19.9 AN UPDATE ON THE NWS IMPLEMENTATION OF THE WSR-88D LEVEL II DATA COLLECTION AND DISTRIBUTION NETWORK

Tim Crum *, Chris Gilbert, Steve Smith, and John Heimer
WSR-88D Radar Operations Center, Norman, Oklahoma

Jami Casamento, Phil Cragg, Tom Sandman, and Warren Blanchard
NOAA/National Weather Service, Silver Spring, Maryland

1. INTRODUCTION

At the 2003 AMS Annual Meeting the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) announced plans to electronically collect and distribute Weather Surveillance Radar - 1988 Doppler (WSR-88D) Level II data in real time. Level II data are the highest spatial resolution data (reflectivity, radial velocity, and spectrum width) the WSR-88D produces. This includes 256 data levels from all scans of the radar. The NWS has implemented the Level II Data Collection and Distribution Network to replace the in situ recording of Level II data and to meet new NWS operational requirements for use of the Level II data in real time. An additional benefit of the network is to make these data available to external users (users outside the WSR-88D Program) such as universities and the private sector. An initial look and update of these plans were described earlier (Crum et al, 2003a and 2003b).

The NWS has nearly completed the implementation of the full operational capability of this ambitious project. By the fall of 2004, 121 NWS and 3 Department of Defense (DOD) contiguous United States (CONUS) operational WSR-88D systems were transmitting Level II data to the National Climatic Data Center (NCDC), National Centers for Environmental Prediction (NCEP), and other users in real time. By early 2005 the network will have been expanded to include 8 additional DOD WSR-88D systems located in the CONUS. The DOD sites are being added to the Level II network based on NCEP requirements.

This paper describes progress the NWS has made in implementing this project, plans for the future, and challenges.

* Corresponding author address: Dr. Tim Crum, WSR-88D Radar Operations Center, 1200 Westheimer Drive, Norman, OK 73069; e-mail: Tim.D.Crum@noaa.gov.

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2. OVERVIEW OF THE NWS LEVEL II DATA COLLECTION AND DISTRIBUTION NETWORK

A schematic of the flow of Level II data from WSR-88D sites to end-users is in Figure 1. In implementing the Level II network, the NWS leveraged the successful Collaborative Radar Acquisition Field Test (CRAFT) Project (Droegemier et al 2002). Initially the NWS added PCs at those NWS WSR-88D sites not a part of the original CRAFT network. The PCs executed software that compressed (BZIP2) and routed the Level II data using the Unidata Local Data Manager (LDM) software. This expanded the network from 60 sites to 124 sites.

The NWS then added 128 kbps of bandwidth per radar to the NWSNet communications network between NWS weather forecast offices (WFOs) and their regional headquarters (located at Bohemia, NY; Fort Worth, TX, Kansas City, KS; and Salt Lake City, UT). Servers at the regional headquarters began sending the data via connections to a designated regional Abilene Network/Internet2 gigapop (http://abilene.internet2.edu) to enter the data into the Abilene Network/Internet2 "cloud." Using the LDM technology, the data were routed to the CRAFT server at the University of Oklahoma for further redistribution.

In an April 13, 2004 NOAA Press Release, the NWS announced the four Internet2 top-tier sites for the Level II project. The NWS operates a server in the MAX Gigapop on the University of Maryland campus. In addition, the following three organizations (with point of contact) serve as top-tier sites.

- Education and Research Consortium of the Western Carolinas (ERC), Dr. Max Lennon, 828-350-2010, maxlennon@ercwc.org
- Purdue University, Professor Matthew Huber, 765-494-3258, huberm@purdue.edu
- University of Oklahoma, Professor Kelvin K. Droegemeier, 405-325-0453, kkd@ou.edu

Servers at the four top-tier sites send the full Level II data stream, via Internet2, to up to four designated second-tier sites. These second-tier sites, located on university campuses, in turn send the full data stream or selected subsets of the Level II data to third-tier sites. Unidata has orchestrated this collaborative approach of sharing Level II data among the university and research community.

There are no restrictions on the redistribution and

use of WSR-88D Level II data. Commercial use of the data is encouraged. Commercial users can obtain the services of the top-tier sites listed above or any other recipient of the data to satisfy their Level II data needs.

The NWS has established a temporary Web site (http://www.roc.noaa.gov/NWS_Level_2) to facilitate distribution of network updates and information.

3. INITIAL LEVEL II NETWORK PERFORMANCE

The latency of Level II data traveling from radars to users connected to top-tier sites is usually less than 5s. The radars "bundle" 100 radials of data at a time for transmission, which can take up to 25s, based on the scanning strategy of the radar. Thus the data are generally available to users within 30s of the time the data are processed by a radar's receiver.

The NWS realized the transition from the proof-of-concept CRAFT network to a full operating capability would be a learning period. The NWS required availability of Level II data is 95% of the time, averaged over the network for a year, when the radars are operational. (The goal of radar availability is 96% averaged for a year.) The NWS has not yet implemented a system to measure the reliability of the Level II data stream network wide. However, subjective estimates are that the reliability has exceeded the 95% goal. There have been occasions of the loss of an entire region's data flow, loss of communications from individual sites, and loss of data from individual sites. The NWS has been learning from these data interruptions to implement procedures to lessen the likelihood of reoccurrence and shorten the duration. The NWS recognizes the interest of users in receiving all the Level II data all the time. The NWS is committed to maximizing data delivery reliability, however, network outages and equipment failures occur and can lead to data loss. The redundancy required for 100% availability is cost prohibitive.

4. USE OF LEVEL II DATA

Monitoring and analysis have identified instances of missing data and led to corrections in the initial implementation. Still, the Level II network has had many success stories in this year of transition to an operational, nationwide network.

The electronic data collection has improved the reliability of data capture into the National Climatic Data Center (NCDC) archives from ~65% to over 95%. This increase, coupled with the NCDC's advances of inserting data into the archives within 24 hours and making the data available via FTP, has encouraged the use of Level II data by an increasing number of researchers. For example, researchers will reap the benefit of the plethora of Level II data collected during the four hurricanes affecting the SE US this summer.

Level II data are being sent in real-time to approximately 22 universities and 8 research laboratories. Government laboratories have been able to reduce the costs of conducting field experiments by using the Level II network to bring the real-time data to the laboratories rather than having to deploy computers and personnel to WSR-88D sites to process the data. The Tropical Prediction Center used Level II data in real time to support hurricane forecast operations in 2004. The Environmental Modeling Center is making preparations for using real time Level II data for development work, which will lead to the use of the data in initializing numerical models.

Private sector users are using Level II data to develop new markets for value-added weather services and products, which provide improved forecast and warning support to the public and weather-sensitive commerce.

5. THE FUTURE

In completing the implementation of this project, the NWS will add an undetermined number of the remaining DoD WSR-88D systems in the CONUS to the Level II network. Additions of other outside the CONUS WSR-88D systems to the network are possible as requirements are validated and funding becomes available.

The NWS will continue to work to improve the reliability and data quality of the national network. The Telecommunications Operations Center within the NWS Chief Information Officer office will monitor the Level II data flow centrally.

The WSR-88D Open Radar Data Acquisition (ORDA), deployment beginning in 2005, will enable the potential for WSR-88Ds to produce higher resolution data in a future software upgrade. For example, higher resolution reflectivity data (0.25 km gate spacing versus today's 1.0 km) and higher resolution azimuthal data (0.5^{o} versus today's 1.0^{o}) might be implemented. Dual polarization is being planned for later in the decade, which will add three channels of data. The NWS will evaluate the archive and operational requirements for collecting, distributing, and archiving these additional data as they become available. Thus, it is possible, at least initially, that not all of these data streams will be added to the real-time data collection, distribution, and archive plans.

The content of the Level II data stream will change slightly with the deployment of the ORDA. The metadata file will contain new information. These metadata are available at the start of each volume coverage. The NWS will provide information describing the data format changes to users in advance of the software change release.

6. SUMMARY

The NWS has nearly completed implementing the full operational capability of the WSR-88D Level II Data Collection and Distribution Network. Basing the full operational capability on the successful proof-of-concept project, CRAFT, the Level II network is compressing, collecting, and distributing WSR-88D Level II data to the NCDC archives and users in real time (latencies less than 5 s) and reliably (greater than 95%). The network has made possible new and exciting research and new commercial applications based upon Level II data.

7. ACKNOWLEDGEMENTS

Just as the CRAFT experiment was a successful collaboration of many government, university, and other organizations, the NWS transition to the full operational capability required continued teamwork among many organizations. Particularly helpful were the staffs of the National Weather Service's Office of Science and Technology, Office of the Chief Information Officer, the weather forecast offices and regional headquarters of the eastern, southern, central and western regions; National Severe Storms Laboratory; Lincoln Laboratory; Unidata; National Climatic Data Center; Internet2; WSR-88D Radar Operations Center; and the University of Oklahoma.

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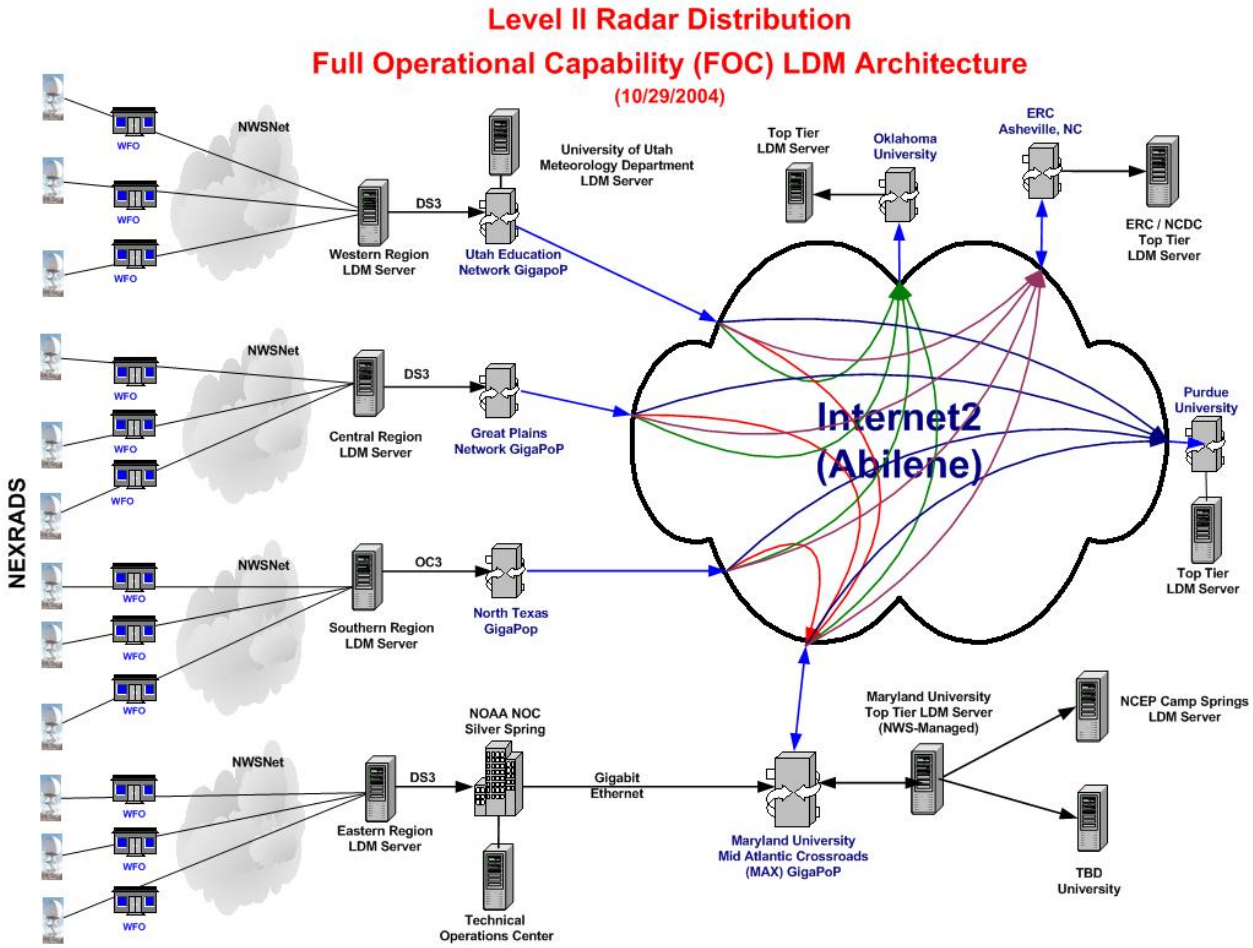

Figure 1. The flow of Level II data from individual WSR-88D sites through the NWS communications infrastructure and Internet2 “cloud” to the top-tier sites.