#213106
March 2013
Commissioned by
Hewlett-Packard Company

HP 2920 Switch Series

Competitive Performance, Power Consumption and TCO Evaluation Versus Cisco Catalyst 2960-S and 3750-X Series

Executive Summary

Today's enterprise networks are facing growing demands for rich media applications like voice and video over IP, which require higher port-density and throughput. Stackable switches, when properly architected, can offer network managers a solution that can be scaled as the needs of the network grow over time. In this report, the HP 2920 switch series was compared against Cisco's Catalyst 2960-S and Catalyst 3750-X series switches.

The performance of the stacking technology used by the HP 2920 Switch Series was compared against the Cisco Catalyst 2960-S and 3750-X series switches. Tolly tests show that the HP 2920 series delivers significantly higher throughput at lower latency in a four-switch stack configuration.

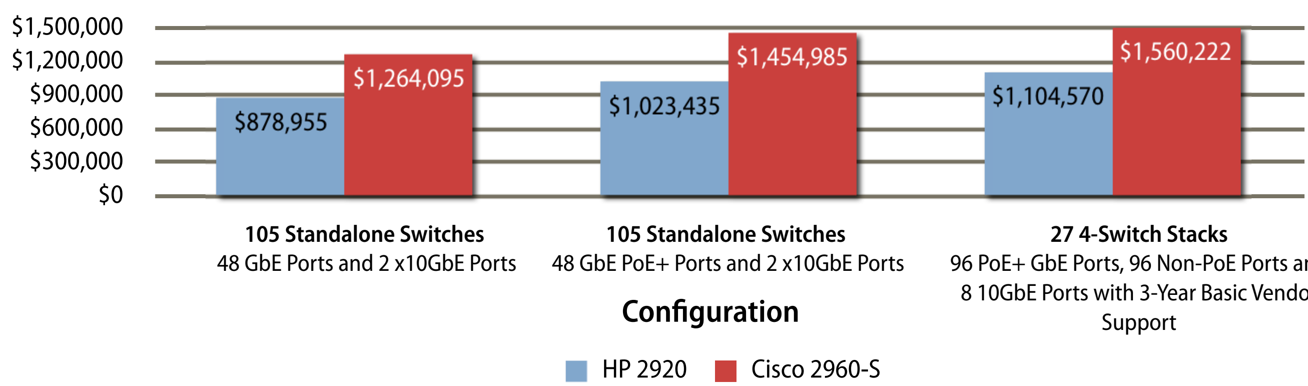
Furthermore, the HP switches implement Energy Efficient Ethernet features, that provide additional savings in long-term power and cooling costs. When fully loaded, the HP 2920 is more power efficient than the the Cisco 2960-S in the TEER test. In addition, the HP 2920 costs, on average 29% less in a 5,000 port deployment than the Cisco 2960-S. See Figure 1 and Table 1.

The Bottom Line

The HP 2920 series switches:

1. Provide up to 58% faster throughput, on average of all frame sizes tested, than the Cisco Catalyst 2960-S in a 2 member stack as a ring
2. Delivered 7.5X faster stack failover than Cisco 2960-S and 140X faster stack failover than the Cisco 3750-X
3. Buffered, on average, up to 12.5X and 11.5X as many frames in a microburst as the Cisco 2960-S and Cisco 3750-X switches, respectively
4. Provided 29% lower TCO than the Cisco 2960-S switches
5. Delivered 29% lower average latency than the Cisco 2960-S and 40% lower average latency than the Cisco 3750-X

Total Cost of Ownership of a 5,000-Port Network Deployment HP 2920 Series Switch vs. Cisco Catalyst 2960-S



Notes: 1. Pricing given above is list price, which does not include any reseller discounts. 2. Pricing obtained from www.costcentral.com in March 2013. 3.Please see Table 1 for details.

Source: Tolly, March 2013

Figure 1

Background

Resource and bandwidth-intensive applications like virtualization, video and audio are driving demand for higher performance and lower latency in the network. Traditionally, network access layer switches delivered the port-density, fault-tolerance and scalability using either a chassis or a stack of fixed-port switches.

As a consequence, the network access layer needs solutions that can not only meet today's performance needs, but also keep pace with the projected increase in network-intensive applications. This is applicable, not only in the core but also at the edge of the network - hence having a cost-effective high availability (HA) solution is critical for future networks.

IT professionals are simultaneously being asked to reduce the total cost of ownership, while retaining the network availability and performance. Network managers must consider networking gear acquisition costs and power consumption aspects when selecting vendors and their equipment.

Hewlett- Packard Company

2920 Switch Series

Performance, Power Consumption and TCO Evaluation

Tolly. Certified

Tested January 2013

Total Cost of Ownership Comparison of a 5,000-port Network Deployment of HP 2920 Switches versus Cisco Catalyst 2960-S

DUT	Port Configuration	Per Unit Acquisition Cost (US $)	Per Unit Power and Cooling Costs Over 3 yrs. (US $)	No. Of Units in a 5,000-port Deployment	Projected 3-year TCO (US $)
HP 2920	4-Switch Stack with 96 PoE+ GbE ports, 96 non-PoE GbE ports and 8 10GbE ports with 3-year basic vendor Support	$39,896	$1,014	27	**$1,104,570**
	Standalone switch with 48 GbE ports and 2 x 10GbE ports	$8,159	$212	105	**$878,955**
	Standalone switch with 48 GbE PoE+ ports and 2 x 10GbE ports	$9,459	$288	105	**$1,023,435**
Cisco Catalyst 2960-S	4-Switch Stack with 96 PoE+ GbE ports, 96 non-PoE GbE ports and 8 10GbE ports with 3-year basic vendor Support	$56,920	$866	27	**$1,560,222**
	Standalone switch with 48 GbE ports and 2 x 10GbE ports	$11,845	$194	105	**$1,264,095**
	Standalone switch with 48 GbE PoE+ ports and 2 x 10GbE ports	$13,615	$242	105	**$1,454,985**

Note:
A 5,000 port deployment is assumed to consist of:

- 27 units of a four-switch stack configuration with up to 96 PoE+ GbE ports, 96 non-PoE GbE ports and 8 10GbE ports, or
- 105 units of a switch configuration with 48 GbE PoE+ ports and 2 10GbE ports.
- For a detailed breakdown of the acquisition costs and power consumption test results used to derive the power and cooling costs, please refer to the companion document to this report, Tolly document 213106-Appendix, available at www.tolly.com.

The acquisition costs, plus the power and cooling costs of the unit solution are extrapolated to a 5,000-port deployment size when multiplied by a factor of 27 for the 4-switch stack configuration, or by a factor of 105 for the 48-port standalone switch configuration.

Source: Tolly, March 2013 Table 1

Total Cost of Ownership (TCO)

As can be seen in Figure 1 and Table 1, acquisition costs (hardware, software licensing, support contracts, etc.) as well as the power and cooling costs of a standalone 48-port PoE+/non-PoE switch and a stack of 4-switches were used to estimate the total cost of ownership (TCO) of a hypothetical 5,000-port deployment over a 3-year period.

Engineers used single-unit list prices for HP and Cisco switches based on www.costcentral.com prices in March 2013. No reseller or VAR discounts were applied for either quote.

The detailed breakdown of the pricing used in the TCO model can be found in the companion document for this report, Tolly document 213106-Appendix.

The TCO estimates show that the HP 2920 series switches delivered significant TCO savings over the comparable Cisco 2960-S switch.

In a standalone 48-port PoE+ switch configuration, the HP 2920 switch delivered a savings of 29% in TCO over the Cisco Catalyst 2960-S.

In a 4-switch stack configuration, the HP 2920 switch delivered a TCO savings of 29% over the Cisco Catalyst 2960-S. See Figure 1 and Table 1.

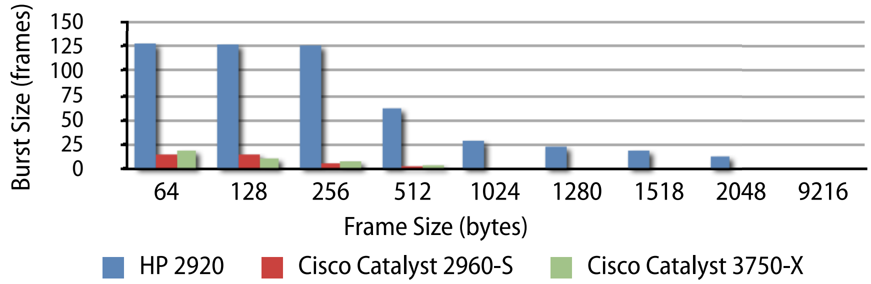
Performance Test Results

Microburst Tolerance

Microbursts are defined as sub-second periods of time when major bursts of network usage occurs causing the utilization of network interfaces to become temporarily oversubscribed. This can possibly result in packet loss, depending on the network device's capacity to buffer the excess packets. The HP 2920 demonstrated the capability to buffer considerably larger microbursts - 12.5

Microburst Tolerance with Simultaneous Bursts across 46 GbE Ports

(as reported by Ixia IxAutomate 7.20GA)



Notes: Two GbE ports were used to send microbursts to the other 46 GbE ports on the same switch.

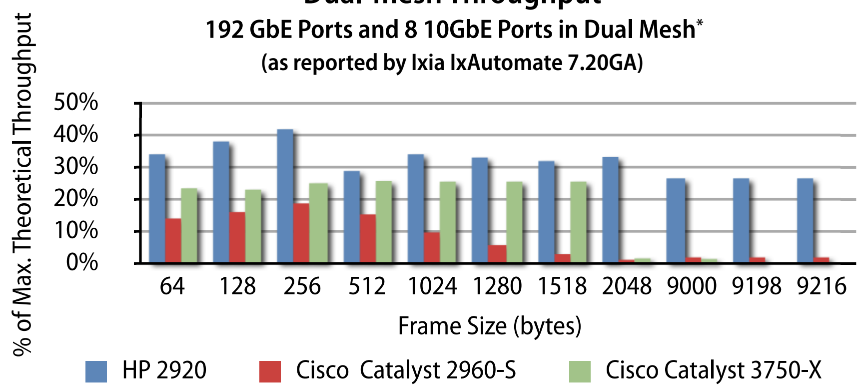
Source: Tolly, January 2013

Figure 2

4-Member Stack as a Ring Topology Performance: RFC2889 Layer 2 Dual-mesh Throughput

192 GbE Ports and 8 10GbE Ports in Dual Mesh*

(as reported by Ixia IxAutomate 7.20GA)



* The Cisco Catalyst 3750-X used 144 GbE ports and 8 10GbE ports.

Source: Tolly, January 2013

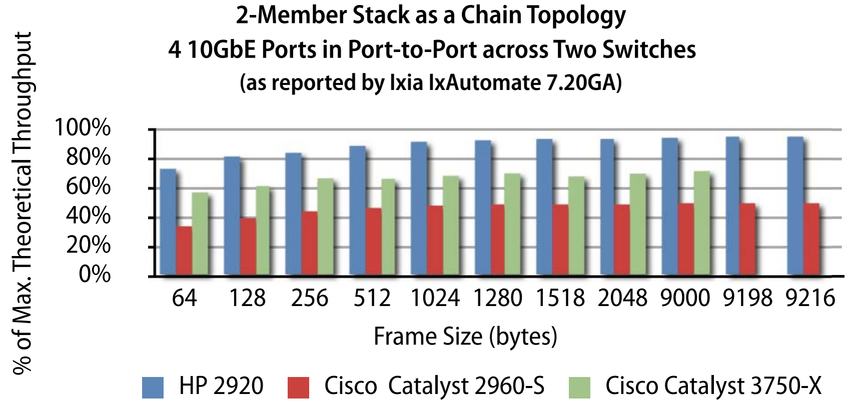
Figure 3

Single Stacking Cable: RFC 2889 Layer 2 Throughput

2-Member Stack as a Chain Topology

4 10GbE Ports in Port-to-Port across Two Switches

(as reported by Ixia IxAutomate 7.20GA)



Note: One stacking cables between two switches. Two 10GbE ports on one switch sent/received traffic to/from two 10GbE ports on the other switch. 20Gbps bidirectional (40Gbps aggregated) as the maximum theoretical throughput across two switches.

Source: Tolly, January 2013

Figure 4

times more frames, compared to the Cisco 2960-S and 11.5 times more than Cisco 3750-X. See Figure 2.

Two GbE ports were used to send microbursts to the other 46 GbE ports on the same switch.

Four Member Stack Layer 2 Full-Mesh Throughput

Performance tests focused on evaluating the aggregate throughput and latency exhibited by the products under test as per the RFC 2889 methodology. The HP 2920 and Cisco Catalyst 2690-S were configured with 192 GbE ports in full-mesh and eight 10GbE ports in full-mesh. The Cisco Catalyst 3750-X used 144 GbE ports and 8 10GbE ports. This configuration allows each port to send and receive traffic from any other port in the switch-stack, thus representing a highly unrestricted distribution of traffic. Tests show that the HP 2920 switch consistently delivered better throughput than the Cisco Catalyst 2960-S and 3750-X. See Figure 3.

Two Member Stack Layer 2 Throughput

In a 2-Member stack as a chain configuration, the HP 2920 stacking link delivered 92% faster throughput, on average than the Cisco 2960-S and 63% faster average aggregate throughput than the Cisco 3750-X. See Figure 4.

In a 2-Member stack as a ring topology, the HP 2920 delivered 100% line rate with 4 10GbE ports (with 20Gbps bidirectional, 40Gbps aggregated throughput across stacking links). The Cisco Catalyst 3750-X also delivered line rate with 4 10GbE ports, but the 2960-S performed at less than half that. See Figure 5.

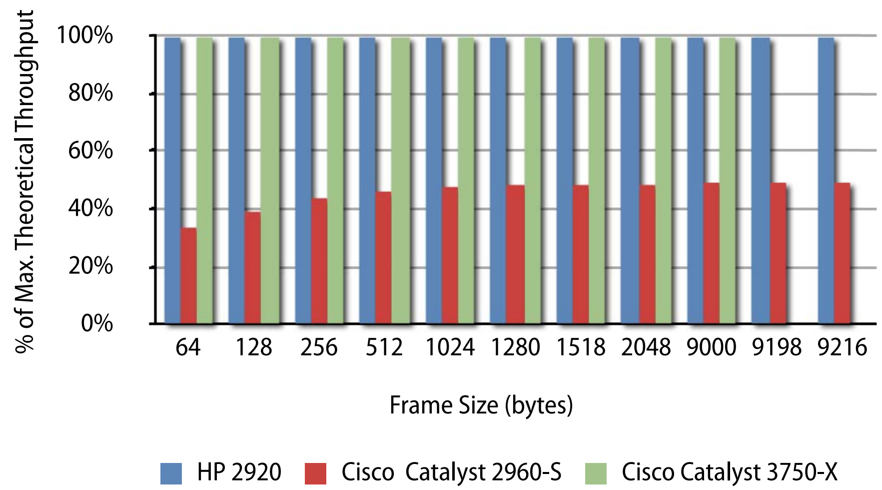
Four Member Stack Layer 2 Latency

The HP 2920 delivered consistently lower latency compared to the Cisco 2960-S and 3750-X.

2-Member Stack as a Ring Topology Performance: RFC2889 Layer 2 Throughput

4 10GbE Ports in Port-to-Port across Two Switches

(as reported by Ixia IxAutomate 7.20GA)



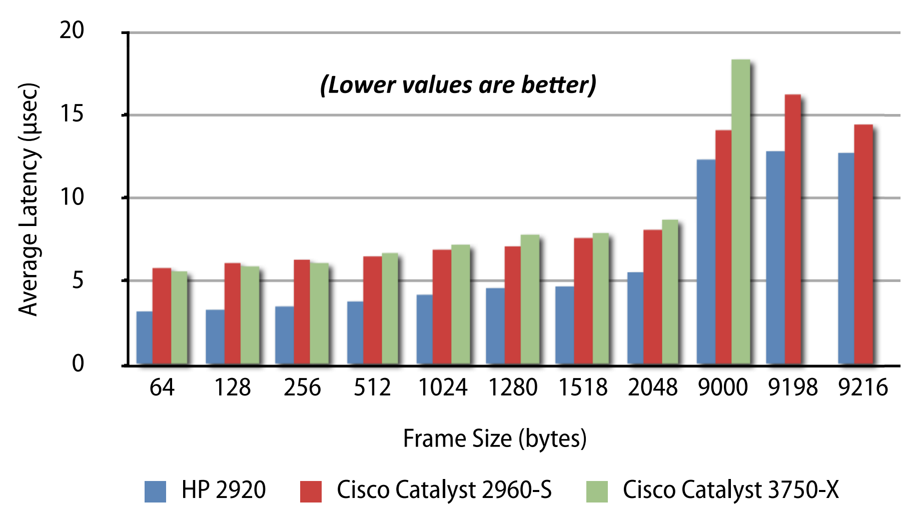
Note: Two stacking cables between two switches. Two 10GbE ports on one switch sent/received traffic to/from two 10GbE ports on the other switch. 20Gbps bidirectional (40Gbps aggregated) as the maximum theoretical throughput across two switches.

Source: Tolly, January 2013 Figure 5

RFC 2889 Layer 2 Store-and-Forward Latency

@5% Load across 192 GbE Ports and 8 10GbE Ports in Dual Mesh[1]

(as reported by Ixia IxAutomate 7.20GA)



Notes: 1. The Cisco Catalyst 3750-X used 144 GbE ports and 8 10GbE ports.
2. Cisco 2960-S had frame loss in some test iterations for frame size 1024 to 1518 and in all test iterations for frame size 2048 to 9216.

Source: Tolly, January 2013 Figure 6

The HP 2920 exhibited between 3.2 and 12.7 microseconds of latency for the 64- to 9216-byte frame sizes. In comparison, the Cisco 2960-S exhibited latency between 5.8 and 14.1 microseconds, and the Cisco 3750-X demonstrated up to 18.3 microseconds of latency up to 9000 bytes frame size. See Figure 6.

Four Member Stack Average Convergence Time

Tolly engineers measured the average convergence time for all switches under test in a 4-Member stack ring. The worst of these times was taken as the measurement used to compare the performance of the switches. The HP 2920 delivered ultra low convergence time at 105.36 ms, compared to 904 ms for the Cisco 2920-S and nearly 15,000 ms for the Cisco 3750-X. See Figure 7. HP's convergence time was 140X faster than the Cisco Catalyst 3750-X.

Telecommunication Energy Efficiency Ratio

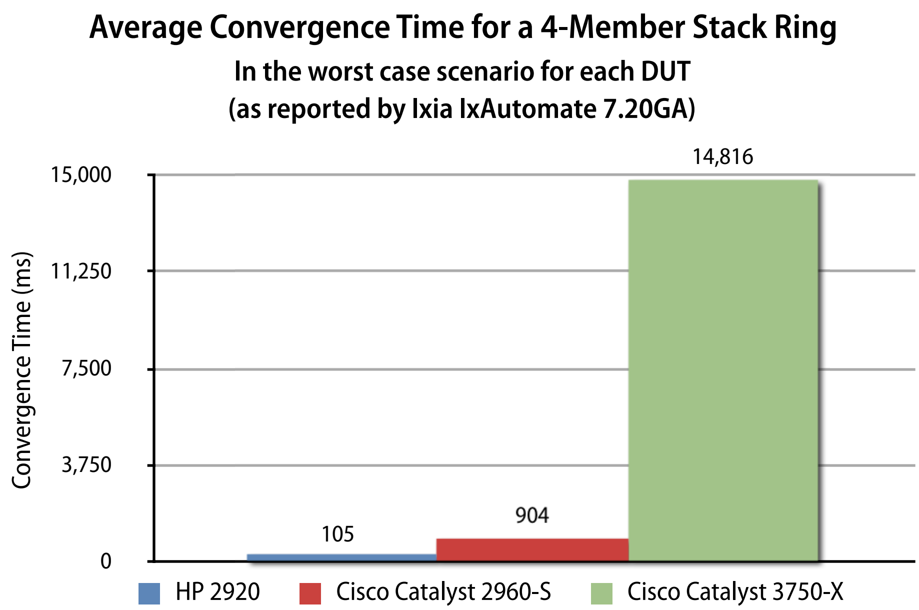
HP 2920 supports up to 4 10GbE ports while Cisco 2960-S only supports 2. When both switches were fully loaded, the HP 2920 provided higher Gbps/Watts results than Cisco 2960-S. See Figure 8.

Quality of Service (QoS)

Tolly engineers verified that HP2920 supports Layer 2 QoS on a standalone switch and across a stacking link. Streams with different 802.1p priorities had different throughput when passing through the stacking cable.

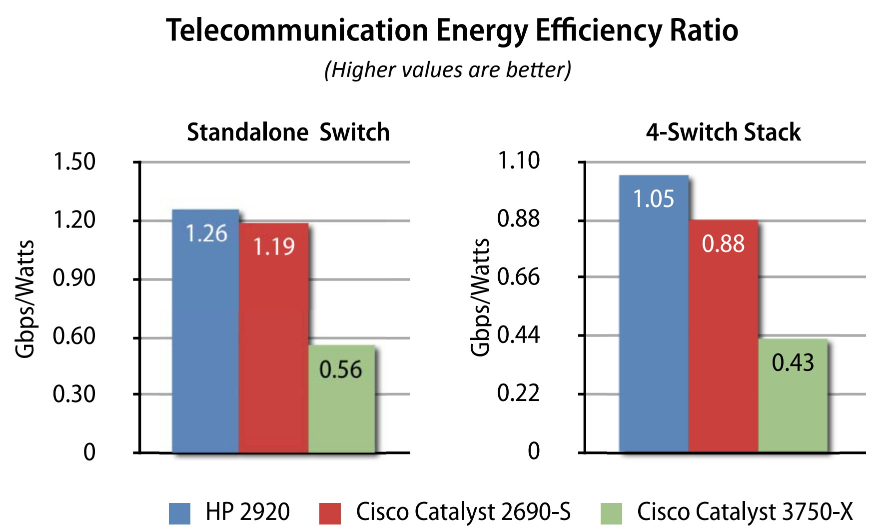
Test Bed Setup

The devices under test consisted of up to four HP and Cisco switches, as shown in Table 4. Each vendor solution was connected to an Ixia Optixia XM12 traffic generator for test traffic generation and validation purposes. A desktop running Microsoft Windows 7 was



Note: Engineers disconnected one stacking cable in each test. For each DUT, engineers tested disconnected the stacking cable connecting Master to Member 1, Master to Member 3, and Member 2 to Member 3. The worst case scenario (with the maximum average convergence time) for each DUT is reported here.

Source: Tolly, January 2013 Figure 7



Note: 1. See Table 2 for ports used in the test. For Cisco 3750-X, a different configuration was tested: 2 switches with 24 GbE ports and 2 switches with 48 GbE ports were used as a stack while the other two devices used all 48 GbE ports switches. So 3750-X stack's result is not directly comparable with the other two switch stacks.
2. For 4-switch stack test, two 10GbE ports on each switch were used to pass traffic as switch 1 --> 2 --> 3 --> 4 --> 1. HP 2920 had 4 ports on each switch. So there were two ports on each HP 2920 passing traffic as a pair locally.
3. Four 4-switch stack test, Cisco 2960-S stack had 82% frame loss and Cisco 3750-X stack had 36.2% frame loss when passing traffic across switches as in note while the HP 2920 stack passed 100% traffic. The total passed traffic was 352 Gbps for HP 2920, 206 Gbps for Cisco 2960-S and 195 Gbps for Cisco 3750-X.
4. For the standalone switch test, HP 2920 used 4 10GbE ports while Cisco 2960 only supported 2 10GbE ports.

Source: Tolly, January 2013 Figure 8

connected to the LAN to manage the switches, as well as to configure the Ixia traffic generator using Ixia IxAutomate application.

To measure the power consumption, the switches were connected to the Voltech PM300A Universal Power Analyzer.

Test Methodology

Four Member Stack Layer 2 Full-mesh Throughput

To measure the throughput, each switch under test was connected to the Ixia Optixia XM12 chassis using 192 GbE ports (144 GbE ports for Cisco 3750-X) and eight 10GbE ports. The 192 GbE ports (144 GbE ports for Cisco 3750-X) were configured in a full-mesh topology, meaning that each port on the switch sent traffic to, and received traffic from every other port in the switch. The 10GbE ports were connected in a separate full-mesh by themselves.

The test traffic consisted of bidirectional streams of Layer 2 traffic consisting of frames of 64-, 128-, 256-, 512-, 1024-, 1280-, 1518-, 2048-, 9000-, 9198- and 9216-bytes, as specified by the RFC 2889 and DUT specification for jumbo frames.

The Ixia IxAutomate application was used to configure the Ixia ports to generate the test traffic, and to find the maximum zero-loss throughput using binary search algorithm. Each test was run for 60 seconds, and repeated three times to ensure repeatability of the results. Final results were announced as the average of the three test runs.

Four Member Stack RFC 2889 Layer 2 Store-and-Forward Latency

The test bed setup and network topology for the latency tests was the same as that used for the throughput tests. The test traffic consisted of frames/packets ranging in size from 64 to 9216 bytes.

Since the Cisco 2960-S exhibited average throughput as low as 2.9% for 1518-byte frames in the four member stack full mesh test, engineers ran the latency tests at 5% line-rate on all the switches under test. The average "store and forward" latency was measured and reported as the average of three test runs, each lasting 60 seconds.

Two Member Stack Layer 2 Throughput

Two member stack in chain topology and ring topology were both tested to evaluate the throughput across the stacking links. In both tests, two 10GbE ports on one switch was used to send traffic to two 10GbE ports on the other switch as pair-to-pair. RFC2889 template in IxAutomate was used for tests.

Microburst Tolerance Tests

To test the microburst tolerance of the devices under test, engineers connected the 48 GbE PoE+ ports on the switch to the Ixia chassis. The 48 GbE ports were split into two sets of 24 ports each. One port in each set was used to send microburst traffic to all other 23 ports in the same set.

Telecommunication Energy Efficiency Ratio

Device Under Test	Port Configuration	ATIS Weighted Average Power (W_{ATIS})	Measured Throughput	Telecommunication Energy Efficiency Ratio (Gbps/W_{ATIS})
HP 2920	Standalone Switch (48GbE Ports + 4 10GbE Ports)	70.0	88Gbps	1.26
	4-Switch Stack (96 GbE PoE+ and 96 GbE Ports, 16 10GbE Ports)	334	352Gbps	1.05
Cisco Catalyst 2690-S	Standalone Switch (48GbE Ports + 2 10GbE Ports)	57.4	68Gbps	1.19
	4-Switch Stack (96 GbE PoE+ and 96 GbE Ports, 8 10GbE Ports)	234	206.4Gbps	0.88
Cisco Catalyst 3750-X	Standalone Switch (48GbE Ports + 2 10GbE Ports)	122.3	68Gbps	0.56
	4-Switch Stack (72 GbE PoE+ and 72 GbE Ports, 8 10GbE Ports)	450.1	195Gbps	0.43

Note: 1. For Cisco 3750-X, a different configuration was tested: two switches with 24 GbE ports and two switches with 48 GbE ports were used as a stack while other two devices used all 48 GbE ports switches. So 3750-X stack's result is not directly comparable with the other two switch stacks.
2. For the 4-switch stack test, two 10GbE ports on each switch were used to pass traffic as switch 1 --> 2 --> 3 --> 4 --> 1. HP 2920 had 4 ports on each switch. So there were two ports on each HP 2920 passing traffic as a pair locally.
3. ATIS-weighted Power (W_{ATIS}) = 0.1*(Power draw @ 0% load) + 0.8*(Power draw @ 10% load) + 0.1*(Power draw @ 100% load)
4. Test traffic consisted of an Internet Mix (iMIX) distribution of TCP packet sizes: 57% at 64-bytes, 7% at 570-bytes, 16% at 594-bytes and 20% at 1518-bytes

Source: Tolly, January 2013 Table 2

The microburst traffic consisted of the standard frame sizes from 64-bytes to 9216-bytes at line-rate, and the number of frames in the microburst were generated using a custom command issued from Ixia IxAutomate. Thus, two microbursts at the given burst size were input to the device under test at the same time, and the no-loss microburst size was determined at each frame size. Tests were repeated three times to ensure consistency in the results.

Power Consumption Tests for TCO Analysis

To measure the power consumption, engineers used the same configuration on the HP 2920 and Cisco 2960-S. In the standalone switch test, each switch had 48 GbE ports in snake configuration and two 10GbE port as a pair passing bidirectional iMIX traffic. In the four-member stack test, each switch used 48 GbE port as a snake to pass traffic locally. One 10GbE port on member 1 switch and one 10GbE port on member 3 switch passed traffic as a pair.

Tolly used four 48-port HP 2920 switches and Cisco 2960-S switches to test but only two 48-port and two 24-port 3750-X switches, which led to the exclusion of the 3750-X from the TCO analysis.

Tolly engineers followed the methodology prescribed by two ATIS (Alliance for Telecommunications Industry Solutions) standards documents:

- ATIS-0600015.03.2009: Energy Efficiency for Telecommunication Equipment: Methodology for Measuring and Reporting For Router and Ethernet Switch Products, and
- ATIS-0600015.2009: Energy Efficiency for Telecommunications Equipment: Methodology for Measuring and Reporting - General Requirements

HP 2920 Series Feature Comparison

Feature	HP 2920	Cisco 2960-S
Routing	IPv4/IPv6 Static Routes IPv4 RIP Routes	IPv4 Static Routes
10 GbE Support (Max # of ports: fixed or modular)	4 (Modular)	2 (Fixed)
10 GbE Connectivity	10GBase-T, SFP+	SFP+
Serial Console Ports	RJ-45, USB	RJ-45
Removable Power Supply	Yes	No
Maximum PoE/PoE+ Power Budget (with EPS)	740 W with internal, modular power supply 1440 W with EPS*	740W with SKU No EPS
IEEE 802.3az (Energy Efficient Ethernet)	Yes	No
Operating Temperature	Up to 55 Degrees Celsius	Up to 45 Degrees Celsius

Note: These features were not tested by Tolly as part of this evaluation.
*Available in 2013
Source: HP, January 2013

Table 3

The power consumption of each product was measured at various load points: idle (0%), 10% and 100%. The test traffic consisted of an Internet Mix (IMIX) distribution of TCP packets of various sizes: 57% at 64-bytes, 7% at 570-bytes, 16% at 594-bytes and 20% at 1,518-bytes.

The final power consumption was reported as a weighted average calculated using the formula:

$$W_{ATIS} = 0.1*(\text{Power draw at 0\% load}) + 0.8*(\text{Power draw at 10\% load}) + 0.1*(\text{Power draw at 100\% load}).$$

The formula above applies to access layer switches. Once again, all measurements were taken over a period of 60 seconds at each load level, and repeated three times to ensure repeatability of the results. Final results were reported as the average of the three runs.

Telecommunication Energy Efficiency Ratio (TERR)

The switch configuration for the TEER test and the power consumption measurements used TCO analysis test are different and not equally comparable. For the TEER test, Tolly engineers used all supported 10GbE ports. Each HP 2920 used 4 10GbE ports and each Cisco 2960-S used 2 10GbE ports.

For the 4-switch stack test, 2 10GbE ports on each switch were used to pass traffic as follows: switch 1 –> 2 –> 3 –> 4 –> 1. The HP 2920 has 4 ports on each switch and there were two ports on each HP 2920 passing traffic as a pair locally. 48 GbE ports on each switch passed traffic as a snake locally.

For the standalone switch test, HP2920 used 4 10GbE ports passing traffic as two pairs, while the Cisco 2960-S used 2 10GbE ports passing traffic as a pair. 48 GbE ports on each switch passed traffic as a snake locally.

Device(s) Under Test

Vendor	Software Version	Model Name	Module(s) Included
Hewlett-Packard Company	WB.15.11.0003	J9728 HP 2920-48G Switch	J9731A HP 2920 2-port 10GbE SFP+ Module J9150A HP 10-GbE SFP+ SR Transceiver J9733A HP 2920 2-port Stacking Module J9734A HP 2920 0.5m Stacking Cable
		J9729A HP 2920-48G-PoE+ Switch	

Vendor	Software Version	Model Name	Module(s) Included
Cisco Systems, Inc.	IOS Ver 15.0	WS-C2960S-48TD-L Catalyst 2960-S 48GigE, 2 x 10G SFP+ LAN Base	SFP-10G-SR 10GBASE-SR SFP+ Transceiver C2960S-STACK Catalyst 2960S FlexStack Stack Module optional for LAN Base CAB-STK-E-0.5M Cisco FlexStack 50cm stacking cable (included with the stack module)
		WS-C2960S-48LPD-L 48 GigE PoE+ 370W, 2 x 10G SFP+ LAN Base	

Vendor	Software Version	Model Name	Module(s) Included
Cisco Systems, Inc.	IOS Ver 15.0	WS-C3750X-24T-S v01	C3KX-PWR-350WAC PSU
			C3KX-NM-10G 10G Module With 2X SFP+
		WS-C3750X-48T-S V01	C3KX-PWR-350WAC PSU
			C3KX-NM-10G 10G Module With 2X SFP+
		WS-C3750X-24P-S V01	C3KX-PWR-715WAC PSU
			C3KX-NM-10G 10G Module With 2X SFP+
		WS-C3750X-48P-S V01	C3KX-PWR-715WAC PSU
			C3KX-NM-10G 10G Module With 2X SFP+

Source: Tolly, January 2013

Table 4

Interaction with Competitors

In accordance with Tolly's Fair Testing Charter, prior to the start of the testing, Tolly personnel invited representatives of Cisco Systems to participate in the project. Cisco Systems did not respond to this invitation.

For more information on the Tolly Fair Testing Charter, visit:
http://www.tolly.com/FTC.aspx.

About Tolly

The Tolly Group companies have been delivering world-class IT services for more than 20 years. Tolly is a leading global provider of third-party validation services for vendors of IT products, components and services.

You can reach the company by E-mail at *sales@tolly.com*, or by telephone at +1 561.391.5610.

Visit Tolly on the Internet at:
http://www.tolly.com

Test Equipment Summary

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

Vendor	Product	Web
Ixia	Chassis Type: Optixia XM12 Software: IxAutomate 7.20GA IxOS 6.10.750.24 GA-Patch1 IxNetwork 6.00.254.26	IXIA TESTED http://www.ixiacom.com/
Voltech	PM3000A Universal Power Analyzer	http://www.voltech.com/products/poweranalyzers/PM3000.aspx

Terms of Usage

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