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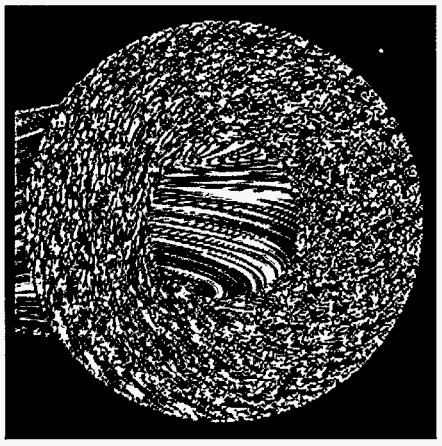
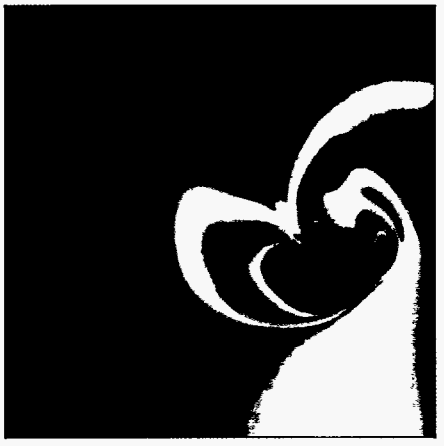
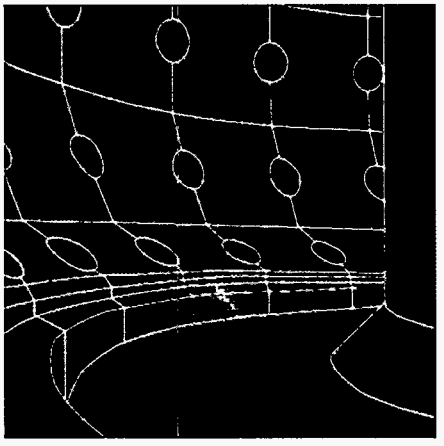
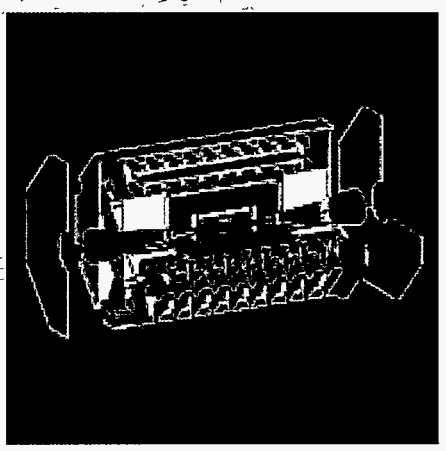
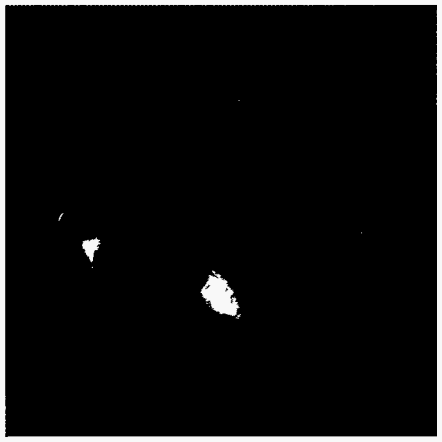
ESnet The Energy Sciences Network Strategic Plan

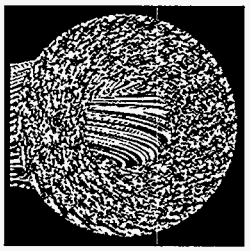
U.S. Department of Energy • December 1996

DOE/ER-0697

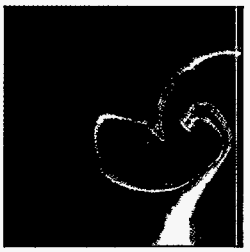




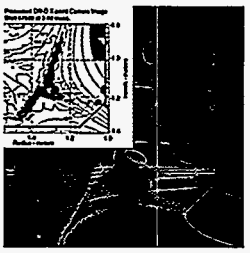
On the Cover



Cut-away view of plasma turbulence in a tokamak. This image was produced at the National Energy Research Scientific Supercomputer Center as part of a program focused on developing the most advanced computational models of tokamak physics using the most powerful high-performance computing and communications environments in a multinational multidisciplinary collaboration.
http://www.acl.lanl.gov/GrandChal/Tok/

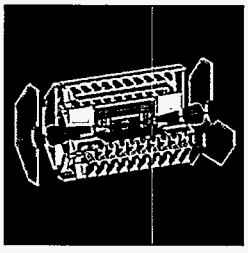


Multifluid adaptive mesh refinement simulation of the NOVA hypersonic jet experiments conducted at Lawrence Livermore National Laboratory. Efficient high resolution finite difference methods and adaptive mesh refinement techniques, coupled with modern supercomputer architectures and networks, allow detailed studies of experimental flows where only indirect visualization is possible.
http://www.llnl.gov/CAFDA/CAFDA.html



Video image of energy concentrated in plasma in the diverter region of the DIII-D tokamak at General Atomics Inc. To speed up image processing time for the analysis shown in the insert, the calculation was distributed via ESnet to a network cluster of 44 workstations located at the National Energy Research Scientific Supercomputing Center, General Atomics, and Lawrence Livermore National Laboratory.
http://fusion.gat.com/

General circulation models or global climate models describe the circulation and thermodynamics of the atmosphere and oceans. The ability to access and use massively parallel computers and set up workstation clusters, combined with improved simulation approaches, have greatly enhanced scientists' ability to model and understand complex climatic phenomena.
http://www.acl.lanl.gov/GrandChal/GCM/gcm.html



Conceptual drawing of the ATLAS detector under construction for the Large Hadron Collider at the European Laboratory for Particle Physics (CERN). The primary purpose of the detector will be studies of the origin of mass at the electro-weak scale; therefore, the detector has been designed for sensitivity to the largest possible Higgs mass range. The detector will also be used for studies of top quark decays and for supersymmetry searches.
http://oasis1.phy.bnl.gov/USATLAS/welcome.html

Depiction of the electrostatic potential for cesium bound to an 18-crown-6 molecule. Crown ethers are a class of molecules being considered for separating high-level nuclear wastes at Department of Energy sites. Accurate modeling calculations on molecules as large as crown ethers require supercomputer class machines and high-speed networks.
http://www.emsl.pnl.gov:2080/emslweb/orgs/tm-s.html

ESnet
The Energy Sciences Network

Strategic Plan

http://www.es.net/

Contents

U.S. Department of Energy
Washington, DC 20585

December 1996

DISCLAIMER

Executive Summary

The goal of the Energy Sciences Network (ESnet) Program is to provide a highly capable and reliable communications infrastructure that supports the Department of Energy's (DOE) missions and enables DOE researchers to tap the power of leading-edge information technologies. ESnet provides an essential infrastructure that enhances national competitiveness and accelerates the development of future generations of high-performance, distributed computing systems and networks. These computing systems and networks are vital to modern scientific research. In addition, they enable development of new approaches to energy management, environmental restoration and waste management, national security, industrial processing, and health care, and also facilitate public access to government information.

Extensive networks developed by the DOE's high-energy physics and fusion energy research communities were the forerunners of the ESnet. These networks initially provided improved access to high-energy accelerator sites and to the Magnetic Fusion Energy Supercomputer Center, which opened at Lawrence Livermore National Laboratory in 1974. By the mid-1980s, it became apparent that this successful model should be the basis for a comprehensive approach to supporting the energy research community. In 1986, Dr. Alvin Trivelpiece, then Director of the DOE's Office of Energy Research, established the ESnet. A Technical Coordinating Committee and an Advisory Panel were appointed and chartered to ensure that the requirements of the energy research community were met. ESnet now supports DOE collaborative research, both nationally and internationally, by providing seamless, multiprotocol connectivity among key scientific facilities, computing resources, and educational activities. The international connectivity component is shared with the National Aeronautics and Space Administration, the National Science Foundation, and the Defense Advanced Research Projects Agency. DOE networking and computing research programs help keep ESnet at the leading edge of technology.

Today, ESnet is one of DOE's success stories. High-performance computing, scientific and engineering research, computational science, and a spectrum of interactions among people at widely dispersed sites are critical to the success of the DOE. ESnet, now an indispensable part of DOE programs and a key element of the Internet, is so integrated into day-to-day operations that it is almost impossible to visualize how DOE's programmatic offices and national laboratories could accomplish their missions without it. As such, ESnet is the DOE's largest multiprogram collaborative activity.

As computing and communications requirements of DOE programs evolve, improved ESnet capabilities will be needed to provide higher levels of network performance, to support wider network availability, to transmit greater volumes of information at faster rates, and to enable use of more sophisticated applications. This strategic plan describes how the ESnet Program will continue to provide support to the DOE and its research communities, while positioning itself to meet the challenges of integrating the DOE's facilities, information, and expertise into a more effective and responsive enterprise.

ESnet Program Strategic Plan

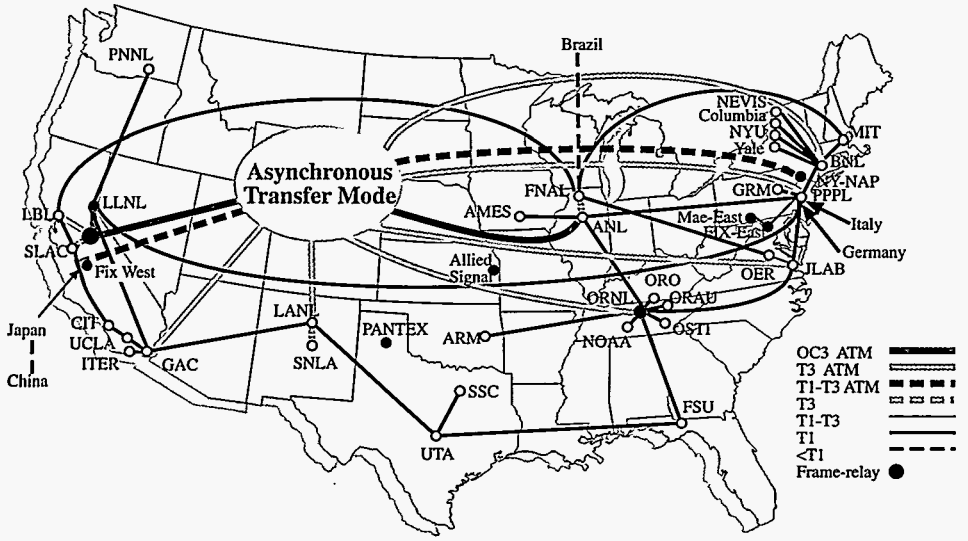
Mission

The mission of the Energy Sciences Network (ESnet) Program is to provide highly capable and reliable communications infrastructure and leading-edge network services that support DOE's missions. The program emphasizes advanced network and distributed computing capabilities needed for forefront scientific research and other DOE programs, thus enhancing national competitiveness and accelerating development of future generations of communication and computing technologies. Participating DOE programs and their partners actively contribute to program planning and implementation, and collaborate on development of new technologies that will drive upcoming generations of research capabilities.

Strategic Response

In recognition of the constantly changing environment facing the DOE and its research communities and the reshaping of their various missions, priorities, and business practices, the ESnet program will provide a timely strategic response to:

- support DOE's general missions in science and technology, energy resources, environmental quality, and national security, and facilitate accomplishment of the specific missions of participating DOE programs and their partners
- provide production-quality networking services, based on state-of-the-art data facilities and technologies, to bind the DOE national laboratories, research facilities, and their researchers and collaborators into a cohesive, integrated research environment, and to support DOE's research missions and priorities in a cost-effective manner
- support and contribute to the development of the Global Information Infrastructure and the national Next Generation Internet.



The ESnet Backbone in service in mid-1996. ***http://www.es.net/***

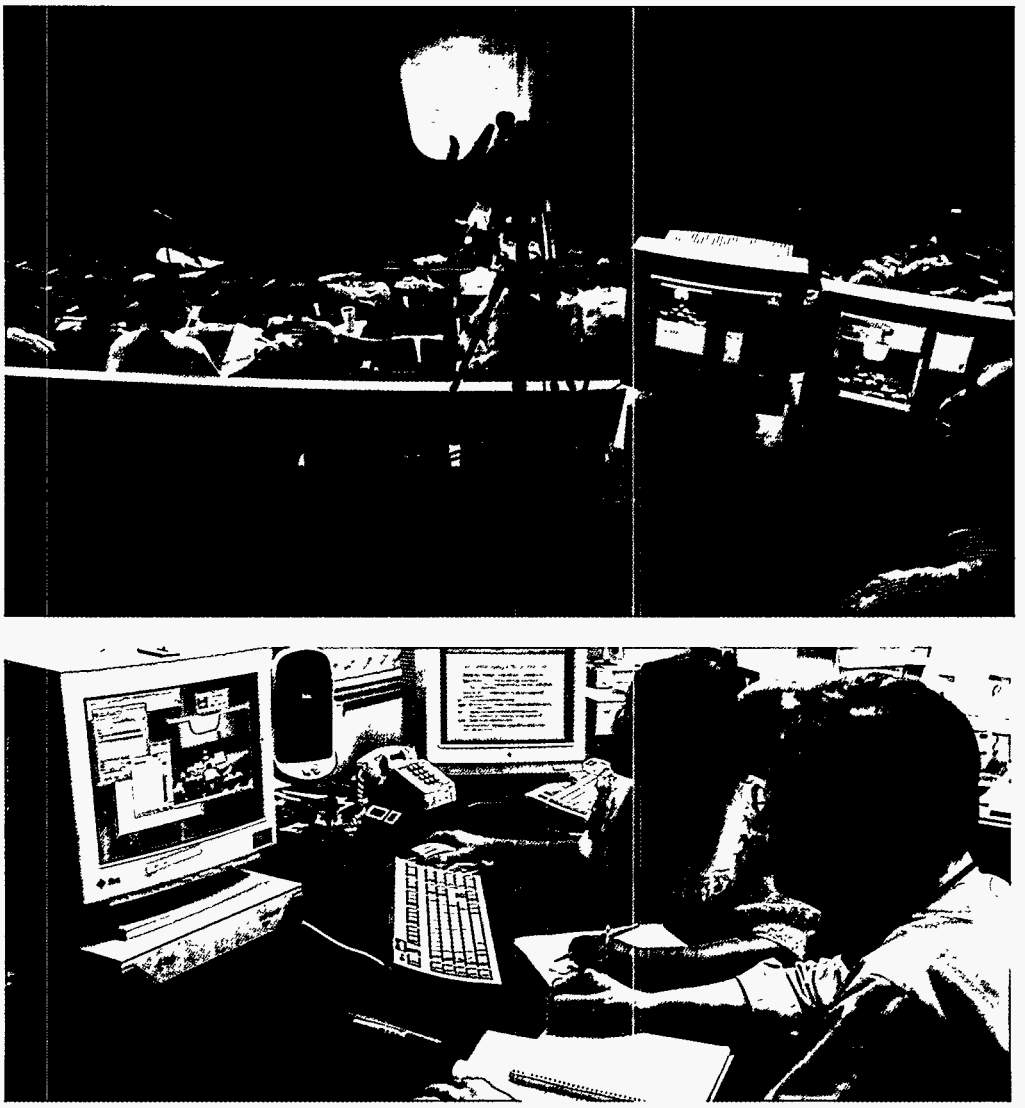
Message from ESnet Steering Committee

In the current milieu of rapidly changing technology, increasing capacity utilizations, and the critical role that networking plays in the infrastructure supporting research, it is of paramount importance that we have a strategy which will enable us to continue and build upon the eminence that the ESnet has achieved since its inception in 1986. This plan, which has been endorsed by an ESnet Steering Committee composed of representatives of the scientific programs supported by ESnet, provides the framework and guidance necessary to ensure that the ESnet Program attains objectives which are essential to meeting the goals of DOE's research programs.

Larry Price, ESSC Chair
Sandy Merola, former ESSC Chair

ESnet provides our 600-plus users from 123 institutions in 20 countries with the quality of network services essential for a state-of-the-art laboratory. As a new facility, Jefferson Lab has been set up from the start to take advantage of the modern networking, distributed computing, and collaboratory environments provided by ESnet. In 1997, we will begin acquiring a terabyte of raw data per day. ESnet will be the pipeline for providing both raw and processed data to our highly distributed user community and for providing them with remote access to our collaboratory resources.

R. Roy Whitney
Thomas Jefferson National Accelerator Facility



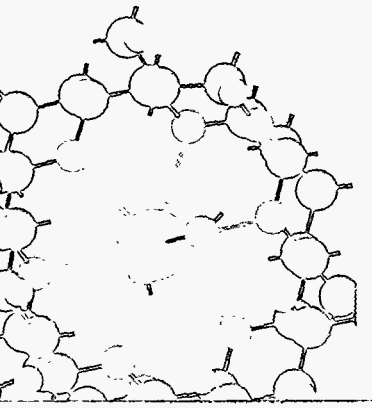
Multicast Backbone, or MBONE, enables geographically separated scientists to collaborate via electronically shared audio, video, and whiteboard sessions. Scientists in the Tokamak Fusion Test Reactor Project participate in a weekly physics meeting that originates at the Princeton Plasma Physics Laboratory. Video images of this weekly meeting are broadcast over ESnet using DOE-developed MBONE capabilities. ***http://www.lbl.gov/Web/MBONE.html***

Vision

"a future in which advanced network capabilities enable seamless collaborations for DOE and its researchers"

In the future, DOE researchers, staff, and management will have seamless and ubiquitous access, via shared collaborative information and computational environments, to the facilities, data, and colleagues needed to accomplish their goals.

This network-based collaborative environment will enable DOE to combine system-wide resources and personnel, unencumbered by geography or time,



thereby increasing productivity, reducing cost, and enabling the development of new capabilities.

Customers

The ESnet customer base is composed of researchers and research program managers in universities, industry, and government agencies. Members of the user community are located throughout the United States and, through partnering agreements and collaborations, at locations around the globe.

The majority of the ESnet customers can be classified as follows:

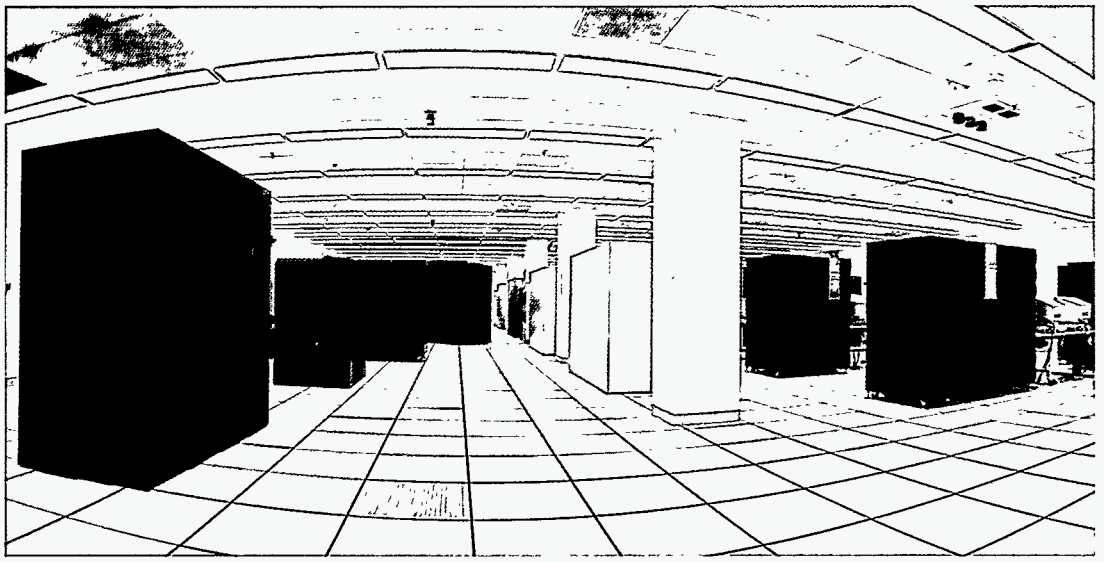
- ◇ direct users of ESnet services, including programs of the Office of Energy Research, Defense Programs, Human Resources and Administration, and the Energy Information Administration; other DOE offices; and national and international DOE collaborators
- ◇ those in the information technology community who benefit from program leadership in networking and advanced technology developments
- ◇ others who benefit indirectly from the enhanced research programs supported by program services, including the nation's industry, educational institutions, and citizens.

Objectives and Strategies

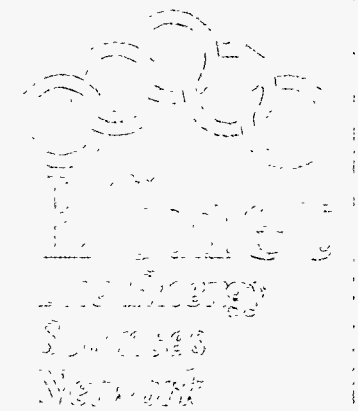
Specific objectives, supported by strategies and success indicators, have been identified and are described below. Achieving these objectives will satisfy the ongoing process of identifying the requirements of ESnet's customer base, and will provide for effective implementation of an infrastructure of networking and related services, while enabling development of new technologies and architectures.

Although the general Internet is approaching gridlock, DOE has had the foresight to provide its users with ESnet. My high-energy physics experiment, ZEUS, at the DESY laboratory in Hamburg, Germany, is thousands of miles away from my office at the University of Wisconsin in Madison. Without ESnet I could not communicate with my students, other personnel in our group that reside in Hamburg, and my other collaborators on ZEUS. I also would not be able to manipulate and analyze data, look at event pictures, or collaborate on physics results.

Professor Wesley Smith
University of Wisconsin



The National Energy Research Scientific Computing Center, located at Lawrence Berkeley National Laboratory, supplies production high-performance computing services to the nation's energy research community via ESnet. ***http://www.nersc.gov***



ESnet is essential to the research efforts within the Theory, Modeling, and Simulation program at Pacific Northwest National Laboratory. It is especially critical for us to have high-speed communication links to the National Energy Research Scientific Computing Center (NERSC). Our researchers continuously use the resources at NERSC to run large-scale calculations, with much of the data moved back to local machines for analysis. ESnet also provides us with the ability to communicate with our collaborators and share information over the Internet. ESnet provides us with the ability to conduct state-of-the-art collaborative research projects easily, efficiently, and securely.

Maureen I. McCarthy
Senior Research Scientist
Pacific Northwest National Laboratory

Objective 1: Sustain and Increase Customer Satisfaction

The program will continue to satisfy the requirements of its customer base. It will accomplish this goal by engaging programmatic and partner customers with networking technologies and services and by providing mechanisms for feedback.

Strategies

- Include customers in the planning process.
- Consider customer benefit in the design of services and the selection of technologies.
- Publicize activities and publish results, with an emphasis on the use of electronic media.
- Identify and replicate successes.

Success Indicators

- Increased awareness of ESnet capabilities.
- Increased demand for and use of ESnet connections and services.

Objective 2: Maintain and Enhance Production Services

The program will provide an infrastructure of networking and related services that enables ESnet users to succeed in their missions.

Strategies

- Meet programmatic requirements for domestic and international connectivity, bandwidth, and service quality.
- Promote advanced technologies to the production level.
- Support DOE and Office of Energy Research strategic plans and initiatives.
- Coordinate and interface with other components of the Internet.

Success Indicators

- Measurable increase in sites connected to ESnet.
- Increased bandwidth availability.
- New technologies put into production-level service.
- Decreased network outages.

Objective 3: Promote Leading Edge Applications and Technologies

The program will provide the architecture, infrastructure, and enabling technologies that support distributed collaborative environments at a world-class level. The ESnet will support virtual laboratories, remote facilities on-line, and DOE's high-performance computing centers, including the DOE2000 Initiative.

Strategies

- Solicit new technical requirements from Office of Energy Research programs and other ESnet partners.
- Establish and coordinate appropriate technical working committees.
- Partner with users and commercial providers to develop new services.
- Use high-performance test beds to develop advanced services.
- Coordinate with DOE, government-wide, university, commercial, research, and network entities to leverage development efforts.

Success Indicators

- Completion of test beds that develop or assess emerging technologies.
- Establishment of partnerships with providers, industry, and customers.
- Development of advanced pilot projects that promote leading-edge applications and technologies.

Objective 4: Provide Effective and Efficient Implementations

The program will increase user effectiveness and productivity by deploying cost-effective technologies. Where appropriate, ESnet will actively pursue collaborations with other programs and agencies to accomplish its objectives more effectively.

Strategies

- Use and promote cost-effective technologies.
- Pursue cost sharing with other programs when common needs can be met.
- Use commercial services when appropriate.
- Maintain an optimal balance of central and distributed facilities.
- Correlate services with user needs.
- Identify and promote innovative technological solutions.
- Provide useful technical guidance to DOE management.
- Promote open standards.

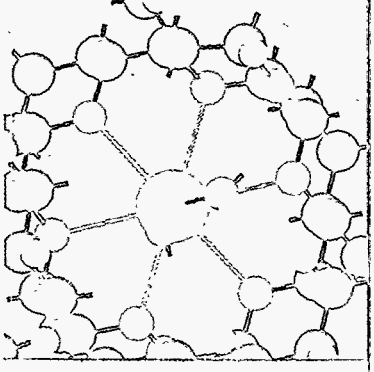
Success Indicators

- Deployment of innovative technology solutions that increase user effectiveness.
- Usage measurements and projections that validate deployment decisions.
- Reduction of costs for existing services through consolidation and elimination of duplication.

Progress in magnetic fusion energy science is increasingly dependent on collaborative research utilizing personnel and resources located around the country at the national laboratories, universities, and in industry. Tokamak experiments, which favor interactive operations, greatly benefit when researchers have real-time connections to experimental facilities and their instrumentation.

ESnet has long provided us with robust connections to our experimental facilities and data. Using high-performance workstations connected over the T3 ESnet backbone, the paradigm of merely logging into a facility to use their computers is being replaced by one of distributed computing and file services in support of experimental operations and scientific data analysis. We are now capable of increased utilization of resources regardless of their geographic location as is the case with my research from Lawrence Livermore National Laboratory on the DIII-D tokamak at General Atomics in San Diego.

Tom Casper, Lawrence Livermore National Laboratory



Data on the flow of flue gases in an industrial boiler are shown as streamlines in the CAVE (Cave Automatic Virtual Environment) at Argonne National Laboratory. High-speed telecommunications allow scientists from different parts of the nation to remotely collaborate on this research.
http://www.mcs.anl.gov/home/freitag/SC94demo/project/nalco.html

SecureNet, which uses ESnet for Wide Area Networking, will enable DOE scientists at one laboratory to use ASCI teraflop classified computing resources at other DOE laboratories. Even before these machines are running, SecureNet enables DOE researchers to work together on classified subjects in new and productive ways. Previously, in classified code development with researchers at Los Alamos National Laboratory and Sandia National Laboratories, we had to travel and mail classified tapes. With SecureNet I can telnet to a secure LAN at Sandia, and examine and run test problems in the Sandia environment.

Bing Young, Physicist
Lawrence Livermore National Laboratory

Challenges

The program must overcome a number of challenges to successfully implement this strategic plan. These challenges are not insurmountable, but overcoming them will require a dedicated effort, support by management, and funding if ESnet is to continue as DOE's premiere network for enabling scientific research.

Technological and Operational Challenges

Enabling Technology

The program supports the DOE research community and its partners by providing leading-edge, production-quality, service-based support. As the pace and complexity of technology development continues to accelerate, program managers must select and make available appropriate enabling technologies. In making decisions regarding these new technologies, managers must balance the need to match and facilitate program support requirements in

a production-quality service environment with the need to provide a high return on investment and maintain consistency with ongoing commercial development efforts.

Changing Environment

The program must continue to emphasize leading-edge, production-quality service in the face of a changing environment characterized by limited financial resources and downsized organizations. This situation is becoming increasingly challenging because of:

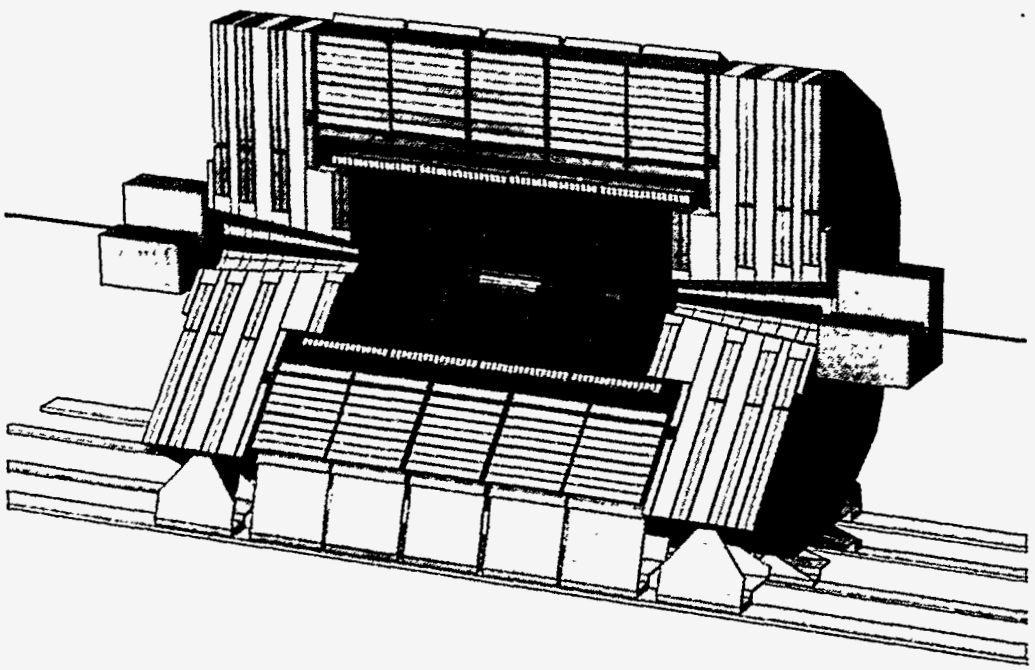
- ◇ increased interaction and cooperation with other DOE programs, agencies, and commercial organizations that are also undergoing substantial changes
- ◇ increased demand for short-term, quick-return solutions rather than investments in long-term, more effective approaches
- ◇ the accelerating pace of technological evolution, coupled with rapid growth of user requirements and expectations.

Improved Integration

The most effective approach for providing an advanced computing and communication environment will involve a thorough integration of program activities and requirements with computer science research, computer security, emerging technologies, and commercially available services and technology.

Our high energy physicists use ESnet for video teleconferences with worldwide collaborators who are designing the next generation of elementary particle detectors for experiments at Fermilab and CERN.

Edward May, Argonne National Laboratory



Compact muon solenoid (CMS) detector being planned for construction at CERN in Geneva, Switzerland. ESnet is already essential for connecting the U.S. collaborators during the planning phase, expecially with regard to accessing remote computing resources used in the large-scale simulations needed for the detailed physics design of the detector. ***http://cmsinfo.cern.ch/cmsinfo/Welcome.html***

We are using ESnet systems to link the Oak Ridge and Sandia National Laboratories' Paragon computers to create a distributed computer capable of undertaking computational problems that have been unapproachable until now. ESnet's forward-thinking implementation of asynchronous transfer mode technology is allowing us to make this connection highly effective, scalable, and completely transparent to the programmers and scientists at Oak Ridge and Sandia.

Ken Kliewer
Director of the Oak Ridge Center for Computational Sciences

Balance

A major success of the ESnet Program has been achievement of an effective balance of centralized and distributed service components. As the environment continues to evolve rapidly, maintaining the proper balance between these service components will be important.

Organizational Challenges

Improved Cooperation/Integration with Other DOE Programs

The need for substantially increased effectiveness in downsized organizations will require additional effort to create synergism with other program areas in DOE. A challenge will be to cooperate effectively while maintaining the leading-edge, high performance character of the program.

Improved Connections with the Scientific Research Community

The impact of the program on scientific research can be enhanced by increased interaction with the user community. Although the program has been effective to date, better coupling with the user community will be required in the future.

Effective Interagency and International Coordination/ Cooperation

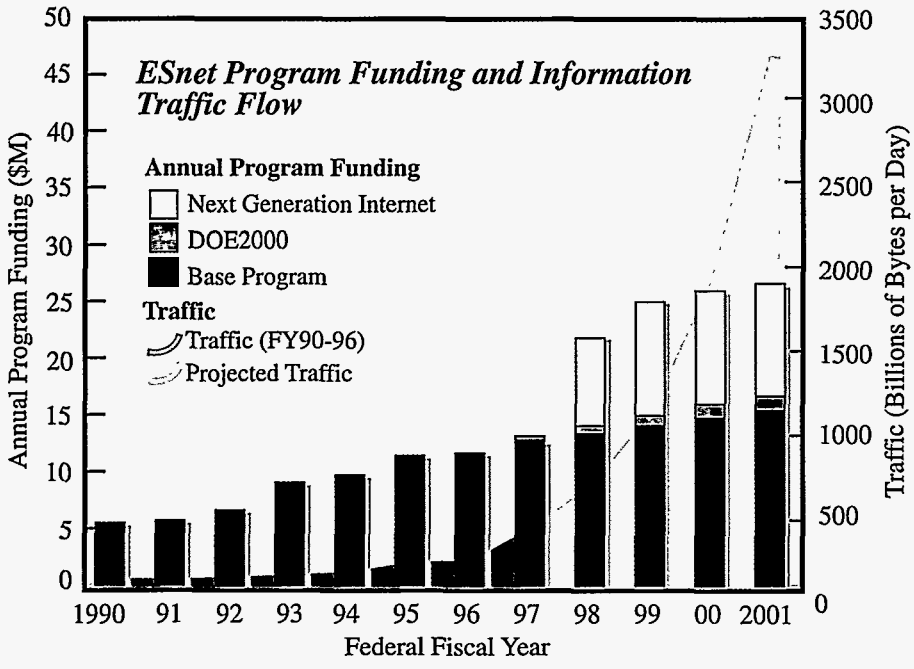
With various federal agencies connecting to the Internet and other high-speed domestic and international networks, the challenge will be to make the best use of the increased connectivity among various agencies without duplicating the connectivity to a particular site. Because of the high cost of international links, coordination becomes of significant importance when connecting internationally. Interagency coordination and cooperation will be the key to effective establishment and use of the connectivity.

Funding

Demand for connectivity and bandwidth has been outstripping decreases in cost of services, particularly for international access. Alternate approaches to funding, such as shared support of new capabilities, may be needed at the very time the ESnet community is least able to absorb it.

Program Implementation Framework

Successful implementation of the strategic plan is dependent on well-established and tested principles, and on associated processes that will ensure continued success of the program. A key guiding principle is maintenance and improvement of the quality and capability of ESnet services through the continuous involvement of the user community, DOE sponsors, other government agencies, industrial concerns, and commercial providers. Maintenance and improvement are based on an awareness of changing requirements, assessment and deployment of emerging technologies, and effective sharing and leveraging of resources.



Past and projected ESnet Program funding compared with increasing information traffic transmitted over the network.

We demonstrated, for the first time, remote operation of a major magnetic fusion energy experiment from a site on the other side of the country via ESnet. The Alcator C-Mod tokamak (a device that uses powerful magnetic fields to confine hot, dense plasmas) at MIT in Massachusetts was operated over ESnet from a control room at Lawrence Livermore National Laboratory in California.

Martin Greenwald, Massachusetts Institute of Technology - Plasma Fusion Center

Implementation Principles

Provide a High Level of Dependability

Participating programs, member laboratories, universities, and their national and international collaborators depend on the ESnet Program for networking services and connections.

Maintain and Improve the Base of ESnet Services

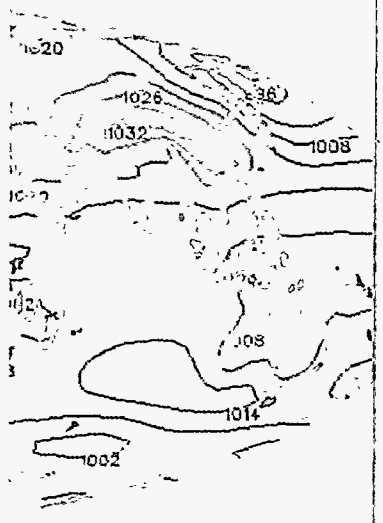
Maintenance of the base of service in network performance, network availability, and support of network-based applications is a guiding principle of the program. Another key principle is improvement of this service as programmatic requirements evolve and new technologies emerge.

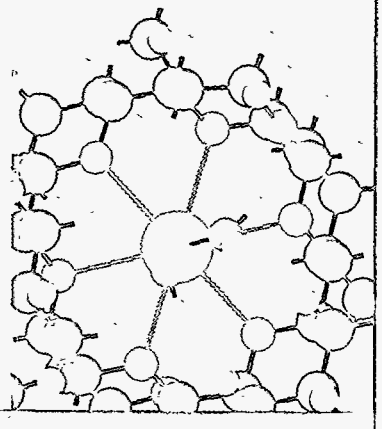
Provide New Capabilities

The program is purposefully evolving from basic network connections to the higher level networking services needed to support distributed collaborative applications and environments needed by DOE science programs. These capabilities will enable development of DOE's virtual laboratories, remote facilities on-line, high-performance computing centers, and the DOE2000 Initiative to provide the next-generation scientific research environment.

Continue the Quality of Service

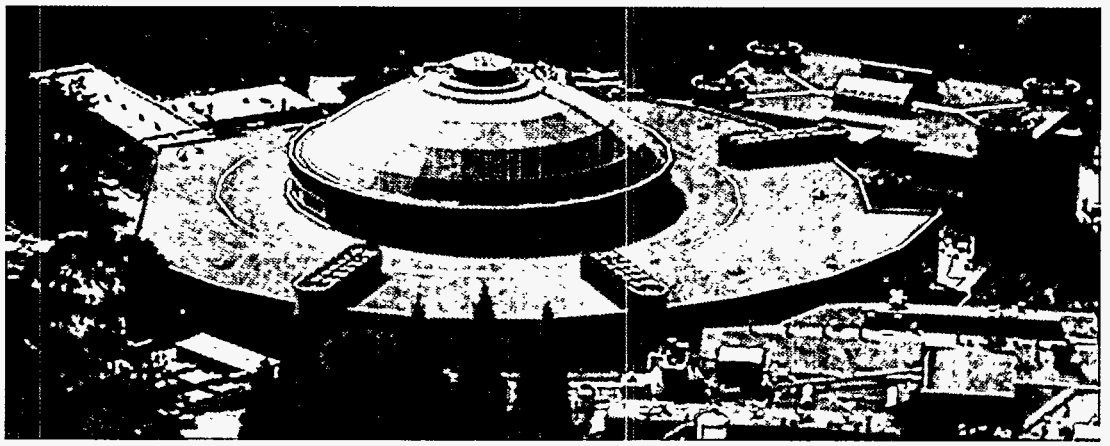
ESnet production services, in terms of reliable bandwidth, connectivity, and new technologies deployed, must continue to be of high quality. This high-quality service is essential for maintaining user satisfaction and ensuring the continued success of the program.





The Energy Information Administration (EIA) was established on October 1, 1977, by the Department of Energy Organization Act to support the establishment of a comprehensive, unified, and credible energy information and analysis program within the Executive Branch. EIA's mission is to inform the DOE, the Congress, the Executive Branch, and the public regarding the nation's energy situation by administering a central and comprehensive program for collecting, interpreting, validating, analyzing, and disseminating energy information. The high-speed Internet connection provided by ESnet has provided EIA an excellent means to accomplish this mission in a reliable and efficient manner. Without ESnet, EIA would have to procure its own Internet provider.

Paul P. Herr
Automated Data Processing Service
Engineering Information Administration



The Spectro-Microscopy Collaboratory provides remote collaborative capability to researchers performing experiments on beamlines at the Advanced Light Source at Lawrence Berkeley National Laboratory.
http://www-itg.lbl.gov/BL7Collab.html

Implementation Processes

Deployment Priorities

Priorities for deployment of connectivity, upgrades, and networking services to support new applications and facilities are established in concert by the ESnet Steering Committee, which is composed of program (user) representatives, ESnet management, and DOE sponsors of the program.

DOE Program Involvement

Programs within DOE are involved at all levels of planning and implementation activities of the ESnet Program. Input, evaluations, and feedback are solicited from program managers within DOE, and from member laboratories and universities through the program's outreach component. This component increasingly will be used to publicize the ESnet Program, its support of DOE programs, and its user base.

Partnership with Users

Active participation of users in all aspects of the program is ensured through the composition of the committees that establish program priorities and address requirements. Users also participate in working groups and task forces that focus on policy and technical issues in collaboration with ESnet management, sponsors, and industry.

ESnet Community Partnership

ESnet community sites partner with each other in ESnet activities in support of their programmatic missions. Sites partner with ESnet management in areas such as network monitoring, local support for network services and upgrades, local services in support of distributed computing, coordination of ESnet-wide distributed computing and collaboratory activities, and pilot projects for developing and testing new infrastructure.

Partnership with Industry

The ESnet Program involves representatives from industry in its activities. Industry provides and maintains the communications infrastructure, and is an essential component, along with ESnet users, management, sponsors, and partners, in the development of test beds and pilot projects to evaluate new technologies and services. This integrated, collaborative approach ensures the rapid deployment of cost-effective solutions in a production environment.

External Review

The program is reviewed periodically to ensure that its management, technologies, and capabilities adequately meet the requirements of its mission, as defined by its community of users and its sponsors. External peer review is a driving force in the development and implementation of the program. Reviews are conducted on both a routine and an extraordinary basis as issues critical to the program arise. These reviews also provide avenues for:

- improving coordination with participating Office of Energy Research and DOE-wide programs that have a vested interest in ESnet
- establishing collaborations with other agencies with similar concerns
- increasing awareness of emerging technologies and improved levels of services.

Research and Development

The R&D component of the program performs research in areas of strategic importance to the program mission. The program's role in technology leadership promotes development of future generations of science capabilities for DOE and the nation. This component also assesses the practicality of emerging technologies and services to meet the needs of the program and its partners.

The National Science Foundation (NSF) has enjoyed a long and fruitful relationship with DOE and other federal agencies that have significant networking research programs. In both the established Federal Networking Council and the new Large Scale Networking Working Group of the Computing, Information, and Communications R&D Committee, the ESnet team has taken a leadership role in coordinating agency networking activities. For example, ESnet personnel recently played a vital role in developing new network measurement tools that address Internet congestion issues. There is a high level of synergy between NSF's goal of promoting high-performance networking among the nation's research universities and DOE's goal of developing high-performance networking among the nation's energy research laboratories and their research partners in universities and industry.

George Strawn
Division Director, Networking and Communications Research Infrastructure, National Science Foundation
and Co-Chair of the Federal Networking Council

Measures of Success

The ESnet program generates and makes publicly available the comprehensive performance measures used for network management. Program performance is measured against the Success Indicators established for each of the program's four primary objectives. In addition, feedback from reviews, sponsors, users, and the program's outreach effort is the ultimate indicator of success.

Leverage Other Work

The program is building on its existing cooperative and collaborative relationships with commercial providers, industry, government agencies, and other components of the Internet to:

- provide the appropriate leverage and flexibility for its national and international connectivity needs
- avoid duplication of effort in its R&D activities.

Standards and Coordination Efforts

The program participates in the development of network connectivity and services standards through the continued involvement of ESnet management in the activities of the Internet Engineering Task Force. Effective coordination with other national and international networking activities is achieved by the continued involvement of program representatives with the U.S. Federal Networking Council. Existing ties with the National Science Foundation and the National Aeronautics and Space Administration will be strengthened to foster further collaborative ventures and shared connectivity, broadening the role of the program in the Global Information Infrastructure and the national Next Generation Internet.