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An Evaluation of Access Tier Local Area Network Switches

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Abstract

This reports tabulates the Test and Evaluation results of the Access Class Switch tests conducted by members of Department 9336. About 15 switches were reviewed for use in the enterprise network as access tier switches as defined in a three tier architecture. The Access Switch Tier has several functions including: aggregate customer desktop ports, preserve and apply QoS tags, provide switched LAN access, provide VLAN assignment, as well as others. The typical switch size is 48 or less user ports. The evaluation team reviewed network switch evaluation reports from the Tolly Group as well as other sources. We then used these reports as a starting point to identify particular switches for evaluation. In general we reviewed the products of dominant equipment manufacturers. Also, based on architectural design requirements, the majority of the switches tested were of relatively small monolithic unit variety.

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Joe Brenkosh (9336), Diana Eichert (9333), and Brian Kellog (9336) provided significant assistance in developing the test plans and in conducting the switch evaluation tests. Their help made it possible to test the quantity of switches covered in this report and to test them in more depth and with a higher degree of confidence in the results.

1. Introduction

Sandia's network architecture specifies a network design based on the implementation of a three-tier topology of Core, Distribution, and Access Tier switches. Each tier of the topology has specialized, and consolidated functions. The Core tier is at the top of the hierarchy, farthest from the customer drop. The Access tier is at the bottom of the hierarchy, closest to the customer. The access tier is sometimes referred to as the edge tier. The distribution tier connects the core and the access tiers.

The Access Tier includes the largest total number of switches in Sandia's network, representing a significant capital and operational investment. The access tier contains nearly twenty times the number of switches found in the combined Core and Distribution Tiers.

Today the access layer switches in the Enterprise Building Block present a wide variety of modularity, age and software. There are more access layer switches in the Enterprise than any other network component. This is a key resource to manage. The access layer has significant impact on system availability, management, and resources. Given the number of network elements represented by the Access layer, there is also significant impact on lifecycle cost and total cost of ownership associated with this layer.

Many of Sandia's network switches in the access tier are near end of life and will soon need to be replaced. Our purpose in performing this switch evaluation is to quantitatively review and evaluate a cross section of network switches for use within the access tier.

The Access Switch Tier has several functions that include: aggregate customer desktop ports, preserve and apply QoS tags, provide switched LAN access, provide VLAN assignment, as well as others. For a number of reasons, the network architecture recommends the use of small monolithic access layer switches. The typical switch size should be 48 or less user

ports. Other requirements are desktop drops capable of 100Mbps Ethernet, a design target of 40 active ports (out of 48) per switch, 1Gbps Ethernet uplink ports to the Distribution Tier switch. The design target for the uplink bandwidth contention ratio is 4:1.

The evaluation team reviewed network switch evaluation reports from the Tolly Group as well as other sources. We then used these reports as a starting point to identify particular switches for evaluation. In general we reviewed the products of dominant equipment manufacturers. It should be noted that the product space for 48 port or smaller monolithic switches is very large. There are some switches in this product space that appear to be decent contenders for use in the access tier that we were not able to test because of cost and time constraints. Also, based on architectural design requirements, the majority of the switches tested were of relatively small monolithic unit variety.

2. Evaluated Switches

In an attempt to compare like switches, we grouped equipment into three classes. The classes were commodity monolithic switches, high end monolithic switches, and modular switches. The monolithic switches are characterized by a fixed form factor and port count. The main difference between commodity and high end monolithic switches is the switching speed of the user ports. The commodity switches are limited to 10/100 Mbps ports and the high-end switches support 10/100/1000 Mbps user ports. Modular switches start with a chassis that will support some number of card slots. The user can then install service cards of the type desired.

Commodity Monolithic Switches

3Com 4400 24Port/48 Port

The 4400 Switch family offers high-performance, feature-rich 10/100 Ethernet LAN switching options that range from a fully featured high-density model to an attractively

priced entry-level model that can be upgraded to the enhanced feature set.

All four of this family's managed switches support hot-swappable resilient stacking, as well as Gigabit or Fast Ethernet up-links via optional plug-in modules. One switch offers Power over Ethernet.

The 4400 48-Port switch delivers high-density switching in an affordable platform. A massive 17.6 Gbps switching fabric enables forwarding up to 10.1 million packets per second (pps). Advanced QOS (Quality of Service) functionality and multi-layer traffic classification permit prioritization of mission-critical applications and real-time traffic. The 4400 24-Port switch offers the same features as the 48-port model, with a forwarding rate of 6.6 pps.

- High-speed performance on all ports, with forwarding up to 10.1 million pps or 6.6 million pps
- QOS functionality identifies and prioritizes applications such as enterprise resource planning (ERP) systems, LAN telephony, and video streaming
- Mix and match any 4400 series switch to create a stack with up to 192 10/100 Ethernet connections
- 802.1x Network Login and RADIUS support, along with advanced application filtering, provide complete network security
- Combine Power over Ethernet and data switching in the 4400 PWR Switch, saving rack space and excess cabling which simplifies installation of networking devices
- Hot swappable stacking and resilient network connections enhance reliability
- Spanning Tree, Rapid Spanning Tree, resilient links, link aggregation, and optional Advanced Redundant Power System ensure fault tolerance and smooth operation

- Add optional switching modules to provide resilient high-speed connections such as Gigabit Ethernet backbone links

BayStack 470-48T

The 470 Switch is a stackable 10/100 Mbps Ethernet Layer 2 switch. It includes two built-in GBIC (Gigabit Interface Converter) uplink ports and built-in stacking ports in a compact, 1 rack-unit high design. It is designed to provide high-density desktop connectivity for mid-size and large enterprise customer wiring closets.

The switch has considerable configuration flexibility: Ports 47/48 can be configured as either 10/100BASE-TX or use one or both of the built-in GBIC's. Up to eight Switches can be stacked to achieve up to 384 10/100 ports for high-density desktop switching. A single software image supports four different switch types. Distributed Multi-Link Trunking (DMLT) is supported across all switches in the stack

Cisco 2948G

The Catalyst 2948G, 2948G-GE-TX, and 2980G switches are designed for high-performance, high-density wiring-closet applications. The Catalyst 2948G, 2948G-GE-TX, and 2980G switches interface with networking equipment using Ethernet (10BASE-T), Fast Ethernet (100BASE-T), and Gigabit Ethernet (1000BASE-T) interfaces. Depending on the model, the switches also support Gigabit Interface Converters (GBICs) or small form-factor pluggable (SFP) modules.

The Catalyst 2948G switch tested has 48 autosensing and autoconfiguring 10/100BASE-T Fast Ethernet fixed ports and two (GBICs).

Cisco Catalyst 2950G-12

The Cisco Catalyst 2950G-12 has twelve 10/100BASE-T ports and two Gigabit Interface Converter (GBIC) ports. The 2950G come in a 24 and 48 port version. The switch's relatively small size allows the unit to easily sit on a desk

and makes about the same amount of noise as a PC. The switch tested was running Cisco Internetworking Operation System (IOS) Software (C2950-I6Q4L2-M), Version 12.1(12c) EA1, Release Software (fc1). It contained a Cisco WS-C2950G-12-EI (RC32300) processor (revision F0).

FastIron 4802 48 Port

This switch delivers stackable high density layer two wire-speed switching to the wiring closet.

- Based on Foundry's next-generation JetCore ASIC chipset
- 48 10/100 ports and 2 Gigabit Ethernet ports (Mini-GBIC) consuming just 1.5 rack units Industry's smallest footprint
- Integrated ASIC based wire-speed bandwidth provisioning, network monitoring and traffic accounting
- Hot swappable, redundant load sharing AC or DC power supplies - Industry's first in a stackable form factor
- Ships with full Layer 2 and base Layer3, Upgradeable to full Layer 3 including IP, IPX, AppleTalk, OSPF and BGP4

Linksys EF1324

This switch allows you to upgrade your network to Gigabit speed with Layer 3 management and 24x 10/100 ports + two Gigabit Ethernet ports. Perfect for today's large-scale network demands, this new 24-Port Switch delivers Layer 3 switching and fast speeds for your network applications with integrated Gigabit connectivity.

This Layer 3 switches routes packets based on IP address, so unlike standard (Layer 2) switches, it can link different subnets without the need for a router. This Switch's Layer 3 switching provides maximum network control, regulating traffic and eliminating bottlenecks. The switch also has a Web management interface.

SMC6709L2 TigerSwitch 10/100

The switch has eight 10/100BASE-T and one 10/100/1000BASE-T port. It has two expansion slots: one that supports 100BASE-FX SMF/MMF and the other that supports 1000BASE-T/SX/LX. This Switch is by far the most compact switch tested. It takes up very little space on a desk and is extremely quiet. The switch tested was running firmware version 03.10, hardware version 03.00 and flash version 26.00.

High End Monolithic Switches

Nortel Networks BayStack 380-24T

This switch is designed to provide high-density high-bandwidth connectivity to desktops, other switches, servers, and other network devices. The switch offers a resilient solution that minimizes capital and operational expenses. The robust security features offer protection against unauthorized access to data traffic. The switch is Web-manageable and also supports Redundant Power Supply (RPS) and Uninterruptible Power Supply (UPS) options.

Key Features:

- 24 10/100/1000 ports and 4 SFP GBIC ports provide high-density desktop switching and server farm aggregation
- 20 SFP and 4 full-size GBIC ports provide high-density wiring closet Layer 2 aggregation
- MultiLink Trunking (MLT) provides up to 8 Gbps to another switch or server. It also provides load-balancing and automatic fail-over protection.
- 10 PSU for power redundancy.
- MAC address-based security, Radius authentication and SNMPv3 support for secure access and data traffic protection.
- Comprehensive management suite includes web management, Device Manager and menus and will support Optivity Network Management System (NMS)* and Optivity Switch Manager (OSM)*. Supports four groups of

Remote Monitoring (RMON) and is (Simple Network Management Protocol (SNMPv3) compliant.

Extreme Networks Summit 5i

The Extreme Summit 5i has twelve 100/1000BASE-T ports and four GBIC ports. Instead of the twelve 100/1000BASE-T ports, the Summit 5i also can come with twelve 1000BASE-SX or 1000BASE-LX ports. The switch tested was running Extremeware Version 6.2.2 (build 68) by Release_master 01/15/02 16:58 and BootROM version 7.6.

The switch is the ideal switch for mid-tier aggregation in enterprise, basement customer premise equipment (CPE) for metro area networks, and for server load balancing/web caching. With a compact 2U factor, this switch integrates non-blocking Wire-Speed IP/IPX Routing and Layer 2 switching with advanced capabilities like Policy-Based Quality of Service, server load balancing, web cache redirection and access control. The switch is available in three configurations with twelve 100/1000BASE-T, 1000BASE-SX, or 1000BASE-LX ports plus four GBIC-based 1000BASE-X ports, it also comes with built-in redundant power supplies for increased fault tolerance.

Foundry Edgelron 24G

The switch features 24 10/100/1000 RJ-45 ports and 4 combo GbE RJ-45/mini-GBIC slots in a 1-RU form factor ideal for wiring closet distribution and data center installations. It also supports jumbo frames, making it an ideal solution for server connectivity and network attached file servers. This switch has a switching performance of up to 48Gbps and a forwarding rate performance of up to 35.7Mpps.

Modular Switches

Cisco Catalyst 6506

This 6-slot chassis provides intermediate port densities, ideal for many wiring closet and core network deployments.

Key Features:

- Supports all Catalyst 6500 modules, including all:
- Supervisor engines
- Switch fabric modules
- Fast Ethernet modules
- Gigabit Ethernet modules
- 10 Gigabit Ethernet modules
- Voice modules
- Flex Wan Modules
- ATM modules
- Multi Gigabit services modules (content services, firewall, intrusion detection, IPSec/VPN, network analysis, and SSL acceleration)
- Supports both CatOS and IOS software
- Provides maximum uptime with redundancy and rapid 2-3 second fail-over across supervisor engine.

The Firewall Security System is a three-slot model providing a turnkey solution that integrates a Cisco Catalyst 6000 Supervisor 2 (with integrated Policy and Multilayer Switch Feature cards [PFC2/MFC2] for system control, routing services, and dual-Gigabit-Ethernet ports); a Firewall Service Module providing 5 Gbps of firewall services; and a single open slot for site customization.

The IPSec VPN systems takes advantage of the Cisco Catalyst IPSec VPN Service Module and provides up to 2 Gbps of Triple Data Encryption Standard (3DES) encryption. The IPSec VPN System also provides a broad suite of services and a multitude of I/O interfaces inherent in the 6500 Series.

Extreme Networks BlackDiamond 6808

The chassis series switch provides world class Ethernet switching. With the flexibility to act as an aggregation point for a large number of edge switches and its carrier class reliability

and security features, the switch has been deployed with “NEBS level 3 compliance” in both large enterprise and carrier networks. Additionally this switch series has an extensive offering of interfaces, so your investments in SONET, ATM, or other legacy technologies are fully protected. In addition to this eight slot chassis two other chassis sizes are available to support a wide range of needs from the edge to the core, with all three chassis delivering cutting-edge performance, reliability, and scalability.

All three chassis Features

Advanced resiliency and fault tolerance for carrier class performance

- NEBS level 3 compliance
- Passive backplane supports redundant, load-sharing, hot-swappable switch fabric modules
- Hot-swappable I/O modules and fan trays
- Fully redundant, load-sharing, hot-swappable power supplies
- IEEE 802.3ad load sharing and redundant PHY
- Hitless Failover and Hitless Software Upgrade
- Dual switch configurations and ExtremeWare images
- Extreme Standby Router Protocol (ESRP™) and Virtual Router Redundancy Protocol (VRRP)
- OSPF Equal Cost Multipath Routing (ECMP)
- Ethernet Automatic Protection Switching (EAPS)

Foundry FastIron 800

This family of switches is the first in the industry to provide Enterprise customers with a complete end-to-end LAN solution.

Supporting the wiring closet to the LAN backbone based on a single product family. These systems simplify sparring, network operations and administration for dramatic savings in Total Cost of Ownership (TCO).

These systems deliver unparalleled port density, advanced Layer 2/3 feature sets, a rich Quality of Service (QOS), bandwidth management for Voice over IP (VoIP) and 10 Gigabit Ethernet interfaces to scale the network backbone with massive bandwidth capacity.

3. Testing Procedure

Evaluation Criteria

There are many variables that one can use in trying to evaluate the performance of a network switch. In an attempt to quantify the switches under test, we considered six evaluation sections. Then within each section the test team devised several test criteria. In broad terms the six evaluation sections included: Functionality and Interoperability, Management and Diagnostics, Similarity of Management Interface to Cisco, Performance, Security and Access Control, and Total Cost of Ownership. Each section had multiple items that were tested. This test plan was developed in collaboration with the Telecommunications Operation Department, Dept. 9334, and tried to capture all the functions currently used in the network and functions that will most likely be implemented in the future. An emphasis was placed on testing how well a switch was able to implement a standard, rather than a proprietary protocol that is unable to communicate with switches from different vendors. Appendix A: Test Suite lists the tests in detail.

Test Configuration

Appendix A: Test Suite provides the specific details of each test performed. Here we provide additional information on the test setup and configuration to allow consistent repeatability of the test with a documented test environment.

Performance and Functionality Testing

For performance testing the evaluation team relied upon Spirent communications test gear. We used the Spirent Smartbits 6000B network performance analysis system to test the switches on various performance benchmarks.

The tester can support up to 12 different modules. The specific modules we used are the LAN-3311A, which supports data rates of 1000 Mb/s on two GBIC-based ports and the LAN-3100A, which supports 10/100BASE-TX Ethernet on 8 ports.

The Spirent chassis was version 2.00.010. The LAN-3311A was using firmware version 3.50.054 and the LAN-3100A was using firmware version 1.05.002. The Spirent tester comes with multiple applications that test different performance aspects. The ones we used in this test were SmartApplications and Advanced Switch Test II (ASTII). SmartApplications was version 2.50, its API version was 1.00-28, and its library version was 3.12-115. ASTII was version 2.10.015, its API version was 2.10.015, and its library version was 3.12-115.

The test setups depended on the feature set to be tested. Figure 1 shows the basic test setup used for performance testing. We used a terminal server to access the console port of each switch under test. This allowed the testers to have remote access to each switch. The Smartbits tester was connected to the network and also accessible remotely. Connections were made between the Smartbits and the "unit under test," UUT, as shown below. After completion of each test, the connection between the UUT and the Smartbits tester was removed and re-connected to the next UUT.

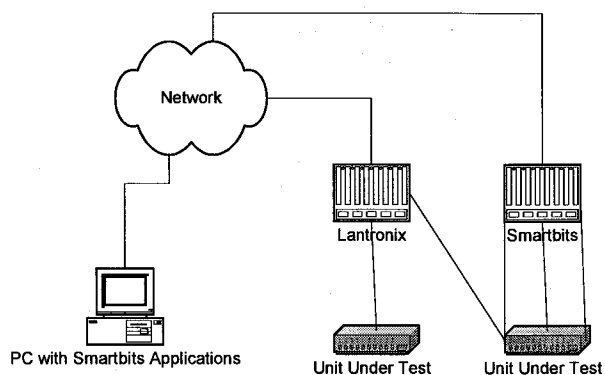


Figure 1 -- Performance Testing Setup

For non-performance testing, each test setup was designed specifically to illustrate if the feature under test worked correctly. Figure 2

shows an example of the "Olsberg Triangle" test setup. This test configuration was so named after one of the team members, Ron Olsberg, who devised it. The evaluation team used this setup for testing the spanning tree protocol. The spanning tree tests consisted of connecting two existing switches, an Extreme and a Cisco, to the UUT. After establishing the triangle, spanning tree was activated and verified before testing began. Each UUT was connected to both the Extreme and the Cisco switches so that every switch in the triangle had two paths to the other two switches. Each switch was monitored to determine if the spanning tree protocol was working. If all the switches properly implemented the spanning tree protocol, then the switches would automatically disable links to break the loop. However, connectivity between all three switches must be maintained to pass the test. Disconnecting the active connection for each side of the triangle and then verifying that the inactive connection transitioned to the active state also tested spanning tree.

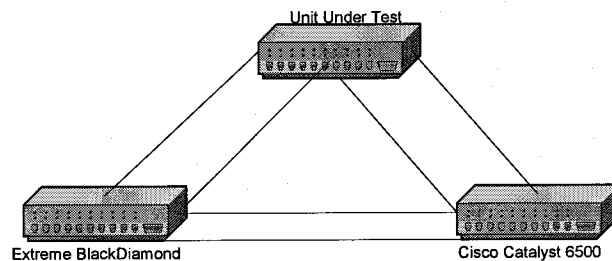


Figure 2 -- The Olsberg Triangle

Other Testing

In addition to the performance and functionality tests, we evaluated the UUT for SNMP and security features. To perform these tests we built and configured a server running the FreeBSD operating system. Applications on the server include a limited time license for StatScout to evaluate SNMP to each UUT. Additionally, we installed a public domain application to test Radius and TACACS+ security authentication.

Cost Analysis

There are several aspects to network switch cost. For comparison purposes the evaluation team only quantified the acquisition cost for the hardware. If one were to consider the total cost of ownership for the equipment over a specified time period, then other factors must also be considered. Cost of ownership must include the cost of operations in addition to the hardware acquisition costs. Operational costs are difficult to quantify because they are highly dependent on operating procedures and policies. However, one can identify some of the cost components that go into quantifying operational cost. This cost will include the cost of support and service contracts, software (or firmware) upgrades, space and power as well as other costs. In looking at the acquisition cost, we considered two cost elements. The first element is the bare switch cost, or the cost to provide customer drops. The second cost element is the uplink cost to provide connectivity between the access switch and a distribution switch. This second cost can vary depending on the uplink speed and type. To quantify this cost the evaluation team looked at the cost to provide a 1000 Mbps long haul fiber link between the access switch and the distribution switch. We considered two contention ratios between the customer port bandwidth and the uplink bandwidth. A smaller contention ratio provides better performance, which may be required, for some network services such as streaming video.

Typically vendors will quote the list price of their equipment. However, rarely does one pay the full list price. For the purpose of comparison we evaluated the switches based on street price. That is the price one would pay for the commodity from any number of vendors. We used web searches to identify vendors that are selling the equipment and to determine the going cost for a particular item.

Results

We used six evaluation criteria to quantify the switches under examination. In broad terms, the six evaluation criteria included: Functionality and Interoperability, Management and Diagnostics, Similarity of Management Interface to Cisco, Performance, Security and Access Control, and Total Cost of Ownership. With the exception of cost, these criteria are fixed characteristics of the switch. Because of the variable nature of market pricing, we considered switch acquisition cost by itself.

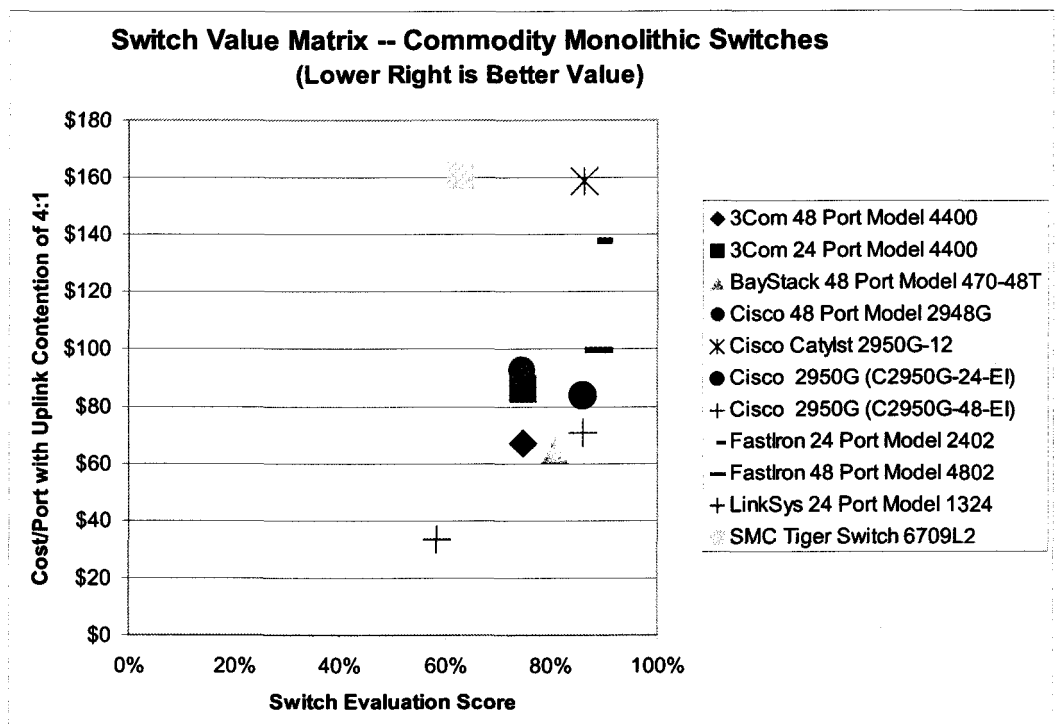


Figure 3

We performed a series of tests, based on the evaluation tests given in Appendix A: Test Suite, on each switch. We then converted the results of these tests into a switch evaluation score. Each individual test carries equal weight in determining the switch's evaluation score. If a switch passed a particular test we counted that as a score of one; a failed test counted as a zero score. We then calculated the average score across tests performed on the switch and that a percentage value. In some cases not all tests were performed for all switches. When that occurred, the absence of the test did not improve nor degrade the switch evaluation score. These test results are given in Appendix D: Test and Evaluation Results.

When comparing switches, it is reasonable to expect that a more expensive unit will provide better functionality and more features than a less expensive switch. To account for this difference, we can look at the switch value. In other words, what is the switch's evaluation score in conjunction with the cost of the switch? Figure 3 and Figure 4 are plots of the switch value results. The value of switch increases as the switch's evaluation score rises and the switch cost goes down. In the figures, switches that are towards the lower right-hand corner of the chart provide better value.

The tables in Appendix E: Switch Cost list the number of vendors identified as selling a particular item, the median cost, the lowest cost found, and the highest cost found. In most cases there were a dozen or more available vendors for any particular item. We used the median cost with a switch provisioned for a 4:1 uplink to user port

speed contention ratio.

Conclusions

In most cases all the switches under test performed well with an evaluation score between 70% and 90%. In general, the modular switches had slightly better evaluation scores than the monolithic switches. This is expected since the modular switches tested were designed to support significantly more ports and bandwidth than the monolithic switches. The cost per port for the commodity monolithic switches was typically under a \$100. For the commodity monolithic switches the value scores of the Bay Network, 3Com, and Cisco equipment were similar and the result indicate that they offered the best value. While for the high-end monolithic switches the Foundry and Bay Network Switches offered the better value.

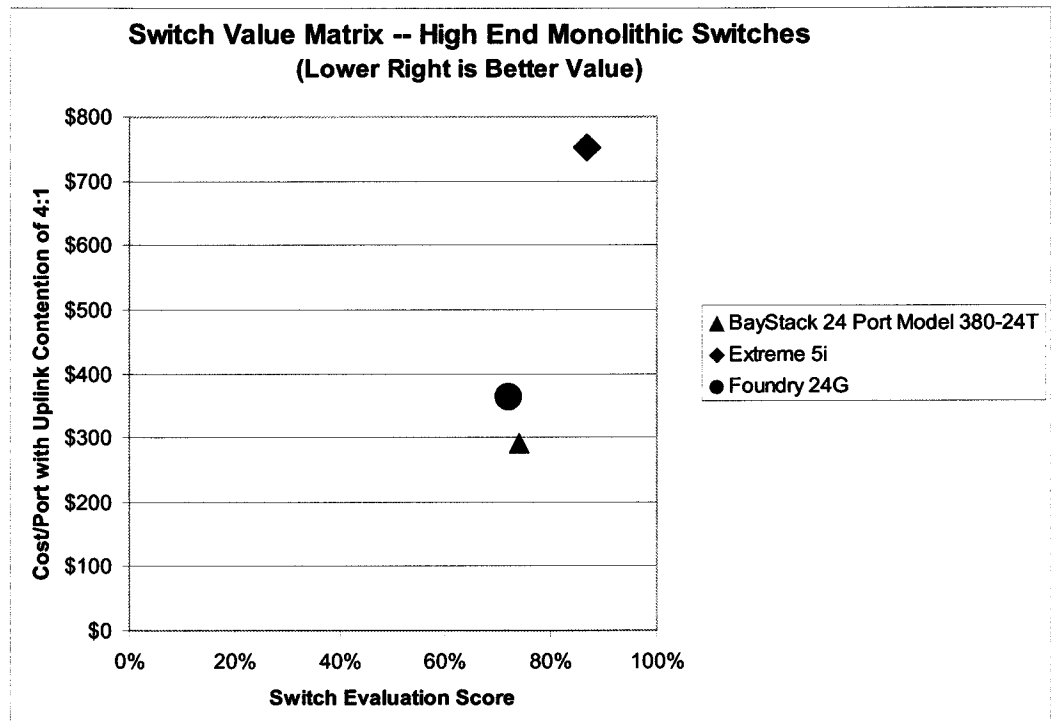


Figure 4

A. Appendix: Test Suite

Technical Qualification Evaluation Test Plan for Access Layer Switches and Cubicle Class Switches

For all tests, record the switch firmware version, type of chassis, and type of cards. Also record the Smartbits cards and firmware used for the test. If testing from a PC or workstation, note the particular version of OS, and other programs being used. Note UUT means Unit Under Test.

Functionality and Interoperability

Test: Port Capacity

Purpose: Determine the maximum number of user ports available on the switch.

Method: Assess the maximum number of ports. This is a fixed number for monolithic switches. For modular switches, identify the maximum number of ports by type with the assumption that the switch is populated with all user ports of a single type. Modular switches shall be configured with a minimum of suitable uplink ports for the evaluation. For modular switches note the maximum number of available free slots taking into account installation of management and support cards.

Test: Monolithic Switch Module Availability

Purpose: To determine if it is possible to add ports to the switch for uplink.

Method: Assess the number and type of module slots available for high speed port uplink.

Test: Availability of gigabit ports

Purpose: To determine the number of available gigabit ports.

Method: Assess the availability and type of gigabit Ethernet ports.

Test: Untagged VLAN support

Purpose: To determine if UUT supports VLANs.

Method: Configure 3 VLANs on the UUT. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN. Verify that there is not communication between different VLANs.

Test: Tagged VLAN support

Purpose: To determine if UUT supports Tagged VLANs.

Method: Configure 3 Tagged VLANs on the UUT. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN.

Test: 802.1d

Purpose: To determine if UUT supports 802.1d Spanning Tree Protocol.

Method: Configure 3 VLANs on the UUT. Configure 3 VLANs all UUTs. Connect the devices so that they form a loop. Enable 802.1d for the ports involved. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN. Disconnect one cable from the UUT and verify that connectivity to the other devices remain. Reconnect the cable and remove the other cable. Verify that connectivity remains to the other devices.

Test: 802.1w

Purpose: To determine if UUT supports 802.1w Rapid Spanning Tree Protocol.

Method: Configure 3 VLANs on the UUT. Configure 3 VLANs all UUTs. Connect the devices so that they form a loop. Enable 802.1w for the ports involved. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN. Disconnect one cable from the UUT and verify that connectivity to the other devices remain. Reconnect the cable and remove the other

cable. Verify that connectivity remains to the other devices.

Test: 802.1s

Purpose: To determine if UUT supports 802.1w Multiple Spanning Tree Protocol.
Method: Configure 3 VLANs on the UUT. Configure 3 VLANs all UUTs. Connect the devices so that they form a loop. Enable 802.1s for the ports involved. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN. Disconnect one cable from the UUT and verify that connectivity to the other devices remain. Reconnect the cable and remove the other cable. Verify that connectivity remains to the other devices.

Test: PVST

Purpose: To determine if UUT supports Per VLAN Spanning Tree Protocol.
Method: Configure 3 VLANs on the UUT. Configure 3 VLANs all UUTs. Connect the devices so that they form a loop. Enable PVST for the ports involved. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN. Disconnect one cable from the UUT and verify that connectivity to the other devices remain. Reconnect the cable and remove the other cable. Verify that connectivity remains to the other devices.

Test: PVST+

Purpose: To determine if UUT supports Per VLAN Spanning Tree Protocol Plus.
Method: Configure 3 VLANs on the UUT. Configure 3 VLANs all UUTs. Connect the devices so that they form a loop. Enable PVST+ for the ports involved. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN. Disconnect one cable from the UUT and verify that connectivity to the other devices remain. Reconnect the cable and remove the other cable. Verify that connectivity remains to the other devices.

Test: Rapid PVST

Purpose: To determine if UUT supports Rapid Per VLAN Spanning Tree Protocol.
Method: Configure 3 VLANs on the UUT. Configure 3 VLANs all UUTs. Connect the devices so that they form a loop. Enable Rapid PVST for the ports involved. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN. Disconnect one cable from the UUT and verify that connectivity to the other devices remain. Reconnect the cable and remove the other cable. Verify that connectivity remains to the other devices.

Test: PortFast or Equivalent

Purpose: To determine if UUT supports PortFast or Equivalent options to Spanning Tree Protocol.
Method: Configure 3 VLANs on the UUT. Configure 3 VLANs all of the other UUTs. Connect the devices so that they form a loop. Enable PortFast or the equivalent for the ports involved. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN. Disconnect one cable from the UUT and verify that connectivity to the other devices remain. Reconnect the cable and remove the other cable. Verify that connectivity remains to the other devices. Record the time it takes to use the other link.

Test: CDP

Purpose: To determine if UUT supports Cisco Discovery Protocol.
Method: Configure CDP on each UUT. Connect the devices so that they form a loop. Verify the neighbors for each UUT to determine if CDP is functioning.

Test: 802.1Q

Purpose: To determine if UUT supports 802.1Q Tunneling.
Method: Configure 3 VLANs on the UUT. Configure 3 VLANs on a Cisco Catalyst

60XX. Configure a port on each device to support 3 802.1Q tagging. Connect the two devices. Test with Smartbits to determine if each VLAN provides communication with other ports in its VLAN.

Test: 802.3ad

Purpose: To determine if UUT supports 802.3ad Trunking.

Method: Configure a VLANs on the UUT. Configure the same VLAN on a Cisco Catalyst 60XX. Configure a 100 Megabit/sec. port on each device to support 802.3ad. Connect the two devices. Test with Smartbits to determine connectivity and bandwidth. Then add another port on each switch to the same trunk. Connect these two ports. Test with smartbits for connectivity and bandwidth. Add another port and repeat. Physically disconnect all but one 802.3ad trunk port on each switch. Rerun the test.

Test: 802.1p

Purpose: To determine if the UUT has 802.1p priority queuing support and if it works appropriately.

Method: First determine if the box is capable of doing priority queuing. If it does, assign three priority levels. Then oversubscribe the UUT so that 60% of the traffic is high priority, 35% of the traffic is medium priority, and 10% is low priority. Analyze dropped packets. If differentiated service is working appropriately there will be no drops on medium or high priority packets and roughly half the low priority packets will be dropped.

Test: Differentiated Service support

Purpose: To determine if the UUT has differentiated service support, and if it works appropriately.

Method: First determine if the box is capable of doing differentiated service. If it does, assign three priority levels. Then oversubscribe the UUT so that 60% of the traffic is high priority, 35% of the traffic is medium priority, and 10% is low priority.

Analyze dropped packets. If differentiated service is working appropriately there will be no drops on medium or high priority packets and roughly half the low priority packets will be dropped.

Result:

Management and Diagnostics

Test: Command Line Interface

Purpose: To determine if UUT supports a command line interface (CLI).

Method: Note the availability of a local console port and a terminal operated command interface.

Test: Telnet In session support

Purpose: To determine if UUT has “telnet in” capability.

Method: Assign an IP address to the UUT and also a default route. Connect UUT to the router having the default route. Attempt to telnet to the UUT.

Test: Telnet Out session support

Purpose: To determine if UUT has telnet capability.

Method: Assign an IP address to the UUT and also a default route. Connect UUT to the router having the default route. Attempt to telnet from the UUT.

Test: Ping Out support

Purpose: To determine if UUT has the ability to initiate a ping to a device.

Method: From the management interface of the UUT attempt to ping to another device on the network. Note if the ping capability is available from the command line interface and the web management interface.

Test: Web HTTP/S session support

Purpose: To determine if UUT is accessible by HTTP or HTTPS.

Method: Configure the UUT (if needed) to support HTTP access. Attempt to access the UUT with a web browser. Attempt to configure the UUT from the browser.

Test: SSH Version 1 or 2 session support

Purpose: To determine if UUT supports SSH access.

Method: Assign an IP address to the UUT and also a default route. Connect UUT to the router having the default route. Attempt to SSH to the UUT.

Supports SSH Version 2:

Supports SSH Version 1:

Test: Proprietary Switch Management Software

Purpose: Determine if it is possible to manage the UUT through vendor supplied software.

Method: Assesses the availability of customized software for switch management. Does the software provide functionality beyond that available through the command line or HTTP interface?

Test: Switch Stacking

Purpose: To determine if the UUT supports multi-unit management via a single management interface.

Method: Assess the availability of managing more than one switch as a single unit by identifying if the switch supports a stacking connector and the appropriate management commands. Note the number of units controllable via one management interface.

Test: SNMP read access

Purpose: To determine if UUT supports SNMP read access.

Method: Configure the UUT to support SNMP read access. Attempt to perform a snmpwalk from a test machine.

Test: SNMP write access

Purpose: To determine if UUT supports SNMP write access.

Method: Configure the UUT to support SNMP write access. Attempt to perform a snmpset from a test machine. Verify using snmpget.

Test: Netflow support

Purpose: To determine if UUT supports netflow.

Method: Configure the UUT to support netflow. Use an existing netflow host to collect data.

Test: Sflow support

Purpose: To determine if UUT supports sflow.

Method: Configure the UUT to support sflow. Use an existing sflow host to collect data.

Test: Statscout support

Purpose: To determine if UUT supports statscout.

Method: Configure the UUT to support statscout. Use an existing statscout host to collect data.

Test: MRTG support

Purpose: To determine if UUT supports MRTG.

Method: Configure the UUT to support MRTG. Use an existing mrtg host to collect data.

Test: Hot Swap support

Purpose: To determine if UUT supports hot swapping.

Method: Attempt to hot swap various cards and power supplies on the UUT, if supported.

Test: Broadcast Rate

Purpose: To determine the performance characteristics of the UUT.

Method: Run the UUT through the **Broadcast Rate** Advanced Switch Layer II (ASTII) test:

Test: Frame Errors

Purpose: To determine the performance characteristics of the UUT.

Method: Run the UUT through the **Frame Error** Advanced Switch Layer II (ASTII) test:

Test: Learning Rate

Purpose: To determine the performance characteristics of the UUT.

Method: Run the UUT through the **Learning Rate** Advanced Switch Layer II (ASTII) test:

Test: Backplane capacity

Purpose: To determine the backplane switching capacity

Method: Note the manufactures stated backplane capacity

Security and Access Control

Test: TACACS+ support

Purpose: To determine if UUT supports TACACS+ access.

Method: Use an existing TACACS+ server or configure a new one. Perform the necessary steps to configure the UUT for TACACS+ access. Attempt to log on to the UUT.

Test: Radius Server support

Purpose: To determine if UUT supports Radius authentication server access.

Method: Use an existing Radius server or configure a new one. Perform the necessary

steps to configure the UUT for Radius access. Attempt to log on to the UUT.

Test: User Password support

Purpose: To determine if UUT supports user passwords.

Method: Configure a user account on the UUT. Attempt to telnet to the UUT and log on as the user. Attempt to run the enable command to elevate privileges.

Test: Password recovery

Purpose: To determine if UUT supports password recovery

Method: Attempt to recover the password on the UUT. Note if the existing configuration has been deleted.

Test: User Authorization Levels

Purpose: To determine if the UUT supports different levels of access for viewing and altering switch configuration data.

Method: Create two user accounts. Assign view privileges to one and modification privileges to the other. Verify that the account with view only privileges can not modify the switch configuration.

Test: ACL MAC Testing

Purpose: To determine if UUT supports ACL based upon MACs.

Method: Test connectivity between ports on UUT using Smartbits. Record the MAC address of one of the ports. Add an ACL entry to block the MAC address. Verify that connectivity is disabled.

Test: ACL Logging

Purpose: Verify that connections denied by ACLs are logged.

Method: Using any or all of the ACL tests, examine the log file to determine if event has been logged.

Test: Redundant modules

Purpose: To determine if UUT has redundant modules.

Method: If UUT has redundant processor modules, etc. cause them to fail over.

Test: Port Mirroring

Purpose: Does the UUT support port mirroring

Method: Configure two ports on the switch to form a LAN. Attach one of these ports to a data source. Monitor the other port as the sink. Configure a third port to mirror the sink port. Monitor traffic on the mirror port and compare it to traffic on the sink port.

Test: File Upload or Download

Purpose: Determine the methods available to upload or download system files to the UUT

Method: Assess the methods available to move files to or from the UUT. Check for SNMP, BootP, TFTP, SCP, Xmodem or other console port transfer

Management Interface Compatibility with Cisco Switches

Test: CLI Look and Feel

Purpose: To determine if UUT supports Cisco CLI Look and Feel.

Method: While performing other tests, note how similar the console commands are to the Cisco CLI. If possible, contact the vendor and ask for a percentage.

Test: Vty Password support

Purpose: To determine if UUT supports Cisco-like vty access.

Method: Configure the UUT so that it asks for a password from a telnet session, but does not require a user name. Telnet to the UUT, and then attempt to log on.

Test: Vty Enable Password support

Purpose: To determine if UUT supports Cisco-like vty enable access.

Method: Configure the UUT so that it asks for a password from a telnet session, but does not require a user name. Telnet to the UUT, and then attempt to log on. After logging on, attempt to run the enable command to elevate user privileges.

Performance

Test: Throughput

Purpose: To determine the performance characteristics of the UUT.

Method: Run the UUT through the **Throughput** test as described in RFC 1242.

Test: Latency

Purpose: To determine the performance characteristics of the UUT.

Method: Run the UUT through the **Latency** test as described in RFC 1242.

Test: Latency Store and Forward

Purpose: To determine the performance characteristics of the UUT.

Method: Run the UUT through the Latency Store and Forward frame-loss-rate test as described in RFC 1242.

Test: Back-to-Back

Purpose: To determine the performance characteristics of the UUT.

Method: Run the UUT through the **Back-To-Back** test as described in RFC 1242.

Test: Forward Pressure

Purpose: To determine the performance characteristics of the UUT.

Method: Run the UUT through the **Back Pressure** Advanced Switch Layer II (ASTII) test:

Test: ACL Size

Purpose: To determine maximum ACL size.

Method: Using vendor supplied information, record the maximum ACL size for the UUT.

Test: Port Security

Purpose: To ensure that only an authorized MAC address can use a specific port.

Method: Using Smartbits verify connectivity between two ports on the UUT. Record the MAC address of one of the ports. Turn on port security for the port that will record the MAC address. Switch the connections to the ports. Verify that connectivity is disabled. Disable port security. Verify that connectivity is enabled.

Purchase and Operating Cost

Test: List Price

Purpose: To determine the list price as configured.

Method: Obtain the list price of the UUT as configured

Test: Cost Per Port

Purpose: To determine the price per port.

Method: Obtain the list price of the UUT. Calculate cost per port. Note this must be normalized when each UUT is configured differently.

Test: Service Contract Cost

Purpose: To determine the service contract cost.

Method: Obtain the service contract cost per year for the UUT.

Test: Tech Support Contract Cost

Purpose: To determine the tech support contract cost.

Method: Obtain the tech support contract cost per year for the UUT.

Test: Technical-support hours

Purpose: Determine the standard coverage hours for technical support.

Method: Contact the vendor or the vendor literature to determine the hours of coverage for standard technical support. Note if it possible to obtain if it possible to obtain extended hours of coverage.

Test: Tech Support Usefulness

Purpose: To determine how good is tech support.

Method: Contact vendor with specific questions. Was good support received?

Test: Reliability

Purpose: To determine the reliability of the UUT.

Method: Obtain information on the reliability of UUT from the vendor and also other sources, including in-house testing.

Test: Warranty Period

Purpose: Determine the duration of the standard warranty.

Method: Contact the vendor or the vendor's literature to determine the length of the warranty.

B. Appendix: RFC 1242 Performance Tests

Throughput Test Methodology

The Throughput test tests the fastest rate at which a device can forward frames without error. If a single frame is dropped, the test fails and repeats at a lower data rate.

The Throughput test satisfies the terminology criteria of RFC 1242 and the test methodology specified in RFC 2544. From RFC1242, throughput is *the maximum rate at which none of the offered frames are dropped by the device*. From RFC 2544, the methodology to measure throughput is to *send a specific number of frames at a specific rate through the UUT and then count the frames that are transmitted by the UUT*. SmartApplications measures throughput by first sending a series of frames with a particular source and destination MAC address to the device under test. Frames are sent from a particular SmartBits port and are intended to be received by another SmartBits port.

Test Setup

Inter-frame Gap (IFG) is determined by the initial rate in the test setup. If the initial rate is set to 100%, frames are sent initially with the IFG set to the minimum legal size for the topology and speed of the transmitting SmartCard. The number of frames sent is determined by the length of time the test is to run. Frames are validated by counting only frames generated by the sending port and not packets sent by the switch. Keep-alive and routing update frames are not counted as received frames.

If the initial rate is 100%, the frame rate for the first test trial for a given frame length is the maximum rate for the test topology and speed of the transmitting SmartCard. If all frames sent from the transmit SmartBits port are received by the receiving port, no further

trials are attempted, and the maximum frame rate is recorded as the throughput.

If the first trial fails, indicated by the loss of even a single frame, then the tester reduces the frame rate for the second trial by 20% and repeats the trial. Once a trial succeeds, the tester raises the rate to halfway between the successful rate and the last failed rate. Each subsequent trial uses a binary search to find a rate that is halfway between the last failed rate and the last successful rate. The test will not finish until the frame loss percent is less than or equal to the resolution value in the test setup.

The tester automatically logs the results of the test to a file. The file shows the maximum data rate by port pair and the aggregate frame data rate, as well as the percentage of maximum theoretical frame data rate achieved for each frame size.

This test is performed the number of times specified in the test set-up configuration and the trial results averaged.

Packet Loss Test Methodology

The Packet Loss Rate test measures the percentage of frames that should have been forwarded by the UUT but were lost. It satisfies the terminology criteria of RFC 1242 and the test methodology specified in RFC 2544. From RFC 1242, Packet Loss Rate is the *percentage of frames that should have been forwarded by a network device under steady state (constant) load that were not forwarded due to a lack of resources*. The test allows for varying frame sizes: from 64 bytes to 1518 bytes for Ethernet ports.

How the Test Runs and Results Are Found
From RFC 2544, the methodology to measure packet loss is to *send a specific number of frames at a specific rate through the UUT to be tested and count the frames that are transmitted by the UUT*.

The Packet Loss Rate test operates in essentially the same manner as the Throughput test. First a packet burst is

transmitted at the maximum possible rate, for a specified time interval. After all packets are transmitted, the receiving port is queried to determine how many packets were received. The number of packets not received is determined, and the percentage of loss is calculated.

Counting only frames generated by the sending port, not packets sent by the switch validates frames. Keep-alive and routing update frames are not counted as received frames.

This test is performed a specified number of times, and the results are averaged. Many-to-1 and 1-to-Many Tests with Ethernet. If the UUT bundles multiple streams into one virtual circuit, SmartApplications counters reflect the number of packets received per virtual circuit, not per stream.

Back to Back Test Methodology

The Back-to-Back test checks the buffering capability of the device under test. This test satisfies the terminology criteria of RFC 1242 and the test methodology of RFC 2544.

How the Test Works

The Back-to-Back test operates in essentially the same manner as the Throughput test. First a packet burst is transmitted for a specified period.

If all packets are received at the receiving port, the test is successful and stops.

If even one packet is lost, the number of packets sent in the burst is halved, and the test is retried.

If all packets are received in this subsequent trial, the number of packets sent is increased to halfway between the successful and unsuccessful trials, and another trial is run. This pattern repeats until the actual number of packets that can be forwarded in a burst is determined. This test is performed a specified number of times, and the results are averaged.

Latency Test Methodology

The Latency test measures packet delay, as defined in RFC 1242.

How SmartApplications Calculates Latency

The sending SmartCard sends a burst of frames, at a frame size specified in the configuration, through the UUT at a specified throughput rate. In the middle of the burst stream, it inserts one frame with an identifying trigger (tag). The time when the trigger frame is fully transmitted is the Transmit Timestamp. The time the receiving SmartCard recognizes the trigger frame is the Receive Timestamp.

SmartApplications then calculates the latency as: $(\text{Receive Timestamp}) - (\text{Transmit Timestamp}) = \text{Latency}$. Specifically, SmartApplications first measures the cut-through rate and then calculates the store and forward rate with this calculation: $(\text{Cut Through Rate}) - (\text{Frame Bit Time}) = \text{Store and Forward Rate}$. The Latency test is performed at a user-specified frame rate. Cut-through (Bit-forwarding) Latency Calculation

For cut-through device measurements, SmartApplications calculates latency as FIFO (first in-first out), meaning it calculates the difference between the time that the end of the first bit of a transmitted frame reaches the UUT's input port (Transmit Timestamp) and the time the first bit of the same frame is seen on the UUT's output port (Receive Timestamp).

For Store and Forward device measurements, SmartApplications calculates latency as Last In/First Out (LIFO). That is, it calculates the difference between the time that the end of the *last* bit of a transmitted frame reaches the UUT's input port (Transmit Timestamp) and the time that the end of the *first* bit of the same frame leaves the UUT's output port (Receive Timestamp).

It is recommended that you run the Throughput test before you run the Latency test, to obtain the optimum throughput rate of

the UUT. Then use the throughput rate obtained from the Throughput test for the Max Rate in the Latency test. Using a proven optimum rate prevents the tagged frame from being lost because of performance rate issues. SmartApplications always measures latency and yields results for both “store and forward” and “bit-forwarding (cut-through)” devices, regardless of the UUT.

The SmartMetrics Compensation Mode (selectable on the Latency Test tab) enables SmartApplications to render the same latency results as would be produced by other SmartBits applications (such as SmartWindow) in SmartMetrics mode, when the transmitter and receiver are running at different speeds.

With this option disabled, the Latency test runs as usual, with the trigger pattern at the usual offset in the frame. In this case, however, if the transmitter and receiver are running at different speeds, the latency result

will be different from what it would be in a SmartMetrics test (for example, run using SmartWindow).

When this option is enabled, the trigger pattern is offset to the same position in the frame where the Signature field is placed in a SmartMetrics mode test. As a result, SmartApplications can produce the same latency result as a SmartMetrics application. The SmartMetrics Compensation mode makes it possible to maintain continuity with past results, when this is desired.

When any 10/100Mb SmartCard or module is used in an SMB-200/2000 chassis, the latency test duration is limited to 112 seconds when the packet size is 64 bytes and you are testing at 100% line rate in the 100Mb mode.

The RFC 1242 test results for each unit tested are cataloged in the following pages.

3Com 4400-48P

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: 3Com
Product Name: 4400-48P 3C17204
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
Throughput test length: 5 seconds
Average of: 1 trial
Port pairs active: 2
Mode: Bi-directional
Date: Thu Jun 26 11:50:00 2003

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,10,01) to (01,10,02)	148809	84459	45290	23496	11973	9615	8127
(01,10,02) to (01,10,01)	148809	84459	45290	23496	11973	9615	8127

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,01) to (01,10,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,02) to (01,10,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	595240	337836	181160	93984	47892	38460	32508
FPS Passed Rate	595236	337836	181160	93984	47892	38460	32508
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	10.2	16.4	30.1	45.0	87.0	107.5	125.1
(01,10,01) to (01,10,02)	9.8	14.5	25.1	45.2	87.6	106.5	125.7

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	5.1	6.1	9.6	4.1	5.0	5.0	3.6
(01,10,01) to (01,10,02)	4.7	4.2	4.7	4.2	5.7	4.1	4.2

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

=====

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,01) to (01,10,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,02) to (01,10,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

=====

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,10,01) to (01,10,02)	297620	168918	90580	46992	23946	19230	16254
(01,10,02) to (01,10,01)	297620	168918	90580	46992	23946	19230	16254

Back-to-back SUMMARY: Total Port-Pairs

=====

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	1190480	675672	362320	187968	95784	76920	65016

3Com 4400-24p

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: 3Com
Product Name: 4400-24P 3C17203
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
Throughput test length: 5 seconds
Average of: 1 trial
Port pairs active: 2
Mode: Bi-directional
Date: Thu Jun 26 10:32:07 2003

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,10,01) to (01,10,02)	148809	84459	45290	23496	11973	9615	8127
(01,10,02) to (01,10,01)	148809	84459	45290	23496	11973	9615	8127

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,01) to (01,10,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,02) to (01,10,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	595240	337836	181160	93984	47892	38460	32508
FPS Passed Rate	595236	337836	181160	93984	47892	38460	32508
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	10.8	14.2	24.3	44.8	85.7	109.5	125.1
(01,10,01) to (01,10,02)	10.1	14.7	24.9	45.3	86.3	110.2	125.6

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	5.6	3.9	3.8	3.8	3.8	7.0	3.6

(01,10,01) to (01,10,02) 4.9 4.5 4.4 4.3 4.4 7.8 4.1

Spirent Communications - SmartBits PacketLoss Test Results

Vendor Name: 3Com
Product Name: 4400-24P 3C17203
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
PacketLoss test length: 10 seconds
Average of: 1 trial
Port pairs active: 2
Mode: Bi-directional
Date: Thu Jun 26 10:43:05 2003

Port-Pair PacketLoss as a percentage of total

Table with 8 columns: Frame size, Max attempted, and four pairs of (start, end) coordinates. Values represent packet loss percentages, mostly 0.00 or 100.00.

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

Table with 8 columns: Frame size, 100Mb offered, Burst Seconds, Offered %, and four pairs of (start, end) coordinates. Values represent back-to-back test results.

Back-to-back SUMMARY: Total Port-Pairs

Summary table with 8 columns: Frame size, Frames Rcv'd, and four pairs of (start, end) coordinates. Values represent total frames received.

Bay 470-48T

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: BayNetworks
Product Name: 470-48T
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
Throughput test length: 5 seconds
Average of: 1 trial
Port pairs active: 2
Mode: Bi-directional
Date: Wed Jun 25 16:23:31 2003

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	93.43	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	140449	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	140449	84459	45290	23496	11973	9615	8127
(01,04,01) to (01,04,02)	1388889	844594	452898	234962	119732	96154	81274
(01,04,02) to (01,04,01)	1388889	844594	452898	234962	119732	96154	81274

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	94.38	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	94.38	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,01) to (01,04,02)	93.33	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,02) to (01,04,01)	93.33	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	3273810	1858108	996378	516916	263410	211538	178802
FPS Passed Rate	3058676	1858106	996376	516916	263410	211538	178802
Percentage	93.43	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	1419.1	472.0	450.4	447.4	501.8	520.8	529.2
(01,04,01) to (01,04,02)	691.3	18.0	15.5	19.8	33.3	39.8	45.8

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	1413.9	461.7	430.0	406.5	419.8	418.3	407.7
(01,04,01) to (01,04,02)	690.7	16.9	13.5	15.7	25.1	29.6	33.6

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

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Frame size           64      128      256      512      1024      1280      1518
Max attempted       100.00  100.00  100.00  100.00  100.00  100.00  100.00
-----
(01,07,01) to (01,07,02)  0.000  0.000  0.000  0.000  0.000  0.000  0.000
(01,07,02) to (01,07,01)  0.000  0.000  0.000  0.000  0.000  0.000  0.000
(01,04,01) to (01,04,02)  6.849  0.000  0.000  0.000  0.000  0.000  0.000
(01,04,02) to (01,04,01)  6.847  0.000  0.000  0.000  0.000  0.000  0.000
    
```

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

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Frame size           64      128      256      512      1024      1280      1518
100Mb offered       1592 168918  90580  46992  23946  19230  16254
1 Gb offered        15929 1689190  905798  469924  239464  192308  162548
Burst Seconds       0.0107 2.0000  2.0000  2.0000  2.0000  2.0000  2.0000
Offered %           100.00 100.00  100.00  100.00  100.00  100.00  100.00
-----
(01,07,01) to (01,07,02)  1592 168918  90580  46992  23946  19230  16254
(01,07,02) to (01,07,01)  1592 168918  90580  46992  23946  19230  16254
(01,04,01) to (01,04,02)  15929 1689190  905798  469924  239464  192308  162548
(01,04,02) to (01,04,01)  15930 1689190  905798  469924  239464  192308  162548
    
```

Back-to-back SUMMARY: Total Port-Pairs

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Frame size           64      128      256      512      1024      1280      1518
Frames Rcv'd       35045  3716216  1992756  1033832  526820  423076  357604
    
```

Cisco 2948G

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Cisco
Product Name: 2948G
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
Throughput test length: 5 seconds
Average of: 1 trial
Port pairs active: 2
Mode: Bi-directional
Date: Mon Jun 23 15:12:59 2003

For learning to be performed successfully I had to disable auto-neg on all Spirent tester ports.

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02) 100M	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,04,01) to (01,04,02) 1G	1488095	844594	452898	234962	119732	96154	81274
(01,04,02) to (01,04,01)	1488095	844594	452898	234962	119732	96154	81274

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,01) to (01,04,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,02) to (01,04,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	3273810	1858108	996378	516916	263410	211538	178802
FPS Passed Rate	3273808	1858106	996376	516916	263410	211538	178802
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	96.8	103.3	112.5	139.1	180.4	217.0	265.6
(01,04,01) to (01,04,02)	1.7	2.2	3.4	5.3	9.3	11.5	13.6

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
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Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	91.7	93.0	92.0	98.1	98.5	114.5	144.2
(01,04,01) to (01,04,02)	1.2	1.2	1.4	1.2	1.2	1.3	1.5

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

=====

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,04,01) to (01,04,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,04,02) to (01,04,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

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Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
1 Gb offered	2976190	1689190	905798	469924	239464	192308	162548
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,04,01) to (01,04,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,04,02) to (01,04,01)	2976190	1689190	905798	469924	239464	192308	162548

Back-to-back SUMMARY: Total Port-Pairs

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Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	6547620	3716216	1992756	1033832	526820	423076	357604

Cisco 2950

Rerun of SmartApp tests after receiving a new/repaired box

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Cisco
 Product Name: 2950
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 Throughput test length: 5 seconds
 Average of: 1 trial
 Port pairs active: 3
 Mode: Bi-directional
 Date: Mon Aug 04 14:29:47 2003

Maximum port-pair throughput with no loss

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Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,07,03) to (01,07,04)	148809	84459	45290	23496	11973	9615	8127
(01,07,04) to (01,07,03)	148809	84459	45290	23496	11973	9615	8127
(01,04,01) to (01,04,02)	1488095	844594	452898	234962	119732	96154	81274
(01,04,02) to (01,04,01)	1488095	844594	452898	234962	119732	96154	81274

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Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,03) to (01,07,04)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,04) to (01,07,03)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,01) to (01,04,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,02) to (01,04,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	3571430	2027026	1086958	563908	287356	230768	195056
FPS Passed Rate	3571426	2027024	1086956	563908	287356	230768	195056
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

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Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	139.1	139.8	161.2	192.9	218.2	235.5	273.2
(01,07,03) to (01,07,04)	139.5	140.1	161.5	193.1	218.5	235.7	273.3
(01,04,01) to (01,04,02)	10.0	11.6	10.9	14.9	17.4	19.9	22.9

(Store and Forward) Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,01) to (01,07,02)	134.0	129.6	140.8	151.9	136.3	133.0	151.8
(01,07,03) to (01,07,04)	134.3	129.9	141.0	152.1	136.6	133.2	151.8
(01,04,01) to (01,04,02)	9.5	10.5	8.9	10.9	9.3	9.6	10.7

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,03) to (01,07,04)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,04) to (01,07,03)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,04,01) to (01,04,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,04,02) to (01,04,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
1 Gb offered	2976190	1689190	905798	469924	239464	192308	162548
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,07,03) to (01,07,04)	297620	168918	90580	46992	23946	19230	16254
(01,07,04) to (01,07,03)	297620	168918	90580	46992	23946	19230	16254
(01,04,01) to (01,04,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,04,02) to (01,04,01)	2976190	1689190	905798	469924	239464	192308	162548

Back-to-back SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	7142860	4054052	2173916	1127816	574712	461536	390112

Foundry 4802

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Foundry
 Product Name: 4802
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 Throughput test length: 5 seconds
 Average of: 1 trial
 Port pairs active: 2
 Mode: Bi-directional
 Date: Thu Jun 12 12:36:23 2003

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,10,01) to (01,10,02)	148809	84459	45290	23496	11973	9615	8127
(01,10,02) to (01,10,01)	148809	84459	45290	23496	11973	9615	8127
(01,02,01) to (01,02,02)	1488095	844594	452898	234962	119732	96154	81274
(01,02,02) to (01,02,01)	1488095	844594	452898	234962	119732	96154	81274

Frame size	64	128	256	512	1024	1280	1518
(01,10,01) to (01,10,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,02) to (01,10,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,02,01) to (01,02,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,02,02) to (01,02,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	3273810	1858108	996378	516916	263410	211538	178802
FPS Passed Rate	3273808	1858106	996376	516916	263410	211538	178802
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through) Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,10,01) to (01,10,02)	10.0	16.6	27.4	45.1	86.1	106.7	139.7
(01,02,01) to (01,02,02)	18.3	9.9	11.3	15.1	21.5	24.4	27.7

(Store and Forward) Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,10,01) to (01,10,02)	4.9	6.3	7.0	4.1	4.2	4.2	18.2
(01,02,01) to (01,02,02)	17.7	8.8	9.2	11.1	13.3	14.2	15.5

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

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=====
```

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,10,01) to (01,10,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,02) to (01,10,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,02,01) to (01,02,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,02,02) to (01,02,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	289830	168918	90580	46992	23946	19230	16254
1 Gb offered	2898291	1689190	905798	469924	239464	192308	162548
Burst Seconds	1.9477	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,10,01) to (01,10,02)	289830	168918	90580	46992	23946	19230	16254
(01,10,02) to (01,10,01)	289830	168918	90580	46992	23946	19230	16254
(01,02,01) to (01,02,02)	2898291	1689190	905798	469924	239464	192308	162548
(01,02,02) to (01,02,01)	2898291	1689190	905798	469924	239464	192308	162548

Back-to-back SUMMARY: Total Port-Pairs

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	6376242	3716216	1992756	1033832	526820	423076	357604

The test data above was gathered early on in our performance testing and consequently did not have the third GigE test pair.

The following test data has the two 100M test pairs and the GigE test pair performance data.

Due to the default way the Spirent tester choose sequential MAC addresses for these tests, the following modifications were made prior to this test run.

Changed the Spirent tester parameters to not use sequential MAC addresses.
Entered this hidden command via the Foundry 4802 console "fes-no-span-mode"

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Foundry
Product Name: 4802
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
Throughput test length: 5 seconds
Average of: 1 trial
Port pairs active: 3
Mode: Bi-directional
Date: Tue Sep 02 14:01:15 2003

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,07,03) to (01,07,04)	148809	84459	45290	23496	11973	9615	8127
(01,07,04) to (01,07,03)	148809	84459	45290	23496	11973	9615	8127
(01,04,01) to (01,04,02)	1488095	844594	452898	234962	119732	96154	81274
(01,04,02) to (01,04,01)	1488095	844594	452898	234962	119732	96154	81274

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,03) to (01,07,04)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,04) to (01,07,03)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,01) to (01,04,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,02) to (01,04,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	3571430	2027026	1086958	563908	287356	230768	195056
FPS Passed Rate	3571426	2027024	1086956	563908	287356	230768	195056
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Vendor Name: Foundry
Product Name: 4802
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
Latency test length: 10 seconds

Average of: 2 trials
 Port pairs active: 3
 Mode: Bi-directional (Measured on one receiving card only)
 Date: Tue Sep 02 14:05:37 2003

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,01) to (01,07,02)	9.5	14.9	25.3	45.7	86.8	106.9	126.2
(01,07,03) to (01,07,04)	9.5	15.0	25.3	45.7	86.8	107.0	126.2
(01,04,01) to (01,04,02)	8.6	9.5	10.7	14.4	21.1	25.5	27.8

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,01) to (01,07,02)	4.3	4.7	4.8	4.7	4.9	4.4	4.8
(01,07,03) to (01,07,04)	4.4	4.7	4.9	4.7	4.9	4.6	4.7
(01,04,01) to (01,04,02)	8.1	8.5	8.7	10.3	12.9	15.2	15.7

Spirent Communications - SmartBits PacketLoss Test Results

Vendor Name: Foundry
 Product Name: 4802
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 PacketLoss test length: 10 seconds
 Average of: 1 trial
 Port pairs active: 3
 Mode: Bi-directional
 Date: Tue Sep 02 14:13:14 2003

Port-Pair PacketLoss as a percentage of total

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,03) to (01,07,04)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,04) to (01,07,03)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,04,01) to (01,04,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,04,02) to (01,04,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Vendor Name: Foundry
 Product Name: 4802
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 Back-to-back test length: 2 seconds
 Average of: 10 trials
 Port pairs active: 3
 Mode: Bi-directional
 Date: Tue Sep 02 14:21:03 2003

Port-Pair Back-to-back

=====

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
1 Gb offered	2976190	1689190	905798	469924	239464	192308	162548
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,07,03) to (01,07,04)	297620	168918	90580	46992	23946	19230	16254
(01,07,04) to (01,07,03)	297620	168918	90580	46992	23946	19230	16254
01,04,01) to (01,04,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,04,02) to (01,04,01)	2976190	1689190	905798	469924	239464	192308	162548

Back-to-back SUMMARY: Total Port-Pairs

=====

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	7142860	4054052	2173916	1127816	574712	461536	390112

LinkSys

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Linksys
Product Name: Product
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
Throughput test length: 5 seconds
Average of: 1 trial
Port pairs active: 2
Mode: Bi-directional
Date: Wed Jul 23 10:24:17 2003

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,07,03) to (01,07,04)	148809	84459	45290	23496	11973	9615	8127
(01,07,04) to (01,07,03)	148809	84459	45290	23496	11973	9615	8127

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,03) to (01,07,04)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,04) to (01,07,03)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	595240	337836	181160	93984	47892	38460	32508
FPS Passed Rate	595236	337836	181160	93984	47892	38460	32508
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	13.6	18.7	28.9	49.2	90.0	110.5	129.5
(01,07,03) to (01,07,04)	13.7	18.8	28.9	49.2	90.2	110.7	129.6

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	8.4	8.4	8.4	8.2	8.1	8.1	8.0
(01,07,03) to (01,07,04)	8.6	8.5	8.5	8.3	8.2	8.2	8.2

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

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=====
```

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,03) to (01,07,04)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,04) to (01,07,03)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,07,03) to (01,07,04)	297620	168918	90580	46992	23946	19230	16254
(01,07,04) to (01,07,03)	297620	168918	90580	46992	23946	19230	16254

Back-to-back SUMMARY: Total Port-Pairs

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	1190480	675672	362320	187968	95784	76920	65016

SMC 6709L2

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: SMC
 Product Name: 6709L2
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 Throughput test length: 5 seconds
 Average of: 1 trial
 Port pairs active: 2
 Mode: Bi-directional
 Date: Mon Jun 30 11:18:44 2003

Maximum port-pair throughput with no loss

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,10,01) to (01,10,02)	148809	84459	45290	23496	11973	9615	8127
(01,10,02) to (01,10,01)	148809	84459	45290	23496	11973	9615	8127

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,01) to (01,10,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,02) to (01,10,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	595240	337836	181160	93984	47892	38460	32508
FPS Passed Rate	595236	337836	181160	93984	47892	38460	32508
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	8.1	13.2	23.4	44.0	84.8	105.4	124.5
(01,10,01) to (01,10,02)	8.6	13.7	24.0	44.4	85.5	105.9	124.9

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	2.9	3.0	3.0	3.0	2.9	2.9	3.0
(01,10,01) to (01,10,02)	3.5	3.5	3.5	3.5	3.5	3.5	3.4

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,01) to (01,10,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,02) to (01,10,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,10,01) to (01,10,02)	297620	168918	90580	46992	23946	19230	16254
(01,10,02) to (01,10,01)	297620	168918	90580	46992	23946	19230	16254

Back-to-back SUMMARY: Total Port-Pairs

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	1190480	675672	362320	187968	95784	76920	6501

Bay 380-24T

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: BayNetworks
 Product Name: 380-24T
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 Throughput test length: 5 seconds
 Average of: 1 trial
 Port pairs active: 2
 Mode: Bi-directional
 Date: Thu Jun 26 09:28:00 2003

Maximum port-pair throughput with no loss

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,10,01) to (01,10,02)	1488095	844594	452898	234962	119732	96154	81274
(01,10,02) to (01,10,01)	1488095	844594	452898	234962	119732	96154	81274

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,01) to (01,10,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,02) to (01,10,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	3273810	1858108	996378	516916	263410	211538	178802
FPS Passed Rate	3273808	1858106	996376	516916	263410	211538	178802
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	62.0	61.2	69.2	91.4	145.6	167.6	178.5
(01,10,01) to (01,10,02)	3.8	5.1	7.2	10.9	16.4	17.9	19.6

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	56.8	51.0	48.8	50.4	63.7	65.1	57.0
(01,10,01) to (01,10,02)	3.2	4.1	5.2	6.8	8.3	7.6	7.5

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

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Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,01) to (01,10,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,02) to (01,10,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
1 Gb offered	2976190	1689190	905798	469924	239464	192308	162548
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,10,01) to (01,10,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,10,02) to (01,10,01)	2976190	1689190	905798	469924	239464	192308	162548

Back-to-back SUMMARY: Total Port-Pairs

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	6547620	3716216	1992756	1033832	526820	423076	357604

Extreme Summit 5i

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Extreme Mod-11501
Product Name: Summit 5i
Software Version: SmartApplications V 2.50
Library Version: 3.12-115
Firmware Version: 2.00.00...
Serial Number: 60012365
Throughput test length: 5 seconds
Average of: 1 trial
Port pairs active: 3
Mode: Bi-directional
Date: Tue Aug 19 11:09:08 2003

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,04,01) to (01,04,02)	1488095	844594	452898	234962	119732	96154	81274
(01,04,02) to (01,04,01)	1488095	844594	452898	234962	119732	96154	81274
(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,07,03) to (01,07,04)	148809	84459	45290	23496	11973	9615	8127
(01,07,04) to (01,07,03)	148809	84459	45290	23496	11973	9615	8127

Frame size	64	128	256	512	1024	1280	1518
(01,04,01) to (01,04,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,02) to (01,04,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,03) to (01,07,04)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,04) to (01,07,03)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	3571430	2027026	1086958	563908	287356	230768	195056
FPS Passed Rate	3571426	2027024	1086956	563908	287356	230768	195056
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,01) to (01,04,02)	5.8	6.2	6.8	7.9	12.2	13.7	15.3
(01,07,01) to (01,07,02)	96.7	86.2	96.3	116.9	186.8	178.0	211.3
(01,07,03) to (01,07,04)	82.1	100.4	96.2	116.2	172.0	177.8	196.4

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,04,01) to (01,04,02)	5.3	5.2	4.7	3.9	4.1	3.5	3.2
(01,07,01) to (01,07,02)	91.5	76.0	75.9	75.9	104.9	75.6	89.8
(01,07,03) to (01,07,04)	77.0	90.1	75.7	75.3	90.0	75.3	74.9

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

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```

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,04,01) to (01,04,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,04,02) to (01,04,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,03) to (01,07,04)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,04) to (01,07,03)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

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=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
1 Gb offered	2976190	1689190	905798	469924	239464	192308	162548
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,04,01) to (01,04,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,04,02) to (01,04,01)	2976190	1689190	905798	469924	239464	192308	162548
(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,07,03) to (01,07,04)	297620	168918	90580	46992	23946	19230	16254
(01,07,04) to (01,07,03)	297620	168918	90580	46992	23946	19230	16254

Back-to-back SUMMARY: Total Port-Pairs

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	7142860	4054052	2173916	1127816	574712	461536	390112

Cisco 6506

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Cisco 6506
 Product Name: Catalyst
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 Throughput test length: 5 seconds
 Average of: 1 trial
 Port pairs active: 3
 Mode: Bi-directional
 Date: Wed Sep 03 15:56:28 2003

Maximum port-pair throughput with no loss

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(01,07,01) to (01,07,02)	148809	84459	45290	23496	11973	9615	8127
(01,07,02) to (01,07,01)	148809	84459	45290	23496	11973	9615	8127
(01,07,03) to (01,07,04)	148809	84459	45290	23496	11973	9615	8127
(01,07,04) to (01,07,03)	148809	84459	45290	23496	11973	9615	8127
(01,01,01) to (01,01,02)	1488095	844594	452898	234962	119732	96154	81274
(01,01,02) to (01,01,01)	1488095	844594	452898	234962	119732	96154	81274

Frame size	64	128	256	512	1024	1280	1518
(01,07,01) to (01,07,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,02) to (01,07,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,03) to (01,07,04)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,07,04) to (01,07,03)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,01,01) to (01,01,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,01,02) to (01,01,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	3571430	2027026	1086958	563908	287356	230768	195056
FPS Passed Rate	3571426	2027024	1086956	563908	287356	230768	195056
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	194.0	207.7	198.5	240.9	280.8	312.9	360.9
(01,07,03) to (01,07,04)	197.3	201.0	201.5	244.1	280.6	326.1	375.2
(01,01,01) to (01,01,02)	6.0	6.7	7.5	11.0	16.0	17.5	21.5

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	188.8	197.5	178.1	199.9	198.9	210.5	239.4
(01,07,03) to (01,07,04)	192.2	190.7	181.1	203.1	198.6	223.7	253.7
(01,01,01) to (01,01,02)	5.4	5.7	5.5	7.0	7.9	7.2	9.3

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

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=====
```

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,02) to (01,07,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,03) to (01,07,04)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,07,04) to (01,07,03)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,01,01) to (01,01,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,01,02) to (01,01,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

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=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
1 Gb offered	2976190	1689190	905798	469924	239464	192308	162548
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,07,01) to (01,07,02)	297620	168918	90580	46992	23946	19230	16254
(01,07,02) to (01,07,01)	297620	168918	90580	46992	23946	19230	16254
(01,07,03) to (01,07,04)	297620	168918	90580	46992	23946	19230	16254
(01,07,04) to (01,07,03)	297620	168918	90580	46992	23946	19230	16254
(01,01,01) to (01,01,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,01,02) to (01,01,01)	2976190	1689190	905798	469924	239464	192308	162548

Back-to-back SUMMARY: Total Port-Pairs

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	7142860	4054052	2173916	1127816	574712	461536	390112

Extreme BlackDiamond 6808

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Extreme
 Product Name: BlackDiamond 6808
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 Throughput test length: 5 seconds
 Average of: 1 trial
 Port pairs active: 3
 Mode: Bi-directional
 Date: Wed Jul 30 12:39:00 2003

Maximum port-pair throughput with no loss

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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```

(01,04,01) to (01,04,02) Fiber	1488095	844594	452898	234962	119732	96154	81274
(01,04,02) to (01,04,01) GBIC	1488095	844594	452898	234962	119732	96154	81274
(01,10,01) to (01,10,02) 1000BT	1488095	844594	452898	234962	119732	96154	81274
(01,10,02) to (01,10,01) Copper	1488095	844594	452898	234962	119732	96154	81274
(01,12,01) to (01,12,02) 100SX	148809	84459	45290	23496	11973	9615	8127
(01,12,02) to (01,12,01) Fiber	148809	84459	45290	23496	11973	9615	8127

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
(01,04,01) to (01,04,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,02) to (01,04,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,01) to (01,10,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,02) to (01,10,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,12,01) to (01,12,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,12,02) to (01,12,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	6250000	3547298	1902176	986840	502874	403846	341350
FPS Passed Rate	6249998	3547294	1902172	986840	502874	403846	341350
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

```
-----
```

(01,04,01) to (01,04,02)	5.6	6.1	6.6	8.2	12.1	13.7	15.3
(01,10,01) to (01,10,02)	6.3	6.6	7.2	8.3	12.2	14.7	16.1
(01,12,01) to (01,12,02)	14.1	18.0	28.2	62.9	89.5	110.9	128.8

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,04,01) to (01,04,02)	5.1	5.1	4.6	4.2	3.9	3.5	3.2
(01,10,01) to (01,10,02)	5.8	5.5	5.2	4.3	4.0	4.4	4.0
(01,12,01) to (01,12,02)	9.0	7.7	7.8	22.0	7.5	8.5	7.4

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,01) to (01,04,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,04,02) to (01,04,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,01) to (01,10,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,02) to (01,10,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,12,01) to (01,12,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,12,02) to (01,12,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
1 Gb offered	2976190	1689190	905798	469924	239464	192308	162548
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,04,01) to (01,04,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,04,02) to (01,04,01)	2976190	1689190	905798	469924	239464	192308	162548
(01,10,01) to (01,10,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,10,02) to (01,10,01)	2976190	1689190	905798	469924	239464	192308	162548
(01,12,01) to (01,12,02)	297620	168918	90580	46992	23946	19230	16254
(01,12,02) to (01,12,01)	297620	168918	90580	46992	23946	19230	16254

Back-to-back SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'd	12500000	7094596	3804352	1973680	1005748	807692	682700

Foundry FastIron800

Spirent Communications - SmartBits Throughput Test Results

Vendor Name: Foundry
 Product Name: FastIron800
 Software Version: SmartApplications V 2.50
 Library Version: 3.12-115
 Firmware Version: 2.00.00...
 Serial Number: 60012365
 Throughput test length: 5 seconds
 Average of: 1 trial
 Port pairs active: 3
 Mode: Bi-directional
 Date: Thu Jun 12 16:41:31 2003

All Spirent Test Ports were set to Force Auto-Neg for the tests to pass.

Maximum port-pair throughput with no loss

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```

Frame size	64	128	256	512	1024	1280	1518
100Mb MaxRate	148810	84459	45290	23496	11973	9615	8127
1 Gb Max Rate	1488095	844595	452899	234962	119732	96154	81274
Avg % passed	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Acceptable Loss %	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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```

(01,10,01) to (01,10,02)	148809	84459	45290	23496	11973	9615	8127
(01,10,02) to (01,10,01)	148809	84459	45290	23496	11973	9615	8127
(01,02,01) to (01,02,02)	1488095	844594	452898	234962	119732	96154	81274
(01,02,02) to (01,02,01)	1488095	844594	452898	234962	119732	96154	81274
(01,05,01) to (01,05,02)	1488095	844594	452898	234962	119732	96154	81274
(01,05,02) to (01,05,01)	1488095	844594	452898	234962	119732	96154	81274

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
(01,10,01) to (01,10,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,10,02) to (01,10,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,02,01) to (01,02,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,02,02) to (01,02,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,05,01) to (01,05,02)	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(01,05,02) to (01,05,01)	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Throughput SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Maximum Rate	6250000	3547298	1902176	986840	502874	403846	341350
FPS Passed Rate	6249998	3547294	1902172	986840	502874	403846	341350
Percentage	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Spirent Communications - SmartBits Latency Test Results

Mode: SmartMetrics Comp. Mode

(Cut Through)Port-Pair Latency in microseconds (us) [or ms where noted]

```
=====
```

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

```
-----
```

(01,10,01) to (01,10,02)	15.2	20.5	31.7	52.0	92.8	113.3	132.2
(01,02,01) to (01,02,02)	6.3	6.8	7.7	9.6	13.5	15.5	17.2
(01,05,01) to (01,05,02)	5.8	6.3	7.2	9.1	13.1	14.9	16.8

(Store and Forward)Port-Pair Latency in microseconds (us) [or ms where noted]

Frame size	64	128	256	512	1024	1280	1518
Percent load	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,10,01) to (01,10,02)	10.1	10.3	11.3	11.1	10.9	10.9	10.8
(01,02,01) to (01,02,02)	5.7	5.8	5.7	5.6	5.4	5.3	5.1
(01,05,01) to (01,05,02)	5.2	5.3	5.1	5.1	5.0	4.6	4.6

Spirent Communications - SmartBits PacketLoss Test Results

Port-Pair PacketLoss as a percentage of total

Frame size	64	128	256	512	1024	1280	1518
Max attempted	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,10,01) to (01,10,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,10,02) to (01,10,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,02,01) to (01,02,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,02,02) to (01,02,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,05,01) to (01,05,02)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(01,05,02) to (01,05,01)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spirent Communications - SmartBits Back-to-back Test Results

Port-Pair Back-to-back

Frame size	64	128	256	512	1024	1280	1518
100Mb offered	297620	168918	90580	46992	23946	19230	16254
1 Gb offered	2976190	1689190	905798	469924	239464	192308	162548
Burst Seconds	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Offered %	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(01,10,01) to (01,10,02)	297620	168918	90580	46992	23946	19230	16254
(01,10,02) to (01,10,01)	297620	168918	90580	46992	23946	19230	16254
(01,02,01) to (01,02,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,02,02) to (01,02,01)	2976190	1689190	905798	469924	239464	192308	162548
(01,05,01) to (01,05,02)	2976190	1689190	905798	469924	239464	192308	162548
(01,05,02) to (01,05,01)	2976190	1689190	905798	469924	239464	192308	162548

Back-to-back SUMMARY: Total Port-Pairs

Frame size	64	128	256	512	1024	1280	1518
Frames Rcv'	12500000	7094596	3804352	1973680	1005748	807692	682700

C. Appendix: Advanced Switch Tests (ASTII)

Forward Pressure Test

The Forward Pressure test allows you to determine how the UUT handles congestion. Specifically, this test allows you to determine if forward pressure exists when the receive ports of the UUT become congested. Forward pressure is defined as the point where the UUT inhibits or aborts its back-off algorithms in an attempt to increase its forwarding performance under congested conditions. The Forward Pressure test enables you to simulate congestion on specific receiving ports of the UUT to determine if forward pressure occurs.

NOTE: Forward pressure is indicated if no frame loss occurs under congested condition. When forward pressure occurs, the Inter-frame Gap is smaller than the legal limit.

Broadcast Forwarding Test

The Broadcast Forwarding test allows you to test the broadcast forwarding performance of the UUT. This test allows you to measure the throughput and frame loss of the UUT for broadcast traffic patterns (one-to-many and many-to-many).

Error Filtering Test

The Error Filtering test allows one to determine how the UUT handles error frames. The tester simulates various types of error frames to determine the ability of the UUT to recognize specific errors, and filter (drop) the frames that contain the errors. The Error Filtering test is run in continuous burst mode.

Address Learning Test

The Address Learning test allows you to determine the address learning rate of the UUT. The address learning rate is the maximum rate at which the device can learn new MAC addresses without flooding or dropping frames. This test is run using a binary search algorithm to determine the

address learning rate. This test utilizes port pairs consisting of learn ports and test ports. By allowing you to specify the **Number of Addresses** and **Frame Size**, the Address Learning test can help you determine the following:

How increases in the **Number of Addresses** affects the UUT's address learning rate.

How increases in the **Frame Size** affects the UUT's address learning rate.

NOTE: For this test, you must set up a **Monitor** port. The Monitor port allows one to determine if the UUT flooded frames during the test.

Forward Pressure Test Results

Frame Loss Rate Percentage	Packet Size, in bytes						
	64	128	256	512	1024	1280	1518
3Com 48 Port Model 4400	1.2%	0.6%	0.3%	18.7%	50.0%	50.0%	50.0%
3Com 24 Port Model 4400	1.2%	0.6%	0.3%	0.1%	48.3%	50.0%	50.0%
BayStack 48 Port Model 470-48T	55.0%	52.6%	53.6%	55.0%	53.7%	56.4%	56.8%
Cisco 48 Port Model 2948G	0.8%	1.8%	67.9%	67.9%	73.9%	71.0%	75.6%
Cisco Catylst 2950-12	50.6%	50.3%	50.1%	50.1%	50.0%	50.0%	50.0%
FastIron 24 Port Model 2402							
FastIron 48 Port Model 4802	0.8%	0.4%	30.7%	67.1%	68.5%	68.4%	68.6%
LinkSys 24 Port Model 1324	57.6%	66.6%	66.6%	66.6%	66.6%	66.6%	66.6%
SMC Tiger Switch 6709L2	1.2%	0.6%	0.3%	0.2%	0.1%	0.0%	25.5%
BayStack 24 Port Model 380-24T	0.8%	24.4%	69.6%	69.7%	69.6%	69.6%	69.6%
Extreme Summit 5i	0.8%	0.4%	0.2%	0.1%	0.0%	0.0%	0.0%
Foundry 24G	0.8%	0.4%	0.2%	0.1%	0.0%	0.0%	0.0%
Cisco Model 6506	0.8%	0.4%	0.2%	0.1%	0.1%	0.0%	0.0%
Extreme Model 6808	0.4%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%
FastIron Model 800	0.0%	1.6%	97.9%	95.9%	92.0%	90.0%	

Broadcast Forwarding Test Results

In the test results tables a value of "0" indicates the test failed and a value of "1" indicates the test passed.

Switch:	3Com Model 4400-48			Packet Size				
Score:	13%							
	64	128	256	512	1024	1280	1518	
Loading	10	0	0	0	1	1	1	1
	20	0	0	0	0	1	1	1
	30	0	0	0	0	0	1	1
	40	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0
	60	0	0	0	0	0	0	0
	70	0	0	0	0	0	0	0
	80	0	0	0	0	0	0	0
	90	0	0	0	0	0	0	0
	100	0	0	0	0	0	0	0

Switch:	3Com Model 4400-24			Packet Size				
Score:	13%							
	64	128	256	512	1024	1280	1518	
Loading	10	0	0	0	1	1	1	1
	20	0	0	0	0	1	1	1
	30	0	0	0	0	0	1	1
	40	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0
	60	0	0	0	0	0	0	0
	70	0	0	0	0	0	0	0
	80	0	0	0	0	0	0	0
	90	0	0	0	0	0	0	0
	100	0	0	0	0	0	0	0

Switch:	Bay 470-48T			Packet Size				
Score:	0%							
	64	128	256	512	1024	1280	1518	
Loading	10	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0
	60	0	0	0	0	0	0	0
	70	0	0	0	0	0	0	0
	80	0	0	0	0	0	0	0
	90	0	0	0	0	0	0	0
	100	0	0	0	0	0	0	0

Switch:	Cisco 2948G		Packet Size					
Score:	17%							
		64	128	256	512	1024	1280	1518
Loading	10	0	0	1	1	1	1	1
	20	0	0	0	0	1	1	1
	30	0	0	0	0	1	1	1
	40	0	0	0	0	0	0	1
	50	0	0	0	0	0	0	0
	60	0	0	0	0	0	0	0
	70	0	0	0	0	0	0	0
	80	0	0	0	0	0	0	0
	90	0	0	0	0	0	0	0
	100	0	0	0	0	0	0	0

Switch:	Cisco 2950G-12		Packet Size					
Score:	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Switch:	Foundry FastIron 4802		Packet Size					
Score:	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Switch:	Linksys 1324			Packet Size				
Score:	0%							
		64	128	256	512	1024	1280	1518
Loading	10	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0
	60	0	0	0	0	0	0	0
	70	0	0	0	0	0	0	0
	80	0	0	0	0	0	0	0
	90	0	0	0	0	0	0	0
	100	0	0	0	0	0	0	0

Switch:	SMC Tiger Switch 6709L2			Packet Size				
Score:	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Switch:	Bay 380-24T		Packet Size					
Score:	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Switch:	Foundry 24G		Packet Size					
Score:	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Switch:	Extreme Summit 5I		Packet Size					
Score:	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Switch:	Cisco 6506							
Score:	Packet Size							
	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Switch:	Foundry FastIron800							
Score:	Packet Size							
	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Switch:	BlackDiamond							
Score:	Packet Size							
	100%							
		64	128	256	512	1024	1280	1518
Loading	10	1	1	1	1	1	1	1
	20	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1
	40	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1
	60	1	1	1	1	1	1	1
	70	1	1	1	1	1	1	1
	80	1	1	1	1	1	1	1
	90	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1

Error Filtering Test Results

	Over	Under	CRC	SCORE
3Com 48 Port Model 4400	P	P	P	100%
3Com 24 Port Model 4400	P	P	P	100%
BayStack 48 Port Model 470-48T	P	P	P	100%
Cisco 48 Port Model 2948G	P	P	P	100%
Cisco Catylst 2950-12	P	P	P	100%
FastIron 24 Port Model 2402	P	P	P	100%
FastIron 48 Port Model 4802	P	P	P	100%
LinkSys 24 Port Model 1324	F	P	P	67%
SMC Tiger Switch 6709L2	P	P	P	100%
BayStack 24 Port Model 380-24T	F	P	P	67%
Extreme Summit 5i	P	P	P	100%
Foundry 24G	F	P	P	67%
Cisco Model 6506	F	P	P	67%
Extreme Model 6808	P	P	P	100%
FastIron Model 800	P	P	P	100%

D. Test and Evaluation Results

Legend

Symbol	Description
Pass	Passed Test
Fail	Failed Test
I	Indeterminate Test
NA	Not Applicable
NS	Not Supported
A	Feature/Function Available (Not Tested)
Comp	Compatible with Function (but not fully conformant with specification)
LLT	Limited Lifetime Warranty
NT	Not Tested

Commodity Monolithic Switches

		3Com 24 Port Model 4400	3Com 48 Port Model 4400	BayStack 48 Port Model 470-48T Note 2(Exclude 64b test)	Cisco 48 Port Model 2948G	Cisco Catalyst 2950G-12	FastIron 24 Port Model 2402	FastIron 48 Port Model 4802, Note 1	LinkSys 24 Port Model 1324	SMC Tiger Switch 6709L2
	Evaluation Score	75%	75%	81%	74%	86%	89%	89%	58%	63%
Test	Test Description									
1.1a	Port Capacity(copper) 10/100/1000 Mbps	24/24/0	48/48/0	48/48/0	48/48/0	12/12/0	24/24/0	48/48/0	24/24/0	8/8/0
1.1b	Uplink(fiber) Ports 10/100/1000 Mbps	0/2/2	0/2/2	0/0/2	0/0/2	0/0/2	0/0/2	0/0/3	0/0/2	0/0/1
1.3	Gigabit Port Availability	2	2	2	2	2	2	2	2	1
1.4	Untagged VLAN Support	P	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
1.5	Tagged VLAN Support 802.1q	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
1.6	802.1d Standard Spanning Tree	Pass	Pass	Pass	Comp	Comp	Pass	Pass	Comp	Pass
1.10	PVST+	Comp	Comp	Comp	Comp	Comp	Pass	Pass	Comp	Comp
1.12	PortFast	NT	NT	NT	Pass	Pass	Pass	Pass	NT	
1.15	802.3ad	Fail	Fail	Comp	Fail	Pass	Pass	Pass	Fail	Pass
2.1a	CLI	A	A	A	A	A	A	A	NS	
2.1b	"CLI" Configure Menu	A	A	A	NS	NS	NS		A	
2.2	Telnet In	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
2.3	Telnet Out	NS	NS	NS	Pass	Pass	Pass	Pass	NS	NS
2.4	Ping Out	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
2.5	Web Interface	A	A	A	I	A	A	A	A	A
2.6	SSH Verion 1/Version 2	NS	NS	A/A	NS	A/I	A/NS	A/NS	NS	NS

2.7	Switch Management Software	A	A	A	A	A	A	A	NS	NS
2.8	Switch Stacking	A	A	A	NS	NS	NS	NS	NS	NS
2.9	SNMP Read	v1(P)	v1(P)	v2c(P)	NT	v2c(P)	v2c(P)	v2c(P)	v1(P)	v1(P)
2.10	SNMP Write	v1(P)	v1(P)	v2c(P)	NT	v2c(P)	v2c(P)	v2c(P)	v1(P)	v1(P)
2.17	Port Mirroring	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
2.18	File Upload/Download	Pass	Pass	Pass	Pass	Pass	Pass	Pass	NT	NT
3.1	Compatibility to Cisco IOS Look & Feel	Low	Low	Avg	Avg	High	High	High	Low	Low
4.1	Throughput (Two 100M & 1G Pairs)	100%	100%	99%	100%	100%	NT	100%, Note 1	100%, Note 2	100%
4.2a	Latency Cut-Through 10/100 Ports	10/126	10/126	447/529	96/259	139/273	NT	10/126, Note 1	14/130	8/125
4.2b	Latency Cut-Through 1000 Ports	NT	NT	18/46	2/13	10/23	NT	9/28, Note 1	NA	NA
4.3a	Latency Store & Forward 10/100 Ports	4/10	4/8	407/462	91/157	130/152	NT	4/5, Note 1	8/9	3/4
4.3b	Latency Store & Forward 1000 Ports	NT	NT	14/34	1/1	9/11	NT	8/16, Note 1	NA	NA
4.3	FrameLossRat *Throughput same as 1.4.1	0%	0%	0% Exc 64B	0%	0%	NT	0%		0%
4.4	Back-to-Back Test	100%	100%	100%	100%	100%		100%, Note 1	100%	100%
4.5	Forward Pressure, frame loss rate	24.4%	21.5%	54.7%	51.3%	50.2%	NT	43.5%	65.3%	4.0%
4.6	Broadcast Rate Forwarding	13%	13%	0%	17%	100%	NT	100%	0%	100%
4.7	Error Filtering (over size/under size/CRC)	100%	100%	100%	100%	100%	NT	100%	67%	100%
4.8	Learning Rate *Address Learning	100%	100%	100%	92%	100%	NT	100%	100%	100%
4.9	Backplane Capacity Manu Spec Gb/s	13.6	8.8	2.5	12	6.4		34	9.6	3.8
5.1	TACACS+	NS	NS	NS	Pass	Pass		Pass	NS	NS
5.2	Radius	Pass	Pass	Pass	Pass	Pass		Pass	NS	NS
5.3	User Password	A	A	A	A	A		A	NT	NS
5.5	User Authorization Levels	A	A	A	A	A	A	A	NT	NS
5.9	Port Security	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
6.7	Reliability, MTBF, Hrs	176,294	406,393	?	146,280	482,776	111,755	100,836	?	70,080
6.8	Warranty Period Hardware/Software	LLT/1Yr	LLT/1Yr	1Yr	LLT	LLT/	1Yr/90D ay	1Yr/90Da y	1Yr	LLT/

High-End Monolithic Switches

		Bay/Stack 24 Port Model 380-24T	Extreme 5i	Foundry 24G
	Switch Score	74%	87%	72%
Test Num	Test Description			
1.1a	Port Capacity(copper) 10/100/1000 Mbps	24/24/24	0/12/12	24/24/24
1.1b	Uplink(fiber) Ports 10/100/1000 Mbps	0/0/4	0/0/4	0/0/4
1.3	Gigabit Port Availability	4 Shared	4	4 Shared
1.4	Untagged VLAN Support	Pass	Pass	Pass
1.5	Tagged VLAN Support 802.1q	Pass	Pass	Pass
1.6	802.1d Standard Spanning Tree	Pass	Pass	Pass
1.10	PVST+	Comp	Pass	Comp
1.12	PortFast	NT	NS	NT
1.15	802.3ad	Fail	Comp	Fail
2.1a	CLI	NS	A	A
2.1b	"CLI" Configure Menu	A	NS	NS
2.2	Telnet In	Pass	Pass	Pass
2.3	Telnet Out	NS	Pass	Pass
2.4	Ping Out	Pass	Pass	Pass
2.5	Web Interface	A	A	A
2.6	SSH Verion 1/Version 2	NS	A/A	NT
2.7	Switch Management Software	A	A	A

2.9	SNMP Read	Pass, v2c	P, v2c	P, v2c
2.10	SNMP Write	P, v2c	P, v2c	P, v2c
2.15	Hot Swap, modular switches	NA	NA	NA
2.16	Redundant Modules, modular switches	NA	NA	NA
2.17	Port Mirroring	Pass	Pass	Pass
2.18	File Upload/Download	Pass	Pass	Pass
3.1	Compatibility to Cisco IOS Look & Feel	Low	Avg	High
4.1	Throughput (Two 100M & 1G Pairs)	100%	100%	100%
4.2a	Latency Cut-Through 10/100 Ports	61/179	82/211	Fail
4.2b	Latency Cut-Through 1000 Ports	4/20	6/15	Fail
4.3a	Latency Store & Forward 10/100 Ports	49/65	75/105	Fail
4.3b	Latency Store & Forward 1000 Ports	3/8	3/5	Fail
4.3	FrameLossRat *Throughput same as 1.4.1	0%	0%	Fail
4.4	Back-to-Back Test	100%	100%	Fail
4.5	Forward Pressure, frame loss rate	53.3%	0.2%	0.2%
4.6	Broadcast Rate Forwarding	100%	100%	100%
4.7	Error Filtering (over size/under size/CRC)	67%	100%	67%
4.8	Learning Rate *Address Learning	100%	100%	100%
4.9	Backplane Capacity Manu Spec Gb/s	24	32	48
5.1	TACACS+	NS	Pass	Pass
5.2	Radius	Pass	Pass	Pass
5.3	User Password	A	A	A
5.5	User Authorization Levels	A	A	A
5.9	Port Security	Pass	Pass	Pass
6.7	Reliability, MTBF, Hrs	?	50,000	52,560
6.8	Warranty Period Hardware/Software	1Yr	?	1Yr/90Day

Modular Switches

		Cisco Model 6506	Extreme Model 6808	FastIron Model 800
	Switch Score	88%	87%	89%
Test Num	Test Description			
1.4	Untagged VLAN Support	Pass	Pass	Pass
1.5	Tagged VLAN Support 802.1q	Pass	Pass	Pass
1.6	802.1d Standard Spanning Tree	Comp	Pass	Pass
1.10	PVST+	Comp	Pass	Pass
1.12	PortFast	Pass	NS	Pass
1.15	802.3ad	Pass	Comp	Fail
2.1a	CLI	A	A	Pass
2.1b	"CLI" Configure Menu	NS	NS	NS
2.2	Telnet In	Pass	Pass	Pass
2.3	Telnet Out	Pass	Pass	Pass
2.4	Ping Out	Pass	Pass	Pass
2.5	Web Interface	A	A	A
2.6	SSH Verion 1/Version 2	A/I	A/A	A/NS
2.7	Switch Management Software	A	A	A
2.9	SNMP Read	P, v2c	F, v1	P, v2c
2.10	SNMP Write	P, v2c	F, v1	P, v2c
2.15	Hot Swap, modular switches	A	A	A
2.16	Redundant Modules, modular switches	A	A	A
2.17	Port Mirroring	Pass	Pass	Pass
2.18	File Upload/Download	Pass	Pass	Pass

3.1	Compatibility to Cisco IOS Look & Feel	High	Avg	High
4.1	Throughput (Two 100M & 1G Pairs)	100%	100%	100%
4.2a	Latency Cut-Through 10/100 Ports	194/375	14/129	6/17
4.2b	Latency Cut-Through 1000 Ports	6/22	6/16	15/132
4.3a	Latency Store & Forward 10/100 Ports	178/254	7/22	5/6
4.3b	Latency Store & Forward 1000 Ports	5/9	3/6	10/11
4.4	Back-to-Back Test	100%	100%	100%
4.5	Forward Pressure, frame loss rate	0.2%	0.1%	62.9%
4.6	Broadcast Rate Forwarding	100%	100%	100%
4.7	Error Filtering (over size/under size/CRC)	67%	100%	100%
4.8	Learning Rate *Address Learning	100%	100%	100%
4.9	Backplane Capacity Manu Spec Gb/s	?	384	256
5.1	TACACS+	Pass	Pass	Pass
5.2	Radius	Pass	Pass	Pass
5.3	User Password	A	A	A
5.5	User Authorization Levels	A	A	A
5.9	Port Security	Pass	Pass	Pass
6.7	Reliability, MTBF, Hrs	59,808	50,000	?
6.8	Warranty Period Hardware/Software	1Yr/90Day	?	1Yr/90Day

E. Switch Costs

Commodity Monolithic
Switch Cost

	3Com 4 Port Model 4400	3Com 24 Port Model 4400	BayStack 48 Port Model 470-48T	Cisco 48 Port Model 2948G	Cisco 2950G (C2950G-12-EI)	Cisco 2950G (C2950G-24-EI)	Cisco 2950G (C2950G-48-EI)	FastIron 24 Port Model 2402	FastIron 48 Port Model 4802	LinkSys 24 Port Model 1324	SMC Tiger Switch, 8 Port
Median Cost/User Port	\$46.18	\$44.63	\$58.50	\$86.53	\$133.18	\$71.29	\$64.79	\$105.38	\$83.51	\$33.21	\$35.65
w/uplink at 4:1	\$67.08	\$86.42	\$64.87	\$92.91	\$158.68	\$84.04	\$71.16	\$137.67	\$99.66	\$33.21	\$160.65
w/uplink at 2:1	\$87.98	\$86.42	\$71.25	\$99.28	\$158.68	\$84.04	\$77.54	\$137.67	\$115.80	\$33.21	\$160.65
Number of User Ports	48	24	48	48	12	24	48	24	48	24	8
Number of Uplink Ports	2	2	2	2	2	2	2	2	2	2	1
Number of Suppliers	20	23	17	24	24	27	26	3	2	18	7
Switch Median Cost	\$2,217	\$1,071	\$2,808	\$4,154	\$1,598	\$1,711	\$3,110	\$2,529	\$4,008	\$797	\$285
Switch Low Cost	\$1,858	\$735	\$2,519	\$1,875	\$1,299	\$1,449	\$2,615	\$2,097	\$3,497	\$742	\$272
Switch High Cost	\$2,300	\$1,180	\$3,704	\$7,829	\$2,406	\$2,646	\$4,692	\$2,895	\$4,520	\$848	\$307
Uplink Cost 4:1	\$1,003	\$1,003	\$306	\$306	\$306	\$306	\$306	\$775	\$775		\$1,000
Uplink Cost 2:1	\$2,006	\$1,003	\$612	\$612	\$306	\$306	\$612	\$775	\$1,550		\$1,000
Total Median Cost 4:1	\$3,220	\$2,074	\$3,114	\$4,460	\$1,904	\$2,017	\$3,416	\$3,304	\$4,783	\$797	\$1,285
Total Median Cost 2:1	\$4,223	\$2,074	\$3,420	\$4,766	\$1,904	\$2,017	\$3,722	\$3,304	\$5,558	\$797	\$1,285

Table 1

High-End Monolithic
Switch Cost

	BayStack 24 Port Model 380-24T	Extreme 5i	Foundry EdgeIron 24G
Median Cost/User Port	\$291.5 3	\$752.9 4	\$363.5 0
w/uplink at 4:1	\$291.5 3	\$752.9 4	\$363.5 0
w/uplink at 2:1	\$291.5 3	\$752.9 4	\$363.5 0
Number of User Ports	20	12	20
Number of Uplink Ports	4	4	4
Suppliers	15	8	1
Switch Median Cost	\$5,056	\$8,729	\$6,495
Switch Low Cost	\$4,480	\$8,362	
Switch High Cost	\$6,580	\$9,086	
Uplink Cost 4:1	\$775	\$306	\$775
Uplink Cost 2:1	\$775	\$306	\$775
Total Median Cost 4:1	\$5,831	\$9,035	\$7,270
Total Median Cost 2:1	\$5,831	\$9,035	\$7,270

Table 3

Gbic Interface
Module Cost

	1000BaseIX Gbic	1000BaseIX mini- Gbic	3Com 1000BaseIX Module
Number of Suppliers	10	21	24
Switch Median Cost	\$306	\$775	\$1,003
Low Cost	\$119	\$395	\$884
High Cost	\$426	\$861	\$1,244

Table 2

Distribution:

1	MS0797	D. Eichert, 9333	1	MS0874	P. J. Robertson, 1751
1	MS0797	M. Ernest, 9333	1	MS9012	R. D. Gay, 8949
			1	MS9012	S. C. Gray, 8949
1	MS0806	L. Stans, 9336,	1	MS9019	S. J. Marburger, 89451
1	MS0806	J. P. Brenkosh, 9336	1	MS9019	P. D. Warner, 9317
5	MS0806	J. M. Eldridge, 9336	2	MS0899	Technical Library, 9616
1	MS0806	A. Ganti, 9336	1	MS9018	Central Technical Files, 8945-1
1	MS0806	S. A. Gossage, 9336			
1	MS0806	T. C. Hu, 9338			
1	MS0806	B. R. Kellogg, 9336			
1	MS0806	L. G. Martinez, 9334			
1	MS0806	M. M. Miller, 9336			
1	MS0806	J. H. Naegle, 9336			
5	MS0806	R. R. Olsberg, 9336			
1	MS0806	L. G. Pierson, 9336			
1	MS0806	T. J. Pratt, 9338			
1	MS0806	J. A. Schutt, 9336			
1	MS0806	J. D. Tang, 9336			
1	MS0806	T. D. Tarman, 9336			
1	MS0806	L. F. Tolendino, 9334			
1	MS0806	J. S. Wertz, 9336			
1	MS0806	D. J. Wiener, 9336			
1	MS0806	E. L. Witzke, 9336			
1	MS0812	M. J. Benson, 9334			
1	MS0812	L. D. Byers, 9334			
1	MS0812	B. Dominguez, 9334			
1	MS0812	M. D. Gomez, 9334			
1	MS0812	C. M. Keliiaa, 9336			
1	MS0812	J. H. Maestas, 9334			
1	MS0812	S. D. Olsen, 9334			
1	MS0812	M. A. Rios, 9334			
1	MS0812	G. Rudolfo, 9334			
1	MS0812	T. J. Spears, 9334			
1	MS0812	V. K. Williams, 9334			
1	MS0812	P. L. Manke, 9338			
1	MS0812	R. L. Adams, 9338			
1	MS0812	D. B. Bateman, 9338			
1	MS0812	E. J. Klaus, 9338			
1	MS0812	R. L. Moody, 9338			
1	MS0622	D. S. Rarick, 9310			
1	MS0799	G. E. Connor, 9333			
1	MS0801	A. L. Hale, 9300			
1	MS0801	F. W. Mason, 9320			
1	MS0801	M. R. Sjulín, 9330			
1	MS0805	A. Maese, 9335			
1	MS0805	W. D. Swartz, 9329			
1	MS0806	C. R. Jones, 9317			
1	MS0807	J. F. Mareda, 9617			
1	MS0807	J. P. Noe, 9328			
1	MS0813	R. M. Cahoon, 9311			
1	MS0822	C. Pavlakos, 9326			
1	MS0823	J. D. Zepper, 9324			
1	MS0785	R. L. Hutchinson, 5516			
1	MS0785	J. T. Michalski, 5516			