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Project Title: **"Communications Management System for Realtime Radar Wind Retrievals"**

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Executive Summary

The WSR-88D network provides only single-Doppler scanning over most areas in the U.S., so the wind measurements are limited to the velocity component along the radar beam. The cross-beam winds are not measured, but are often considered critical for nowcasting severe storms and hazard weather conditions and indispensable for initializing high-resolution numerical weather prediction models. To solve this problem, substantial progress has been made at NSSL in recent years in retrieving high-resolution vector winds from WSR-88D level-II data. Related progress has been made in advanced variational methods and associated computer application packages. In particular, a prototype Radar Wind Retrieval (RWR) package became ready for real time tests in June 2002 and has been running since that time on a small, but dedicated workstation to retrieve high-resolution vector wind fields using realtime WSR-88D Level II data from eight New England radars. The package produces realtime displays of the retrieved vector winds with data files on-line at http://gaussian.gcn.ou.edu:8080/NewEngland/index.shtm.

The objective of this project is to develop an automated Internet communications management system for realtime tests and applications of the RWR package. The package contains 5 major components that perform 5 operations: (1) Level II data fetching, (2) decoding, (3) quality controlling and vector wind retrieving, (4) graphic displaying and (5) web-based on-line dissemination (or delivery). The proposed management system is designed to monitor each step of operation, detect fault events and make timely corrections. This will improve the reliability and quality of the retrievals and minimize the need for human intervention. It will also monitor the data flow and computer resource usage to maximize the realtime RWR efficiency and capabilities. In addition to automated reporting and recording fault events, it will collect differences of the retrievals with respect to other observations and model predictions to improve data quality control and error statistic estimation.

This proposal targets the FY03 HPCC Theme 2: Technologies for Collaboration, Visualization, and Analysis. The proposed fault management and log management system for radar data in support of numerical modeling for storm events also fits Theme 3: Disaster Monitoring or Response.

Problem Statement

The central piece of the Radar Wind Retrieval (RWR) package is its 3rd component: data quality control and vector wind retrieval. This component leverages the basic research conducted in the past several years at NSSL and the University of Oklahoma in developing advanced variational methods and state-of-art adjoint techniques for Doppler radar wind retrieval and data assimilation. Although this central component has been continuously improved and produced quality retrievals (better than expected), the remaining components are relatively new. As the new components are connected and combined with the central piece into the RWR package, the realtime aspects introduce new challenges and unexpected problems that require an automated Internet communications and data handling management system.

The Radar Wind Retrieval package is a combination of software from a variety of commercial vendors, government agencies, and public domain software providers. In particular, Unidata Local Data Manager

(LDM) is used to transfer realtime WSR-88D Level II data, WDSS II or an internal decoding software is used to decode data, the advanced variational method and adjoint technique are used to retrieve vector wind fields, GrADS is used to produce graphics, and Java and C++ are used to display the graphics on the Web and put the data files into ftp sites.

The package is experiencing a variety of unexpected problems. Examples include (but not limited to): interruptions of data communication link that caused LDM failures in fetching realtime data; incorrect formats in the radar data that caused failures in decoding; bugs in algorithm code that crashed the computation or communication under certain circumstances, bursts of load in computation or communication that caused the computer run out of memory or disk space, etc. It will be very difficult and human-labor intensive to monitor all the aspects of the RWR performance. It will be even more difficult and costly if the tasks are performed routinely every day, and continuously day and night. It is not only extremely difficult, but also nearly impossible to manually identify and correct all the problems realtime in time. Thus, an automated management system is critically important for realtime testing and application of the Radar Wind Retrieval (RWR) package. This system is also needed for maintaining a data log of the archive in a managed way, so that the data, which will be archived in huge volumes, can be easily retrieved for re-analyses and related research efforts.

Proposed Solution

The proposed solution builds upon the recent successes derived from the two ongoing projects, the Collaborative Radar Acquisition Field Test (CRAFT, funded initially by a grant from the Oklahoma State Regents for Higher Education) and the High-Resolution Radar Wind Retrieval Project (HRWRP, supported by NOAA FY 2002 New England High-Resolution Temperature and Air Quality Forecasting Pilot Program which was called by the Congress). It is designed to augment the existing effort with CRAFT and HRWRP and to accelerate realtime tests and applications of the RWR.

We propose the creation of a realtime communications management system designed to address the complexities introduced by handling high bandwidth, realtime data over the Internet. The following functions will be included in the management system:

Fault management
(1) Alarm surveillance: Setting criteria for reporting alarms, alarms can be further categorized as communications alarm, processing alarm, environmental alarm, etc. Fault event detection and reporting, the report includes information such as severity and probable causes. (2 Diagnostics: Running diagnostics for determining where and when the fault occurred. (3) Fault correction: Reload software, restart process, and restore previous state.

Communication management
The management system can monitor the network communications. If LDM did not receive radar data for a period of time, it can ping the remote site to see if the network is down. It can

also determine if the bandwidth needs to be increased or not. If the bandwidth is insufficient, then the management system will distribute the processing and computational load to an additional machine. Sometimes radar data arrive in bursts, so the management system should be able to adjust the communication and computations based on such a abrupt nature of the input data.

Real-time data flow management
The RWR package contains five major components to run aforementioned five major processes. Each component will report its status to the management system periodically. The management system will restart the process if one process died. The management system will restart the whole platform if one process died more than certain times. The interactions between the management system and the components are recorded in the log file. For a large component, such as the third component, it will be divided into modules. The management system monitors each module independently. So the problem can be quickly isolated. The quality and stability of real-time data flow will be assured by having the management system.

Computer system management
The management system will monitor the computer system that runs the RWR, and collect information on the usage of disk space, memory and CPU time. The collected information will provide a reliable basis for the future expansion of the computer system demanded by an upgraded RWR, enlarged input data types and amount, and expanded dissemination (or delivery).

In general, a comprehensive management system should be scalable, reliable, and can be distributed. Moreover, the management system must be agile enough to be able to support the ever-changing technologies. The design goals for the proposed management system include a reusable framework and platform-independent, a flexible architecture to meet changing requirements, an open architecture to work with a wide variety of technologies, and an easy to use front end.

The designed management system will be:

- scalable and distributable. This means as the number of users grow, more computing resources can be added to the new load. Some functions may be performed on more than one machine.
- Supportive for major management functional areas including fault, performance, log, and security management.
- able to encapsulate the details about the managed elements such that future support for new elements can be added incrementally.
- able to interoperate with legacy systems.
- able to automate present manual tasks.
- able to support Web browser based user interface.

Based on these requirements, the logic of the management system will be implemented using Enterprise Java Beans (EJB). EJB can make the system modular and component-based. User operations will be mapped to session beans. Entity beans will be used to manage persistence storage of the managed objects. Popular Web browsers will support the interface of the management system. It allows the managers or users easily access and use the system from remote locations.

The proposed management system can be expanded to manage other applications important across NOAA. Implemented with Java and XML, it can run on any platforms. Also, it can look up information and invoke scientific method dynamically using SOAP, UDDI, and WSDL (see Appendix: Related IT terms). All these will make the proposed management system a paradigm applicable to other realtime packages, such as the Warning Decision Support System II (WDSSII) developed at NSSL and the Advanced Regional Prediction System (ARPS) developed at the University of Oklahoma. For example, it can look up and identify areas where severe storms emerge (or move in) and then can provision the system dynamically to fetch high-band level II data from radars in those areas, to retrieve high-resolution vector wind fields over those areas and to disseminate the products on-line realtime.

Analysis:

Although development of RWR has just begun, it has produced better than expected retrievals that have attracted attention from a variety of potential users. For example, Jeffrey Tongue at NOAA/NWS suggested that incorporating the "derived wind fields into the NOAA/NWS AWIPS would make the product very valuable operationally"; Mark Fresch at NWS/NEXRAD ROC wanted to know how the dealiasing in data quality control is done; and Joseph Schaefer, the director of SPC at NWS/NCEP introduced the RWR web site to their forecasters. Although the potential benefits and customers of the realtime RWR products have not been fully explored yet, the products can certainly be ingested into the AWIPS. Furthermore, they may be used as super-observations (input data) for high-resolution numerical weather predictions (at NCEP), but the reliability and robustness of the RWR must be further improved and ensured through a series of on-line tests with realtime level-II data from multiple WSR-88D radars. *Such a test has only very recently become possible (since this June) due to the availability of real-time level-II data through the CRAFT project and the support from NOAA FY 2002 New England High-Resolution Temperature and Air Quality Forecasting Pilot Program (called by the Congress).*

The management system provides a highly leveraged, cost effective solution to manage the complicated, realtime data analysis process associated with RWR. It will monitor the major aspects of the RWR performance, collect fault information and error statistics for further improving the RWR, and identify and correct a variety of aforementioned problems associated with realtime. The management system automates many manual tasks which otherwise will be very labor-extensive and even impossible to accomplish. As the system continues to grow in size and complexity, it will be even more difficult to manually monitor the system on a 24-hour basis. It may take currently takes an experienced person several hours to isolate and correct a difficult problem, but the management system will be capable of fixing the problem autonomously in seconds.

Performance

Milestones

- Receive award notification (estimated) and begin project — February 1, 2003
- Order hardware and software — March 1, 2003
- Complete detailed design — April 1, 2003

- Complete management functions May 15, 2003
- Complete Web browser based user interface June 1, 2003
- Complete system test July 1, 2003

Deliverables

- Complete the deployment of the realtime Radar Wind Retrieval (RWR) prototype package used to retrieve high-resolution vector winds from WSR-88D level-II data using realtime data from eight New England radars. The RWR software package shall be created using Enterprise Java Beans and XML files (for the application logic) and HTML files (for the user interface).
  August 1, 2003

Appendix: Related IT terms

Simple Object Access Protocol (SOAP) is an HTTP-XML-based protocol that enables applications to communicate over the Internet, by using XML documents called SOAP messages. SOAP is compatible with any object model, because it includes only functions and capabilities that are absolutely necessary for defining a communication framework. Thus, SOAP is both platform and software independent. SOAP supports transport using any conceivable protocols. SOAP supports any method of encoding data, which enables SOAP-based applications to send virtually any type information. SOAP also has the ability to make a Remote Procedure Call (RPC).

Universal Description, Discovery and Integration (UDDI) is a platform-independent, open framework for describing services, discovering businesses, and integrating business services using the Internet. UDDI takes advantage of World Wide Web Consortium (W3C) and Internet Engineering Task Force (IETF) standards such as Extensible Markup Language (XML), HTTP, and Domain Name System (DNS). UDDI protocol is the building block that will enable business to quickly, easily and dynamically find and transact with one another using their preferred applications.

Web Services Description Language (WSDL) is an XML-based specification schema for describing the operational information of a Web service such as interface and end points. WSDL defines XML grammar for describing contracts between a set of endpoints exchanging messages. Contracts provide documentation for distributed systems and serve as a recipe for automating the details involved in applications communications. WSDL may be used to design specifications to invoke and operate Web Services on the Internet. Using WSDL, Web Services can be enabled to access and invoke remote applications and databases.