Miercom

Lab Testing Summary Report

August 2013

Report SR130801

Product Category:

Enterprise Switch

Vendor Tested:

HUAWEI

Product Tested:

S12700 Series Agile Switches

Miercom PERFORMANCE VERIFIED™

Key findings and conclusions:

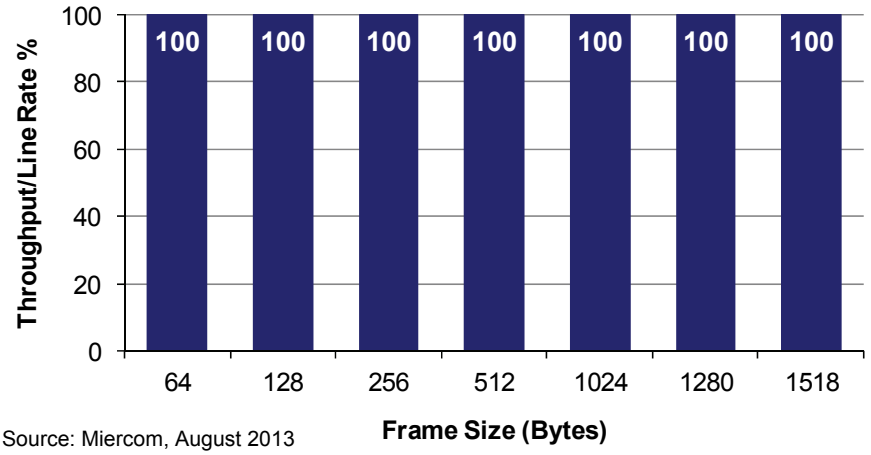
- **Huawei S12708 agile switch demonstrates 100% line rate throughput with 384 10GE ports in full line rate throughput tests**
- **As a next-generation core switch for campus networks, the S12708 switch has full programmability, is SDN ready, and supports Protocol Oblivious Forwarding (POF)**
- **Resilient operation continues with fully loaded 384 10GE ports even after removing one of four switching fabric modules**
- **Ethernet Ring Protection Switching (ERPS) and Smart Ethernet Protection (SEP) demonstrated fault recovery in less than 50 milliseconds on an Open Ring Network**
- **Support for hardware-based Bidirectional Forwarding Detection (BFD) with fast fault detection and switch back without packet loss**

Huawei Technologies engaged Miercom to evaluate the S12700 series agile switches. Testing focused on Software-Defined Networking (SDN) / Programmability capability, performance, throughput, scalability and failover capability.

The S12700 series are LAN switches for campus core applications. There are two models in the series: S12708 and S12712. The S12712 has 12 slots for line card modules. The model tested, the S12708, offers eight slots for line card modules.

Performance testing verified 100% line rate throughput for all packet sizes with zero frame loss, low latency and low jitter. The switching fabric N + 1 redundancy was verified at the conclusion of the throughput test by removing one of the four switching fabric modules while the switch was fully loaded with full-mesh traffic.

Figure 1: Huawei S12708 Agile Switch RFC 2544 Layer 2 Throughput



Source: Miercom, August 2013

The Huawei S12708 agile switch forwarded full line rate traffic with zero loss for all frame sizes tested. The switch was configured with 384 x 10GE ports in full mesh configuration and conducted in accordance with RFC 2544.

The programmability tests involved a Huawei Campus Controller to "program" or direct one or more S12708 switches. The advanced programmability test was one of the first practical examples of SDN that Miercom has observed in hands-on testing.

Feature testing included CPU protection, fast fault detection based on support for Bidirectional Forwarding Detection (BFD) and protection and recovery switching based on support for Ethernet Ring Protection Switching (ERPS).

Throughput Tests

Tests were conducted in accordance with RFC 2544 to determine Layer 2 throughput, latency, jitter and frame loss on the S12708 agile switch.

Layer 2 frames were forwarded at 100% of line rate for all frame sizes with zero frame loss. The frame sizes tested ranged from 64 to 1518 bytes. See *Figure 1* on *page 1*.

The average latency observed across all 384 of the 10GE ports ranged from 3.9µsec for 64-byte packets to 29.7µsec for 1518-byte packets.

The average jitter observed across all ports ranged from 1.8µsec for 64-byte packets to 5.0µsec for 1518-byte packets. See *Figure 2* for both latency and jitter measurements.

Large frames, 1518 bytes, were used to validate aggregate throughput. Small frames of 64 bytes were used to validate packet handling capability.

N + 1 Redundancy

The S12700 series agile switches have four switching fabric modules. Following the RFC 2544 throughput test, for which the S12700 series agile switch was fully loaded with full-mesh traffic, one of the fabric modules was removed, stressing the backplane.

The switch had sufficient capacity in the remaining three switching fabric modules to quickly recover, stabilize and resume operating at full line rate.

Programmability

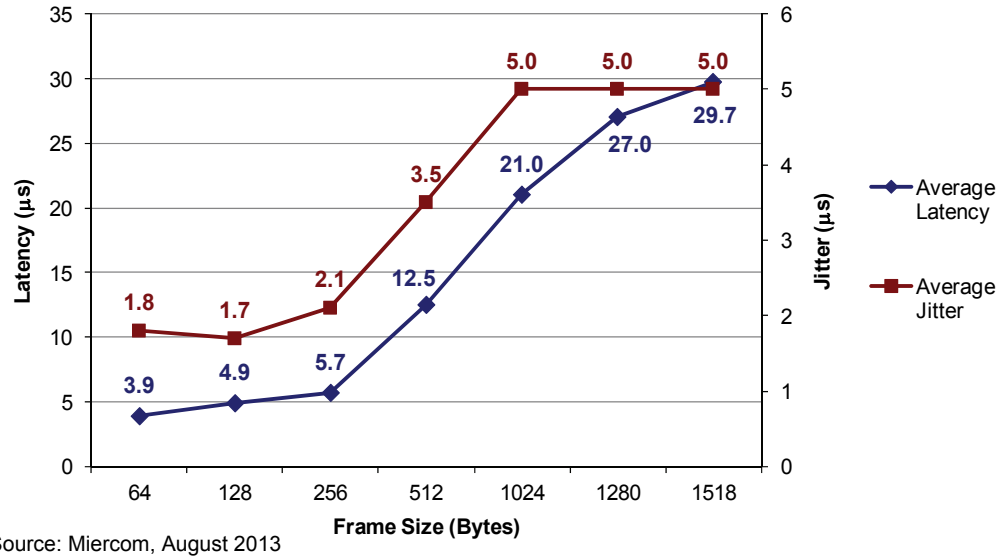
Programmability of the S12700 series agile switches is provided by the Huawei SDN forwarding plane technology, Protocol Oblivious Forwarding (POF). Miercom believes POF to be more capable than the original specification on which it is based, OpenFlow 1.3 from the Open Networking Foundation.

POF offers full backward compatibility with OpenFlow 1.3 and applies to all routing protocols, while OpenFlow applies to only IP routing.

POF provides benefits to user organizations in the present and can future-proof the switching infrastructure for the long haul.

POF enables users to make changes to the switching infrastructure that typically requires a patch from the vendor. Examples include trying a new protocol, testing a new RFC handle or adding a specific security requirement for handling traffic.

Figure 2: Huawei S12708 Agile Switch
Average Latency and Average Jitter

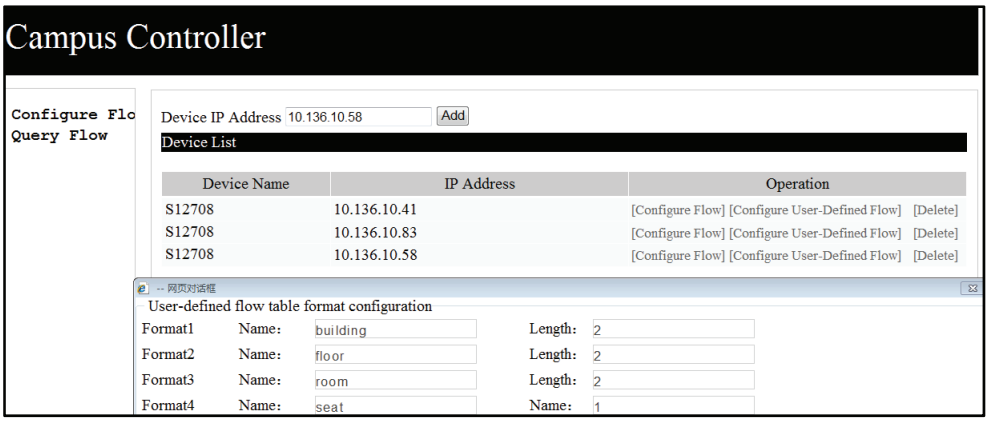


Source: Miercom, August 2013

The Huawei S12708 agile switch demonstrated excellent low latency with consistent (low jitter) performance during testing with full line rate traffic to 384 x 10GE traffic load in accordance with RFC 2544.

The Huawei S12700 series agile switches provide an easy-to-use interface for adding custom header information to Ethernet frames for special purpose use of Software Defined Networking (SDN). In this example, the custom header was specified to indicate specific location details: building, floor, room and seat numbers. Command instructions to the switch could then make traffic forwarding decisions based on these simple locations identified in these fields.

Figure 3: Huawei S12700 Agile Switch Campus Controller Interface



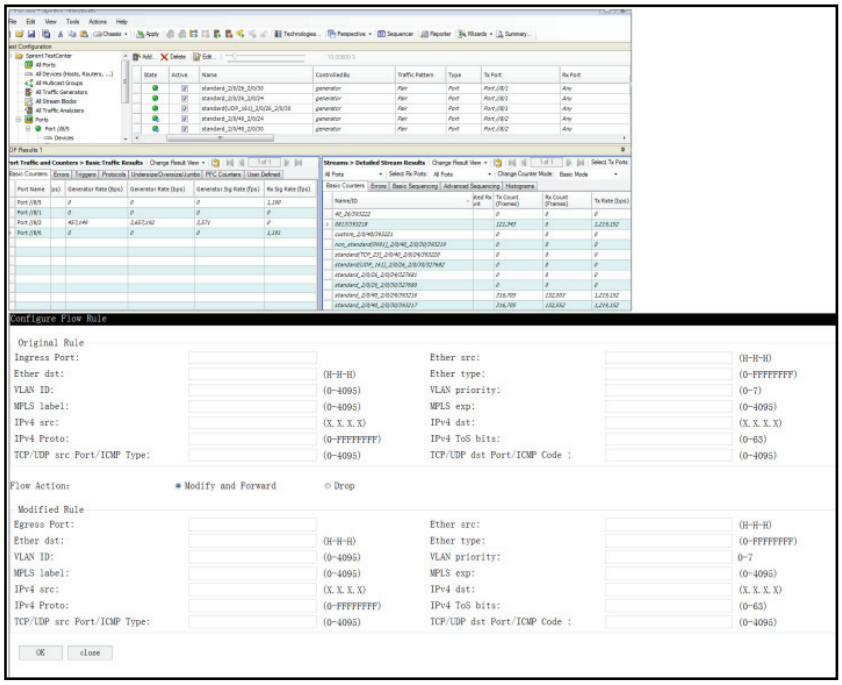
Source: Miercom, August 2013

Because POF applies to all protocols, in the future it will be able to control traffic types that have yet to be introduced.

Basic Programmability A Huawei Campus Controller successfully programmed a S12700 agile switch to forward a non-standard Ethernet packet type, 0x0889, created from the Spirent TestCenter traffic generator.

Usually, a switch will drop non-standard traffic types that are not defined as valid Ethernet frame types. In this test, however, we programmed a S12700 agile switch to forward traffic (non-standard 0x0889 type) generated from the Spirent TestCenter through the switch under test. The Spirent test system accurately reported the non-standard Ethernet frames being forwarded through the switch when it was programmed to do so. We also verified that the switch would drop these non-standard frames when we removed the command to forward the non-standard traffic, as expected.

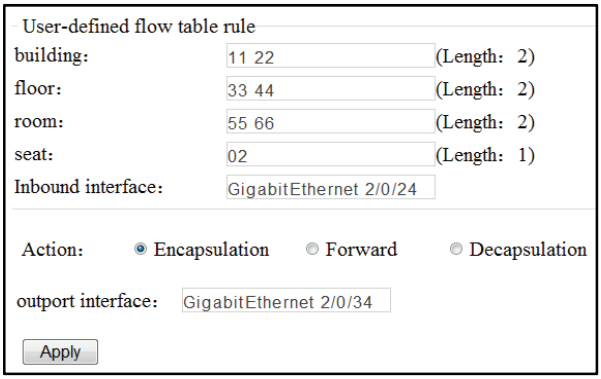
Figure 4: Huawei S12700 Agile Switch SDN Programmable Interface and Spirent TestCenter Generating Custom Ethernet Frames



Source: Miercom, August 2013

The Huawei Campus Controller interface is shown here and used to program the SDN functionality of the S12700 agile switch. The interface of the Spirent TestCenter, shown here, was used to generate traffic and monitor the custom Ethernet frames used in the testing to prove the non-standard Ethernet frame-handling ability of the Huawei S12700 agile switch.

Figure 5: User-defined Flow Table Rule Sets



Source: Miercom, August 2013

A user-defined rule example for the Campus Controller shown here is used to apply, forward or remove the custom header for traffic through the Huawei S12700 agile switch.

Advanced Programmability In this test, three Huawei S12700 agile switches were used to simulate a small campus network. In *Diagram 1* on *page 7*, DUT-2 is the core switch. DUT-1 and DUT-3 are access switches that connect directly to users.

Testing verified that the core switch can be programmed by the Campus Controller to encapsulate packets with a non-standard, additional header containing administrator-defined information.

The Campus Controller also could provide the commands to remove the added header as well as define the destinations to which traffic can be forwarded.

As shown in *Diagram 1*, the non-standard, additional header was user-defined information, including the building, room, floor and seat.

The success of this test was one of the first practical examples of SDN that Miercom has observed in hands-on testing.

Rate Limiting & Blocking Protection

Three tests carried out with the Spirent Test Center validated the ability of the Huawei S12700 series agile switches to protect the CPU from overburdening of resources due to excessive traffic.

Rate Limiting The S12700 agile switch overcame a simulated DoS flood attack of double the designated traffic rate. The Spirent Test Center generated 64 Kbps of traffic. The amount of traffic allowed to pass through the switch by its rate limiting functionality was 32 kbps. CPU utilization stayed below three percent for the duration of the test.

Rate Limiting and Blocking The switch was subjected to DoS flood attack of 150 packets per second, which exceeded the defined threshold.

The switch blocked the IP addresses of offending sources for five minutes. CPU utilization remained less than three percent for the duration of the test.

Whitelist A whitelist of IP addresses that were to be excluded from blocking during the DoS attack in the test were entered into the ACL of a S12700 agile switch.

The switch successfully allowed traffic from the whitelist of IP addresses to pass through uninhibited even when traffic exceeded the threshold for rate limiting and blocking.

The CPU was protected as utilization remained below five percent for the duration of the test.

Note: The Huawei S12700 series agile switches can be configured to send an SNMP alert when the traffic limit is reached.

Bidirectional Forwarding Detection

Linkage Huawei S12700 series agile switches support Bidirectional Forwarding Detection (BFD) linkage between switches.

BFD is a detection protocol that verifies connectivity between network nodes and provides rapid failure detection, while maintaining low overhead. It is a single, standardized method of detecting link, device and protocol failure for any encapsulation topology at any protocol layer and over any media.

One of the problem scenarios that BFD solves is the lack of fast fault detection where no routing protocols exist, such as the lower layers of Ethernet. Without BFD, an Ethernet node cannot rely on an “interface down” event to trigger network reconvergence. It must wait for higher layer protocol timers to time out before determining that a neighboring node is not reachable.

In this test, two Huawei S12700 series agile switches (DUT-1 and DUT-2) and a Huawei S5700 series switch (S57) were linked in a VLAN. A BFD session was initiated between DUT-1 and DUT-2. Linkage was verified as shutting down Port 1 on DUT-1 caused Port 2 on DUT-2 to shut down. See *Diagram 2* on *page 8*.

Linkage under OSPF This test validated the ability of the S12700 series agile switches with BFD enabled and running under Open Shortest Path First (OSPF) to quickly detect a failure, recover in the desired timeframe and reroute traffic.

OSPF is a Layer 3 interior routing protocol for IP networks. Because BFD is protocol-neutral and can be used at any layer, it can provide failure detection under OSPF.

In *Diagram 3* on *page 8*, the two Huawei S12700 series agile switches (DUT-1 and DUT-2) with BFD enabled and running under OSPF were linked with two other Huawei switches (Switch 3 and Switch 4).

The test generation platform delivered routable, 128-byte traffic at 10,000 frames per second (fps) to Port 1 of DUT-1 and Port 1 of DUT-2. The direct route between DUT-1 and DUT-2 was set as higher cost path, forcing traffic to flow via Switch 3 and Switch 4.

A failure was created by disconnecting the link between Switch 3 and Switch 4. The switch over of traffic to the direct (higher cost) path between DUT-1 and DUT-2 and reconvergence occurred in 65 milliseconds (ms), one-third less time than the expected 100ms.

It was very impressive to note that cutover back to the original state occurred without any packet loss under a heavy traffic load condition.

Ethernet Ring Protection Switching

Tests were conducted to validate the support of the Huawei S12700 series agile switches for Ethernet Ring Protection Switching (ERPS), which provides protection and recovery switching in less than 50 ms for Ethernet traffic in a ring topology. It also insures that no loops are formed.

In the event of a failure, a single ring in the ring topology that usually is blocked is unblocked to allow traffic to flow and reconvergence to occur.

ERPS on Open Ring Network This test utilized an ERPS “semi ring” neighboring a Spanning Tree Protocol topology.

The ERPS semi ring in *Diagram 4* on *page 8* consisted of two Huawei S12700 series agile switches (DUT-1 and DUT-2). The tester generated 10,000 fps of routable IP traffic via Path A.

The spanning tree protocol caused the switch to block the connection between the C3750 (Cisco switch) and DUT-2 to avoid a looping condition. Also, the ERPS semi-ring connection blocked Port 6 of S57_1.

A link failure of Port 1 on DUT 1 was introduced. STP switched the state of the connection between the C3750 and DUT-2 to forwarding from blocking, allowing traffic to flow and reconvergence to occur.

Recovery of the spanning tree topology occurred in 139 ms. Recovery to the original topology took 12 ms.

For the ERPS rerouting test, the Port 5 connection from S57_1 to DUT-2 was interrupted, causing the ERPS semi ring to reconverge with traffic flowing through Path C.

Multiple Instances of ERPS Support for ERPS and the ability to properly route traffic through a test network of two ERPS rings was validated in this test. See *Diagram 5* on *page 9*.

The same load of routable IP traffic was used as in the previous test, 10,000 fps.

The Huawei S12700 series agile switches are DUT-1 and DUT-2. Huawei S5700 series switches are S57_1 and S57_2.

Loop avoidance in ERPS is achieved by guaranteeing that at any time, traffic may flow on all but one of the ring links. That link, the Ring Protection Leader (RPL), is blocked under normal conditions. In case of a failure, one end of the RPL is unblocked to allow it to handle traffic.

For this test, Port 3 on DUT-1 was configured as the RPL for one instance of ERPS. Port 2 on S57_1 was configured as the RPL for the second instance of ERPS. The ports initially would be blocked to avoid a looping condition.

Upon interrupting traffic by disconnecting Port 1 on DUT-2, the ring topology reconverged to Path B. The interruption and reconvergence took 16 ms.

The switches in the ERPS rings were set to allow one minute to elapse before reconverging the network, which took 7.25 ms. One minute was a good length of time to help avoid route flapping by ensuring a stable, reconnected state.

Smart Ethernet Protocol

This test proved the S12700 series agile switches can successfully reroute traffic through a hybrid environment with fast reconvergence, minimum cutover times and no route flapping. A hybrid ring consisting of a SEP “semi ring” neighboring a Multiple Spanning Tree Protocol (MSTP) network was utilized. See *Diagram 6* on *page 9*.

Smart Ethernet Protection (SEP) protocol delivers fault convergence in under 50ms for ring networks. Multiple Spanning Tree Protocol (MSTP) configures a separate Spanning Tree for each VLAN group and blocks all but one of the possible alternate paths within each Spanning Tree.

In the test bed, the DUT is a S12700 agile switch. C3750, a Cisco switch, is the root switch for the MSTP network. S57_1, S57_2 and S57_3 are Huawei S5700 series switches.

In normal state, the MSTP topology blocks Port 3 of the DUTs to prevent a looping condition. Also, the SEP semi-ring topology blocks Port 6 of switch S57_3.

Upon interrupting Port 2 on the DUT, the MSTP reconverged to allow traffic to flow in 19.7 ms.

When the port connection was restored, cutover back to the original topology took 22.4 ms after the configured wait time of one minute to avoid route flapping.

A second interruption, Port 5 of the DUT, forced a reconvergence of the SEP semi ring. Traffic was then rerouted to Path C. The time needed to reconverge was 45.7 ms.

When the port connection was restored, cutover back to original topology took 8.4 ms after the configured wait time of one minute to avoid route flapping.

Easy Operation Solution

Two tests verified the functionality of the Easy Operation Solution in the Huawei S12700 series agile switches. The functionality is rare and ingeniously simple.

The first test utilized a S12700 agile switch as a "commander" to aid in the initial configuration of new devices on the network. In the second test, the commander aided in updating software of the same devices.

In *Diagram 7* on *page 9*, the S12700 agile switch is the DUT. When new, un-configured devices were added to the network (Huawei S5700 switches, S57_1 client and S57_2 client), they obtained the configuration file from the SFTP server in the following way. They contacted the gateway (DHCP server) to obtain the IP address of the commander, which redirected to the SFTP server.

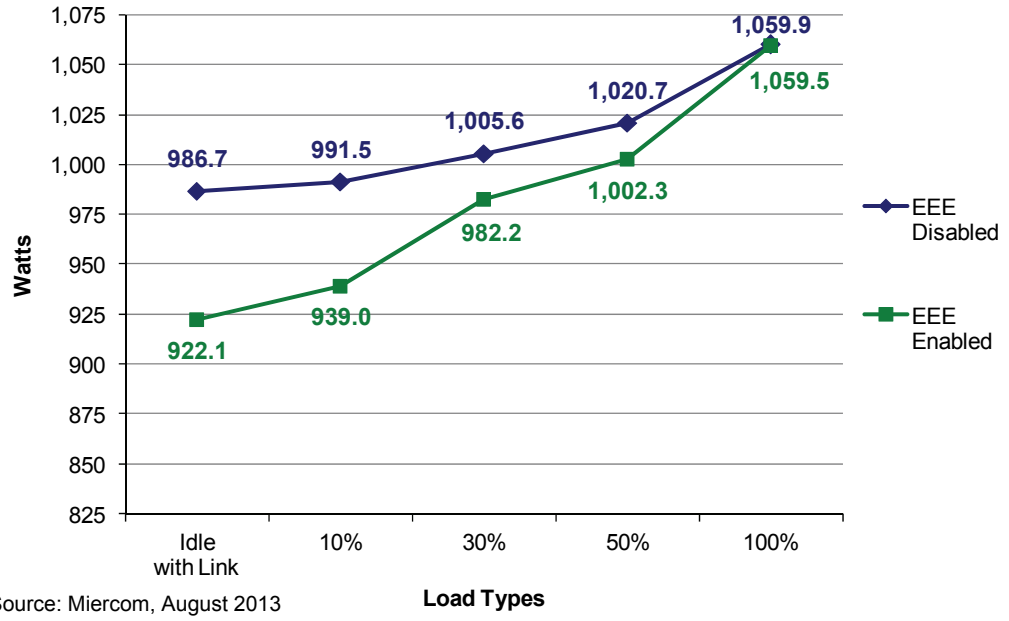
In the second test, Client1 and Client2 followed the same path to the SFTP server to update software. Examples of software that can be updated include the configuration file and firmware. Patches also can be received in this way, a time-saving alternative to contacting the vendor.

As a commander, the Huawei S12700 series agile switches can command 255 devices.

Energy-Efficient Ethernet

This portion of testing validated support of the Huawei S12700 series agile switches for IEEE

Figure 6: Huawei S12700 Agile Switch Power Savings
Due to Energy Efficient Ethernet (IEEE 802.3az)



Source: Miercom, August 2013

The Huawei S12700 agile switch exhibits very low power consumption during fully loaded 384 x 1GE port tests. Additional energy savings was achieved when 802.3az Energy Efficient Ethernet setting was enabled on the switch. The switch exhibits lower power consumption than most switches in this class, even before the EEE savings feature was enabled.

802.3az, the Energy Efficient Ethernet standard, which allows energy to be saved on a per-port basis by capitalizing on the periods of inactivity between packet transmission and powering down the physical interface for brief periods of time during periods of low link utilization.

The S12700 agile switch was tested for power consumption with EEE disabled. Results then were compared to results with EEE enabled.

With all 384 links up, no traffic and EEE disabled, the measured power consumption for the S12700 agile switch was 986.7 watts. It is a testament to the switch's energy-efficient switching fabric that consumption only increased by less than 74 watts, to 1,059.9 watts while handling a 100% load of Layer 2, IMIX traffic.

With EEE enabled, the S12700 agile switch consumed 922 watts with all 384 links up and no traffic applied. It then was tested while handling various levels of IMIX traffic: 10% (939 watts), 30% (982), 50% (1,002) and 100% (1,060). See *Figure 6* on *page 6* for more details.

MAC Address Table Capacity

Testing verified a capacity of 1,048,576 addresses for the MAC table of the Huawei S12700 series agile switches. This number is slightly higher than the vendor specification of one million.

FIB Routing Table Capacity

Testing verified a capacity of 3 million IPv4 routes and one million IPv6 routes.

Bottom Line

The Huawei S12700 series agile switches can play a significant role in campus networks now and for years to come, thanks to its future-proof design and capability to accommodate evolving user needs.

Key components of the future-proof design include large capacity of MAC, FIB and ARP tables as well as its SDN-ready/programmable architecture.

Overall, we found the Huawei S12700 series agile switches to be full-featured, high-performance Layer 2 and Layer 3 Ethernet LAN switches for core campus network applications.

The switches provide a strong combination of high performance, a rich feature set, high resiliency and excellent programmability for multiple protocols.

Diagram 1: Programmability

Enhanced Function of Programmability

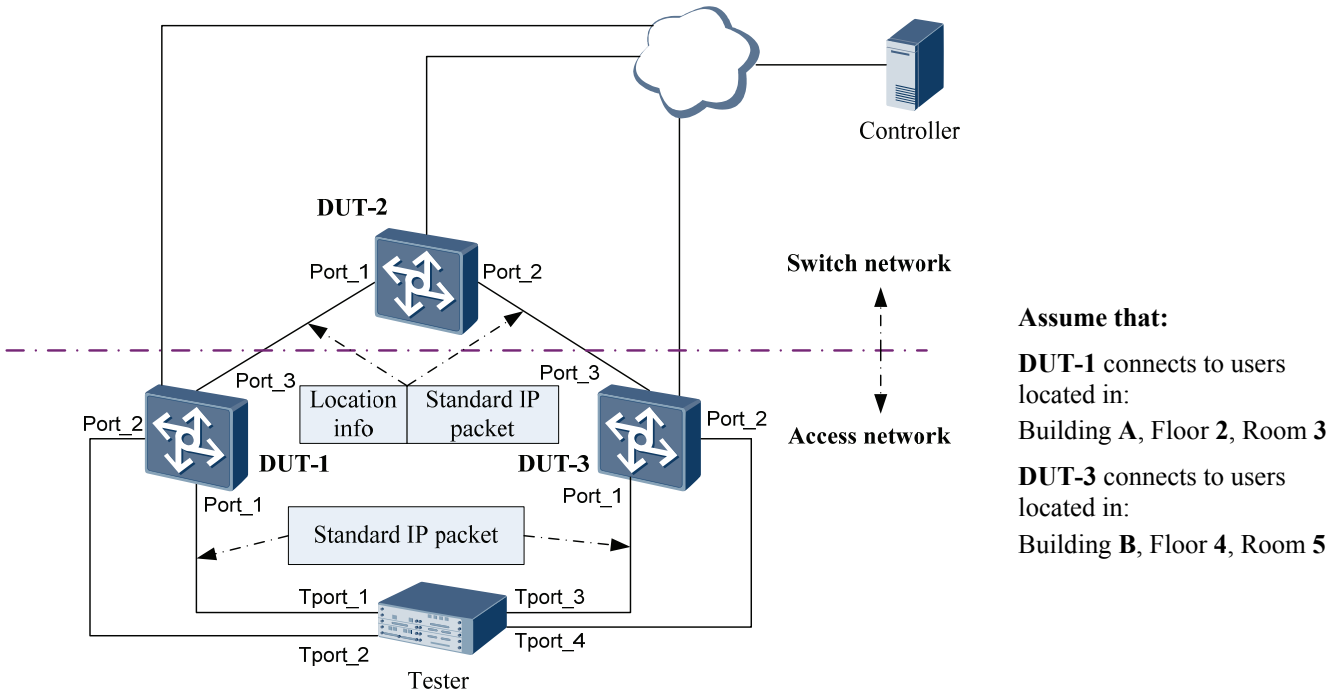


Diagram 2: Bidirectional Forwarding Detection
Linkage between BFD and Interface

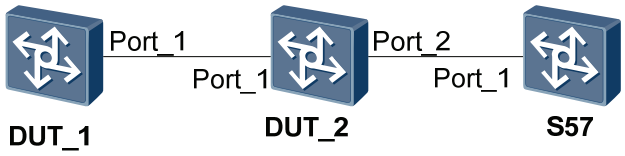


Diagram 3: Bidirectional Forwarding Detection
Linkage under OSPF

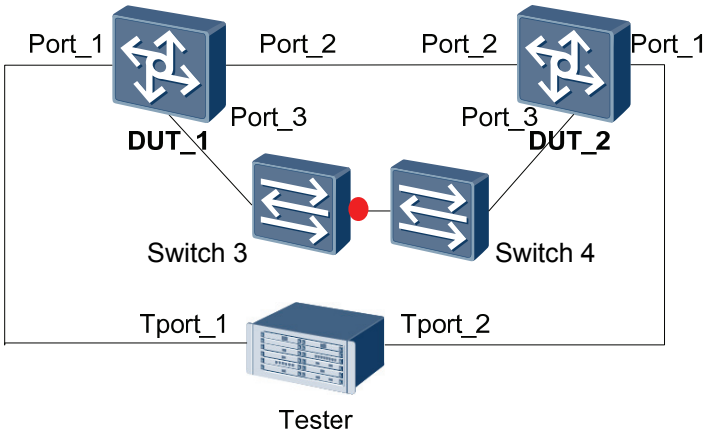
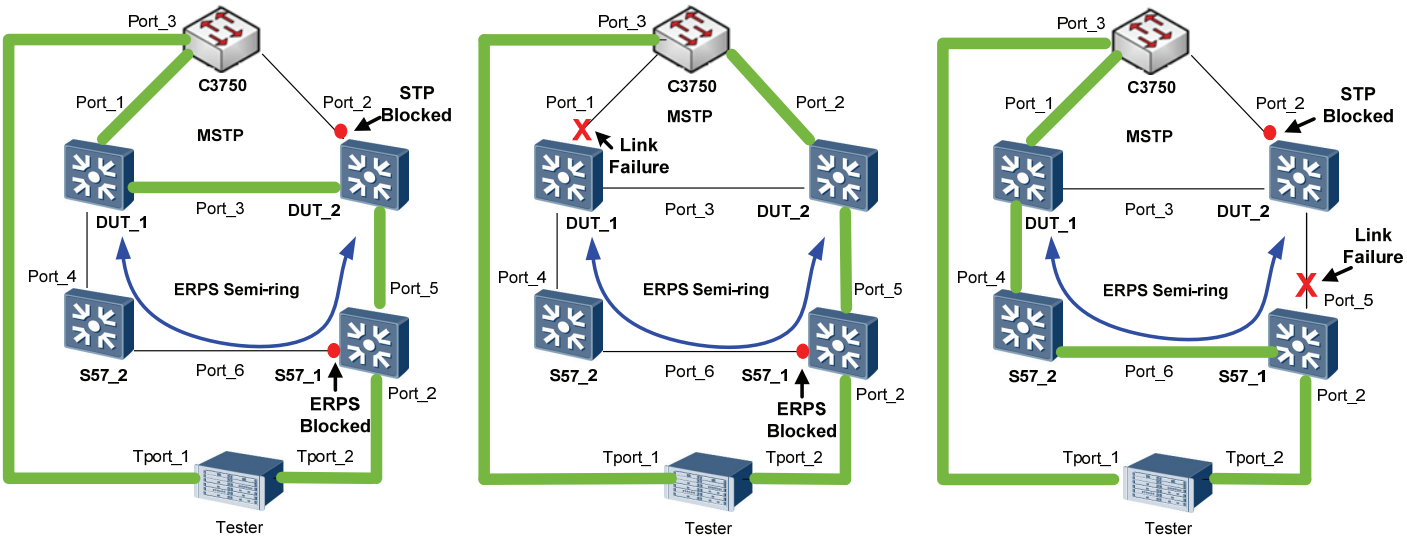


Diagram 4: Ethernet
ERPS (G.8032) on an Open Ring Network



Path A **Path B** **Path C**

Diagram 5: Ethernet - ERPS Multi-Instance

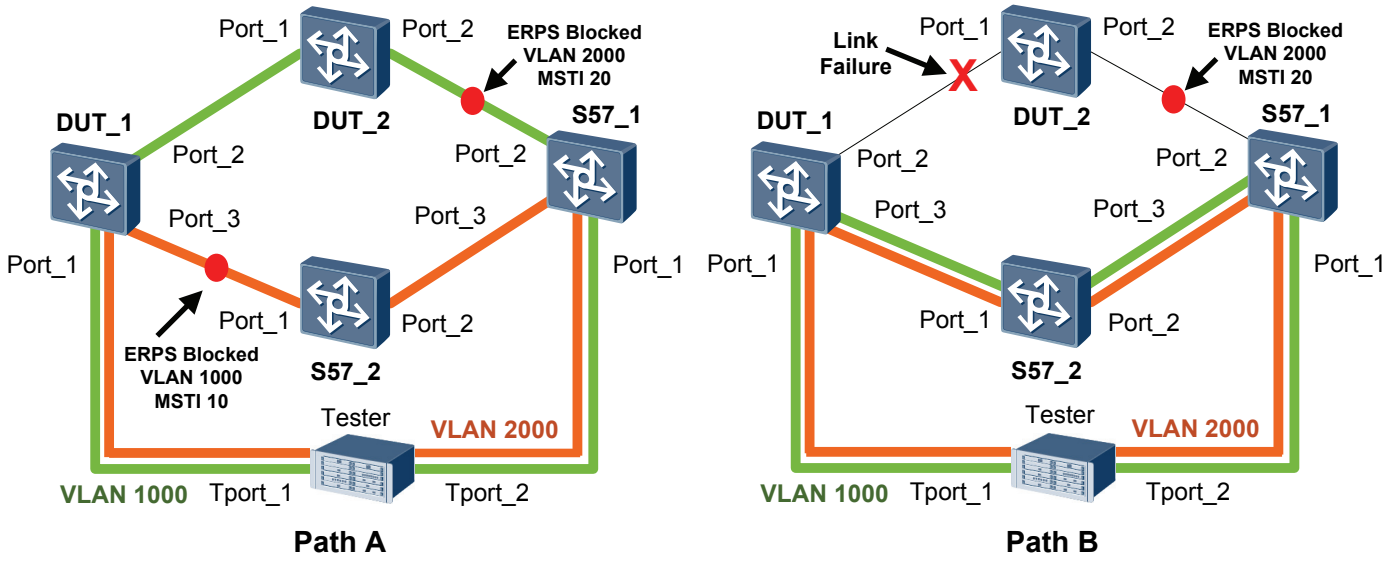


Diagram 6: SEP on an Open Ring Network

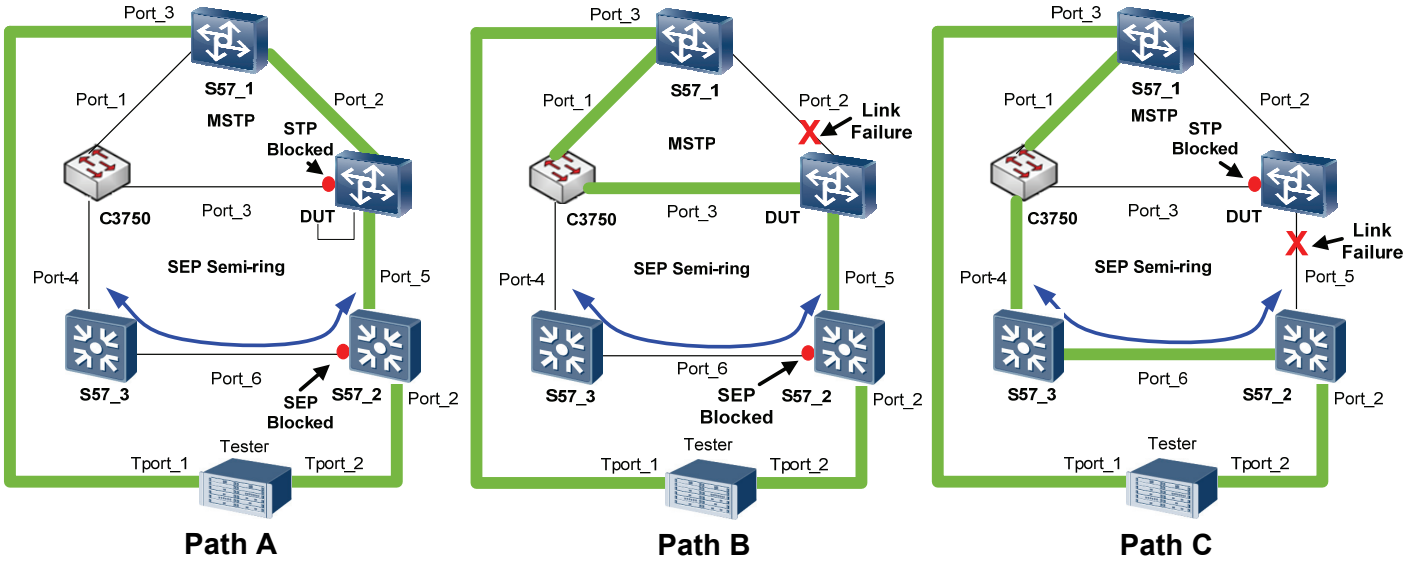
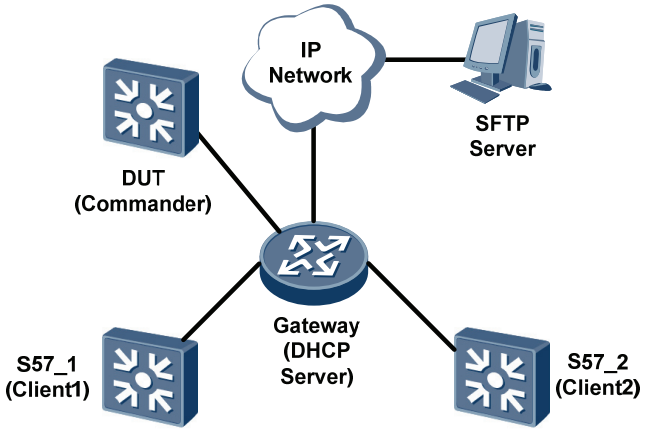
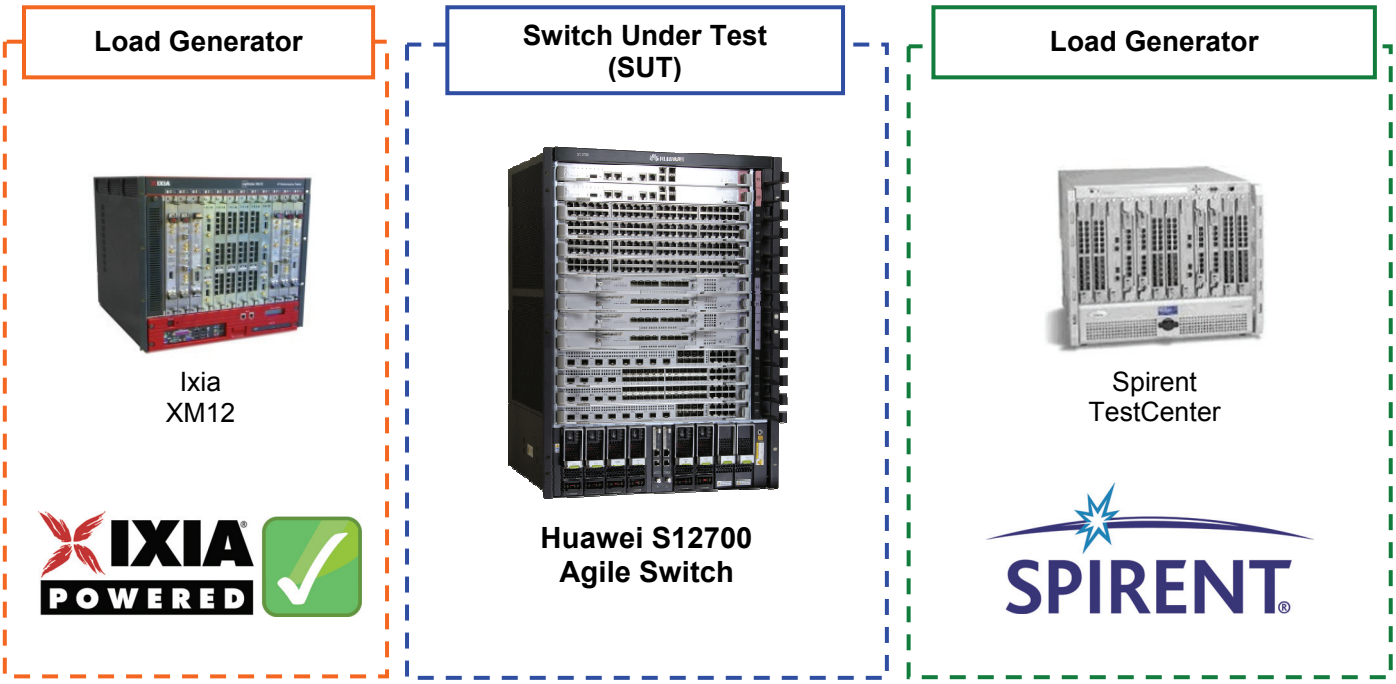


Diagram 7: Easy Operation with Commander



This topology was used for demonstrating deploying new devices, updating software and loading patches through SFTP.

Test Bed Diagram



Source: Miercom, August 2013

How We Did It

The Huawei S12700 agile switch was evaluated for Software-Defined Networking (SDN) programmable capability, performance, features and energy efficiency. The Huawei S12700 agile switch chassis evaluated was running the latest firmware available. We tested the Huawei S12708 agile switch, however, while on-site, we also observed the operation of other switches in the S12700 series. Specific results apply to the Huawei S12708 switch, but general implementation procedures are the same for all models in the Huawei S12700 series agile switches.

For performance testing, Miercom and Huawei engineers used load generators to ensure that the maximum potential of the switch was validated. For feature testing, the load generators were configured to specifically test certain functionalities to verify that they were working appropriately and routing correctly. Energy efficiency was determined by measuring energy consumption without any energy saving features enabled and then repeating the testing with these features turned on to compare savings.

State of the art, industry recognized test and measurement equipment was used in the testing. Two different traffic generators were used including the Ixia XM12 running IxNetwork version 5.50.121.48 and Spirent TestCenter running version 3.76.0076.

Utilizing RFC 2544, RFC 3918, and RFC 2889 standards for load testing, Miercom was able to obtain industry applicable metrics for latency, throughput, and other statistical measurements such as out of sequence errors and jitter to ensure validity of the metrics observed. Analyzing the statistics, we were able to produce accurate results for public distribution.

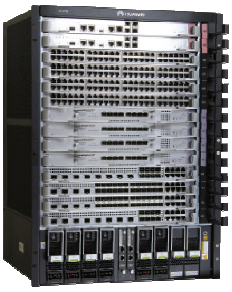
The tests in this report are intended to be reproducible for customers who wish to recreate them with the appropriate test and measurement equipment. Current or prospective customers interested in repeating these results may contact reviews@miercom.com for details on the configurations applied to the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

Miercom Performance Verified

The performance of Huawei S12700 series agile switches was verified by Miercom in hands-on testing.

The switches proved fully programmable, full line rate throughput, and excellent resiliency and redundant fault tolerant configuration. Excellent, below industry average power consumption was noted while the switch was fully loaded in test scenarios.

The switches achieved the performance required for applicability in a campus core deployment and achieved the Miercom Performance Verified Certification.



Huawei S12700 Agile Switch

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