NGI/CE/05

Title: **"Preparing to use NWS operational data over the NGI/Abilene network "**

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Proposal Theme:	Theme 1, Advance Network Technologies: NGI (also relevant to Theme 3, Disaster Planning, Mitigation, Response & Recovery)

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Executive Summary

This project is a multi- NOAA Line Office, university collaboration designed to test, for the first time, the feasibility of using the realtime radar data delivered over the NGI/Abilene network for National Weather Service (NWS) River Forecast Center flash flood warning operations. More specifically, we will use a flash flood application as a tool to assess the performance (i.e., the latency and reliability) of a new NWS network. What makes this project and situation unique is it represents a departure from the traditional way the NWS transmits operational data. Historically, NWS has moved operational data over secured leased lines that they manage end-to-end. Thus this venture by NWS toward using the NGI (a non-dedicated, externally managed network) for operational data has become a high-visibility effort upon which the future usage of the NGI by the NOAA units for operations may rest.

Several years ago, HPCC funded the highly successful demonstration project called Collaborative Radar Acquisition and Field Test (CRAFT). In February 2003, the Director of the NWS's announced plans to extend CRAFT nationwide with the deployment of a realtime delivery system for WSR-88D data using the NGI/Abilene network as its backbone. The National Severe Storms Laboratory (NSSL) and the NWS Hydrologic Laboratory (OHD) plan to build upon this success.

The NWS's operational security requirements are tighter than those considered during the CRAFT research project. Although latency and reliability issues were tested as part of Project CRAFT, the proposed NWS network architecture is notably different than the CRAFT network. The added security constraints will, no doubt, have an effect on network performance. Now that the NWS has defined the networking architecture for distributing these data, specific tests can be conducted during this transition phase from the CRAFT network. We believe alternate network configurations are possible that will both insure low latencies and high reliability and will be economical to adopt, but we need to run the tests outlined in this proposal to support any specific configuration changes we may wish to suggest.

The implications of this proposal are national in scope. The distribution of these data over the new NWS network will be used by numerous NWS applications (such as the flash flood application used here); will be used by NWS' National Center for Environmental Prediction (NCEP) for supporting initialization of forecast models; will be distributed to the university community (through UNIDATA); will be distributed to other government agencies for research; and will be distributed to the private sector all using this network infrastructure. The previously funded HPCC and ESDIM proposals leveraged by this project are **"Moving Realtime WSR-88D Base Data Over The NGI"** and **"A Real-time, NGI-Based, Direct Digital Ingest and Archive of WSR-88D Base Data as a Prototype for a National System"**, respectively. This project also leverages Project IFLOW, an OAR Sea Grant Extension project that supports the networking and computing infrastructure needed for this project.

Problem Statement

The National Severe Storms Laboratory (NSSL), the National Weather Service (NWS) Office of Hydrologic Development (OHD), and the University of Oklahoma (OU) are proposing to collaborate on an experiment to test the network performance (i.e., latency, and reliability) of realtime, high-resolution radar data transmitted over the new NWS network that uses a non-dedicated, externally managed network (NGI/Abilene) as a backbone.

Traditionally, operational NWS data have been collected and disseminated using secure, leased lines operated solely by the NWS. Breaking from tradition, the NWS has committed to the collection and dissemination of high-resolution WSR-88D Level II radar data in realtime over the NGI/Abilene network.

Until recently, these data have only been available to a select few government laboratory and university researchers. As a result, at the present time there are virtually no operational NWS applications using these data on a regional or national scale (the data are used locally at each radar site where transmission over a WAN is not required). OAR's NSSL has extensive expertise in utilizing these data in regional hydrologic applications and is positioned to help. Work needs to be done to 1) prove a network architecture that uses a mix of leased lines and the NGI/Abilene for data transmission can meet the criteria suitable for operations (reliability, and latency) and 2) prove the value of using these realtime high-resolution radar data in operational applications.

Proposed Solution

Project CRAFT used an ad-hoc combination of T1, 56K, and 64K lines to collect and distribute the radar data (i.e., it was a collection of disparate networks). In contrast, the new NWS network will be standardized. A star configuration will be used to connect all radars within each of the NWS Regions to the local Regional Headquarters operations center with a minimum bandwidth of 128K. These centers will be connected to the nearest (or in some cases, least expensive) NGI/Abilene access point using DS3 leased circuits for transmission over the NGI/Abilene network, through the Maryland GigaPop, to NWS operations.

NSSL and NWS/OHD researchers have identified a candidate flash flood application (i.e., QPE-SUMS) to help test the latency and reliability issues that arise when using realtime data over a non-dedicated, externally managed network to pave the way for use of these data in general NWS operations. The NWS Hydrologic Forecast Office (OHD) does not currently have an operational flash flood forecasting product that makes a direct use of these radar data in realtime, but NSSL does (QPE-SUMS) and it will be used in this test.

OAR and OU will assist NWS in determining the performance of this network. Alternatives being considered for security include a mix of firewalls and Virtual Private Network-like services. Impacts these security alternatives may have on performance will be assessed. Plans are to utilize tools developed in the earlier HPCC funded CRAFT proposal to measure and monitor data latency and reliability. Latencies are expected to improve in some respects where bandwidth will be increased, however, for those T1 connections that will be replaced by 125kb/s or 256kb/s leased lines, the latencies may increase. Reliability is expected to improve, given the standardization of the network design and 24x7 operational management of on the NWS leased lines. Data transmission is accomplished using Unidata's Local Data Manager (LDM) software. LDM has several configurable parameters that can be changed to optimize transmission. One option we will focus on is the size of the buffer controlling the amount of data stored when a connection is down. When the connection is reestablished, the buffer dumps the stored data collected by the radar during the time the network link was down. What is learned about the reliability of this new network will help determine the appropriate setting for the LDM buffer size.

A second goal of this project will be assessing the current network architecture and, if warranted by the test results, making specific recommendations for modifying the architecture to improve reliability and latency by, for example, using a distributed multi-node data delivery approach rather than the single-node data delivery approach being constructed. The single-node approach, we believe, could lead to single point of failure issues. Conversations with the UNIDATA experts at data dissemination and creators of the LDM software concur. The multi-node approach will allow for redundancy and fewer network hops, improving latencies.

The project will be run over a period of about 12 months, long enough to capture a reliable data record on the reliability and latencies.

In summary, funds are requested in FY04 1) to assess the performance issues confronted when using these realtime radar data delivered over a mixed network consisting of both leased lines and the NGI/Abilene backbone and 2) assess the possible alternate network configurations that could improve overall data delivery speed and reliability.

This proposal primarily targets **Theme 1** of the FY04 HPCC themes (Advance Network Technologies; NGI). The proposed solution is consistent with the NOAA Enterprise Target Architecture. It builds upon the successful HPCC and ESDIM projects and utilizes Abilene and NOAA's high bandwidth network connectivity to transmit high resolution, realtime data needed for this project. The proposal also has aspects of **Theme 3** (Disaster Planning, Mitigation, Response and Recovery: Information Support for warning decision systems) since it involves testing the feasibility of using realtime data for flash flood warnings in NWS operations.

Analysis

We believe now is the time to conduct this project. We can leverage all the hardware and networking infrastructure is in place and being paid for by the NWS (taking the CRAFT network nationwide) and OAR Sea Grant (supporting the hydrologic testbed for testing the flash flood algorithm). Therefore, the cost for HPCC to sponsor this important effort is minimal, mostly Joint Institute and Contract personnel.

The NWS is presently designing the network to collect, transmit and deliver these radar data. One of the authors of this proposal has been involved in the design process. We are well positioned to utilize what we have learned during the past 5 years from the CRAFT project to assist the NWS. Software tools developed under CRAFT that measure the latency and reliability can easily be adapted for use with the new network architecture. In addition, programs such as sFlow will be considered to monitor traffic volume between NWS radar sites, Regional Headquarters nodes, and the Maryland GigaPop. One feature of sFlow is it measures not only the volume of traffic, but also where it comes from and where it is going (traffic source and destination).

We will assess the performance of the proposed NWS network design. NWS plans to collect all the data and distribute it at a single point (i.e., the Maryland GigaPop). It is possible a distributed data collection and distribution design using the Regional Headquarters sites might improve performance, increase reliability, and reduce latencies.

We propose to use a realtime flash flood algorithm to help determine the network performance. The precipitation estimation algorithm is called QPE-SUMS (Quantitative Precipitation Estimation and Segregation Using Multiple Sensors) and OAR's National Severe Storms Laboratory developed it.

NWS has committed $250K to the University of Oklahoma to keep the existing CRAFT network operating until it transfers the entire NWS WSR-88D network of 121 CONUS radars and 11 DoD select radars into its new architecture. NWS has also invested and/or committed over $400K for hardware and installation expense to get the remaining 60 radars onto the NWS/CRAFT network and to establish the collection nodes at each of the 4 NWS Regional Headquarters sites and at the Maryland GigaPop. OAR's Sea Grant program has already invested $30K this year to keep the infrastructure operating in the Tar River Basin. NWS/OHD has committed $15K in personnel expense to assess the flash flood algorithm performance. NSSL has committed $35K toward salaries of Federal and Joint Institute personnel (CIMMS). However, successful completion of this project will require additional support beyond that committed for hardware and communications and that is the basis for this proposal. If this project were to

be done independently of the NWS and Project CRAFT, the total would be at least $1.3M, not including the personnel expense needed to design, install and maintain the network.

Performance Measures

FY04 Milestones:

02/04 Receive notification of proposal approval.
03/04 Get QPE-SUMS algorithm working at NWS Office of Hydrologic Development in "quasi-operational" environment.
04/04 Begin assessment of the new NWS network's performance with respect to measuring the latency and reliability using the connection between the KOUN radar at NSSL in Norman, Oklahoma to NWS Hydrologic Development Laboratory in Silver Spring, Maryland.
09/04 As NWS finishes network installation of all 121 CONUS radars using single-node configuration to distribute Level II radar data, collect performance statistics network and begin discussion with NWS and UNIDATA with respect to alternative network designs to the single distribution point configuration model (i.e., single point of failure model). Provide suggested network changes, as appropriate, depending upon results of performance results.
04/05 Complete traffic monitoring of realtime radar data for use in future optimization of NWS network.

FY04 Deliverables:

09/04 Complete assessment of the performance as impacted by enhanced security features and look for ways to minimize impacts, if warranted. Provide report to NWS network design team.
03/05 Complete study of latency and reliability using realtime flash flood algorithm after 12 months of monitoring performance. Make these results available to NWS/OHD and NWS NCEP for consideration as they prepare to use these data for operations in their flood warning systems and forecast models, respectively.
04/05 Depending upon test results, work with UNIDATA and NWS to explore alternate, yet economical, design changes (e.g., add memory to key nodes) and configuration changes (e.g., changes to LDM parameters) to improve data delivery and reliability to the government, university, and private sector users. Take into consideration that both government and private sector users will require "operational quality" data streams.
05/05 Assess the performance of the proposed NWS network design (e.g., single point of collection and distribution through the Maryland GigaPop) and make appropriate recommendations to NWS (e.g., a distributed data collection and distribution design using the Regional Headquarters sites might improve performance and reduce latencies).