DEVELOPING A FRAMEWORK FOR EFFECTIVE NETWORK CAPACITY PLANNING

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ABSTRACT

As Internet traffic continues to grow exponentially, developing a clearer understanding of, and appropriately measuring, network's performance is becoming ever more critical.

An important challenge faced by the Information Resources Directorate (IRD) at the Johnson Space Center in this context remains not only monitoring and maintaining a secure network, but also better understanding the capacity and future growth potential boundaries of its network. This requires capacity planning which involves modeling and simulating different network alternatives, and incorporating changes in design as technologies, components, configurations, and applications change, to determine optimal solutions in light of IRD's goals, objectives and strategies.

My primary task this summer was to address this need. I evaluated network-modeling tools from OPNET Technologies Inc. and Compuware Corporation. I generated a baseline model for Building 45 using both tools by importing "real" topology/traffic information using IRD's various network management tools. I compared each tool against the other in terms of the advantages and disadvantages of both tools to accomplish IRD's goals. I also prepared step-by-step "how to design a baseline model" tutorial for both OPNET and Compuware products.

INTRODUCTION

As networks became more and more involved, deploying different and sometimes incompatible technologies and trying to monitor the behavior of these networks become increasingly difficult. Round-the-clock network availability along with optimized network and application performance is mission-critical to IRD. For this reason, products like OPNET by OPNET Technologies Inc. and Vantage suite by Compuware Corporation enable users to be more effective in understanding their IT infrastructure, applications, and its anticipated network growth.

Capacity planning in this regard helps provide a clearer understanding of the limits to, and capacity of, IRD's network infrastructure before changes are implemented in light of evaluation of various scenarios. For instance, the individual merits of new technology (such as VoIP) can be assessed and planned before deployment. These tools are able to model the network, and measure the network and application performance. Understanding the detailed traffic volumes, flows, and network architectures is the first step in identifying and correcting problems before any new deployment [1,2].

In order to establish and evaluate various design alternatives however, a baseline model of the IT infrastructure must be generated first. Importing "real" network traffic and topology information from various network management tools can create baseline model. Using this baseline model, "what-if" (sensitivity) analyses can be conducted by altering specific attributes of the baseline model to determine when the infrastructure under analysis might exceed capacity, how re-routing might affect network performance, and how much load a link is able to handle before it begins to degrade. This process can help identify appropriate network design options based on different utilization characteristics and selected topology changes. Both OPNET and Compuware products are evaluated for network capacity planning and baseline models were developed using both packages. Below both products are summarized and then the developed model is explained.

PRODUCT REVIEW

As networks get more complex, with diverse set of technologies and more stringent requirements for application performance, problem solving becomes more difficult. When slowdowns of mission-critical applications occur, IT staff needs tools to track the source of the bottlenecks. In order to troubleshoot performance problems, IT staff needs a complete picture of the IT infrastructure first. There are a variety of tools to help IT staff more effectively design and deploy networks, diagnose network and application performance problems, and predict the impact of network changes. Of those, OPNET and Compuware products are summarized below.

OPNET Technologies, Inc. is a leading provider of management software for networks and applications. **OPNET's IT Guru** enables users to model the entire network, including its routers, switches, protocols, servers, and the individual applications they support. The function of the various modules is summarized below. Of those, Multi-Vendor Import and Flow Analysis modules were used extensively along with other network management tools in our study [3]:

- **Multi-Vendor Import (MVI) Module** is able to import both the topology as well as traffic information in order to create an accurate baseline model.
- **Flow Analysis Module** provides the capability to visualize traffic flows and analyze the impact of failures.
- **Net Doctor Module** identifies potential or existing trouble spots in the network, as well as helps determine whether or not the network is optimally configured.
- **Expert Service Prediction (ESP) Module** helps determine the topology and traffic service projections, perform iterative simulations to automatically analyze the impact of increased load over time.
- **Application Troubleshooting and Deployment (ACE) Module** helps to capture, filter, and synchronize applications from multiple network segments.
- **Application Decode (ADM) Module** enhances the visualizations and diagnoses offered by ACE module, using the application and protocol decode engine from Sniffer Technologies.
- **Virtual Network Environment (VNE) Server** module provides an on-line, integrated view of the network by collecting data and creating a unified network view for planning, engineering, and operations.

Compuware Corporation has products for every aspect of the application life cycle. **Compuware's Vantage** suite is an application service management solution to manage application performance from the end-user perspective. It is able to troubleshoot application performance problems of Web-services-based applications in production. This helps users to understand why transactions are not meeting their expected service level agreements (SLAs) by giving insight into the transaction's programming components. Response time metrics, integrated with end-to-end performance analysis proactively identify and solve performance problems. It also has a number of modules and the function of various modules is summarized below. Application Expert and Predictor are used in our study.

- **ClientVantage** ensures that applications are available and perform at acceptable levels by tracking response times, resource usage, application faults and availability.
- **ServerVantage** monitors servers, applications and databases and produces web-based network management reports.

- **NetworkVantage** handles network performance management with an application perspective by uncovering, who the infrastructure is serving, what applications demand the most resources and how to troubleshoot performance problems.
- **Application Expert** is able to demonstrate how changes in network bandwidth, latency, load and TCP window size affect each end user's response time.
- **Predictor** is able to perform simple growth planning and WAN provisioning based on the key performance metric, the application response time experienced by the end users.

The following section summarizes the baseline models that were developed using both products.

MODELING

The baseline network infrastructure model is developed using the OPNET's MVI module for Building 45. MVI module lets IT people to import both the topology as well as traffic information in order to create an accurate model of the current network. This module is able to obtain network topology, configuration, and utilization data from a variety of sources, leveraging existing information to enable advanced network and application troubleshooting and planning [4].

Network topology is created first using this module. There are a number of different options to create this topology such as creating an empty scenario and building the topology manually using the icons provided, or using the importing option of the MVI module. We have chosen the "importing" function because it gives us the exact network topology. The MVI module is able to pull data from sources such as CiscoWorks, HP OpenView, and various other management tools. We have utilized CiscoWorks for the generation of the necessary device configuration files (config, cdpneighbors, vlan and version) for each switch and router [5].

The MVI module's "Import Device Configurations" function lets you to either import a completely new topology or lets you to import only some of the modified devices (using the files generated). Initially, an entire new topology for Building 45 is generated as can be seen in Fig. 1. This topology also includes Building 46 and 32 core switches. Fig. 2 shows the multilayer topology. If one of the icons is double-clicked, you can see the underlying topology. For example, by double-clicking the B45 icon, you can get the topology seen in Fig. 1.

Once the topology is created, then the traffic information needs to be added. There are different ways of adding this traffic information. The network model can be loaded with "traffic matrix" information, which represents end-to-end traffic flows. Alternatively, a background traffic load of the baseline network can be loaded onto the model. Traffic and/or utilization data can be loaded from various sources, such as Cisco NetFlow

Collector, HP OpenView, Sniffer Pro, MRTG, etc. First, we have used MRTG traffic data and created the model. Later, the traffic flow was collected from Sniffer and used for importing. (Switch and router names on Fig. 1 are deliberately cleared).

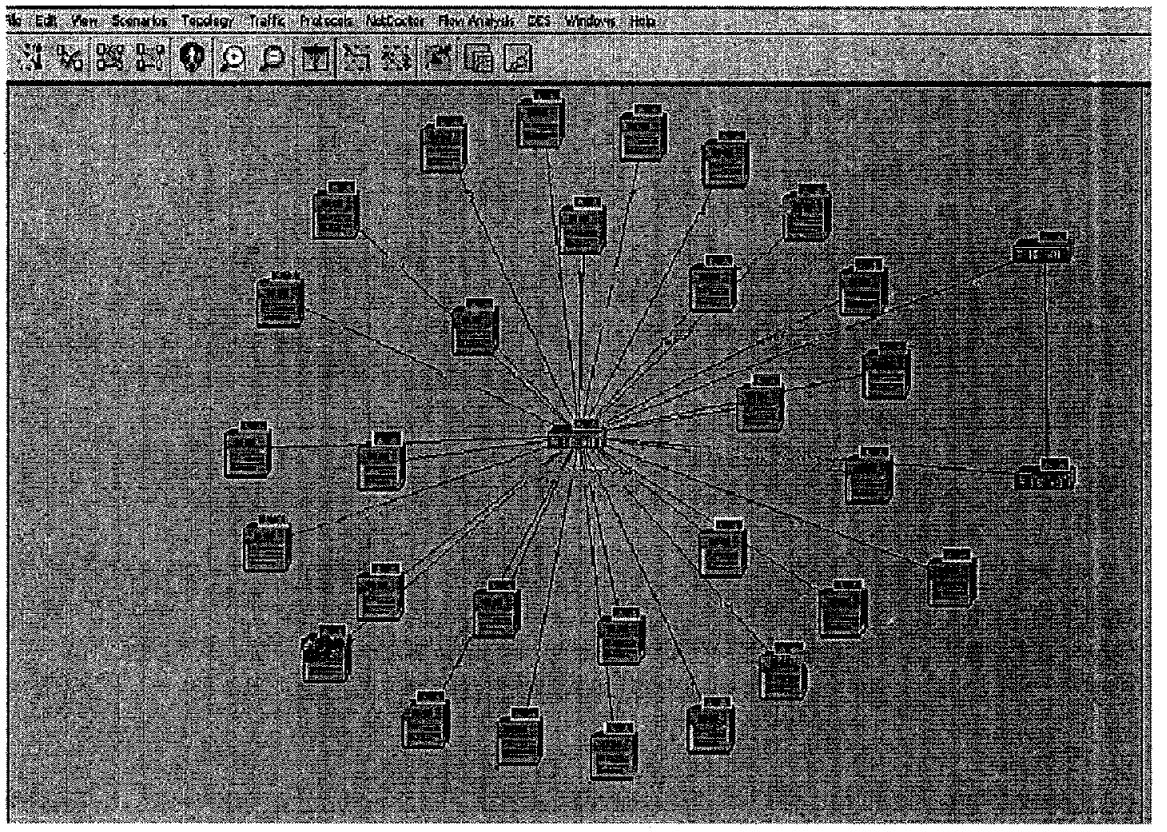

Fig. 1. Building 45 Network Topology

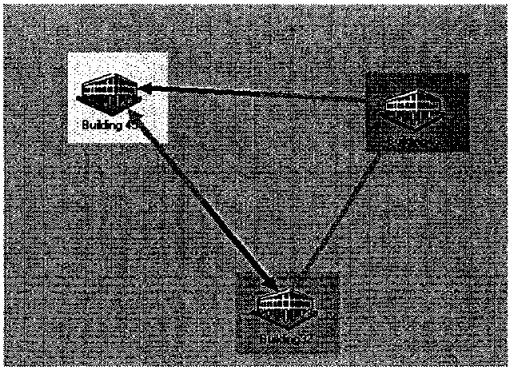

Fig. 2. Multilayer Topology

Once the baseline model is created, the Flow Analysis Module of OPNET is used in order to provide us the capability to visualize traffic flows, analyze the impact of failures, and design fault tolerant networks by pinpointing the actual and potential bottlenecks of the network. This module is also capable of predicting the impact of router failures that uses multiple IP routing protocols and showing how utilizations change in the network over a specific time period. Various global, node and link statistics, such as link utilization, throughput in bit/sec and traffic sent and received were also collected.

Baseline model was also constructed using the **Compuware** tools. For that purpose, a Sniffer file was used to create new tasks in Application Expert. Both filtered and unfiltered trace files were used for the creation of various tasks. We have used Response Time Analysis chart to show the impact that various nodes have on the overall response time of a task. This chart shows the response time and percentage of total response time attribute to each node in the task. We also have used Thread Analysis to view the files or commands such as SQL statement or HTTP commands an application is sending over the network to easily understand the time and duration of a thread and the relationship between threads [6].

Once the tasks were created using Application Expert, then the topology was created. We have created the topology for Building 45 manually using Predictor. The user profiles, which were created with Application Expert, were used for the traffic generation. Traffic import in this case did not work because the Compuware software was not able to detect any of the Sniffer capture cards. Fig. 3 shows the model, which was developed manually using Predictor.

CONCLUSION

Both OPNET and Compuware products were evaluated for network capacity planning. Baseline model for Building 45, which includes the topology and traffic information, was built using both products. Compuware Vantage suite is easier to model. It quickly provides application performance from the end user perspective. Modeling capabilities of OPNET on the other hand, was superior. It is difficult to model; however, detailed network and application performance analysis can be done using this product.

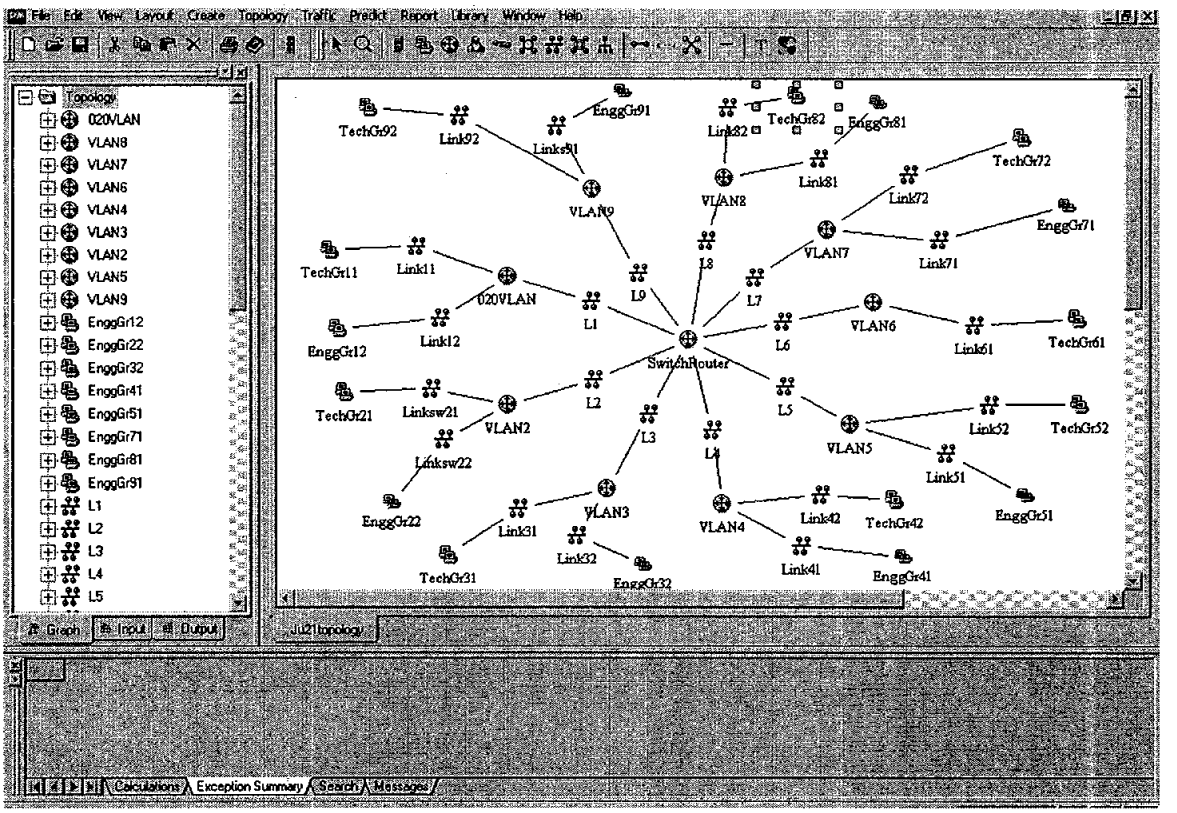

Fig. 3. Building 45 Network Model using Compuware

REFERENCES

1. Behrouz Forouzan, "Data Communications and Networking," McGraw Hill, 2001.

2. Mani Subramanian, "Network Management: Principles and Practice", Addison-Wesley, 2000.

3. Network Monitoring Tools, http://www.slac.stanford.edu/xorg/nmtf/nmtf-tools.html

4. Opnet ITGuru, http://www.opnet.com/products/itguru/home.html

5. CiscoWorks, http://www.cisco.com/warp/public/44/jump/ciscoworks.shtml

6. Compuware's Predictor, http://www.compuware.com/products/vantage/1020_ENG_HTML.htm