NGI/CE/02

Optimizing and Securing High-Performance Data Flows on a Dense Wave Division Multiplexing Network Test Bed

FY 2005 Proposal to the NOAA HPCC Program

September 13, 2004

| Title Page | Proposed Project | Budget Page |

Principal Investigator: **Michael A. Doney**

Line Organization: OAR
Routing Code: R/FST
Address:

NOAA Forecast Systems Laboratory
Information & Technology Services
325 Broadway
Boulder, CO 80305-3328

Phone: (303) 497-6364
Fax: (303) 497-7259
E-mail Address: Michael.A.Doney@noaa.gov

Alex Hsia	Tony Wu	Pete Sakosky
Alex.Hsia@noaa.gov	Tony.Wu@noaa.gov	sakosky@ucar.edu

Proposal Theme: **Advanced Networking Technologies**

Funding Summary:

Michael A. Doney	Peter A. Mandics
Network Manager	Chief Information Officer
Forecast Systems Laboratory	Forecast System Laboratory

Optimizing and Securing High-Performance Data Flows on a Dense Wave Division Multiplexing Network Test Bed

Proposal for FY 2005 HPCC Funding

Prepared by: Michael A. Doney

Executive Summary:

NOAA is making excellent advances in super computing and planning for the development of an enterprise network architecture. However, NOAA currently does not have a distributed network test facility for evaluating new network technologies, other than in local environments, although the benefits of such a facility are numerous. The primary challenges for building a NOAA network test facility include 1) limited access to dark fiber for experimental purposes, 2) the high cost for obtaining high-speed ($\geq$ 10 Gigabit per second (Gbps)) networks from commercial service providers, and 3) lack of a standard IT security solution for 10 Gbps data rates. Recent advances in optical networking are significant because they directly address these first two challenges, and other research in high-speed network security offers promising solutions for the third. NOAA would be well served by developing a way to test and integrate new network technologies in order to gain vital experience for promoting NOAA research and operations.

We propose to develop an optical network test bed using Dense Wavelength Division Multiplexing (DWDM) by leveraging NOAA's existing investment in a metropolitan fiber optic network. We will be partnering with both the National Center for Atmospheric Research (NCAR) and the National Environmental Satellite, Data and Information Service's National Geophysical Data Center (NESDIS/NGDC) to execute this proposal. This network test bed will provide a platform for integrating DWDM technology, and for determining how DWDM will best serve NOAA research and operations, but it will also address other important challenges. The optimization of data flows and server input/output at 10 Gbps will require study, testing and tuning, and the question of how to secure data flows at this rate will also be addressed. The experienced gained will readily translate to all NOAA regions, super computing and data archive sites, who will need to address these common network issues soon.

Problem Statement:

In the near future, NOAA will need to obtain access to 10 Gbps networks in order to interconnect super computing and data storage sites. In Vice Admiral Lautenbacher's NOAA 2007 Annual Guidance Memorandum, he states, "…By 2011, we must have a culture, process, and systems approach that can plan for and seamlessly apply new technologies to realize our goals. Part of this approach will require test beds that rapidly evaluate new technologies needed to improve products and services…." NOAA currently does not have an installation for evaluating new network technologies capable of supporting 10 Gbps data flows in metropolitan or wide area networks (WANs).

The challenges for building a diversified test network can be both technical and non-technical. Some of the obstacles that inhibit NOAA's ability to test new network technologies in a distributed environment are: the limited availability of fiber optic cable for experimental research in metropolitan, regional and wide area networks, the commercial costs for 10 Gbps network bandwidth is prohibitively expensive, and there are no standard IT security solutions for distributed super computing and data resources on a national scale at 10 Gbps. DWDM is a viable next generation network technology that will address many of these challenges, but NOAA has no experience working with DWDM, 10 Gbps networking, data flows or IT security at this rate.

Proposed Solution:

We propose to implement a DWDM network test bed by utilizing the NOAA-owned dark fiber in the Boulder Research and Administrative Network (BRAN). DWDM technology uses the physical properties of light to maximize how logical networks can be assigned in fiber optic media. Light is divided into individual wavelengths, or waves, and each is equivalent to a dedicated network path. DWDM is protocol agnostic, meaning it is not dependent on any transport protocol. For example, a wave could carry IP packets, Ethernet frames, ATM cells, fiber channel or other storage protocols. This feature provides tremendous flexibility for network applications in a single infrastructure. With today's technology, up to 32 individual waves can be multiplexed together and selectively added to or dropped at logical nodes along the network topology. Therefore, NOAA could apply this technology to obtain a much more efficient use of the limited fiber resources available at NOAA sites. As for network bandwidths, DWDM supports multiple network speeds via a variety of optical components- the most important are 1.0 and 10 Gbps Ethernet for this proposal.

The proposed DWDM network test bed will include a pair of optical network switches with Gigabit Ethernet (GbE), 10 GbE, and DWDM components to be procured and located at NOAA Boulder and at NCAR. A Gigabit Ethernet switch will be attached at the NOAA site to accommodate additional 1.0 GbE connections. An optical tap will be procured to allow passive monitoring of all 10 GbE data flows. In addition, three 64-bit computer systems running a Linux operating system and supporting 10 GbE will be procured to transmit, receive, monitor and secure the data flows. Two systems will be located at NOAA and one at NCAR.

This metropolitan network test bed, including the end nodes, will be a point-to-point dedicated network in a secure "closed-loop" configuration. That is, it will only have one access point to the NOAA firewall at the Forecast Systems Laboratory (FSL) for the purpose of uploading test data. Access to this network test bed will be strictly controlled through this firewall, but will be provided to NOAA and NCAR investigators on this proposal. The NOAA end of this test bed will have no other attachment to any network, and the NCAR end of this test bed will have no attachment to any network whatsoever.

The proposed network test bed will provide a platform to:

1. Acquire direct DWDM experience,

2. Optimize multi-Gbps data flows for performance, and

3. Test and determine the best security solution(s) for high-speed links. This effort will begin with an evaluation of the appropriateness of existing public domain systems and utilities.

Analysis:

NOAA's investment in the BRAN dark fiber network in 1999 creates an ideal environment for building a metropolitan network test bed. The BRAN was founded by the cooperative workings of city, state and federal governments, and NOAA has undisputable access rights to 24 of the 96 single mode strands of fiber that ring the city of Boulder. While the availability of this fiber for research use is a unique opportunity within NOAA, it remains a NOAA-wide resource, and as such, testing and optimization of DWDM technology in this environment will directly lead to more intelligent and efficient use of limited fibers in other NOAA regions.

The presence of NCAR as a network neighbor on the BRAN is also a benefit to the proposal of a NOAA network test bed. NCAR has many of the same interests in terms of testing and developing DWDM and securing multi-Gbps data flows, because their climate modeling and super computing needs closely parallel those of NOAA. NCAR also serves as the manager of the Front Range GigaPoP (FRGP), which provides the primary WAN services for all of NOAA Boulder and is NOAA Boulder's key interchange point with Abilene/Internet2, commercial Internet, and the National Lambda Rail (NLR) in Denver. NGDC as a partner on this proposal will also help to ensure that the optimization of high-speed data flows are directly focused on real needs for NOAA's massive data archives and distribution plans.

The cost of obtaining high-speed network links from commercial service providers can be prohibitively expensive. In comparison, by creating regional partnerships and sharing the costs, high-speed network links become very reasonable. For example, the Central Region's NOAA Boulder NOC has partnered with the FRGP to lease dark fiber from Boulder to Denver, and to share the cost burden for participating in NLR. As such, NOAA Boulder's cost to participate in NLR is $85K/year (for five years). This dark fiber access to NLR will initially provide NOAA Boulder with multiple switched Ethernet circuits at one Gbps, a national 10 Gbps IP network, and access to a quick-start facility for new research projects, Internet2 and the Global Lambda Integration Facility. By comparison, the commercial cost for a single 10 Gigabit link between Boulder and Denver is $332K/year, and ~$500K/year for a 200 Megabit link between Denver and Kansas City. Since NLR is built on partnerships, dark fiber and DWDM technology, this proposal plans to demonstrate the same approach, in a network test bed, that could eventually be applied throughout NOAA to realize additional WAN cost savings.

The timing on this proposal coincides with NOAA's decision to participate in the NLR network through the FRGP in partnership with the weather and climate research community. The experience gained and lessons learned from this proposed NOAA network test bed will be extremely valuable as NOAA determines how to make the most of NLR. The inherent scalability of DWDM in a NOAA network test bed creates a new opportunity for NOAA to take advantage of the benefits of a national fiber optic network (when warranted), while simultaneously developing the high performance networking experience to serve NOAA super computing needs. The best and most logical application of NLR at NOAA would be to interconnect the NOAA super computing sites and headquarters. Similarly the NOAA National Data Centers will need multi-gigabit links to the NPP & NPOES ingest/processing facilities, to the NOAA research labs and to other data centers for backup purposes. To do so will require significant time and effort to obtain better connections (such as dark fiber access) into the regional GigaPoPs. What *can* and should be done, is to take advantage of the NOAA-owned dark fiber network in Boulder (BRAN), and begin building, testing, and integrating this capability to better understand and prepare for a NLR-like potentiality for the NOAA national enterprise.

Performance Measures:

Factors to be considered in determining the success of this project include:

1. A functioning metropolitan DWDM network between NOAA and NCAR that supports the utilization of multiple wavelengths over a single fiber. (10GbE, and 2 x 1GbE).

2. A functioning 64-bit three-host test bed for extremely high-speed data flows between individual hosts (2-8 Gbps flows on a single connection over the network).

3. A measurable performance increase in data flow rates due to optimized flows.

4. A 10 Gbps network monitoring system to evaluate high-speed security and packet-capture tools. This also includes the evaluation and incorporation of a responsive Intrusion Detection System (IDS).

Milestones

Month 01 – Evaluate optical network vendors and server solutions; begin procurement.
Month 03 – Receive and install network and server components.
Month 04 – Initialize DWDM network of multiple wavelengths.
Month 06 – Begin testing/monitoring of multi-Gbps data flows.
Month 12 – Optimized flows and security solutions documented.

Deliverables

- A multi-wavelength DWDM network test bed that is available for wider test scenarios within NOAA.
- A 10 Gbps test infrastructure for evaluating high-speed data flows, security and packet capture tools.
- Documented flow behavior for multi-Gbps data flows, such as an automated script procedure for modifying host interface and buffer parameters for optimizing performance.
- Documentation on the NOAA DWDM network test bed, including lessons learned and recommended best practices for optimizing and securing high-speed data flows.

Matching Resources

This proposal has a fairly large cost for optical hardware components; therefore, no personnel compensation is included in the budget. Instead, the personnel time of the investigators are offered as a portion of the matching resources applied to this proposal.