Computation Institute

20 years of grid computing

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Argonne National Laboratory & The University of Chicago

Talk at HPDC, Delft, June 22, 2012

My co-authors (1)

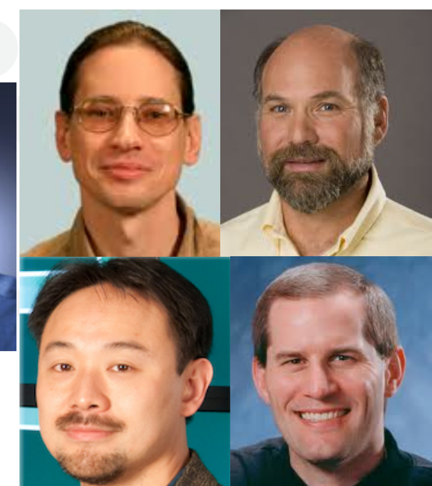
Condor-G: A Computation Management Agent For Multi-institutional Grids: James Frey

Todd Tanenbaum, Miron Livny, Steven Tuecke

Grid Information Services For Distributed Resource Sharing: Karl Czajkowski

Carl Kesselman, Steven Fitzgerald

Application Experiences With The Globus Toolkit: Sharon Brunett, Karl Czajkowski



Steven Fitzgerald, Andrew Johnson

Carl Kesselman, Jason Leigh, Steven Tuecke

My co-authors (2)

Decoupling Computation And Data Scheduling in Distributed Data-intensive Applications: Kavitha Ranganathan

Resource Co-allocation in Computational Grids: Karl Czajkowski, Carl Kesselman

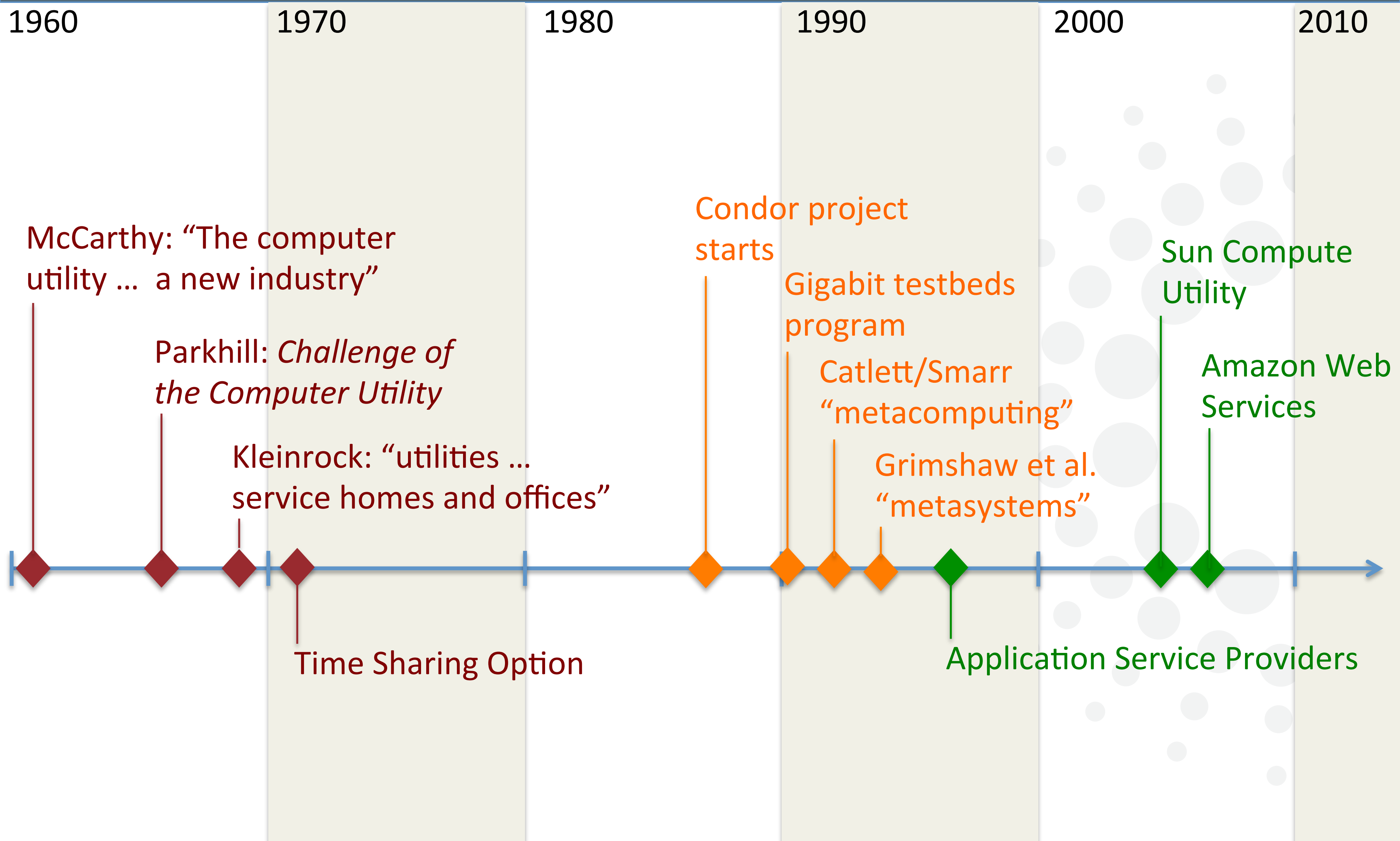
Security For Grid Services:

Von Welch, Frank Siebenlist
John Bresnahan, Karl Czajkowski
Jarek Gawor, Carl Kesselman
Sam Meder, Laura Pearlman
Steven Tuecke

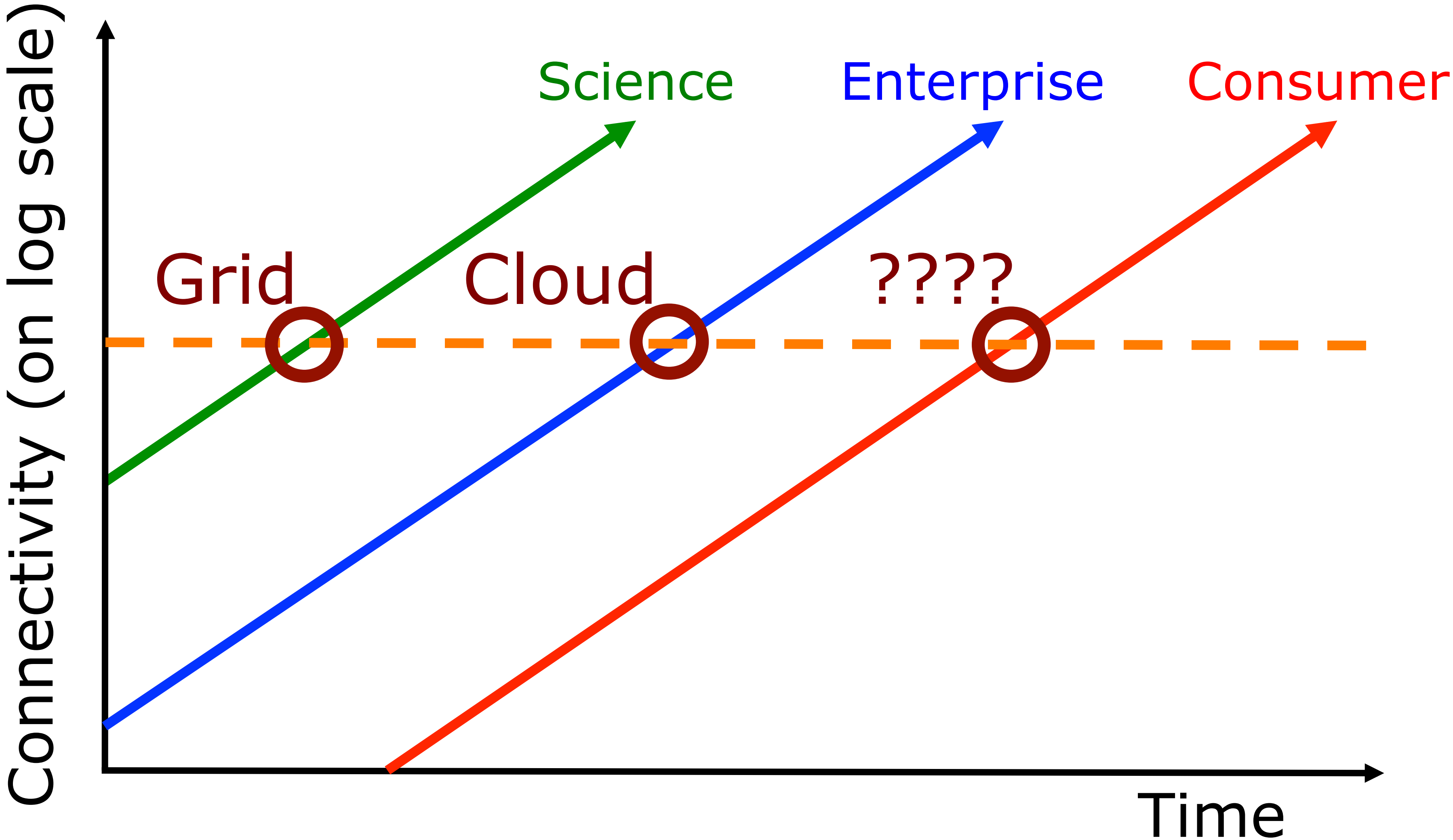
The original grid vision

- Accelerate discovery and innovation by providing on-demand access to computing
  - “the average computing environment remains inadequate for [many] computationally sophisticated purposes”
  - “if mechanisms are in place to allow reliable, transparent, and instantaneous access to high-end resources, then … it is as if those resources are devoted to them”
- [*The Grid*, Chapter 2, 1998]

The on-demand idea certainly isn't new

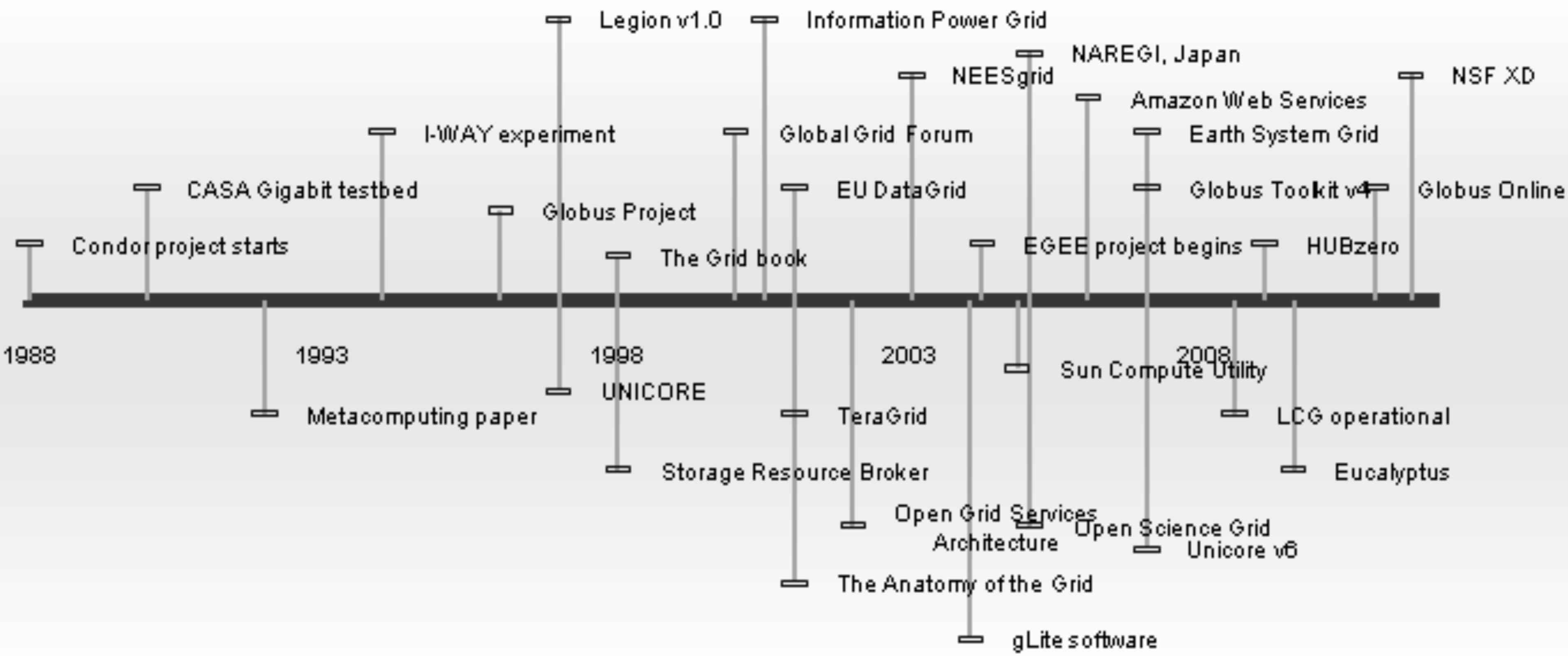


“When the network is as fast as the computer's internal links, the machine disintegrates across the net into a set of special purpose appliances”
(George Gilder, 2001)



"A simple back of the envelope calculation shows that [McCarthy's] idea can never work."

The history of Grid, more specifically



I. Foster, C. Kesselman, "The History of the Grid," High Performance Computing: From Grids and Clouds to Exascale, Advances in Parallel Computing Series, Vol. 20, IOS Press, 2011.

Focus on abstractions and mechanisms

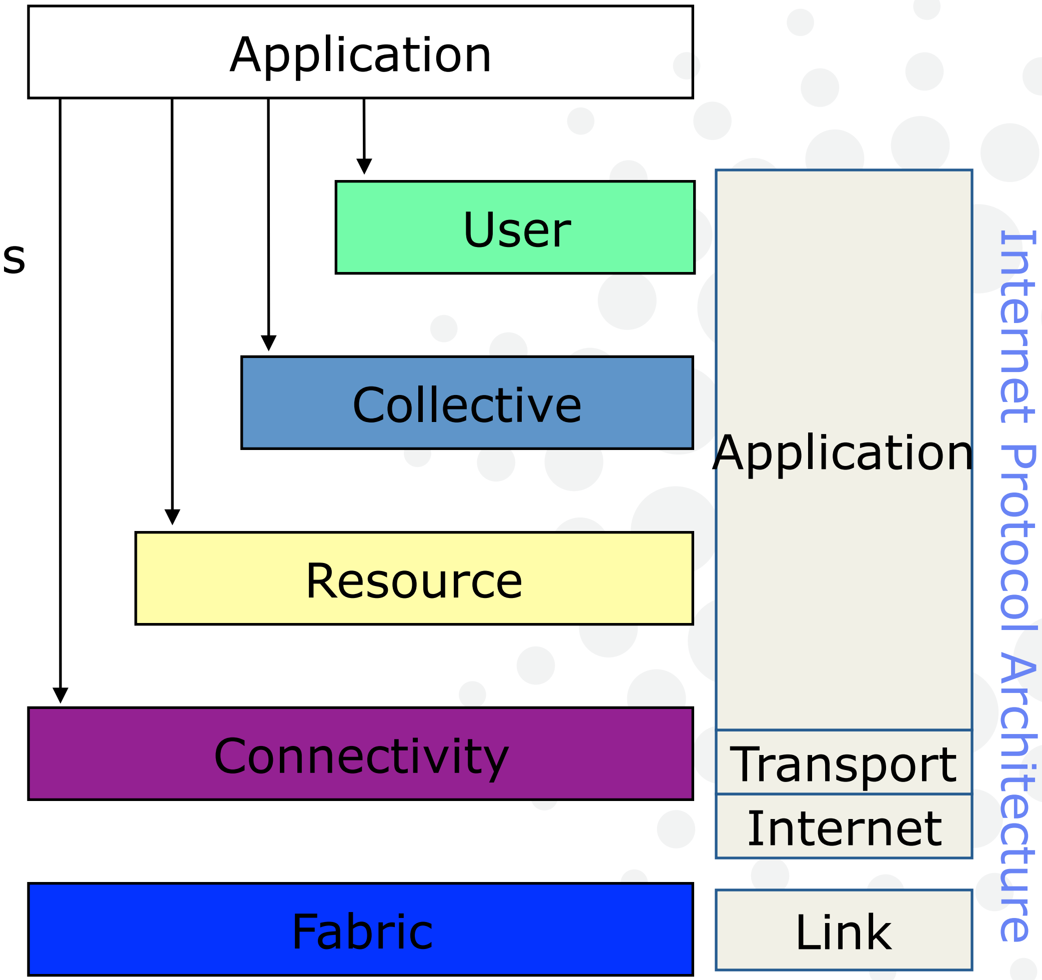
"Specialized services": user- or appln-specific distributed services

"Managing multiple resources": ubiquitous infrastructure services

"Sharing single resources": negotiating access, controlling use

"Talking to things": communication (Internet protocols) & security

"Controlling things locally": Access to, & control of, resources



"The Anatomy of the Grid," 2001

The … problem that underlies the Grid concept is coordinated resource sharing and problem solving in **dynamic, multi-institutional virtual organizations**. The sharing that we are concerned with is not primarily file exchange but rather direct access to computers, software, data, and other resources, as is required by a range of collaborative problem-solving and resource-brokering strategies emerging in industry, science, and engineering. This sharing is, necessarily, highly controlled, with resource providers and consumers defining clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs. **A set of individuals and/or institutions defined by such sharing rules form what we call a virtual organization (VO).**

Examples (from AotG, 2001)

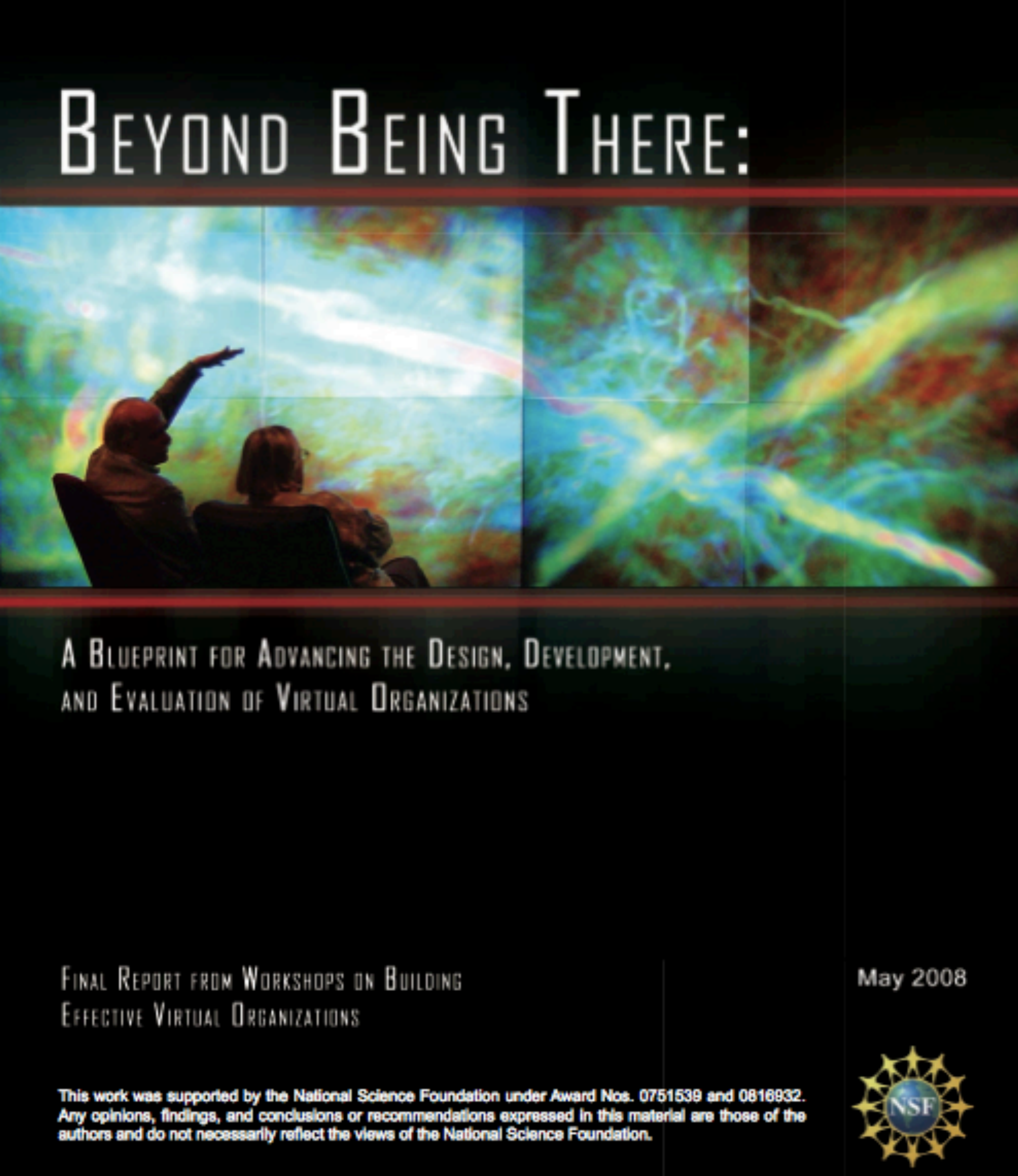
- “The application service providers, storage service providers, cycle providers, and consultants engaged by a car manufacturer to perform scenario evaluation during planning for a new factory”
- “Members of an industrial consortium bidding on a new aircraft”
- “A crisis management team and the databases and simulation systems that they use to plan a response to an emergency situation”
- “Members of a large, international, multiyear high-energy physics collaboration”

From the organizational behavior and management community

"[A] group of **people** who interact through interdependent tasks guided by common purpose [that] works across space, time, and organizational boundaries with links strengthened by webs of **communication technologies**" — Lipnack & Stamps, 1997

- Yes—but adding cyberinfrastructure:
  - People → *computational agents & services*
  - Communication technologies → *IT infrastructure*

Collaboration based on rich data & computing capabilities

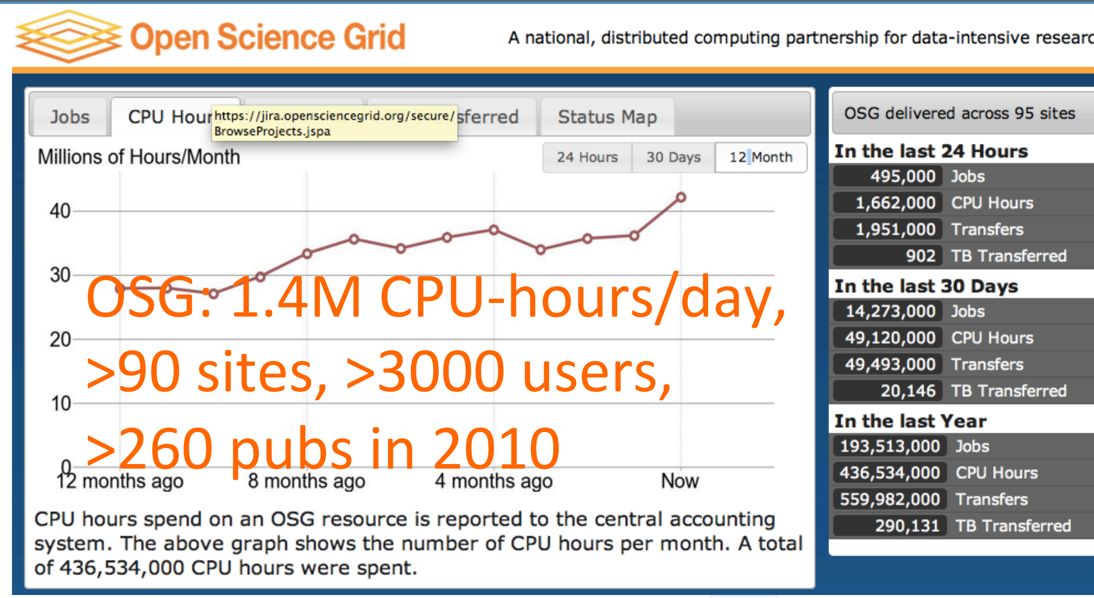


[Search “BEVO 2008”]

NSF Workshops on Building Effective Virtual Organizations

Big science has achieved big successes

LIGO: 1 PB data in last science run, distributed worldwide



OSG: 1.4M CPU-hours/day, >90 sites, >3000 users, >260 pubs in 2010

Robust production solutions
Substantial teams and expense
Sustained, multi-year effort
Application-specific solutions,
built on common technology

ESG: 1.2 PB climate data delivered to 23,000 users; 600+ pubs

All build on Globus Toolkit software

Things we got right

- Close partnerships with application groups with substantial problems
- Focus on resource models and low-level mechanisms vs. all-encompassing frameworks
- Definition of data movement & security protocol conventions to encourage interoperability
  - E.g., GridFTP, Grid Security Infrastructure, and SRM, defined in Open Grid Forum, IETF, etc.
- Virtual organizations as an organizational principle for collaborative work

Things we got wrong

- Unrealistic expectations that supercomputer centers could become “cloud providers”
- Web Services
- European vs. U.S. competition
- Overly focused on big science

What has changed? Causation or just correlation? Discuss …

- Thousands of people learned about the joys of large-scale distributed systems
- Virtual organization concepts and technologies
- Now routine to move 10s of terabytes (e.g., GridFTP moves > 1 petabyte per day)
- High throughput computing is mainstream (e.g., Condor runs millions of jobs per day)
- Large Hadron Collider will soon find the Higgs
- Earth System Grid supports >25,000 users
- Commercial cloud computing

Small science is struggling

More data, more complex data

Ad-hoc solutions

Inadequate software, hardware

Data plan mandates

Looking forward

- Exploding data volumes and earlier successes mean that many people face challenges of big data, big compute, big collaboration
- Networks are several orders of magnitude faster than when Grid started
- Commercial cloud providers provide a substrate on which powerful new capabilities can be built with new economies of scale

Complexity is large and growing

Time

Run experiment
Collect data
Move data
Check data
Annotate data
Share data
Find similar data
Link to literature
Analyze data
Publish data

Can we extract this complexity?

Process automation for science

Time

Run experiment
Collect data
Move data
Check data
Annotate data
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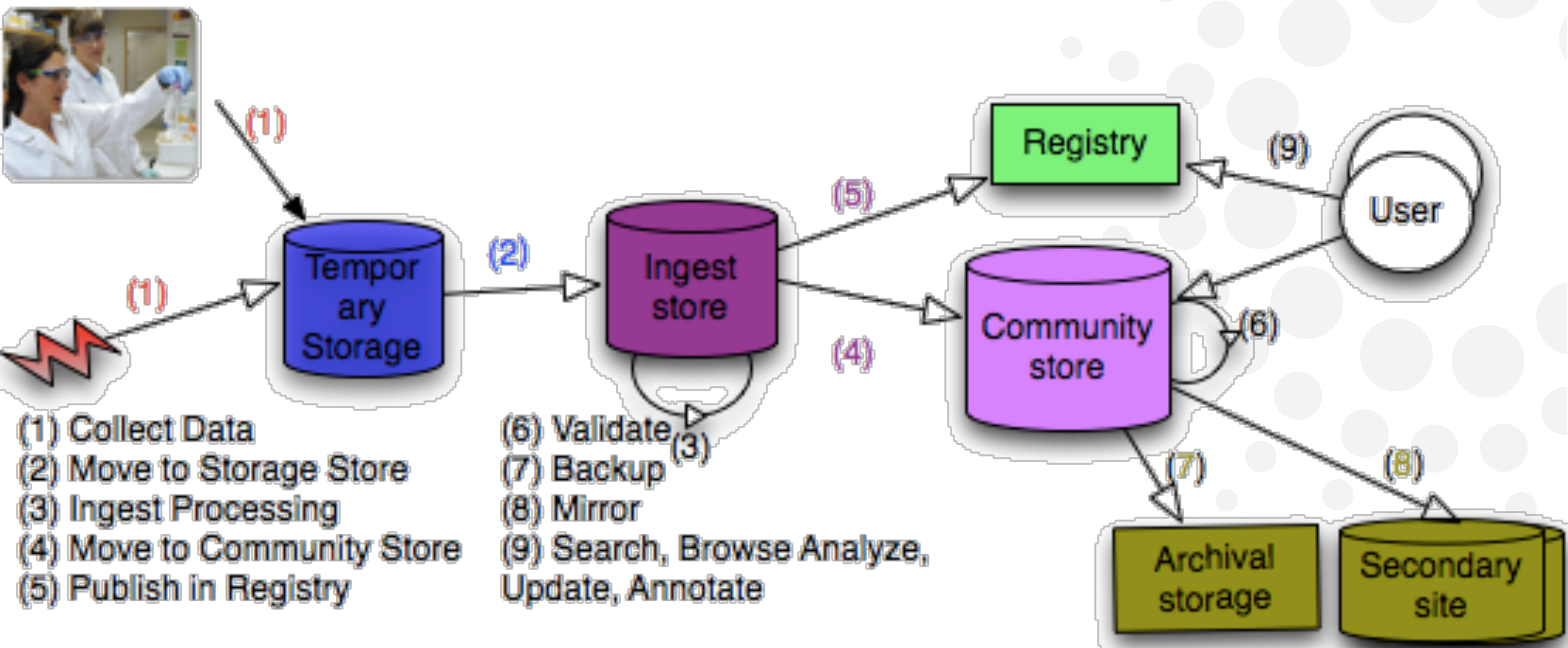
?
Research IT
as a service
?

A first take at characterizing process

Dark Energy Survey Metagenomics Climate science
Genomics Land use change X-ray source data
Biomedical imaging High energy physics Nielsen data



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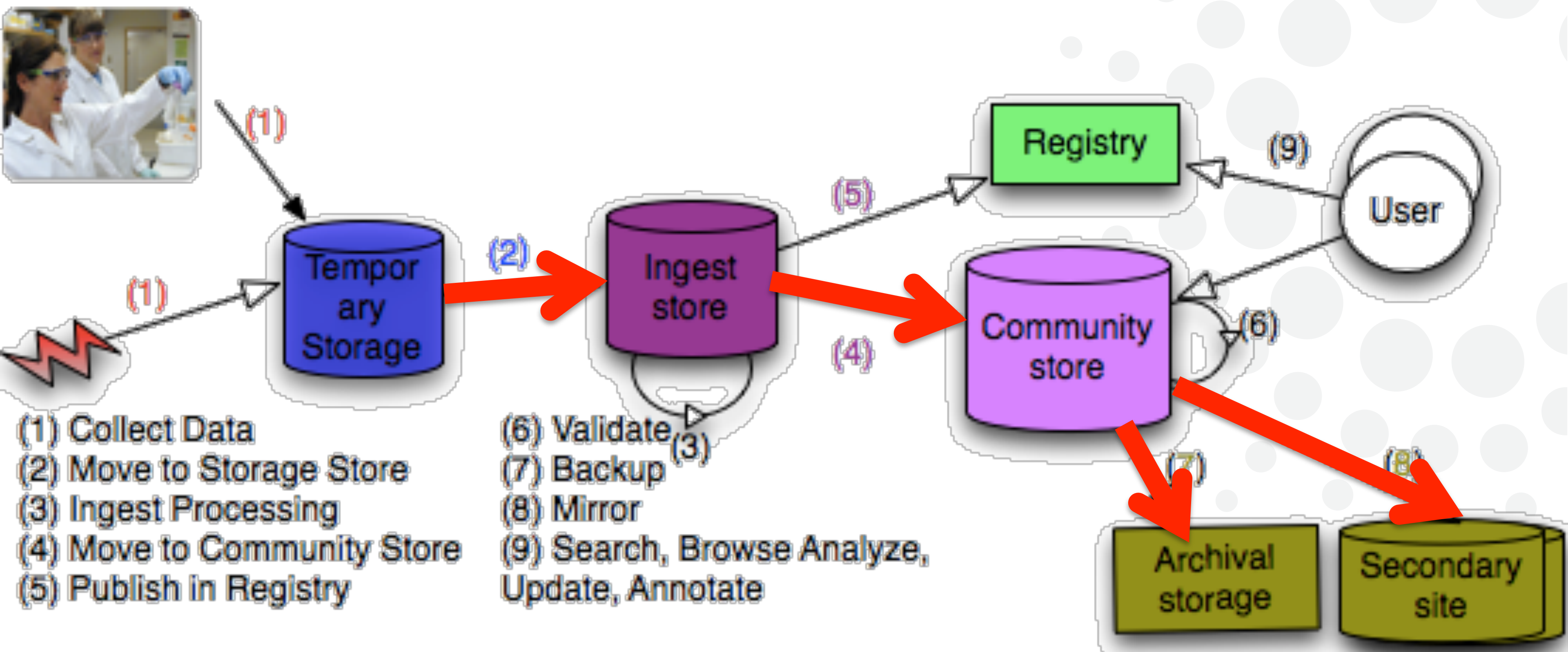
Biomedical imaging   High energy physics   Nielsen data



Software as a Service (Gartner)

1. The application is owned, delivered, and managed remotely by one or more providers
2. The application is based on a single code base that is consumed in a one-to-many model by all contracted customers at any time
3. The application is licensed on pay-per-use or subscription basis

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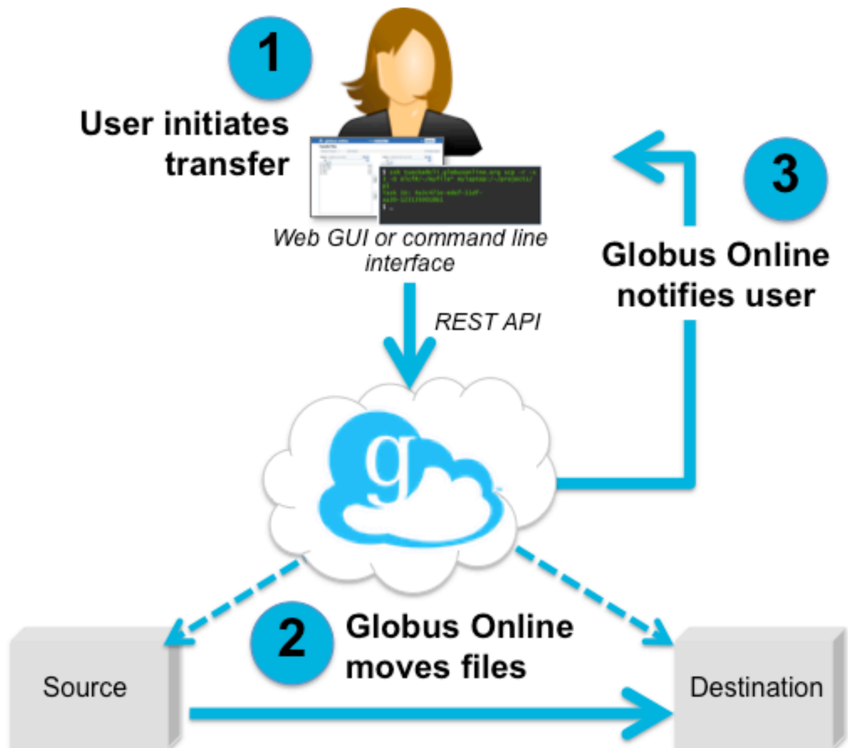
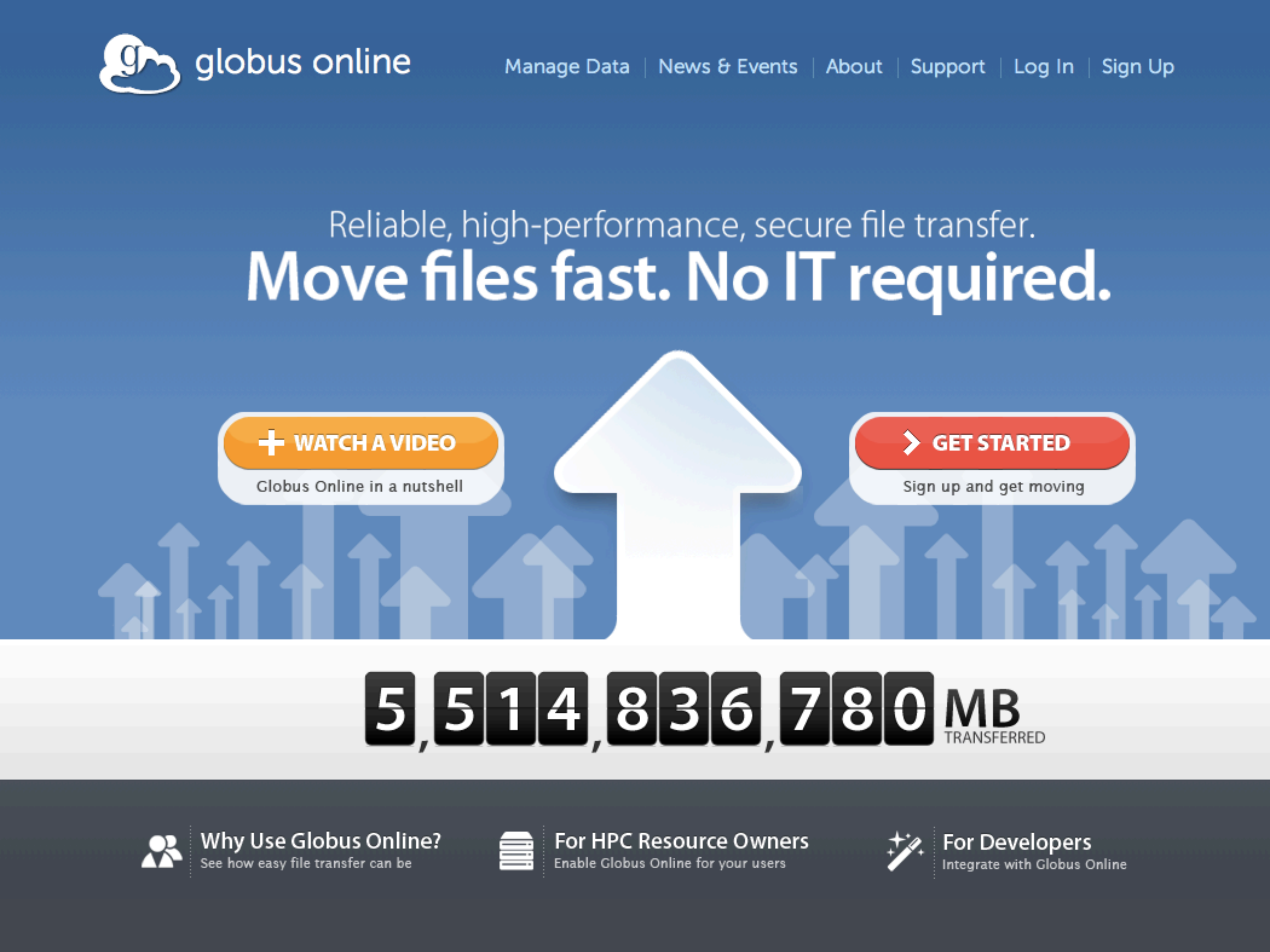
4. The application behind the service is properly web architected—not an existing application web enabled [D. Terrar]

Globus Online: Data transfer as SaaS

- Reliable file transfer.
  - Easy "fire-and-forget" transfers
  - Automatic fault recovery
  - High performance
  - Across multiple security domains
- No IT required.
  - Software as a Service (SaaS)
    - No client software installation
    - New features automatically available
  - Consolidated support & troubleshooting
  - Works with existing GridFTP servers
  - Globus Connect solves "last mile problem"
- >5000 registered users, >5 Petabytes moved



Recommended by XSEDE, NERSC, Blue Waters, and many campuses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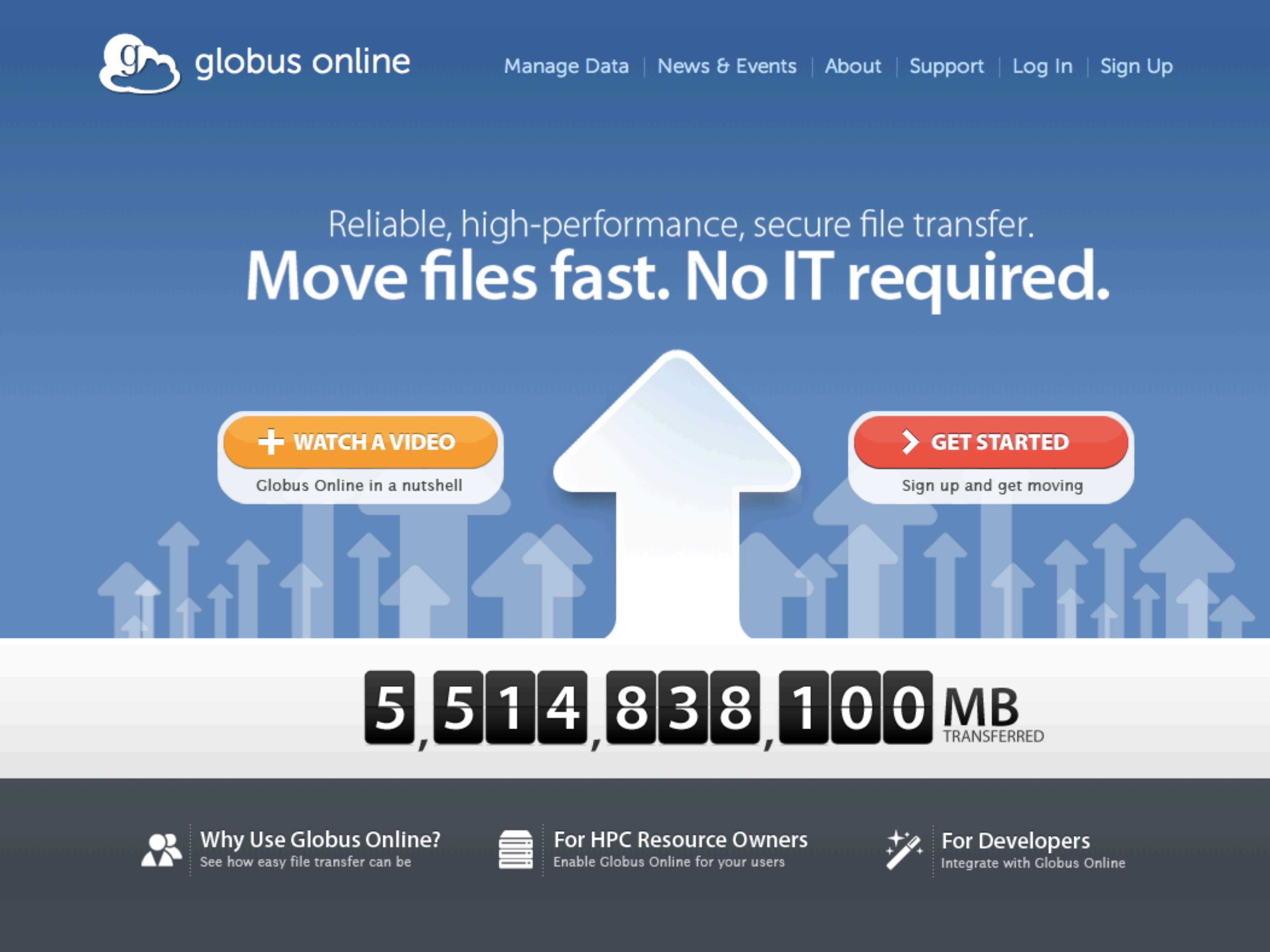
Reliable, high-performance, secure file transfer.
Move files fast. No IT required.
WATCH A VIDEO
Globus Online in a nutshell
GET STARTED
Sign up and get moving
5,514,836,780 MB
TRANSFERRED
Why Use Globus Online?
See how easy file transfer can be
For HPC Resource Owners
Enable Globus Online for your users
For Developers
Integrate with Globus Online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globus online

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5,514,839,780 MB TRANSFERRED

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Dark Energy Survey use of Globus Online

- Dark Energy Survey receives 100,000 files each night in Illinois
- They transmit files to Texas for analysis … then move results back to Illinois
- Process must be reliable, routine, and efficient
- They outsource this task to Globus Online

Blanco 4m on Cerro Tololo

Image credit: Roger Smith/NOAO/AURA/NSF

BLUE WATERS

SUSTAINED PETASCALE COMPUTING

NCSA

SIGN IN   SIGN UP

Reliable, high-performance, secure file transfer by Globus Online.

Blue Waters has partnered with the Globus Online file transfer service.

You may access this service by entering your Blue Waters username and password.

NOTE - If you are accessing this file transfer service for the first time, you will be asked to link your Blue Waters account to a Globus Online account (if you don't have a Globus Online account you'll be able to create one).

Sign In

Use Your NCSA Blue Waters login   alternate login

Username

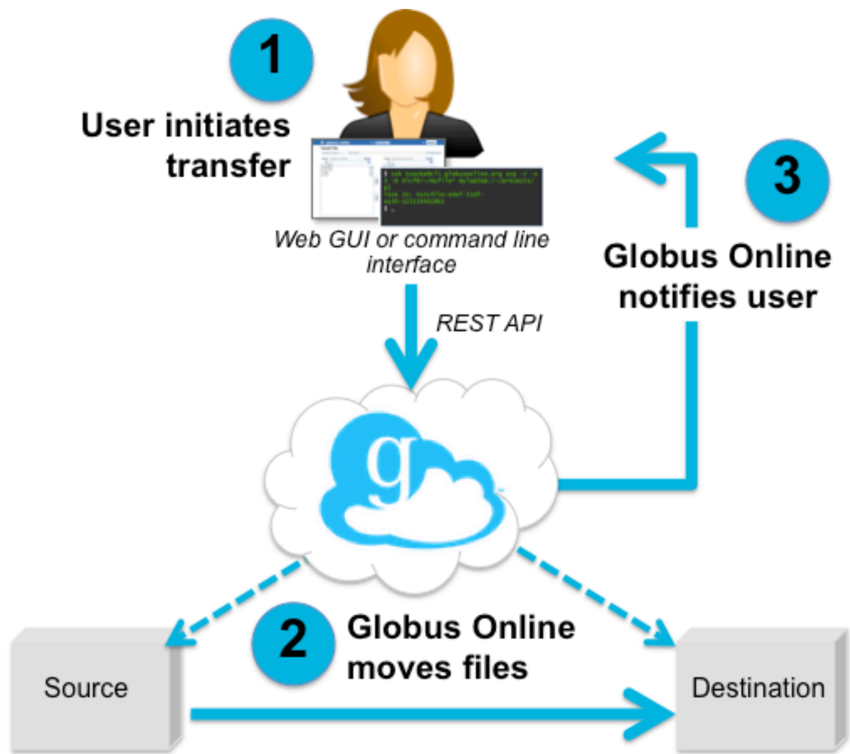
Password

Sign In

Resources   Support   Sign In   Sign Up

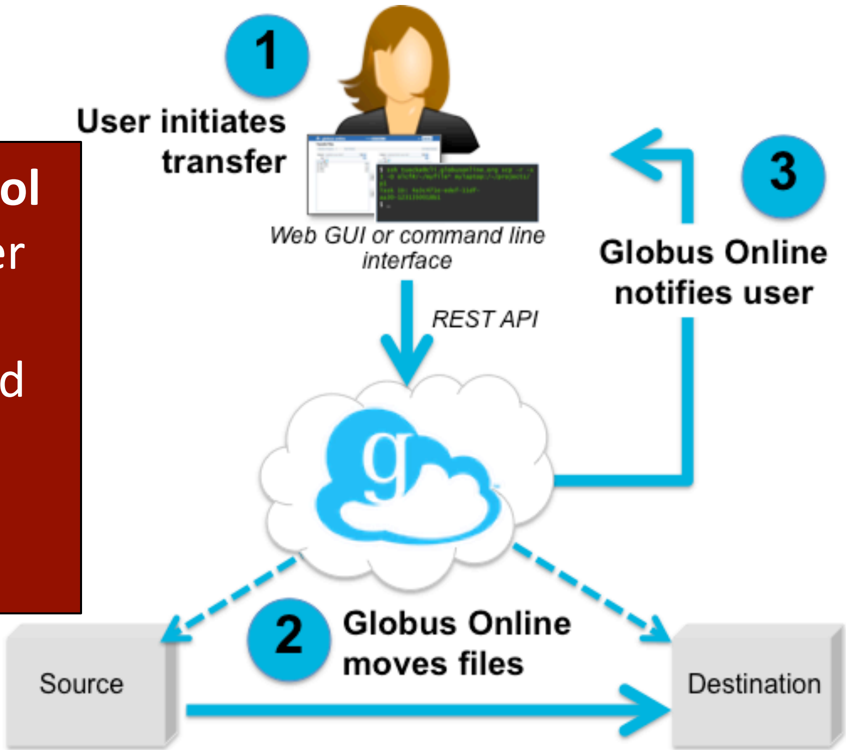
powered by globus online

Globus Online under the covers



User Hub manages user identities and profiles
Group Hub manages groups and policies
Resource Hub for resource definitions

Globus Online under the covers



Monitoring and control
Auto-tuning of transfer parameters
Detection & attempted correction of errors
Manual intervention when required

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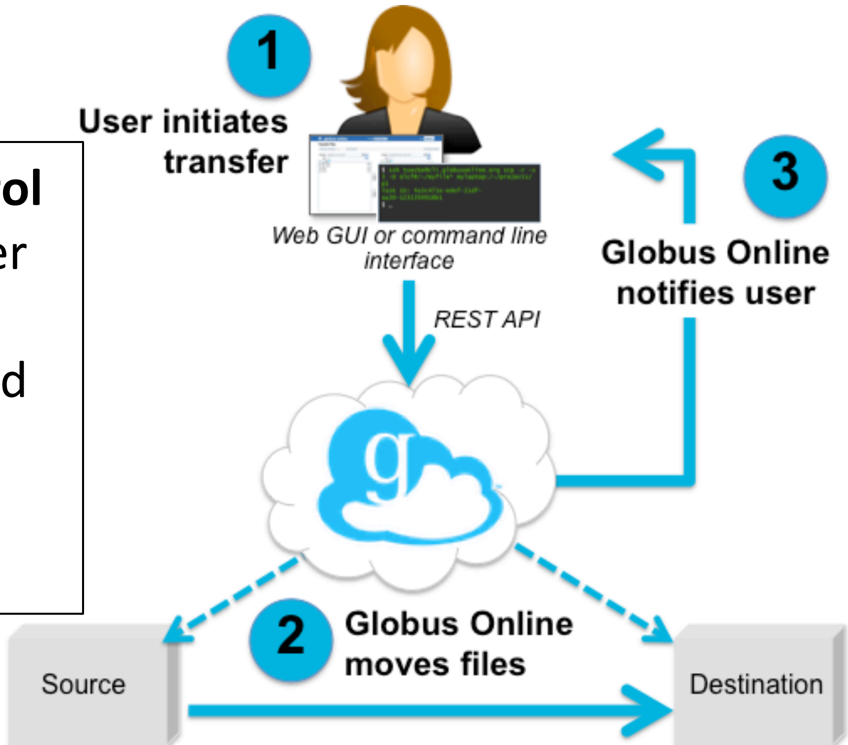

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Reliable cloud-based infrastructure
EC2 for transfer management
S3 for system state
SimpleDB for lock management
Replication across availability zones

Globus Online under the covers

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- Auto-tuning of transfer parameters
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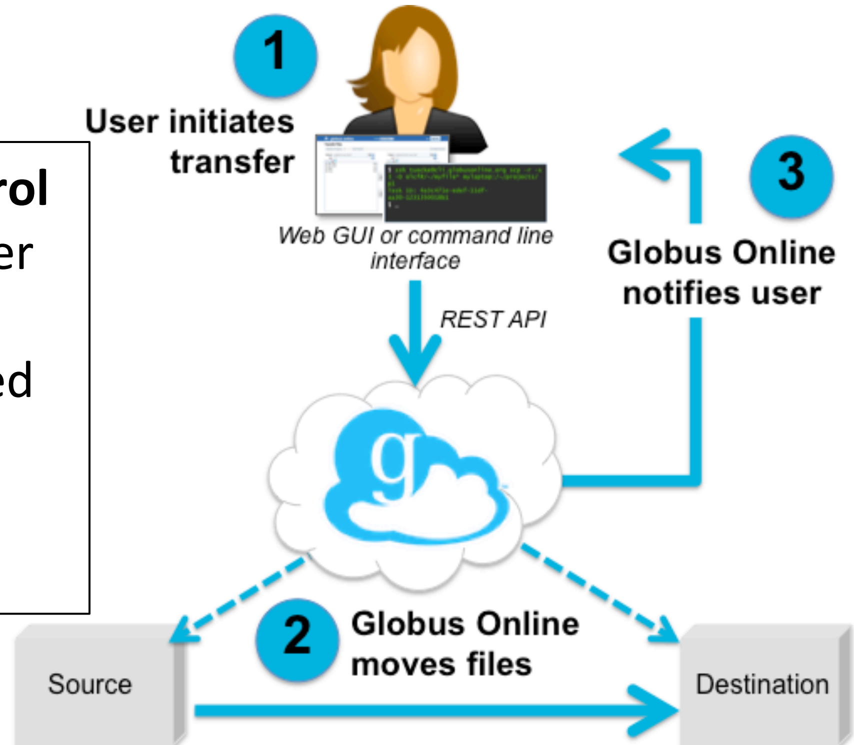

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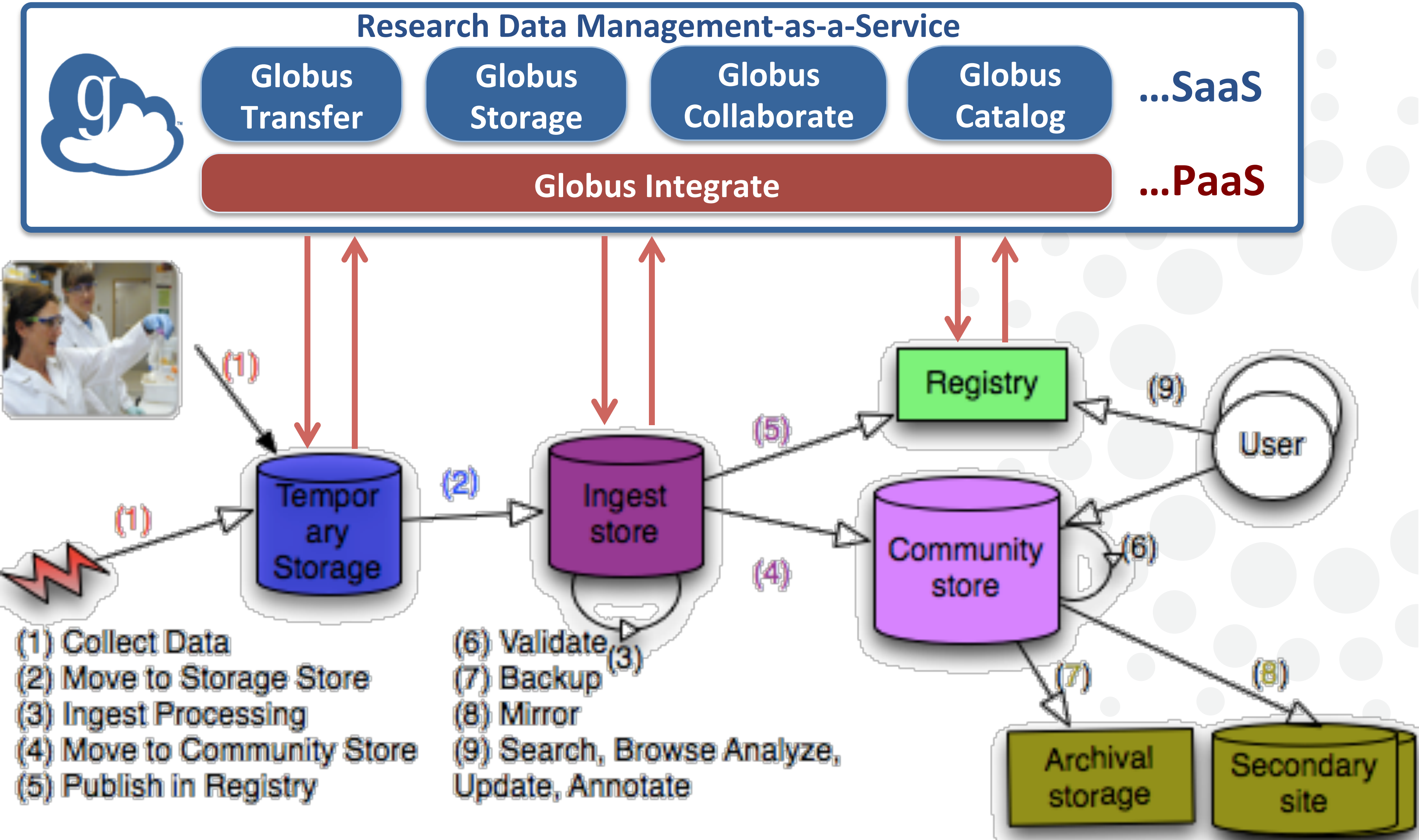
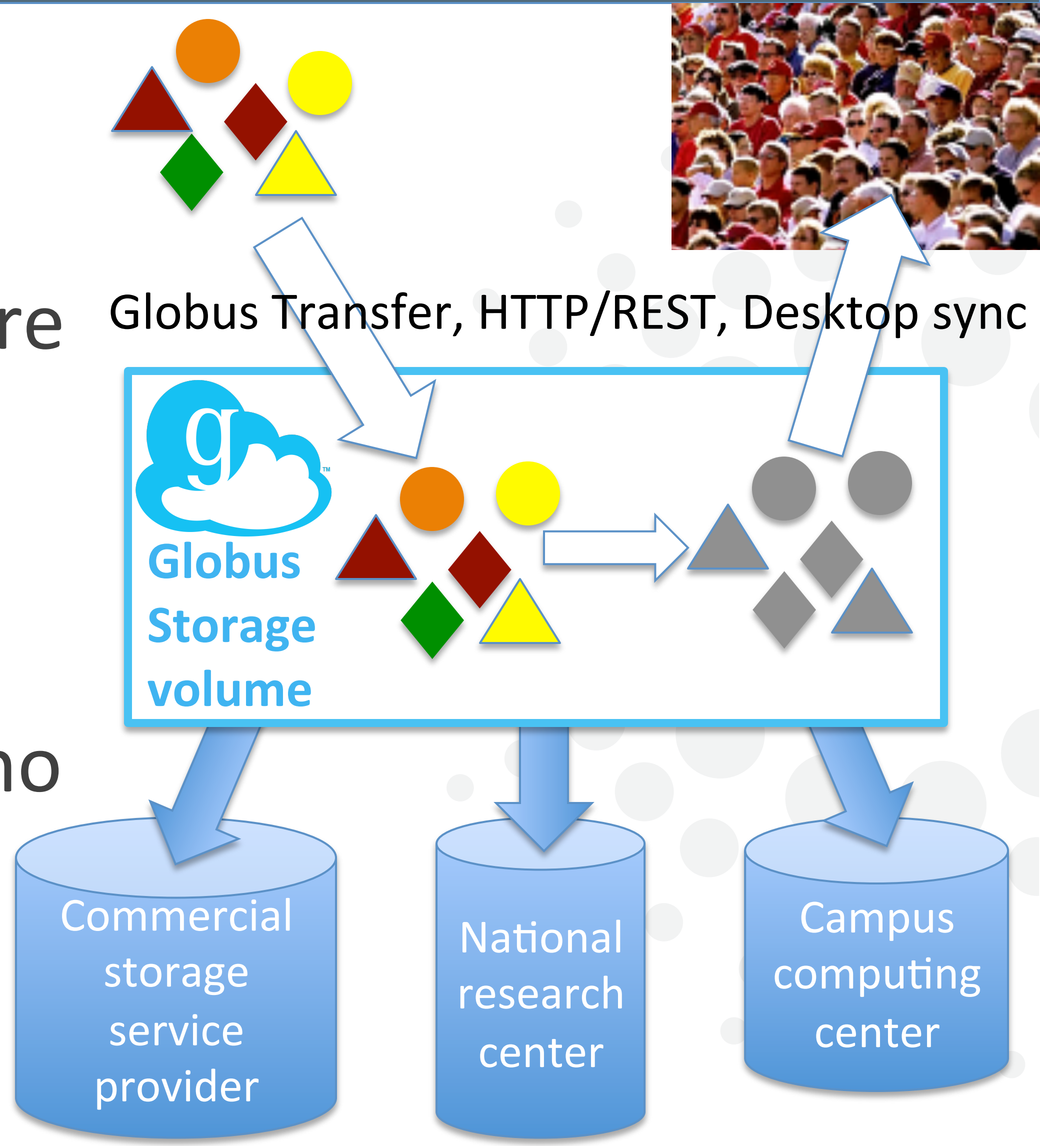
Further steps towards process automation



Globus Storage: For when you want to …

- **Place** your data where you want
- **Access** it from anywhere via different protocols
- **Update** it, **version** it, and take **snapshots**
- **Share** versions with who you want
- **Synchronize** among locations



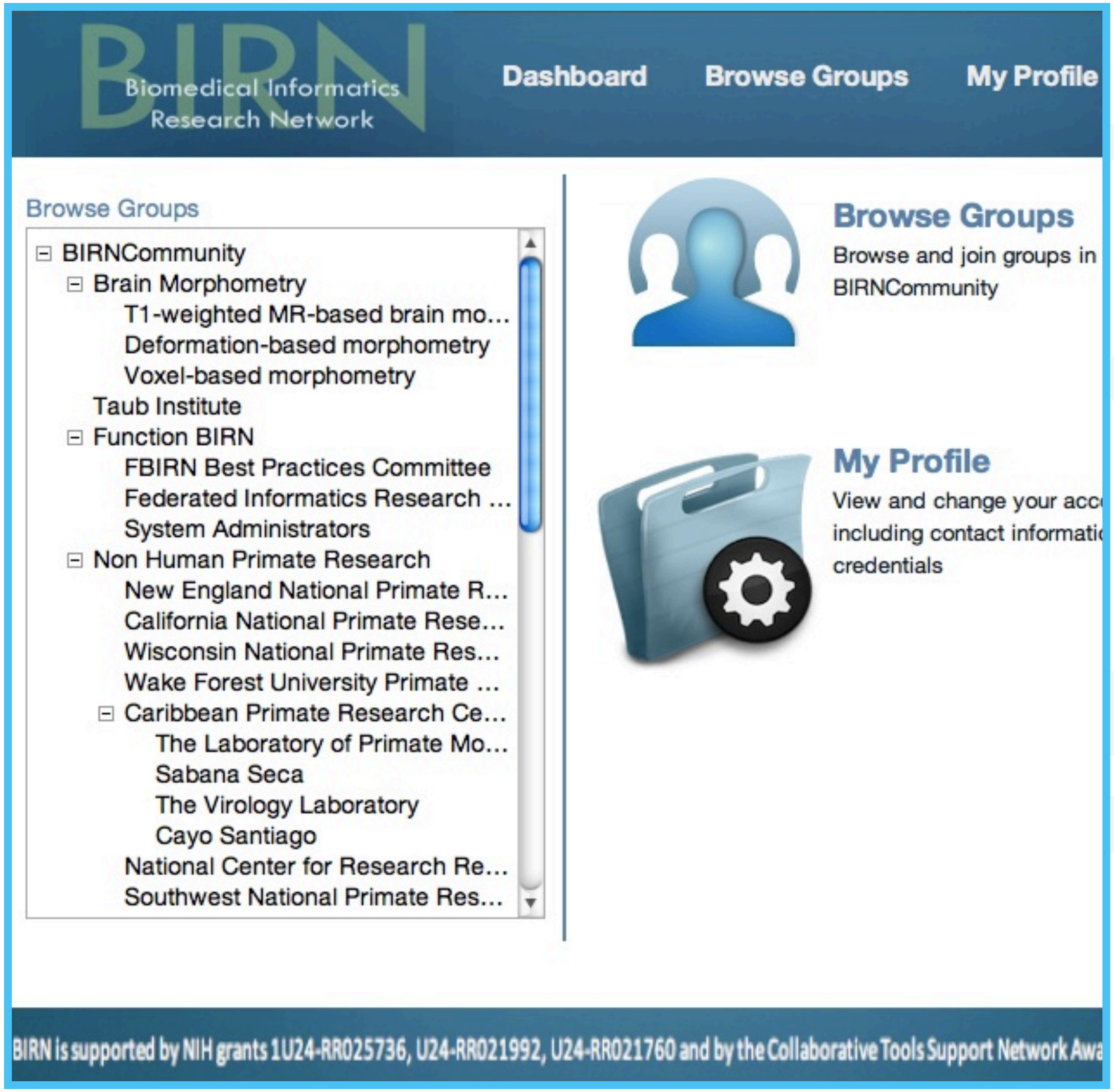
Globus Collaborate: For when you want to

Join with a few or many people to:

- Share documents
- Track tasks
- Send email
- Share data
- Do whatever

With:

- Common groups
- Delegated mgmt



Globus Integrate: For when you want to

Write programs that access/manage user identities, profiles, groups, resources—and data …

Globus Transfer
- In production use
- Service and Web UI enhancements continue

Globus Storage
- Early release available in March
- Generally available in Q3

Globus Collaborate
- Initial projects starting in March
- Early release sometime in Q3

Globus Integrate
- Transfer API available
- User profile, group APIs in alpha
- APIs for Storage, Collaborate planned after app release

Globus Connect Multi User

Globus Connect

… via REST APIs and command line programs

Let’s rethink how we provide **research IT**

Accelerate discovery and innovation worldwide by providing **research IT as a service**

Leverage software-as-a-service to

- provide millions of researchers with unprecedented access to powerful tools;
- enable a massive shortening of cycle times in time-consuming research processes; and
- reduce research IT costs dramatically via economies of scale

History of the Grid in words and pictures

The History of the Grid

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[§]*Department of Industrial and Systems Engineering, University of Southern California*
[=]*Information Sciences Institute, University of Southern California*

Abstract. With the widespread availability of high-speed networks, it becomes feasible to outsource computing to remote providers and to federate resources from many locations. Such observations motivated the development, from the mid-1990s onwards, of a range of innovative Grid technologies, applications, and infrastructures. We review the history, current status, and future prospects for Grid computing.

I. Foster, C. Kesselman, "The History of the Grid," High Performance Computing: From Grids and Clouds to Exascale, Advances in Parallel Computing Series, Vol. 20, IOS Press, 2011.

History of the Grid: Please contribute!

1) Access paper at http://scr.bi/Ln1QVv (this has line numbers)
2) Comments, critiques, additions, deletions
   -- Via email to foster@anl.gov, carl@isi.edu
   -- Or, via Scribd.Com at URL above
   -- In either case, use line numbers
3) We'll acknowledge all contributors in the next version (but we reserve editorial control)

Thank you!

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