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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. The NWS 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. (Crum et al, 2005, 2003a and 2003b) An added network benefit is making these data available to users outside the WSR-88D Program such as universities and the private sector.

The NWS completed the full operational capability of the Level II network in 2004. Now 121 NWS and 13 Department of Defense (DOD) operational WSR-88D systems located in the contiguous United States are transmitting Level II data to the National Climatic Data Center (NCDC), National Centers for Environmental Prediction (NCEP), and other users in real time. The list of sites that are a part of the network is at: http://www.roc.noaa.gov/NWS_Level_2/ListOf_Level2_Sites.pdf. In addition, the Level II data from the two DOD WSR-88Ds in South Korea (Camp Humphreys and Kunsan Air Base) are collected electronically. These data are available on a next-day basis from the archives (<http://www.ncdc.noaa.gov/oa/radar/radarresources.html>).

This paper describes progress the NWS has made since implementing the Level II Data Collection and Distribution Network and plans for the future.

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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 the Level II top-tier sites is in Figure 1. In implementing the Level II network, the NWS leveraged the successful Collaborative Radar Acquisition Field Test (CRAFT) Project (Gratz 2006, Droegemeier et al 2002). The NWS allocated 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, MO; and Salt Lake City, UT). Level II data from DOD radars on the network are sent to the adjoining NWS WFO where the data are inserted into the Level II network. Servers at the regional headquarters send the data via commercial communications to a designated regional Abilene Network/Internet2 gigapop (<http://abilene.internet2.edu>) to enter the data into the Abilene Network/Internet2 Wide Area Network. Using the Unidata Local Data Manager (LDM) technology, the data are routed to the four Level II Internet2 top-tier sites. The NWS operates redundant servers in the MAX Gigapop on the University of Maryland campus. In addition, the following three organizations (with point of contact) serve as the Level II data top-tier sites.

- Education and Research Consortium of the Western Carolinas (ERC), Hunter Goosmann, 828-350-2415, hgoosmann@ercwc.org
- Purdue University, Professor Matthew Huber, 765-494-3258, huberm@purdue.edu
- University of Oklahoma, Joel Martin, 405-325-4574, Joel.Martin@ou.edu

Servers at the four top-tier sites send the full Level II data stream, via Internet2, to 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 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 established a Web site (http://www.roc.noaa.gov/NWS_Level_2) to facilitate distribution of network updates and information.

3. LEVEL II NETWORK PERFORMANCE

The latency of Level II data is usually less than 5s when traveling from radars to the top-tier sites, which meets the NWS latency requirement of 60s. The radars “bundle” 100 radials of data at a time for transmission, which can take up to 25s to collect, 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 required availability of Level II data is 95% of the time, averaged over the network for a year, when the radars are operational. (The availability goal for each radar is 96% averaged for a year.) The network has experienced outages at sites and at the regional hubs which impacted users, but the network still exceeded the specified network-wide availability requirement of 95%.

4. A NEW LEVEL II NETWORK APPROACH

The NWS recognizes the interest of users in receiving Level II data and is working to increase data delivery reliability. Taking advantage of a NOAA initiative to consolidate NWS weather communications networks into a single architecture NOAA Net was created. The Level II network is proposed to use this new architecture in 2008. Figure 2 contains a draft of the proposed network architecture. The primary changes are the use of the NOAA Net and the initial distribution of the data to two NWS sites rather than to the four NWS regional servers. This new architecture provides redundancy and will include around-the-clock monitoring and restoration service for network outages.

5. USE OF LEVEL II DATA

The electronic data collection improved the reliability of data capture into the 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, encouraged the use of Level II data by an increasing number of users. Software from the WSR-88D Radar Product Generator, which uses Level II data to generate Level III products, is included in the Common Operations and Development Environment (CODE) (Ganger et al. 2005) and is available at <http://www.weather.gov/code88d/>. In addition, the NCDC has developed user-friendly software to help users display the archived data (<http://www.ncdc.noaa.gov/oa/radar/jnx/index.html>).

Level II data are sent in real-time to over 25

universities and research laboratories. The NCEP uses Level II data in real time for numerical model initialization. The WSR-88D Radar Operations Center uses the data to monitor data quality and assist sites in improving radar performance.

An increasing number of private sector users use Level II data in developing new markets for value-added weather services and products, which provide improved forecast and warning support to the public and weather-sensitive commerce.

6. FUTURE CHANGES TO THE LEVEL II DATA

The NWS will add WSR-88D systems to the Level II network as requirements are validated and funding becomes available. With the implementation of WSR-88D software Build 9 and an associated replacement of the existing Radar Product Generator hardware, the WSR-88D will be capable of sending Level II data to real-time users from FAA WSR-88Ds. (Build 9 beta testing is scheduled to begin in March 2007 and full network deployment is scheduled to begin in May 2007.)

The WSR-88D Open Radar Data Acquisition deployment (Cate and Hall 2005), completed in October 2006, enables the potential for WSR-88Ds to produce higher resolution data. For example, higher resolution reflectivity data (0.25 km gate spacing versus today’s 1.0 km) and higher resolution azimuthal data (0.5° versus today’s 1.0°) is proposed for implementation in Build 10 (beta testing is scheduled to begin in January 2008 and full network deployment is scheduled to begin in April 2008). Implementation of a dual polarization capability is planned to begin in late 2009, which will potentially add three moments of data to the Level II data stream. The NWS is evaluating the archive and operational requirements for collecting, distributing, and archiving these additional data (higher resolution and dual polarized). Due to increased communications costs for electronically collecting these larger data streams, it is possible, at least initially, that not all of these new data will be added to the real-time data collection, distribution, and archive network.

The addition of the higher resolution and dual polarized data will require a change in the Level II data format. The NWS will provide sample data and a draft interface control document describing the new data format in the first quarter of 2007. While the NWS will announce where users can obtain information about the new data format, users can check the Level II web site (http://www.roc.noaa.gov/NWS_Level_2) for further updates.

6. SUMMARY

The NWS WSR-88D Level II Data Collection and Distribution Network became operational in 2004. The network of 134 WSR-88Ds 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 commercial applications based upon Level II data. The NWS plans to change the architecture of how the Level II data are collected and redistributed to users. This change is being investigated to improve the reliability of the delivery of Level II data to users and to support an increased amount of data. The format of Level II data will likely change in 2008. The change is needed to enable the collection of higher resolution and dual polarized data.

7. ACKNOWLEDGEMENTS

Just as the CRAFT experiment was a successful collaboration of many government, university, and private sector partners, the continued operation of the Level II Data Collection and Distribution Network has been a team effort among many organizations. Particularly helpful have been the Level II top tier sites: the University of Oklahoma, Purdue University, the Education and Research Consortium of the Western Carolinas, and the University of Maryland; 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; Unidata; the National Climatic Data Center; Internet2; and the WSR-88D Radar Operations Center.

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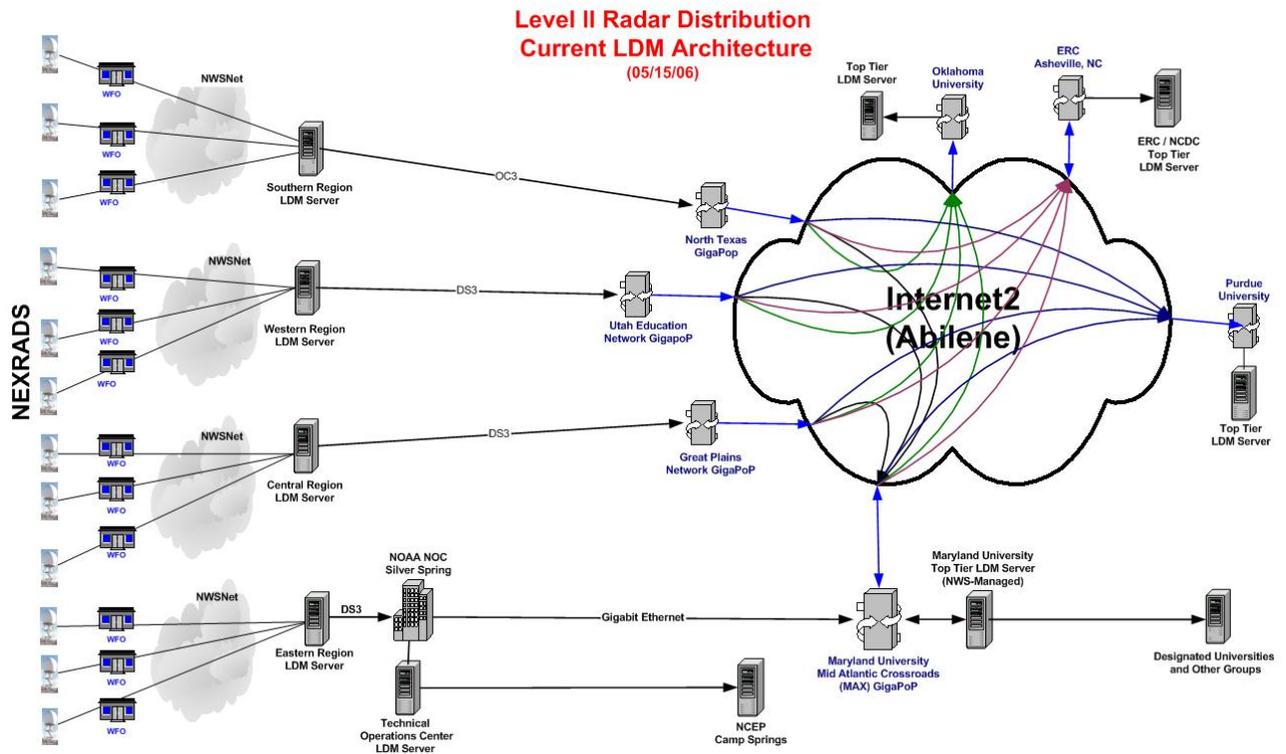


Figure 1. The flow of Level II data from individual WSR-88D sites through the NWS communications infrastructure and Internet2 to the top-tier sites.

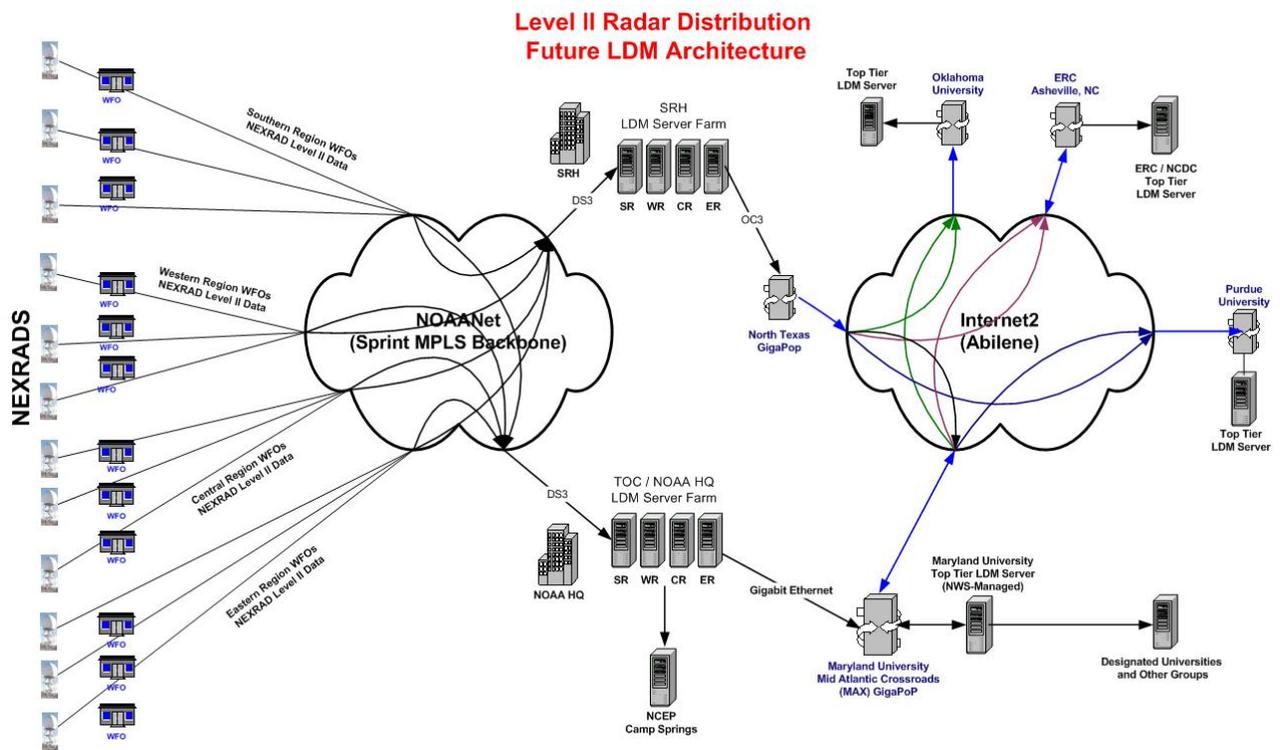


Figure 2. The draft network architecture for the real-time collection and distribution of Level II data via NOAANet and Internet2 to the top-tier sites.