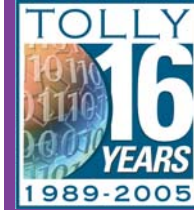


Nortel

Ethernet Routing Switch 5510, 5520, 5530

Layer 2 Performance, Resiliency and Ease of Use



Test Summary

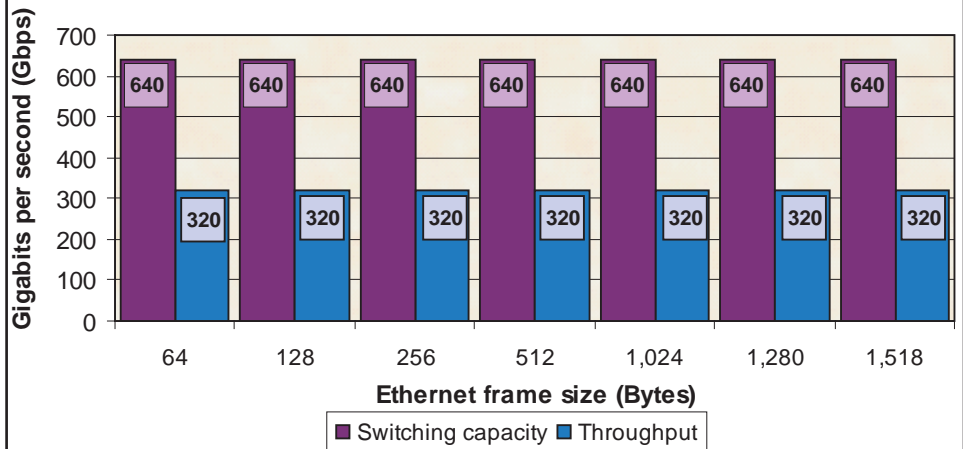
Premise: When considering the purchase of stackable switches, network managers need to know the performance characteristics of the available products. Buyers need to know the bidirectional performance characteristics in a multiple switch stack configuration, plus what impact, if any, a device outage will have on the overall performance of the switching stack.

Nortel commissioned The Tolly Group to evaluate the Layer 2 switching performance, resiliency and ease of use delivered by the company's stackable Ethernet Routing Switch 5510, 5520 and 5530. The Nortel Ethernet Routing Switch 5510 is a single rack-unit stackable Gigabit Ethernet (GbE) Layer 3 routing switch designed to provide high-density Gigabit desktop connectivity to mid and large enterprise customers' wiring closets. In addition to all the features available in the Ethernet Routing Switch 5510, the Ethernet Routing Switch 5520 is equipped with a Power over Ethernet (PoE) capability and the Ethernet Routing Switch 5530 additionally can support up to 12 SFP ports and dual 10-GbE uplinks. All Ethernet Routing Switch 5500 models can be stacked together and managed as a single entity.

Test Highlights

- Delivers superior stacking performance up to 640 Gbps of switching capacity in an eight-switch stack using Nortel Ethernet Routing Switch 5510-48T and 5520-48T-PWR when handling frame sizes of 64 through 1,518 bytes with ultra-low latency
- Achieves wire-speed performance across 48 GbE ports of a Nortel Ethernet Routing Switch 5510-48T in a standalone configuration, when handling Ethernet frame sizes of 64 through 1,518 bytes
- Achieves up to 160 Gbps of switching capacity and 80 Gbps of aggregate Layer 2, zero-loss throughput in a configuration of two 5510-48T switches
- Enables a failed device to be hot-swapped in the stack and acquire software and configuration files without requiring a stack reboot, thereby maintaining mission-critical applications
- Enables quick per-port configuration of basic security features

Zero-loss ($\leq 0.001\%$) Aggregate Layer 2 Throughput of Ethernet Routing Switch 5510-48T in an Eight-switch Stack Configuration (320 GbE ports)
As reported by SmartBits SmartFlow

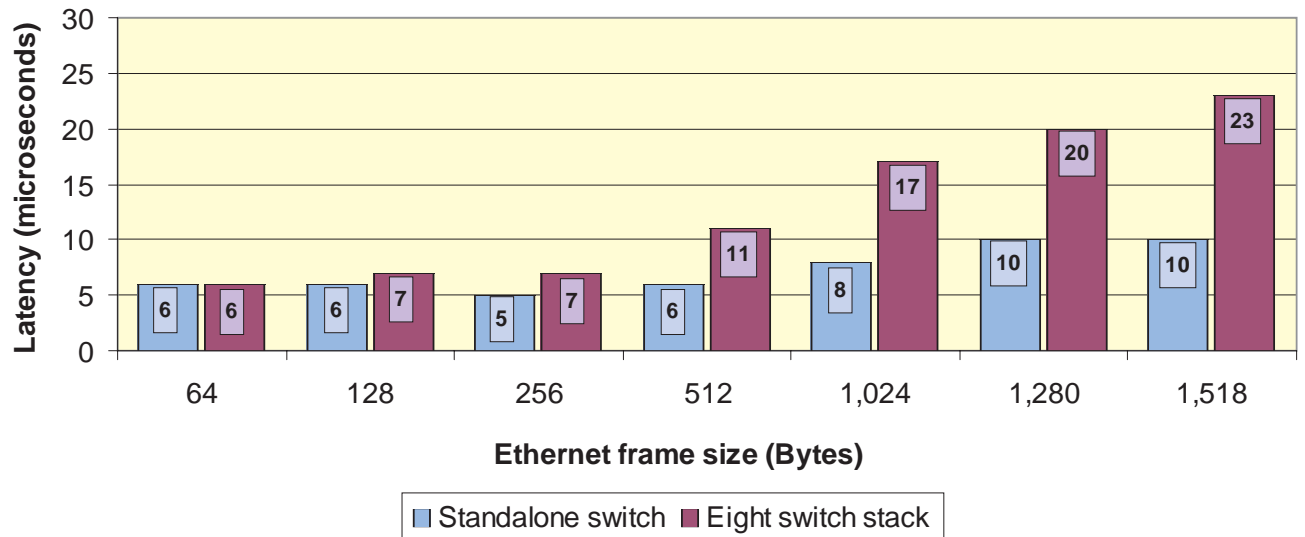


Note: A custom port-pairing scheme was used. See the "Test Configuration and Methodology" section.

Source: The Tolly Group, September 2005

Figure 1

Average Store and Forward Latency (Microseconds) of the Ethernet Routing Switch 5510-48T
Eight-switch Stack and Standalone Switch Scenarios As Reported by SmartBits SmartFlow



Note: The offered load used to measure latency was 90% of the theoretical maximum; Latency reported in the chart is "cut-through" latency.

Source: The Tolly Group, September 2005

Figure 2

Tolly Group engineers measured the amount of usable Layer 2, zero-loss throughput as experienced by users. In addition, they reported the stackable switching capacity, or the total switching throughput "external" to users and "internal" between switch stack elements. Engineers also noted the latency and standard deviation (Jitter) of the three Nortel stackable switches in a variety of configurations and different traffic frame sizes.

Engineers examined an Intelligent Auto Unit Replacement feature to verify that in the event of a switch failure within the stack, other switches continue to function and the dormant unit can be hot swapped without impacting stack activity. Lastly, Tolly

Group engineers noted their observations regarding the ease-of-use for enabling quick per-port configuration of basic security features.

All tests were conducted in September 2005 at Nortel facilities in Santa Clara, Calif. and audited by Tolly Group personnel. Throughput results reported by The Tolly Group are taken directly from the SmartBits test tool used in testing and identify the full-duplex throughput across the switch fabric. The Tolly Group also is reporting a bandwidth capacity measurement commonly used by vendors, representing the aggregate capacity of traffic flowing across all ports in a test configuration.

RESULTS AND ANALYSIS

ZERO-LOSS THROUGHPUT IN AN EIGHT-SWITCH STACK

The Tolly Group tested the Ethernet Routing Switch 5510-48T (seven switches) and 5520-48T-PWR (one switch) in an eight-switch stack configuration. In this test, a total of 320 GbE ports were used (40 ports per switch) and connected to the 320 SmartBits ports. Engineers used a custom port-pairing scheme. For details of the port-pairing scheme, see the "Test Configuration and Methodology" section. The Tolly Group verified that the Ethernet Routing Switch 5510-

48T and Ethernet Routing Switch 5520-48T-PWR switches in this configuration provided 320 Gbps (640 Gbps full duplex) of zero-loss aggregate Layer 2 throughput using 320 GbE ports for the Ethernet frame sizes of 64, 128, 256, 512, 1,024, 1,280 and 1,518 bytes. The stackable switching capacity was 640 Gbps. (See Figure 1.)

This test also proved that the Nortel stacking solution functions properly with mix of Power over Ethernet (PoE) switches and non-PoE switches in the same stack and that mixing the two types doesn't have

any impact on the performance. No PoE client devices (e.g. VoIP phone, WLAN AP) were actually connected during the testing as all ports were used for traffic generation equipment.

The Tolly Group also measured the average latency and calculated its standard deviation values in the eight-switch stack configuration. (SmartFlow calculates the standard deviation from its measured latency values and reports.) The Nortel Ethernet Routing Switch 5510 and Ethernet Routing Switch 5520 switches in the stack configuration demonstrated very low latency and standard deviation,

Nortel

**Ethernet
Routing Switch
5510, 5520, 5530**

**Zero-Loss
Throughput,
Resiliency and Ease of Management**



tion, introducing just 6-23 microseconds of average latency and 0-9.7 microseconds of standard deviation. (See Figure 2.)

**ZERO-LOSS THROUGHPUT:
NORTEL 5510-48T AND
TWO STACKING PORTS**

Nortel

Ethernet Routing Switch 5510 Product Specifications*

Feature

Switch fabric

- 160 Gbps (5510 and 5520)
- 192 Gbps (5530)

Stackable switching capacity

- 80 Gbps per switch
- Up to 640 Gbps for a full stack of eight

Power over Ethernet

- IEEE 802.3af (5520 only)

Link aggregation

- Distributed MultiLink Trunking for link fail-over

- IEEE 802.3ad

Quality of Service

- IETF DiffServ (DSCP) and IEEE 802.1p

Security

- Denial-of-Service (DoS) protection

Traffic flow analysis

- IPFIX (IP Flow Information Export)

Port forwarding/filtering performance

- For 10 Mbps: 14,880 pps maximum (64-byte packets)
- For 100 Mbps: 148,810 pps maximum
- For 1000 Mbps: 1,488,100 pps maximum
- For 10 Gbps: 14,880,950 pps maximum (5530 only)

Network protocol and standards compatibility

- 10BASE-T/100BASE-TX/RJ-45/1000BASE-T
- IEEE 802.3u Autonegotiation on Twisted Pair
- IEEE 802.3x (10/100 Flow Control)
- IEEE 802.3z 1000BASE-SX and 1000BASE-LX
- IEEE 802.3ae 10 Gigabit XFP (5530 only)
- IEEE 802.1d MAC Bridges
- IEEE 802.1Q (VLAN Tagging)

- IEEE 802.1D Spanning Tree Protocol

SFP GBICs

- 1000BASE-SX
- 1000BASE-LX
- 1000BASE-CWDM

10 Gigabit XFPs (5530 only)

- 10GBASE-LR
- 10GBASE-ER
- 10GBASE-SR

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URL: <http://www.nortel.com>

**Vendor-supplied information not verified by The Tolly Group*

The Tolly Group tested the Ethernet Routing Switch 5510-48T in a configuration with two switches and measured the throughput across the 5510-48T switch at the bottom of stack only. In this test, the primary DUT was the Ethernet Routing Switch 5510-48T at the bottom of the stack; the Ethernet Routing Switch 5510-48T at the top was utilized to provide the connectivity between the SmartBits ports and the stacking ports (Nortel provides two full-duplex 20 Gbps stacking connections and these cannot be connected to the SmartBits directly) The Tolly Group verified that the Ethernet Routing Switch 5510-48T switch at the bottom of the stack provided 80 Gbps of zero-loss, Layer 2 throughput using 40 Gigabit Ethernet ports (of the 48 on the device) and two stacking ports

for the Ethernet frame sizes of 64, 128, 256, 512, 1,024, 1,280 and 1,518 bytes. Engineers used a custom port-pairing scheme. For details of the port-pairing scheme, see the "Test Configuration and Methodology" section. The stackable switching capacity was 160 Gbps. (See Figure 3.)

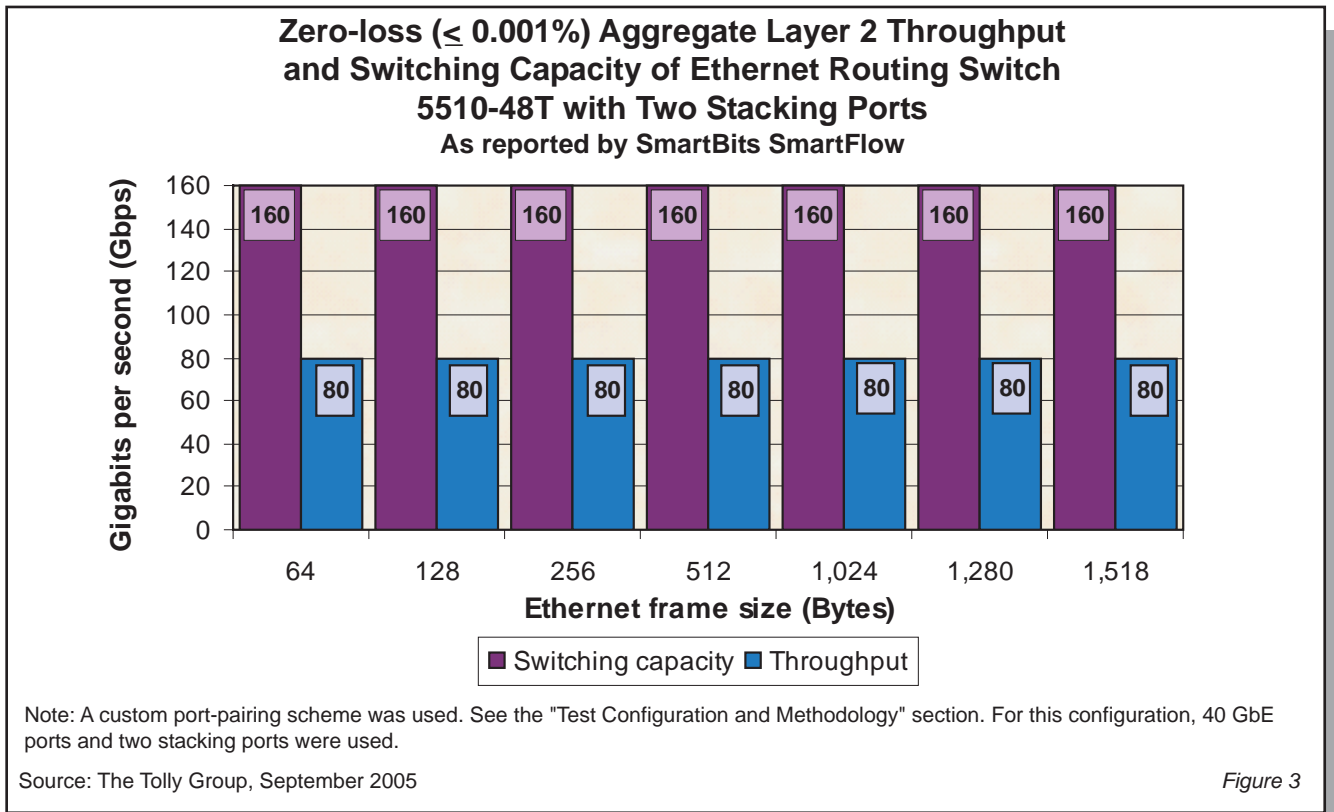
The test results prove that the Ethernet Routing Switch 5510-48T can utilize two full-duplex 20 Gbps connections to the other Ethernet Routing Switch 5510-48T and 40 full-duplex GbE ports of the switch were connected to the 40 GbE SmartBits ports.

**ZERO-LOSS THROUGHPUT:
NORTEL 5510-24T AND
TWO STACKING PORTS**

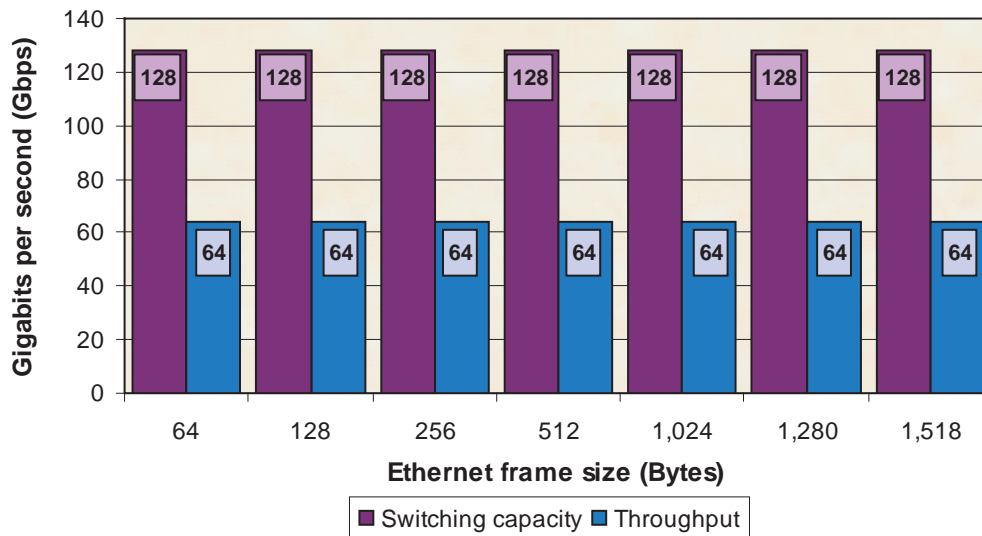
The Tolly Group tested the Ethernet Routing Switch 5510-

24T in a configuration with three switches and measured the throughput across the Ethernet Routing Switch 5510-24T in the middle of stack. The Ethernet Routing Switch 5510-24T supports 24 10/100/1000 Base-T ports and two GBIC ports. Ports 23 and 24 offer configuration flexibility by allowing network administrators to configure each port as either 10/100/1000 or make use of SFP and CWDM GBICs. In this test, the primary DUT was the Ethernet Routing Switch 5510-24T in the middle of the stack and the Ethernet Routing Switch 5510-24T switches at the top and bottom of the stack were used to connect with the Spirent tools.

The Tolly Group verified that the Ethernet Routing Switch 5510-24T in the middle of the stack provided 64 Gbps of zero-



**Zero-loss ($\leq 0.001\%$) Aggregate Layer 2 Throughput
and Switching Capacity of Ethernet Routing Switch
5510-24T with Two Stacking Ports
As reported by SmartBits SmartFlow**



Note: A custom port-pairing scheme was used. See the "Test Configuration and Methodology" section. For this configuration, 24 GbE ports and two stacking ports were used.

Source: The Tolly Group, September 2005

Figure 4

loss, Layer 2 throughput using 24 GbE ports and two stacking ports for the Ethernet frame sizes of 64, 128, 256, 512, 1,024, 1,280 and 1,518 bytes. The stackable switching capacity across all ports was 128 Gbps. (See Figure 4.) Engineers used a custom port-pairing scheme. For details on the port-pairing scheme used, see the "Test Configuration and Methodology" section.

The test results prove that the Ethernet Routing Switch 5510-24T supported and fully utilized a full-duplex 20 Gbps connection to the top Ethernet Routing Switch 5510-24T, another full-duplex 20 Gbps connection to the bottom Ethernet Routing Switch 5510-24T and, finally, 24 full-duplex GbE ports of the middle switch were connected to the 24 GbE SmartBits ports.

ZERO-LOSS THROUGHPUT FOR A STANDALONE SWITCH

Engineers measured the zero-loss ($\leq 0.001\%$) Layer 2 throughput (across 48 GbE ports) of a Nortel Ethernet Routing Switch 5510-48T in a standalone configuration, when handling Ethernet frame sizes of 64, 128, 256, 512, 1,024, 1,280 and 1,518 bytes. See the "Test Configuration and Methodology" section for a detailed port-pairing description. Engineers also measured the average latency and its standard deviation in the same configuration. Standard deviation of the latency values is a statistical method of calculating how much the latency of a set of received packets varies from the mean. It is similar to jitter.

The Tolly Group verified that the Ethernet Routing Switch 5510-48T provides wire-speed throughput for all ports by recording 48 Gbps of zero-loss, Layer 2 throughput using 48 GbE ports for the Ethernet frame sizes of 64, 128, 256, 512, 1024, 1280 and 1,518 bytes.

Tolly Group auditors also measured the average latency and jitter in this configuration for the Ethernet frame sizes of 64, 128, 256, 512, 1,024, 1,280 and 1,518 bytes. Latency was measured using the "cut-through" method. The Nortel Ethernet Routing Switch-5510 switches in standalone mode demonstrated very low latency and standard deviation by recording 5-20 microseconds of average latency and 0.9-9.9 microseconds of standard deviation.

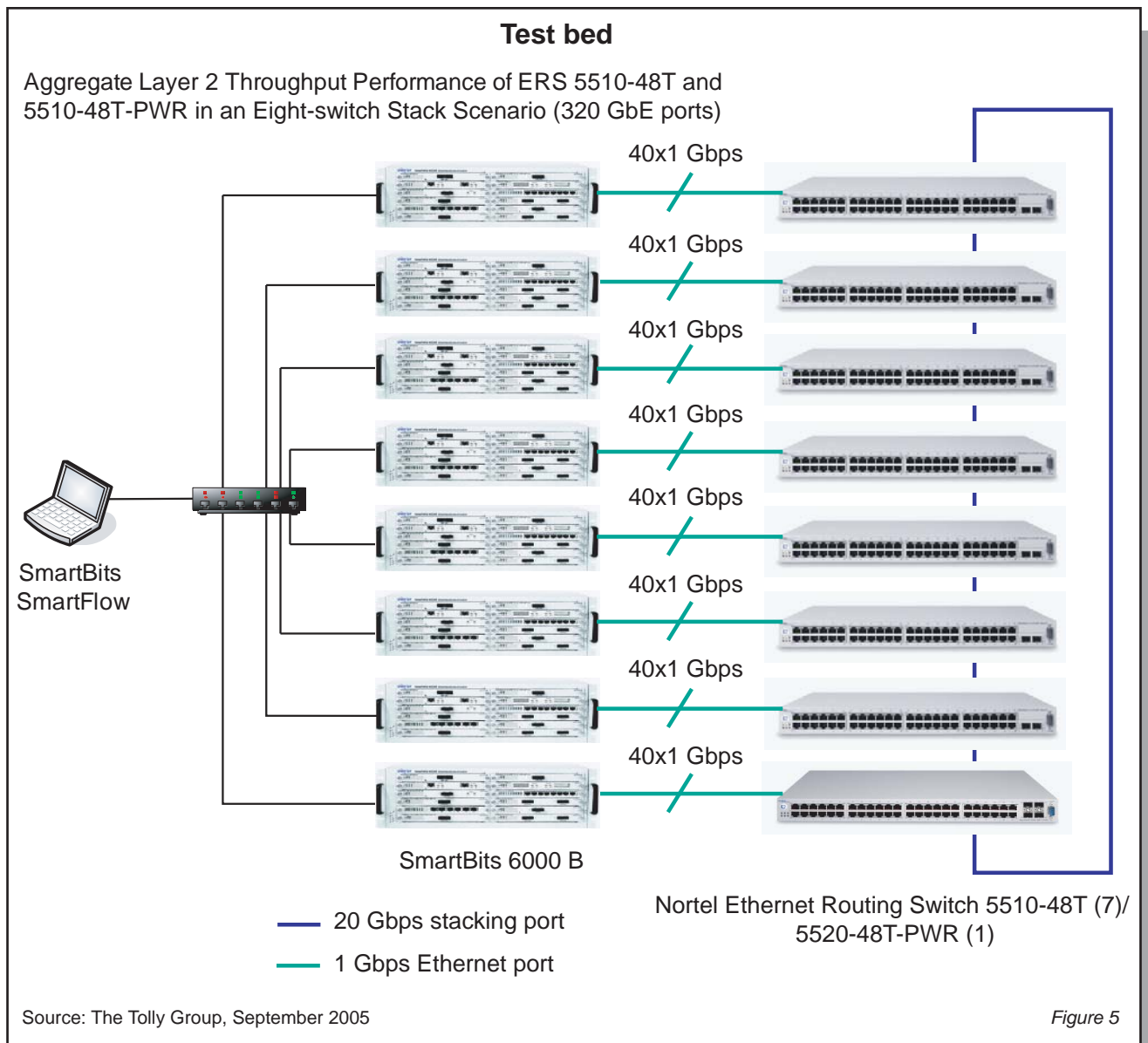
"INTELLIGENT AUTO UNIT REPLACEMENT" VERIFICATION

The Tolly Group verified that even in the event of a single switch failure within a stack of Ethernet Routing Switches, the other switches continue to function. The Tolly Group also verified that Nortel's Intelligent Auto Unit Replacement feature enables a failed device to be hot-swapped in and automatically download the master image and configuration files

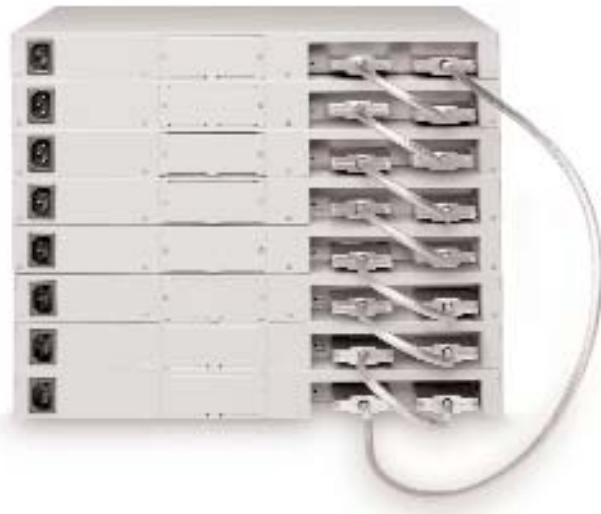
used by the other switches in the stack without requiring a reboot of the stack. The business benefit of not requiring a stack reboot is that mission-critical applications such as IP telephone calls or on-line Web sessions remain active even as a switch is being replaced. This test was performed only on the Ethernet Routing Switch 5530 but, according to Nortel, this feature is available on all Ethernet Routing Switch 5500 models, since they support the same software.

EASE OF USE/ MANAGEMENT

This test was a demonstration of the single-click security provisioning for the Ethernet Routing Switch 5530-24TFD switch. (While this feature was tested only on this switch, it is available on all of the Nortel Ethernet Routing Switch 5500 models.) This feature is available as a standalone Java application or it can be browser-based. The demonstration used the Netscape browser. First,



Nortel Ethernet Routing Switch Back View Eight-Switch Stack with Connected Stacking Ports



Source: The Tolly Group, September 2005

Figure 6

engineers clicked on the switch ports needed to provision with a feature or features. Then a list of available features was presented via a drop-down menu, and users could click on the one(s) they wanted and apply them.

The security provisioning applications were accessed through a QoS wizard. This wizard allows switch administrators to quickly configure basic security features by enabling per-port security protection from attacks such as ARP spoofing, DHCP spoofing, and DHCP snooping. The demonstration did not involve testing any simulated attacks or threats, but the interface was very simple and intuitive.

TEST CONFIGURATION AND METHODOLOGY

For performance tests, The Tolly Group tested three Nortel stackable switches, all running version 4.2.0.4 of the switch software: Ethernet Routing Switch 5510, 5520, and 5530.

According to Nortel, this was production software generally available to the customer base.

For the Layer 2, zero-loss throughput test of the stand-alone Ethernet Routing Switch 5510-48T the test bed was configured such that the SmartBits SmartFlow port-pairing scheme was: Port #1 of the switch was destined for Port #2, and Port #3 for Port #4 and so on. So, the total number of ports involved in this test was 48 ports, which in turn connected to the same number of SmartBits ports.

Engineers measured the Layer 2 throughput of the switch in a stand alone configuration (48 GbE ports) for the Ethernet frame sizes of 64, 128, 256, 512, 1,024, 1,280 and 1,518 bytes. Also, engineers measured the average latency and its standard deviation (calculated and reported by the SmartFlow) in the same configuration.

For the test, engineers set up the

SmartBits cluster, configured the switch for Layer 2 in stand-alone mode and then connected the SmartBits cluster to the switch. Engineers also configured SmartFlow for the appropriate port-pairing scheme, frame sizes, load profile and test duration. Then they ran the test and record the results. The test was repeated twice more and the results were averaged.

For the zero-loss Layer 2 throughput test of the Ethernet Routing Switch 5510-48T and 5510-48T-PWR in an eight-switch stack configuration, SmartBits SmartFlow was configured for the following port-pairing scheme: 20 ports of the switch #2 were destined for the 20 ports of the switch #1 and the other 20 ports of the switch #2 were destined for the 20 ports of the switch #3 and so on across the eight-switch stack. Finally, 20 ports from switch #1 were destined for 20 ports of switch #8. The total number of ports involved in this test was 320 ports, which in turn connected to the same number of SmartBits ports. The test procedure was similar to the stand-alone Ethernet Routing Switch test. (See Figures 5 and 6.)

For the zero-loss Layer 2 throughput test of the Ethernet Routing Switch 5510-48T in a three-switch stack configuration (24 GbE ports and two stacking ports), SmartBits SmartFlow was configured for the following port-pairing scheme: 10 ports of the switch in the middle of the stack were paired with 10 ports of the switch in the top, the other 10 ports of the switch in

the middle were paired with 10 ports of the switch in the bottom and the remaining four ports of the switch in the middle were paired each other. The procedure was similar to the standalone Ethernet Routing Switch test.

For the zero-loss Layer 2 throughput test of the Ethernet Routing Switch 5510-48T in a dual-switch stack configuration

(40 GbE ports and two stacking ports), SmartBits SmartFlow was configured for the following port-pairing scheme: 40 ports of the switch in the bottom of the stack were paired with 40 ports of the switch in the top of the stack. The test procedure was similar to the standalone Ethernet Routing Switch test.



The Tolly Group gratefully acknowledges the providers of test equipment used in this project.

Vendor	Product	Web address
Spirent Communications	SmartFlow ver 4.7	http://www.spirentcom.com
Spirent Communications	SmartBits 6000C ver 2.6	http://www.spirentcom.com

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PROJECT PROFILE

Sponsor: Nortel

Document number: 205137

Product Class: Stackable Gigabit Ethernet switch

Products under test:

- Ethernet Routing Switch 5510-24T
- Ethernet Routing Switch 5510-48T
- Ethernet Routing Switch 5520-48T-PWR
- Ethernet Routing Switch 5530-24TFD

Testing window: September 2005

Software status:

- Generally available

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