U.S. DEPARTMENT OF ENERGY

BERKELEY LAB

ESnet
ENERGY SCIENCES NETWORK

Science Networks: Foundations for Multi-Site Workflows

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Workflow Community Talk
Virtual
14 May 2025

What is a Science Network?

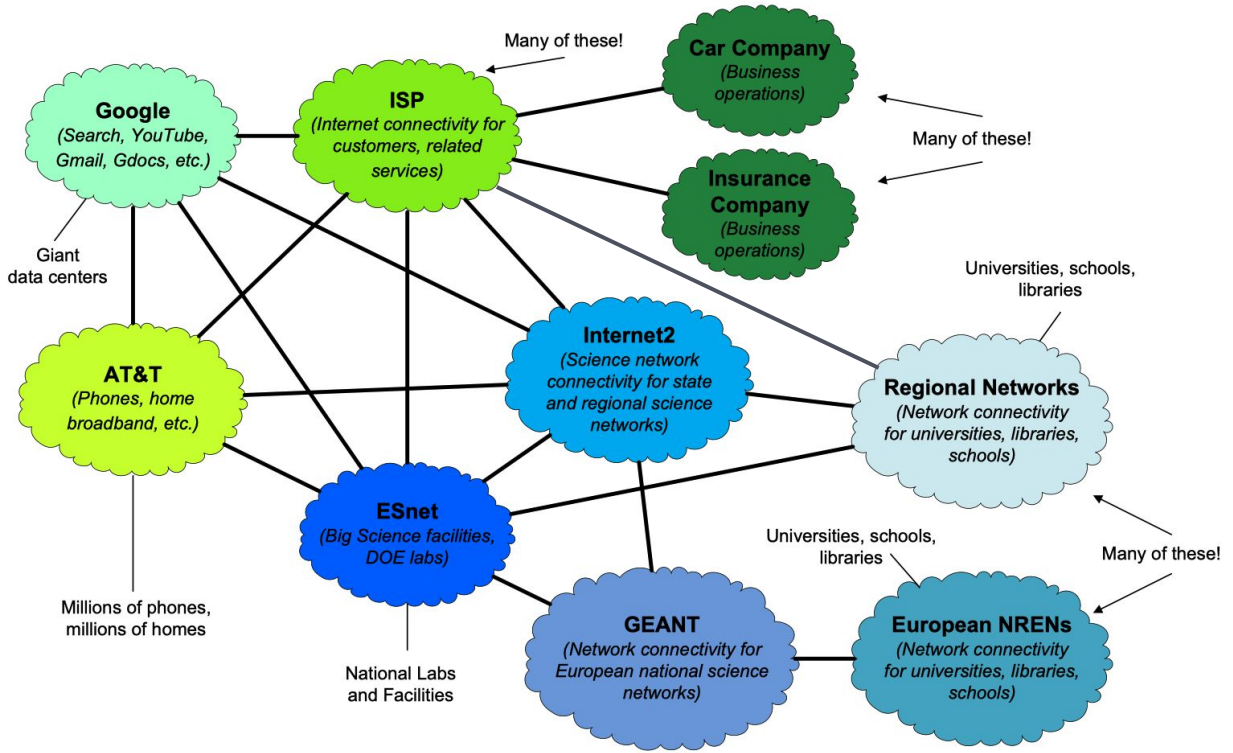
- Downloading data, using a cloud-enabled app, calling a REST API, streaming content - all of these happen via the network
  - What does "**via the network**" actually mean?
  - What is "**the network**" anyway?
- Most of us are familiar with the notion of an ISP (ATT, Verizon, Comcast, etc)
  - Internet access at home (Netflix, online gaming, etc.)
  - Data for phones (Facebook, maps, Google, etc.)
  - This is "the Internet" that most people see
- Science networks interconnect scientific sites
  - HPC facilities, data facilities
  - Particle accelerators (LHC, light sources, …), tokamaks, microscopes, …
- Science networks use the same protocols as the rest of the Internet
- They are also connected to the rest of the Internet

The Internet

- The Internet is composed of a large number of individual networks
  - Each is run by some entity for its own reasons
    - Google
    - US Department of Defense
    - Ford Motor Company
    - US Department of Energy (ESnet!)
    - AT&T
  - Each network connects to others for its own reasons
- In general, networks are more valuable when connected to each other
  - But remember – **this connectivity happens for selfish reasons**
  - Not all networks are the same – each exists for its own reasons

Selected networks and their missions

- Simplified to illustrate a couple of points
  - Types of networks
  - Types of relationships
- Green palette: commercial
- Blue palette: science



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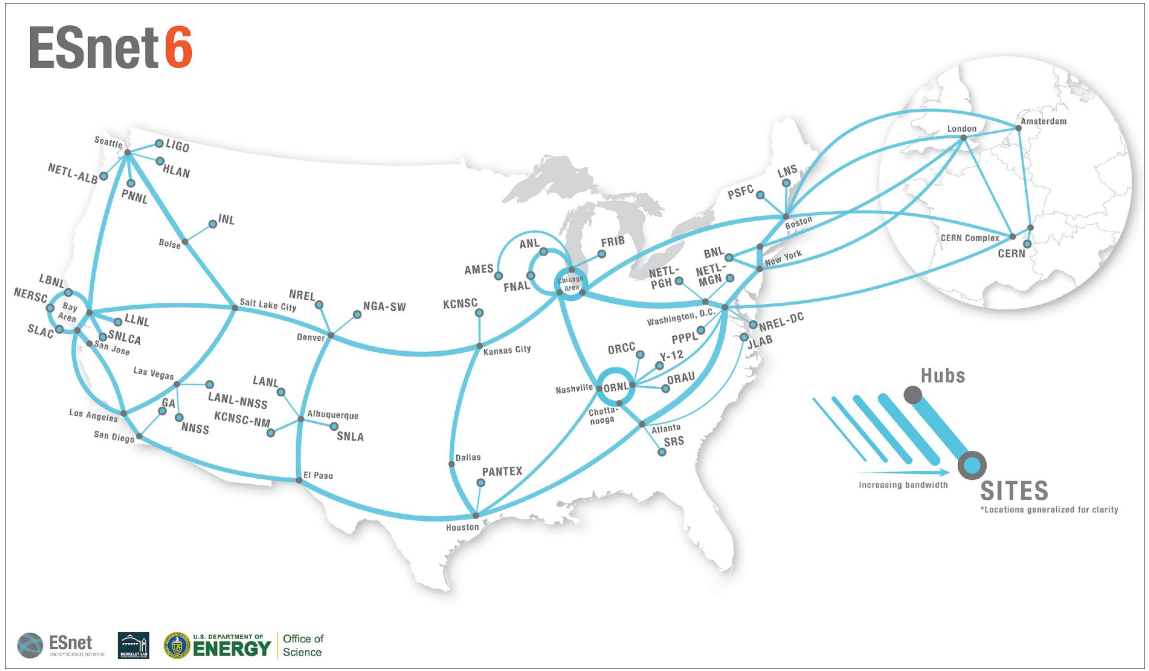
Notes about different networks

- The previous diagram is a drastic simplification
  - https://www.caida.org/projects/as-core/2020/
- Key points:
  - All networks exist for a specific reason
    - Some networks provide connectivity between networks
    - Some networks primarily serve their own users
    - Some networks provide connectivity to users who access services provided via different networks (e.g. Google)
  - These lines are blurry, but it's a useful way to think about it
- Network mission influences engineering, policy, reliability, etc.
  - Not all networks are built the same way
  - Not all networks can support all use models
  - Science networks have a different traffic profile than commercial networks

This is not an ISP



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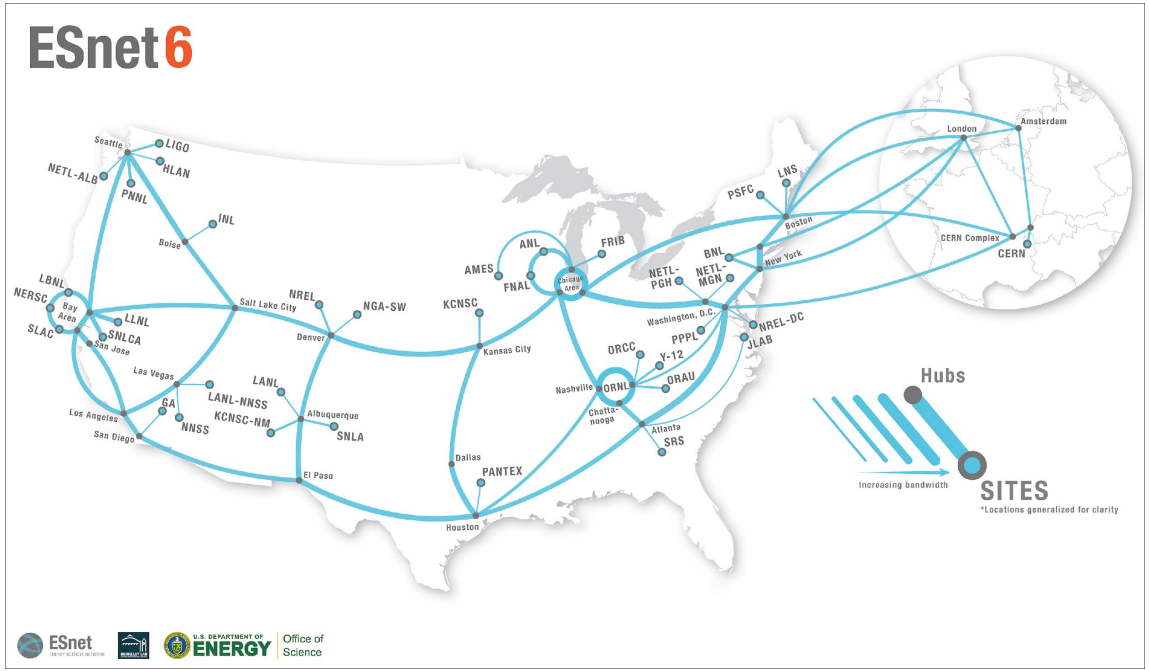
It’s a DOE User Facility, built for science



We do this by offering unique capabilities and optimizing the facility for data acquisition, data placement, data sharing, data mobility.

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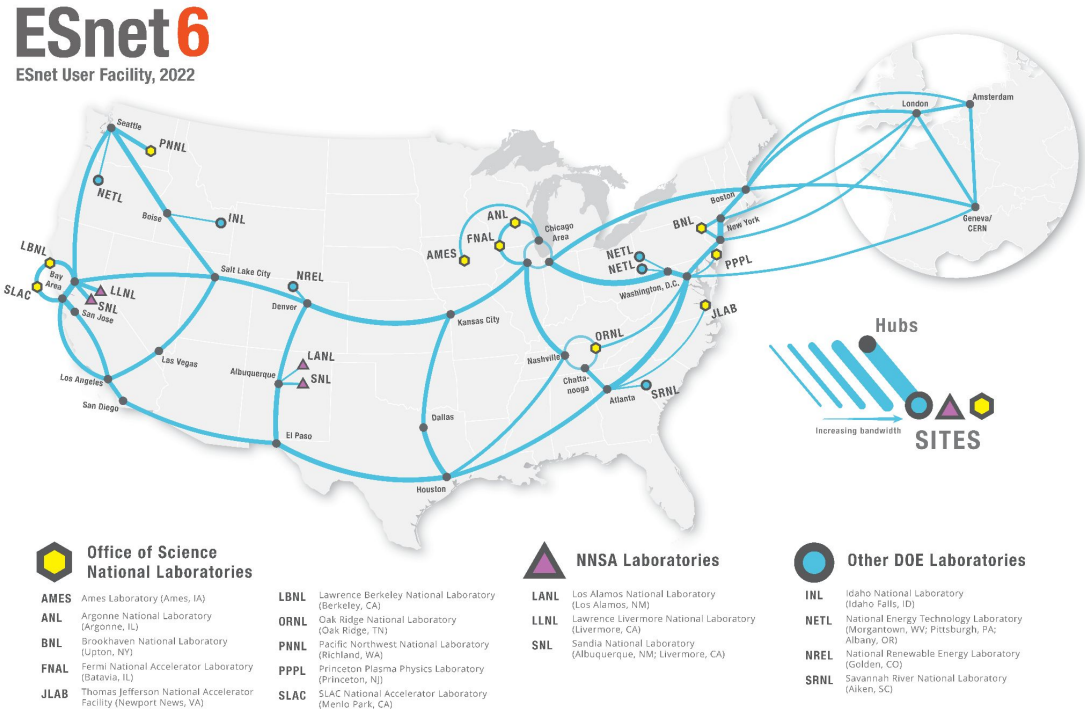
ESnet is the DOE'S data circulatory system…

- ESnet supports the DOE scientific research ecosystem.
- Interconnects all national labs and user facilities
- Provides reliable, high-performance connectivity to global research collaborations, the Cloud, and the larger Internet.



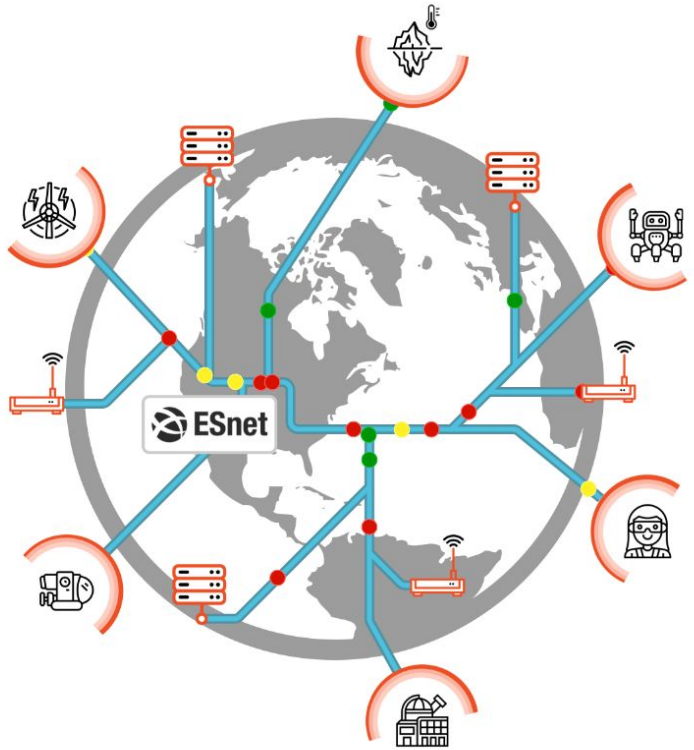
…and the stage for a global science laboratory.

ESnet's Vision

Scientific progress will be completely unconstrained by the physical location of instruments, people, computational resources, or data.

ESnet's Mission

Networking that accelerates science.



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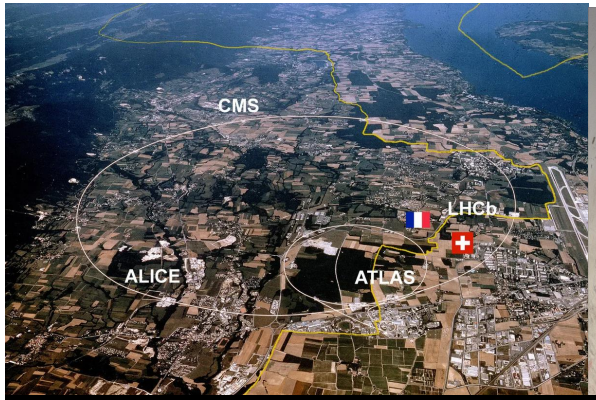
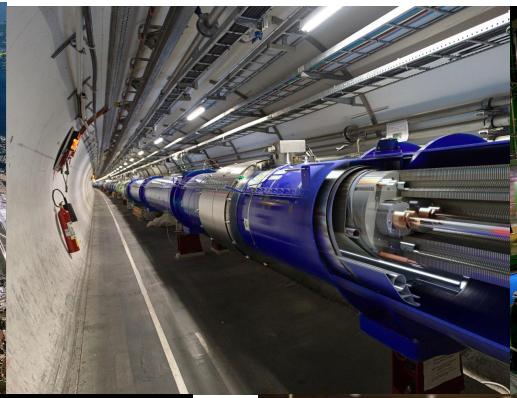
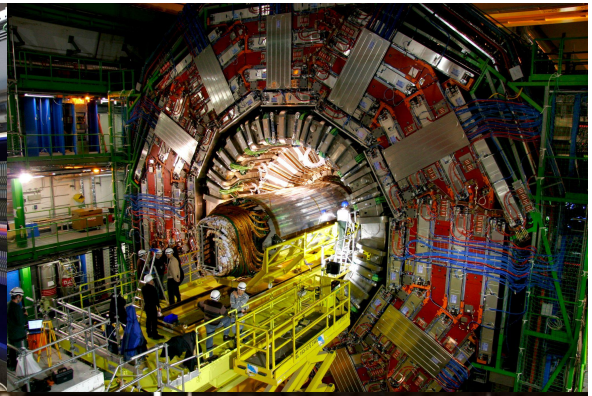
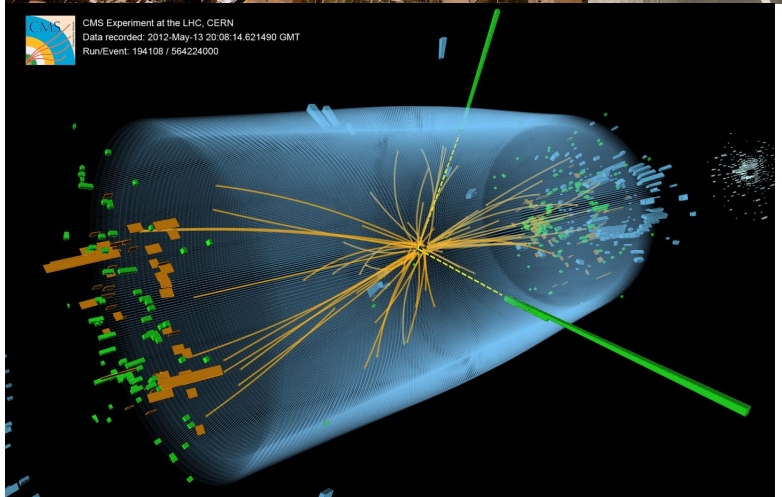
Example: Large Hadron Collider



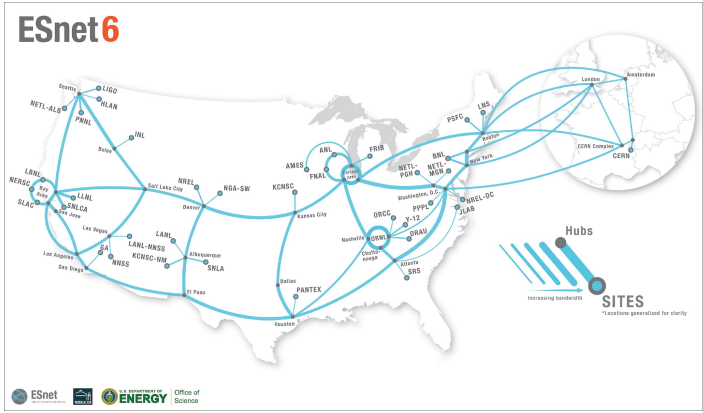


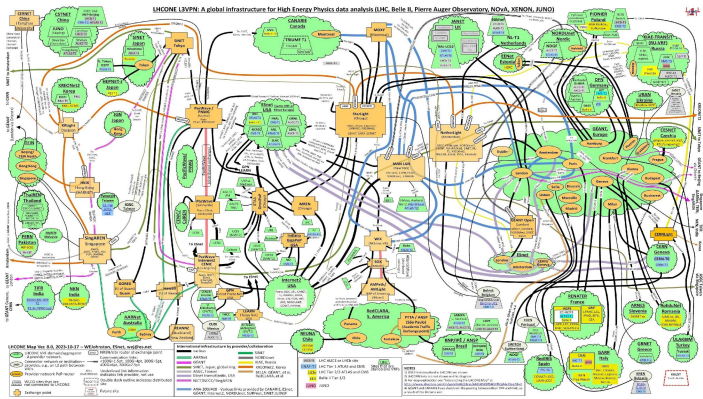




Example: Large Hadron Collider

- ESnet is the primary carrier of LHC data traffic in the United States
- Brookhaven National Laboratory (ATLAS) and Fermilab (CMS) Tier 1 sites
- Collaborate with regional networks and exchange points to connect LHC computing on campuses
- Play a leading role in the global science network collaboration supporting LHC (for decades!)





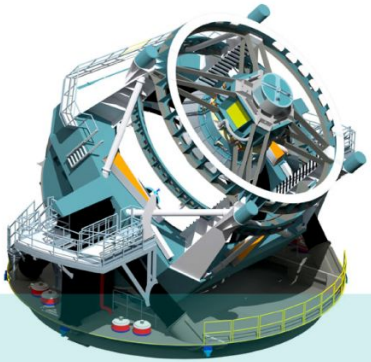
Example: Vera Rubin Observatory

- Data comes from the telescope in Chile to SLAC
  - World's largest digital camera on telescope in Chile
  - Data path traverses many networks, including ESnet
  - Prompt analysis and alert generation at SLAC
- Multinational networking collaboration required to get the data to SLAC
- Data products (alerts, as well as data releases) distributed from SLAC to scientists globally

Rubin Data Management System includes both making data and serving data to users

Raw Data: 20TB/night

Sequential 30s images covering the entire visible sky every few days



LSST SCIENCE PIPELINES

Prompt Data Products

- Alerts incl. science, template and difference image cutouts — 60s — via Alert Streams
- Catalogs of detections incl. difference images, transient, variable & solar system sources — 24h — via Prompt Products
- Raw & processed visit images (PVIs), difference images — 80h — via Image Services

Data Release Data Products

Final 10yr Data Release:

- Images: 5.5 million x 3.2 Gpixels
- Catalog: 15PB, 37 billion objects

via Data Releases

Community Brokers

Rubin Data Access Centres (DACs)

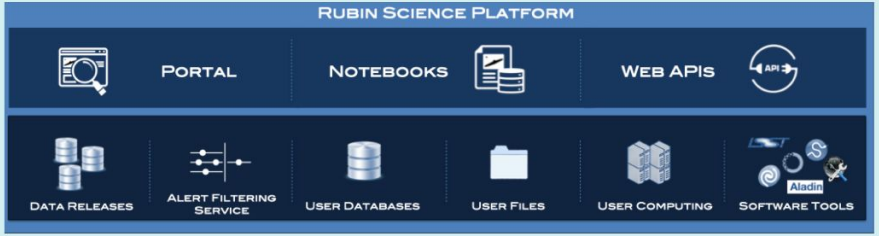
USA (USDF)
Chile (CLDF)
France (FRDF)
United Kingdom (UKDF)

Independent Data Access Centers (IDACs)

Access to proprietary data and the Science Platform require Rubin data rights

Rubin Science Platform

Provides access to LSST Data Products and services for all science users and project staff.



Credit: Leanne Guy

Science Networks Support Science

- The LHC and Rubin Observatory are examples
- Many, many, many more experiments and collaborations
  - Particle accelerators (light sources, physics, …)
  - Fusion research (tokamaks, stellarators)
  - Genomics and life sciences (gene sequencers)
  - HPC to support all of this and more
- Each facility, experiment, and research group uses networking
  - Connect to experiments, facilities, computing
  - Transfer data
  - Multi-facility workflows

The ESnet user facility:
Data-circulatory system for all 28 SC facilities

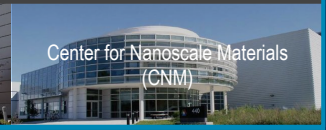
>30,000 science users

ASCR High End Computing (HEC)

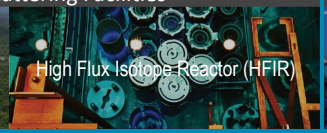
ASCR High Performance Scientific Network

BES X-Ray Light Sources

BES Nanoscale Science Research Centers (NSRCs)



BES Neutron Scattering Facilities



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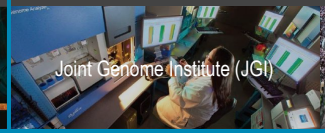

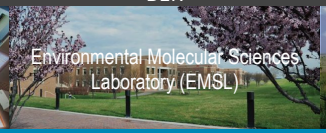

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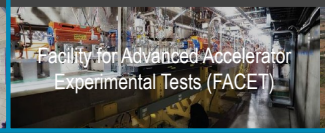

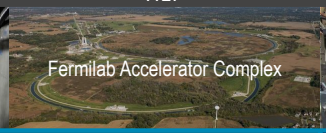

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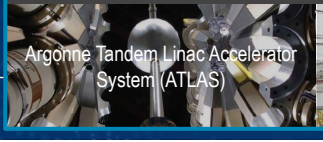

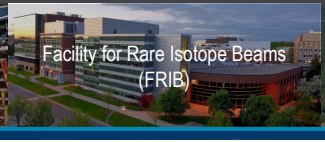

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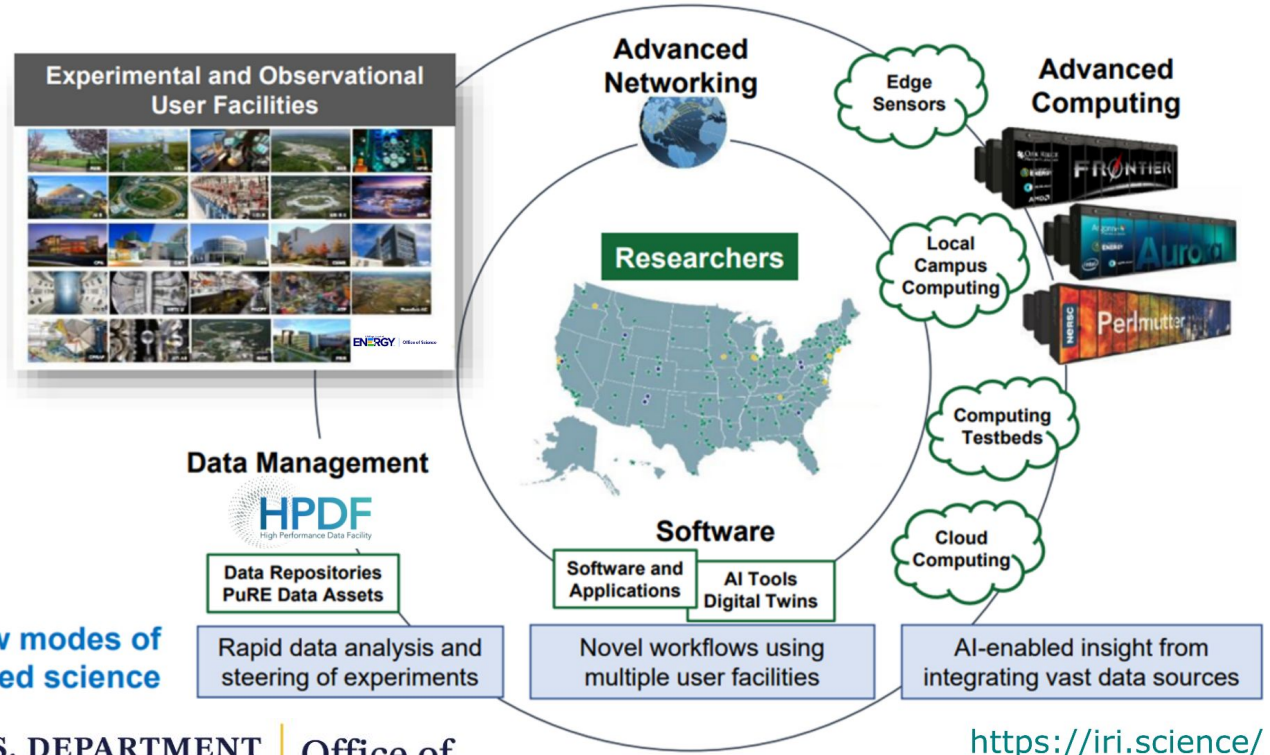
DOE's Integrated Research Infrastructure (IRI) Vision:
To empower researchers to meld DOE's world-class research tools, infrastructure, and user facilities seamlessly and securely in novel ways to radically accelerate discovery and innovation



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https://iri.science/

Multi-Site and Multi-Facility Workflows

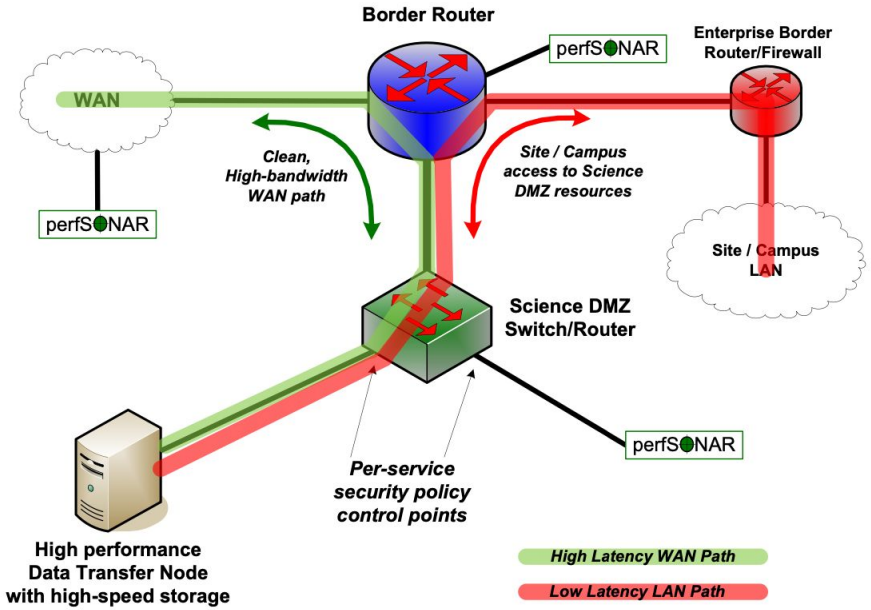
- So what is a multi-facility workflow?
  - Easy: it's a workflow involving more than one facility
  - But what does it actually mean?
- Lots of workflow components - all via the network
  - Data transfer
  - Orchestration
  - Return of results
  - Computing/analysis
  - APIs
- What needs to be done to enable this stuff?

Key Point: Stable and Performant Services

- It's easy to imagine automating to the human interface
  - Lots of ssh scripts out there, for example
  - This kind of thing is where a lot of people start
- Machine interfaces are much better
  - No need for machines to use human interfaces
  - In many cases, machine interfaces are much better for machines
- But if there's no human, then it has to work all the time
  - Machines can't reason their way out of a problem
  - Hard failures (e.g. something crashed) can be caught and corrected
  - Soft failures are much more difficult
    - It's just slow - what is the agent supposed to do?
- Services supporting multi-facility workflows have to work all the time, and perform consistently well

Wide Area Interface for Workflow Services

- Multi-facility workflows take place via the WAN
- Interface between services and the WAN needs to be clean
  - Performant and secure
  - Easy to operate and maintain
- Science DMZ model is best practice
- https://fasterdata.es.net/science-dmz/



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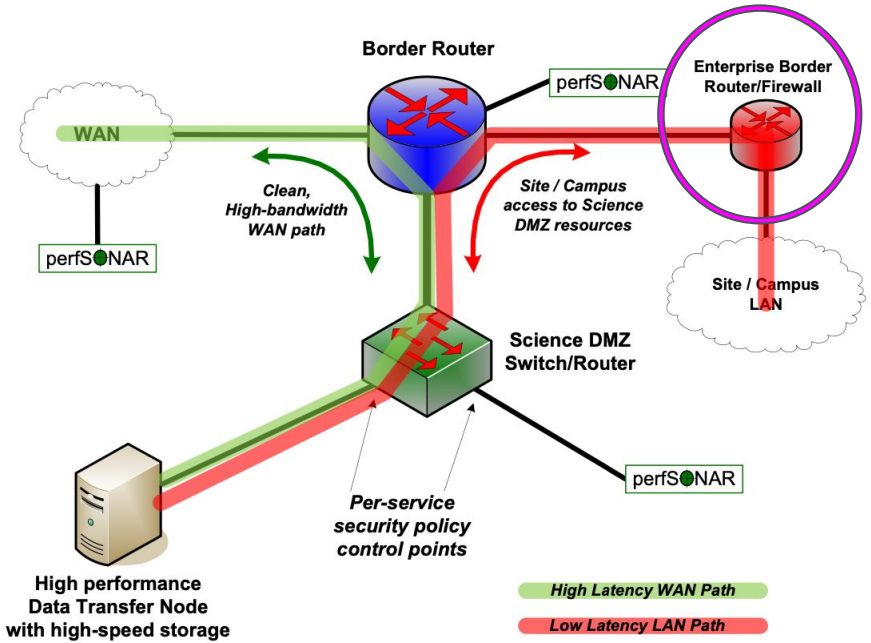
Limitation Is An Enabler

- Only approved services in the Science DMZ
  - Services that can be secured with stateless firewalls
  - Complexity is the enemy
- Allows space for performant security
- Control vs. Data can be handled separately
  - Enterprise firewall is fine for REST control messages
  - Need Science DMZ for high performance data



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Science Networks Support Science

- Science networks, together, form a separate “Science Internet”
  - Capabilities not available in the commercial Internet
  - Performance not available in the commercial Internet
- Effective use of Science Networks is key for modern science
  - End site architecture: Science DMZ
  - Performant workflow services to support multi-site collaborations
- Looking forward to continuing our work together

In conclusion – ESnet's vision:

Scientific progress will be **completely unconstrained** by the physical location of instruments, people, computational resources, or data.

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Thanks!

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