Bruce J. Brown[*]
Northrop Grumman Information Technology

1. INTRODUCTION

The AWIPS wide area network (WAN) provides the point-to-point and multipoint-to-point communication capability for National Weather Service (NWS) AWIPS sites. It is a private, nationwide network for weather data distribution among the AWIPS sites. It interconnects about 150 AWIPS sites: Weather Forecast Offices (WFOs), Collocated River Forecast Centers (RFCs)/WFOs, Regional Headquarters, National Centers, and the Network Control Facility (NCF) in CONUS, Alaska, Hawaii, Guam, and Puerto Rico. The network has built-in redundant features and backup schemes to support the network availability.

As the communications hub for AWIPS, the NCF proactively monitors the WAN by using COTS network management, network capacity planning tools, and in-house developed software to monitor the network including circuit availability, circuit quality, backup circuit functionality and router configuration.

The NWS (OCIO and OST/SEC) and Northrop Grumman Information Technology (IT) worked together to develop an engineering approach to manage continued AWIPS network growth and expansion to meet the ever-increasing need for more information. A major challenge is predicting when and where the increased data flow from new and expanding applications will impact communications and network infrastructure. When should the NWS plan to increase the capacity of the AWIPS WAN and which links must be increased? Do servers need to be resized and upgraded? What is the impact to the response times of new applications given the existing infrastructure link capacity and infrastructure components?

In order to answer these questions, Northrop Grumman IT developed an AWIPS network simulation model. The model allows AWIPS planners to simulate various Awhat-if@ scenarios to study the impact of proposed changes. Of particular interest, the model addresses four specific applications: (1) the central collection of WSR-88D Level II and Level III archive data, (2) distribution of the Eta model data at 12 Km resolution, (3) the central collection of the fully deployed NWS Digital Forecast Database (NDFD), and (4) the transmission of local gridded databases among WFOs.

2. MODEL DESCRIPTION AND FEATURES

The model uses OPNET Technologies Modeler software as its operating environment and runs on a high-performance 1.9 GHz, Windows 2000 or NT workstation with 2 GB RAM. A multitiered geographical user interface is used to allow quick navigation to all sites. A top-level or enterprise view of the model is shown in Figure 1. The model is based on the actual system architecture including actual communication and routing protocols (e.g., frame relay and open shortest path first [OSPF]), link types and sizes, path delays, and hub connectivities evident in the zoomed view of Figure 2. Also included are the routers, switches, workstations, LANs, and servers that comprise each of the WFOs, RFCs, and the NCF, as shown in Figure 3. The fidelity of the model is enhanced using actual near real-time traffic imported from the Agilent NetMetrix network monitoring system. This traffic data ensures that the Aas-is@ baseline of the model accurately reflects the actual existing network loading.

Using information collected from reports, concept-of-operations papers, and subject matter experts, the WSR-88D, Eta-12, NDFD, and inter-site coordination applications and data were explicitly modeled. Traffic data for each of these applications is generated within the model and transported over the network to the appropriate destinations. Key application characteristics, parameters, and related formulas have been placed in a Microsoft Excel spreadsheet that has been interfaced with the model. This design feature allows individuals familiar with Excel to be able to change the application parameters employed within the model without the need to understand complex programming languages.

3. MODEL REPORTING CAPABILITIES

To best meet the objectives of determining network, application, and component impacts and interrelationships, we categorized the results into three broad areas: (1) capacity planning and burden assessment, (2) application performance, and (3) server sizing. Although the model can provide results for well over a hundred categories, for ease of interpreting the results we selected 13 parameters as having the most practical usefulness. The areas and parameters are as follows:

---

[*]Bruce J. Brown, Northrop Grumman Information Technology, McLean, VA 22102; e-mail brown.bruce@northropgrumman.com.

$ Capacity Planning and Burden Assessment
-   Link throughput (bits/sec)
-   Link utilization (percent)
-   PVC throughput/load (bits/sec)
-   PVC discarded frames (number)
-   Node transmission/reception load (bits, bits/sec)
-   TCP connectivity (bytes)
-   Queuing delay (sec)

$ Application Performance
-   Application traffic sent (bytes/sec)
-   Application traffic received (bytes/sec)
-   Application response time (sec)

$ Server Sizing
-   Server CPU utilization (percent)
-   Server disk utilization

The model provides results for each parameter in a graphical format (see Figure 4). A typical model run covers a 24-hour period.

4. APPLYING THE MODEL

The model can be used to answer Awhat-if@ questions that would be too complex using other means. For example, a typical problem is to estimate the additional network loading that results through the introduction of a new application at all WFOs. The objective is to ensure that the communications links are properly sized and the network routing is optimized to allow the application to properly perform its intended function without impacting other applications. Another objective is to make sure that servers supporting the application are properly specified in terms of numbers of CPUs and memory. To program the new application into the model, the functional characteristics may be entered into the Excel spreadsheet or may be embedded directly into the model=s application profile tables. If an operating prototype of the application is available, another technique is to employ the OPNET Technologies Application Characterization Environment (ACE) tool that captures key data exchange parameters for automated entry into the model.

Another beneficial area of investigation is failure analysis. The model may be used to examine network performance and application impacts should there be a failure of any entity such as a router or circuit. Any device or link may be programmed to fail at a specific time or according to a probabilistic time distribution. This type of analysis is especially useful in examining the potential effectiveness of secondary routing designs and the need to have excess capacity in selected circuits.

5. CONCLUSION

So far, the AWIPS WAN has served its purpose well. The network architecture has supported increased circuit utilization, bandwidth consumption, and additional products of varying volumes and timeliness

requirements. The AWIPS WAN is an evolving network. As new application and traffic requirements arise, the capacity of the network must be managed and adjusted to continue providing reliable support.
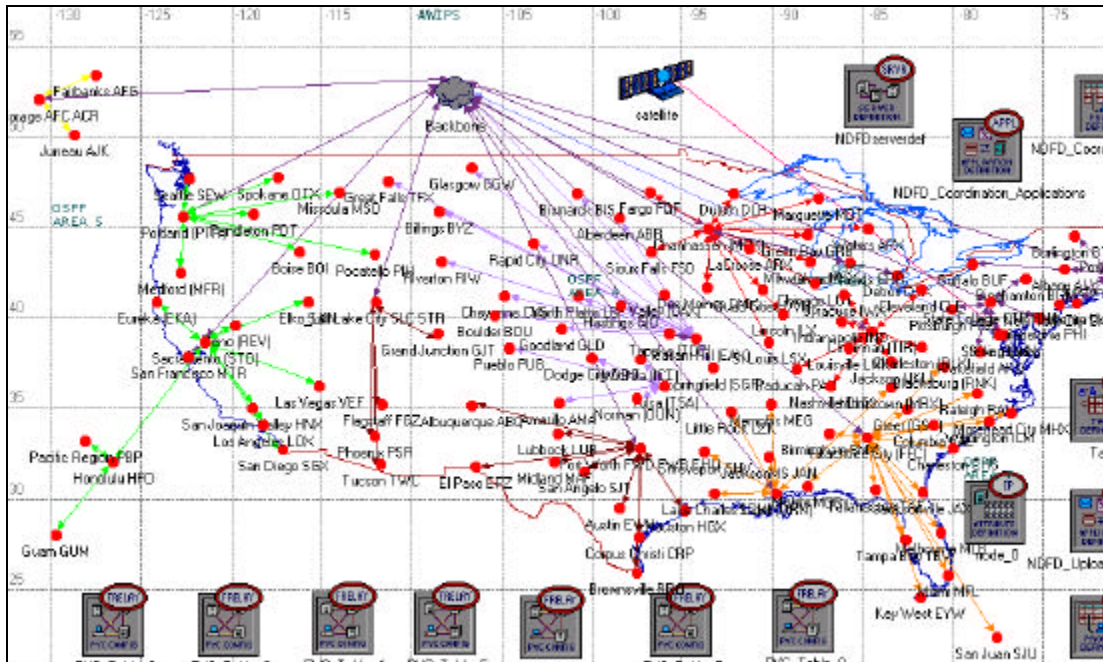
Figure 1. AWIPS Communications Network Model (ACNM) Top-Level Showing Weather Forecast Offices (WFOs), River Forecast Centers (RFCs), the Network Control Facility (NCF), and communication hubs.
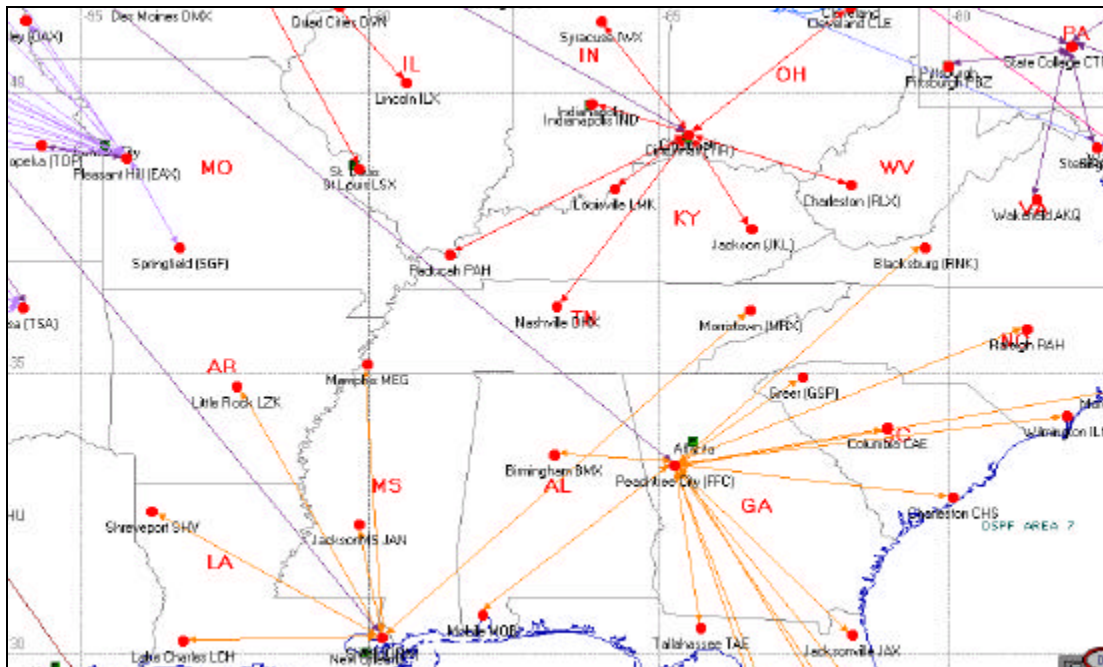

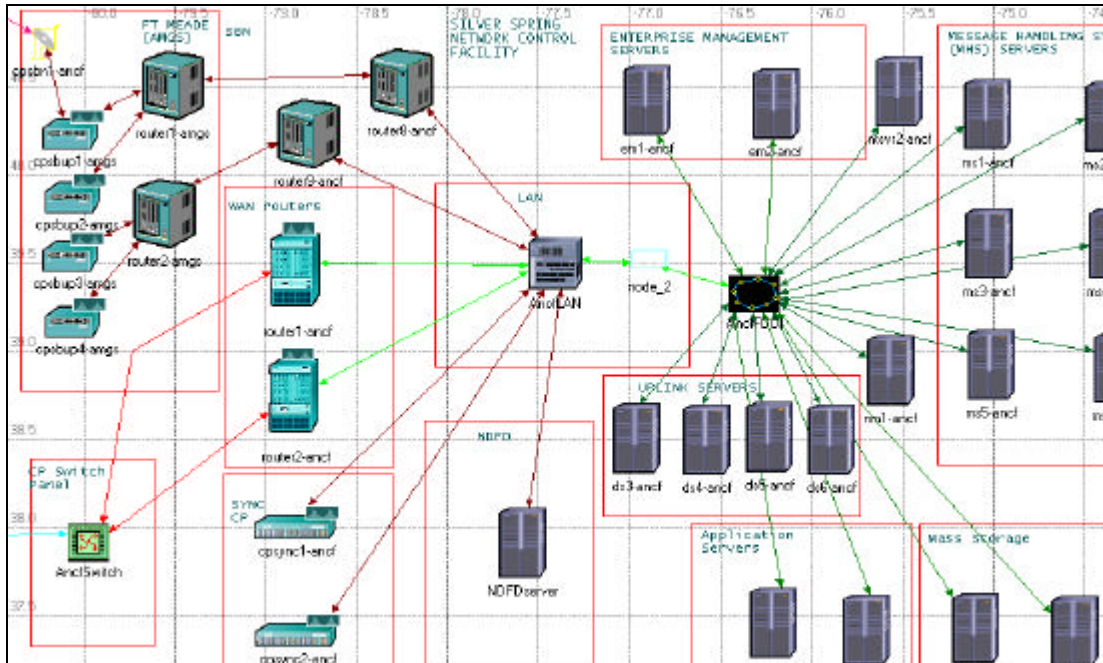Figure 2. Zoomed View of Southern and Eastern Regions

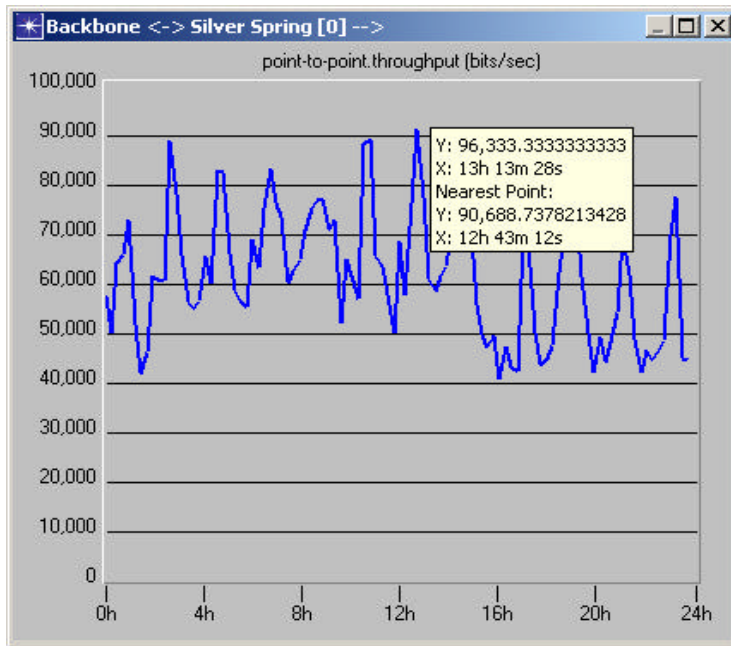Figure 3. Detailed System Configuration for the Network Control Facility (NCF)

Figure 4. Sample Result Showing Link Throughput in Bits/Sec over a 24-Hour Period for a Selected Application