U.S. Department of Energy's
Office of Science

High-Performance Networks for Scientific Applications -- A Perspective --

Network Research Program
PI Meeting
BNL
September 28-30, 2005

Walt Polansky
Advanced Scientific Computing Research Program

Advanced Scientific Computing Research Program

-- Mission --

Deliver forefront computational and networking capabilities to scientists nationwide that enable them to extend the frontiers of science, answering critical questions that range from the function of living cells to the power of fusion energy.

-- Delivery mechanisms --

- **world-class research portfolio**
- **research collaborations and partnerships**
- **high-performance computing and network resources**

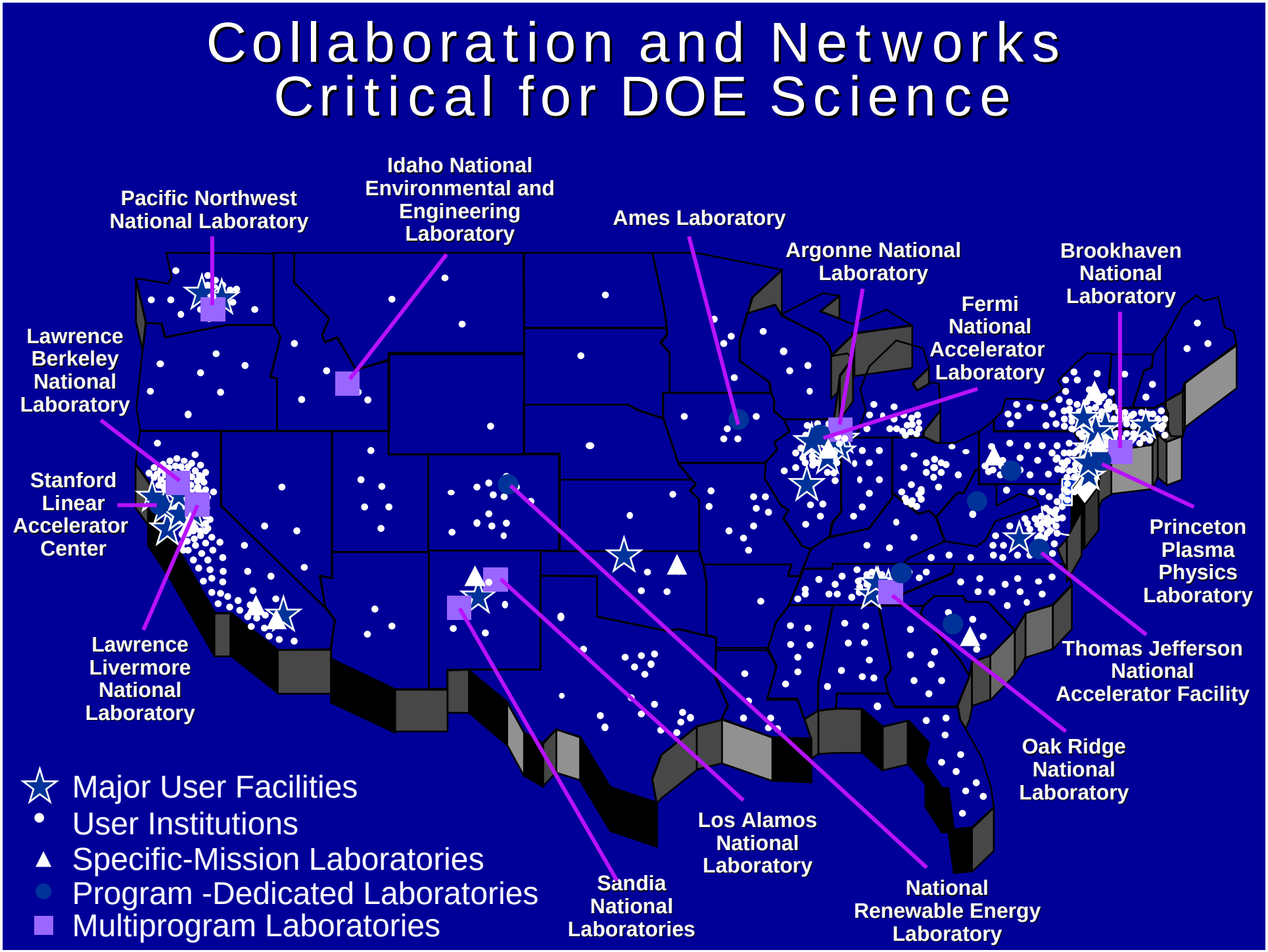
Legislative Support

Energy Policy Act of 2005

(http://www.ase.org/uploaded_files/policy/Energy_Bill_Final.pdf)

"the Secretary of Energy shall conduct and support basic and applied research in high-performance computing and networking to support fundamental research in… and provide computing and networking infrastructure support…"

Collaboration and Networks Critical for DOE Science



Research Areas

Materials Sciences and Engineering
- Catalysis
- Ceramics
- Condensed Matter Physics
- Corrosion
- Electronic Properties of Materials
- Experimental Techniques & Instrument Devel.
- Fluid Dynamics and Heat Flow
- Intermetallic Alloys
- Magnetism and Magnetic Materials
- Materials Physics and Chemistry
- Mechanical, Physical, and Structural Properties
- Metallic Glasses
- Metallurgy, Metal Forming, Welding & Joining
- Nano- and Microsystems Engineering
- Neutron and Photon Scattering
- Nondestructive Evaluation
- Photovoltaics
- Polymer Science
- Radiation Effects
- Superconductivity
- Surface Science
- Synthesis and Processing Science
- Theory, Modeling, & Computer Simulation

Geosciences
- Geochemistry of Mineral-fluid Interactions
- Geophysical Interrogation of Earth's Crust
- Rock-fluid Dynamics
- Biogeochemistry

Biosciences
- Natural Photosynthetic Mechanisms
- Complex Hydrocarbons and Carbohydrates
- Carbon Fixation and Carbon Energy Storage
- Biochemistry, Biocatalysis, Bioenergetics, Biomaterials, and Biophysics

Chemical Sciences
- Analytical Chemistry
- Atomic, Molecular & Optical Sciences
- Chemical Kinetics
- Chemical Physics
- Catalysis
- Combustion Dynamics
- Electrochemistry
- Heavy Element Chemistry
- Interfacial Chemistry
- Organometallic Chemistry
- Photochemistry
- Photosynthetic Mechanisms
- Radiation Chemistry
- Separations Science
- Solar Energy Conversion
- Theory, Modeling, & Computer Simulation
- Thermophysical Properties

Physics
- High Energy and Particle Physics
- Heavy Ion & Medium Energy Nuclear Physics
- Accelerator and Detector R&D
- Particle Astrophysics
- Physics Theory

Fusion Sciences
- Experimental Plasma Physics
- Theory, modeling, and simulation
- Accelerator Physics
- Plasma Diagnostics R&D
- Specialized Materials Science
- Tritium Science
- Microwave Systems R&D
- Integrated Fusion Systems

- BES - Basic Energy Sciences
- HEP & NP - High Energy Physics; Nuclear Physics
- FES - Fusion Energy Sciences
- BER - Biological & Environmental Research
- ASCR - Advanced Scientific Computing Research

Life Sciences
- Human Genome
- Structural Biology
- Microbial Genome
- Low Dose Radiation Research
- Functional Genomics
- Human Subjects in Research
- Structural Biology Facilities
- Genome Instrumentation
- Computational & Structural Biology

Medical Sciences
- Molecular Radiopharmaceutical Development
- Boron Neutron Capture Therapy
- Molecular Nuclear Medical Imaging
- Imaging Gene Expression
- Biomedical Engineering

Environmental Sciences
- Decade to Century Climate Modeling
- Atmospheric Radiation Measurement (ARM)
- Atmospheric Science & Chemistry
- Carbon Cycle Research
- Ocean Sciences
- Ecosystem Function and Response
- Information & Integration
- Integrated Assessment of Climate Change
- Bioremediation of Metals & Radionuclides
- Environmental Molecular Sciences Lab

Mathematics and Advanced Computing
- Linear Algebra Libraries
- Scientific Computing & Network Testbeds
- Advanced Computer Science
- Applied Mathematics
- Advanced Computing Facilities
- Advanced Computing Software and Collaboratory Tools

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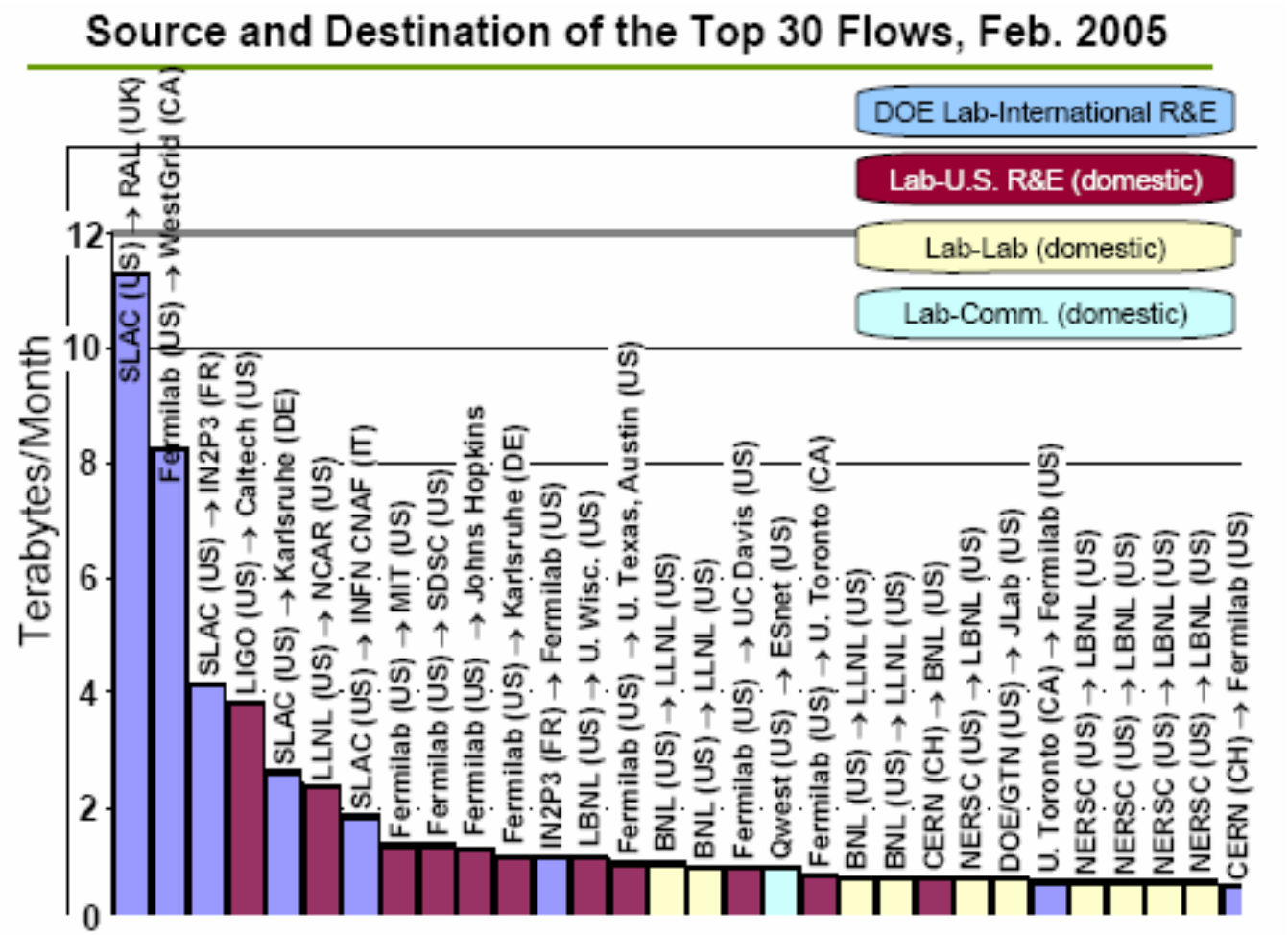
ESnet Traffic Characterization



Science Requirements for Networks (circa. 2003)

Science Area	2003 End2End Throughput	2008 End2End Throughput	5-10 Years End2End Throughput	Remarks
High Energy Physics	0.5 Gb/s	100 Gb/s	1,000 Gb/s	High bulk throughput
Climate (Data and Computation)	0.5 Gb/s	160-200 Gb/s	N x 1,000 Gb/s	High bulk throughput
SNS Nanoscience Centers		1 Gb/s	1,000 Gb/s + QoS for control channel	Remote control and time critical throughput
Fusion Energy	0.066 Gb/s (500 MB/s burst)	0.198 Gb/s (500 Mb/s, 20 sec. burst)	N x 1,000 Gb/s	Time critical throughput
Astrophysics	0.013 Gb/s (1 TB/wk.)	N*N multi-cast	1,000 Gb/s	Computational steering and collaborations
Genomics Data & Computation	0.091 Gb/s (1 TB/da.)	100s of users	1,000 Gb/s + QoS for control channel	High throughput and steering

Threats

- Viruses
- Worms
- Malicious software downloads
- Spyware
- Stolen credentials
- Insider Threat
- Denial of Service
- Rook kits
- Session Hijacking
- Agent hijacking
- Man-in-the-middle
- Network spoofing
- Back doors
- Trojan Horses
- Exploitation of software flaws
- Phishing
- Pharming

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Illustrative Example Credential Theft

- **Degree of compromise**
  - **20, or more sites**
  - **1,000s of computers**
  - **Unknown number of accounts**
- **Mode of Operation**
  - **Hijack legitimate username/password through keyboard sniffers, or trojaned clients and servers**
  - **Log onto system as legitimate user and perform reconnaissance**
  - **Using ‘off the shelf’ rootkits, gain root access**
  - **Install sniffers, compromise services, modify ssh-keys**
  - **With knowledge from data gathered, move to next system**

Do commonly applied countermeasures such as, expiration of logon credentials and revocation of privileges, work effectively in an open science environment ?

Trends in Cybersecurity ?

- **Firewall everything, except vetted applications having strong business needs**
- **All software installed by trained and certified system administrators**
- **Never grant administrator privileges to users**
- **All systems run automated central configuration management and centralized protection management**
- **No access from untrusted networks**
- **Degree of conformance and compliance with regulations to drive best practices**
- **Access to computing and network systems (HSPD-12) is further constrained.**

Network Infrastructure -- Major Considerations --

- **Preserve Unique Features of DOE Science**
  - **Access to national user facilities**
  - **Participation in international collaborations**
  - **Ability to host scientific data bases and data repositories**
  - **Ability to innovate and prototype new capabilities and technologies**
  - **Ability to advance science in a global arena**

- **Protect taxpayer investments**
  - **Scientific talent**
  - **High performance computing resources**
  - **Experimental systems**
  - **Desktop and laptop systems**

Future ?

- **Leverage the potential of optical networks for science data transport**
- **Robust, secure and cost-effective transmission protocols for science**
- **Collaborative approaches to create and to implement innovative network solutions; partnerships coupling application domain scientists with network researchers, software developers, etc. (SciDAC model ?)**
- **Complete confidence from policy makers that network and the information transmitted over them, although open, are secure**

Workshops and Reports

- **High Performance Network Planning Workshop, August 2002**
  http://www.doecollaboratory.org/meetings/hpnpw/

- **Blueprint for Future Science Middleware and Grid Research and Infrastructure, August 2002**
  http://www.nsf-middleware.org/MAGIC/default.htm

- **DOE Science Network Meeting, June 2003**
  http://gate.hep.anl.gov/may/ScienceNetworkingWorkshop/

- **Cyberinfrastructure Report**
  http://www.cise.nsf.gov/evnt/reports/toc.htm

- **The Office of Science Data-Management Challenge, Report from the DOE Office of Science Data-Management Workshops, November, 2004**
  http://www.sc.doe.gov/ascr/Final-report-v26.pdf