Computation Institute

Grid, cloud, and beyond

What we have learned about computing on demand

Ian Foster

Computation Institute

Mathematics and Computer Science Division

Department of Computer Science

Argonne National Laboratory & The University of Chicago

Argonne Training Program on Extreme Scale Computing

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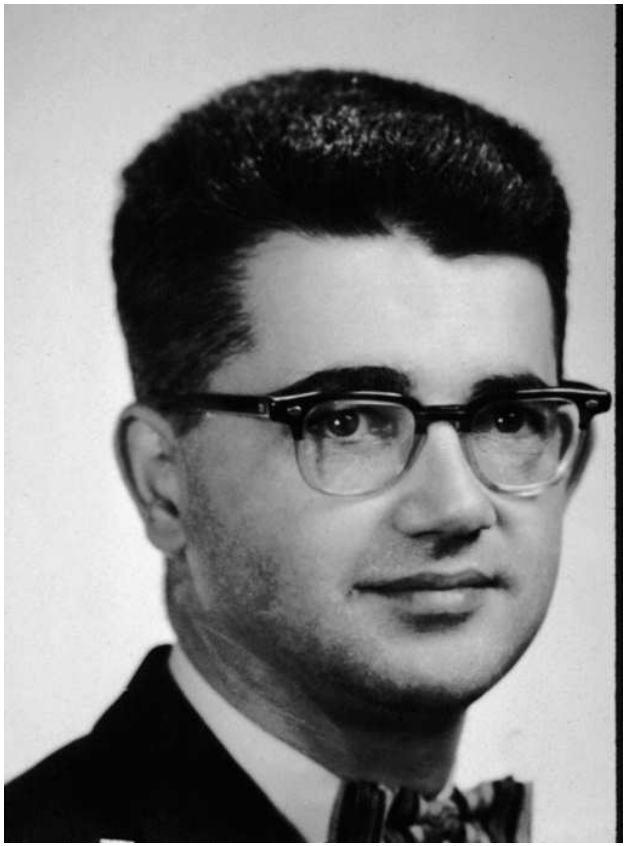
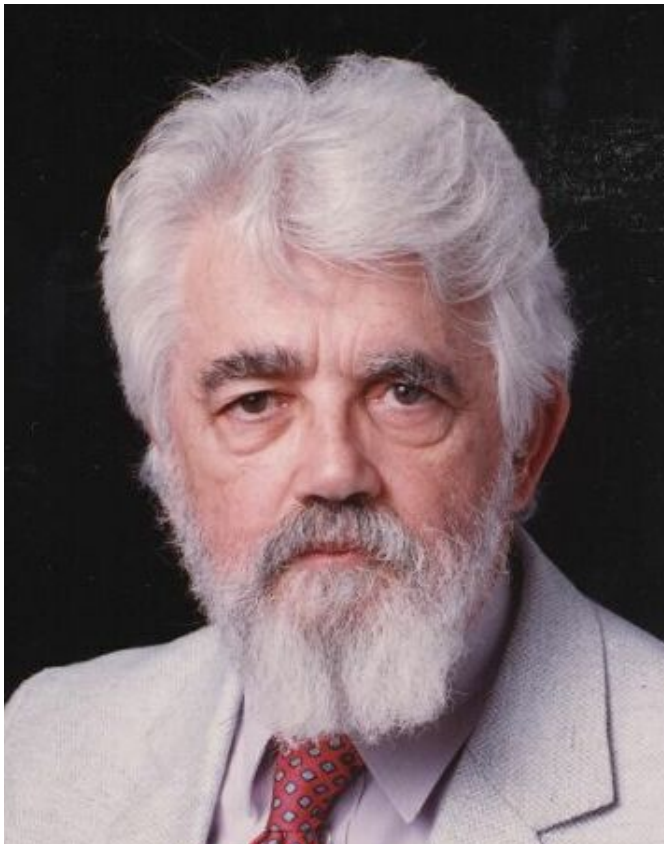
Civilization advances
by extending
the number of important operations
which we can perform
without thinking about them

Alfred North Whitehead (1911)

"Computation may someday be organized as a public utility … The computing utility could become the basis for a new and important industry."

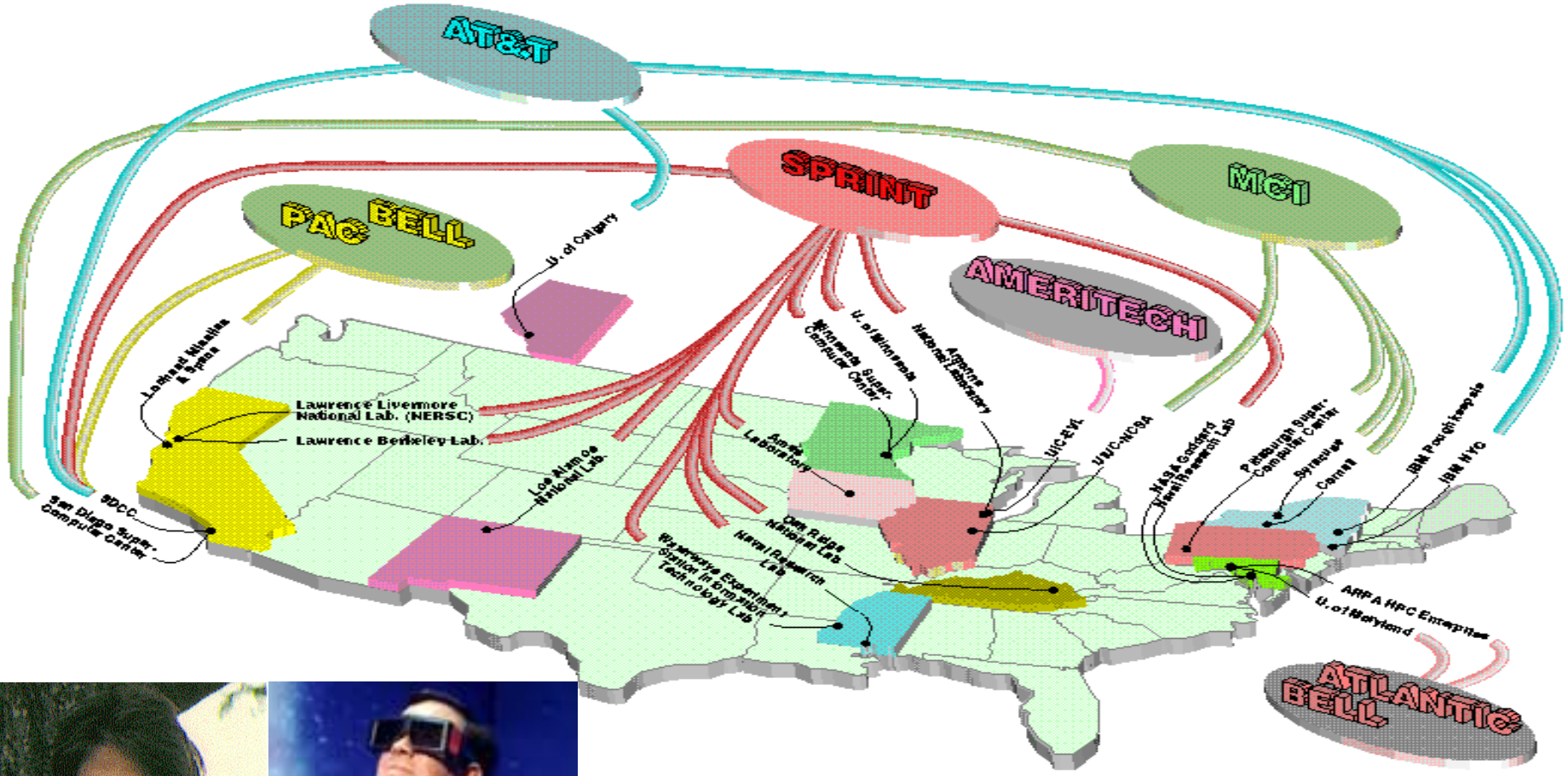


John McCarthy (1961)

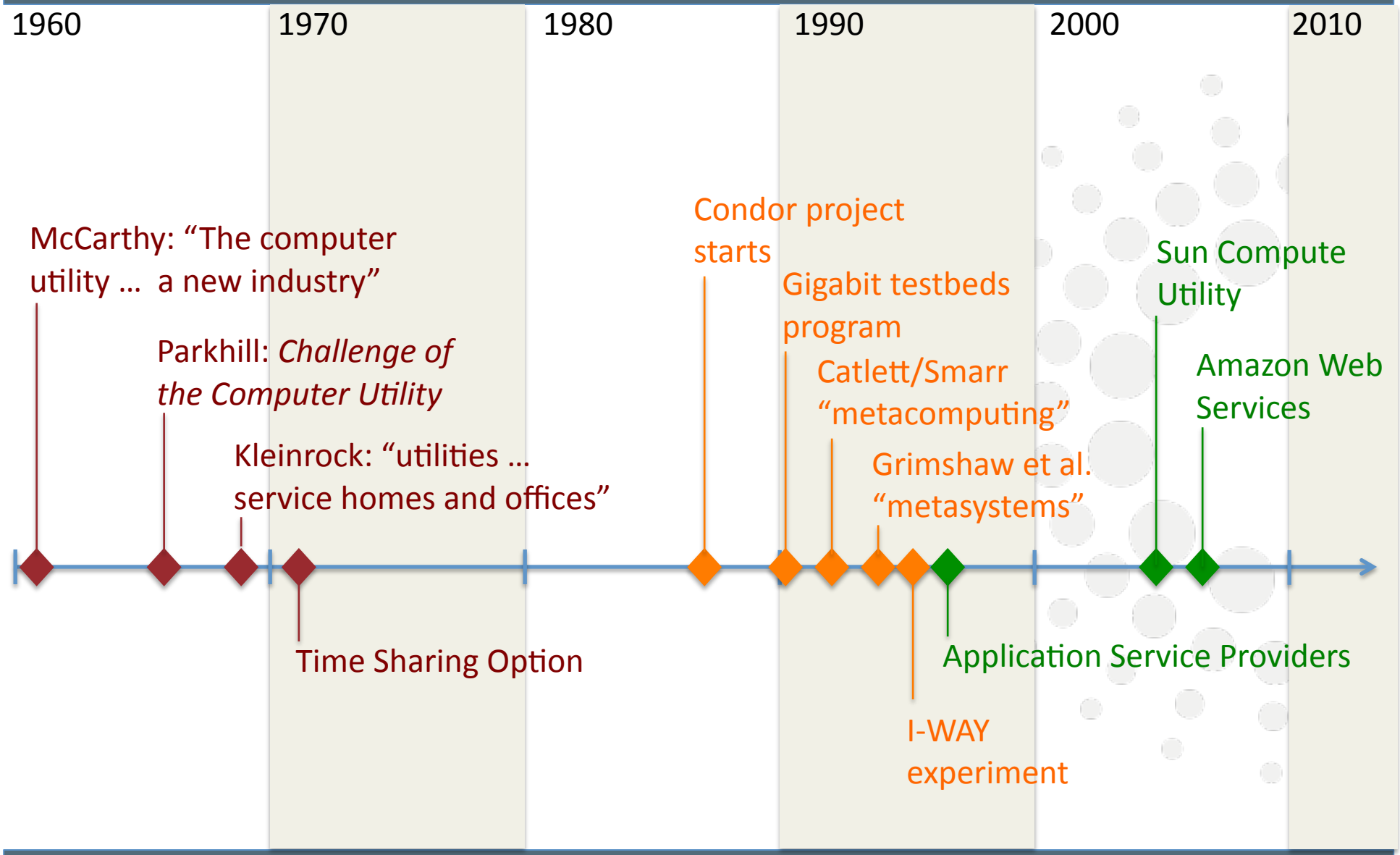


“A simple back of the envelope calculation shows that this idea can never work.”

I-WAY experiment: SC'95, San Diego



Evolution of the on-demand idea



The 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]

Focus on abstractions and mechanisms

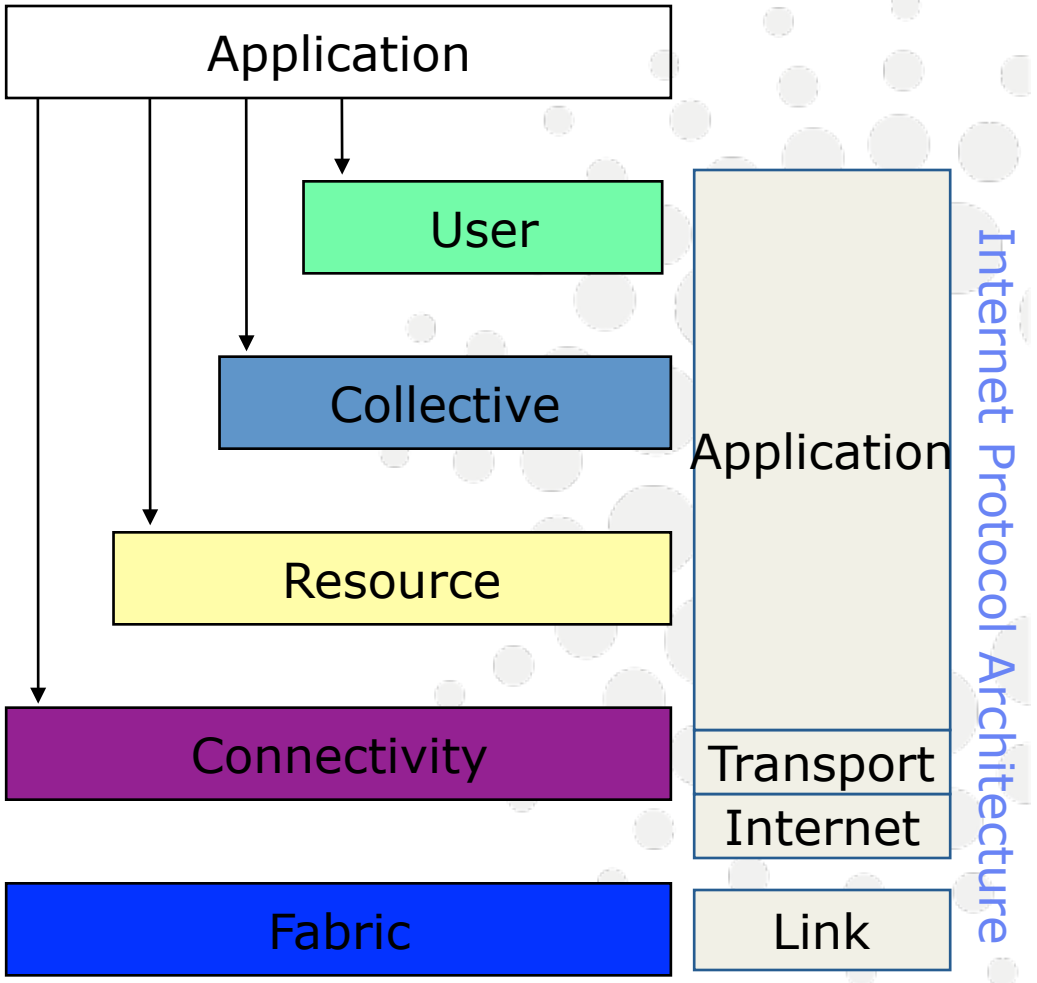
"Specialized services": user- or appln-specific distributed services

"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

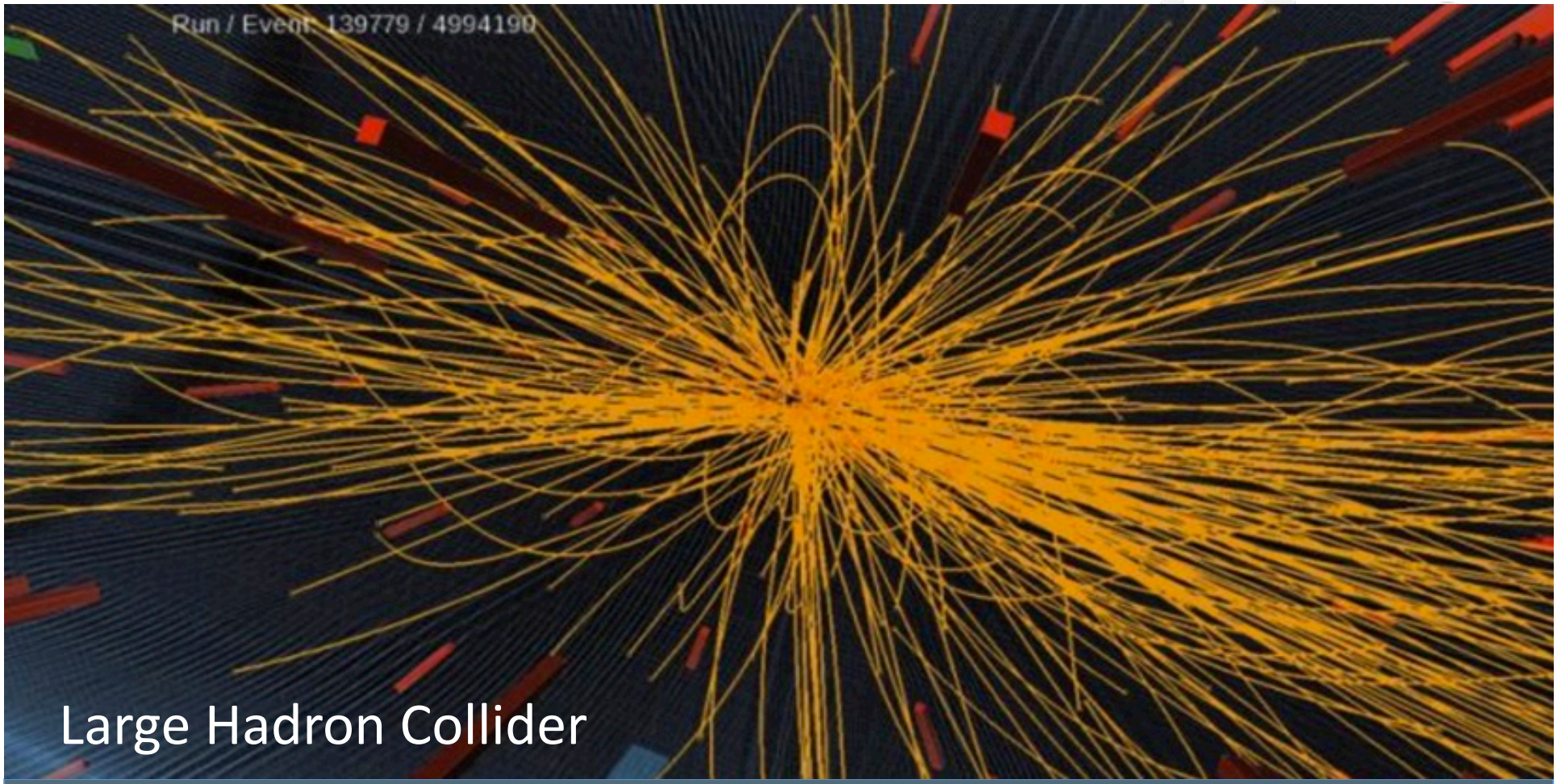
The … problem that underlies the Grid concept is coordinated resource sharing and problem solving in **dynamic, multi-institutional virtual organizations**. The sharing that we are concerned with is not primarily file exchange but rather direct access to computers, software, data, and other resources, 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).**

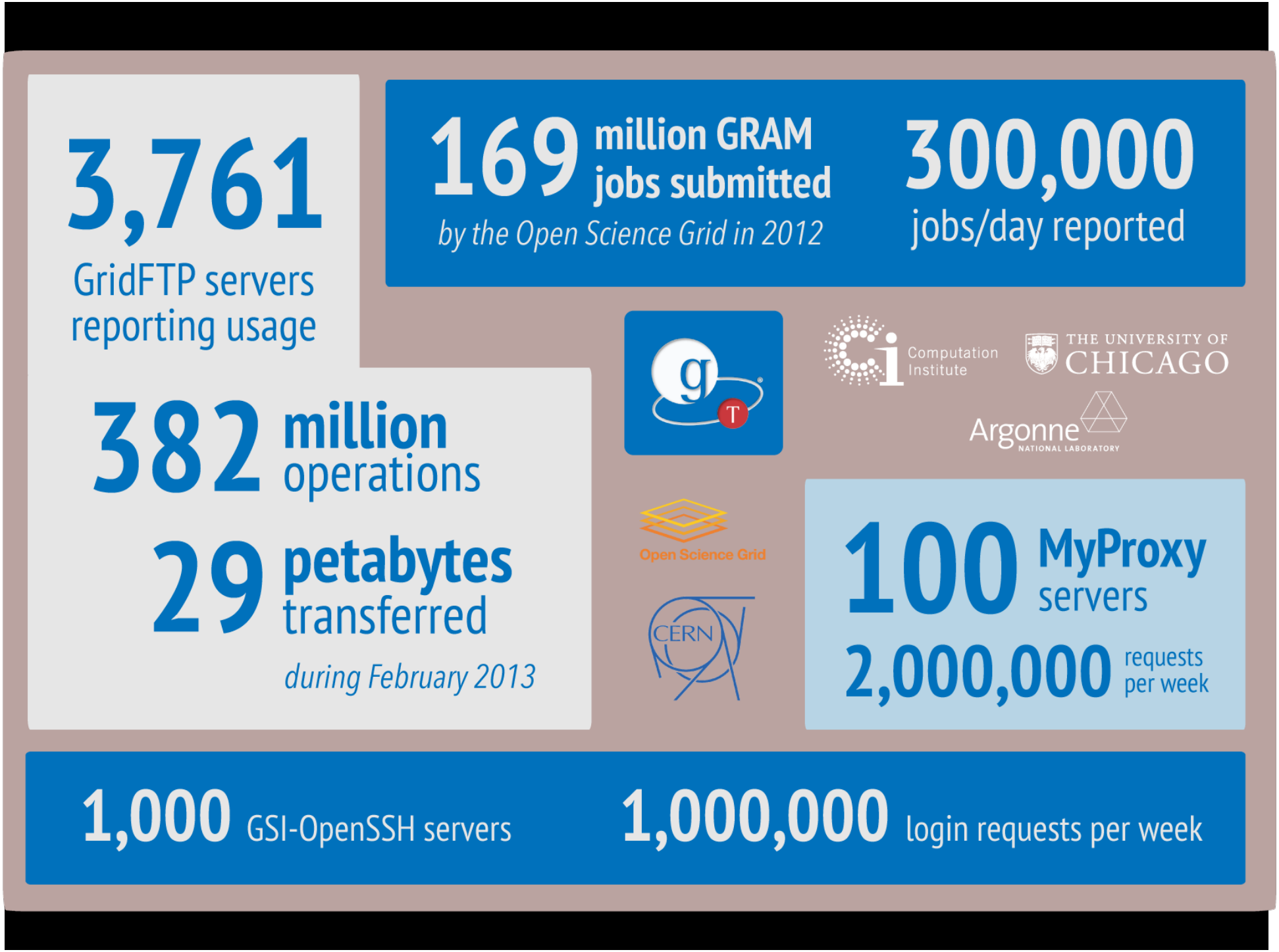
Examples (from AotG, 2001)

- "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"

Grid technology accelerates discovery

Higgs discovery "only possible because of the **extraordinary achievements** of … **grid computing**"—Rolf Heuer, CERN DG




3,761
GridFTP servers reporting usage
169 million GRAM jobs submitted
by the Open Science Grid in 2012
300,000
jobs/day reported
382 million operations
29 petabytes transferred
during February 2013
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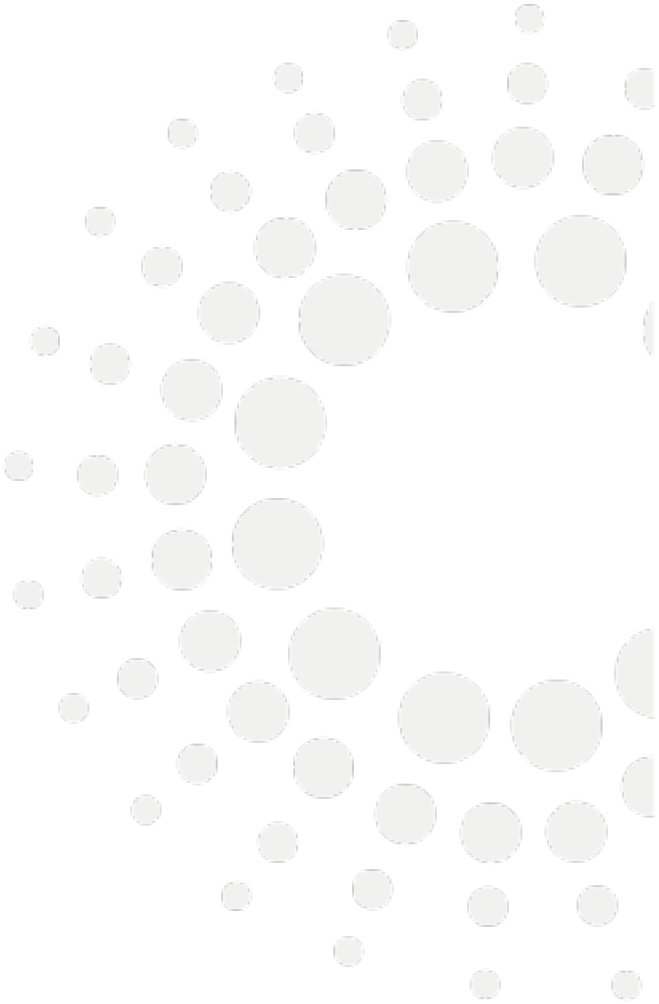
Open Science Grid
CERN
100 MyProxy servers
2,000,000 requests per week
1,000 GSI-OpenSSH servers
1,000,000 login requests per week

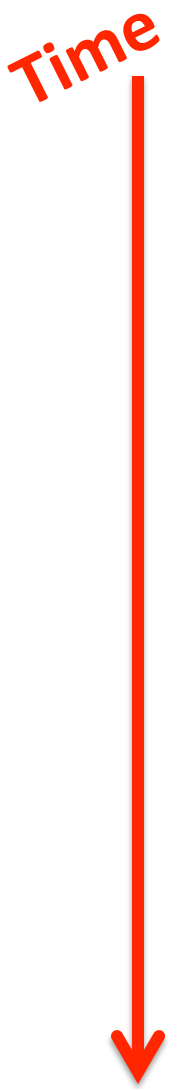
What has changed? { Causation or just correlation? Discuss …

- Thousands of people learned about the joys of large-scale distributed systems
- Virtual organization concepts and technologies
- Now routine to move 100s of terabytes (e.g., GridFTP moves >1 petabyte per day)
- High throughput computing is mainstream (e.g., Condor and Globus run millions of jobs per day)
- Large Hadron Collider found the Higgs
- Earth System Grid supports >25,000 users
- Commercial cloud computing has exploded

Looking forward



Complexity in research is large and growing



Run experiment

Collect data

Move data

Check data

Annotate data

Share data

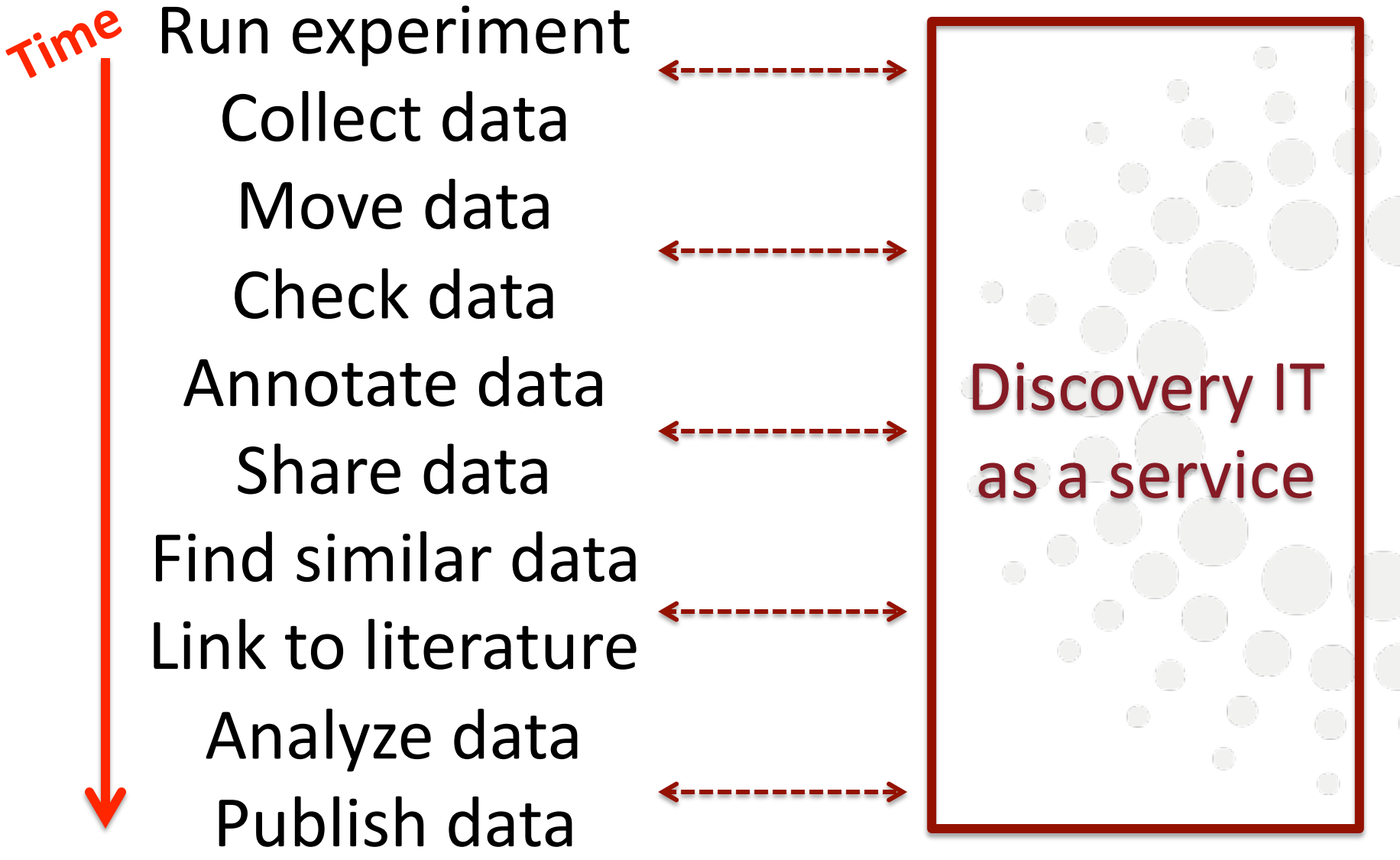
Find similar data

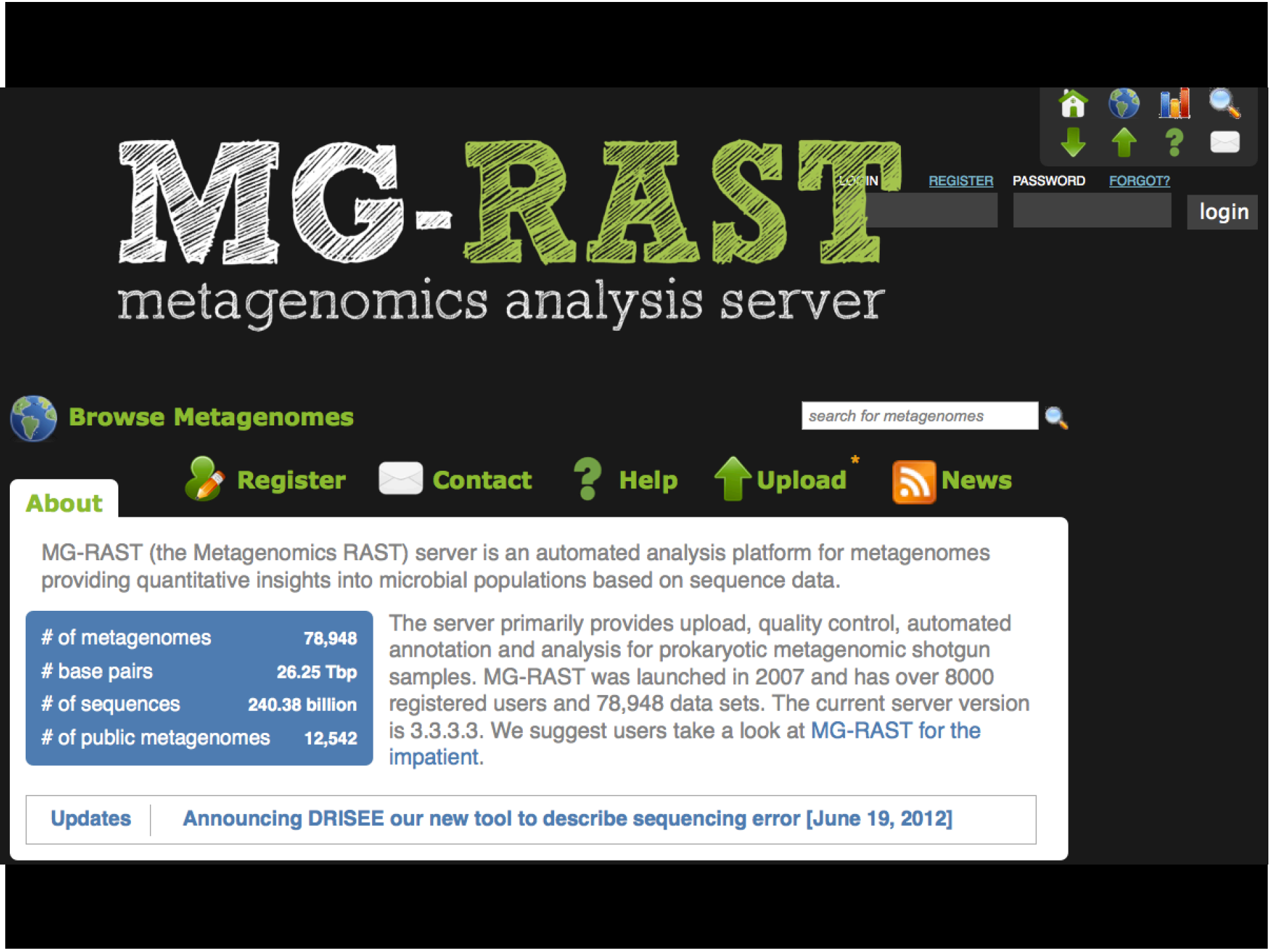
Link to literature

Analyze data

Publish data

Process automation for discovery




MG-RAST
metagenomics analysis server
LOGIN
REGISTER
PASSWORD
FORGOT?
login
Browse Metagenomes
search for metagenomes
Register
Contact
Help
Upload
News
About
MG-RAST (the Metagenomics RAST) server is an automated analysis platform for metagenomes providing quantitative insights into microbial populations based on sequence data.
# of metagenomes 78,948
base pairs 26.25 Tbp
of sequences 240.38 billion
# of public metagenomes 12,542
The server primarily provides upload, quality control, automated annotation and analysis for prokaryotic metagenomic shotgun samples. MG-RAST was launched in 2007 and has over 8000 registered users and 78,948 data sets. The current server version is 3.3.3.3. We suggest users take a look at MG-RAST for the impatient.
Updates
Announcing DRISEE our new tool to describe sequencing error [June 19, 2012]

Managing data should be easy …

… but it's often hard and frustrating!

Staging Store

Expired credentials

Permission denied

Quota exceeded

Network failed. Retry.

Archive

Mirror

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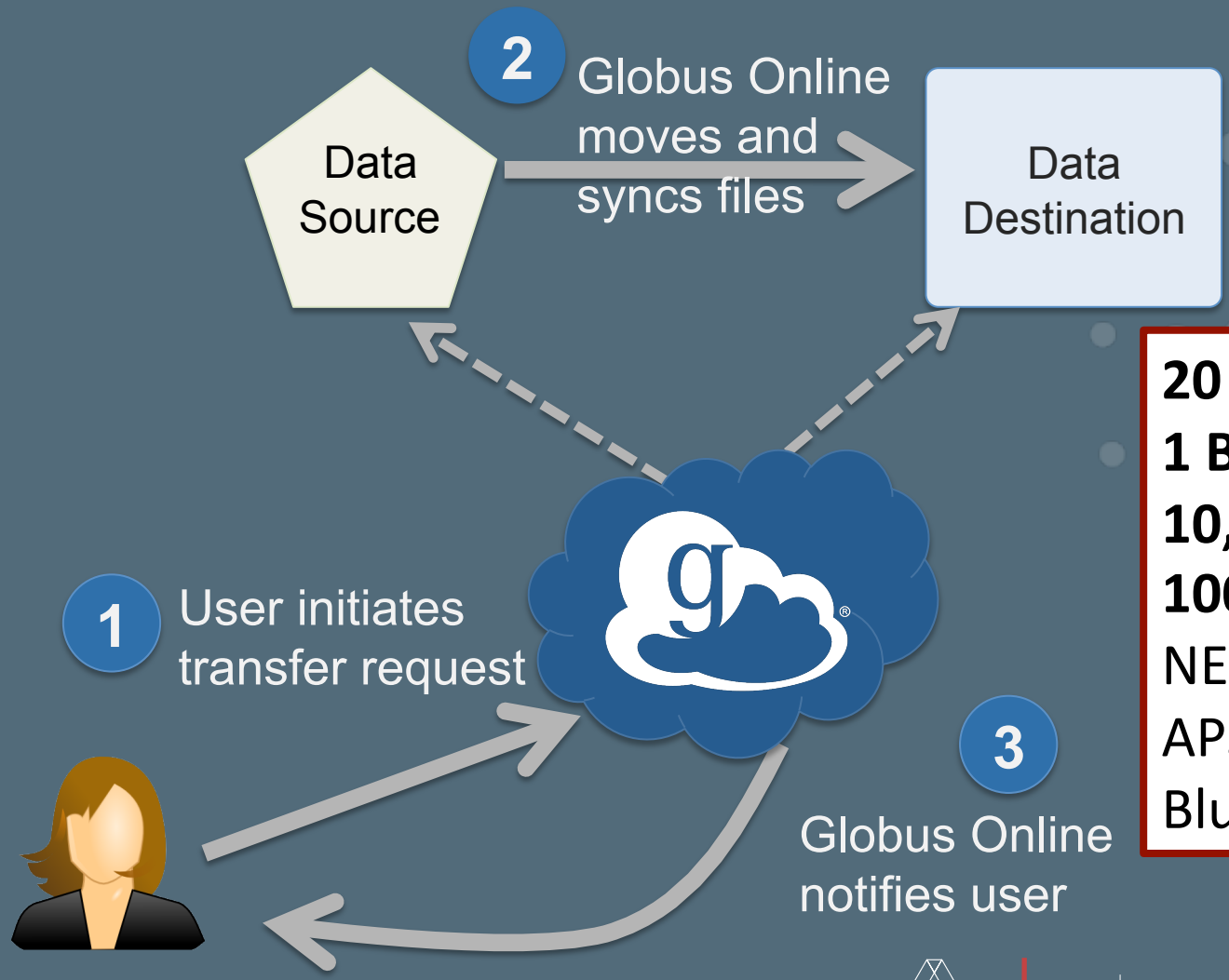
We started with reliable, secure, high-performance **file transfer** …



20 PB moved
1 B files
10,000 users
100s of endpoints
NERSC, ALCF, OLCF,
APS, ALS,
Blue Waters, XSEDE

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… and then made it simple to **share** big data off existing storage systems

2 Globus Online tracks shared files; no need to move files to cloud storage!

Data Source

1 User A selects file(s) to share, selects user or group, and sets permissions

3 User B logs in to Globus Online and accesses shared file

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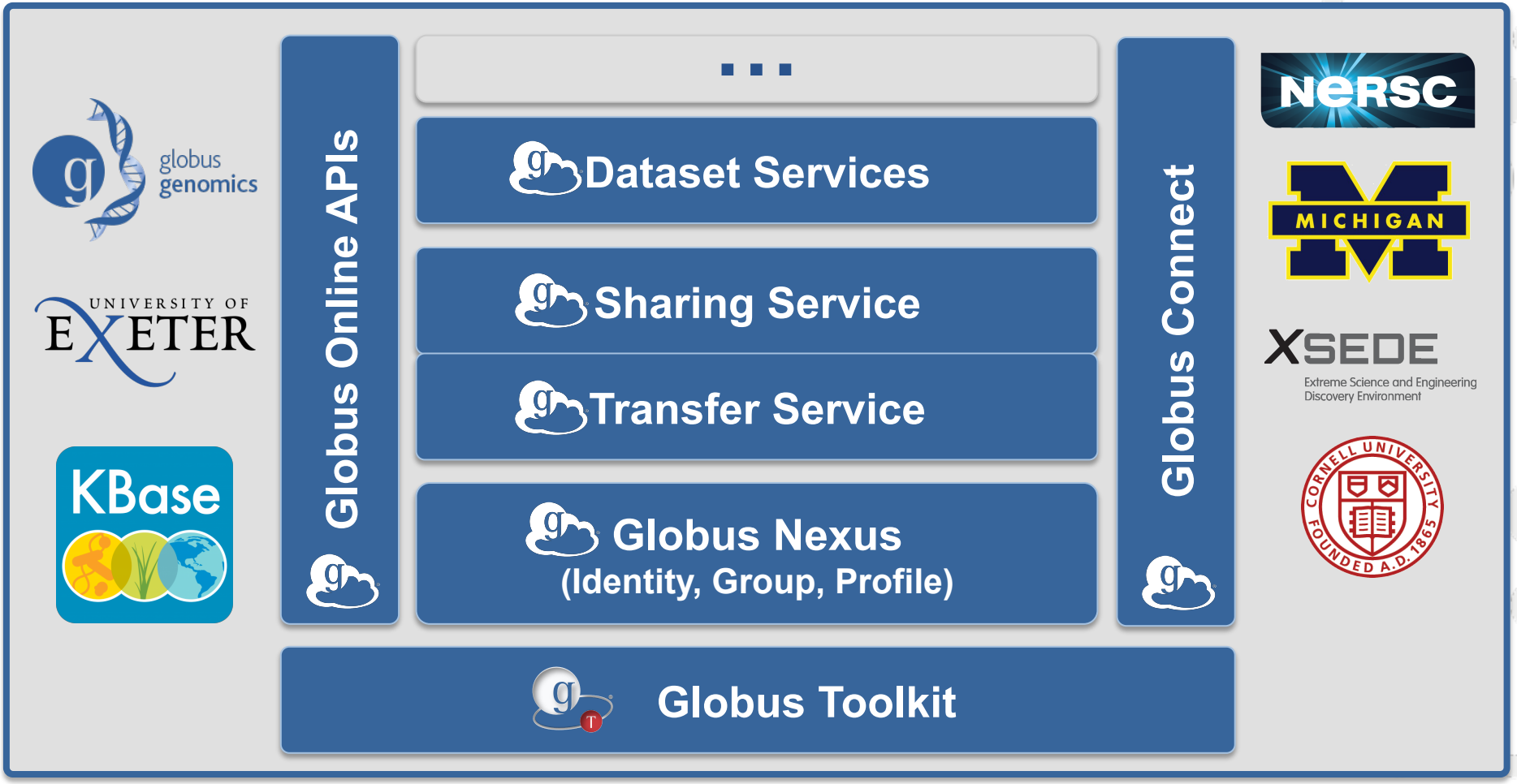
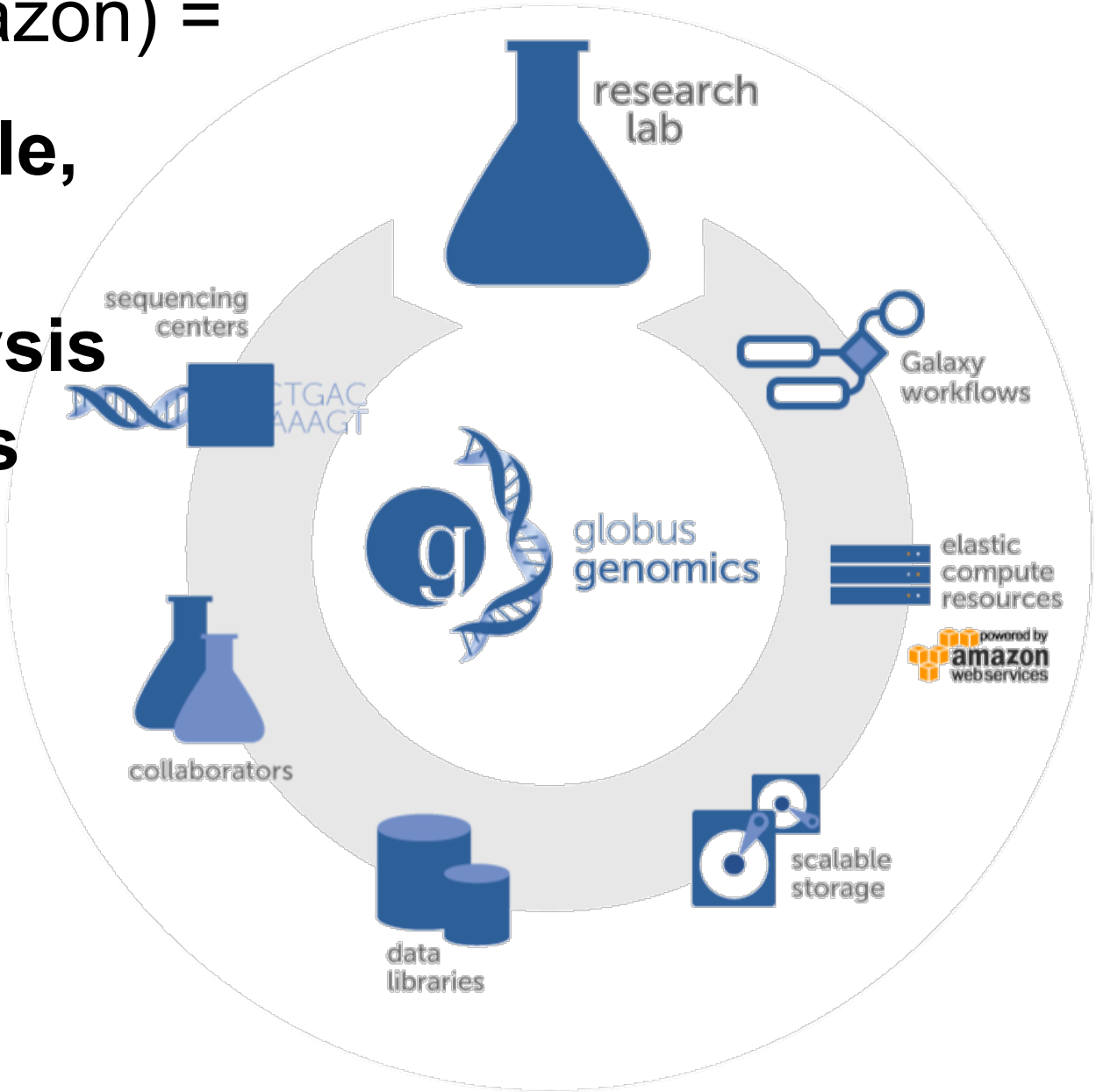
And are now expanding to a platform

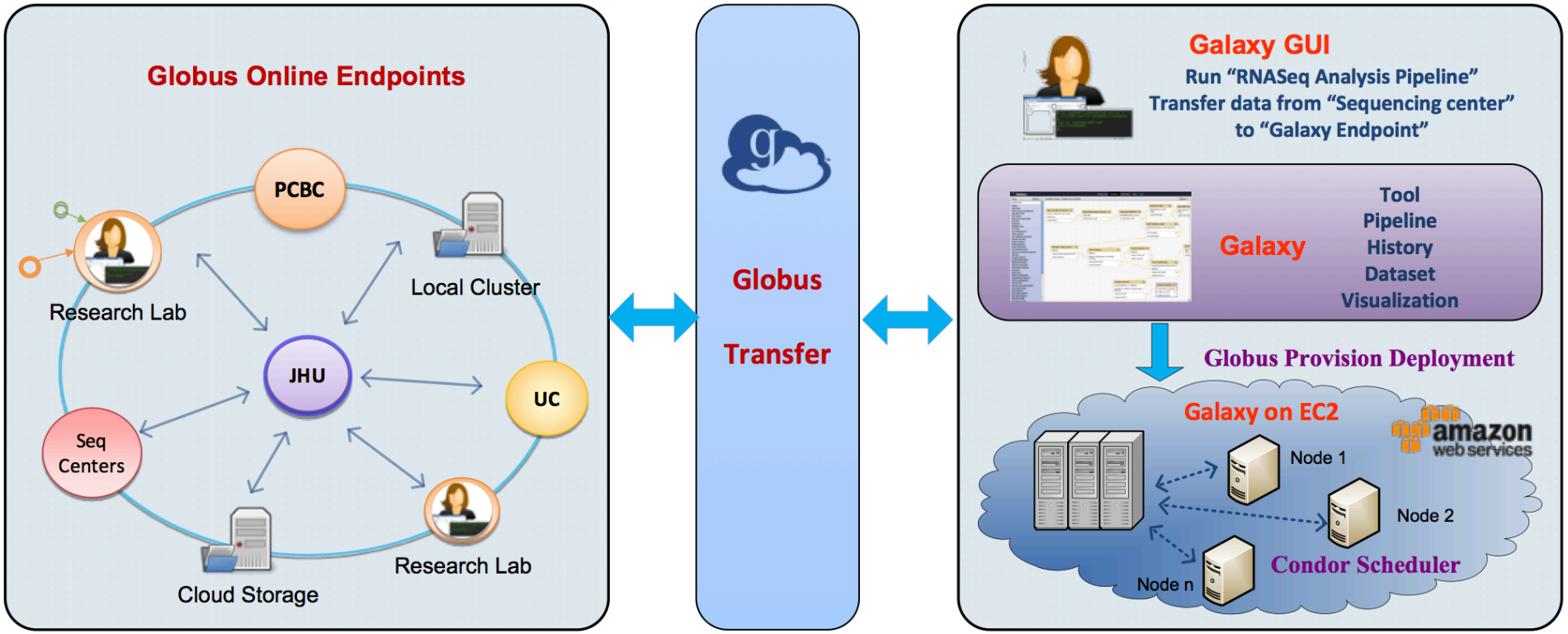


Data management SaaS (Globus) +
Next-gen sequence analysis pipelines (Galaxy) +
Cloud IaaS (Amazon) =

Flexible, scalable, easy-to-use genomics analysis for all biologists



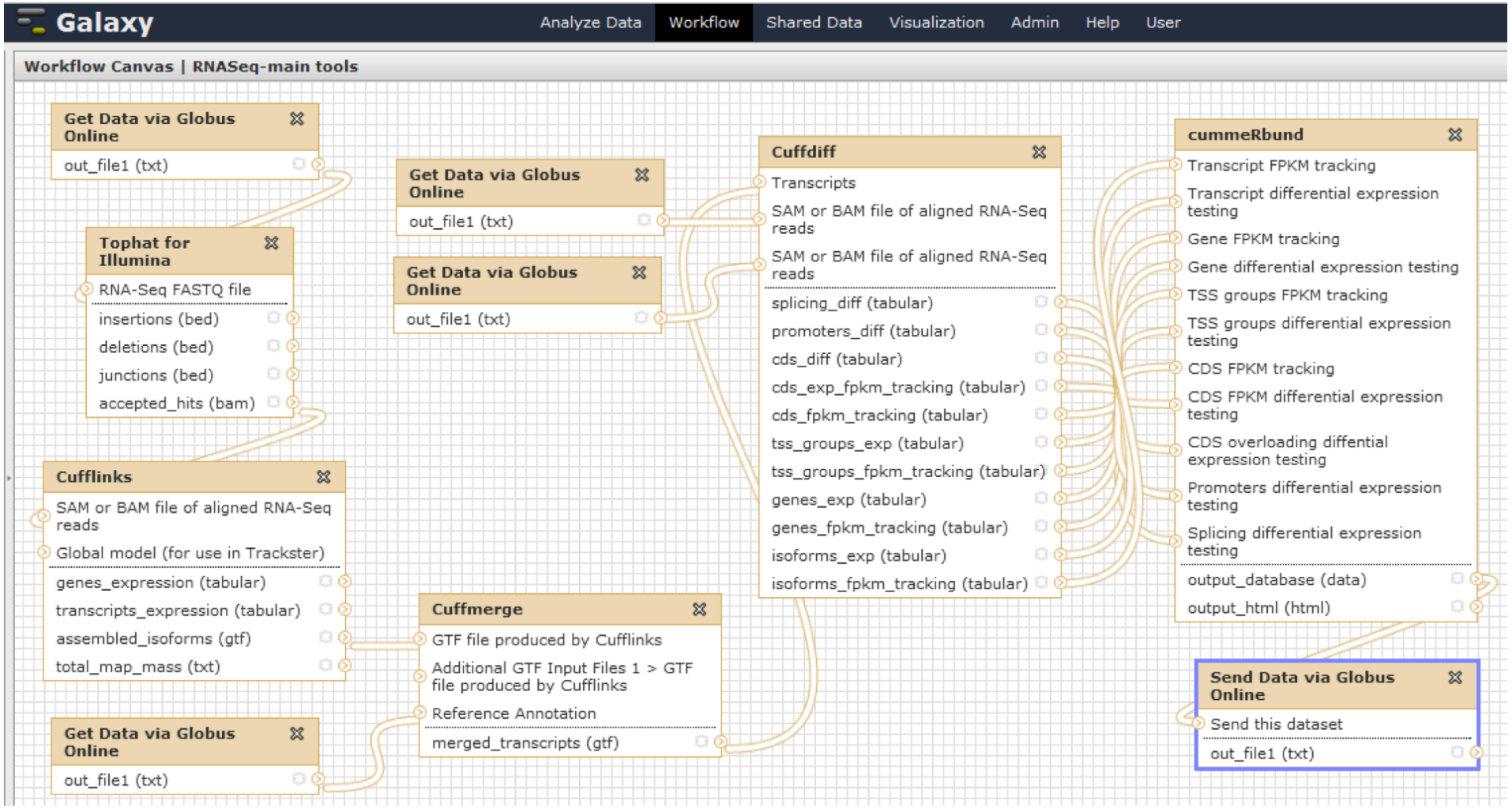
Globus Genomics service



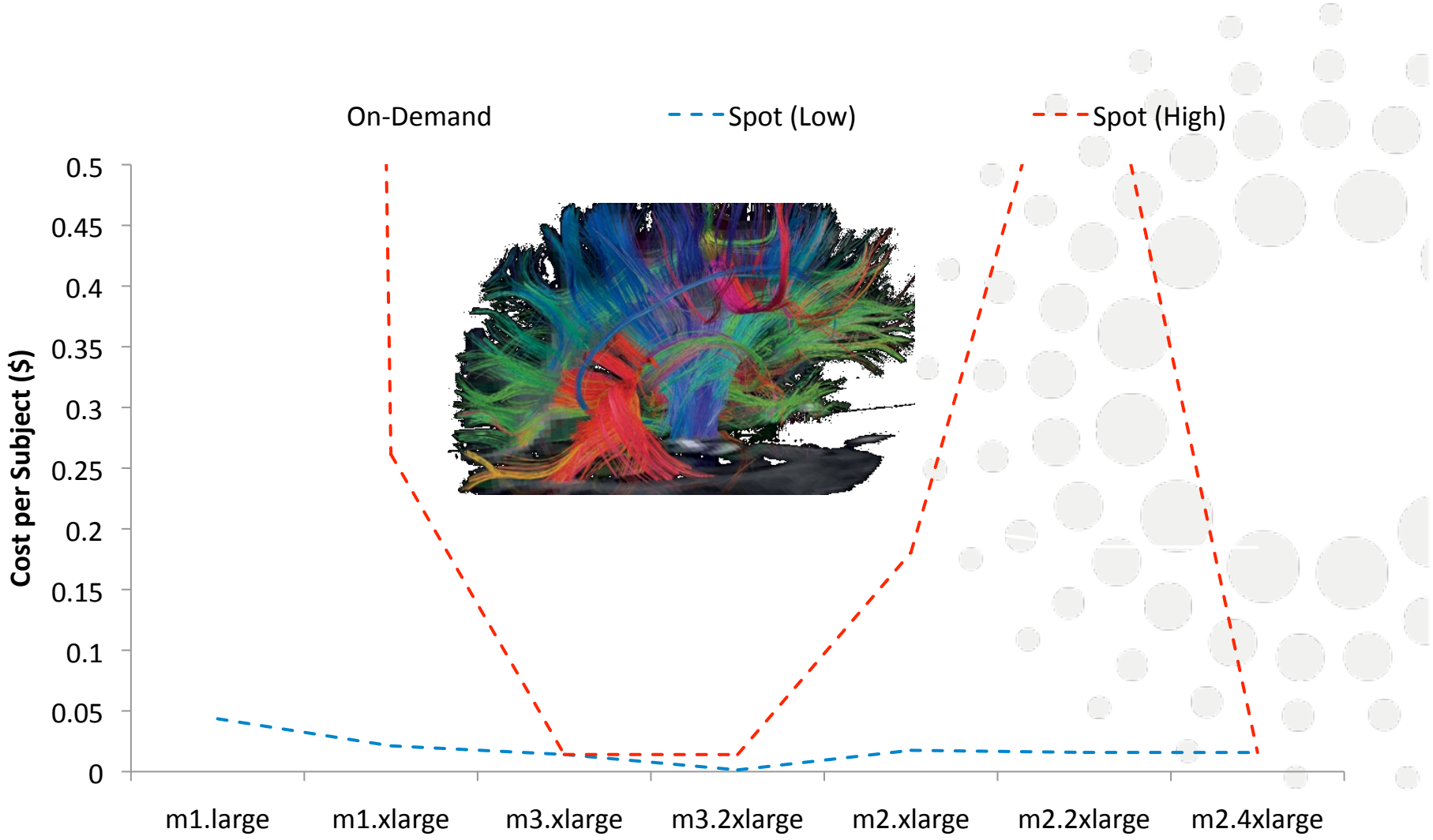
Data Transfer and Sharing

Data Analysis

RNA-Seq pipeline



Amazon pricing for imaging pipeline



Credit: Kyle Chard

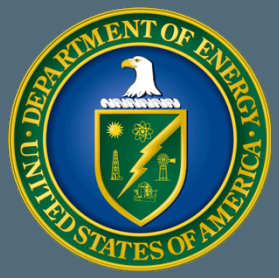
Computing on demand for science

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

Thanks to ...



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Thank you! Questions?

foster@anl.gov
foster@uchicago.edu