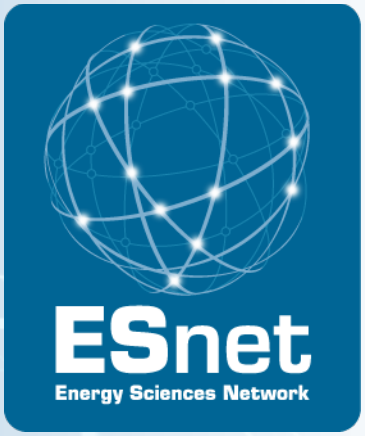

The Science DMZ:
Solving Data Mobility Challenges with the right architecture and the right tools

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ESnet Science Engagement

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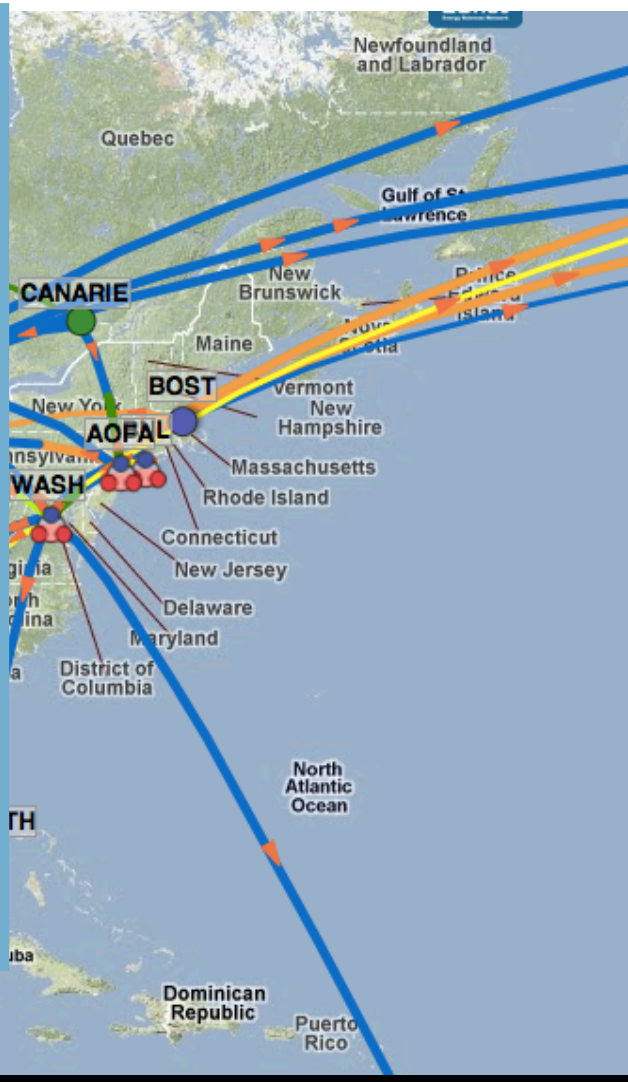
Overview

- What is ESnet?
- Why use the network (vs. hard drive, FedEx)?
- Understanding network performance and expectations
- Science DMZ overview and architecture
- Integration with Globus Online
- Benefits to science

What is ESnet?

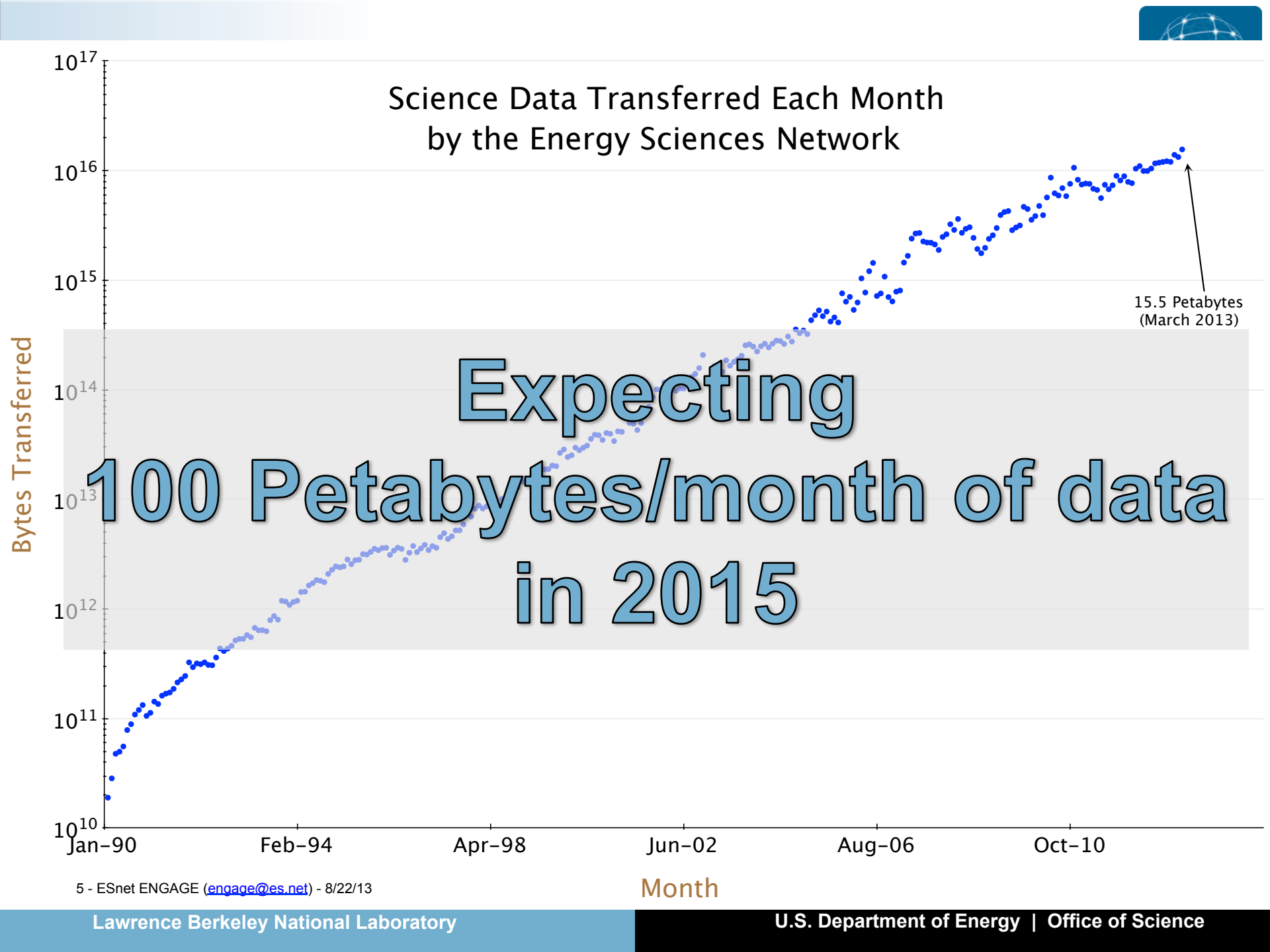
- A high-performance network linking DOE Office of Science researchers to global collaborators and resources around the world, including:
  - Supercomputer centers
  - User Facilities
  - Multi-program labs
  - Universities
  - Connectivity to Internet and Cloud providers
- A national DOE user facility providing:
  - Tailored data mobility solutions for science
  - *Dedicated Science Engagement team to support researchers*
  - Collaboration services e.g. audio/video conferencing



ESnet **Supports DOE Office of Science**

The Office of Science supports:

- 27,000 Ph.D.s, graduate students, undergraduates, engineers, and technicians
- 26,000 users of open-access facilities
- 300 leading academic institutions
- 17 DOE laboratories


Science Data Transferred Each Month
by the Energy Sciences Network
15.5 Petabytes
(March 2013)
Bytes Transferred
Month
Jan-90
Feb-94
Apr-98
Jun-02
Aug-06
Oct-10
Expecting
100 Petabytes/month of data
in 2015

The Future: Data Mobility Services Over Networks

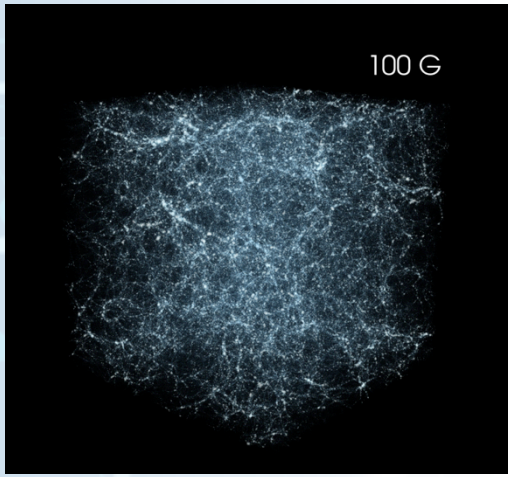
Data transfer between facilities is best achieved using networks

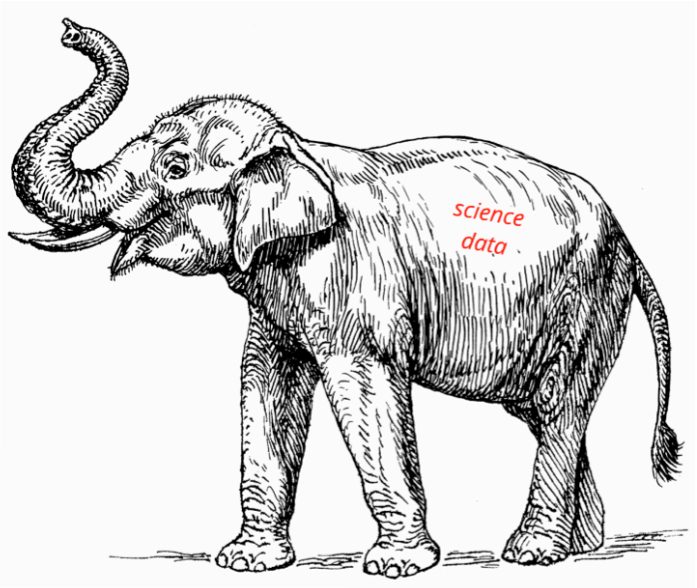
- Physical media transport is time-consuming and error-prone
- People physically transporting disks are a gating factor and reduce science productivity and output
- Multi-facility workflows, data mobility services are the future
  - ✓ *The structure of modern science assumes that global research networks exist and function properly*

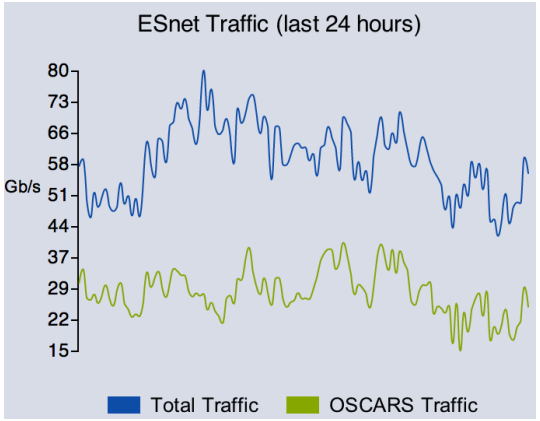
Several types of long distance data services, including:

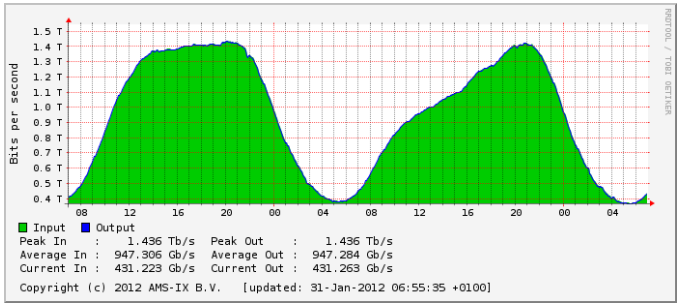
- Movement of data sets between HPC facilities
- Download historical data for model input/reference (e.g. weather)
- Ingest of experimental data for analysis
- Serve data sets or results to remote users

The Wide Area is Engineered for Elephants









Your Campus Network Should Be Engineered for Elephants too!!

Many collaborations still rely on “Sneakernet” – Why?

© 2013 Western Digital

© 2013 FedEx

Common Issues Impeding Network Adoption and Performance

Local Networks are typically built for business use cases, not science – which leads to:

Hardware:

- Firewalls, naively configured or deployed
- "Lossy" Networks
- Systems that aren't well configured, default settings

Software:

- Legacy data transfer tools (scp)

Culture:

- "We've always shipped disks"

© 2013 Renee Richardson photography

Time to Raise Your Network Expectations:
Time to Copy 1 Terabyte

On a…

10 Mbps network: 300 hrs (12.5 days)

100 Mbps network: 30 hrs

1 Gbps network: 3 hrs (are your disks fast enough?)

10 Gbps network: 20 minutes (need really fast disks and a filesystem)

These figures assume some headroom left for other users

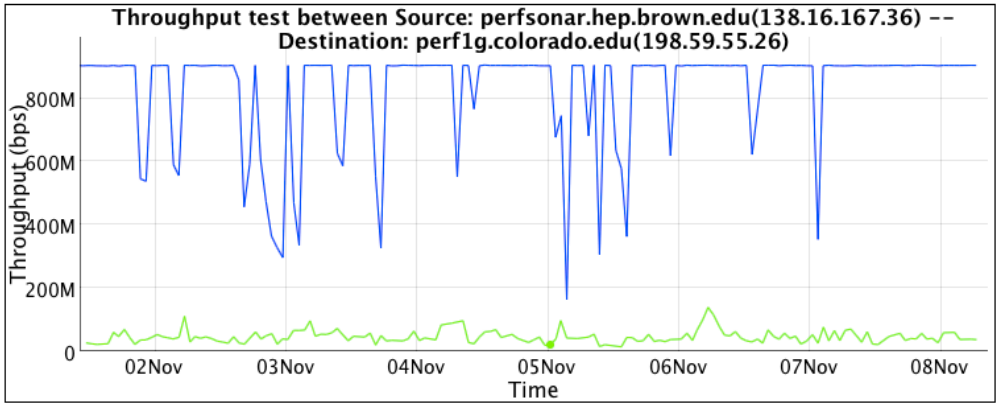
Compare these speeds to:

- USB 2.0 portable disk
  - 60 MB/sec (480 Mbps) peak
  - 20 MB/sec (160 Mbps) reported on line
  - 5-10 MB/sec reported by colleagues
  - 15-40 hours to load 1 Terabyte

Firewall Performance Example

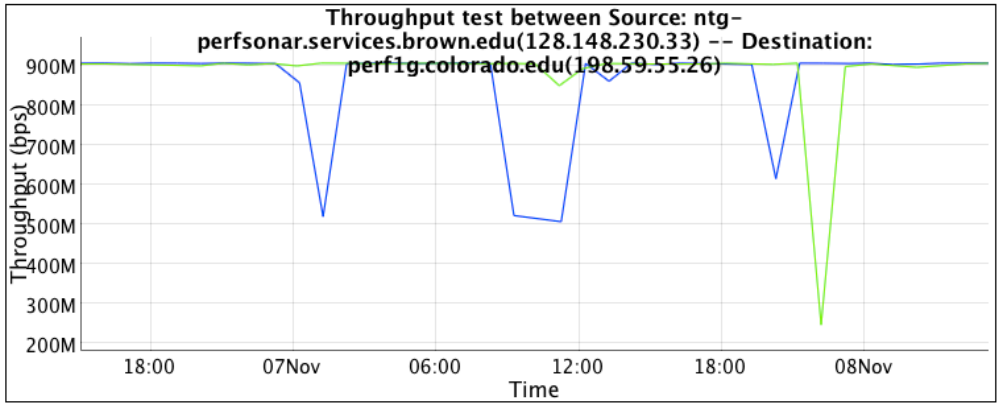
Observed performance, via perfSONAR, through a firewall:

Almost 20 times slower!



Observed performance, via perfSONAR, bypassing firewall:

Traffic was unimpeded by additional processing or resource constraints



Soft Failures

- An automatic network test alerted ESnet to reduced/poor performance on some of our network high latency paths
- Routers did not detect any issues
  - perfSONAR/specialized performance software detected the problem
- PerfSONAR measured a 0.0046% packet loss
  - 1 packet in 22000 packets
- Performance impact of this: (outbound/inbound)
  - To/from test host 1 ms RTT : 7.3 Gbps out / 9.8 Gbps in
  - To/from test host 11 ms RTT: 1.2 Gbps out / 9.5 Gbps in
  - To/from test host 51ms RTT: 800 Mbps out / 9 Gbps in
  - To/from test host 88 ms RTT: 500 Mbps out / 8 Gbps in

CONCLUSION: Data transfer across the US was more than 16 times slower than it should have been. Science is impacted, researchers get frustrated.

Legacy Data Transfer Tools

In addition to the network, using the right data transfer tool is critical

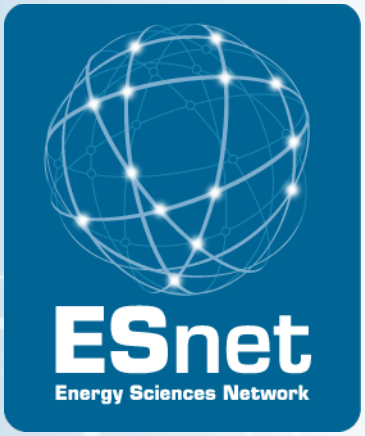
Sample Results:

Data transfer from Berkeley, CA to Argonne, IL (near Chicago).
RTT = 53 ms, network capacity = 10Gbps.

Tool	Throughput
scp:	140 Mbps
HPN patched scp:	1.2 Gbps
ftp	1.4 Gbps
GridFTP, 4 streams	5.4 Gbps
GridFTP, 8 streams	6.6 Gbps

globus online

Note that to get more than 1 Gbps (125 MB/s) disk to disk requires RAID.



Achieving these results:

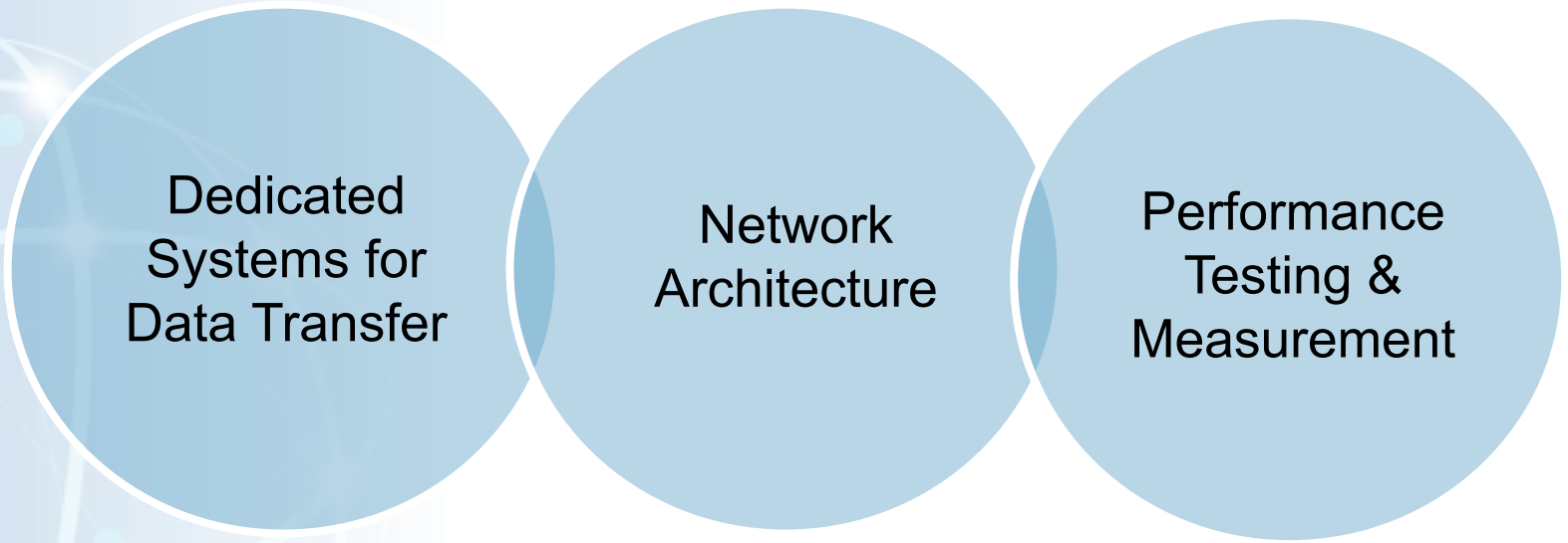
Globus Online-enabled The Science DMZ

What is the Science DMZ?

The Science DMZ is a model for network architectures, system configurations, cybersecurity policies, and performance tools that together create an optimized environment for data-intensive science.

The Science DMZ serves the specific requirements of science applications – “the elephants,” which have entirely unique characteristics compared to “general purpose” or business-oriented applications.

The Data Transfer Trifecta: The "Science DMZ" Model



Data Transfer Node

- High performance
- Configured for data transfer
- Proper tools like Globus Online

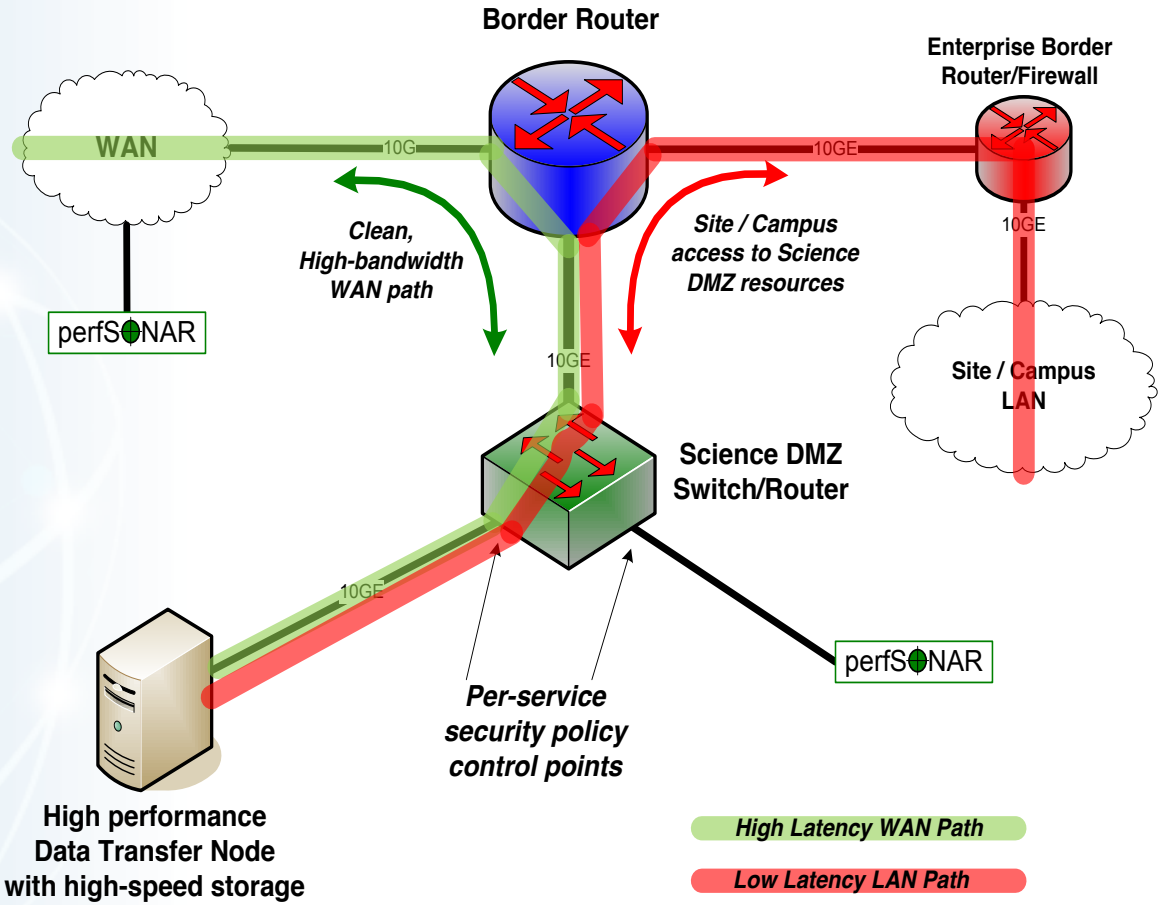
Implementation Location

- Dedicated location for DTN
- Easy to deploy - no need to redesign the whole network

perfSONAR

- Enables fault isolation
- Verify correct operation
- Widely deployed in ESnet and other networks, as well as sites and facilities

Simple Science DMZ



Science DMZ Takes Many Forms

There are many ways to combine the Science DMZ elements – it all depends on what you need to do

- Small installation for a project or two
- Facility inside a larger institution
- Institutional capability serving multiple departments/divisions
- Science capability that consumes a majority of the infrastructure

Some of these are straightforward, others are less obvious

Many Universities and Labs are now creating Science DMZs

- A new NSF program (CC-NIE) is funding several campuses to build a Science DMZ
- Joining the Internet2 “innovation platform” requires having a Science DMZ (http://www.internet2.edu/network/index-innov.html)

Globus Online and the Science DMZ

ESnet recommends Globus Online / GridFTP for data transfers to/from the Science DMZ

Key features needed by a Science DMZ

- High Performance: parallel streams, small file optimization
- Reliability: auto-restart, user-level checksum
- Multiple security models: ssh key, X509, Open ID, Shibboleth, etc.
- Firewall/NAT traversal support
- Easy to install and configure

Globus Online has all these features

ESnet Diagnostic Tool: 10 Gbps IO Tester

- 16 disk raid array: capable of > 10 Gbps host to host, disk to disk
- Runs anonymous read-only GridFTP
- Accessible to anyone on any R&E network worldwide
- 3 deployed on now (west coast, midwest, east coast)
  - lbl-diskpt1.es.net, anl-diskpt1.es.net, bnl-diskpt1.es.net
- Have been used to debug many problems
- Registered as Globus Online “Endpoints”
- See: http://fasterdata.es.net/disk_pt.html

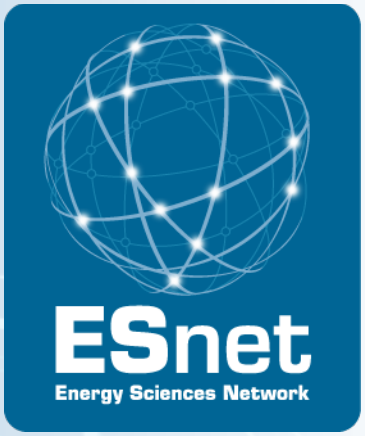
For More Information

http://fasterdata.es.net/science-dmz/

Paper on the Science DMZ to be presented at SC13:

- http://www.es.net/assets/pubs_presos/sc13sciDMZ-final.pdf

Questions? email engage@es.net



Extra Slides

Photon Science Data Increase

Many detectors are semiconductors

- Similar technology to digital cameras
- Exponential growth
- Increase in sensor area (512x512, 1024x1024, 2048x2048, …)
- Increase in readout rate (1Hz, 10Hz, 100Hz, 1kHz, 1MHz, …)

Data infrastructure needs significant change/upgrade

- Most photon scientists are not “computer people”
  - Different from HEP, HPC centers
  - They need data issues solved – they don’t want to solve them
  - ***They should not have to be come network experts!***
- Physical transport of portable media has reached a breaking point
- Default configs no longer perform well enough

ALS Beamline 8.3.2

Broad science portfolio: Applied science, biology, earth sciences, energy, environmental sciences, geology, cosmological chemistry

Detector upgrade → large increase in data rate/volume (50x)

Detector output: sets of large TIFF files

Beamline scientist Dula Parkinson reached out to LBLnet

LBLnet reached out to ESnet

Infrastructure improvements

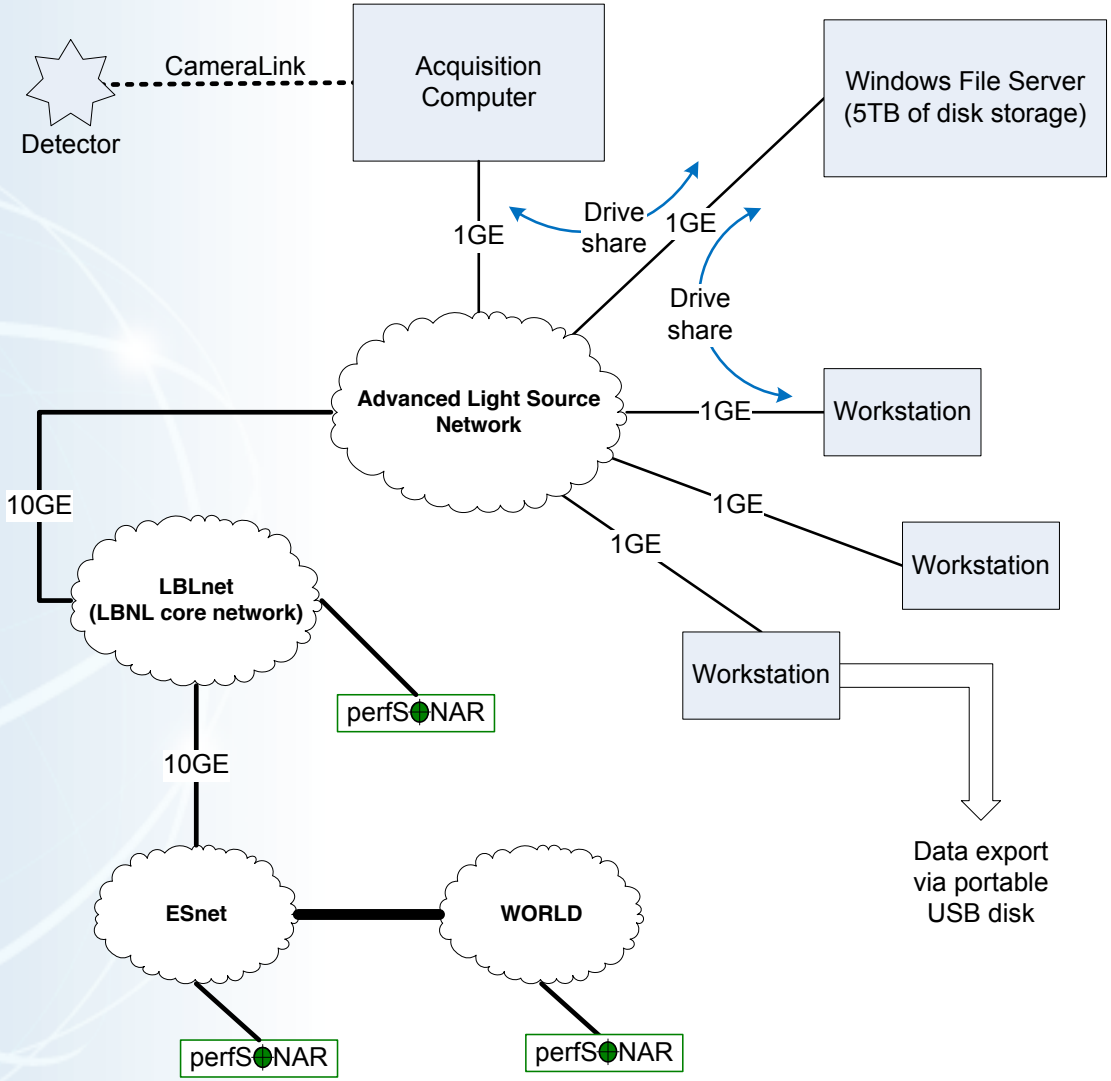
- Used perfSONAR to find failing router line card
- DTN built from Fasterdata reference design

NERSC collaboration

- Data workflow (python scripts, etc.)
- Data analysis

Collaboration is ongoing

Original Workflow Infrastructure



Improved Workflow Infrastructure