INTRODUCTION

Once viewed as internal utilities for interorganization communication, the networks of today are being built to deliver essential business processes to partners and to customers. It is critical for organizations to be able to proactively manage the available bandwidth and systems for effective overall performance management.

Network management is a term that encompasses many complex, interrelated disciplines. Many organizations define the elements of network management as FCAPS — fault management, configuration management, accounting/billing, performance management, and security management — and try to address each element. However, the primary emphasis in many organizations is on fault determination and event isolation and correlation. These are critical elements, obviously, but the changing nature and complexity of the network are elevating the importance of performance management.

Enterprise networks are increasingly becoming a critical delivery mechanism for the products and services of a company. Corporate intranets are being accessed by business partners and even the public to perform basic business transactions. The purchase of books, the tracking of packages, and home banking are just a few examples of goods and services being delivered over the Internet.

With this trend, the enterprise network is both more critical to the day-to-day business operations of an entity and under more stress. The bandwidth demands are skyrocketing.

The Current State of Performance Management; Proactive Performance Management; Developing a Baseline; Online Utilization Reports; Automated Trend Analysis; Trouble Ticket Reports; A Proactive Plan

PAYOFF IDEA

With the network becoming a critical delivery mechanism for business processes (e.g., customer access over the Internet), proactive performance management is more critical than ever. This article provides network managers with a comprehensive overview of this strategic element of network management and offers a self-evaluation checklist to benchmark the organization's current capabilities.
ing as the usage of the new Web-based applications grows. The potential for bottlenecks grows. To meet these increasing demands, LAN and WAN switches are being deployed. Service providers are augmenting the private network. The performance of this new network is much more complex to manage than its relatively static and stable, in-house router-based predecessor.

THE CURRENT STATE OF PERFORMANCE MANAGEMENT
Organizations today often have a variety of different tools to help manage the performance of the network. Those that have mainframes deployed are running a version of TME 10 NetView. SNMP (Simple Network Management Protocol) management applications by HP, IBM, Sun, Cabletron, and others are being widely deployed. Applications from router and switch vendors help to manage those elements and devices. A wide range of specific point tools provide information limited to a particular facet of performance management.

These tools are utilized to conduct many different types of network performance analysis:

- monitor real-time network performance
- network performance threshold alarms
- historical network performance reports
- network performance service level agreements (SLAs)
- LAN capacity planning
- WAN capacity planning
- server capacity planning
- network modeling
- baselining
- benchmarking

The analysis is performed using performance reports from a very wide range of network components:

- routers
- serial links
- frame relay CIR
- Ethernet segments
- token-ring segments
- hubs
- LAN switches
- WAN switches
- servers
- workstations
- applications
Despite the plethora of tools and the variety of tasks that are undertaken in the typical enterprise network, comprehensive and proactive performance management still eludes many organizations. The barriers are numerous. In many cases, there is insufficient staff available that have the experience and training necessary to configure and administer the system, write applications to enhance the system, and maintain the system. As a result, organizations often resort to reacting to network performance problems rather than proactively managing the network’s performance.

Exhibit 1 should be used to evaluate the current state of performance management within an organization.

**EXHIBIT 1 — Performance Management Checklist**

1. Do you know the exact state of the network across the enterprise at any given time? Yes__ No__
2. Do you know the demand on network resources? Yes__ No__
3. Do you know how and where things have changed on the network? Yes__ No__
4. Do you know where problems are emerging — or are about to emerge? Yes__ No__
5. Do you know who is using the network? Yes__ No__
6. Do you have instant accessibility of real-time performance data? Yes__ No__
7. Do you have real-time trending statistics from across the enterprise? Yes__ No__
8. Do you have reliable access to critical information for making business decisions? Yes__ No__
9. Are you able to identify over/under utilized resources? Yes__ No__
10. Can you spot trouble before it starts? Yes__ No__
11. Are you able to plan your network’s growth with accurate usable information? Yes__ No__
12. Can you see, analyze, and baseline all ports on all routers, hubs, and switches? Yes__ No__
13. Can you provide management with the network reports it wants? Yes__ No__

Proactive performance management is the gathering of statistical data for monitoring and correcting the operation, and measuring the overall effectiveness of the network as well as aiding in the network planning and analysis process. Performance management is not performed in a vacuum, however. It must be integrated with other network management functions, like fault management and event correlation, to be maximally effective. Performance and fault management should be tightly integrated to ensure NMS and operations staff are aware of potential errors or trends that could impact client services.
Performance management involves establishing a set of performance objectives for resources and addressing the following steps:

1. Monitoring: tracks resource and communication activities in order to gather the appropriate data for determining performance.
2. Thresholding: sets and modifies the operational standards (e.g., threshold values) by which the system performance is monitored and judged.
3. Reporting: involves the presentation of gathered data.
4. Analyzing and trending: consists of trending and statistical analysis, which was performed by network operators and planners to assess the results of performance measures. New software systems now do this for you.
5. Modeling: imports performance data to predict where additional resources will be required to meet SLAs and to understand what impact a new application will have on current resources.
6. Tuning: focuses on the adjustment or reconfiguration of resources and communications activities to improve performance.

Exhibit 2 illustrates the relationships between these various activities and the key interaction between performance management steps and fault management.

Exhibit 3 lists the required elements of a proactive performance management system or set of systems.

DEVELOPING A BASELINE

In order to begin a process of enhancing the performance management capabilities of an organization, one must begin with a baseline. With today’s technology, few problems are caused by equipment failure. Most are caused by the increasing demands being placed on large and complex networks. To get a jump on these problems, one needs a comprehensive picture of the network that can be used for the analysis and modeling efforts that are part of any ongoing network design task.

One must have a baseline of past activity by which to judge present and future performance. With a baseline established, network hot spots can be acted on quickly or can be predicted and prevented altogether. Developing a baseline requires the focus on the first three activities in performance management: monitoring, thresholding, and reporting.

Most organizations have implemented products and systems that are already gathering information about network performance. SNMP MIB performance metrics represent specific performance characteristics of network elements. SNMP MIB attributes are periodically polled and trend data is collected over a period of time. Some metrics are requested on a demand-only basis, while others are collected only when an alarm con-
EXHIBIT 2 — Proactive Performance Management Activities

- Monitoring
  - Fault Management
  - Notification
  - Automation

Performance Management

- Thresholding
- Analyze and Trend
- Reporting

- Tuning
- Modeling
dition exists on the network. Networks contain a wealth of information in their SNMP MIBs and Remote Monitoring (RMON) data. However, collecting and analyzing the data can be an arduous, resource-intensive process. The development of a network baseline should pull together the relevant SNMP and RMON data that are indicators of network performance. Exhibit 4 illustrates these indicators.

Resource availability statistics, derived from the fault management system, are the actual measure of the accessibility of a network resource when compared to the time the resource should be available. It must be noted that there is a clear distinction between reliability and availability. Reliability is the measure of the network’s ability to function without failure. Availability is the measure of the network’s ability to serve the purpose for which it was installed (from the user perspective). Availability depends on the reliability of the network, as well as the efficiency of the network control staff to restore services after a failure. As noted previously, clients will primarily be concerned with service availability, whereas

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**EXHIBIT 3 — Required Elements of a Proactive Performance Management System**

<table>
<thead>
<tr>
<th>Required Elements</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor hardware, software, remote links, and systems</td>
<td>Enables shift from reactive to proactive network performance management</td>
</tr>
<tr>
<td>27 × 7 collection of SNMP and RMON statistics</td>
<td>Enables staff to quantify network performance; improves understanding of network health and performance</td>
</tr>
<tr>
<td>Automatic notification of performance alerts</td>
<td>Increases end-user satisfaction and productivity; avoids additional headcount and capital expenditures</td>
</tr>
<tr>
<td>Predictive trend analysis</td>
<td>Predicts when next trouble spots will occur and identifies cause; solves problems before they impact network service levels</td>
</tr>
<tr>
<td>Daily reports and reviews of network performance trends and capacity trends</td>
<td>Enables true proactive management; provides necessary factual data and frees up IT personnel to focus on more strategic objectives</td>
</tr>
</tbody>
</table>

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**EXHIBIT 4 — Indicators of Network Performance**

<table>
<thead>
<tr>
<th>Network</th>
<th>Resource Availability</th>
<th>Quality of Service</th>
<th>Capacity</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Link status</td>
<td>Disrupted seconds %</td>
<td>Bandwidth</td>
<td>Bandwidth usage %</td>
</tr>
<tr>
<td>Routing</td>
<td>Device/interface status</td>
<td>Packets dropped %</td>
<td>Packets per second</td>
<td>Packet per second %</td>
</tr>
<tr>
<td>LAN (Ethernet, Token Ring)</td>
<td>Status</td>
<td>Error packets</td>
<td>Bandwidth</td>
<td>Bandwidth usage %</td>
</tr>
</tbody>
</table>
the network control center will also be concerned with actual component reliability.

- Quality of service is the measure of service delivery in terms of number of errors, packets or circuits dropped, etc.
- Capacity or throughput is the measure of the network size and can be measured in terms of bandwidth, number of WAN links in the physical layer, or packet processing speed in the routing layer.
- Utilization is the measure of the actual use of a resource when compared to its theoretical throughput.

Once the appropriate monitoring is set in place, thresholding allows network technicians to monitor, identify, analyze, and react to changes in system and network performance. When conditions occur that cause monitored parameters to fall outside of predetermined thresholds, the management system can be set to trigger alarms or monitor and report changes in system status. For each indicator of interest, thresholds must be carefully selected. Thresholds that are too rigid will result in frequent alarms, while thresholds that are too relaxed can result in performance degradation that may be overlooked by support personnel. In the development of a baseline, thresholds can identify current hot spots and potential problems.

The final step in developing a network baseline is the development of pertinent reports for communication to various constituents. This then becomes an ongoing process, particularly with new tools that allow the easy publishing of the information via corporate intranets. Performance and capacity reports can be generated using a variety of reporting tools. These tools provide an automated process to easily summarize SNMP MIB element data that has been collected from network objects. The reporting features of these tools allow for report generation as well as immediate online viewing of the data.

Performance reports are useful to clients, the network operations staff, and the network systems planning group. These reports will provide the vehicle to assist network planners in preventing future outages and drops below the minimum service levels agreements (SLAs), as well as allowing sufficient time for the network system planning to provide necessary network resources for the future. An excellent medium for providing personnel with reports is via HTML Web pages over the corporate intranet. Performance problems may be due to inadequate resources (e.g., bandwidth), inefficient processes (e.g., unnecessary encapsulation of protocols), or an inefficiently used resource (e.g., excessive noise on a circuit requiring retransmission). Some sample performance and capacity reports are described below.
• Resource availability report: The minimum/average/maximum availability of the network resource reported for a day/week/month; 99.91 percent availability over a period of time.
• Resource maintainability report: the mean time to repair (MTTR) for the network resource.
• Resource failure report: the number of resources reported to be unavailable for more than ‘n’ time.

Online Utilization Reports
The following reports can be provided online to the user community:

• LAN utilization
• interface utilization statistics
• environmental reporting

Automated Trend Analysis
A statistical analysis is needed for graphs of collected data. The analysis could contain a description of the data’s behavior, including any trends. It may contain an opinion with a recommendation to change. It can provide the statistics derived from the data for those who like such numbers. The enclosed statistics should include data set minimum, maximum, average, standard deviation, and linear regression parameters. For example, the bandwidth utilization graph with an analysis tells one if the usage trend is increasing to the point of degraded performance. If so, it will predict a theoretical date that performance will hit 100 percent and it will advise one to upgrade the bandwidth speed. Separate advice should be provided to accommodate serial links, Ethernet, and token ring. However, if bandwidth utilization is normal, it should tell one that. All this information allows one to predict when upgrades will be required, if needed, rather than passively wait for some device to fail due to saturation.

Trouble Ticket Reports
Clients need to have confidence that their trouble ticket report is seriously considered as a source of identifying and attacking the problems that they are encountering. They also need to know who is handling their problem, that the problem is understood from their perspective, some projected time frame when can it be resolved, and when the problem is considered resolved by the management system. Some trouble ticket reports will be generated by conditions within the network system itself and routed to operations prior to client reports. In many cases, problems will be resolved automatically as they occur or prior to client reporting.

Reports issued for user feedback should include the following:
A PROACTIVE PLAN

Network systems planning is the process of using historical operating data, as well as estimated future resource requirements, to determine the optimal design of the network. The ultimate goal of network systems planning is to make optimal use of network resources to ensure network services are provided at a level necessary to meet client demands and SLAs while maintaining cost-effectiveness.

An extremely important aspect of Network System Planning is network optimization. Optimization involves balancing the efficient use of network resources, client requirements, and costs. Effective network optimization requires a detailed understanding of the following areas:

- client business requirements
- client priorities (i.e., response time vs. availability)
- disaster recovery requirements
- network protocols (WIN NT, TCP/IP, AppleTalk)
- transmission methods and media (analog, digital, fiber, copper, microwave)
- comparison of vendor-provided services vs. in-house supported services
- application design and implementation
- component capacity and throughput (client systems as well as switches)
- component compatibility
- industry trends
- available technology and future directions
- standards efforts
- network metrics/indicators and their interpretation
- network modeling
- costs and return on investment (ROI)

The importance of having a planning group that understands all of the above items and their interrelationships cannot be overstated. A network
design omitting even one of these items could result in undesirable consequences.

Input to the planning process can come from any area of network management. Specifically, these can include, but are not limited to:

- performance reports
- trouble ticket reports
- component configuration
- client resource usage estimates
- security requirements
- costs

Component configuration refers to understanding the limitations of each component in the network with regard to capacity as well as physical limitations (number of available slots, power requirements, environmental limitations, etc.). In addition, planners must be aware of future changes to vendor-supplied components such as incompatible hardware upgrades or software that will no longer be supported.

The most difficult piece of planning data to gather is an accurate list of future client resource requirements. In many cases, end users may not have the technical skills or tools to estimate network resource requirements.

This process of optimizing the network design as performed in the network systems planning function is a key to turning the performance management function from being reactive to being proactive. This is the critical function that will allow organizations to prevent problems from occurring. By utilizing the reports generated from the monitoring and thresholding activities, potential bottlenecks can be identified and the resolution of those bottlenecks can be set in place before they hamper network performance.

SUMMARY

Today’s networks are becoming very critical and very visible elements in the day-to-day operation of a business. The complexity of these networks will continue to grow as the demands on them increase over time. Network performance management is an essential component of an overall strategy for these new networks. If you are a bank and your customers become frustrated with your home banking service because of network bottlenecks and long response times, they will find somewhere else to bank. It is that easy.

Today, many organizations are forced into reacting to performance issues rather than anticipating them. Often, they simply throw bandwidth at the problem although a bottleneck is caused by overutilization of a device, system, or component. Putting in place a proactive performance management system that assists in identifying current and future trouble
spots will be key to the organization’s ability to respond to new demands on the network.

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