# 3A.1 THE REFRESHED WSR-88D LEVEL II DATA COLLECTION AND DISTRIBUTION NETWORK

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## 1. INTRODUCTION

The National Weather Service (NWS) collects Weather Surveillance Radar–1988, Doppler (WSR-88D) Level II data at select sites primarily via NOAAnet, now OPSnet. As of January 2011, the WSR-88D sites on the Level II network include all 121 NWS WSR-88Ds, plus 13 DOD and 5 FAA WSR-88Ds (139 radars total). The two WSR-88D Radar Operations Center (ROC) WSR-88D test bed systems are also on the network intermittently to provide real-time data to external users to test new data streams (e.g., Dual Polarization) or new formats (e.g., MSG31).

As the use of Level II data has grown, the methods for data transport, immediacy and storage have evolved accordingly. The NWS has a requirement to archive WSR-88D Level II data for post-event analysis, algorithm development, algorithm tuning, data quality studies, etc. When network-wide archiving began in 1994, the data was recorded on 8mm tapes in the Radar Data Acquisition (RDA) shelter and physically shipped to the National Climatic Data Center (NCDC). The recording equipment in the RDA efficiently stored 10 tapes, but was plagued with a relatively high failure rate. In addition, a technician had to travel to the RDA to retrieve recorded tapes for shipment to NCDC. This approach led to data latencies (time between data collection and data archive at NCDC) of up to 6 weeks and a data collection rate of 65% or less network wide.

Over time, an operational requirement developed for Level II data in real-time for assimilation into numerical forecast models at the National Center for Environmental Prediction (NCEP). Meeting this need required a new approach to Level II data collection. The concept of real-time network transmission of Level II data was proven in a collaborative effort (Collaborative Radar Acquisition Field Test project - CRAFT) involving 59 WSR-88D sites, several NOAA offices, the University of Oklahoma, University of Washington, National Science Foundation, Unidata, and private industry. In April 2002, the NWS Corporate Board's Operations Committee approved the deployment of a network-based solution to collect Level II data.

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The NWS Office of Science and Technology System Engineering Center, NWS Office of the Chief Information Officer, and the ROC collaborated to design the NWSNet / Internet2 WSR-88D Level II network. The initial solution was to aggregate the data from each WSR-88D site to one of four associated regional headquarters. Servers at the regions transmitted the data over Internet 2, making it available to users in seconds. The NWS Telecommunications Operations Center (TOC) was tasked to monitor, support and maintain the system when it became operational in 2004. Level II data flow was monitored via the MAX, an NWS server located at the University of Maryland. Local Data Manager (LDM), developed by Unidata, was selected as the software application used to disseminate data across the Level II network. LDM was chosen for its rich suite of software tools, reliability of data transmission, flexibility with how the data is handled, and ease of configuration.

The NWSnet regional-server Level II network design boosted data availability to 95+% and a latency of less than 10s. However, the design exposed two significant issues:

(1) The majority of the network IT equipment (at the regional headquarters) was only staffed during normal working hours.
(2) While the servers at the regional headquarters were designed for high availability, the network connectivity from each region to their independent Internet 2 gateways was not. These issues left the system prone to extended regional outages which led to user community demands for higher data delivery reliability.

## 2. NETWORK REFRESHMENT

In 2009, the ROC was tasked with improving the Level II network design. The regional server implementation was eliminated in favor of a national concept. In addition to increasing data reliability, the technology "refreshment" addressed the need of replacing information technology equipment that had exceeded end-of-life support. The new national system continues to be monitored 24/7 by the TOC. The NWSnet (regional frame relay) connection to Internet 2 has been migrated to OPSnet (Fig.1).

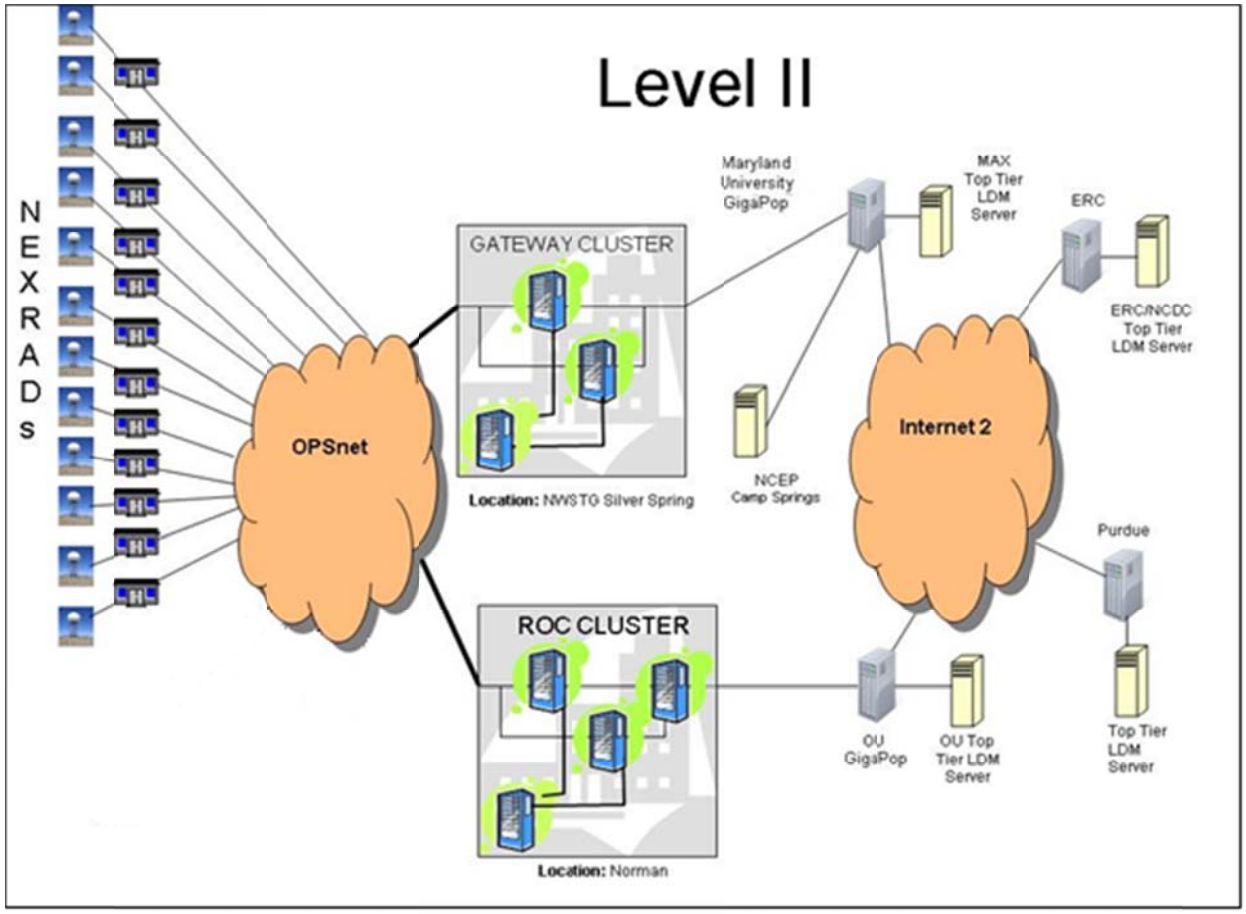


**Fig. 1**. Depiction of the refreshed WSR-88D Level II network (January 2011). Level II data flows from radar sites, left side of figure, via the OPSnet "cloud" to two national clusters/aggregation points: primary at the NWS Telecommunications Gateway (NWSTG) and backup at the WSR-88D Radar Operations Center (ROC). The data are sent to two separate Internet2 GigaPops for distribution to the Top Tiers and then on to a wide variety of Level II users.

### 2.1 Redundancy and Backup

To reduce single point of failure concerns, an on-line national backup facility has been established at the ROC in Norman, OK. The ROC houses a 24/7 support center for WSR-88D systems that provides backup monitoring of the Level II network. A second Internet 2 access gateway has been implemented at the University of Oklahoma. The new design ensures duplicate Level II data feeds onto Internet 2 from two geographically diverse locations.

Each facility (TOC and ROC) houses a cluster of servers that allow for seamless aggregation of data. The biggest constraint on the new design was the limited bandwidth out of each WSR-88D site. This complicated the design by only allowing the transmission of one Level II data stream per site. Finding it was not feasible (cost) to increase bandwidth at each site, the new design relied upon each national server monitoring system status and automatically changing roles as needed.

The automatic changing of roles ensures only one national Level II server is allowed to communicate directly with WSR-88D sites at any given time. Any one of four processors in the Level II system (two at the TOC and two at the ROC) can support the aggregation role. A set of deterministic rules determine the role of each server.

In "Normal" or default operation, the TOC receives (aggregates) the Level II data directly from the WSR-88D sites. If the primary server fails (or goes off-line for maintenance), the secondary server within the cluster is automatically promoted to primary server and takes over the aggregation role. If both servers in the TOC fail, or go off line, the aggregator role will be automatically transferred to the primary server in the alternate cluster at the ROC in Norman. When a TOC server comes back on line at the TOC, the system will automatically return aggregation to the TOC. Server roles can be manually assigned to a primary server at any time

The new monitor page shows additional information, including the connectivity to the WSR-88D sites, between the Level II clusters and to the Level II Top Tiers. The monitor gathers the Level II data and can provide historical information as well.

### 2.2 Other Advantages of Network Refresh

The new national Level II system is part of the WSR-88D baseline and is supported as part of the WSR-88D system. The ROC is responsible for hardware, software, security, testing, and configuration management for the system. As part of this effort a new, comprehensive test facility was built at the ROC. The test facility allows developers and engineers to test the complete pathway of Level II data, from collection at the WSR-88D to final dissemination over Internet 2.

## 3. PLANNED WORK

The NWS servers at the MAX were deployed in 2004 and are the last vestige of the original infrastructure, and beyond the end of serviceable life. The ROC hosts a ROC Distribution Server (RDS) to disseminate WSR-88D Level II data to the Top Tiers. The ROC is planning to deploy a TOC Distribution Server (TDS) to replicate this dissemination method, in Spring 2011. This would meet the Internet 2 gateway functional requirements the MAX serves today.

The ROC support for Level II is an ongoing effort. There are several approved projects which will further increase the capacity and stability of Level II. The next major effort for the Level II system is to connect the Radar Product Generator (RPG) which transmits Level II from a WSR-88D directly to OPSnet. This will remove all regional and site-specific connections (i.e., SonicWalls) to ensure no other active component is actively involved in the transmission of data to the Level II system.

Beginning in 2011, the WSR-88D network will be upgrading to dual-polarized transmission which is expected to double the amount of data transmitted over the Level II network.

## 4. ACKNOWLEGEMENTS

Operational support and monitoring of Level II data is performed by the NWS TOC. The ROC performs hardware, software, and lifecycle support. Distribution is supported from the Top Tiers at the University of Oklahoma, Purdue University, and The Education and Research Consortium of the Western Carolinas, Inc. (ERCWC)/Education and Research Network (ERN)/ERC Broadband (ERCB). Unidata provides support for the LDM that the Level II network relies on. It's interesting to note that what started as a collaborative effort with the CRAFT Project in the late 1990s continues to thrive and advance as a collaborative effort.

## 5. REFERENCES

Crum, T. et al, 2009: NWS WSR-88D and TDWR-SPG data collection and distribution network status and plans. 26th *Conf. on Interactive Information and Processing Systems*, Atlanta, GA, Amer. Meteor. Soc., Paper 4.6.

Kelleher, K. E., and several co-authors, 2007: Project CRAFT: A real-time delivery system for NEXRAD Level II data via the Internet. *Bull. Amer. Meteor. Soc.*, **88**, 1045-1057.

## 6. RELATED WEB SITES

- ERC Real-Time Level II Data Monitoring Site:
  - http://www.ercbroadband.org/index.php/level-ii-data-status
- Project updates and other Level II information:
  - **http://www.roc.noaa.gov/WSR88D/Level_II/Level2Info.aspx**
- Project updates and other Level II information:
  - **http://www.roc.noaa.gov/WSR88D/Level_II/Level2Info.aspx**
- NWS Real-Time Level II Data Monitoring Site:
  - **http://weather.noaa.gov/monitor/radar2/**
- NWS Real-Time Level III Product Site Status:
  - **http://weather.noaa.gov/monitor/radar3/**
- NWS RPCCDS Information for product users:
  - **http://www.nws.noaa.gov/tg/rpccds.html**
- WSR-88D build specific training materials:
  - **http://www.wdtb.noaa.gov/**
- NCDC Radar Resources: Order Level II and Level III Archive Data Via FTP, Use NCDC Java Viewer to View Level II and Level III Archive Data, etc.
  - **http://www.ncdc.noaa.gov/oa/radar/radarresources.html**
- Run RPG Software, LINUX Platform: The Common Operations and Development Environment (CODE)
  - **http://www.weather.gov/CODE88D**