P2.3 PERFORMANCE MEASURES FOR THE AWIPS COMMUNICATIONS NETWORK

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1. INTRODUCTION

The National Weather Service (NWS) is currently evaluating a proposed consolidation of its Information Technology (IT) networking services (Curran 2005; Sandman 2005). Under this proposal, the existing Frame Relay Wide Area Network (WAN) currently employed for the Advanced Weather Interactive Processing System (AWIPS) Communications Network would be superseded by a Multi-Protocol Label Switching (MPLS) WAN. The planned transition to the MPLS WAN is to be implemented in two phases: an initial MPLS Pilot demonstration followed by the migration of all AWIPS sites within the continental United States to an MPLS WAN. The MPLS Pilot demonstration is being completed by Raytheon Technical Services, under contract DG133W-05-CQ-1067, to evaluate system requirements and to develop strategies for migration of AWIPS sites to an MPLS WAN.

As part of this effort, the NWS Field Systems Operations Center, Test and Evaluation Branch (TEB) will monitor the performance of the AWIPS Communications Network over the existing Frame Relay WAN and the proposed MPLS WAN. The TEB is also conducting an Operational Acceptance Test (OAT) in parallel to the MPLS Pilot. In addition to monitoring network performance, the OAT will validate the procedures for installation of the hardware required for the MPLS network and verify that documentation and other technical support services are adequate to support the use of an MPLS WAN for AWIPS network communications.

2. BACKGROUND

Services for NWS network communications are currently procured, managed, and operated on a distributed basis. Although the NWS Telecommunication Operations Center leads configuration and procurement activities, the individual headquarters offices, Regions, National Centers, and other NOAA Line Offices each manage their own IT infrastructures. Similarly, major operational programs, such as AWIPS, procure, operate, and manage independent network infrastructures.

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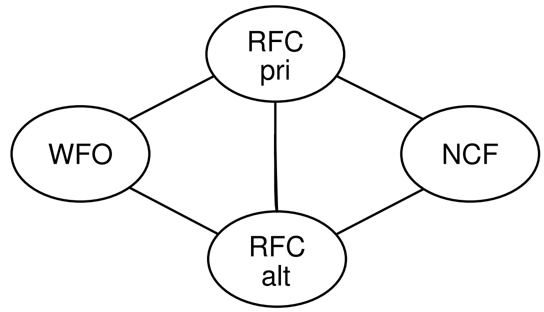

Figure 1: Frame Relay point-to-point network architecture. The Frame Relay WAN provides a primary (pri) route to the NCF and a redundant alternative (alt) route.

Systems analysis suggests that a single, carrier-provided MPLS network may support most requirements for NWS network communications and may allow implementation of a NOAA-wide network infrastructure.

2.1 *AWIPS Communications Network*

The AWIPS Communication Network is currently supported by a carrier-provided Frame Relay WAN. The Frame Relay WAN employs a hub and spoke architecture in which network communications are relayed through the River Forecast Centers (RFCs). A highly simplified block diagram of the existing Frame Relay WAN architecture is shown in Figure 1. As indicated, each Weather Forecast Office (WFO) is connected to two RFCs. The RFCs are interconnected and are connected to the Network Control Facility (NCF). The Frame Relay WAN provides a primary RFC for each WFO and a redundant route to the network through an alternative RFC.

The proposed MPLS WAN architecture is shown in Figure 2. As indicated, each AWIPS site is directly connected to the MPLS WAN. The proposed MPLS WAN will be configured to provide a Virtual Private Network (VPN) to isolate NOAA communications from other Internet traffic. The Frame Relay WAN supports Point-to-Point, Point-to-Multipoint,

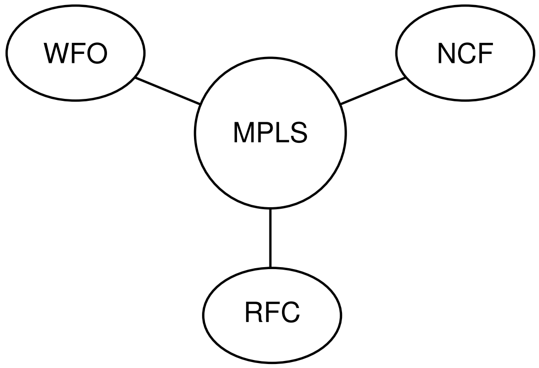

Figure 2: MPLS any-to-any network architecture. Each AWIPS site will directly connect to the MPLS WAN.

and Multipoint-to-Point communications. The proposed MPLS WAN will fully support the existing AWIPS Communications Network connectivity.

2.2 *MPLS Pilot/OAT Strategy*

The use of MPLS WAN services for AWIPS operations cannot be adequately tested in a simulated environment and must be tested at active field sites. A limited MPLS WAN will be deployed at the AWIPS sites listed in Table 1. The sites listed include two Weather Forecast Offices (WFOs), two River Forecast Centers (RFCs), and the AWIPS Network Control Facility (NCF). Two WFO control sites, PBZ and LZK, have been included in the Pilot/OAT to compare ongoing AWIPS network communications over the Frame Relay WAN.

Network communications were initially monitored for a period of 30 days to establish the baseline performance of the existing Frame Relay WAN. Network performance data were collected by TEB during this period.

The transition of AWIPS communications to the MPLS WAN will be completed in two phases: an initial startup period followed by 30 days of operations using the MPLS WAN. The MPLS WAN will be the preferred path for AWIPS network communications throughout the 30 day evaluation period. Sites will conduct their normal operations using the MPLS WAN during the evaluation period. Standard Operating Procedure (SOP) will be followed using the MPLS WAN as the primary network for AWIPS communications and ADTRAN (dial backup) as the backup system. Site and NCF personnel will report any problems discovered during operation of the system.

Reliable broadband network services are required for AWIPS operations; and network communications will be carefully monitored throughout the Pilot/OAT. The MPLS Pilot/OAT may require certain novel and unproven procedures; hence there is some risk of a loss or degradation of network communications during the MPLS Pilot/OAT. The existing Frame Relay WAN circuits will be kept in place throughout the OAT; and AWIPS communications may be returned to the Frame Relay WAN should network performance fall below acceptable levels or in the event of an MPLS network outage.

Table 1: Sites selected for the MPLS Pilot/OAT.

Site ID	Type	Location
Pilot/OAT Sites		
ABR	WFO	Aberdeen, SD
FGF	WFO	Grand Forks, ND
KRF	RFC	Pleasant Hill, MO
MSR	RFC	Chanhassen, MN
NCF	NCF	Silver Spring, MD
Control sites (Frame Relay WAN)		
PBZ	WFO	Pittsburgh, PA
LZK	WFO	Little Rock, AR

3. NETWORK PERFORMANCE

The benchmarks for the evaluation of network performance include: the System/Segment Specification, the Service Level Agreement, and the baseline performance of the current Frame Relay WAN. Other factors such as network outages and the reliability of network services will also be considered.

System/Segment Specification: The required performance characteristics for the AWIPS Communications Network are provided in Section 3.2 of the System/Segment Specification SSS-001-1994R1 (1998). Network performance characteristics are stated as a percentile of products that must satisfy a specific time goal. For example, 99.9 % of all high priority products less than or equal to 5 Kbytes in size must be received within 1 min. The System/Segment Specification provides an extensive list of minimum performance characteristics and considers such factors as the priority, size, product class, and the context of the communication.

Service Level Agreement: The MPLS service provider, Sprint, has provided specific commitments for the quality of network services in a Service Level Agreement (SLA). The figures-of-merit relevant to the MPLS Pilot/OAT include the Packet

Loss, Round-trip Delay, and Jitter. The commitments for quality of service for these parameters are listed in Table 2. The levels indicated are monthly averages for packet level measurements.

Table 2: Sprint Service Level Agreement Commitments.

Packet Loss	Round-trip Delay	Jitter
0.1 %	$<$ 55 ms	$<$ 2 ms

Baseline Performance: Comparison with the current level of performance is perhaps the most direct method for establishing the performance of the MPLS WAN. The evaluation of the MPLS WAN will be based in part on a such a comparison. Ideally, all measures of network communications performance obtained for the MPLS WAN should equal or exceed those obtained for the existing Frame Relay WAN.

Network Outages: Network outages may be determined from NCF, Office of the Chief Information Officer (OCIO), and/or Sprint trouble tickets. Anytime that the MPLS WAN is not available and ADTRAN or the Frame Relay WAN is used will be counted as an MPLS outage for the purposes of the Pilot/OAT.

4. NETWORK MONITORING

Network communications will be monitored using the Product Availability Monitoring System (PAMS). PAMS was developed by the TEB to measure the performance of network communications. The system has been used in numerous OATs and demonstration projects to evaluate proposed changes in network communications (Nguyen and Fucundo 2000; Nguyen and Buckingham 2001; Buckingham and Nguyen 2002). PAMS monitors end-to-end network communications at the Internet Protocol layer: Each product sent over the AWIPS Communications Network is logged both at the sending and at the receiving servers. The log entries contain a time stamp, product identifier, and World Meteorological Organization heading that may be used to uniquely identify each product. The time stamp is by reference to the AWIPS clock, which is synchronized across the network to within a stated uncertainty of $\pm$1 sec.

PAMS relies on off-line analysis of the server message logs: The log files are pushed from the site servers onto a server located at Weather Service Headquarters and ultimately onto a local work station for analysis. The header information and time stamp for each log entry may be queried to provide diagnostic information regarding network communications. These methods place very little burden on network communications and are relatively noninvasive.

The figures-of-merit considered for the Pilot/OAT include the product delay time, Δt, and the product success rate, R. The product success rate, expressed in percent, is given by the following equation,

$$R = \frac{n_r}{n_s} 100,$$

where n_s is the number of products sent and n_r is the number products received in a given time interval. The product delay is given by the following equation,

$$\Delta t_i = t_{ri} - t_{si},$$

where t_{si} is the time that product i was sent and t_{ri} is the time the product was received. The time averaged product delay time is given by

$$\overline{\Delta t} = \frac{1}{n_r} \sum_i \Delta t_i,$$

where n_r is the number of products received in the time interval.

Representative data obtained using PAMS are shown in Table 3. These data describe the baseline performance of the Frame Relay WAN on 7/6/2006. The TEB will monitor the end-to-end communications between the WFO sites and the NCF using PAMS throughout the 30 day evaluation period. The hourly and daily average product delays and product success rates will be calculated and compared with the baseline data. These methods may also be readily adapted to test for compliance with the required minimum performance characteristics provided in the System/Segment Specification SSS-001-1994R1 (1998).

It should be noted that the SLA is stated in terms of packet communications and that PAMS monitors communications at the product level. The SLA commitments cannot, therefore, be directly assessed using PAMS. The packet level performance may, however, be inferred from the measured performance at the product level.

5. FUTURE WORK

The MPLS hardware was successfully installed and tested and the system was turned over to Raytheon Technical Services for migration of the Pilot/OAT sites to the MPLS WAN. The initial tests of AWIPS

Table 3: Daily average AWIPS Communications Network performance data for 7/6/2006.

Site ID	Products	Bytes	R (%)	$\overline{\Delta t}$ (min)	Δt_{min} (min)	Δt_{max} (min)
NCF to Sites						
ABR	2944	1943453	92.36	0.290	0.050	123.250
FGF	2946	1946653	100.00	0.239	0.067	3.067
PBZ	2945	1945899	100.00	0.232	0.067	2.350
LZK	2946	1946653	100.00	0.261	0.067	4.450
Sites to NCF						
ABR	4147	68009902	99.98	0.179	0.017	1.067
FGF	4607	63670015	100.00	0.183	0.000	1.633
PBZ	7300	79080224	100.00	0.161	0.000	0.533
LZK	9350	117556523	100.00	0.199	0.017	0.883

communications over the MPLS WAN were, however, not fully successful. AWIPS network communications appear to be failing at the X.400 Application layer. The AWIPS Message Handling System is based on the X.400 standard and this protocol has largely been eclipsed by the Simple Mail Transfer Protocol (SMTP) for Internet communications. It appears that the AWIPS Message Handling System may be incompatible with the protocols currently used for Internet communications. Trouble shooting of the MPLS circuits is ongoing at this time.

The acquisition of the baseline performance data for the Frame Relay WAN is complete. Performance data for AWIPS network communications over the MPLS WAN will be obtained once the network communications problems have been resolved.

6. CONCLUSION

The MPLS Pilot/OAT process uncovered serious problems in the proposed implementation of the MPLS WAN during the initial startup phase. A work-around was developed, however, the utility of network performance measurements with the work-around in place was uncertain. The Pilot/OAT was suspended until the network problems can be resolved. It is uncertain whether the MPLS WAN can be implemented with the current AWIPS Message Handling System. Completion of the MPLS Pilot/OAT may be differed until SMTP has been implemented for AWIPS.

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