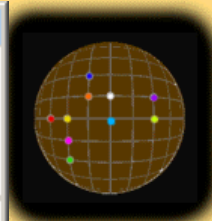
- [NSF Announces First Awards in New Information Technology Research Initiative](#)
- [Universities of Florida, Chicago to Lead Way for Ultra-powerful Computer Data Grid](#)

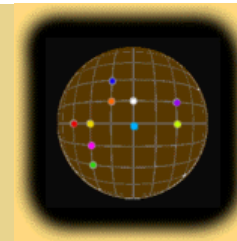
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**The Challenge: Data-Intensive Science and Virtual Data**

The GriPhyN (Grid Physics Method) collaboration is a team of experimental scientists and in formation technolo...

Done Internet





# GriPhyN Senior Personnel

**Bruce Allen, University of Wisconsin - Milwaukee**

**Andrea Arpaci-Dusseau, University of Wisconsin, Madison**

**Remzi Arpaci-Dusseau, University of Wisconsin, Madison**

**Paul Avery, University of Florida**

**Randall Bramley, Indiana University**

**Julian J. Bunn, California Institute of Technology**

**Ann Chervenak, University of Southern California**

**Thomas A. DeFanti, University of Illinois at Chicago**

**Ian T. Foster, University of Chicago**

**Michael J. Franklin, University of California, Berkeley**

**Dennis Gannon, Indiana University**

**Robert W. Gardner, Indiana University**

**Takako M. Hickey, California Institute of Technology**

**Robert Hollebeck, University of Pennsylvania**

**John E. Huth, Harvard University**

**Stephen M. Kent, Fermilab**

**Carl Kesselman, Information Sciences Institute, University of Southern California**

**Albert Lazzarini, California Institute of Technology**

**Miron Livny, University of Wisconsin - Madison**

**Keith A. Marzullo, University of California, San Diego**

**Reagan W. Moore, University of California, San Diego (San Diego Supercomputer Center)**

**Richard P. Mount, Sanford University (Stanford Linear Accelerator Center)**

**Veronika Nefedova, Argonne National Laboratory**

**Harvey B. Newman, California Institute of Technology**

**Lawrence E. Price, Argonne National Laboratory**

**Sanguthevar Rajasekaran, University of Florida**

**Joseph Romano, University of Texas at Brownville**

**Jennifer Schopf, Northwestern University**

**Arie Shoshani, Lawrence Berkeley National Laboratory**

**Alexander Sandor Szalay, Johns Hopkins University**

**Valerie Taylor, Northwestern University**

**Steven Tuecke, Argonne National Laboratory**

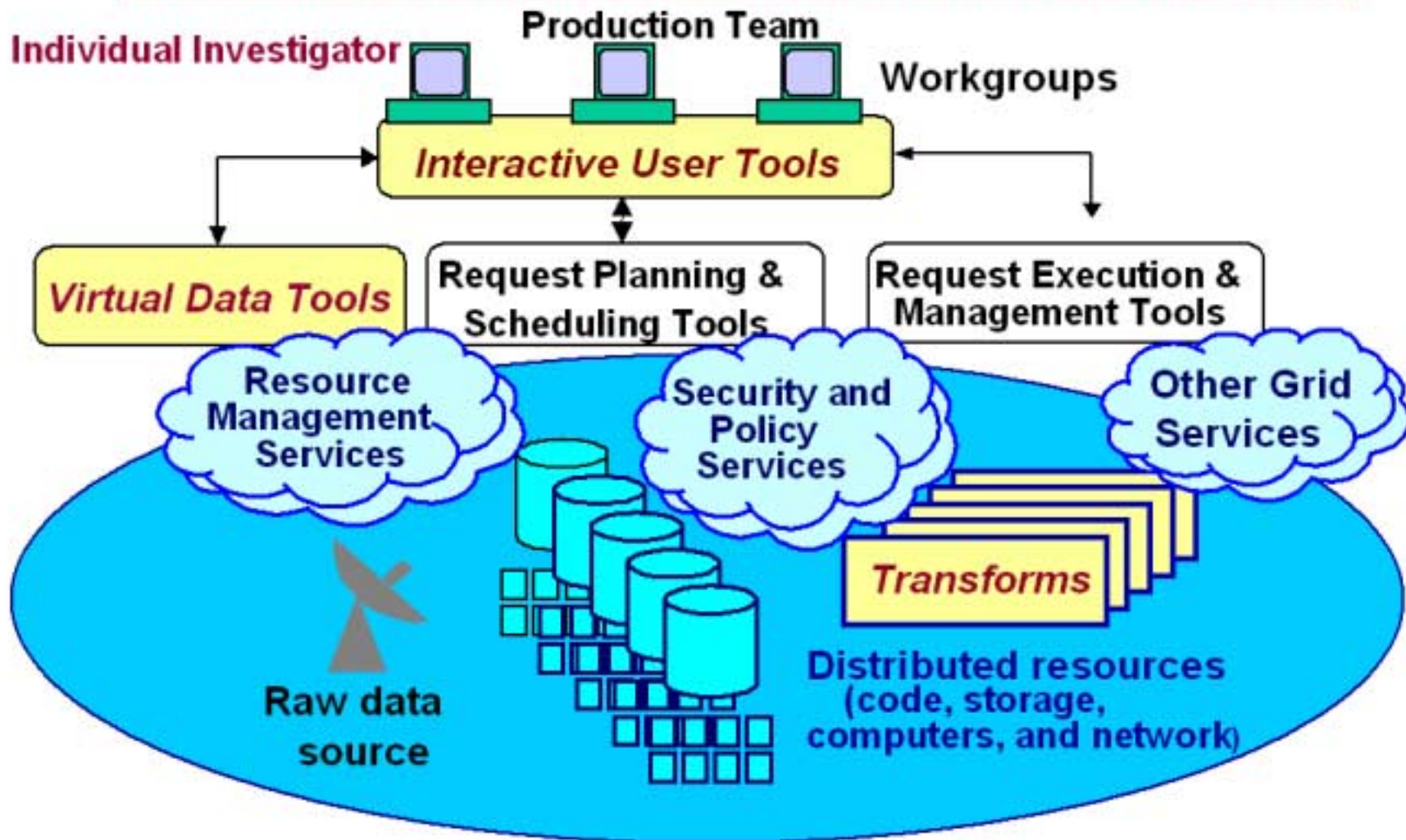
**Roy D. Williams, California Institute of Technology**



# GriPhyN: PetaScale Virtual Data Grids

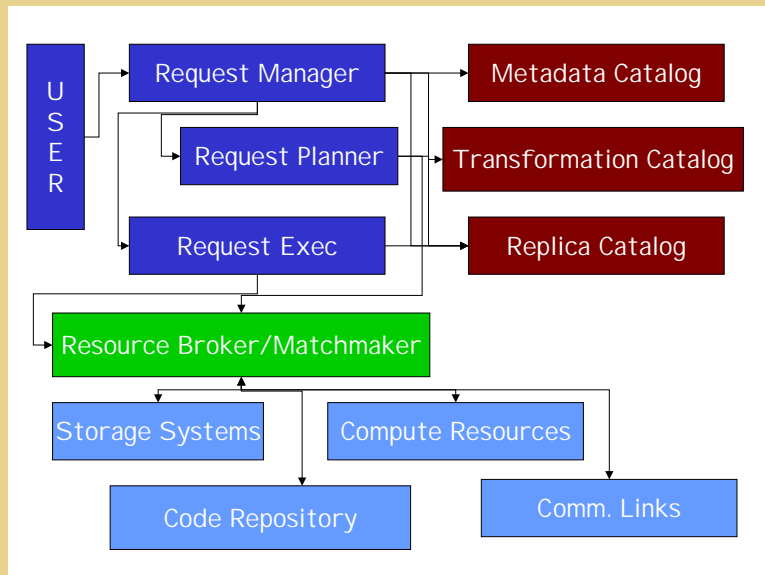


## Build the Foundation for Petascale Virtual Data Grids

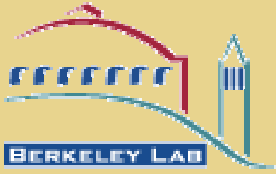




# Virtual data



- Transformation catalog contains rules for generating data that does not exist.
- When user requests data several things may happen:
  - Data is fetched from best location
  - Processing is moved to location of data
  - Procedures to generate requested data are executed



# GriPhyN long term plan

- IT research funded for 5 years (2001 - 2005), \$12M
- Propose 18 Tier 2 centers at universities around U.S. plus networking, estimate \$58M





HEPCCC Grid Initiative - Microsoft Internet Explorer

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- [CCGrid'2001](#)
- [iGrid 2000](#)
- [IEEE HPDC](#)
- [GRID'2000](#)
- 
- Other Grid & related projects

## The DataGrid Project

The DataGrid Project is a proposal made to the European Commission for shared cost research and technological development funding. The project has six main partners:

<a href="#">CERN</a> - <i>The European Organization for Nuclear Research near Geneva on the French/Swiss border</i>	<a href="#">CNRS</a> - <i>France - Le Comité National de la Recherche Scientifique</i>	<a href="#">ESRIN</a> - <i>the European Space Agency's Centre in Frascati (near Rome), Italy</i>
<a href="#">INFN</a> - <i>Italy - Istituto Nazionale di Fisica Nucleare</i>	<a href="#">NIKHEF</a> - <i>The Dutch National Institute for Nuclear Physics and High Energy Physics, in Amsterdam</i>	<a href="#">PPARC</a> - <i>United Kingdom - Particle Physics and Astronomy Research Council</i>

and fifteen associated partners:

<a href="#">CESNET</a> - <i>Czech Republic</i>	<a href="#">Commissariat à l'énergie atomique (CEA)</a> - <i>France</i>
<a href="#">Compagnie des Signaux</a> - <i>Systèmes d'information - France</i>	<a href="#">Computer and Automation Research Institute</a> , <i>Hungarian Academy of Sciences (MTA SZTAKI)</i>
<a href="#">Consiglio Nazionale delle Ricerche (CNR)</a> - <i>Italy</i>	<a href="#">DATAMAT</a> <i>Ingegneria dei Sistemi S.p.A. - Italy</i>
<a href="#">Helsinki Institute of Physics</a> - <i>Finland</i>	<a href="#">IBM</a> <i>United Kingdom Limited</i>
<a href="#">Institut de Fisica d'Altes Energies (IFAE)</a> - <i>Barcelona</i>	<a href="#">Istituto Trentino di Cultura (IRST)</a> - <i>Italy</i>

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# Work packages

<i>work package</i>	<i>coordinator</i>
<b>middleware</b>	
1	Grid Work Scheduling <a href="#">Cristina Vistoli</a>
2	<a href="#">Grid Data Management</a> Ben Segal
3	<a href="#">Grid Monitoring Services</a> Robin Middleton
4	<a href="#">Fabric Management</a> Tim Smith
5	Mass Storage Management <a href="#">John Gordon</a>
<b>infrastructure</b>	
6	Testbed and Demonstrators <a href="#">François Etienne</a>
7	Network Services <a href="#">Christian Michau</a>
<b>applications</b>	
8	<a href="#">HEP Applications</a> Hans Hoffmann
9	<a href="#">Earth Observation Applications</a> Luigi Fusco
10	Biology Applications <a href="#">Christian Michau</a>
<b>management</b>	
11	Dissemination INFN - CNR
12	Project Management <a href="#">Fabrizio Gagliardi</a>

3 years, 2001 - 2003, \$9M euros

Adopted by WP2

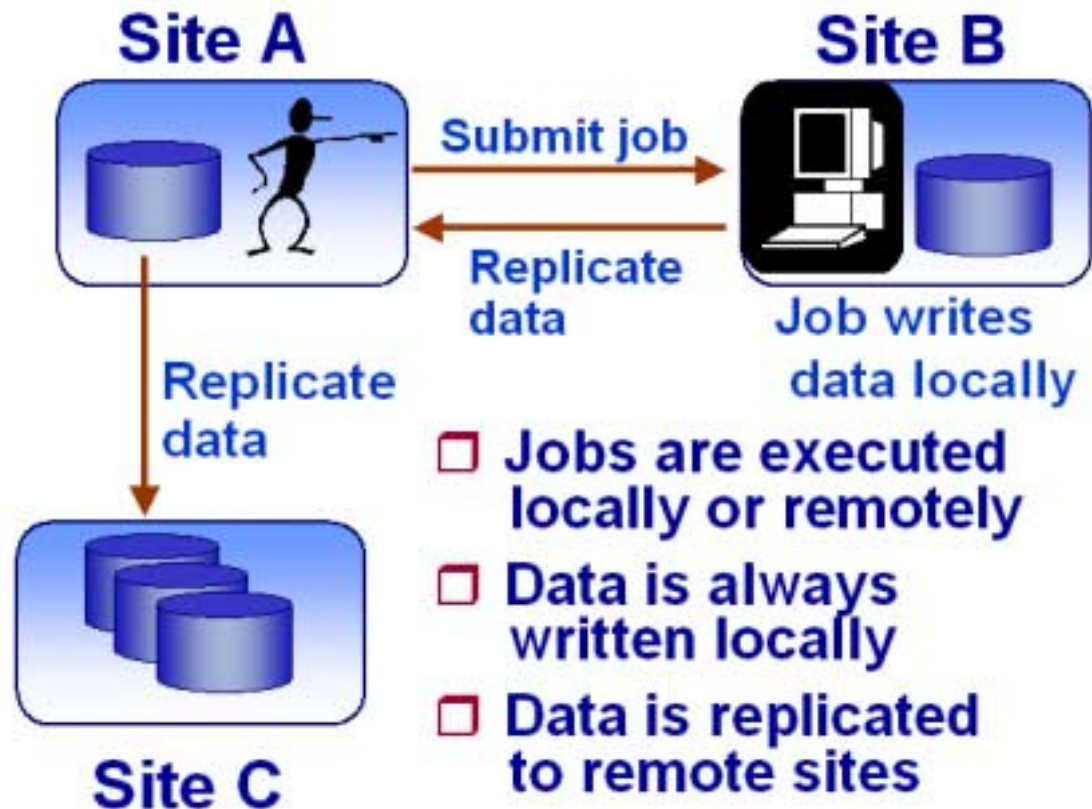


## Grid Data Management Prototype (GDMP)



### Distributed Job Execution and Data Handling: Goals

- Transparency
- Performance
- Security
- Fault Tolerance
- Automation

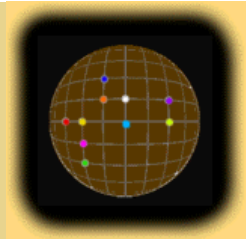


- Jobs are executed locally or remotely
- Data is always written locally
- Data is replicated to remote sites

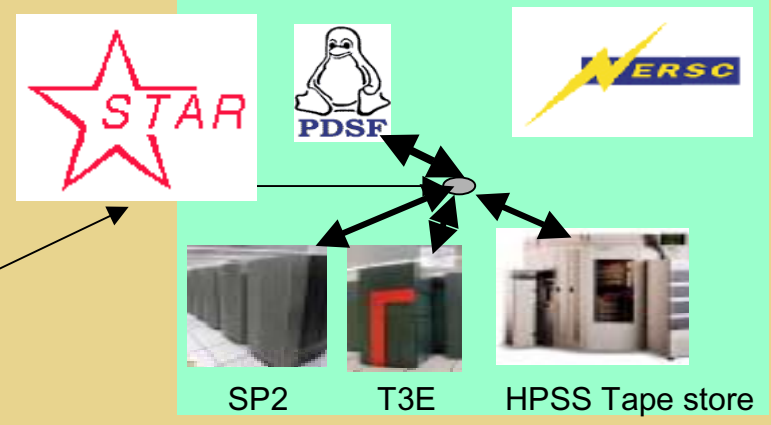
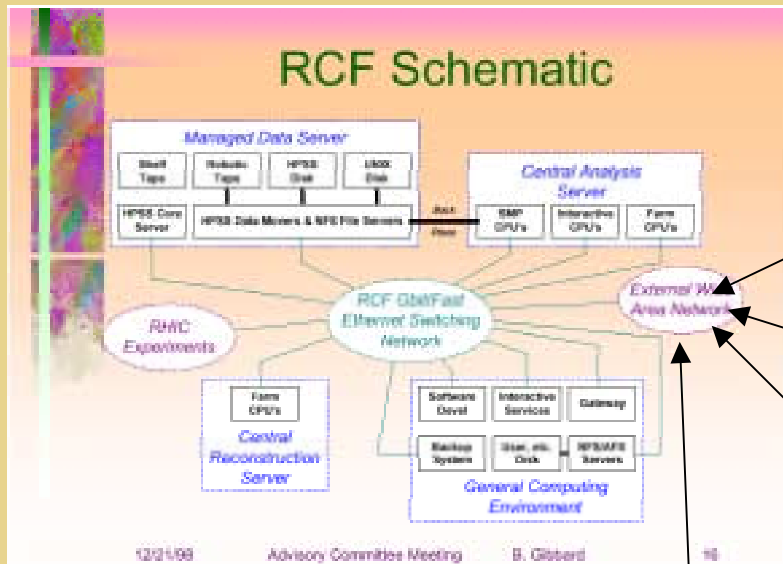


# Estimated Schedule

- PPDG
  - 1999/2000 evaluation of middleware tools, development & evolution of architecture
  - 2001 develop storage resource managers and deploy site-to-site file replication service
  - 2002 deploy multi-site cached file access service
- GriPhyN
  - 2001 prototype transformation catalog
  - Develop funding for Tier2 centers
  - 2002 - 2005 ...
- EU DataGrid
  - 2001 requirements analysis and prototyping
  - 2002 development
  - 2003 integration



# Implementation for STAR



UCLA

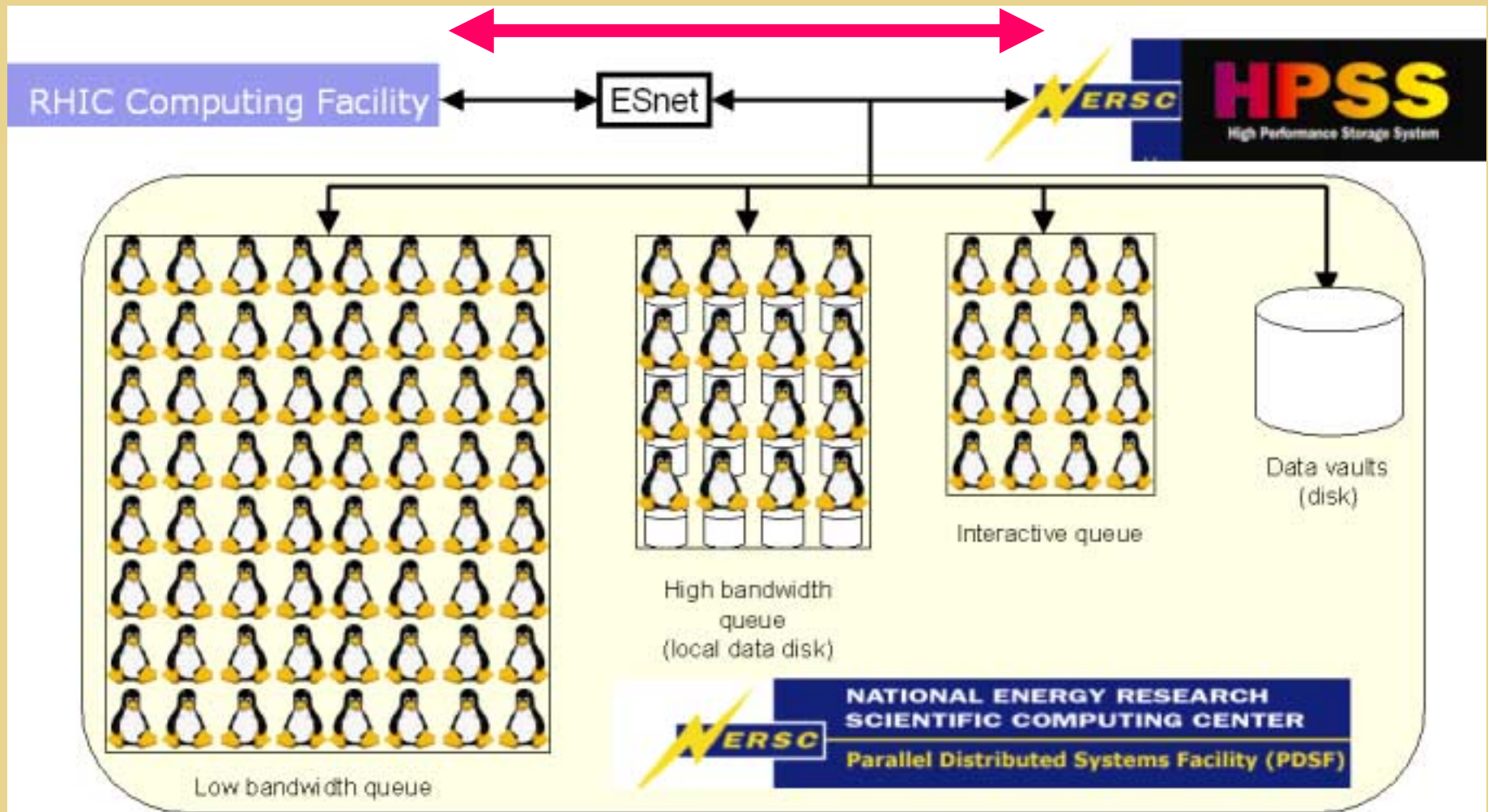
U. Of Washington

... other universities ...





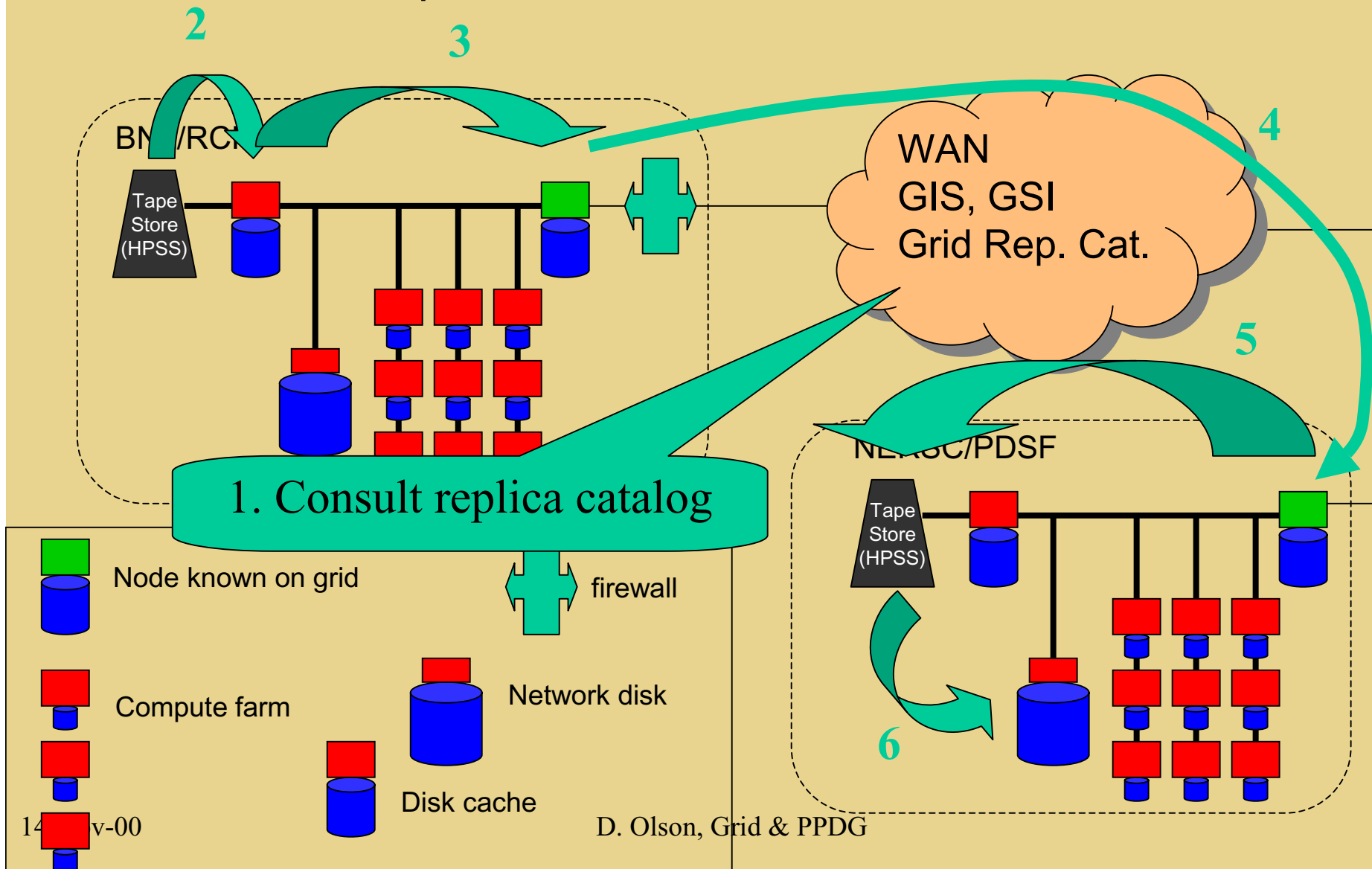
First step is data replication between RCF and NERSC

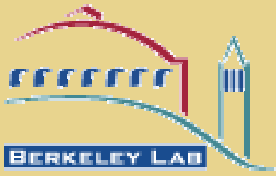






# Consider replication from BNL/RCF to NERSC/PDSF

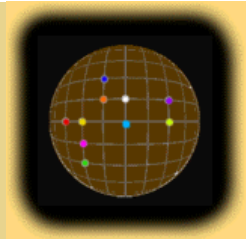




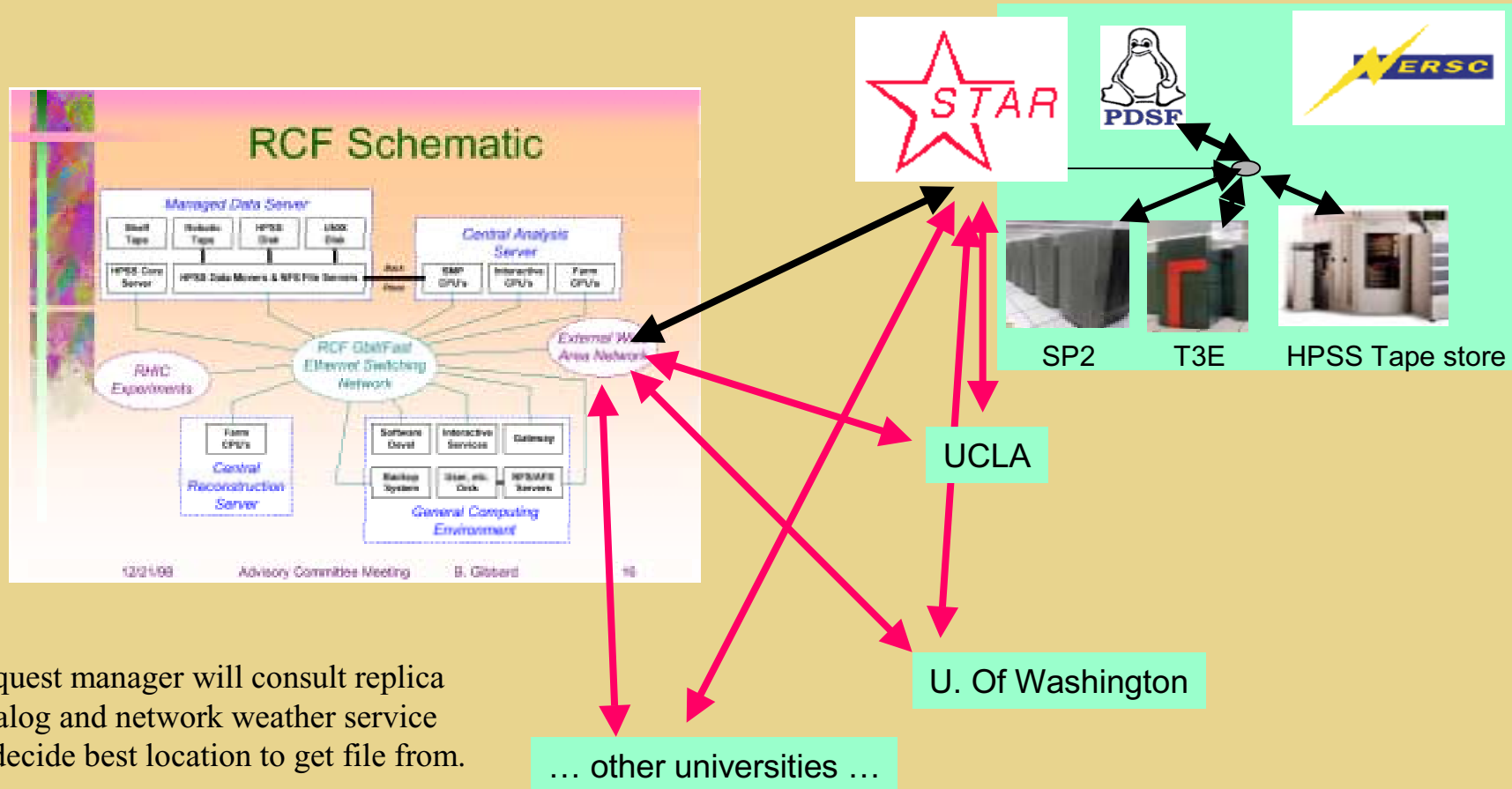
# Steps in replication

1. Decide what files to replicate, consult replica catalog
2. Stage files to disk from HPSS (tape)
3. Move to grid node with cache disk for WAN network transfer
4. Move across WAN to destination grid node
5. Store in remote HPSS system
6. Move to disk

Storage management software at each site and grid middleware should be able to carry this out in a robust and automated way.



# Second step is cached file access at universities



Request manager will consult replica catalog and network weather service to decide best location to get file from.



# Resources

- <http://www.globus.org>
- <http://www.gridforum.org>
- <http://www.ppdg.net>
- <http://www.griphyn.org>
- <http://grid.web.cern.ch/grid>
- <http://www.ipg.nasa.gov/>



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