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Results on the Evaluation of CrossKey's Dyband™ Product for Traffic Shaping Performance

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ABSTRACT

This report presents results on the evaluation of the Dyband product from CrossKeys Systems Corporation. The product is Dyband Dynamic Bandwidth Management System, Release 1.2. Test results of the Dyband system evaluation indicate that the Dyband can provide effective bandwidth management and network monitoring capabilities. Dyband reacts quickly to congested conditions on access lines by controlling the transfer rates of individual hosts and making fair allocation of bandwidth according to pre-specified profiles and policies. Dyband achieves real-time bandwidth control by using a 10 milliseconds (ms) cycle for assessing traffic flow and by applying two congestion management mechanisms: Dynamic Rate Controls and Dynamic Priorities. These dynamic capabilities proved to be very effective in controlling congestion and offering preferential service to hosts transmitting higher priority applications. In addition, Dyband's real-time network monitoring feature provides network managers with a useful insight into network performance.

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Results on the Evaluation of CrossKeys, Dyband™ Product For Traffic Shaping Performance

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This report presents results on the evaluation of the Dyband product from CrossKeys Systems Corporation. The product is Dyband Dynamic Bandwidth Management System, Release 1.2. The evaluation was performed in the summer of 2000 in the PC/LAN laboratory of the MITRE Corporation in Reston, VA. This work was performed under the auspice of the mission-oriented investigation and experimentation (MOIE) entitled ***"Operational Dynamics of Quality of Service (QoS)"***, an Army MOIE sponsored by the Defense Information Systems Agency (DISA) for fiscal year 2000.

Test results of the Dyband system evaluation indicate that the Dyband can provide effective bandwidth management and network monitoring capabilities. Dyband reacts quickly to congested conditions on access lines by controlling the transfer rates of individual hosts and making fair allocation of bandwidth according to pre-specified profiles and policies. Dyband achieves real-time bandwidth control by using a 10 milliseconds (ms) cycle for assessing traffic flow and by applying two congestion management mechanisms: Dynamic Rate Controls and Dynamic Priorities. These dynamic capabilities proved to be very effective in controlling congestion and offering preferential service to hosts transmitting higher priority applications. In addition, Dyband's real-time network monitoring feature provides network managers with a useful insight into network performance.

1. INTRODUCTION

Managing the transmission capacity of DoD networks to provide sufficient bandwidth to fully support the mission-critical traffic applications of deployed forces has become an increasingly complex task. Transmission capacity in the tactical arena provided by a combination of MILSATCOM and/or leased commercial SATCOM is always in short supply and is costly to acquire. Furthermore, the priorities for user access to DoD wide area network (WAN) communications assets and degrees of end-to-end performance vary for different user communities and applications during the phases of a deployed force mission, often changing in a matter of minutes. Quality of Service (QoS) mechanisms and Policy-Based Network Management (PBNM) provides a means to do sophisticated traffic shaping and policing required for allocating available transmission resources to tactical network users according to various criteria. Examples of user connection criteria are 1) the priority of user information at each phase of the mission, 2) the minimum tolerable time needed for delivery of user information, and 3) the statistical nature of the network traffic.

One of the main objectives of this MOIE is to explore the utility of existing and emerging QoS networking and PBNM products that could be implemented into DoD networks to support the communications needs of deployed forces. Using both laboratory testing and simulation efforts, a variety of QoS networking and PBNM products are being evaluated for their specific QoS techniques and capabilities that might deliver improved performance necessary to deployed forces' mission-critical traffic applications. The

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evaluation is focused on the merits of the various approaches to QoS networking, including traffic shaping, admission control techniques, and queue management algorithms to determine which is the best solution. Some of these techniques are implemented in network elements such as routers and hosts or in stand-alone devices such as the Dyband system from CrossKeys

This paper presents the results on the Dyband system evaluation for traffic shaping performance. It is organized as follows: Section 2 provides an overview of the Dyband and its architecture. Section 3 presents the test configurations and test cases. Section 4 provides the test results, and Section 5 provides a summary of our findings and concluding remarks. Appendix A provides CrossKeys Dyband System Requirements.

2. OVERVIEW OF DYBAND BANDWIDTH MANAGEMENT SYSTEM

CrossKeys® Dyband™ is a software-based solution that provides dynamic bandwidth management on broadband access services. It does use a dedicated general-purpose workstation (with Microsoft Windows NT operating system) at key points to do the shaping. It enables broadband service providers to control their aggregate bandwidth usage and their customers' usage down to individual subscribers, increasing the efficiency of connections of a wide area network (WAN) or the Internet and equitably distributing bandwidth to subscribers.

Dyband combines bandwidth management with networks monitoring, performance measurements and reporting of real-time statistics on bandwidth usage. The Dyband system architecture is described in section 2.1.

Dyband provides dynamic traffic shaping at any combination of network points, called Management Points (MPs). An MP represents an individual or aggregate traffic flow associated with physical network devices or logical entities. Bandwidth consumption for individual IP addresses and for aggregate traffic generation points (subnets, groups of IP addresses, and physical interfaces) is managed according to assigned MPs' Normal and Congested Rate Limits and Priorities and the changing network load status. Dyband achieves real-time bandwidth control by using a 10 milliseconds (ms) cycle for assessing individual and aggregate traffic flow and utilizing two congestion management mechanisms: Dynamic Rate Controls and Dynamic Priorities for shaping traffic.

Dynamic Rate Controls: During periods of normal traffic patterns, Dyband allows MPs the Mximum Normal Rate Limit that has been assigned to them. When congestion is detected, Dyband lowers the transfer rate to the pre-specified Maximum Congested Rate Limit at the points of congestion, and only for the affected traffic direction. As congestion is relieved, the transfer rate is allowed to return to its normal limit. The rapid toggling between MPs normal and congested rates makes full use of available bandwidth.

Dynamic Priorities: Dyband's dynamic priority mechanisms give higher-priority subscribers preferred transfer rates while ensuring that lower-priority subscribers are not completely "starved" of bandwidth. Dyband reacts in real-time to network congestion and keeps periods of congestion short, ensuring that no user is completely starved of bandwidth during congestion, unless the policies have been deliberately configured to do so. The system can also be configured to adjust transfer rates based on usage.

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2.1 DYBAND SYSTEM ARCHITECTURE

The Dyband system consists of the following main components (see figure 1).

Shaper – is responsible for shaping traffic and collecting real-time statistics. Shaper runs on a Windows NT 4.0 server that is placed between the interior distribution network and the Internet router. The system must be equipped with three network interface cards (NICs): one interface for connectivity to the CMon for management and control, and two interfaces for shaping and shaping traffic at network key points.

CMon – allows a network administrator to view and modify the MP topology and view real-time performance statistics. CMon is typically installed on a system at a network operation center (NOC) facility and can be configured to manage multiple Shapers

Archiver – is responsible for extracting rea;-time statistics from up to four Shapers and sorting them for historical references and analysis. Archiver is typically installed on a system at a NOC facility. Archiver was not used in our laboratory-testing configuration.

Miner – allows a network administrator to generate and view reports that contain historical performance data. Miner is typically installed on the same system as CMon. Miner was not used in our laboratory-testing configuration.

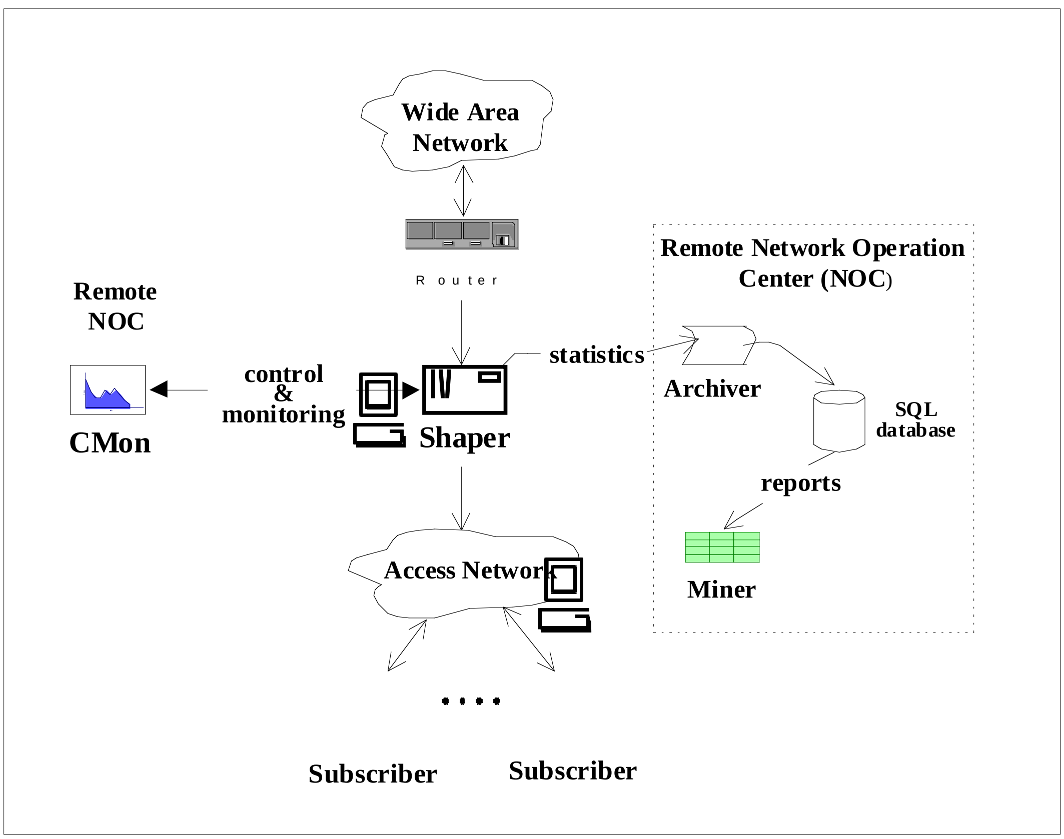

Figure 1. CrossKeys Dyband Components in a Generic Broadband Network

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3. DYBAND TESTING

3.1 GOALS

We proceed with the Dyband evaluation testing in a controllable laboratory environment with the following goals:

1. Testing Dyband ability to dynamically provide privileged bandwidth allocations to selected network users under both normal and congested conditions
2. Testing Dyband ability to limit access to bandwidth-intensive, low-priority traffic in order to enhance the transfer rate and priority of mission-critical traffic.
3. Validating the accuracy and repeatability of Dyband real-time measurements.
4. Assessing how easily users can configure and deploy DyBand different service policies.

3.2 TEST CONFIGURATION

The network configuration for the Dyband lab evaluation testing is set to represent a subset of a hypothetical scenario with joint force commanders responding to a notional crisis. In this scenario, the commands are grouped in four nodes; three of which are situated in one LAN separated from the fourth node by a single bottleneck WAN link. Three nodes on one LAN emulate a component commander (e.g., Army, Maritime, or Air component commander) and the node on the other side of the WAN link emulates the Command Joint Task Force (CJTF).

Traffic data for the lab testing is selected to emulate some of the diverse types of mission-related, information exchanges (IEs) that might take place among the commanders in the four nodes, such as:

- Mission-critical, data intensive exchanges that may include graphic-intensive maps
- Mission-critical, small sized exchanges, of high priority requiring timely delivery; e.g., data for situational awareness
- Routine-priority, data intensive exchanges
- Low-priority, data intensive traffic, such as weather forecasts

Figure 2 shows the lab's setup for the four-node network configuration scenario. It consisted of two LANs interconnected by a single 1 Mbps link. The Shaper software was installed on a system running Microsoft Windows NT Server operating system version 4 Service Pack 4. The system had three network interface cards: a management interface, which connects to the CMon, and two shaping interfaces: interface 0, which connect to the hub, and interface 1, which connects to the Cisco 4000 router. The Shaper controlled traffic on the two shaping interfaces allowing inbound and outbound traffic to pass at the maximum rates defined by the policies and profiles configured on the CMon.

The CMon software was installed on another system running Microsoft Windows NT Server operating system version 4 Service Pack 4. The CMon provided the following functions:

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- Create the policies and profiles that govern the shaping of network traffic
- Create a logical representation of the network by creating subnets and groups
- Observing the aggregate inbound and outbound traffic at the MPs and providing real-time performance statistics
- Enable autodiscovery of IP addresses on the desired subnets

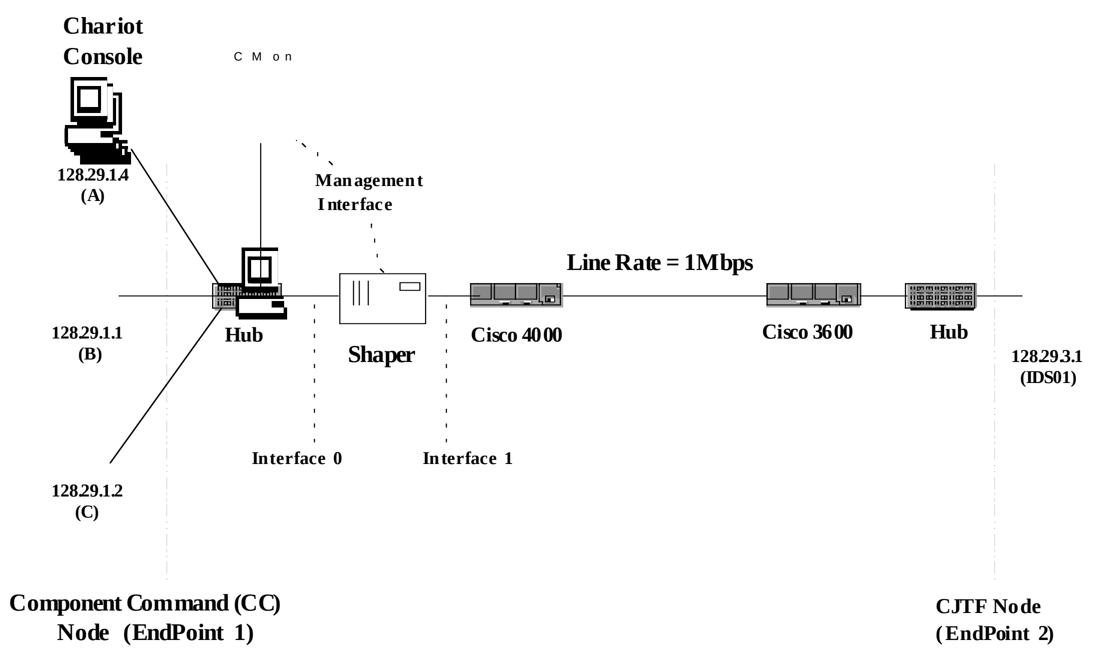

Figure 2. Lab's Test Configuration

3.3 TRAFFIC CONFIGURATION

The Chariot console and Endpoints software from Net iQ (previously Ganymede) were used to generate the traffic loads for the lab testing. The Chariot console resided on a PC running Microsoft Windows NT Server operating system version 4 Service Pack 4. Chariot endpoints resided on four PCs running Microsoft Windows NT Server operating system version 4 Service Pack 4. They provided the mean to make logical connections to reflect flow of traffic in the network configuration and to measure the performance of traffic throughput.

The following identifies the applications selected for the four EndPoint hosts.

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Host Address	**Host Name**	
128.29.3.1	DS01 (CJTF)	Emulates the CJTF node with an FTP server, SAP/R3 server, and HTTP server.
128.29.1.1	GTN_TESTER	Emulates an entity at the component command (CC) node uploading low-priority FTP files to a remote FTP server at the CJTF node.
128.29.1.2	NFB1	Emulates an entity at the component command (CC) node uploading low-priority FTP files to a remote FTP server at the CJTF node.
128.29.1.4	GANYMEDE	Emulates an entity at the CC node exchanging mission-critical, high-priority applications consisting of a mixture of large-sized exchanges (HTTP) and small-sized exchanges (SAP/R3) with a remote server at the CJTF node (DS01).

Table 1 provides a description of the Chariot applications selected to emulate the flow of network traffic during the testing.

Table 1. Chariot Application Scripts

Traffic Application	Chariot Script File Name	Description
Pair 1: Web Graphics (Mission-critical)	HTTPGIF.SCR	This script emulates the traffic of an HTTP GIF (graphical image file) transfer. Endpoint 1, as the client, requests a GIF file from Endpoint 2, as the Web server. The default file size is 10,000 bytes.
Pairs 2 - 5: SAP/R3 (Mission-critical)	SAPAUTHP.SCR SAPINV.SCR SAPLOGIN.SCR SAPPUROR.SCR	The four scripts, each with its own connection, emulate a set of small-sized exchanges between EndPoint 1 and EndPoint 2. They represent a series of symmetric and asymmetric request/responses related to a business transaction.
Pairs 6 and 7: File Transfer (Send) (Low-Priority)	FILERCVL.SCR	This script emulates the traffic of a file transfer. Endpoint 1 requests a file from Endpoint 2, and gets it back. The default file size is 100,000 bytes.

3.3 TEST CASES

We first conducted baseline tests to establish metrics for the transfer rate of the three subscribers (Hosts A, B, and C) with and without line congestion. Shaper was set to provide same priority level to all three transmitting hosts; that is; all were given equal access to the 1 Mbps line bandwidth.

We then tested the efficiency of Dyband in providing preferential treatment to the host identified as transmitting mission-critical applications through using Dyband dynamic bandwidth control capabilities, while observing whether Dyband provide at the same time consistent service to other hosts (transmitting low-priority FTP applications).

The MPs were configured within the Shaper hierarchical tree structure to represent the network points and their logical relationships. Dyband's interfaces 0 and 1 were represented as "Parent" for all MPs below them in a tree. Both the normal and congested rate limits, for inbound and outbound traffic, for interfaces 0 and 1 were set at 1 Mbps to represent the line bandwidth. The normal and congested rate limits for Host IDS01, for inbound and outbound traffic, were also set at 1 Mbps (see figure 3).

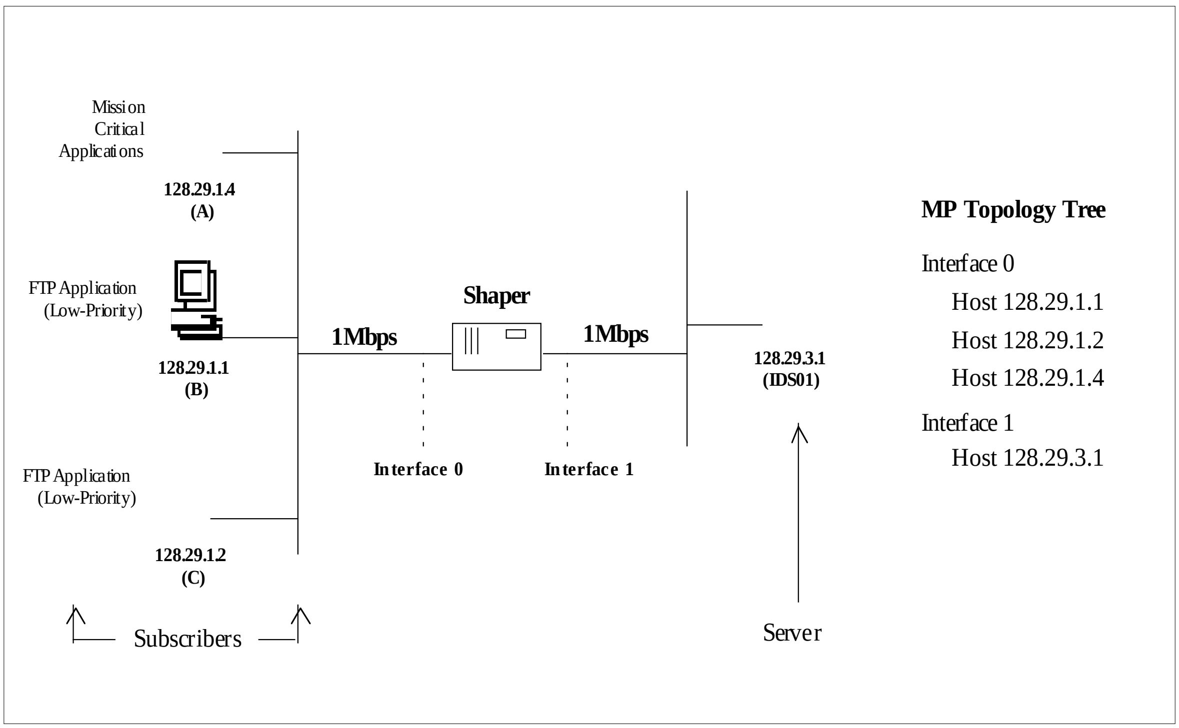

Figure 3. Shaper Setting of MP Topology Tree

We conducted the following five test cases.

- **<u>Test 1</u>** – Baseline test, no congestion
- **<u>Test 2</u>** – Baseline test, congested link
- **<u>Test 3</u>** – Congested link, higher priority for mission-critical traffic
- **<u>Test 4</u>** – Congested link, reduced rate for low-priority traffic

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Test 5 – Congested link, higher priority for mission-critical traffic combined with reduced rate for low-priority traffic

Test 1 – Baseline Test, No Congestion

Test 1 consisted of creating a flow of mission-critical traffic applications transmitted between Host 128.29.1.4 (A) and the IDS01 server, using the Chariot Endpoints software residing on both hosts. One Web HTTP application and four SAP/R3 applications, all TCP-based, were used to emulate a mixture of large and small-sized mission-critical exchanges.

Normal (uncongested) conditions were created on the link by defining Dyband's Normal Maximum Rate setting for Host 128.29.1.4 (A) at 550 kbps (below the 1 Mbps line limit).

Host	Traffic Type	Normal Maximum (Kbps)	Congested Maximum (Kbps)	Dyband™ Priority Range	
				Min.	Max.
128.29.1.4 (A)	**mission-critical**	550	300	0	100

The rate of transfer at the traffic endpoints, Hosts A and IDS01, was measured in both directions, inbound and outbound, using the CMon real-time performance statistics. The throughputs of individual traffic applications were also measured on the Chariot Console and compared with the CMon performance measures[1].

Test 2 – Baseline Test, Congested Link, Equal Priority Setting

Test 2 consisted of adding low-priority, bandwidth-intensive traffic between Hosts B and IDS01 and between Hosts C and IDS01 to flow on the link with the mission-critical traffic from Host A. The additional traffic emulated multiple uploading of files on the server (Host IDS01) at the same time. The Dyband's Normal Maximum Rates setting for all three subscribers (Hosts A, B, and C) were assigned such that the aggregate MP bandwidth (1450 kbps) exceeded the 1 Mbps line limit, creating state of congestion.

Host	Traffic Type	Normal Maximum (Kbps)	Congested Maximum (Kbps)	Dyband™ Priority Range	
				Min.	Max.
128.29.1.4 (A)	**mission-critical**	550	300	0	100
128.29.1.1 (B)	**low priority**	450	225	0	100
128.29.1.2 (C)	**low priority**	450	225	0	100

Test 2 provided traffic setting in which three hosts with different requirements for bandwidth and latency were contending for the 1 Mbps link bandwidth. It was conducted such that equal access to bandwidth was given to each host under both normal and

[1] The Chariot Console provides throughput measurements for each individual application script while the CMon measure the average of host transmission. One should add the measured throughputs on the Chariot and compare it with the CMon measurement.

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congested conditions by assigning identical minimum and maximum values on Dyband's priority ranges to all three hosts.

Test 3 – Congested link, Increased Priority for Mission-Critical Traffic

Test 3 consisted of raising Dyband's Minimum Priority setting for mission-critical traffic (Host A) from 0 to 15 *under both Normal and Congested Conditions*. It was conducted to test the effectiveness of Dyband's dynamic priority in providing preferential service to users who are prioritized for access to bandwidth.

Host	Traffic Type	Normal Maximum (Kbps)	Congested Maximum (Kbps)	Dyband™ Priority Range	
				Min.	Max.
128.29.1.4 (A)	**mission-critical**	550	300	**15**	100
128.29.1.1 (B)	**low priority**	450	225	0	100
128.29.1.2 (C)	**low priority**	450	225	0	100

Observations were made of the performance enhancement to mission-critical traffic (Host A) as well as the impact on low-priority traffic (Hosts B and C).

Test 4 - Congested link, Reduced Rate for Low-Priority Traffic

Test 4 consisted of lowering Dyband's Maximum Rate setting for low-priority traffic (Hosts B and C) *under normal condition from 450 to 300 kbps and under congested condition from 225 to 200 kbps*. In this test, lower rates were used for low-priority traffic even under normal conditions to test the effectiveness of Dyband in providing consistent service to low-priority users under both normal and congested conditions.

Host	Traffic Type	Normal Maximum (Kbps)	Congested Maximum (Kbps)	Dyband™ Priority Range	
				Min.	Max.
128.29.1.4 (A)	**mission-critical**	550	300	0	100
128.29.1.1 (B)	**low priority**	**300**	**200**	0	100
128.29.1.2 (C)	**low priority**	**300**	**200**	0	100

Test 5 - Congested link, Increased Priority for Mission-Critical Traffic Combined with Reduced Rate for Low-Priority Traffic

Test 5 was conducted to test the effectiveness of Dyband's dynamic priority and rate control mechanisms in provide preferential service to users who are prioritized for access to bandwidth while maintaining consistent service to low-priority users.

Dyband's Minimum Priority setting for mission-critical traffic (Host A) were raised from 0 to 30 *under both Normal and Congested Conditions*. Dyband's Maximum Rate settings for low-priority traffic (Hosts B and C) *under normal condition and congested conditions* were the same as Test 4.

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Host	Traffic Type	Normal Maximum (Kbps)	Congested Maximum (Kbps)	Dyband™ Priority Range	
				Min.	Max.
128.29.1.4 (A)	**mission-critical**	550	300	**30**	100
128.29.1.1 (B)	**low priority**	**300**	**200**	0	100
128.29.1.2 (C)	**low priority**	**300**	**200**	0	100

4. TEST RESULTS

Test 1 results (see Figure 4) confirmed that Dyband passed mission-critical traffic between Hosts 128.29.1.4 (A) and 128.29.3.1 (IDS01) at pre-specified rate of 543 kbps, in an ideal condition (i.e., with no congestion and no other traffic sharing the link).

Test 2 results confirmed that Dyband bandwidth management capability responded to the congested state on the 1 Mbps line by shaping the traffic flowing between its two interfaces according to the MP topology and policy that Dyband had been configured. As Dyband was configured to assign identical minimum and maximum priority values to all hosts, it did provide equitable bandwidth to them.

The following Test 2 results obtained from the CMon real-time performance statistics demonstrate that Host A's transfer rate fell to 354 kbps (a 35% reduction) due to the link congestion. Each host received a fair share of the line bandwidth while bearing a comparable proportion of the congestion (see Figure 5).

Host	Traffic Type	Average Rate (kbps)	% Congestion*	Congestion Delay (ms)**
128.29.1.4 (A)	**mission-critical**	354	68	15
128.29.1.1 (B)	**low priority**	290	66	28
128.29.1.2 (C)	**low priority**	290	66	28

* % Congestion indicates the percentage of the time that transfers were limited to the congested rate.

** Congestion Delay indicates the delay time (in ms) occurring as a result of transfers being denied due to insufficient priority during periods of congestion.

Test 3 results confirmed that Dyband dynamic priority mechanism enabled Host A to transmit the mission-critical traffic at a higher rate (422 kbps) according to its higher priority configuration on Dyband priority range (15 to 100).

Low-priority traffic (Hosts B and C) was still able to flow but at somewhat reduced rates and higher percentages of congestion. Dyband did not make them starve of bandwidth. The following summarizes Test 3 results from Figure 6.

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Host	Traffic Type	Average Rate (kbps)	% Congestion	Congestion Delay (ms)
128.29.1.4 (A)	**mission-critical**	422	50	0
128.29.1.1 (B)	**low priority**	254	75	54
128.29.1.2 (C)	**low priority**	254	75	54

As the Maximum Rate settings for low-priority traffic (Hosts B and C) *under normal condition changed from 450 to 300 kbps and under congested condition from 225 to 200 kbps,* in Test 4, the results confirmed that Dyband responded to the changing traffic conditions by lowering rates of transfer. As identical priorities were assigned to all hosts, the line bandwidth was fairly allocated among the three hosts in proportion to their assigned rates and with each host bearing a comparable proportion of congestion. The following summarizes Test 4 results from Figure 7.

Host	Traffic Type	Average Rate (kbps)	% Congestion	Congestion Delay (ms)
128.29.1.4 (A)	**mission-critical**	354	40	5
128.29.1.1 (B)	**low priority**	254	43	19
128.29.1.2 (C)	**low priority**	254	43	19

Test 5 results confirmed that Dyband dynamic priority mechanism provided further advantage to Host A as its minimum priority setting on Dyband was raised to 30 (i.e., priority range = 30 to 100). The transfer rates of low-priority traffic (Hosts B and C) were only slightly reduced but they bore higher percentages of congestion and congestion delays. The following summarizes Test 3 results from Figure 8.

Host	Traffic Type	Average Rate (kbps)	% Congestion	Congestion Delay (ms)
128.29.1.4 (A)	**mission-critical**	471	31	0
128.29.1.1 (B)	**low priority**	242	50	38
128.29.1.2 (C)	**low priority**	242	50	38

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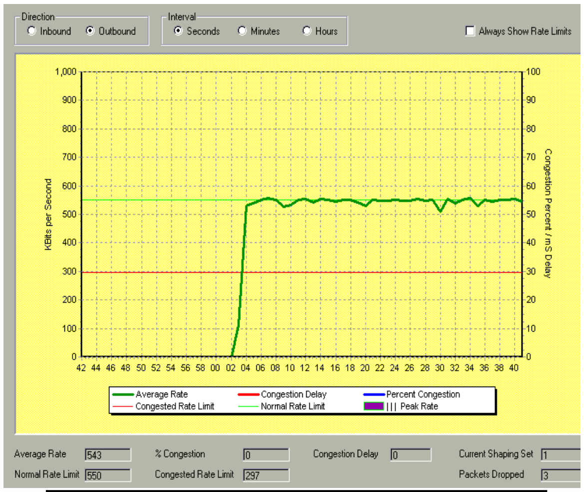
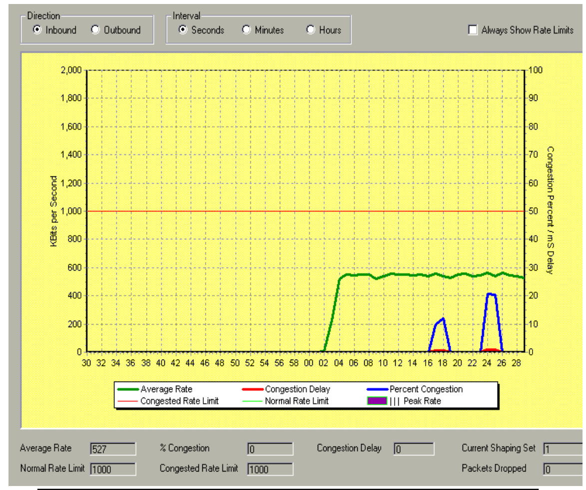
CMon Charts

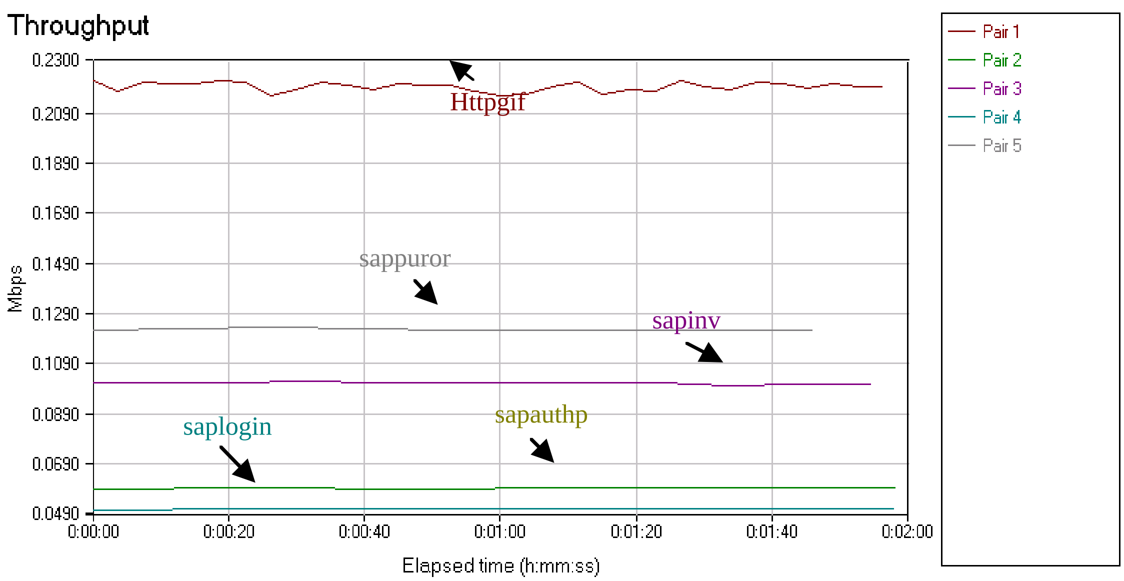


Host 128.29.1.4 (A)
Outbound Traffic Average Rate = 543 kbps



Host 128.29.3.1 (IDS01)
Inbound Traffic Average Rate = 527 kbps

Chariot Chart



Total Throughput of Mission-critical traffic (Pairs 1 - 5) = 539 kbps

Figure 4. Test 1 Results: Baseline Test, No Line Congestion

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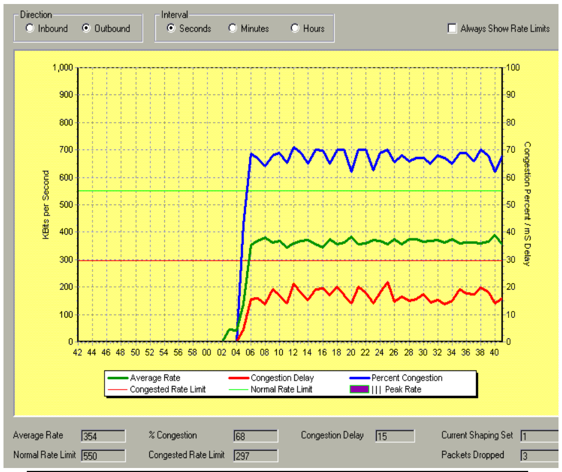
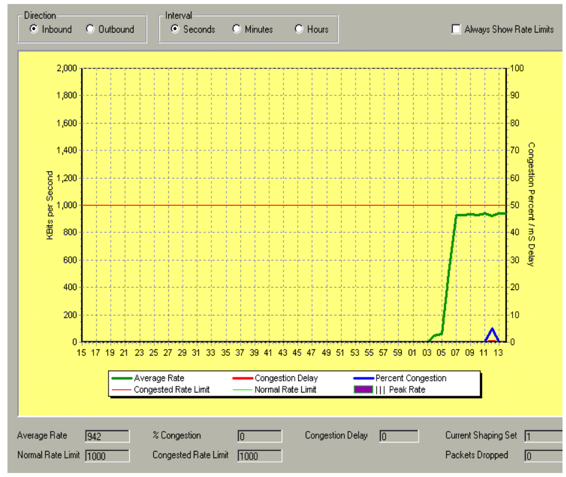
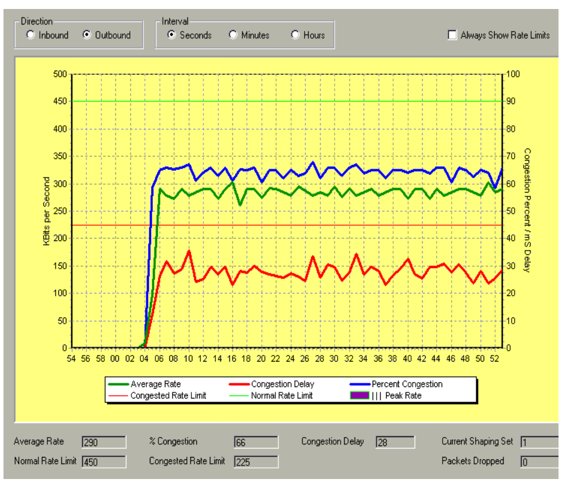


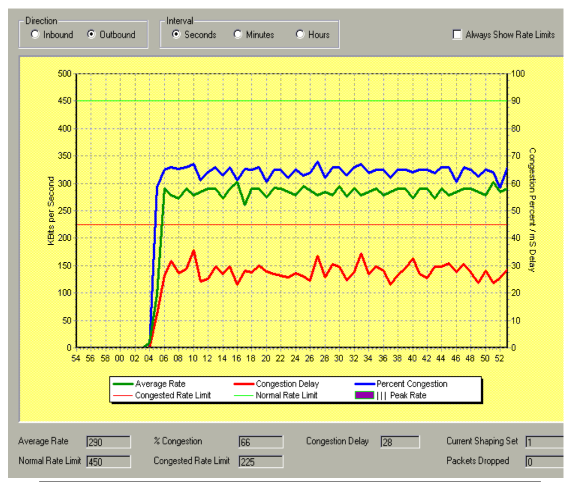
Host 128.29.1.4 (A)
Outbound Traffic Average Rate = 354 kbps
Percent Congestion = 68%
Congestion Delay = 15 ms



Host 128.29.3.1 (IDS01)
Inbound Traffic Average Rate = 942 kbps
Percent Congestion = 0
Congestion Delay = 0



Host 128.29.1.1 (B)
Outbound Traffic Average Rate = 290 kbps
Percent Congestion = 66%
Congestion Delay = 28 ms



Host 128.29.1.2 (C)
Outbound Traffic Average Rate = 290 kbps
Percent Congestion = 66%
Congestion Delay = 28 ms

Figure 5. Test 2 Results: Congested Line, Equal Priority Setting

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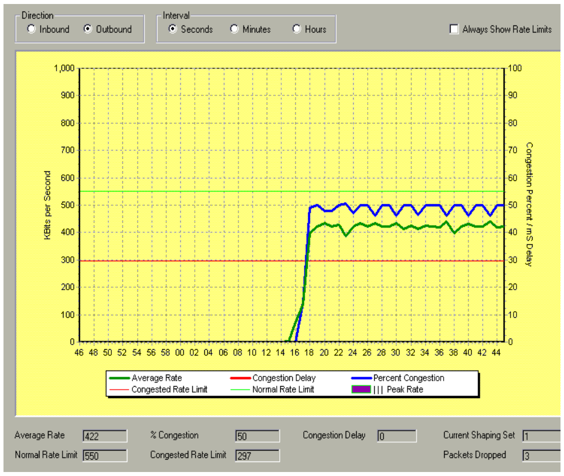
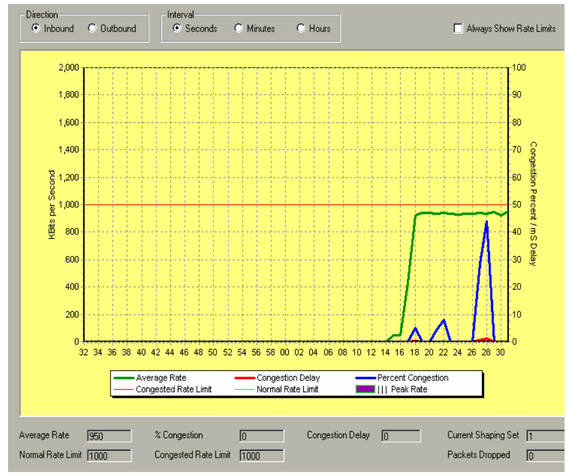
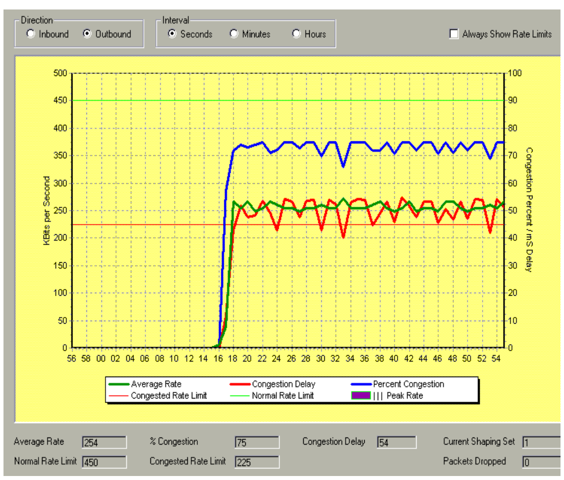


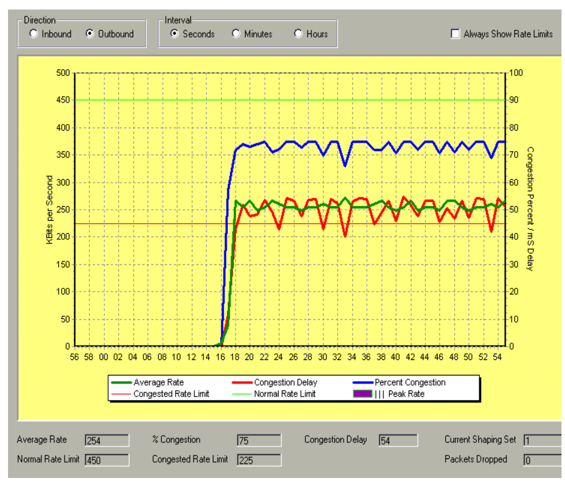
Host 128.29.1.4 (A)
Outbound Traffic Average Rate = 422 kbps
Percent Congestion = 50%
Congestion Delay = 0 ms



Host 128.29.3.1 (IDS01)
Inbound Traffic Average Rate = 950 kbps
Percent Congestion = 0
Congestion Delay = 0



Host 128.29.1.1 (B)
Outbound Traffic Average Rate = 254 kbps
Percent Congestion = 75%
Congestion Delay = 54 ms



Host 128.29.1.2 (C)
Outbound Traffic Average Rate = 254 kbps
Percent Congestion = 75%
Congestion Delay = 54 ms

Figure 6. Test 3 Results: Congested Line, Dynamic Priority Allocation

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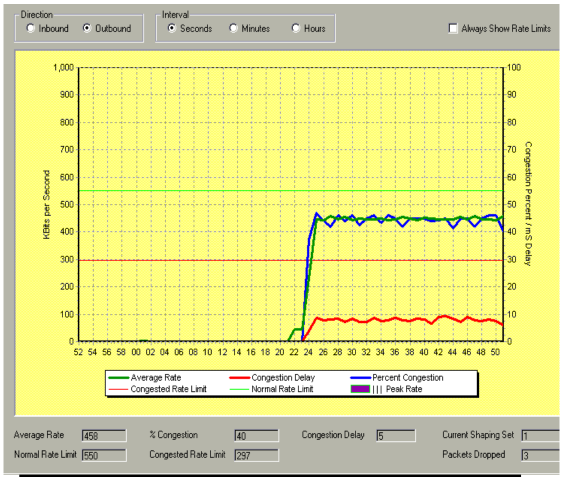
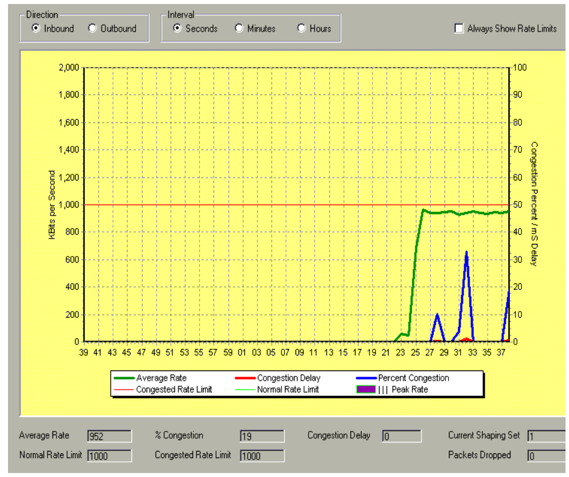
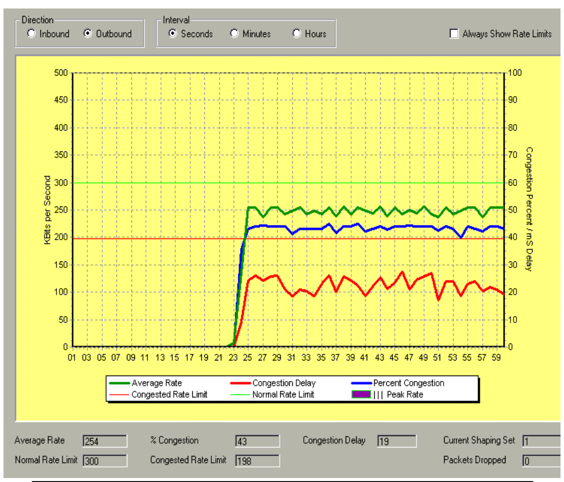


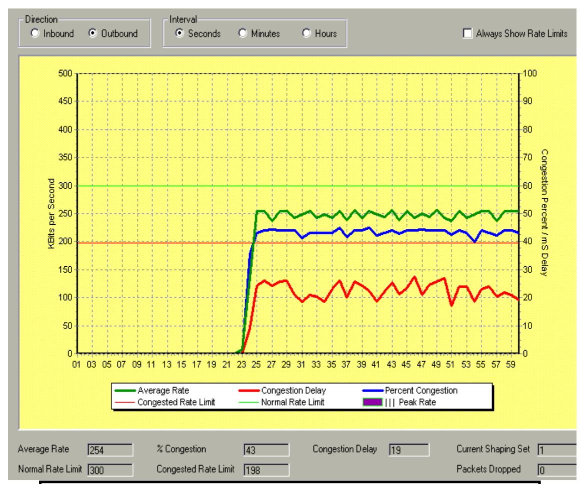
Host 128.29.1.4 (A)
Outbound Traffic Average Rate = 354 kbps
Percent Congestion = 40%
Congestion Delay = 5 ms



Host 128.29.3.1 (IDS01)
Inbound Traffic Average Rate = 962 kbps
Percent Congestion = 19
Congestion Delay = 0



Host 128.29.1.1 (B)
Outbound Traffic Average Rate = 254 kbps
Percent Congestion = 43%
Congestion Delay = 19 ms



Host 128.29.1.2 (C)
Outbound Traffic Average Rate = 254 kbps
Percent Congestion = 43%
Congestion Delay = 19 ms

Figure 7. Test 4 Results: Congested Line, DyBand Dynamic Rate Control

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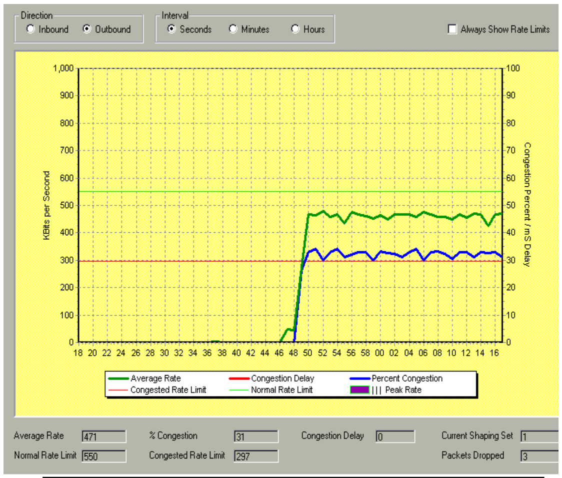
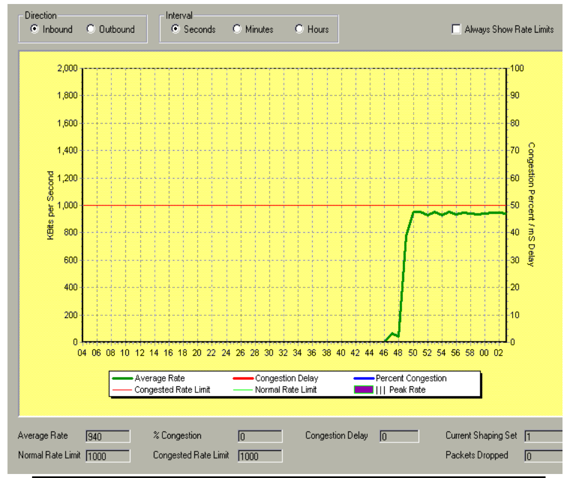
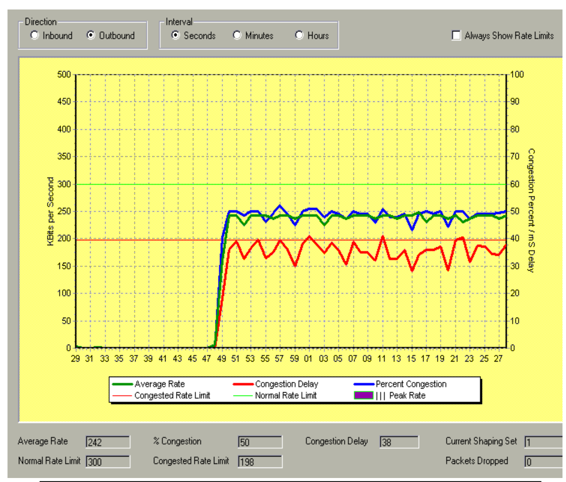


Host 128.29.1.4 (A)
Outbound Traffic Average Rate = 471 kbps
Percent Congestion = 31%
Congestion Delay = 0 ms



Host 128.29.3.1 (IDS01)
Inbound Traffic Average Rate = 940 kbps
Percent Congestion = 0
Congestion Delay = 0

Host 128.29.1.1 (B)
Outbound Traffic Average Rate = 242 kbps
Percent Congestion = 50%
Congestion Delay = 38 ms



Host 128.29.1.2 (C)
Outbound Traffic Average Rate = 290 kbps
Percent Congestion = 50%
Congestion Delay = 38 ms

Figure 8. Test 5 Results: Congested Line, DyBand Dynamic Rate Control and Dynamic Priority Allocation

5. SUMMARY OF FINDINGS AND CONCLUDING REMARKS

We have tested the Dyband traffic shaping performance at the MITRE's PC/LAN Laboratory and demonstrated that Dyband can provide effective bandwidth management and network monitoring capabilities in the presence of link congestion. We demonstrated that Dyband could react quickly to congested conditions by controlling the transfer rates of individual hosts and making fair allocation of bandwidth according to pre-specified profiles and policies. Dyband achieves real-time bandwidth control by using a 10 milliseconds (ms) cycle for assessing traffic flow and by applying two congestion management mechanisms: Dynamic Rate Controls and Dynamic Priorities. These dynamic capabilities proved to be very effective in controlling congestion and offering preferential service to hosts transmitting higher priority applications. Dyband's real-time network monitoring feature shows network managers rate of transfer of each management point for both inbound and outbound traffic over the most recent 60 one-second intervals, the most recent 60 one-minute intervals, or the most recent 24 one-hour intervals.

We conclude that the Dyband bandwidth management and monitoring capabilities have some merit that warrant considering its use in DoD operational deployed networks for managing bandwidth.

By its nature, the testing in a laboratory's controlled environment is limited to the network configuration at hand as well as the types of traffic applications utilized in the tests. We therefore recommend that the laboratory testing be followed by conducting further testing and evaluation of the Dyband traffic shaping and monitoring capabilities in an operational network environment.

In spite of Dyband's fully featured capabilities, we observed that the setting up of policies was somewhat cumbersome. Policies are the rules that govern the rates of transmission for each management point under both normal and congested conditions. In a sizable network, the number of management points, i.e., subnets, groups, the Shaper's two interfaces and each individual terminal with an IP addresses, could be very large. In addition, the application of policies on a group of management points has to follow an ancestral hierarchical order, whereas the traffic demand of a management point can not exceed that of an ancestor. Thus, users must be very careful to check the bandwidth settings of all of MPs within the policy before attempting to change the settings of an MP. When increasing the maximum rate settings of an MP (e.g., a host), users must ensure that the new rates do not exceed those assigned to an ancestor (a subnet) within the tree topology, otherwise the bandwidth that govern the MP would be limited to the ancestor lower rates.

In response to MITRE's observation and comments about Dyband's policies and profiles, CrossKeys engineers indicated that both the *User Guide* and training presentations on the inheritance profiles for Dyband would be enhanced such that:

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- Specific examples will be added to the general discussion in the User Guide, so that the user will have a clearer picture of how Dyband's Inheritance Profiles operate in real-world situations.
- Emphasize to the users the importance of reading the "Results" box in the policy's dialog when selecting the scope of an Inheritance Profile.

Further discussions with CrossKeys engineers indicated that the next release Dyband Dynamic Bandwidth Management System would contain several new features. Dyband Release 1.3 will be ready to operate on Windows and Linux platforms by the end of this calendar year and is expected to run on a Solaris platform by the end of the first quarter 2001. The following provides some of Dyband's Release 1.3 key new features:

- Support for additional network technologies
  - Half-duplex networks
  - Multi-homed networks
- Expanded topology management
  - New management point type: gateway (router)
  - Autodiscovery of gateways and subnets
  - Relaxed nesting rules
    (Groups may now contain subnet, IP address, gateway, and group MPs)
  - Expanded capacity (new total of 50,000 MPs per system)
- Fault tolerance between multiple shapers
- Improved user interface (CMon and Miner)
  - CMon (Configuring/Monitoring Traffic)
    - Simultaneous display of multiple shapers
    - Search capability
    - Clearer graphs and dialogs
  - Miner (analyzing/reporting statistics)
    - Enhanced GUI
    - More printing options
- Enhanced Policy Settings
  - Time-of-day and weekday/weekend control options
  - Additional controls for half-duplex management points

APPENDIX A. CROSSKEYS DYBAND™ SYSTEM REQUIREMENTS

A.1 SHAPER REQUIREMENTS

- Pentium processor, 200 MHz or higher
- 40 MB RAM + (15 KB x number of Management Points managed)
- 500 MB free HD space
- Three network adapters
- Windows NT 4.0 Server with Service Pack 4, 5, or 6a

A.2 CMON REQUIREMENTS

- Pentium processor
- 64 MB RAM
- 10 MB free HD space
- Windows 95, Windows 98, or Windows NT 4.0 with Service Pack 4, 5, or 6a
- Internet Explorer 5.0

A.3 ARCHIVER REQUIREMENTS

- Pentium processor
- 32 MB RAM
- 5 MB free HD space
- Windows 98 or Windows NT 4.0 with Service Pack 4, 5, or 6a
- An ODBC System DSN to an ANSI SQL92-compliant database

A.4 MINER REQUIREMENTS

- Pentium processor
- 16 MB RAM
- 5 MB free HD space
- Windows 95, Windows 98, or Windows NT 4.0 with Service Pack 4, 5, or 6a
- Display adapter and monitor capable of 1024 x 768 resolution or higher, with 256 colors
- An ODBC system DSN to an ANSI SQL92-compliant database.