THE TOLLY GROUP

No. 207237 SEPTEMBER 2007

Nortel

Ethernet Routing Switch 4548GT-PWR

Competitive Layer 2 Performance Evaluation vs Cisco Catalyst 3560G-48PS and 3750G-48PS

TOLLY Up to Spec CERTIFIED Test Summary

Premise: *When considering the purchase of standalone and stackable switches, network managers need to know the performance of the switches, plus what impact, if any, a device outage will have on the performance of the switch stack.*

Nortel commissioned The Tolly Group to evaluate the company's stackable Ethernet Routing Switch 4548GT-PWR to determine its Layer 2 switching performance, stack resiliency and cost-per-Gigabit of throughput delivered.

The Nortel ERS 4548GT-PWR is a member of Nortel's ERS 4500 series of stackable switches that includes Fast Ethernet and Gigabit Ethernet (GbE) models designed to provide high-density desktop connectivity to mid and large enterprise customers' wiring closets.

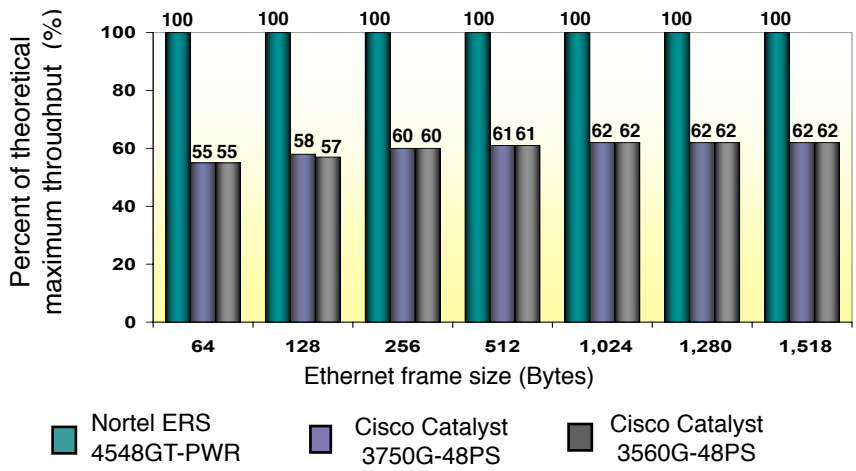
Engineers measured the bidirectional Layer 2 performance of the ERS 4548GT-PWR in a stack configuration and in standalone mode. Engineers also measured the stackable performance and resiliency characteristics of the Nortel ERS 4548GT-PWR in a five-switch stack against a Cisco Systems Inc. Catalyst 3750G-48PS. Tolly Group engineers also measured the standalone performance of the Nortel ERS 4548GT-PWR against the Catalyst 3750G-48PS and Catalyst 3560G-48PS switches to calculate the cost-per-Gigabit of throughput. The Catalyst 3560G-48PS is not a stackable switch and was not used in the five-switch stack performance test. Tests were conducted in May 2007.

Test Highlights

- Achieves 48 Gbps of throughput vs 26 to 30 Gbps for Cisco switches in a standalone configuration.
- Offers a Cost-per-Gigabit of Throughput that is almost 72% lower than Cisco products tested —$70 vs. $250 for the Catalyst 3750G-48PS and $153 for the Catalyst 3560G-48PS
- Delivers over 3X higher performance in a five-unit stack than the Catalyst 3750G —100 Gbps vs. 26 to 30 Gbps
- Exhibits up to 4X more throughput than the Catalyst 3750G-48PS in the stack resiliency test for 64 byte frames
- Uses 72% less time to add a new unit to an operational stack compared to the Catalyst 3750G

Layer 2 Zero-Loss (≤ 0.001%) Throughput of Switches in a Standalone, Full-Mesh Configuration (48 GbE ports tested)

as reported by Spirent SmartFlow 5.5



Source: The Tolly Group, August 2007

Figure 1

Executive Summary

The Nortel ERS 4548GT-PWR demonstrated higher performance and significantly lower cost-per-Gigabit of throughput than competitors tested.

Tolly Group engineers measured the throughput characteristics of a five-unit stack of Nortel ERS 4548GT-PWR switches against a five-unit stack of Cisco Catalyst 3750G-48PS switches.

First, engineers measured the Layer 2, zero-loss throughput as experienced by users in a standalone switch. Engineers used a Nortel ERS 4548GT-PWR switch against Cisco Catalyst 3560G-48PS and 3750G-48PS switches. The ERS 4548GT-PWR switch achieved wire-speed throughput in a standalone switch scenario, while the Cisco switches achieved about 60% of the theoretical maximum throughput across all frame sizes.

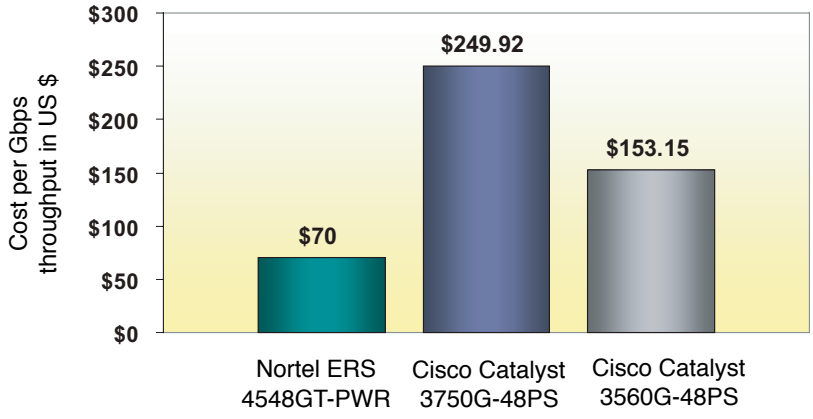
Using the standalone performance results, engineers computed a cost-per-Gigabit of throughput, to obtain the cost of each switch as a factor of performance. The Nortel ERS 4548GT-PWR achieved a cost-per-Gigabit of throughput that was 55 % lower than the Cisco Catalyst 3560G-48PS and 72% lower than the Cisco Catalyst 3750G-48PS.

The Nortel switch stack demonstrated throughput of up to 100 Gbps while the stack of similarly configured Cisco switches demonstrated aggregate performance ranging from 26 to 30 Gbps. The performance of the Catalyst 3750 represented less than a third of the stacking performance delivered by for the Nortel ERS 4500 stack.

A companion Test Summary, Document 207220, details the ERS 4500 Layer 2 performance and resiliency in an eight-switch stack. The ERS 4500 yielded 160 Gbps of zero-loss aggregate Layer 2 throughput using 160 GbE ports for Ethernet frame sizes of 64 to 1,518 bytes. For details, visit:

http://www.tolly.com/DocDetail.aspx?DocNumber=207220

Cost per Gigabit of Throughput in a Standalone Switch Configuration



Source: The Tolly Group, August 2007

Figure 2

Tolly Group engineers also examined the resiliency of a five-switch stack by creating a single unit failure in a VLAN on the throughput of a different VLAN in the stack. Results show that Nortel exhibited 4X greater throughput versus the similarly configured Cisco stack.

Finally, engineers examined the time required to logically provision a switch into an existing two-unit stack. The ERS 4548GT-PWR takes 72% less time than the Cisco devices tested to add a switch to an existing stack.

Standalone Switch Performance

The Nortel ERS 4548GT-PWR was compared against the Cisco Catalyst 3560G-48PS and 3750G-48PS switches in terms of Layer 2 zero-loss (≤ 0.001%) throughput in a standalone full-meshed configuration, when handling Ethernet frame sizes of 64 bytes to 1,518 bytes. Results show that the Nortel ERS 4548GT-PWR achieved 100% of the maximum throughput while handling Layer 2 traffic transmitted across 48 ports in a full-mesh configuration.

The Cisco Catalyst 3560G-48PS and 3750G-48PS only achieved throughput of 54.8% of the theoretical maximum for 64-byte frames; 60% for 256-byte frames; 61.3% for 128-byte frames and 61.9% for 1,024-,1,280- and 1,518-byte frames. For 128-byte frame sizes, the Catalyst 3560G-48PS demonstrated throughput of 57.4% of the theoretical maximum and Catalyst 3750G-48PS demonstrated throughput of 58.3%. (See Figure 1.)

Cost Versus Throughput

For cost-conscious network managers, the switch of choice is one that can perform at a high level while simultaneously keeping the cost low for each Gigabit of throughput delivered.

The Tolly Group used the standalone switch throughput results to calculate a cost-per-Gigabit of throughput for the three switches tested. This is done by dividing the

switch price by the measured standalone throughput. (See Figure 2.)

The Nortel switch offered the lowest cost at just $70 per Gigabit/throughput, 3.5 times less than the Catalyst 3750G-48PS and 2.1 times less than the Cisco Catalyst 3560G-48PS.

FIVE-SWITCH STACK PERFORMANCE

Tolly Group engineers measured the throughput characteristics of a five-switch stack of Nortel ERS 4548GT-PWR against a similarly configured stack of Cisco Catalyst 3750G-48PS switches.

The Tolly Group verified that the Nortel ERS 4548GT-PWR in a five-switch stack provided 100 Gbps of zero-loss aggregate Layer 2 throughput using 100 GbE ports for the Ethernet frame sizes of 64 to 1,518 bytes. By contrast, the Catalyst 3750G-48PS achieved 26, 27.5, 28, and 29 Gbps for the Ethernet frame sizes of 64, 128, 256 and 512 bytes, respectively. The Catalyst 3750G-48PS delivered 30 Gbps for frame sizes of 1,024, 1,280, and 1,518 bytes. (See Figure 3.)

The Tolly Group also measured the jitter in a four-switch stack. Jitter provides a measurement on the variation in latency introduced by the network equipment.

The Nortel ERS 4548GT-PWR switches in the stack demonstrated jitter ranging from zero for frame sizes of 64, 128, 512 and 1,518 bytes; 1.70 microseconds (µsec) for frame sizes 256 and 1,280 bytes, and 9.4 µsec for frame sizes of 1,024 bytes while the Cisco Catalyst 3750G-48PS switch demonstrated 10 µsec for frame sizes 64-, 128-, 256- and 512-, 7 µsec for 1,024- and 4 µsec for 1,280- and 1,518-byte frames. (See Figure 5.)

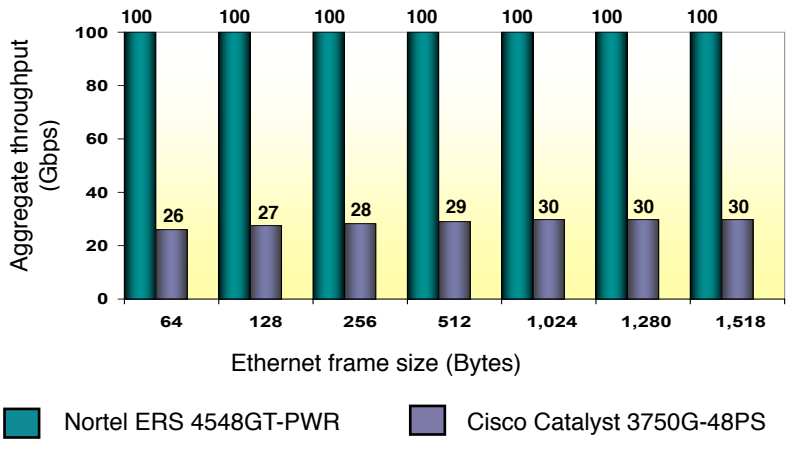
STACK RESILIENCY

Switches in a stack may fail for a variety of reasons, yet users need to minimize the impact of such an unplanned outage.

To determine how the switches under test respond to an outage, Tolly Group engineers simulated a

Zero-Loss (≤ 0.001%) Gigabit Ethernet Layer 2 Throughput in a Five-Switch Stack (100 GbE ports tested)

as reported by Spirent SmartFlow 5.5



Source: The Tolly Group, August 2007

Figure 3

Nortel

ERS 4500 Series

Zero-Loss Throughput, Stack Resiliency and Price-per-Gigabit of Throughput

Product Specifications

Vendor-supplied information not necessarily verified by The Tolly Group

ERS 4500 Series

Dimensions
- Width: 438 mm (17.25 in)
- Height: 1RU 43.7 mm (1.72 in)
- Depth: 368.3 mm (14.5 in)

ERS 4500 Models:
- 4526FX: 24 100 Base FX ports plus 2 combo 10/100/1000 SFP ports, HiStack Ports and RPS slot.
- 4550T: 48 10/100 Base TX ports plus 2 combo 10/100/1000 SFP ports, HiStack ports and RPS slot.
- 4550T-PWR: 48 10/100 802.3af PoE ports plus 2 combo 10/100/1000 SFP ports, HiStack ports, RPS connector.
- 4550GT: 48 10/100/1000 Base TX ports and 4 shared SFP ports plus HiStack ports and RPS slot.
- 4550GT-PWR: 48 10/100/1000 802.3af PoE ports, 4 shared SFP ports plus HiStack ports, RPS connector.

Technical Specifications:
- Resiliency Stacking: Up to 8 Units
- Stacking Ports: 2 built in HiStack ports per switch
- Total stacking architecture: 320 Gbps
- Individual switch architecture: 48.8-184 Gbps

PoE Specifications:
- 802.3af compliant with power classification support
- Maxi. power AC 320 watts
- Max. DTE power AC + RSP 740 watts
- Max power consumption: 150W-470W

Environmental Specifications
- Operating temp. 0 to 50 degrees C
- Peek noise level: 37.2-43.3dBA
- Thermal rating: 222-850 BTU/hr
- Calculated MTBF: 214,524-305,192hrs

For more information contact:

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switch failure in the stack by removing a power cable. Engineers compared the responses of the five-unit Nortel ERS 4548GT-PWR switch stack and the Cisco Catalyst 3750G-48PS, five-switch stack to the switch loss due to the power interruption.

The 100 GbE switch ports in the stack were distributed as 60 GbE ports in VLAN 1 and 40 GbE ports in VLAN 2, and the corresponding input traffic consisted of 64-byte frames at approximately 60 Gbps into VLAN 1 and 40 Gbps into VLAN 2. The test duration was 60 seconds, and switch failure was introduced 30 seconds after the test started in VLAN 2.

Engineers verified that in the five-unit Nortel stack, there was no adverse impact on performance or operation of the remaining four switches when one switch failed. Results show that the Nortel switch stack achieved 60 Gbps throughput across the VLAN1 while Cisco achieved only 14 Gbps. (See Figure 4.)

The results prove that in the event of a failure within a Nortel switch stack, the remaining units remain operational and uplinks continue to provide network connectivity to users.

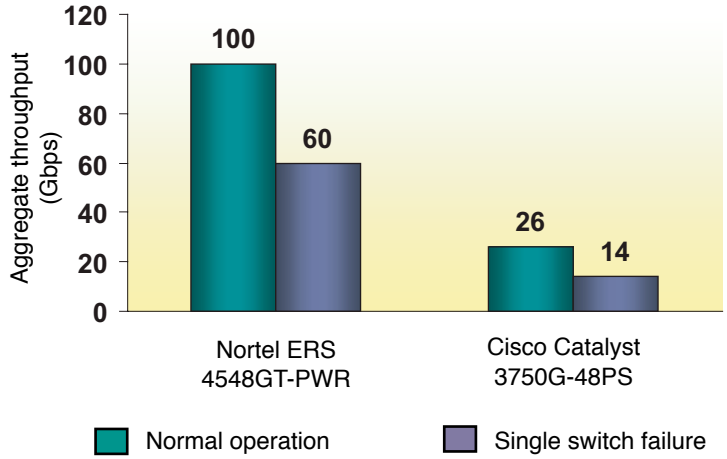
Switch Stack Expansion

A growing business needs a network that can seamlessly scale to accommodate an increasing number of users and applications. This means it should be able to grow without spending a lot of time to build a stack.

Engineers measured the time to logically provision one switch into an existing dual-switch stack. Test results show that Nortel needed only 53 seconds to recognize a Nortel ERS 4548GT-PWR that was added into a dual-switch stack and powered up, while Cisco needed 192 seconds for the same operation with its Catalyst switches.

Layer 2 Stack Resiliency:
Impact of Switch Failures on Throughput (Gbps) in a Five-Switch Stack with 64-byte Frames

as reported by Spirent SmartFlow 5.5



Note: The aggregate throughput was reported for VLAN1 during the entire test duration. Please refer to the test methodology section for details.

Source: The Tolly Group, August 2007 *Figure 4*

This demonstrates that the Nortel ERS 4548GT-PWR requires 3.6X less time than the Cisco Catalyst 3750G-48PS to integrate a new unit into an existing stack

Test Setup and Methodology

The Tolly Group tested a Nortel ERS 4548GT-PWR switch (running software version 5.0.1) against two Cisco switches —a Catalyst 3560G - 48PS and a Catalyst 3750G-PS, with switch, each running software version 12.2. All switches were tested with production software generally available to the customer base.

For traffic generation, engineers utilized a Spirent SmartBits 6000C with SmartFlow version 5.50.

Standalone Switch Performance

Engineers tested the zero-loss throughput for the Ethernet frame sizes of 64 bytes to 1,518 bytes in a full-mesh configuration. The test bed consisted of the DUTs as a standalone switch connected to 48 GbE ports on a SmartBits 6000C traffic generator.

Engineers set up the SmartBits cluster, configured the switch for Layer 2 in standalone mode and then connected the SmartBits cluster to the switch. For measuring the zero-loss throughput, the acceptable frame loss percentage set at less than or equal to 0.0019% The procedure was similar to the five-switch stack described earlier.

Cost Versus Throughput

Engineers used the throughput results and gathered the MSRP retail prices for the switches tested. Engineers acquired prices from Nortel and Unistar-Sparco Computers,Inc.(a Cisco authorized reseller.), respectively. The ERS 4548GT-PWR was prices at $6,995; the Catalyst 3750G-48PS cost $15,495 and the Catalyst 3560G-48PS cost $9,495. Prices

were gathered in July 2007 and represent hardware cost only.

Engineers measured the throughput achieved in standalone switch mode with 1,518-byte packets. Bidirectional traffic was generated in a full-mesh configuration. Engineers computed the cost-per-Gigabit by dividing the cost by the throughput.

Stack Performance

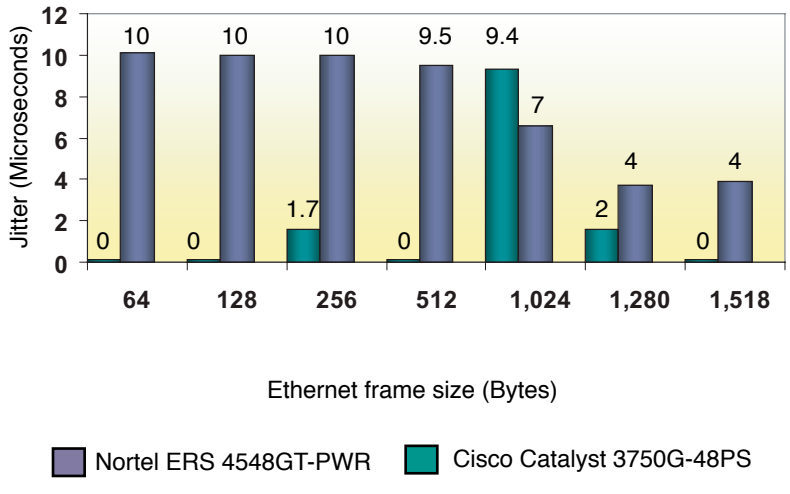
Engineers tested the Layer 2 aggregate throughput of a five-unit switch stack. Each vendor's stack consisted of 48-port GbE switches. Nortel's switch stack consisted of five ERS 4548GT-PWR switches, while the Cisco stack consisted of five Catalyst 3750G-48PS switches.

Both switching stacks were connected to Spirent SmartBits 6000C test systems. From the Spirent test systems, a total of 100 10/100/1000 Base-T ports were connected to the five-switch stack. A total of 20 10/100/1000 Base-T connections were made between each switch and the Spirent test system.

Engineers configured Spirent SmartFlow Version 5.5 for the following port-pairing scheme: 10 ports of the switch #2 were destined for 10 ports of switch #1; another 10 ports of switch #2 were destined for 10 ports of switch #3 and so on across the five-unit stack. Finally 10 ports from switch #1 were destined for 10 ports of switch #5. The test was run on 100 ports using SmartFlow. Traffic consisted of 64- to 1,518-byte frames, transmitted for 60 seconds.

For measuring the zero-loss throughput of the DUTs, the acceptable frame loss percentage was set at less than, or equal to, 0.001%. Engineers also disabled the Spanning Tree Protocol and auto topology feature and increased the MAC aging time limit to 65,535 seconds in the stack.

The Tolly Group also measured jitter in a four-switch stack For measuring the jitter of devices under test, engineers used the "Latency distribution" test of SmartFlow. Each test was run for 60 seconds, repeated three times and results were averaged.



Source: The Tolly Group, August 2007

Figure 5

Stack Resiliency in a Five-Switch Configuration

For the stack resiliency test, the same five-switch stack was set up into two VLANs, with 60 GbE ports in VLAN 1 and the remaining 40 GbE ports in VLAN 2.

The test traffic consisted of 64-byte Ethernet frames transmitted at 100% of line rate across the 100 GbE ports in the stack. The test duration was set at 60 seconds, and switch failure was introduced 30 seconds after the test started by removing the power cable of the switch in the VLAN2. The aggregate throughput across the stack was measured during the 60-second period.

Tests were run for three iterations and the results were averaged.

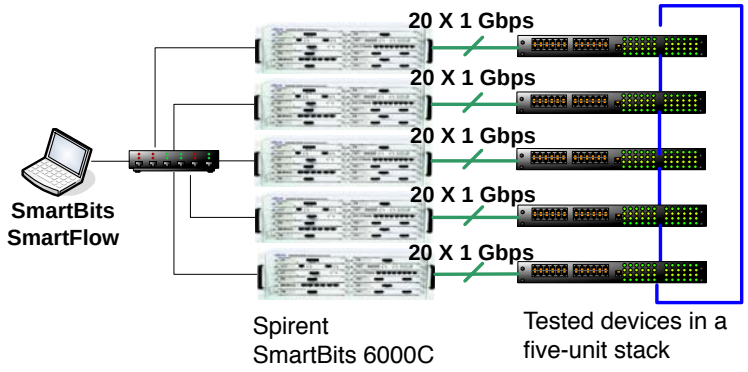
Switch Stack Expansion

Engineers examined the amount of time required for a switch to join a two-unit stack and have it be recognized by other devices.

Nortel's switch stack consisted of two 4548GT-PWR switches, while the Cisco switch stack consisted of two Catalyst 3750G-48PS switches. The new unit added to each stack was the same model present in the stack (ERS 4548GT-PWR and Catalyst 3750G-48PS).

With the switch physically connected to the stack, engineers recorded the time (in seconds using a stopwatch) to provision the switch into the stack. Timing began when the switch was toggled to the "ON" position, downloaded all configuration files onto the new switch, until it was recognized by the stack and displayed as "up" by the management console. Engineers used factory default settings for both vendors at the start of the test.

Test Bed Diagram



Source: The Tolly Group, August 2007

Figure 6

The Tolly Group is a leading global provider of third-party validation services for vendors of IT products, components and services.

The company is based in Boca Raton, FL and can be reached by phone at (561) 391-5610, or via the Internet at:
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E-mail: sales@Tolly.com

VENDOR INTERACTION

The Tolly Group invited representatives from Cisco Systems to participate in the testing as per The Tolly Group's Fair Testing Charter (See http://tollygroup.com/Corporate/FTC.aspx). Representatives from Cisco did not respond to the invitation.

Test Tool Acknowledgement		
Vendor	**Product**	**Web**
Spirent Communications	SmartBits 6000C	http://www.spirentcom.com
Spirent Communications	SmartFlow ver 5.50	http://www.spirentcom.com

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