Large Scale Networking

Definition of LSN PCA

The activities funded under the NITRD Program's LSN PCA maintain and extend U.S. technological leadership in high-performance networks through R&D in leading-edge networking technologies, services, and techniques to enhance performance, security, and scalability. These advances will support Federal agency networking missions and requirements and will provide the foundation for the continued evolution of global scale networks and the services that depend on them. Today's networks face significant challenges in performance, scalability, manageability, and usability that restrict their usefulness for critical national missions. These challenges are addressed by the LSN PCA, which encompasses Federal agency programs in advanced network components, technologies, security, infrastructure, and middleware; grid and collaboration networking tools and services; and engineering, management, and use of large-scale networks for science and engineering R&D.

Broad Areas of LSN Concern

- The development of networks that deliver end-to-end performance at least 1,000 times greater than today
- The development of a manageable, scalable security system to support the evolution of the global Internet and associated applications that require trust
- The development of advanced network services and middleware that enable development of new generations of distributed applications
- Specialized large-scale networks to enable applications with special needs, such as sensor networks and networks for real-time control
- International cooperation in the area of optical network coordination and certificate authorities
- Outreach and cooperation with university and commercial communities
- Network science education and workforce issues

Technical Goals

- End-to-end performance measurement including across institutional and international boundaries
- Network trust, security, privacy, availability, and reliability through research on vulnerability analysis, scalable technologies, security testbeds, and promotion of best practices
- Collaboration and distributed computing environments including grid
- Adaptive, dynamic, self-organizing, self-scaling, and smart networking
- Revolutionary networking research including revisiting networking fundamentals

Illustrative Technical Thrusts

- Federal network testbeds and their coordination with non-Federal networks and testbeds
- Infrastructure support such as Federal Internet exchange points
- Network technologies, components, and services for optical, mobile, wireless, satellite, and hybrid communications
- Middleware to enable applications
- Sensornets
- Large-scale network modeling, simulation, and scalability
- Protocols and network services to support high-performance networking applications such as high energy physics data transfers, astronomy community collaboration, and biomedical research
- Technologies for measuring end-to-end performance

LSN Agencies

					Participating Agency
NIH	DOE/SC	AHRQ	DARPA	NOAA	
NSF	NASA	DOE/NNS	NIST	NSA	DoD/HPCMPO

LSN PCA Budget Crosscut

FY 2004 Estimate	FY 2005 Request
$329.8 M	$332.8 M

LSN PCA: COORDINATION AND ACTIVITIES

LSN HIGHLIGHTS

Agency representatives meet monthly in the LSN Coordinating Group to plan collaborative activities and evaluate Federal R&D in advanced networking technologies. In addition, the CG has established and works with specialized teams to implement agreed-upon policies and to provide interagency coordination. The LSN teams and their roles are:

- Joint Engineering Team (JET) – coordinates connectivity and addresses management and performance of Federal research networks and their interconnections to the commercial Internet
- Middleware and Grid Infrastructure Coordination (MAGIC) Team – coordinates Federal agency grid and middleware research and development and support to grid applications
- Networking Research Team (NRT) – coordinates Federal agency research programs in advanced networking technology and protocols

ANNUAL PLANNING MEETING

The LSN CG holds a yearly Interagency Coordination Meeting at which each agency describes its programs reported under the LSN PCA. This allows the agencies to identify:

- Opportunities for collaboration and coordination with other agencies on networking R&D activities
- LSN R&D focus areas
- Areas of interest to the LSN agencies that are outside or larger than the stated scope of the LSN CG, such as cybersecurity

At the November 3, 2003, planning meeting, participants identified the following three overarching areas in which most of the LSN agencies have significant efforts and interests that would benefit from cooperation:

- Network testbed infrastructure
- Network performance measurement
- Grid outreach

Agencies also developed a broader list of networking R&D areas that are currently of interest to LSN participants. The list appears below. In optical networking, for example, NSF and DOE/SC are directly coordinating their work in building new experimental optical network testbeds to assure that the networks will be complementary, offering cross-network connectivity, experimentation capability, and advanced infrastructure for each agency's community of researchers.

NETWORK TESTBED INFRASTRUCTURE

Several high-performance testbeds are being built to provide an infrastructure for networking researchers within the Federal agencies, some at the national level and others called Regional Operational Networks (RONs). The national networks include:

- NSF's Experimental Infrastructure Networks (EINs)
- DOE/SC's UltraScience Net
- National LambdaRail (NLR)

The RONs include:

- California Research and Education Network 2 (CalREN 2)
- I-Wire (Illinois)
- Mid-Atlantic Exchange (MAX)

Continued on next page

AGENCIES' CURRENT NETWORKING R&D INTERESTS

- Networking Research
  - Basic technology
  - Optical networks
  - Services
  - Applications
- Infrastructure
  - Production
  - Experimental
  - Research
- Collaboration Support
  - Middleware and Grid
  - Collaboration
- Security
- Monitoring and Measurement
- Automated Resource Management
- Wireless, Ad Hoc
  - Wireless/nomadic
  - Crisis response, CIP
  - Sensornet
- Standards and Specifications
- Education and Training

There is an opportunity to coordinate connectivity, research, and applications development for these networks to address larger-scale issues such as transparency across the networks. However, controlled-use networks or dual-use networks will be required to assure that researchers doing research for network development (with a high risk of bringing down the network) do not interfere with applications researchers who require highly reliable networks.

The LSN CG tasked the NRT to study the issue of coordination of network testbed infrastructures and report back on its recommendations.

Network Performance Measurement

Many LSN agencies have active network performance measurement programs and others identified the need to measure end-to-end performance for all points of the network. Critical issues include development of standard interfaces and architectures for network performance measurement. This would enable comparisons of performance measurement across network providers to facilitate end-to-end performance measurement, which are needed in identifying and eliminating network bottlenecks and isolating network faults when they occur. The ability to measure and compare performance across network provider boundaries and to isolate network faults is needed for optimizing end-to-end application performance to take advantage of the increasing network bandwidths.

The LSN CG tasked the JET to investigate mechanisms of coordinating network performance measurement, particularly standard interfaces and architectures, and to provide recommendations on how to improve performance measurement capabilities.

Grid Outreach

Many user and application communities are developing grid capabilities, often focused on their particular needs. The LSN agencies are fostering the development of standardized grid middleware resources, tools, architectures, and infrastructure to facilitate such grid-enabled applications and are encouraging outreach to the user and application development communities so these users can:

- Benefit from the extensive grid resource base and tools that currently exist and are being developed
- Avoid balkanizing grid resources by relying on standardized tools, middleware, and architecture rather than unique discipline-specific grid capabilities
- Benefit from the common policies, resource infrastructure, and the Global Grid Forum (GGF). The GGF is a community-initiated forum of thousands of individuals from government, industry, and research leading the global standardization effort for grid computing.

The LSN CG tasked the MAGIC Team to develop a strategy for outreach to grid user communities to inform them of existing and developing tools, architectures, and capabilities, to promote commonality, and to report back.

Possible FY 2005 LSN Coordination

The LSN CG has identified the following three additional topics in which the LSN agencies have a significant commonality of interest and which hold potential for future collaborative activities:

- Autonomic networking
- High-speed transport
- Security

Current High-Speed Networks

Following is a list of all the networks, called "JETnets," across which LSN and its technical teams foster coordination and collaboration. The JETnets are Federal, academic, and private-sector networks supporting networking researchers and advanced applications development. They are:

- Advanced Technology Demonstration Network (ATDnet), established by DARPA and including the Defense Intelligence Agency, NASA, the Naval Research Laboratory, NSA, and Bell Atlantic
- DARPA's BOSSnet and SuperNet
- DoD/HPCMPO's DREN
- DOE/SC's ESnet and UltraScience Net
- NASA's NREN and NISN
- National LambdaRail (NLR)
- Next Generation Internet Exchange Points (NGIXs)
- NSF's EINs (now called DRAGON and CHEETAH) and vBNS+
- StarLight, the international optical peering point in Chicago
- UCAID's Abilene

LSN R&D PROGRAMS BY AGENCY

SELECTED FY 2004 ACTIVITIES AND FY 2005 PLANS

LSN **NIH** LSN

Healthcare and the Next Generation Networking program – funds testbeds demonstrating advanced networking capabilities such as Quality of Service (QoS), security and medical data privacy, nomadic computing, network management, and infrastructure technology as a means for collaboration.

Applications of Advanced Network Infrastructure Technology in Healthcare and Disaster Management – funds work on applications that demonstrate self-scaling technology; use self-optimizing end-to-end network-aware real-time technology and/or middleware; depend on wireless technology; involve advanced authentication (biometrics or smartcards); and are nomadic or use GIS technology.

NLM Scalable Information Infrastructure Awards – supporting the following 11 testbed projects in FY 2004:

- Scalable Medical Alert and Response Technology (SMART)
- An Adaptive, Scalable, and Secure Internet2-Based Client Server Architecture for Interactive Analysis and Visualization of Volumetric Time Series Data
- National Multi-Protocol Ensemble for Self-Scaling Systems for Health
- Project Sentinel Collaboratory
- Advanced Health and Disaster Aid Network (AID-N)
- Advanced Network Infrastructure for Distributed Learning and Collaborative Research
- Advanced Network Infrastructure for Health and Disaster Management
- Wireless Internet Information System for Medical Response in Disasters (WIISARD)
- Advanced Biomedical Tele-Collaboration Testbed
- A Tele-Immersive System for Surgical Consultation and Implant Modeling
- 3D Telepresence for Medical Consultation: Extending Medical Expertise Throughout, Between and Beyond Hospitals

In FY 2005, NIH plans to:

- *Increase its investment in datagrid infrastructure including middleware and other software development for support of biomedical and clinical research activities using federated databases*
- *Begin exploring optical networking testbeds for data sharing between sites engaged in clinical research and for testing different approaches to conducting distributed queries against federated medical databases*
- *Expand use of wireless networks in clinical research environments*

Computing and networking form a continuum of support services for applications on desktop to high-end platforms. Elements of the continuum include distributed computational resources, clusters of computers, grid infrastructure and applications, and the Extensible Terascale Facility [ETF].) The support networking ranges from high-performance, end-to-end, and fine-grained to episodic network services using optical, fiber, wireless, satellite, and hybrid network links. Program areas and illustrative awards are listed below.

Networking Research Testbed (NRT) program – supports prototyping and benchmarking as part of networking research. The Computer and Network Systems (CNS) Division manages this program. The NRT program supports research in:

- Disruptive technologies and approaches
- Hybrid and experimental designs
- End-device research
- Core technology development
- New protocol research
- Alternative network architectures
- Testbed implementations

Awards were made in FY 2003, including:

- A unified experimental environment for diverse networks
- Testing and benchmarking methods for future network security mechanisms
- Orbit: Open-access research testbed for next generation wireless networks
- Agile and efficient ultra-wideband wireless network testbed for challenged environments
- Heterogeneous wireless access network testbed
- Scalable testbed for next generation mobile wireless networking technologies
- National radio network research testbed (NRNRT)

Experimental Infrastructure Network (EIN) – supports research applications with high-performance networking. EIN complements the NRT program. Some EIN focus areas are:

- Control/management of the infrastructure end to end
- End-to-end performance/support with dedicated provisioning
- Pre-market technologies, experimental hardware, and alpha software
- Significant collaboration vertically and across sites
- Persistence, with repeatable network experiments and/or reconfigurability
- Experimental protocols, configurations, and approaches for high throughput, low latency, and large bursts

EIN projects include: dynamic resource allocation for Generalized Multi-Protocol Label Switching (GMPLS) optical networks (DRAGON); end-to-end provisioned optical network testbed for large-scale e-science applications (CHEETAH, for Circuit-switched High-speed End-to-End Transport ArcHitecture); cyber defense technology experimental research network (DETER); PlanetLab, an overlay testbed for disruptive network services; and WAN-in-Lab.

NSF Middleware Initiative (NMI) – program's goal is to design, develop, deploy, and support a set of reusable, expandable middleware functions and services that benefit applications in a networked environment. In FY 2003, 20 System Integrator (SI) Awards were made to further develop the integration and support for long-term middleware infrastructure. Ten other awards focused on near-term capabilities and tool development.

Funded projects include: disseminating and supporting middleware infrastructure – engaging and expanding scientific grid communities; designing and building a national middleware infrastructure (NMI-2); integrative testing framework for grid middleware and grid environments; extending integrated middleware for collaborative environments in research and education; instruments and sensors as network services; middleware for grid portal development

Strategic Technologies for the Internet (STI) – FY 2003 theme areas are: complex network monitoring, problem detection, and resolution mechanisms; applications that promote collaborative research and information sharing; networked applications tools or network-based middleware;

development of automated and advanced network tools; and innovative access network technologies. Awards include:

- A security architecture for IP telephony
- Network Startup Resource Center (NSRC)
- Plethora: A wide-area read-write object repository for the Internet
- Marist Grid collaboration in support of advanced Internet and research applications
- Implementation of a handle/DNS server
- Efficient diagnostic strategies for wide-area networks (tools and technologies to detect, diagnose, and correct network faults in local broadcast domains, whether they are wired (Ethernet) or wireless)
- Development of an infrastructure for real-time super media over the Internet
- Viable network defense for scientific research institutions
- The Strategic Technology Astronomy Research Team (START) collaboratory: Broadening participation in authentic astronomy research
- Network measurement, monitoring, and analysis in cluster computing
- Toward more secure inter-domain routing
- eXplicit Congestion Control Protocol (XCP) development – potential transport protocol for high-performance network environments
- Media-aware congestion control
- Self-organizing spectrum allocation

NSF International Connections – include these initiatives receiving support in FY 2004:

- TransPac award supports networking to the Asia-Pacific region with two OC-12 Packet Over SONET (POS) links. It supports a 1 GigE circuit between Chicago and Tokyo
- Starlight project provides a 10 GigE facility in Chicago to serve as a peering point for international high-performance optical research networks including links to CERN and Amsterdam
- NaukaNet provides OC-3 links to Moscow and Hong Kong

* AmPath provides OC-2 service from Miami to NAP (Network Access Point) of the Americas

* TransLight program supports additional optical networking connectivity to Canada (Canarie2 network), Prague, Stockholm, and London

Information Technology Research (ITR) Initiative – supports research in theme areas that cut across science disciplines and NSF division interests. ITR research areas that are part of the LSN PCA include:

- Cybertrust: projects in operating securely and reliably and assuring that computer systems protect information
- Education and workforce

Large FY 2003 awards related to LSN include:

- Sensitive Information in a Wired World
- Responding to the Unexpected
- Networked InfoMechanical Systems (NIMS)
- 100 Megabits per Second to 100 Million Households

Extensible Terascale Facility (ETF) Connectivity – networks connect computation and storage components at each ETF site and connect the ETF sites with one another. The sites currently are, or soon will be: ANL, CalTech, IU, NCSA, ORNL, PSC, Purdue University, SDSC, and TACC.

NSF's LSN plans for FY 2005 include:

- *NSF Middleware Initiative (NMI) – will continue to address middleware deployment challenges and develop common enabling middleware and domain-specific cybertools for grid-computing*
- *International research connections – new investments will be made to enable international science and engineering collaborations*
- *Programmable Wireless Networks – capabilities of programmable radios to make more effective use of the frequency spectrum and to improve wireless network connectivity will be exploited*
- *Networking of Sensor Systems – architectures, tools, algorithms, and systems that will make it easy to assemble and configure a network of sensor systems will be created*
- *Internet Architecture – the core architecture of the Internet will be reexamined, because there are signs that the current IP-based architecture cannot handle expected increases in communication loads. This requires devising means to test and eventually deploy*

LSN DOE/SC LSN

Applications-related drivers of the DOE/SC scientific research community's growing needs for high-performance network environments are the following:

- Petabyte-scale experimental and simulation systems will be increasing to exabyte-scale data systems in such areas as bioinformatics, climate, and the Large Hadron Collider
- Computational systems that process or produce data continue to advance with Moore's Law
- Network requirements are projected to double every year.
- The sources of the data, the computational resources, and the scientists are seldom collocated

The result is increasing demands on DOE/SC's network. For example, in five years DOE/SC scientists are expected to need the network to:

- Transfer three petabytes per year
- Move a petabyte of data in 24 hours for the high energy nuclear physics community using secure file movement over a 160 to 200 Gbps "best effort" service
- Provide the cell biology community with shared immersive environments that include multicast and latency and bandwidth guarantees using 2.4 Gbps links with strong QoS guarantees
- Support real-time exploration of remote data sets using secure remote connectivity over 1 to 10 Gbps links to the desktop with modest QoS services
- Support experimental (non-production) networking and grid research using unused wavelengths

DOE/SC works with its users to identify mid- and long-term network requirements. Its Office of Advanced Scientific Computing Research (OASCR) is building partnerships among its networking programs, its researchers, and users of its facilities as well as with other LSN agencies. Other DOE/SC priorities are program integration and priority setting for its facilities and research.

UltraScience Net – new FY 2004 initiative to support a breakable, schedulable, ultra-high-speed, all-optical network for conducting networking research. Its technologies rely on fundamental hardware research results of other LSN agencies. The first UltraScience Net link, 10 GigE from Oak Ridge National Laboratory (ORNL) to StarLight, was put in place in early 2004. Linking to Sunnyvale,California, CERN, and Lawrence Berkeley Laboratory (LBNL) is being done cooperatively with NLR. This network will support end-to-end scientific discovery. Towards that end, DOE/SC is supporting R&D in the following areas:

Networking research – addresses end-to-end network measurement and analysis for applications to enable localization and elimination of bottlenecks, effective tuning of the network path for an application, and resolution of performance issues across provider boundaries. Developing new protocols to support large data transfers; cybersecurity policy and technology advances required for OC-12 to OC-192 speeds; QoS, and dynamic provisioning services.

Middleware research – focuses on: providing transparent and scalable cybersecurity infrastructure; developing services to support collaborative scientific work; integrating remote resources and collaboration capabilities into local experimental and computational environments; and facilitating the discovery and use of scientific data, computers, software, and instruments over the network in a controlled fashion. (The National Collaboratories Program-related research activities that are reported in HCI&IM in FY 2004 have been moved to the LSN PCA for FY 2005 because they are more aligned with LSN concerns).

ESnet – network facilities and testbed activities include maintaining the high-performance production ESnet for DOE/SC mission requirements. DOE/SC has as a goal to transition the UltraScience Net prototype to a production environment and to tighten the coupling of the prototype and ESnet.

Connectivity – developing IPv6 protocol implementation, multiplatform video conferencing services, and implementation of distributed network measurement and analysis tools, in coordination with the NSF cyberinfrastructure program and other LSN agency program managers

DOE/SC plans for LSN efforts in FY 2005 include:

- *Completion of UltraScience Net deployment and initiation of testbed activities*
- *Implementation of fiber ring metropolitan area networks in the Bay Area and Chicago to improve connectivity of ESnet core to DOE laboratories and its reliability*
- *Continue network research, grid middleware, and collaboratory pilot projects in coordination with related efforts at NSF and other agencies*
- *Participate in interagency network measurement collaboration*

LSN NASA LSN

NASA Research and Education Network (NREN) adaptive networking program – developing a tool called Resource Allocation, Measurement and Adjustment System (RAMAS) to reserve bandwidth for applications, either when requested or later. RAMAS features include: passive monitoring and measurement; data capture of OC-3 and OC-12 data streams; graphical user interface (GUI) enabling user-defined specifications to designate traffic of interest and types of information to collect on designated flows; data-collection summarization delivered to a central process/control management system that archives summaries and generates graphical representations; interfaces for Ethernet, ATM, POS, and wireless.

A RAMAS experiment captured low-bandwidth wireless data using secure FTP from a field site connected by wireless to a satellite link to mass storage facilities at Ames Research Center and the University of Cincinnati. The test identified the difficulty of optimizing TCP for satellite transmissions.

In FY 2004, work on RAMAS includes: upgrades to OC-48 and OC-192; enhanced data archive capabilities; enhanced data analysis to reduce massive amounts of data to information; security mechanisms to enable use on the NASA Grid (previously called the Information Power Grid); a distributable RAMAS package, possibly on a CDROM; and identification of performance bottlenecks for selected wireless applications.

Nomadic networking: Portable Satellite Dishes – goal is to enable NASA science and engineering in remote locations. Three components: ad hoc networking, hybrid satellite and terrestrial networking, and mobile IP/IPv6. FY 2004 activities include:

- Implement dynamic source routing, an ad hoc network routing protocol
- Investigate use of directional antennas
- Use portable satellite dishes to demonstrate mobile IP in a hybrid environment
- Evaluate mobile IP/IPv6
- Deploy a portable Ka-band (radio spectrum from 18 GHz to 31 GHz used in satellite communications) satellite dish in collaboration with HP Labs

Mobile Agents Field Experiment – developing techniques for planetary exploration, including command of roving vehicles, wireless on-site networking, and autonomous software testing. Experimental components will include the NREN Transportable Earth Station (TES), a rover, all-terrain vehicles, an astronaut, and a remote mission support team at NASA Johnson Space Center.

Geology ground-truthing experiment – goal is to calibrate satellite-derived geology data with in-situ data taken in real time by on-site geologists. Uses wireless networking and the TES to enable researchers to use mass storage facilities, supercomputers, and the grid to conduct experiments while they are on site.

In one experiment, real-time satellite spectro-radiometer data were transported to a mass storage facility while scientists in Utah uploaded ground spectra data to a second facility. The grid was used to move both data sets to supercomputers at NASA Glenn and NASA Ames Research Centers for analysis. The results were accessed by local scientists and sent to the remote science team, which used the results to locate and explore new critical compositions of interest.

Wide Area Network (WAN) testbed – connects five NASA centers and two exchange points, using Asynchronous Transfer Mode (ATM) and Packet Over SONET (POS) OC-12 and OC-3 circuits. For research and development of technology to enable next-generation NASA missions, demonstrate NASA applications, and transfer technology to enhance the capabilities of NASA operational networks. In FY 2004, MPLS, IPv6, and Differentiated Services (DiffServ) will be deployed on the NREN backbone. The PCMon network monitoring tool will be integrated on the TES platform.

LSN DARPA LSN

Network modeling and simulation – Information Processing Technology Office (IPTO) program supports projects to:

- Develop modeling and simulation tools for online measurement and analysis with the goals of designing better protocols and new services such as for dynamic provisioning
- Predict end-to-end performance and vulnerabilities through traffic pattern analysis
- Dynamically optimize performance

In an effort co-funded with NSF, researchers achieved the largest network simulation – of a 1.1 million-node network – to date. The simulation used 1,500 parallel processors, illustrating the use of parallel processing to improve the scale of network simulations and advance the modeling of network behavior. The simulation results are being used to design better, faster protocols.

A DARPA fast-throughput experiment demonstrated 8.6 Gbps throughput using ten simultaneous flows.It attained 34 petabyte meters per second on a path from CERN through StarLight in Chicago to Sunnyvale, California. This metric attempts to capture the interrelationship between bandwidth and delay.

Cognitive Networking – will assess the feasibility of information and communication networks that possess significant degrees of self-reliance and responsibility for their own behavior and survival. Focuses on self-diagnosis, automatic adaptation to changing and hostile environments, reconfiguration in response to changes in the environment, intelligent negotiation for tasks, and resources and robustness under attack. Will also explore the possibility of a virtual "application-private network," whose on-demand protocols are based on specific application requirements and current network conditions.

Self-Aware Collective Systems – this technology thrust will enable heterogeneous teams of individuals (e.g., people, software agents, robots) and/or organizations (e.g., coalition forces) to rapidly form, easily manage, and maintain virtual alliances concerned with a specific task. Thrust involves two efforts:

- Self-Aware Peer-to-Peer Systems – will develop resilient, scalable sensor/computation networks with decentralized control. This technology will support battlespace awareness by enabling the self-formation of large ad hoc networks of sensors and computational elements within the severely resource-constrained environment (power, bandwidth, stealth) of military operations while enabling networks to survive component failure, network intrusion, and the subversion of elements.
- Collective Cognitive Information Processing for Improved Asset Performance – will develop learning and reasoning algorithms that can identify and classify emergent problems and opportunities for proactive maintenance of equipment and use of sensors in a dynamic operational environment. These new self-aware distributed systems will be able to reflect globally on their overall operation (including understanding trends), and make decisions based on the collective disposition of assets connected by networked sensors (e.g., vehicles or other equipment).

In FY 2005, DARPA work will continue on:

- *Cognitive Networking*
- *Self-Aware Collective Systems*

LSN DOE/NNSA LSN

Distance Computing (DisCom) program – a component of NNSA's Advanced Simulation and Computing (ASC) Program, formerly the Accelerated Strategic Computing Initiative (ASCI). DisCom assists in the development of an integrated information, simulation, and modeling capability to support the design, analysis, manufacturing, and certification functions of DOE's defense programs complex through advances in distance computing. Extends the environments required to support high-end computing to remote sites. Provides remote access to major ASC platforms – Red, Blue Mountain, White, and Q.

In FY 2004, DisCom is delivering additional key communications technologies to efficiently integrate the ASC platforms of Red Storm, Purple, Blue Gene/L, and beyond. Supporting tools development for more reliable and persistent file-transfer mechanisms over the WAN.

DisCom cooperates and collaborates with NSA to closely monitor the IP encryptor technology.

In FY 2005, LSN activities of DOE/NNSA will include:

- *Begin deployment of new tools for reliable, persistent file transfer over the WAN*
- *Continue development of integrated distance computing capabilities for ASC*

LSN NIST LSN

NIST supports network-related programs in its Advanced Network Technologies Division (ANTD) and in the Computer Security Division (CSD) of its Information Technology Laboratory (ITL). Their mission is to provide the networking industry with the best in test and measurement research. Their goals are to improve the quality of emerging networking specifications and standards and to improve the quality of networking products based on public specifications. Their core technical contributions are:

- Models and analyses from specifications to assess consistency, completeness, precision, and performance characteristics
- Prototypes and empirical studies from specifications to determine feasibility
- Test and measurement tools, techniques, metrics, and data to assess conformance, interoperability, and performance

ANTD research programs include:

- Pervasive Computing including Wireless Personal Area Networks (WPAN), service discovery, wireless access networking, wired access, core networks, and wireless ad-hoc networking. Focus areas are UltraWide Band (UWB) and grid computing.
- Agile Switching: routing, signaling, protection, restoration, and network management and metrology
- Internet Telephony including session-initiated protocol (SIP) for voice to support nomadic information appliances, particularly for the health care industry
- Infrastructure Protection for securing core services, secure BGP, and survivable control planes
- Wireless Ad Hoc Networks for architecture, routing, and services, particularly standards, and first responder technologies
- Cryptographic: standards and quantum encryption keys

Details of some projects follow.

FY 2004 priority taskings – evaluating the economic consequences of IPv6; planned a January 2004 workshop on "spam" at the request of the White House

Resilient Agile Networking (RAiN) program – developing, testing, and standardizing technologies for fault-tolerant, self-adaptive and ad-hoc networks. RAiN projects include: survivable control planes (work with the Internet Engineering Task Force (IETF) and the Network Processor Forum to define security mechanisms that will scale to performance levels necessary for the core Internet infrastructure); large-scale BGP attack modeling to characterize the performance impact and benefits of various proposed approaches to secure BGP; new measurement platforms; wireless ad hoc networks (work with public safety agencies to develop requirements and standards for emerging public safety communication and networking technologies)

Self-Managing Systems – conducting research and developing the test and measurement basis and standards foundations for future self-managing systems. Working with DARPA, the Global Grid Forum, Distributed Management Task Force (DMTF), IETF, the Institute of Electrical and Electronics Engineers (IEEE), IBM, Sun Microsystems, Cisco, HP, and others, NIST is: exploring information and knowledge management, learning, and reasoning techniques to enable new levels of autonomic operation of increasingly complex distributed systems; establishing the measurement basis to assist industry in evaluating the behavior and performance of emerging self-managing systems.

Information Security – focuses on cryptographic standards and applications, such as: secure encryption, authentication, non-repudiation, key establishment, and pseudo-random number generation algorithms; standards and guidance for e-Gov and e-Authentication; PKI and Domain Name System (DNS) security standards, interoperability, assurance, and scalability; wireless and mobile devices and smart card security; quantum computing and quantum cryptography (in coordination with DARPA)

GLASS: GMPLS/Optical Simulation Tool – developing a modeling tool to evaluate architectures and protocols for routing, signaling, and management of GMPLS for optical networks and to support multilevel, multiprotocol schemes for traffic engineering, QoS, protection, and restoration. Also developing a modular simulation framework to support: optical network restoration; MPLS DiffServ protocol recovery; GMPLS and optical common control and measurement plane (CCAMP); and a protection and restoration tool to provide multilevel recovery schemes.

In FY 2005, NIST plans in LSN R&D include:

- *Continue work in RAiN program, self-managing systems, cryptographic standards for information security, and the GLASS project*

LSN NOAA LSN

Advanced Information Technology Program – R&D strategy to:

- Explore advanced technologies to make NOAA's vast amount of environmental data available easily, quickly, and completely
- Exploit innovative data access technologies including Web-based tools and agents as they evolve
- Explore emerging security technologies to safeguard NOAA data and information
- Transfer new technology to other NOAA users

NOAA is implementing the strategy through:

- Real-time collaborations such as Internet@sea and Ocean Share
- Seasonal-Interannual Climate Collaboration: Distributed collaboration visualizing the environment
- Access to Data: Satellites, radar, aircraft, in situ, and models
- Fisheries Model Analysis such as for Pollack larvae in Shelikof Strait in Alaska
- Hazardous Spill Response: Anytime, anywhere connectivity

Related NOAA R&D includes:

Computer and network security – projects address: encrypted file systems; firewalls and intrusion detection at gigabit speeds; automated, enterprise-wide patching; and wireless security.

Next Generation Internet program – goal is to use advanced networking technologies to enhance NOAA data collection and dissemination and to support the NOAA HPC architecture. Provides connectivity among seven NOAA sites and to radar sites providing near-real-time weather data. Currently developing phased-array radars (NEXRAD) to collect near-real-time weather data. Deployment of these radars will significantly increase data transport requirements.

Discipline-specific user toolsets – being developed to support collaboration and grid applications. Plans to explore the use of grid systems for data handling, computation, and collaboration, and to test deployment of IPv6 at three NOAA sites.

FY 2005 NOAA plans include:

- *Continue developing advanced networking capabilities*
- *Optical networking*

- *Implement additional network-enabled applications as they become practical, including:*
  - *Collaboratories*
  - *Grid computing*
  - *Storm-scale simulations with immersive environments*
  - *Wireless: Data anywhere, anytime*
  - *Remote operations*

LSN NSA LSN

Laboratory for Telecommunications Sciences (LTS) – programs continue to emphasize transmission of quantum communications through optical elements. This work is part of a joint research program with DOE/SC. Demonstrated a quantum channel on the same fiber as a SONET channel.

In FY 2003, NSA demonstrated techniques for regionalized QoS management and developed a model for QoS pricing of Internet services. In FY 2004 NSA is working to join these two efforts to provide a viable pricing model and requisite enforcement mechanisms. Also continuing are programs on Critical infrastructure protection issues for converged networks. Work slowed in nonlinearities and transients in optical networks, regionalized quality of service management, and firewalls in high-speed networks. Work was phasing out in optical burst-switched protocols.

In FY 2005, NSA will continue network research in:

- *Quantum communications, quality of service, and high- speed network interfaces*

PARTICIPATING AGENCY

LSN HPCMPO LSN

Defense Research and Education Network (DREN) – maintains a production WAN, using MCI services, providing DS-3 through OC-768 links and deploying GigE and 10GigE services. This network supports IP, IPv6, and multicast with increased security. It supports both Continental U.S. (CONUS) and Outside the Continental U.S. (OCONUS) sites. It provides OC-3 and OC-12 peering to OCONUS. Core network expansion by MCI includes OC-192 in June 2004 and OC-768 when required. Key network services provided:

- IP performance: latency, packet loss, and throughput
- ATM availability
- IPv6 and multicast
- Increased security

FY 2004 activities include:

- Connectivity: to the Advanced Technology Demonstration network (ATDnet), StarLight, and other experimental networks to support development of new technologies and services; to remote sites in Alaska and Hawaii, in collaboration with NASA

- IPv6 pilot program: DREN deploys IPv6 native and supports the Abilene IPv6 Transit Access Point (6TAP) testbed and the IPv6/MPLS end-to-end testbed. Services include: efficient routing using protocols such as BGP+, GMPLS, and OSPF; QoS; priority, preemption, policy, authorization, and audit; voice, video and data support; dynamic network monitoring; scalable speeds, including network test and measurement capabilities and passive monitoring with time-stamping.

- Performance measurement: testing 10 GigE equipment. In FY 2004, DREN is able to achieve near wire-speed performance over 80 percent of the time across its OC-12 links.

- Network security: providing end-to-end WAN encryption; developing IPv6 security with beta-testing of NetScreen IPv6 currently in-place. It is considering NS-500 firewall protection. (NS-500 is a GigE security device that uses a Virtual Private Network [VPN].)