1GE Edge Switch Study

Cisco Catalyst 2960X-48LPD-L

HP 2920-48G-PoE+

HP 5120-48G-PoE+ EI

July 2014

Report DR130917L

Contents

1 Overview

Cisco engaged Miercom to conduct a competitive analysis of its Catalyst 2960-X switch versus two comparable Hewlett-Packard switches from the 2920 and 5120 product families.

Miercom executed comprehensive hands-on testing and evaluated the performance of some widely deployed features that are critical for reliable functioning of enterprise networks. The test methodology focused on specific areas in which Cisco believed there were key competitive differentiators between the products.

Test results validated include throughput, latency, energy efficiency, stacking, LACP load balancing and Quality of Services (QoS) performance.

Miercom found that the Cisco Catalyst 2960-X demonstrated superior performances against the competitive switches in the tests featured in this report.

We tested the following switch-configurations of the Cisco Catalyst 2960-X, HP 2920 and HP 5120 product families.

Access Switches Tested

Access Switch	Port Configuration	Power (Watts)
Cisco C2960X-48LPD-L	48 10/100/1000 Ethernet PoE+ and 2 SFP+ uplink interfaces	370 PoE+
HP 2920 48G-PoE+	48 10/100/1000 PoE+ and four dual personality: SFP or 10/100/1000 PoE+	370 PoE+
HP 5120 48G-PoE+ EI	48 10/100/1000 PoE+ and 4 dual personality: SFP or PoE 10/100/1000Base-T	370 PoE+
Cisco C2960X-48FPD-L	48 10/100/1000 Ethernet PoE+ and 2 SFP+ uplink interfaces	740 PoE+

Source: Miercom Ethernet Switch Study, 2014

With the exception of the next section, “About the Switches,” each switch will be identified in the rest of this report by the series name: C2960-X, HP 2920 and HP 5120 EI.

The advantages detailed in this report are either validated results of tests based on industry standard methodologies, offsite validation of product performance or observations recorded during hands-on testing at the Miercom facility.

1.1 Key Findings

- Cisco Catalyst 2960-X exhibited full line-rate throughput while HP 5120 observed 59% frame loss when both downlink ports and 10G uplink interface modules are fully loaded.
- Cisco Catalyst 2960-X exhibited lower RFC 2544 Layer 2 latency for all frame sizes compared to HP 5120.
- Cisco Catalyst 2960-X consumed just under 25% less power than the HP 2920 while handling 100% line-rate traffic in all packet sizes tested and just under 50% less power than the HP 5120.
- Cisco Catalyst 2960-X switch stack exhibited double the maximum stacking capacity of HP 2920 and HP 5120, eight units versus four, providing more port density and throughput.
- C2960-X stack data path converges faster than HP 2920 and HP 5120 when there is a change in stack topology.
- Cisco Catalyst 2960-X switches are backward compatible with Cisco Catalyst 2960-S and 2960-SF series, enabling mixed stacking and providing investment protection.
- Cisco Catalyst 2960-X performed perfect LACP load balancing of Layer 2 traffic across cross-stack LACP member ports while both HP 2920 and HP 5120 failed to load balance effectively. No traffic was observed on cross-stack LACP member ports for HP 5120.
- Cisco Catalyst 2960-X switch remained usable as a standalone unit after being removed from a stack while the HP 2920 became unusable, warranting a hard reset.
- Under adverse network conditions, Cisco Catalyst 2960-X experienced no loss of priority traffic or latency issues while both HP 2920 and HP 5120 experienced loss of priority traffic or increased latency.
- During oversubscription, Cisco Catalyst 2960-X buffer queues were not flushed while HP 5120 experienced 25% buffer queue flushing for smaller packets and 100% flushing with bigger packets.
- Cisco Catalyst 2960-X provided queue level statistics to identify where traffic was dropped while both HP 2920 and HP 5120 lack such troubleshooting information.
- Cisco Catalyst 2960-X optimizes hardware resource usage by sharing common access lists across all ports while HP 2920 does not share the hardware resources across different ports.
- Cisco Catalyst 2960-X did not drop any NetFlow-Lite samples while sampling at a high rate from line-rate traffic while the HP 2920 dropped sFlow samples while sampling at a high rate, even from a low traffic rate.

2 About the Switches Evaluated

Cisco Catalyst 2960X-48LPD-L

The Cisco Catalyst 2960X-48LPD-L is a member of the Cisco Catalyst 2960-X Series of fixed-configuration, stackable Gigabit Ethernet switches that provide enterprise-class access for campus and branch applications. Designed for operational simplicity to lower total cost of ownership, they enable scalable, secure and energy-efficient business operations with intelligent services and a range of advanced Cisco IOS Software features. All switches in the series perform Layer 2 switching and Layer 3 static routing.

The C2960X-48LPD-L has 48 10/100/1000 Ethernet ports, two SPF+ uplink interfaces, a single fixed power supply and 370 watts of available PoE+ power.

The C2960X-48FPD-L has 48 10/100/1000 Ethernet ports, two SPF+ uplink interfaces, a single fixed power supply and 740 watts of available PoE+ power.

HP 2920-48G-PoE+

The HP 2920-48G-PoE+ is a member of the Hewlett-Packard HP 2920 Switch Series for the enterprise edge, remote branch offices and converged networks. All switches in this series perform Layer 2 switching and Layer 3 static IP and RIP routing.

The HP 2920-48G-PoE+ has 44 10/100/1000 PoE+ ports and four dual-personality ports for 10/100/1000 PoE+ or SFP connectivity. In addition, up to four optional 10 Gigabit Ethernet (SFP+ and/or 10GBASE-T) ports can be supported. It also has a modular power supply and provides up to 370 watts of PoE power.

HP 5120 48G-PoE+ EI

The HP 5120 48G-PoE+ EI is a member of the Hewlett-Packard HP 5120 EI Series of switches that are used at the network edge or to connect server clusters in data centers. All switches in this series support static Layer 3 routing.

The HP 5120 48G-PoE+ EI has 48 10/100/1000 PoE+ ports and four dual-personality ports for PoE 10/100/1000Base-T or SFP connectivity. It provides up to 370 watts of PoE power from an internal power supply.

3 Test Bed Setup

Ixia XM12 Chassis

Cisco Switch Under Test

Cisco
Catalyst 2960X-48LPD-L

HP Switches Under Test

HP 2920-48G-PoE+

HP A5120-48G-PoE+

OmniPeek

Source: Miercom Ethernet Switch Study, 2014

Each switch was tested as a standalone unit directly connected to the Ixia XM12 Test System. Stacked configuration testing was performed on the Cisco Catalyst 2960-X and the HP 2920 switches. Standalone tests included RFC 2544 for throughput and latency using IPv4 (Layer 2) bidirectional traffic. Frame sizes ranging from 64-bytes to jumbo frame 9,216 bytes were used in testing. Each switch was subjected to a comprehensive battery of tests to provide a picture of its projected ability to perform in the most demanding real-world data center environments.

RFC 2544 was used as the reference to conduct basic benchmark tests for latency and throughput measurements. Port pairs on the devices under test were selected to force bidirectional Layer 3 traffic across the backplane of the switches.

Tests were conducted for throughput, latency, stacking abilities, LACP load balancing, and traffic monitoring and drops. Tests that measured energy efficiency on a fully loaded chassis were also conducted.

The Ixia XM12 chassis was used with the Ixia Network application as the primary traffic generator that drove network traffic through the switches using a vast library of test methodologies. Ixia (www.ixiacom.com) is an industry leader in performance testing of networking equipment. Ixia's exclusive approach and comprehensive set of online open source test methodologies makes Ixia a clear choice for testing L2-L7 based networking products.

OmniPeek, a portable network analyzer from WildPackets (www.wildpackets.com), was used for analyzing network test PCAP files from testing. The OmniPeek has an intuitive graphical interface for analyzing and troubleshooting enterprise networks. Managing and monitoring network performance is handled by real-time observation of network statistics, such as application vs. network latency, aggregating multiple files and exact drill-down to packets using an interactive dashboard. Problems can be analyzed and fixed across network segments, including those at remote offices.

The tests in this report are intended to be reproducible for customers who wish to recreate them with the appropriate test and measurement equipment. Current or prospective customers interested in repeating these results may contract through Miercom, please contact reviews@miercom.com for details on the configurations applied to the Device under Test and test tools used in this evaluation and Miercom Professional Services representative will provide assistance. Miercom recommends customers conduct their own needs analysis study and test specifically for the expected environment for product deployment before making a product selection.

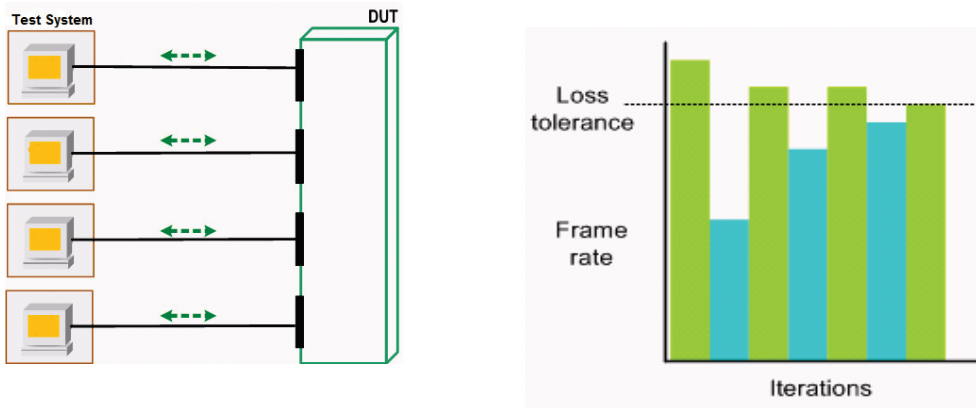
4 Throughput and Latency Performance Test (RFC 2544)

The RFC 2544 throughput test determines the maximum rate at which the switch receives and forwards traffic without frame loss. Frames are sent at a specified rate and a binary search algorithm is used to determine at what rate the switch does not lose frames. Frames can be MAC only, IPv4, IPv6 (with or without Extension Headers) or an IPv4/IPv6 mixture. Results include throughput rates measured as frames per second for each frame size. Starting with the maximum traffic rate, the latency is calculated by subtracting the transmit time stamp from the receive time stamp.

Configuration for the test used the test load generator to forward and receive traffic to and from each directly connected port on the switch. Frames are initially sent at a specified rate, generally the maximum theoretical rate based on the speed of the port. A binary search algorithm is used to obtain a rate whereby the switch does not lose frames. This test is configured with a one-to-one traffic mapping. The results show the maximum throughput of the switch without frame loss. The latency is calculated by subtracting the transmit time stamp from the receive time stamp.

Devices under test were configured for Layer 3 switching (routing) and had port pair combinations such that the traffic is transmitted across the fabric modules (and between the switch modules/line cards). Standard testing practice was followed and conducted in accordance with RFC 2544. All ports were connected to the IXIA load generation tool, and traffic flows of fixed packet sizes in a port pairing fashion between line cards were sent. This test automatically repeats itself using a binary search algorithm and the most reliable data point with traffic throughput observed without loss was reported.

4.1 RFC 2544 Throughput Test System and DUT Configuration

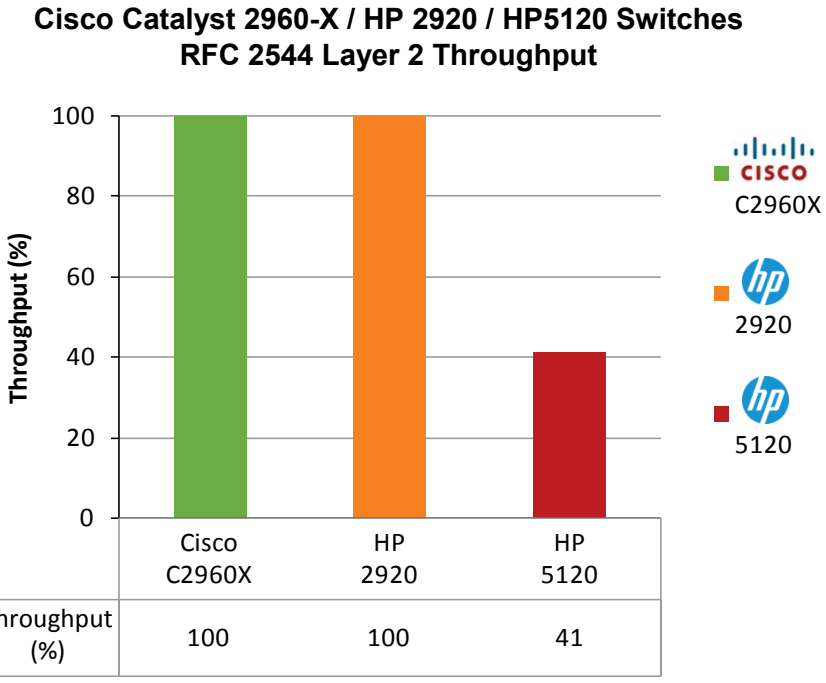


Source: Ixia, IxNetwork

A single C2960-X, HP 2920 and HP 5120 EI were tested for Layer 2 throughput using 48 1GbE ports, with an additional 2 10GbE fiber ports. Layer 2 latency was measured with all 48 1GE copper ports and 2 10GE fiber links loaded.

The Ixia XM12 chassis was used with the Ixia IxNetwork application as the primary traffic generator that drove network traffic through each switch.

RFC 2544 Layer 2 Throughput Test Results with Uplink Module



	Cisco C2960X	HP 2920	HP 5120
Throughput (%)	100	100	41

Source: Miercom Ethernet Switch Study, 2014

Based on RFC 2544, Cisco C2960-X and HP 2920 exhibits full line-rate throughput however HP 5120 observed 59% frame loss when sending IMIX traffic through 24 downlink ports and two uplink interface module. ***Longer bars are better performance.***

Cisco C2960-X and HP 2920 switches successfully achieved 100% line-rate throughput for Layer 2 traffic when sending traffic utilizing the available both downlink ports and the uplink modules. However for HP 5120, we have observed that when traffic is sent across both the uplink modules, there is substantial amount of frame loss observed. We have noticed a 60% frame loss when sending traffic between the 24 downlink ports of 48 and between the two 10G uplink modules.

Throughput Loss Observed on HP 5120

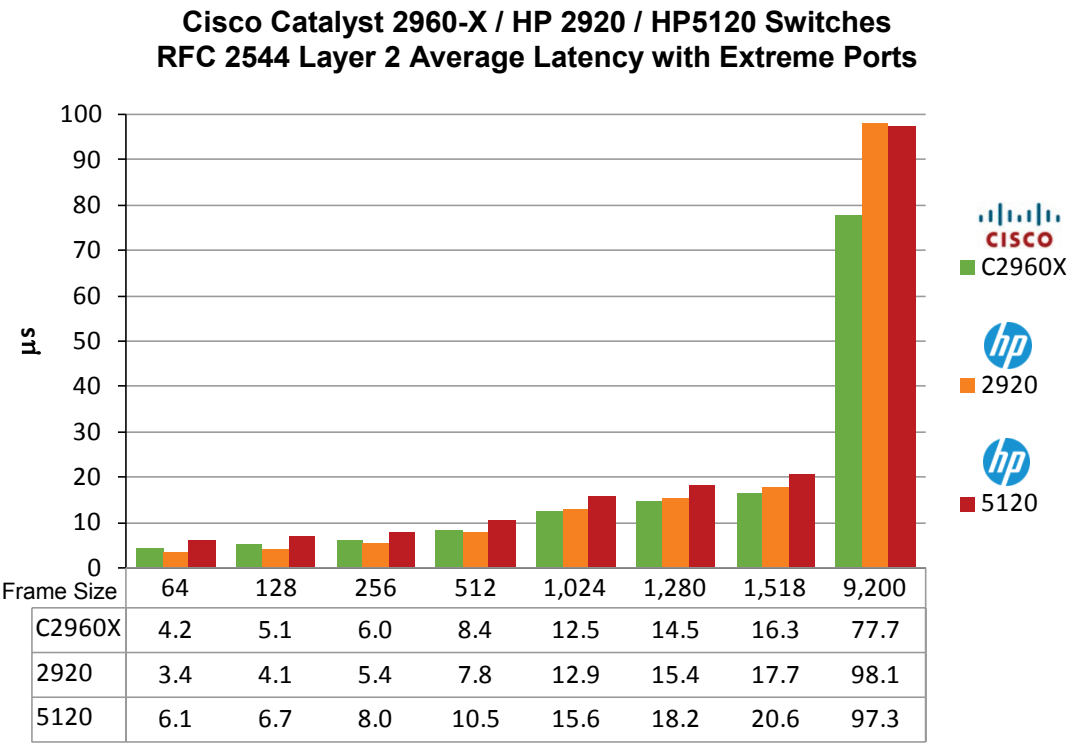
Traffic Item	Tx Frames	Rx Frames	Frames Delta	Loss %
g 1/0/1-12 to g 1/0/33 - 44	554,367,144	276,987,410	277,379,734	50.035
Te 1/1/1 - Te 1/2/1	461,972,610	184,888,092	277,084,518	59.979
Te 1/1/2 - Te 1/2/2	461,972,610	184,896,127	277,076,483	59.977

Screenshot from IxNetwork showing about 60% frame loss for HP 5120 when utilizing 24 ports out of 48 downlink ports and two 10G uplink module interfaces.

We did not observed frame loss for Cisco C2960-X and HP 2920 for this test regardless of the traffic flow configuration. The Cisco C2960-X and HP 2920 proved line-rate performance without loss. Throughput tests were conducted utilizing packet sizes ranging from 64 bytes to 9,200 bytes as well as IMIX distribution.

Similar to the throughput testing, all three switches, HP 2920, HP 5120 and C2960-X were tested for Layer 2 latency using 48 x 1GE ports from small to jumbo frame sizes (see table next page) Latency was measured on the standalone 48 port switch in extreme port pair configuration, for example; Tx from port 1 and Rx on port 48.

4.2 RFC 2544 Layer 2 Average Latency Test Results



Frame Size	64	128	256	512	1,024	1,280	1,518	9,200
C2960X	4.2	5.1	6.0	8.4	12.5	14.5	16.3	77.7
2920	3.4	4.1	5.4	7.8	12.9	15.4	17.7	98.1
5120	6.1	6.7	8.0	10.5	15.6	18.2	20.6	97.3

Source: Miercom Ethernet Switch Study, 2014

Based on RFC 2544, Layer 2 latency for the Cisco Catalyst 2960-X and the HP 2920 and 5120E switches is shown as an average calculated from small to jumbo frame sizes ranging from 64- to 9200-bytes (jumbo). The C2960-X switch had over 20% lower average latency for the jumbo frame size when compared to the HP 2920 and HP 5120. ***Shorter bars depict better performance.***

We observed that Cisco C2960-X has consistent latency across all 48 ports. Similarly, HP 2920 also has consistent latency across all 48 ports. The latency for HP 2920 is less than C2960-X for packet sizes less than 1024 bytes, but the latency of C2960-X is less than HP 2920 for packet sizes of 1024 bytes and greater. Another observation noted was that the HP 5120 latency is more than HP 2920 and C2960-X for extreme ports for all frame sizes less than 9200 bytes.

5 Energy Efficiency

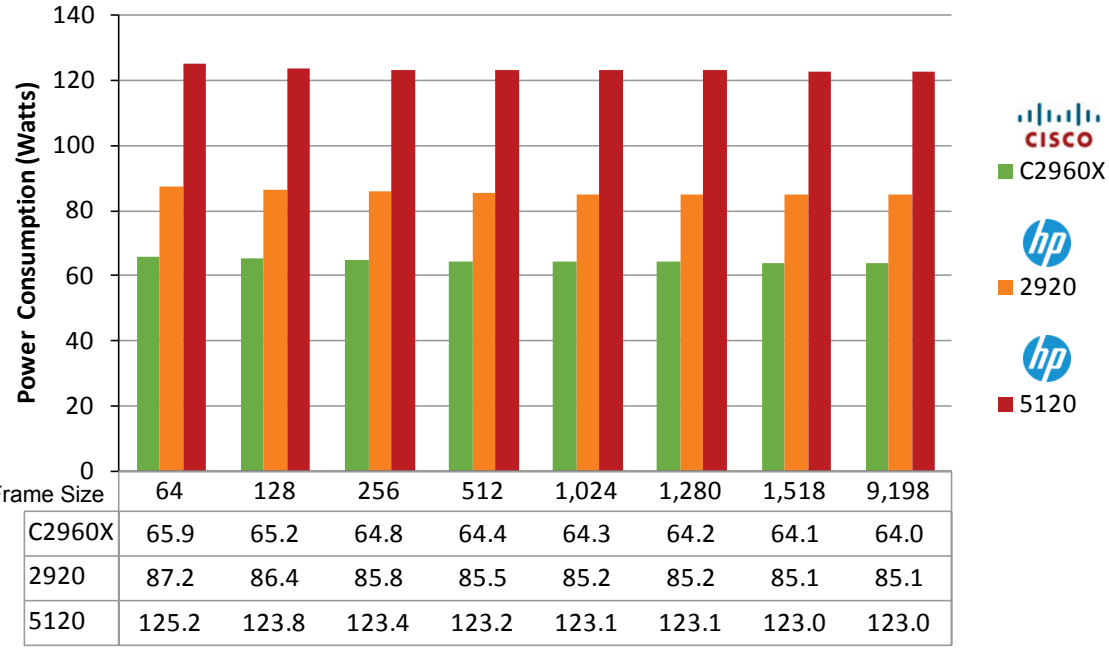
Networks are expanding rapidly, which can result in more power consumption by devices. With technology becoming much more advanced, vendors are designing their switches more efficiently. Switches are now designed to consume less power and are built with energy efficient standards, such as IEEE 802.3az Energy Efficient Ethernet (EEE) and various other green features.

5.1 Power Consumption at Full Traffic Load

Each switch was tested for power consumption while handling 100% line-rate traffic generated by the Ixia XM12. A power consumption meter measured the amount of power used.

5.2 Power Consumption, Full Traffic Load Test Results

Cisco Catalyst 2960-X / HP 2920 / HP 5120 Switches
Power Consumption at Full Traffic Load Test



Frame Size	64	128	256	512	1,024	1,280	1,518	9,198
C2960X	65.9	65.2	64.8	64.4	64.3	64.2	64.1	64.0
2920	87.2	86.4	85.8	85.5	85.2	85.2	85.1	85.1
5120	125.2	123.8	123.4	123.2	123.1	123.1	123.0	123.0

Source: Miercom Ethernet Switch Study, 2014

Validated results show that the C2960-X used just under 25% less power than the HP 2920 while handling 100% line-rate traffic in all packet sizes tested and just under 50% less power than the HP 5120 EI. Lower power consumption is better, resulting in lower heat dissipation there by reducing the cooling requirements. ***Shorter bars depict better performance.***

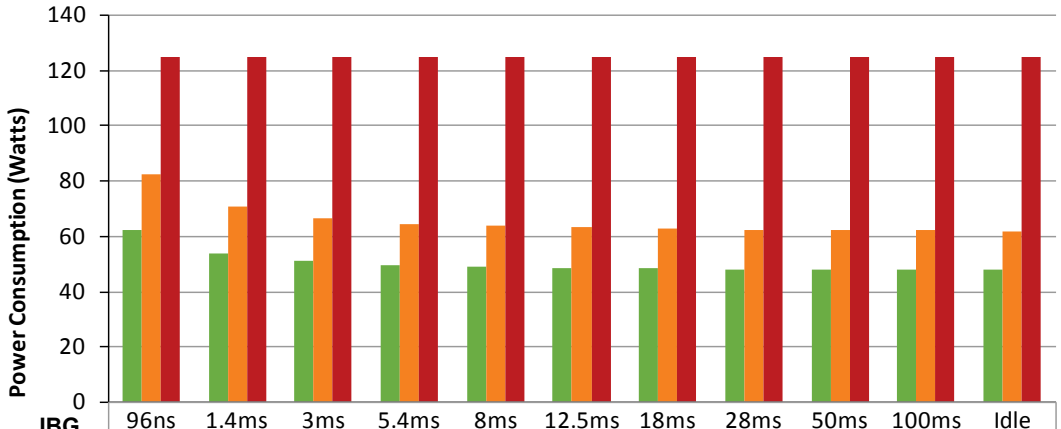
5.3 Energy Efficient Ethernet (EEE)

Both the Cisco Catalyst 2960-X and the HP 2920 support 802.3az Energy Efficient Ethernet (EEE). To determine which switch consumed the least amount of power with EEE enabled, each handled Layer 2 traffic with varying InterBurst Gaps (IBG) between each burst of 1,000 frames.

No power saving will be realized with EEE enabled if the switch is handling 100% line-rate traffic. It was observed that the length of the IBG impacted power consumption. EEE grew more effective as the IBG increased, representing a gradual reduction of traffic.

Power Consumption with EEE Enabled Test Results

Cisco Catalyst 2960-X / HP 2920 / HP 5120 Switches
Power Consumption with Energy Efficient Ethernet Enabled



IBG	96ns	1.4ms	3ms	5.4ms	8ms	12.5ms	18ms	28ms	50ms	100ms	Idle
C2960X	62.2	53.8	51.0	49.6	49.0	48.5	48.3	48.1	48.0	47.9	47.9
2920	82.7	70.6	66.4	64.6	63.7	63.1	62.7	62.5	62.3	62.1	61.9
5120	125.2	125.2	125.2	125.2	125.2	125.2	125.2	125.2	125.2	125.2	125.2

Source: Miercom Ethernet Switch Study, 2014

Testing verified that power savings with EEE enabled increased for both Cisco C2960-X and HP 2920 switches with EEE enabled as the IBG increased. The C2960-X utilized just under one-quarter less power than the HP 2920 for each IBG. HP 5120 does not support EEE and power consumption will be same as with full Traffic load. ***Shorter bars depict better performance****.*

5.4 Switch Hibernation Mode

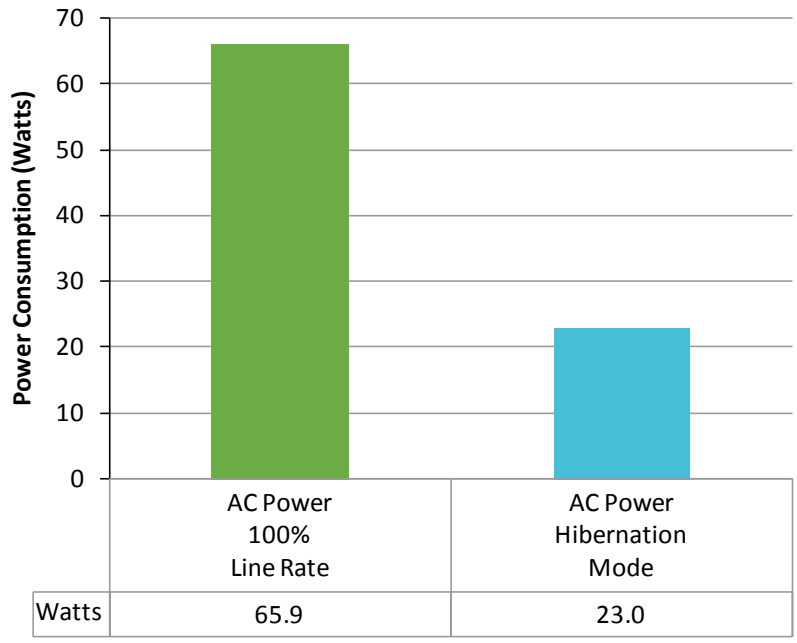
This new power-saving feature is available on all switches in the Cisco C2960-X Series. Both series of HP switches do not have a comparable feature.

Switch Hibernation Mode is designed to power off most of the switch components when the switch is not in use. Power remains available to restart the switch.

The C2960-X switch can be set via the CLI or from a central location by using the Cisco EnergyWise management solution to enter and emerge from Switch Hibernation Mode. While in Switch Hibernation Mode, the C2960X-48LPD-L uses just 23 watts of power.

The following chart and table show power consumption of the C2960-X at 100% line-rate versus Switch Hibernation Mode.

Power Consumption, 100% Line-Rate vs. Hibernation Mode Test Results



Source: Miercom Ethernet Switch Study, 2014

Switch Hibernation Mode, Power Savings for Other X Configurations in C2960-X Switch Series

C2960-X Series Switch	AC Power Consumed 100% Line-Rate (Watts)	AC Power Consumed in Hibernation Mode (Watts)	Power Savings (%)
C2960X-48FPD-L	66.7	26.0	61.0
C2960X-48LPD-L	62.0	23.1	62.7
C2960X-24PD-L	53.1	22.6	57.4
C2960X-48TD-L	47.8	8.7	81.8
C2960X-24TD-L	33.1	6.4	80.7

Source: Miercom Ethernet Switch Study, 2014

Switch Hibernation Mode provides significant power savings to other Cisco X and XR configuration switches in the Cisco Catalyst 2960-X Series of switches. This table shows power savings for five of the configurations, each of which was validated by Miercom independently of the competitive test involving the Cisco Catalyst 2960X-48LPD-L, the HP 2920-48G-PoE+ and the HP 5120-48G-PoE+ EI.

Power Consumption Results

Power Consumption	C2960-X	HP 2920	HP 5120
Full Traffic Load	**Lowest**	**33% more**	**92% more**
EEE Enabled	**Lowest**	**30% more**	**Not supported**
Switch Hibernation Mode	**65% Less**	**Not supported**	**Not supported**

6 Competitive Differentiators for the Stacking Comparison

A stackable switch can function as a standalone unit or can be set up or stacked with other switches to allow higher port capacity and throughput. A stacked set of switches has the characteristics of a single switch, including one IP address, which allows easier remote administration.

Stacking provides general advantages to a network administrator:

- Network administration is handled from one interface, simplifying the setup and operation of the network.
- A small network can be formed with one stackable unit and can be increased by adding additional units when needed.
- Resiliency prevents network failure. Switches in a stack can be configured to failover in order to prevent a complete network failure. Data will continue to flow through the remaining switches in a stack if one unit is removed or fails.

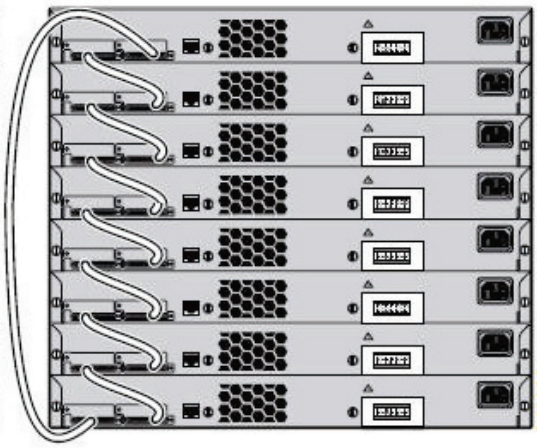
During testing, the C2960-X exhibited specific advantages over the HP 2920 and the HP 5120 EI that are detailed on the following pages.

6.1 Stacking Capacity

Cisco FlexStack-Plus and Cisco IOS Software offer true stacking, with all switches in a stack acting as a single switch unit. FlexStack-Plus provides a unified data plane, a unified configuration and a single IP address for switch management. The advantages of true stacking include lower total cost of ownership and higher availability through simplified management as well as cross-stack features including EtherChannel, Flex Links and Cisco SPAN (Switched Port Analyzer) feature, which is sometimes called port mirroring or port monitoring.

The Cisco C2960-X has double the maximum stacking capacity of the HP 2920 or the HP 5120 EI. Up to eight C2960-X switches can be stacked as one unit with Cisco FlexStack-Plus technology. The maximum bandwidth of a FlexStack-Plus stack is 80 Gbps. Additionally C2960-X member switches will automatically upgrade to the Cisco IOS software version on the master switch and join the stack without additional intervention.

Eight-Member C2960-X Stack, Rear View



Source: Miercom Ethernet Switch Study, 2014

A FlexStack-Plus module has been installed in each Catalyst 2960-X Series switch in this drawing of an eight-member stack. The modules, on the left, are connected by Cisco cabling.

A stack of HP 2920 and HP 5120 EI switches can have a maximum of four switches.

In order to stack HP 2920 switches, a two-port HP 2920 Stacking Module is plugged into each switch before each is booted up. Each module is connected by HP cabling.

If a HP 2920 switch is powered on without a stacking module inserted, stacking is disabled and will be saved in its running configuration. The switch then is in standalone mode.

In order to add the switch to a stack, it is necessary to:

- power down the switch
- insert a stacking module
- configure the switch to operate in stacking mode via the CLI
- reboot the switch to make the new configuration effective

Also, the HP 2920 Stacking Module is not hot-swappable. A stacking module inserted in a HP 2920 series switch after it is running is not automatically enabled. To enable the stacking module and add the switch to a stack, it is necessary to follow the four steps above.

Conversely, the C2960-X offers advantages. Since the Cisco FlexStack-Plus module is hot swappable as mentioned earlier, the C2960-X switch can be added to a stack by inserting the module. The switch does not need to be powered down, configured for stacking mode and rebooted. Once the stack is formed, all members act as a single switching unit with a unified data plane, using a single IP address.

HP 5120 EI switches have HP Intelligent Resilient Framework (IRF) technology, which enables creation of a virtual switching fabric by managing several switches as one logical device.

Miercom engineers noted a difference in configuring a stack of HP 5120 EI switches versus the other two switches. It is a manual process carried out via the CLI. The manual process requires more time than that needed to configure the C2960-X and HP 2920, which occurs automatically as cabling is attached.

The following table provides a snapshot of stacking of each switch tested as per the advertised data sheets.

Stacking Snapshot of Cisco and HP Switches

	Cisco C2960-X	HP 2920	HP 5120
Stacking Technology	Cisco Flex-Stack Plus	Virtual Switching	HP Intelligent Resilient Framework
Maximum Stack Members	8	4	4
Maximum Stack Throughput	80 Gbps	80 Gbps	40 Gbps
Enable Stacking without Additional Configuration	**Yes**	**No***	**No**
Hot Swappable Stacking Modules	**Yes**	**No**	**No**
Add Switches to Stack with No Additional Configuration Required	**Yes**	**No**	**No**
Remove Switches from Stack with No Additional Configuration Required	**Yes**	**No**	**No**
Investment Protection -Backward Compatible Stacking with Older Models	**Yes**	**No**	**No**
Pre-provisioning Stack Member	**Yes**	**Yes**	**No**

Source: Miercom Ethernet Switch Study, 2014

*if switch was booted without stacking module

6.2 Stacking Throughput

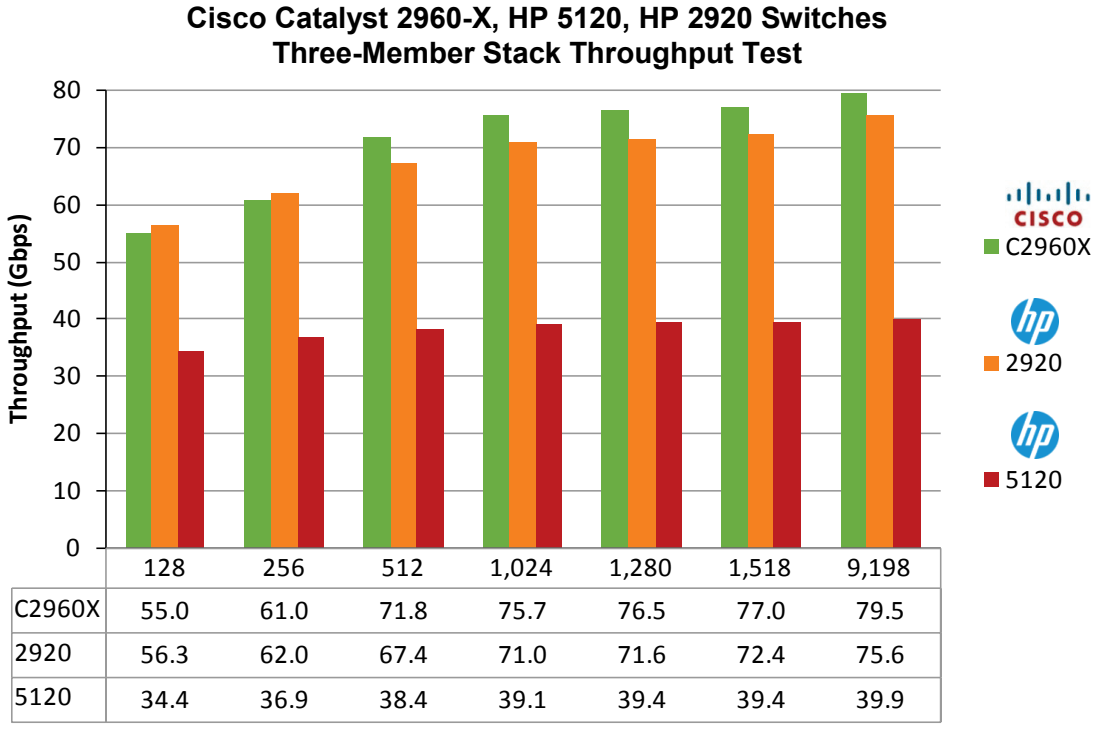
The test verified the maximum throughput capacity of the stack and whether or not any traffic loss occurred. Traffic was transmitted and received using uplink and downlink ports.

A three-member stack of the C2960-X, HP 2920 and HP 5120 was tested. The maximum theoretical throughput of bidirectional traffic through C2960-X and HP 2920 stack ports is 80 Gbps, with the HP 5120 being 40 Gbps.

The Ixia XM12 chassis, hosting Ixia IxNetwork software, was the primary traffic generator. It generated Layer 2 traffic in frame sizes ranging from 64 bytes to 9198 bytes.

Full results are shown in the below chart. The highest throughput reached by the Cisco C2960-X was 99.58% for 9198-byte frames. That equates to 79.50 Gbps of the maximum theoretical throughput of 80 Gbps.

Cisco C2960-X, HP 2920 and HP 5120 Throughput Results



	128	256	512	1,024	1,280	1,518	9,198
C2960X	55.0	61.0	71.8	75.7	76.5	77.0	79.5
2920	56.3	62.0	67.4	71.0	71.6	72.4	75.6
5120	34.4	36.9	38.4	39.1	39.4	39.4	39.9

Source: Miercom Ethernet Switch Study, 2014

Stacking throughput of the C2960-X stack exceeded that of the HP 2920 and HP 5120 for frame sizes ranging from 512 to 9198 bytes. The greatest throughput achieved by the C2960-X stack was 99.58% (79.5 Gbps out of the theoretical maximum throughput of 80 Gbps) for9198-byte frames. Minimum frame size of 100 bytes was needed as we also verified data integrity and correct sequencing. ***Longer bars depict better performance.***

6.3 Backward Compatibility

C2960-X Series switches can be stacked with Catalyst 2960-Sand 2960-SF switches. An organization's investment in existing C2960-S and C2960-SF switches is protected while reaping the benefits of stacking.

The C2960-S is a series of fixed-configuration gigabit Ethernet switches for campus and branch access applications. The C2960-SF is a series of fixed-configuration Fast Ethernet switches that deliver secure and reliable LAN access for branch and medium-sized campus deployments.

C2960-X Series LAN Base switches equipped with a FlexStack-Plus module can be stacked with C2960-S and C2960-SF LAN Base switches equipped with a FlexStack module.

	C2960-X	HP 2920	HP 5120
Maximum Mix Stack Members	4	0	0
Backward Compatibility	**Yes with S and SF series**	**None**	**None**

Stacking Advantages of Cisco over HP Switches

When C2960-X switches are mixed in a stack with C2960-S and C2960-SF switches, the following is true:

- A maximum of four switches can be stacked
- Any combination of C2960-X and C2960-S switches can be utilized
- The master switch can be a member of either the C2960-X or C2960-S series
- The functionality of FlexStack-Plus reverts back to FlexStack capability

The HP 2920 Series of switches, including the HP 2920-48G-PoE+, cannot be stacked with switches from the HP 2910 series. Each series has its own, specific stacking modules.

Models in the different HP 5120 series cannot be stacked. HP 5120 EI switches use a 10GE module to stack. HP 5120 SI switches use 1GE ports for stacking.

6.4 Stack Split

The purpose was to determine if a member switch would remain usable as a standalone unit after it was disconnected from a four-member stack.

A Cisco C2960-X and HP 5120 switches were observed to be usable as a standalone unit after removing from the stack. They automatically rebooted and went into standalone operating mode.

The HP 2920 switch was observed to be unusable. Configuration options were limited to those relating to stacking. More importantly, the switch was not functioning. A hard reset was required to change the configurations options from those related to stacking to factory default settings.

After disconnecting the member switch, the remaining C2960-X, HP 2920 and HP 5120 switches continued to function as a stack.

	C2960-X	HP 2920	HP 5120
Member switch functional as standalone upon removal from four-member stack	**Yes**	**No**	**Yes**

6.5 Stack Convergence

To verify switch stack high availability, a stack convergence test was performed. Stack convergence measures the amount of time it takes for traffic to converge after a stack link has been removed. The purpose was to determine the stack data and control plane convergence time. In order to do that, we would be sending traffic across one of the members in a three-member stack in full ring topology. Before running the test, we needed to determine which stack links were in the forwarding state, and which were in the blocking state. Once this was determined, we pulled the stack cable through which traffic is flowing and observed the stack data convergence time. The link in the blocking state then became active, and traffic converged. The traffic was sent at a rate of 1,000 packets/sec. Every packet loss was equivalent to 1 ms. Theoretically, the data should converge in less than 100 ms.

For HP 5120, stacking cannot be performed in mesh topology, and only chain or ring topology are supported. We also observed that when a stack header is added to the stack traffic, it causes 1.176% loss for 64-byte frames at line-rate. Furthermore, when all the stack ports are loaded on a three-member stack, additional losses are observed. These losses are beyond the stack header.

The following table summarizes the stack convergence time for all three switches tested.

Stack Convergence Time Comparison Summary

	C2960-X	HP 2920	HP 5120
Stack Convergence Time	1 ms	95 ms	88 ms

7 Competitive Differentiators for the LACP Load Balancing Comparison

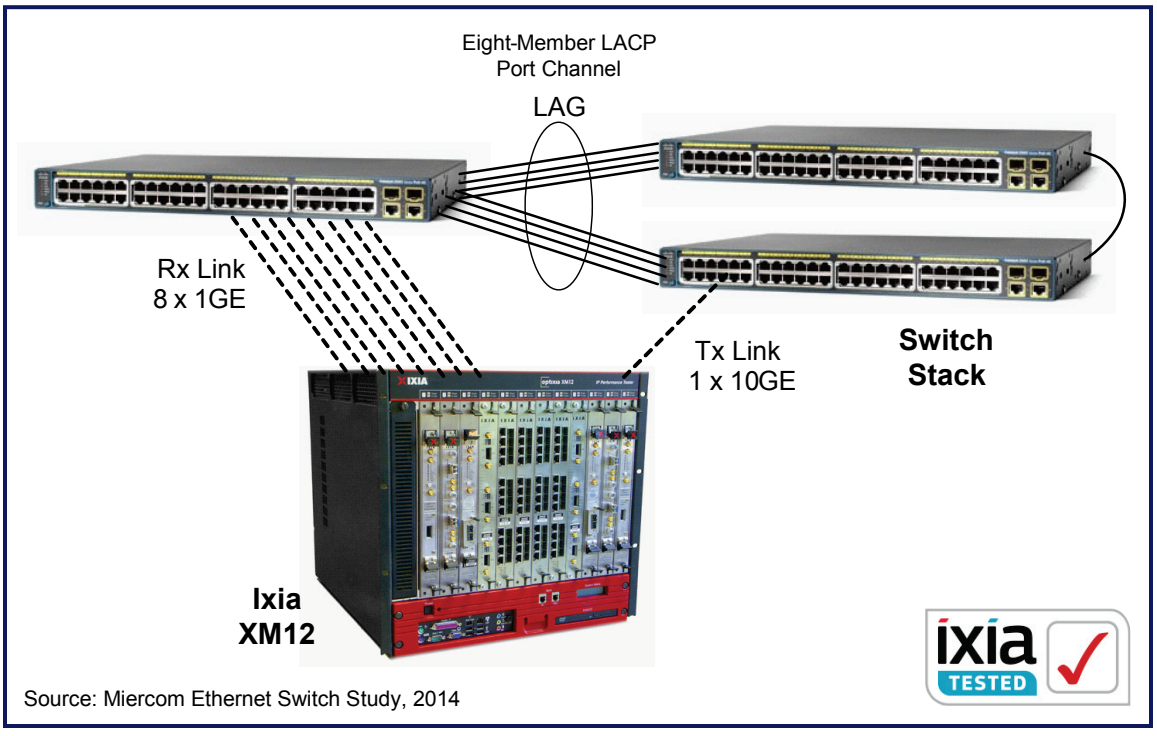
7.1 Cross Stack LACP Load Balancing

The purpose of this test was to examine if the traffic is load balanced across the stack members uniformly and if there was any packet loss on the receiving ports.

This test was conducted to assess the ability of a two-member stack of C2960-X switches, HP 2920 and HP 5120 switches to perform LACP loaded balancing after a simulated network failure.

In testing, two identical DUTs formed a switch stack. Each of the two switches were named stack member A and B. Four of the 1GE ports on both switches were aggregated by LACP, and as a result, the LACP group had a bandwidth of 8 Gbps. This LACP group was connected to a receiving switch and the receiving switch was connected to Ixia's receiving port. The Ixia transmission port was connected to stack member A. They were formed in a single subnet. The Ixia was used to inject Layer 2 traffic across the LACP group. We were interested in seeing if the traffic was load balanced on all LACP member ports and whether there would be any packet loss on the receiving ports. As traffic is being transmitted, the port counters are checked to verify proper load balancing.

Load Balancing Test Bed



Source: Miercom Ethernet Switch Study, 2014

Four 1GE ports on each switch in the two member stack were configured in a port channel, forming an eight-member LACP group to send traffic. Also, eight 1GE ports on each standalone switch (lower left) served as a LACP group to receive traffic.

The Ixia XM12 traffic generator, hosting Ixia IxNetwork software, was connected with both the stack and the standalone switch. The traffic is transmitted to the stack using 1 x 10G to each Stack Member. A total of 90 hosts are simulated across the eight Ixia 1GE ports and one 10G port, 10 hosts on each port.

Traffic from all 10 hosts connected to the 10GE interface on the stack was destined to hosts connected to a 1GE interface on the standalone switch via the eight-member LACP port channel.

The round-trip path of the Layer 2 utilized in the test went through the stack, then to the standalone switch via the LACP port channel and back to the Ixia XM12.

Drop Rate of a LACP Group with 3G Traffic

	Cisco C2960-X	HP 2920	HP 5120
LACP Bandwidth [Gbps]	8	8	8
LACP Group Ports	8	8	8
Injected traffic [Gbps]	3	3	3
Injected traffic Line-Rate [%]	37.5	37.5	37.5
IXIA TX port on	Stack member A	Stack member A	Stack member A
LACP Balance on Stack Member A	**Yes**	**No***	**Yes**
LACP Balance on Stack Member B	**Yes**	**No***	**No Traffic**
Drop Rate [%]	**0**	**0**	**0**

Drop Rate of a LACP Group with 5G Traffic

	Cisco C2960-X	HP 2920	HP 5120
LACP Bandwidth [Gbps]	8	8	8
LACP Group Ports	8	8	8
Injected traffic [Gbps]	5	5	5
Injected traffic Line-Rate [%]	62.5	62.5	62.5
IXIA TX port on	Stack member A	Stack member A	Stack member A
LACP Balance on Stack Member A	**Yes**	**No***	Yes
LACP Balance on Stack Member B	**Yes**	**No***	**No Traffic**
Drop rate [%]	**0**	**20.1**	**24.2**

***Traffic is not load balanced across all the LACP ports.**

Observations

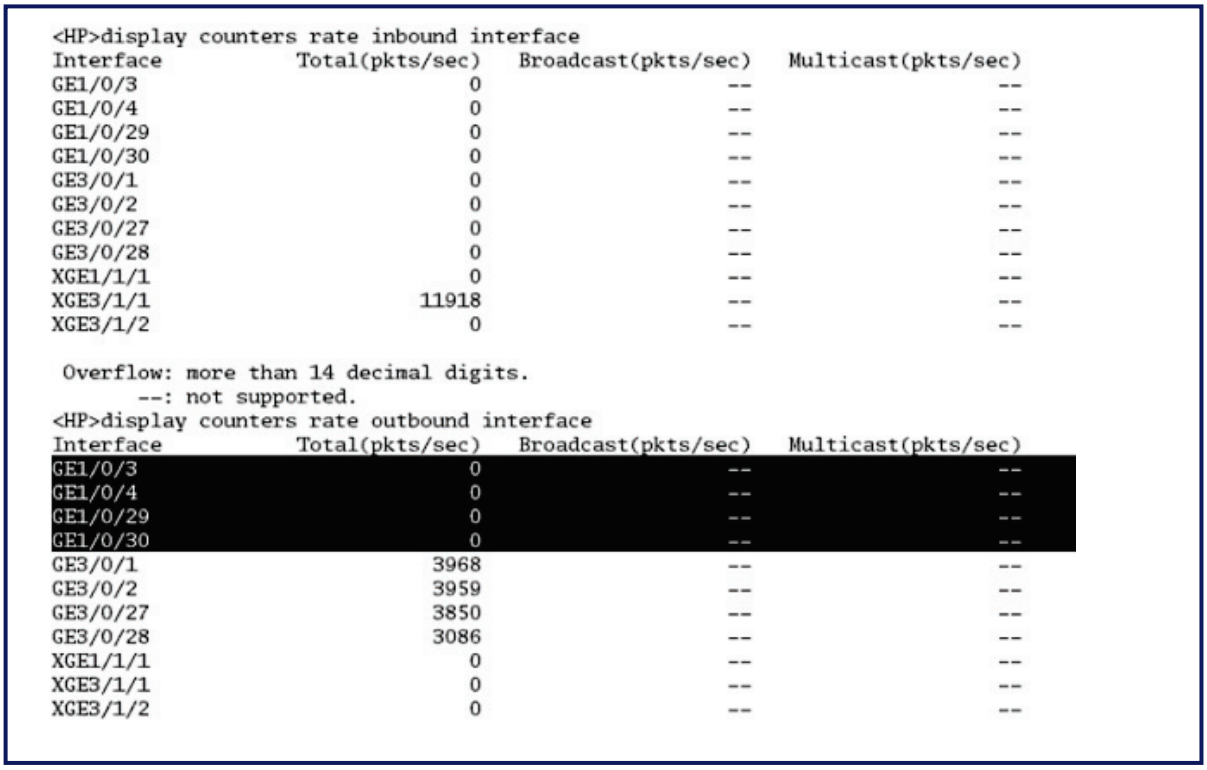
The Cisco C2960-X was able to form cross stack LACP and the traffic was load balanced across the stack members. We did not observe any traffic loss with 3G and 5G input traffic across the eight-member ether channel.

Similarly for the HP 5120 and 2920 switches, we were able to form cross stack LACP with IRF stacking, however the load balancing was not effective and traffic was not received by all members of LACP ports. There is traffic loss of 24.2% and 20.1% for HP 5120 and HP 2920, respectively, due to the uneven load balancing when sending 5G of traffic. We noticed that Dynamic LACP is restricted to native VLAN only if Generic VLAN Registration Protocol (GVRP) is not enabled in the HP 2920. Additionally, the HP 2920 switch was able to load balance L3 traffic only from multiple sources to a single destination. If there are multiple destinations, the load balancing fails.

The following screenshot shows LACP member ports that were not forwarding Layer 2 traffic. This could have been caused by a problem between the stacking and LACP mechanism. The same issue is not observed on the Cisco C2960-X switch.

HP 5120 Switch

No Layer 2 Traffic on Half of LACP Member Ports



```
<HP>display counters rate inbound interface
Interface            Total(pkts/sec)   Broadcast(pkts/sec)   Multicast(pkts/sec)
GE1/0/3                            0                    --                    --
GE1/0/4                            0                    --                    --
GE1/0/29                           0                    --                    --
GE1/0/30                           0                    --                    --
GE3/0/1                            0                    --                    --
GE3/0/2                            0                    --                    --
GE3/0/27                           0                    --                    --
GE3/0/28                           0                    --                    --
XGE1/1/1                           0                    --                    --
XGE3/1/1                       11918                    --                    --
XGE3/1/2                           0                    --                    --

 Overflow: more than 14 decimal digits.
      --: not supported.
<HP>display counters rate outbound interface
Interface            Total(pkts/sec)   Broadcast(pkts/sec)   Multicast(pkts/sec)
GE1/0/3                            0                    --                    --
GE1/0/4                            0                    --                    --
GE1/0/29                           0                    --                    --
GE1/0/30                           0                    --                    --
GE3/0/1                         3968                    --                    --
GE3/0/2                         3959                    --                    --
GE3/0/27                        3850                    --                    --
GE3/0/28                        3086                    --                    --
XGE1/1/1                           0                    --                    --
XGE3/1/1                           0                    --                    --
XGE3/1/2                           0                    --                    --
```

The Layer 2 traffic was perfectly load balanced across all the LACP members of the C2960-X stack. It was not load balanced on the HP 2920 stack.

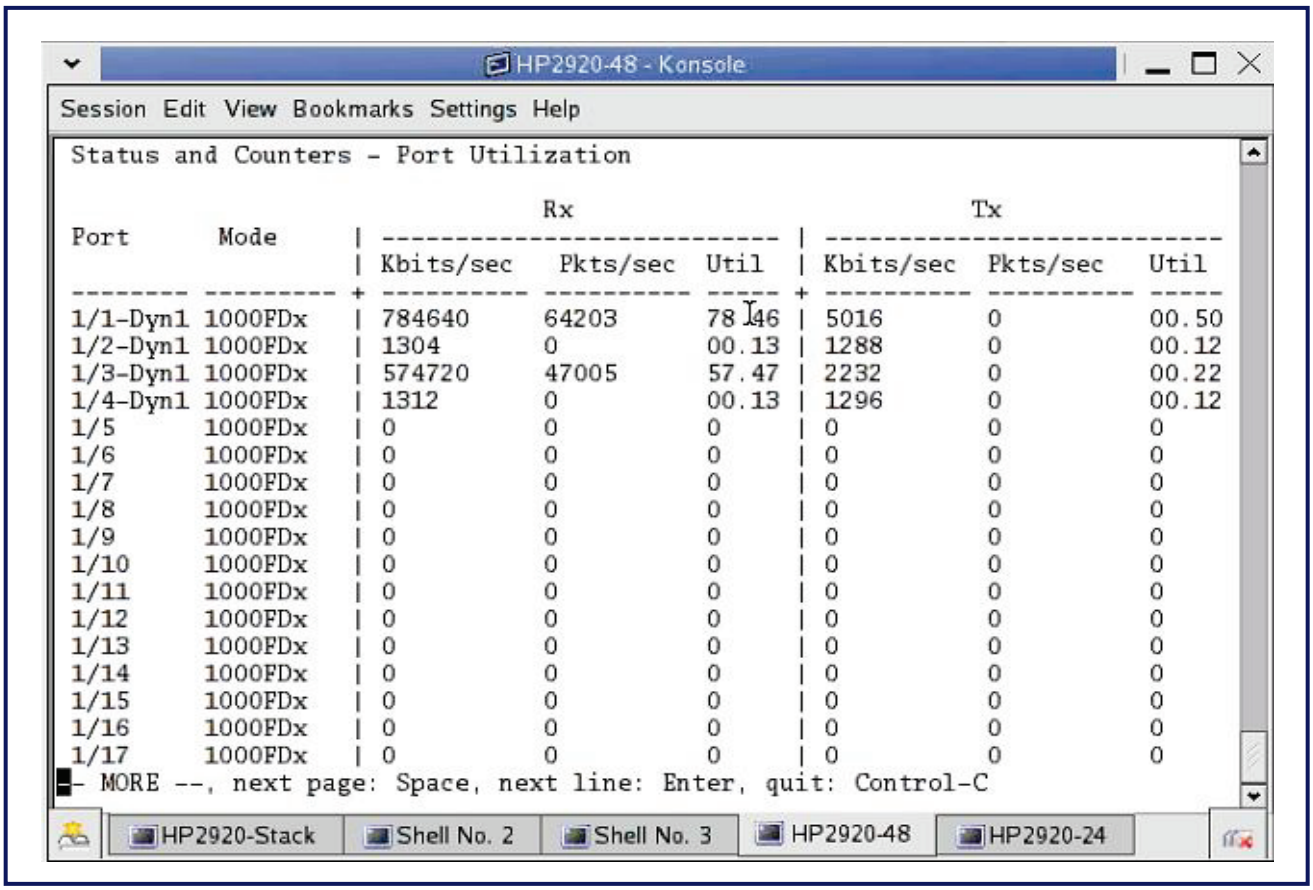
After the port counter in the stack was checked to verify perfect load balancing of traffic across the eight links, a single 1GE link in the port channel was disconnected.

The Cisco C2960-X stack was observed to quickly recover and resume performing perfect load balancing by using the remaining seven active LACP members. Upon reconnecting the 1GE link, the Cisco stack quickly returned to performing perfect load balancing over eight LACP members. Since the Cisco stack was successful in both scenarios, no traffic was lost.

The following screenshot shows two LACP member ports out of four that were not forwarding Layer 2 traffic for HP 2920. As a result of this, traffic loss was observed in the amount of 20% when injecting 5G.

HP 2920 Switch

Layer 2 Traffic not being Received on All LACP Members of the IRF Stack Members



The HP 2920 failed to perform perfect load balancing after the 1GE link was removed. As a result, traffic was lost.

The 10GE port on both the C2960-X and the HP 2920 were not oversubscribed with traffic during the test. Each initially received 4 Gbps from the EtherChannel and 4 Gbps after the link was disconnected.

The C2960-X provides the flexibility to configure port channel/LACP load balancing by using source-based or destination-based forwarding methods such as destination-ip, destination-mac, source-destination-ip, source-destination-mac, source-ip and source-mac. Conversely, the user is not afforded the flexibility to choose the load balancing method for the HP 2920.

The following table summarizes the key findings for the Load Balancing section of the Switch Study.

LACP Load Balancing Switch Comparison Summary

LACP Load Balancing	C2960-X	HP 2920	HP 5120
Layer 2 Traffic	**Perfectly load balanced, no drop**	**Not load balanced, dropping packets**	**Not load balanced, dropping packets**
Disconnect then reconnect one link from the port channel	**Quickly recover and load balanced, no traffic loss**	**Failed to load balance, 20% traffic was lost**	**Failed to load balance, 24% traffic was lost**
Flexibility to choose load balancing method	**Yes**	**No**	**Yes**

Cisco C2960-X consistently and uniformly outperformed the HP 5120 and HP 2920 in the Layer 2 traffic load balancing assessment across all LACP stack members.

8 Competitive Differentiators for the Quality of Service Comparison

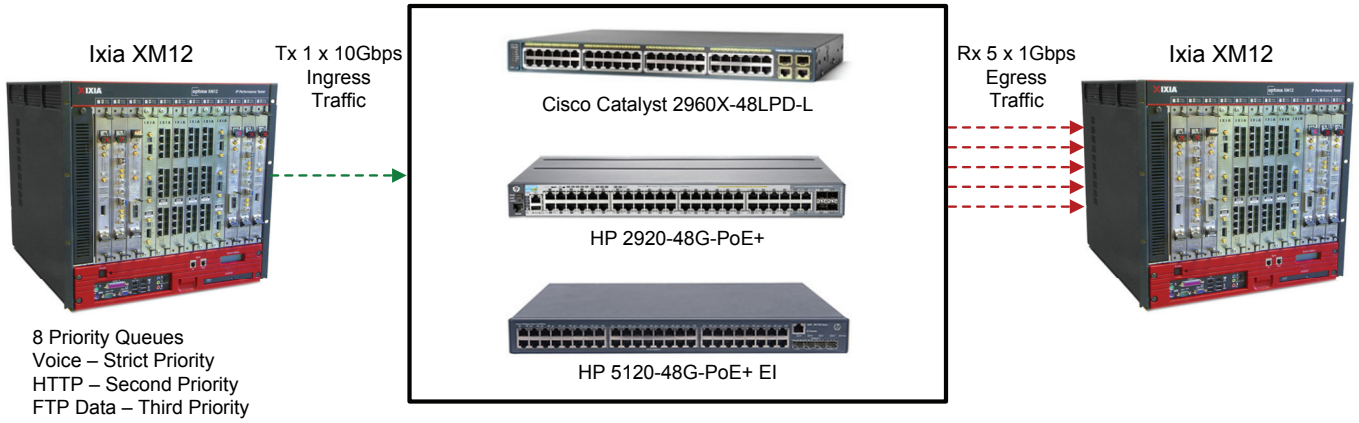
8.1 Priority Traffic Delivery under Adverse Network Conditions

The Cisco C2960-X supports strict priority queue (PQ), which allows delay-sensitive data such as voice to be de-queued and sent before packets in other queues are de-queued. As a result, the C2960-X experienced no loss of priority traffic and had no latency issues in simulated congested conditions. The HP 2920 experienced loss of priority traffic and suffered latency delays.

A single switch was utilized in this test that challenged the ability of Quality of Service (QoS) functionality to deliver priority traffic during a simulated state of network congestion. Each switch was connected to the Ixia XM12 generator hosting Ixia IxExplorer software. Network congestion is simulated using one 10 G port on the Ixia XM12 transmitting to five 1GE port on the switch as shown in the figure below.

Congestion Test Scenario

Test Bed Diagram



Source: Miercom Ethernet Switch Study, 2014

8.2 QoS Remarking and Priority Queue

To conduct the QoS test, the Ixia XM12 was used to send 10G of Ingress traffic to oversubscribe five 1G Egress ports. To do this, we built a total of eight queues with different traffic loads and packet sizes. All traffic streams were monitored for packet loss. The following table shows the type of traffic, packet size sent and percentage of line-rate set for each priority queue.

Priority Queue	Traffic Item	Packet Sizes	% Line-Rate
P0	TCP Port 15	9000	10%
P1	TCP Port 4	2500	10%
P2	TCP Port 10	5000	10%
P3	TCP Port 18	3000	10%
P4	FTP	8000	10%
P5	FTP Data	5000	20%
P6	HTTP	1500	20%
P7	Voice	90	5%

Based on the above set priority queues, voice traffic had the highest priority, which meant it had all the bandwidth it needed. HTTP traffic was assigned the second priority and FTP data traffic with third priority. The purpose of this particular test was to examine if the marking, queuing and strict prioritization, once configured for each switch perform as it should. We were paying particular attention to see if there would be any voice traffic loss once there was traffic congestion.

QoS Traffic Loss Comparison for Different Types of Traffic (% Dropped Packets)

Traffic Profile	C2960-X	HP 2920	HP 5120
Voice Traffic 5%	**0**	**5.74**	**0**
HTTP Traffic 20%	**0**	**47.11**	**40.8**
FTP Data Traffic 20%	**77.7**	**67.34**	**71.4**

We validated the DSCP remarking for all HP 5120, HP 2920 and Cisco Catalyst 2960-X switches. Cisco C2960-X supports strict priority queuing so therefore no voice traffic loss was observed, but we did see that latency increased. In addition, three different types of traffic can be classified on each queue using thresholds. We can classify a maximum of 12 types of traffic using four queues. Much flexibility is offered to configure the buffers, and to shape and share the bandwidth among the queues. We were also able to debug the traffic queues and dropped packets on per port and per queue basis.

HP 2920 does not support strict priority queues, however it does have a higher priority queue. Therefore, we assigned voice traffic to the high priority queue. During congestion, substantial amount of drops for Voice, HTTP and FTP Data are observed as seen in the table on the previous page and the latency also increased significantly. Throughout the configuration of the switch, we noted that only one type of traffic can be classified per queue, which limits the maximum traffic classifications to eight, with a total of eight queues supported. In addition, the HP 2920 switch has very limited debugging resources and there are very limited options to check where the traffic was dropped.

HP 5120 does support a strict priority queue and while there was no voice traffic loss, latency increased significantly as with the HP 2920 switch. HP 5120 scheduling, based on local marked dopt1p, was validated, although scheduling based on local marked dscp did not work. Similarly to the HP 2920 switch, only eight queues with one type of traffic can be classified.

8.3 QoS Flexibility for Functionality

The Cisco C2960-X provides greater flexibility to configure QoS buffers and bandwidth. This flexibility allows network administrators to fine-tune their switches to optimize performance. In the C2960-X, the egress buffer is divided into two pools, reserved and common. The switch uses the common pool when the reserved pool for the egress interface has already been consumed.

When operating as a stack or a standalone switch, the C2960-X has four egress queues per port and three thresholds per egress queue. Since multiple classes of traffic can use the same egress queue (via mapping), a threshold value is used to further differentiate among classes sharing an egress queue.

The C2960-X provides the granularity to configure the thresholds, which define the maximum buffers available (reserved and common) for a given traffic class. As mentioned earlier, a strict PQ allows delay-sensitive data such as voice to be de-queued and sent before packets in other queues are de-queued. The net-net is that a strict approach to queuing gives the end user flexibility, the power to prioritize. The C2960-X will transmit packets designated with the highest priority before any other.

The success of the Cisco approach was validated in the tests of priority traffic delivery under an adverse network condition, which is discussed earlier in this section. The C2960-X received every frame of traffic that was designated as priority. Conversely, the HP switch did not receive every frame that was designated as priority.

The HP 2920 has preset default configurations for bandwidth and buffers allocated to each queue. The end user is not afforded the flexibility to configure bandwidth and buffers to optimize network performance.

For testing, QoS marking was configured manually on the HP 2920, with different traffic assigned to different queues. Conversely, the C2960-X supports Cisco AutoQoS, which simplifies QoS deployment by automating QoS policies. AutoQoS automatically detects the type of device (switch or router) connected and configures the recommended QoS policies.

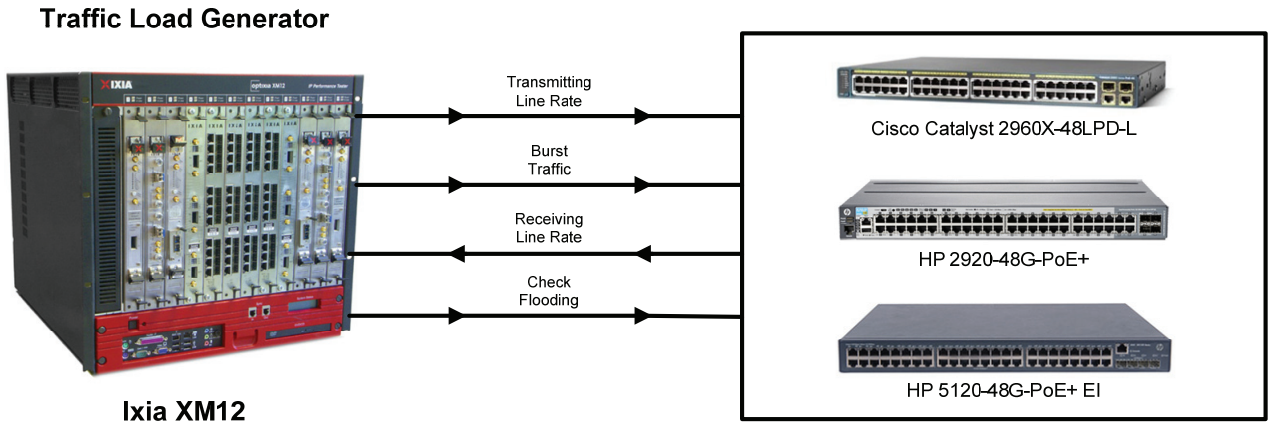
8.4 QoS Egress Buffers Flushing Issue (N+1 Buffers)

The intent of this test is to show the performance of a switch when the buffer capacity is exceeded. A single packet that exceeds the switch buffer capacity should not cause the buffer to flush. Only the additional packet should be dropped. If a switch performs a buffer flush as a remedy to oversubscription, this unwelcome behavior forces data to be retransmitted and may introduce packet loss and reduce network throughput.

In this test, we were to investigate the number of buffers available, the effect of oversubscription on the buffer and the efficiency of using the buffer with different frame sizes.

The following test bed diagram illustrates one of the two sets of 4 ports used to run the test for each switch.

Test Bed Diagram



Source: Miercom Ethernet Switch Study 2014

For this test, we used a total of four ports. The first port sent constant 100% line-rate background traffic with 64, 256 and 1500 frame sizes. The second port sent burst traffic that would change depending on the behavior of switch. The third port was an outbound receiving port for the traffic of the first and second ports which captured the outbound line rate and burst traffic. The third port monitored packet drop when bursty traffic was injected. The last port was used for MAC learning and to make sure there was no flooding. Theoretically, for all three switches, bursty traffic is stored on the buffer. Traffic loss should only happen with packets which exceeded the buffer size.

N+1 Drop Test

Frame Size	Switches	N+1 Drop (Frame)	Dropped Rate (%)
64	C2960-X	1	0
	HP 2920	1	0
	HP 5120	259	24.7
256	C2960-X	1	0
	HP 2920	1	0
	HP 5120	260	25
1500	C2960-X	1	0
	HP 2920	1	0
	HP 5120	450	100.0

QoS Egress Buffer testing concluded that Cisco C2960-X and HP 2920 did not lose any extra packets as buffer capacity was exceeded. For HP 5120, one-quarter (25%) of the buffering is flushed for frame sizes in range of 64-byte to 512-byte and 100% packet loss for frame sizes larger than the range of 1024-1518 bytes.

Observations

For the Cisco Catalyst 2960-X switch, buffer queue flushing was not observed on small, medium and large frame sizes. Only extra packets were dropped with any size packets. This result shows the DUT's buffer mechanism handles bursty traffic properly if traffic exceeded buffer size.

Similar to Cisco, HP 2920 buffer queue flushing was not observed and only the extra packets were dropped with any size packets.

For HP 5120, we have observed nearly one-quarter of the buffer queue flushed for the 64-byte packet size. With bigger packet sizes, such as 1500-byte, the whole egress buffer queue was flushed and 100% of bursty traffic was dropped. HP 5120 did not handle bursty traffic properly if the bursty traffic exceeded the buffer. This symptom was more significant if the frame size was larger.

Quality of Service Features Comparison Summary

	C2960-X	HP 2920	HP 5120
Auto QoS	**Yes**	**No**	**No**
Strict Priority Queue	**Yes**	**No**	**Yes**
QoS Traffic classifications per queue	**3 types of traffic per queues**	**Only 1 type per queue**	**Only 1 type per queue**
Voice Traffic was not dropped during Congestion	**Yes**	**No, 5.74% voice traffic loss**	**Yes, but significant latency increase**
Flexibility to Configure QoS Buffer/Bandwidth to Prioritize Traffic	**Yes**	**No**	**No**
No Flushing of Egress Buffers during congestion	**Yes**	**Yes**	**No**

9 Competitive Differentiators of the Traffic Drop Comparison

The ability to identify where traffic was dropped helps the troubleshooting and debugging of network problems. This contributes to optimal network performance. With the Cisco C2960-X, it is possible to identify where traffic was dropped at the queue level. The HP2920 and HP 5120 do not offer that type of information. Also, debugging is more difficult on the HP switches.

In testing, some frame loss was observed on the C2960-X while handling lower priority traffic. It was fast and easy to pinpoint the location, at the queue level, via a show command on the CLI: “show mlsqos interface <interface name> statistics.”

Summary table of findings shown below, and screen CLI capture shown on the next page.

Comparative Snapshot, Debugging and Troubleshooting

	C2960-X	HP 2920	HP 5120
Debug at Queue Level for Traffic Loss	**Yes**	**No**	**No**
Easy Troubleshooting	**Yes**	**No**	**No**

```
C2960-X#sh mls qos interface gigabitEthernet 1/0/1 statistics
GigabitEthernet1/0/1 (All statistics are in packets)

  dscp: incoming
-------------------------------

  0 -  4 :           0           0           0           0           0
  5 -  9 :           0           0           0           0           0
 10 - 14 :           0           0           0           0           0
 15 - 19 :           0           0           0           0           0
 20 - 24 :           0           0           0           0           0
 25 - 29 :           0           0           0           0           0
 30 - 34 :           0           0           0           0           0
 35 - 39 :           0           0           0           0           0
 40 - 44 :           0           0           0           0           0
 45 - 49 :           0           0           0           0           0
 50 - 54 :           0           0           0           0           0
 55 - 59 :           0           0           0           0           0
 60 - 64 :           0           0           0           0
  dscp: outgoing
-------------------------------

  0 -  4 :      703802           0           0           0           0
  5 -  9 :           0           0           0           0           0
 10 - 14 :           0           0           0           0           0
 15 - 19 :           0           0           0           0           0
 20 - 24 :           0           0           0           0           0
 25 - 29 :           0           0           0           0           0
 30 - 34 :           0           0           0           0           0
 35 - 39 :           0           0           0           0           0
 40 - 44 :           0           0           0           0           0
 45 - 49 :           0           0           0           0           0
 50 - 54 :           0           0           0           0           0
 55 - 59 :           0           0           0           0           0
 60 - 64 :           0           0           0           0
  cos: incoming
-------------------------------

  0 -  4 :           2           0           0           0           0
  5 -  7 :           0           0           0
  cos: outgoing
-------------------------------

  0 -  4 :      703925           0           0           0           0
  5 -  7 :           0           0        4697
  output queues enqueued:
 queue:    threshold1   threshold2   threshold3
-----------------------------------------------
 queue 0:           0           0           0
 queue 1:      703806         119        4697
 queue 2:           0           0           0
 queue 3:           0           0           0

  output queues dropped:
 queue:    threshold1   threshold2   threshold3
-----------------------------------------------
 queue 0:           0           0           0
 queue 1:           0           0           0
 queue 2:           0           0           0
 queue 3:           0           0           0

Policer: Inprofile:            0 OutofProfile:            0
```

10 Competitive Differentiators of the Traffic Monitoring Comparison

10.1 Cisco NetFlow-Lite versus InMon sFlow

Cisco NetFlow-Lite provides traffic monitoring for the Catalyst 2960-X Series, measuring up to 16,000 flows per stack or standalone switch. Traffic monitoring on the HP 2920 and HP 5120 switches is provided by sFlow, developed by InMon Corp.

Comparative Snapshot, NetFlow-Lite versus sFlow

Traffic Monitor	Technology	Sampling	Export Format	Ecosystem
Cisco NetFlow-Lite	Flow-based	1:32 to 1:1,022, configurable	V9 and IPFIX	NetFlow Collector
InMon sFlow	Packet-based	1:32 to 1:hundreds or thousands, depending on link speed	sFlow v5	sFlow Collector

Source: Miercom Ethernet Switch Study, 2014

An observed difference was that NetFlow-Lite records can be viewed on the C2960-X using the CLI. There was no option for viewing sFlow records on the HP switches. Also, sFlow records had to be exported to an external sFlow Collector to be viewed.

10.2 Field Captures

A single C2960-X and HP 2920 switch was utilized for this test. The Ixia XM12 chassis, hosting IxExplorer, sent Layer 3 traffic to a 1G port on each switch.

It was observed that NetFlow-Lite captured more relevant information pertaining to the C2960-X than did sFlow pertaining to the HP2920 as shown in the table on the following page. C2960-X provided flexibility to choose the traffic parameters for monitoring.

Traffic parameters collected by each traffic monitor were verified by Live Action Flow software hosted by a Dell laptop.

Live Action Traffic Parameter Collection

Parameter	NetFlow-Lite	sFlow
Source/Destination MAC Address	**Yes**	**No**
Source/Destination IP Address	**Yes**	**Yes**
Source/Destination Ports	**Yes**	**Yes**
VLAN Information	**Yes**	**No**
Application	**Yes**	**Yes**
Time Stamps	**Yes**	**Yes**
Protocols	**Yes**	**Yes**
Traffic Rate	**Yes**	**No**

Source: Miercom Ethernet Switch Study, 2014

10.3 Traffic Monitoring without Drops

The purpose of this test was to validate the combination of the maximum amount of throughput the C2960-X and HP 2920 could handle while conducting traffic monitoring at the highest rate.

The C2960-X did not drop any NetFlow-Lite samples while sampling at a rates of 1-to-100, 1-to-50 and lastly, vendor-stated maximum, 1-to-32 on 1GE downlink ports while handling 100% throughput from the Ixia XM12. The maximum also applies to 10GE uplinks. However, a 10GE uplink was not tested.

Meanwhile, the HP 2920 dropped sFlow samples while sampling at the initial rate, 1-to-100, at all throughput rates. Throughput was continually lowered in an effort to find the throughput rate at which sFlow samples would not be dropped. It was not found as sFlow samples were still being dropped at 1% throughput from the Ixia XM12.

The advantage of NetFlow-Lite in the C2960-X also extends to the amount of traffic it can capture, full traffic for a half hour. Conversely, sFlow provides only multiple samples for a given flow. Because it periodically samples for 10 seconds, it may not be possible to obtain from the sFlow collector an export of an individual packet for analysis.

Traffic Monitoring Comparison Summary

	Cisco C2960-X	HP 2920
View records using CLI, no need exporting	**Yes**	No
Complete Traffic parameter captured	**Yes**	No
Traffic monitoring without drops	**Yes**	No
Flexibility to choose monitoring parameters	**Yes**	No

11 Competitive Differentiator of the Access Control List Comparison

The switching architecture of the C2960-X enables sharing of common access control lists among ports. The architecture of the HP 2920 does not support sharing. Therefore, more memory must be used when configuring ACLs on each port.

When the same port ACL with three ACE entries is applied on 20 different ports on a C2960-X and HP 5120 switch, only three hardware entries are used since common ACLs are shared among the ports.

The HP 2920 lacks this ability to optimize hardware resource optimization. A total of 8 hardware entries would be applied to program the ACL on each single port of the 20 ports. When the same port ACL is applied on each of these ports, the result is a total of 160 hardware entries being used.

# ACEs in ACL	ACL Usage			
	Interfaces Applied	Cisco C2960-X	HP 2920	HP 5120
3 (2 Deny, 1 Permit)	**0**	**0**	0	0
	1	**3**	**8**	3
	2	**3**	**16**	3
	10	**3**	**80**	3
	20	**3**	**160**	3

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