Detailed Lab Testing Report
DR120119C

SMB Managed Switch Comparison

Cisco
D-Link
Hewlett-Packard
Netgear

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Miercom

http://www.miercom.com

Contents

1.0 Executive Summary

This report discusses the findings of a recent test of web-managed switch products for the SMB (Small and Medium Business) market space. It specifically compares and contrasts the features and performance of the Cisco SF300, SG300, and SG200 series of switches with similar products offered by HP, D-Link and Netgear.

Overall, we were impressed with the comprehensive set of features, performance, overall power efficiency and ease-of-use of the Cisco switches. Specifically, we found that Cisco delivered the highest capacity and scalability of configuration parameters including VLANs, MACs, ACLs, and IP routes. The Cisco switches provided the best resiliency when subjected to DoS attacks. Cisco switches can also be considered more economical when measured using normalized pricing based on Price per gigabit and Price per PoE Watt. In addition, they were the most efficient both in terms of overall energy consumption, and the energy saving capabilities provided. The Cisco switches included in this test were the easiest to configure and implement, forwarded line rate full mesh traffic at all frame sizes with zero packet loss, and provided the most extensive support for IPv6 transitions.

The Cisco switches tested for this report provide the features, performance and support for products used in the SMB environment. Their power saving features, including support for Energy Efficient Ethernet, and the low overall power consumption puts these Cisco products as serious contenders for use in a SMB deployment.

This report sponsored by Cisco Systems, Inc., was produced with data obtained completely and independently as part of the Miercom Ethernet Switch Industry Assessment in which all vendors have equal opportunity to participate and contribute to the test methodology. All vendors involved in these tests were afforded opportunity to represent their products, and vendors still have opportunity to actively participate in the Industry Assessment and challenge any test findings by lab testing.

Bottom line, the Cisco series switches included in this report have demonstrated superiority in the SMB switch market for the areas selected in this analysis.

Rob Smithers

CEO, Miercom

2.0 Overview of Testing

This comparison of web-managed SMB switches from Cisco, Hewlett-Packard, D-Link and Netgear is organized in seven sections of analysis and testing including *Performance*, *Resiliency and Security, Ease of Use*, *Key Features*, *Energy Efficiency*, *Scalability and Capacity*, and *Cost of Ownership*. We examined products in the Cisco SF300, SG300, and SG200 model families, and compared them to products in the D-Link DES-3052, HP E2510, E2620 family, E2810, V-1810, V1910, and Netgear GSM7224P, GS724TP families.

Performance (p10)

The performance measured full mesh throughput at wire speed to determine the maximum throughput each switch could sustain without incurring frame loss. We also verified that each switch can build to their stated MAC address table size. The CPU utilization was observed and recorded while each switch was learning MAC addresses.

Resiliency and Security (p14)

Resiliency and security of the switches were evaluated using a series of attacks including DoS attacks. The overall switch functionality and switch management responsiveness was observed during these attacks. Each switch with built in security protection measures were tested with and without DoS protection enabled to measure their countermeasure effectiveness.

Ease of Use (p15)

Switch administration testing was conducted to determine the ease-of-use in performing routine tasks involving manual configuration of specific parameters while noting the level of support provided by the web interface versus traditional CLI. We compared the relative ease or difficulty on a switch-by-switch basis. Some of the features that were configured included ACLs (Access Control Lists), VLANs, and Static IP Routing.

Key Features (p23)

A comparison of key switch features considered important for the SMB market, including IPv6 transition support, was performed on each switch to determine the level of support provided.

Energy Efficiency (p24)

The overall energy consumption of the device was measured. Energy saving features were enabled for comparison to determine which device provided the greatest overall energy savings. For those switches that support energy saving features, we calculated the percentage of power saved compared to energy saving options turned off. Of the three vendors, only Cisco currently offers managed SMB switch products which support IEEE 802.3az EEE (Energy Efficient Ethernet); the HP, D-Link and Netgear switches provided by Cisco for this evaluation did not have this feature. EEE is an innovative way of reducing the power consumption of network devices based on real-world traffic patterns, and end-user behaviors.

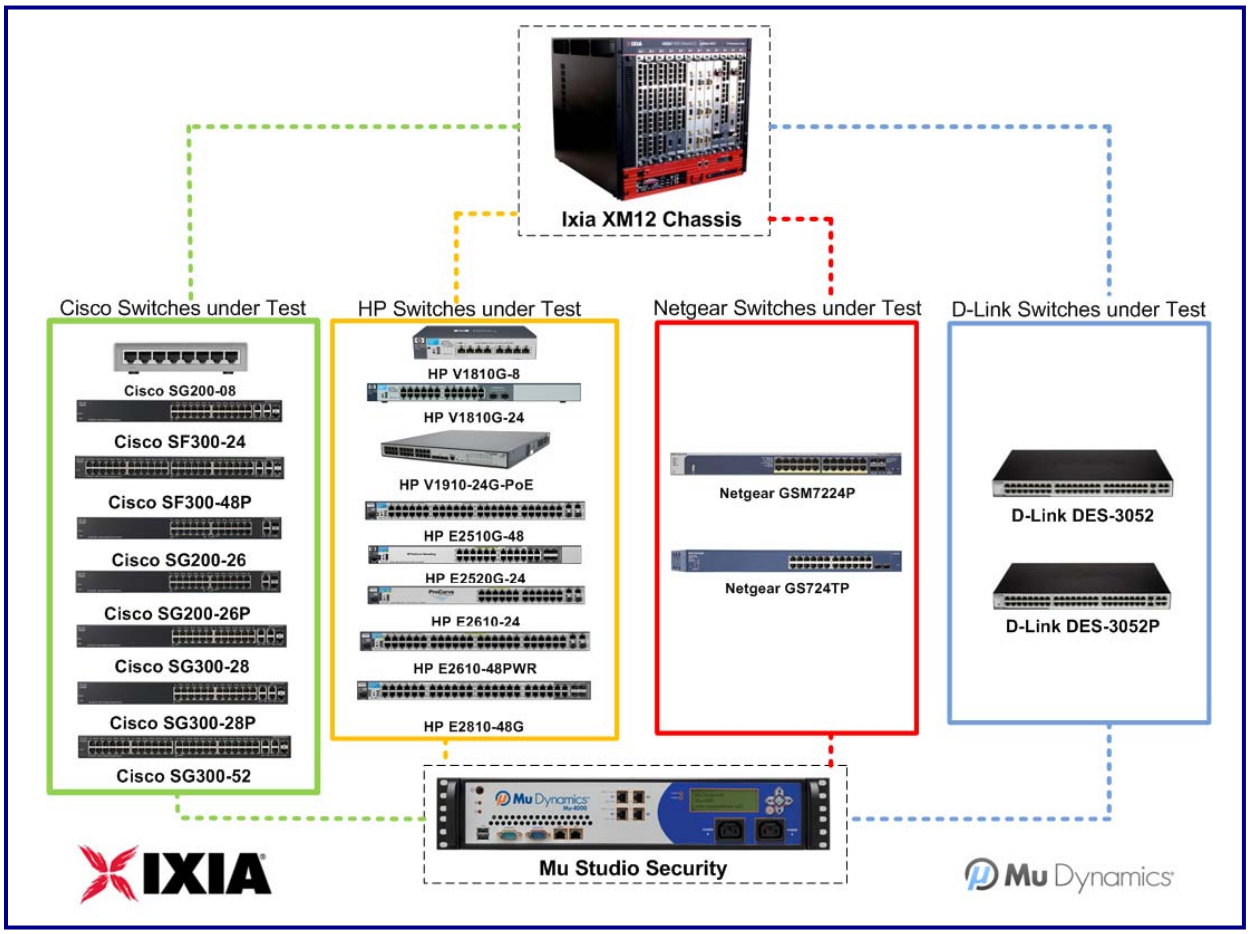
Scalability and Capacity (p27)

The capacity features from all three vendors was compared using published datasheets and a hands-on evaluation. These included the number of IP static routes, number of ACLs, number of VLANs, and the MAC address table size.

Cost of Ownership (p28)

To show why gigabit and PoE enhance the value of the switches, a comparison was made using list prices and applied to watts per gigabit throughput and per PoE watt.

2.1 Test Bed Diagram



2.2 Test Equipment Used

Ixia (www.ixiacom.com) is an industry leader in energy efficiency testing of networking equipment. Ixia's unique approach utilizes coordination of energy measurements with network traffic load – allowing energy consumption to be graphed against network traffic volume. Real-world traffic is generated by Ixia's test platform and test applications, principally IxAutomate for layer 2-3 switching and routing traffic.

Mu Studio Security (www.mudynamics.com) provides a complete service assurance solution for determining the reliability, availability and security of IP-based applications and services. The Mu solution is highly automated, with lights-out fault isolation. Speeding the remediation of software flaws, Mu Studio Security provides actionable reports and complete data on any faults. Mu-based testing is managed via a variety of interfaces, including a highly visual Web-based graphical user interface. Testing can also be remotely controlled using REST- or XML-based APIs for integration into common laboratory automation frameworks such as HPQC or STAF.

3.0 Description of Switches

The switches discussed here are for use in the SMB market. Each switch has different specifications and features. They had 8, 24, 26, 28, 48 or 52 ports with additional gigabit copper or fiber uplinks. Each switch had the latest firmware version installed.

3.1 Cisco (SF300, SG300, SG200 series)

The SG300 switches have a feature called Short Reach, which reduces the transmitter power needed for cable lengths of 10 meters, and link energy detect features for reduced power consumption when interfaces are not in use.
Additionally, the fanless SG300-28 reduces power usage and has low-noise factor, providing increased flexibility for office deployments.
The SG300 and SF300 models support both Layer 2 and Layer 3 switching.
The SF300 switch series contain link energy detect features but do not support Short Reach.
The SG200 switches only support Layer 2 switching. All SG200 switches are fanless.

Model #	Product Class	PoE	Firmware Version	Uplinks	Energy Save
SF300-24	10/100	No	1.1.2.0	2 10/100/1000 2 combo mini-GBIC slots	Yes
SF300-48P	10/100	Yes	1.1.2.0	2 10/100/1000 2 combo mini-GBIC slots	Yes
SG300-52	GbE	No	1.1.2.0	2 combo mini-GBIC slots	Yes
SG300-28	GbE	No	1.1.2.0	2 combo mini-GBIC slots	Yes
SG300-28P	GbE	Yes	1.1.2.0 1.2.7.76**	2 combo mini-GBIC slots	Yes
SG200-26P	GbE	Yes	1.1.2.0 1.2.7.76**	2 combo mini-GBIC slots	Yes
SG200-26	GbE	No	1.1.2.0	2 combo mini-GBIC slots	Yes
SG200-08	GbE	No	1.0.2.0*	N/A	Yes

*This was the latest firmware available for the 8-port device.

The SG300-28P and SG200-26P were tested with firmware versions 1.1.2.0.

**Version 1.2.7.76 was loaded only to test the LED power saving capability.

All Cisco switches featured in this test were equipped with a Web GUI for easy configuration and had built-in energy saving features.

3.2 Hewlett-Packard (V1810, V1910, E2520, E2510, E2620, E2810 series)

The HP E2620 switch series support Layer 3 routing. All other V-Series and E-Series switches from HP in this test support only Layer 2 switching with basic static IP routing.
The V-Series switches also have a power saving feature that powers off LEDs after a specified time for lower power consumption.
The E2810 switch has an optional redundant power supply, enabling maximum uptime in case a power supply fails.

Model #	Product Class	PoE	Firmware Version	Uplinks	Energy Saving capabilities
E2620-24-PPoE+	10/100	Yes	RA.15.06.0009	2 10/100/1000 Base-T 2 combo mini-GBIC	No
E2620-48-PoE+	10/100	Yes	RA.15.06.0009	2 10/100/1000 Base-T 2 combo mini-GBIC	No
E2520G-24-PoE	GbE	Yes	J.14.54	4 combo mini-GBIC slots	No
E2810-48G	GbE	No	N.11.52	4 combo mini-GBIC slots	No
E2510G-48	GbE	No	Y.11.16	4 combo mini-GBIC slots	No
V1810G-8	GbE	No	P.2.2	N/A	Yes
V1810G-24	GbE	No	P.2.2	2 combo mini-GBIC slots	Yes
V1910-24G-PoE	GbE	Yes	1910_5.20.R1513	4 10/100/1000 GBIC slots	Yes

The Hewlett-Packard switches in this test include Web GUIs for configuration.

GUI functionality on the E series switches must be enabled from the CLI before it can be accessed.

All V-Series switches have power saving features.

3.3 D-Link (DES-3052, DES-3052P series)

The D-Link DES-3052 and DES-3052P switches are Layer 2 switches equipped with 10/100 Base-T ports and gigabit copper and fiber uplinks. The DES-3052 switch series does not support any advanced power saving features, other than it does have a fanless design which allows less power usage, improved reliability and increased deployment flexibility.

Model #	Product Class	PoE	Firmware Version	Uplinks	Energy Saving Capabilities
DES-3052	10/100	No	2.00.B27	2 10/100/1000 Base-T 2 Combo SFP	No
DES-3052P	10/100	Yes	2.00.B27	2 10/100/1000 Base-T 2 Combo SFP	No

The D-Link switches are equipped with 48 ports 10/100 copper, and two gigabit copper and two dual-personality gigabit uplinks. Web GUI is supported for administration. These switches do not have additional power saving features.

3.4 Netgear (GSM7224P and GS724TP series)

The Netgear GSM7224P and GS7224TP series switches are Layer 2 PoE switches equipped with 10/100/1000 ports and gigabit fiber uplinks. The Netgear switches do not have any power saving features on these models. A GUI is available for configuration and management of the switches.

Model #	Product Class	PoE	Firmware Version	Uplinks	Energy Saving capabilities
GSM7224P	GbE	Yes	9.0.2.18	4 100/1000 combo GBIC slots	No
GS724TP	GbE	Yes	5.2.0.5	2 1000 combo GBIC slots	No

The Netgear switches are each equipped with 24 auto-sensing 10/100/1000 ports. GSM series has four 100/1000 combo GBIC slots, while the GS series was equipped with two 1000 combo GBIC slots.

4.0 Performance Testing

Performance testing was conducted in accordance with RFC 2889 and consisted of loading each switch with traffic in a full mesh configuration. See the following section for details.

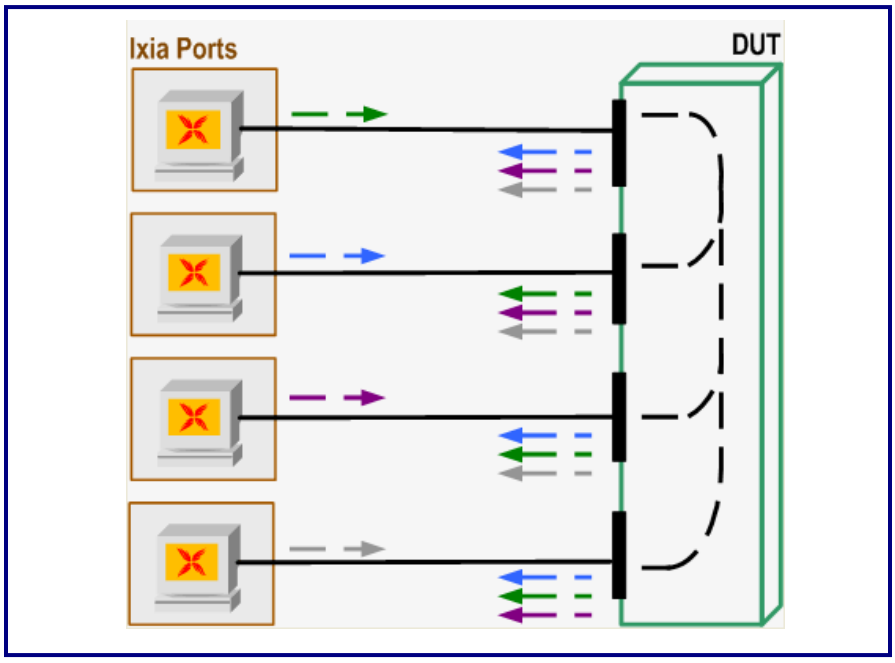
Testing was conducted for 64-byte, 512-byte, and 1518-byte frame sizes. Switch performance metrics recorded for this testing included the maximum throughput and observed frame loss. Performance and responsiveness of the Web GUI while the switch was under load was also monitored during the mesh throughput test.

A MAC hashing test was also performed to validate that each switch can achieve their maximum stated MAC table size. During the MAC learning process, the CPU utilization was monitored and recorded.

4.1 Full Mesh Throughput

The full mesh throughput test verifies cross processor throughput while recording frame loss. Each port on the traffic generator sends traffic to the DUT, while receiving traffic from other ports, as shown below.
The switches were grouped into similar categories to ensure that like switches were tested and compared fairly.

RFC 2889 Fully Meshed



RFC 2889 fully meshed test showing traffic flow between load generator and Device Under Test.

Throughput and Frame Loss

Gig non-PoE			Throughput (Mbps)			% Frame Loss		
			64	512	1518	64	512	1518
Cisco	SG200-08	8-port Gig	46502	58740	60241	0	0	0
	SG200-26	26-port Gig	151134	190906	195784	0	0	0
	SG300-28	28-port Gig	162760	205592	210844	0	0	0
	SG300-52	52-port Gig	302269	381813	391568	0	0	0
HP	V1810G-08	8-port Gig	46501	58739	60240	.002	.002	.002
	V1810G-24	24-port Gig	139507	176220	180722	.001	.001	.001
	E2510G-48	48-port Gig	279017	352443	361446	0	0	0
	E2810-48G	48-port Gig	279013	352443	361446	.001	0	0

Gig PoE			Throughput (Mbps)			% Frame Loss		
			64	512	1518	64	512	1518
HP	E2520G-24	24-port Gig	139508	176221	180723	0	0	.001
	V1910-24G-PoE	28-port Gig	162760	205592	210844	0	0	0
Cisco	SG200-26P	26-port Gig	151134	190906	195784	0	0	0
	SG300-28P	28-port Gig	162760	205592	210844	0	0	0
Netgear	GSM7224P	24-port Gig	139508	176221	180724	0	0	0
	GS724TP	24-port Gig	139508	176221	180724	0	0	0

Page 10/100 non-PoE			Throughput (Mbps)			% Frame Loss		
			64	512	1518	64	512	1518
Cisco	SF300-24	24-port 10/100	37202	46992	48193	0	0	0
D-Link	DES-3052	48-port 10/100	51153	64614	66265	.001	.001	.001

10/100 PoE			Throughput (Mbps)			% Frame Loss		
			64	512	1518	64	512	1518
Cisco	SF300-48P	24-port 10/100	51153	64614	66265	0	0	0
D-Link	DES-3052P	48-port 10/100	51153	64614	66265	.001	.001	.001
HP	E2620-24	24-port 10/100	37202	46992	48193	0	0	0
	E2620-48	48-port 10/100	51153	64614	66265	0	0	0

Notes:

The Cisco Gig non-PoE switches did not exhibit any frame loss.
The HP switches in this same category had frame loss ranging from 0% to .002%.

The HP 2520G-24 in the Gig PoE category had .001% frame loss with traffic using 1518-byte frames.

Cisco 10/100 non-PoE SF300-24 did not have frame loss.
D-Link DES-3052 had .001% frame loss across all tested frame sizes.

The switches in the 10/100 PoE category had no frame loss, except the D-Link DES-3052P which had .001% frame loss.
Frame loss of .001% to.002% is not significant.

4.2 MAC Table Size

The ability of a switch to learn MAC addresses was verified by recording the maximum MAC table size learned. CPU usage while the switch was learning its maximum MAC table was recorded.

The table size was verified by sending random MAC addresses to the switch and viewing the table size in the GUI or CLI. CPU utilization was recorded while the switch was learning MAC addresses. Recording the CPU usage determines how efficient the switch processor is while learning their maximum MAC address table size.

The Cisco 300 series, HP E2620, and Netgear GSM7224P switches have a stated 16,000 MAC addresses; Netgear GS724TP has 4,000 addresses. All of the other switches have 8,000 MAC stated addresses.

The majority of the switches were able to reach their stated MAC table size.
Exact numbers can be found in the table o MAC Address table sizes and utilization on the next page.

4.3 CPU Utilization

The 200 and 300 Cisco switches had a range of 7 to 35% CPU utilization when building MAC tables.

The HP E-Series switches ranged from 11 to 38% CPU usage while building the table.
Hewlett-Packard V1810 switches could not display the CPU utilization.

The D-Link switches had 9 to 13% CPU utilization when building the MAC table.

The HP E-Series switches' MAC table size was verified by using the CLI, a longer process for real time viewing compared to using a GUI. There wasn't any option to show the MAC table size in the GUI.

The Netgear GSM7224P averaged 16% CPU usage. GS724TP does not show CPU utilization in the GUI.

MAC Address Table Sizes and CPU Utilization

Configuration	Model	Datasheet Value	Observed Table Size	Learning CPU Usage
24-port 10/100	Cisco SF300-24	16,384	16,383	7%
	HP E2620-24	16,384	15,917	11%
48-port 10/100	Cisco SF300-48P	16,384	16,383	8%
	D-Link DES-3052P	8,192	8,156	9%
	D-Link DES-3052	8,192	8,156	13%
	HP E2620-48	16,384	15,931	38%
24/28-port gigabit	Cisco SG300-28	16,384	16,383	10%
	HP E2520G-24	8,192	7,980	21%
	HP V1810G-24	8,192	8,178	Not Available
	Cisco SG200-26	8,192	8,192	15%
	Cisco SG200-26P	8,192	8,192	7%
	Cisco SG300-28P	16,384	16,384	17%
	HP V1910-24G-PoE	8,192	8,190	14%
	Netgear GSM7224P	16,384	16,282	16%
	Netgear GS724TP	4,096	4,096	Not Available
48/52-port gigabit	Cisco SG300-52	16,384	16,383	11%
	HP E2510G-48	8,192	8,190	30%
	HP E2810-48G	8,192	8,192	28%
8-port gigabit	Cisco SG200-08	8,192	8,190	35%
	HP V1810G-8	8,192	8,116	Not Available

5.0 Resiliency and Security

5.1 Switch Management Responsiveness with Attacks

The Web GUI on the switch was tested for performance while being subjected to a DoS attack using the Mu-4000 Service Analyzer. This test demonstrates the effectiveness in mitigating attacks that are CPU intensive while maintaining manageability of the switch. If the GUI shows significant degradation or lack of responsiveness, it is an indication that other CPU-centric functions may be impacted as well. All switches in this review have DoS protection disabled by default. We tested the switches first with the default settings, and again with security features enabled.

Cisco

Cisco SF300 and SG300 Series GUIs were unaffected by the DoS attacks, and CPU utilization remained around 15%, whether DoS protection was enabled or not.
SG200-26 experienced high CPU utilization of up to 89%, and the GUI responses became lethargic.
SG200-26P used 8% CPU when DoS protection was either enabled or disabled.
SG200-08 GUI became completely unavailable during the DoS attack. This is a known behavior, since the hardware for this model lacks support for CPU rate limiting. Therefore the switch is vulnerable to a DoS attack.
Cisco SG300-28P GUI was accessible during the DoS attack, with CPU usage averaging 18%. When DoS protection was enabled, the CPU usage dropped to 15%.

Hewlett-Packard

The HP E2620 series of switches remained fully operational during the DoS attack against the GUI. CPU utilization on the E2620-24-PPoE was 35% and 43% on the E2620-48-PoE.
E2520G-24-PoE interface remained accessible during attacks, whether or not protective features were enabled. CPU utilization was below 28%.
E2510 and E2810 models did not offer protective features, and both became inaccessible during attacks.
All three HP V-Series switches have DoS protection. During the attack, the GUI became inaccessible. Once the attack subsided, the Web GUI was usable again.

D-Link

Both D-Link switch models DES-3052 and DES-3052P offer DoS protection features, but they were ineffective during our testing. The management GUI became unresponsive during attacks, whether or not the features were enabled.

Netgear

The Netgear GUI was inaccessible during the DoS attack. When DoS protection was enabled in the GSM7224P, the GUI was operational and CPU usage was 6%. The GS724TP does not support DoS protection features.
Full operation of the management interface was restored to the affected switches when the attacks subsided. It is unknown why the protection features did not block the attacks directed at the switch.

DoS Attacks Summary

Vendor	Model	Pass/Fail
Cisco	SF300/SG300	✓
	SG200-26P	✓
	SG200-08	**X**
	SG200-26	**X**
HP	E2810	**X**
	E2620	✓
	E2520	✓
	E2510	**X**
	V1910/V1810	**X**
D-Link	DES-3052/P	**X**
Netgear	GSM7224P	✓
	GS724TP	**X**

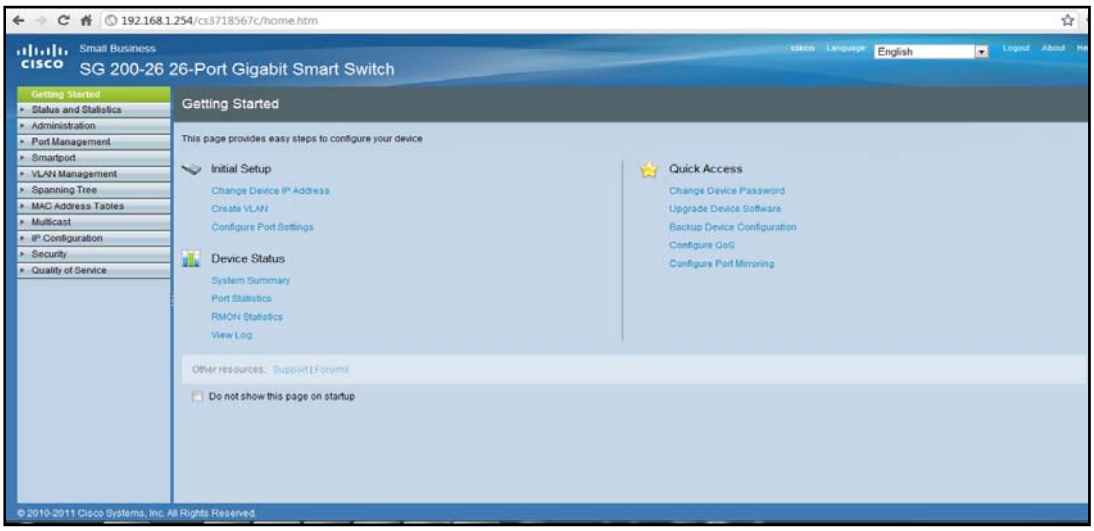
6.0 Ease-of-Use

All switches offered a Web GUI providing administration and monitoring features. Some switches offered more features and settings than others. The following section discusses the differences in Web interfaces. Details about individual vendor utilization of the GUIs are also included.

6.1 Cisco (SF300, SG300, SG200 series)

The Cisco family of switches had a neat and organized Web interface. The menu bar contained all the features needed in easily identified categories for configuration. The following screen shot shows the Getting Started screen that appears after login with the menu bar.

Cisco Getting Started Screen



Getting Started Screen has menu options for Initial Setup, Device Status and Quick Access for upgrades and changes. Choices include configurations from Administration through QoS.

All Cisco switches shared the same interface design. There was an exception for one screen where the SG200-08 showed CPU utilization in numerical format for five seconds, one minute, and five minute averages. The other Cisco products provided instantaneous numerical readouts and included a graph.

Different features and their configurations within the Web interface were examined. The ACL configuration through the GUI interface was easy to find and implement. The features on the GUI allow the user to set up new rules, delete old rules, and set the priority level for the programmed rules of the switch. Over all the Cisco switches were the easiest to configure and implement.

Creating a new VLAN in the Cisco Web interface was easy and intuitive. The menu bar provides an entire section for VLAN Management with options to create a VLAN, change the default settings, assign interfaces to different VLANs, and more. This interface was the easiest to use for configuring and assigning VLANs to the switch.

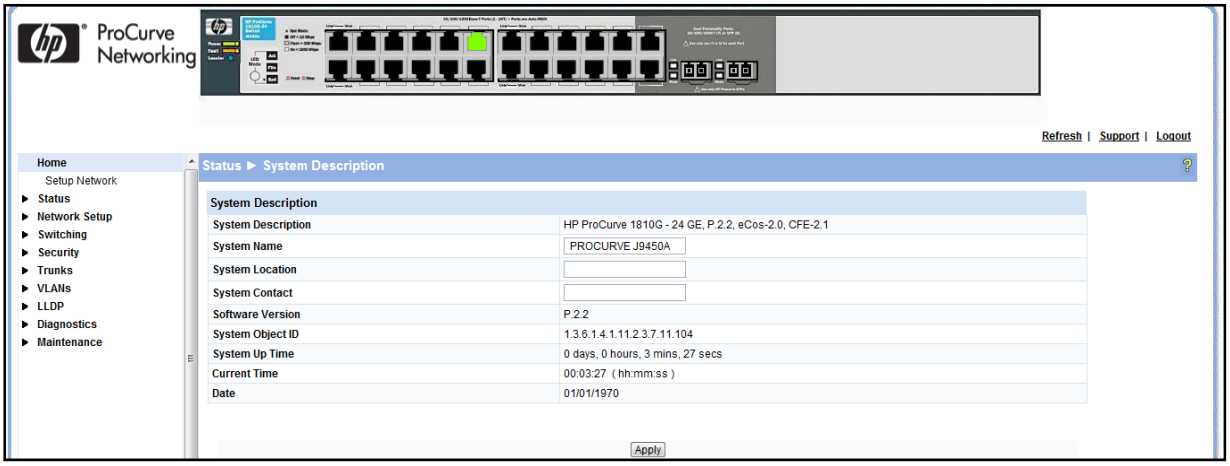
There is also a port status image tool that is used for quickly identifying the ports that were available and active.

6.2 Hewlett-Packard (E2510, E2520, E2620, E2810, V1810G and V1910 series)

The Hewlett-Packard switches came with four different Web GUI interfaces for the different switch series.
The V-18010 Series and E2620 series switches have similar GUIs that were up-to-date, easy to use, and easy to navigate. The V1910 has yet another newer look and feel.
The other E-Series (E2510, E2520 and E2810) switches have a completely different interface using a tabbed format. These E-Switches do not provide as many menu options on the home screen as the V-Series and E2620 series switches. In order to configure functions on the E-Series, it was necessary to go to sub-menus and screens. A screenshot of the three interfaces can be seen below.

V-Series, E2620 family switches and remaining E-Series switches each had their own type of web GUI.

Hewlett-Packard V1810G-Series Home Screen

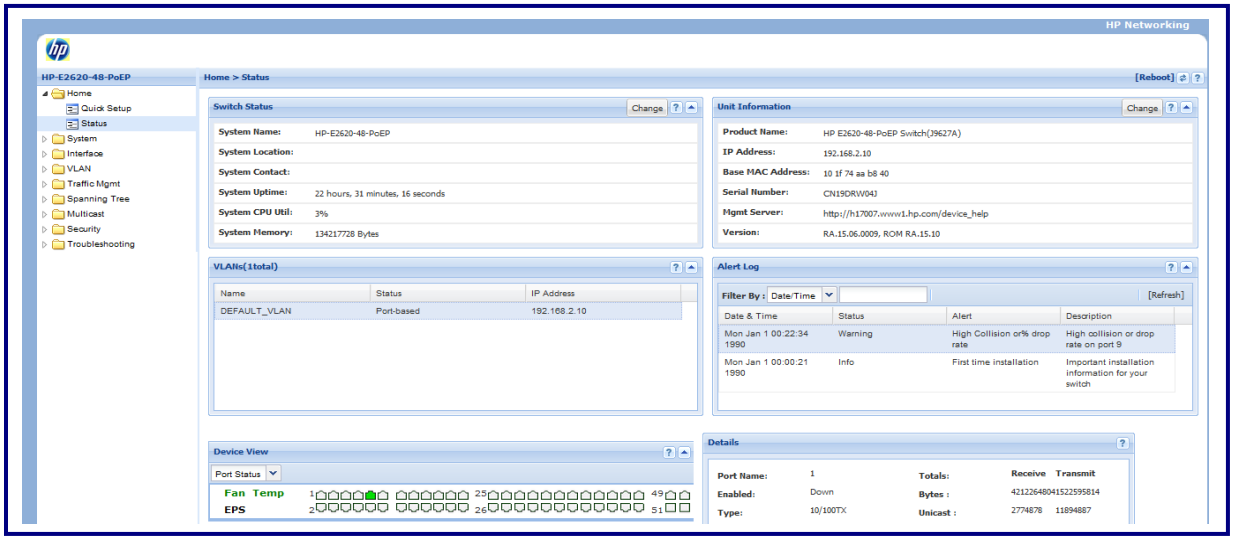


V1810-Series home screen with system description and data input areas.

The V1810-Series GUI has visible options on the home screen and a status bar that shows the port status of the interfaces. The E-Series GUI menu options are hidden until the appropriate tabs are selected. The E-Series home page does not have a status of the ports like the V1810-Series and E2620 switch series provides. If the user wants to see the port status on the E-Series GUI, they must go to a status sub-menu.

Configuring VLANs on the V-Series switches was relatively easy. The GUI provides a VLAN category on a side menu bar. In the menu section, VLANs can be added, deleted, and edited.

Hewlett-Packard E2620 Series Status Screen

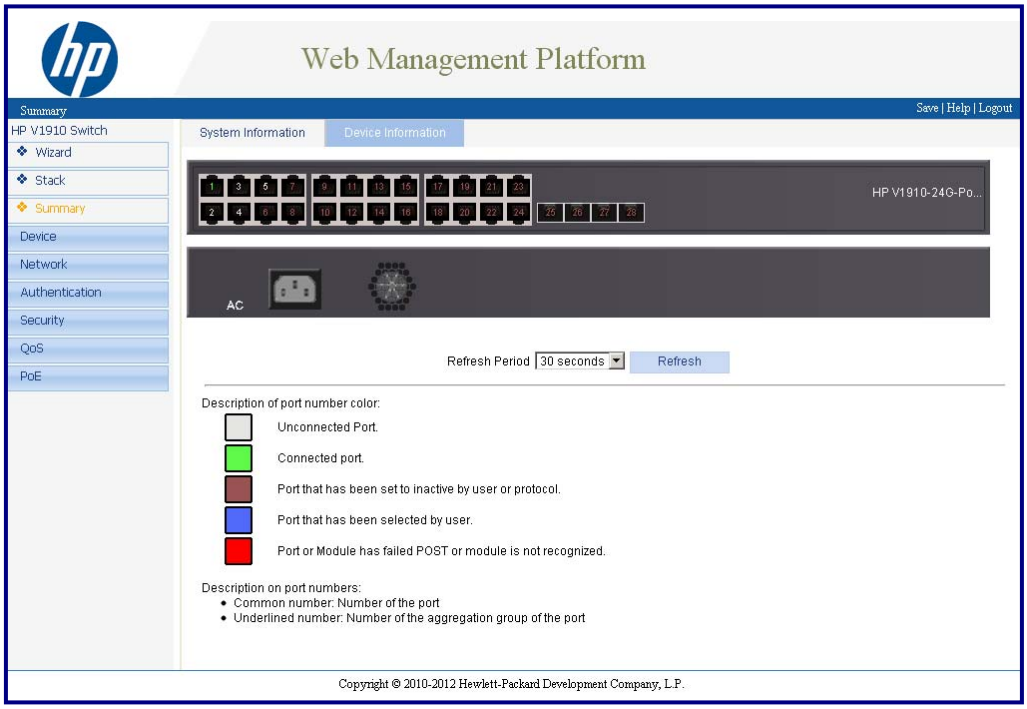


HP E2620 Series Status screen showing CPU and memory usage, MAC address information and version numbers.

The E2620 series switches have a GUI similar to the V-Series GUI. Options such as VLAN management, spanning tree and multicast can be accessed and configured on the same screen without having to go into sub-menus. The GUI has a port status graphic under the status section, allowing administrators to easily identify which ports are active. The collapsible sections on any given page is a unique feature that allows users to hide or keep open sections.

ACL configurations for the two E2620 series switches could only be made within the CLI. The MAC address table is only viewable in the CLI.

Hewlett-Packard V1910G Series Home Screen

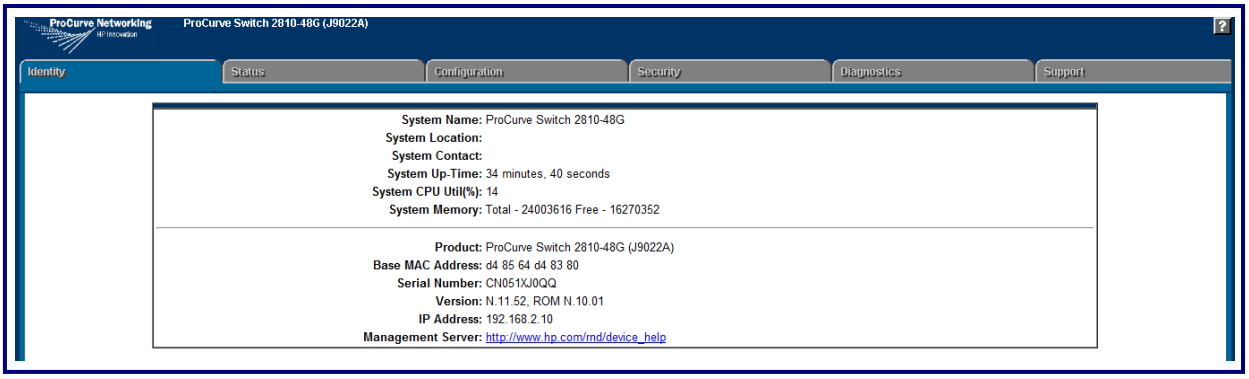


V1910 home screen showing ports and various menu options.

The V1910-Series GUI has a different design from the other HP switches. There are some similarities such as the port usage image and menu options listed on the left. However, menu options had different naming conventions. Finding specific configuration areas was fairly easy to locate. VLAN options and the MAC address table were located under the network tab. Likewise energy saving options were listed under the device tab.

The switches have limited energy saving features such as those offered by most products on the market, including lowest speed and port shutdown. Lowest speed allows the port to throttle down the negotiated line rate to 10 Mbps. Port shutdown cuts power to the port when it is not in use. These features can reduce energy and can be configured for specific times of the day throughout the week.

Hewlett-Packard E-Series Identity Screen



HP E-Series Identity screen showing CPU and memory usage, MAC address information and version numbers.

Not all of the Hewlett-Packard models tested support ACL configurations. ACL configurations are not available in the GUI and can only be accessed through the CLI.

Configuring VLANs on the E-Series requires the user to select configuration tabs. By selecting the VLAN configuration option, a user can add or remove VLANs from that screen.

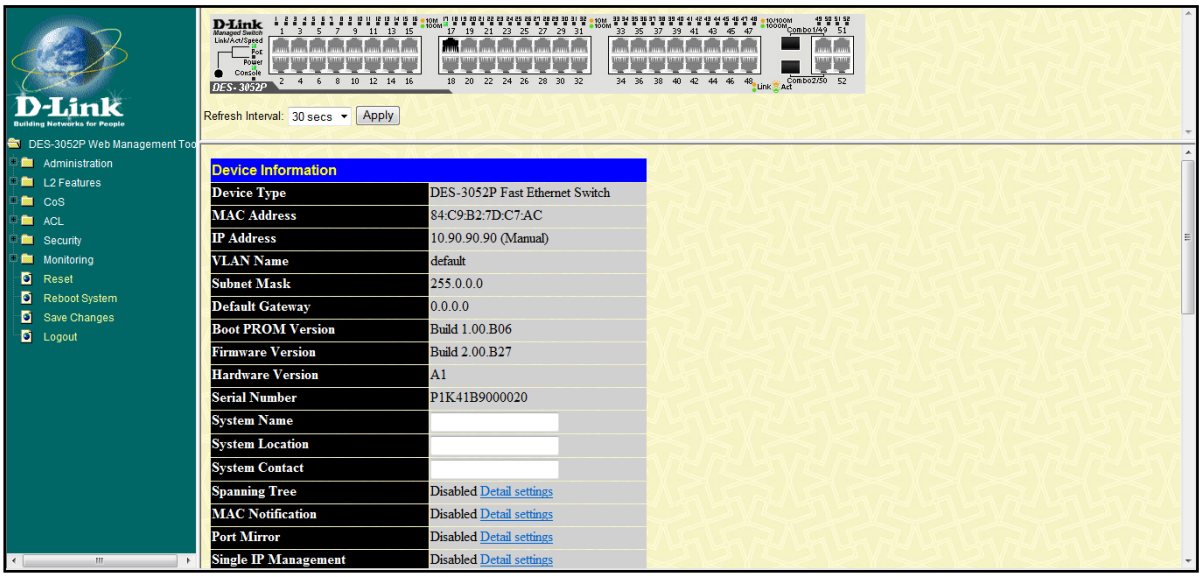
Overall the Hewlett-Packard V-Series and E2620 series switches were much easier to configure than the E-Series switches. The V-Series switches have an intuitive GUI making it easier for configuring. The E-Series switches have a moderately easy GUI, but many features are nested within sub-menus.

6.3 D-Link (DES-3052, DES-3052P series)

Unlike the other vendors, the D-Link GUI was only accessible using Internet Explorer and Firefox. The side menu bar did not load properly when using the Chrome Web browser. Load time for the web interface was slower than the other vendors in this test.

The port status image was a useful tool for quickly identifying which ports were active and in use. This helps an administrator quickly identify which ports on the switch are available instead of physically going to the switch and checking the ports.

D-Link Home Screen



Home screen with port status, IP address, MAC address and version numbers.

When trying to configure ACLs on the switch, it was easy to find the option in the GUI interface. On the menu bar, there is an entire ACL category that allows the user to program the individual ACL rules and to delete rules that are no longer needed.

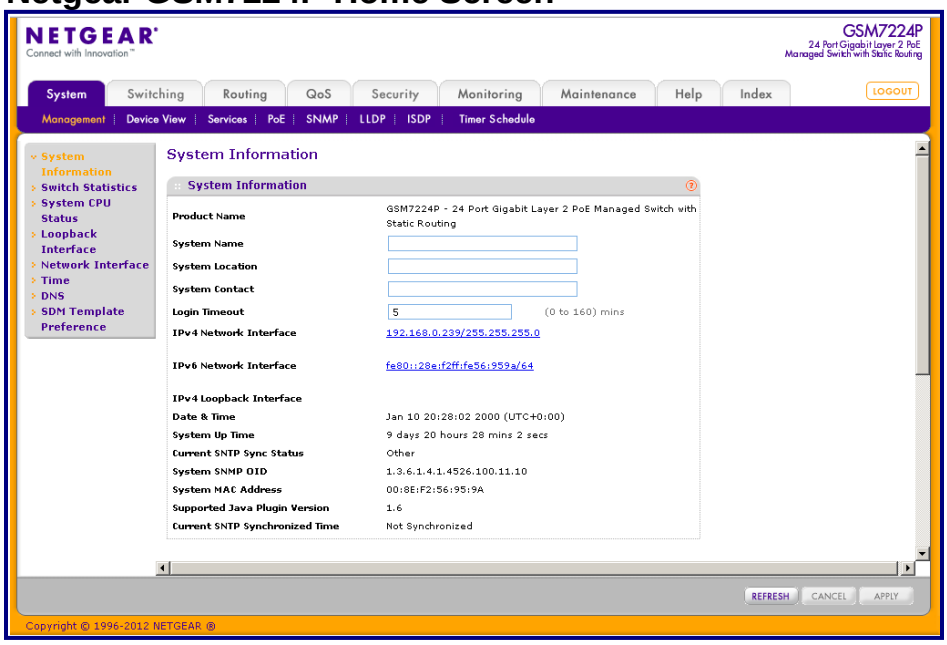
After making configuration changes on the switch, it was easy to save the configuration from an option on the side panel. We liked that the reset, reboot system and logout options were located at the root for easy access.

As with the other vendors, we configured VLAN options. VLANs were fairly easy to configure on the D-Link switches once the section was discovered under the L2 features section.

6.4 Netgear (GSM7224P, GS724TP series)

The Netgear switches had similar GUI's. The GSM7224P supported more features than the GS724TP, therefore there were more tabs for configuration across the top of the GUI. The two GUI's worked smoothly in Internet Explorer, Firefox and Chrome browsers. We found that the Netgear's GUI design was easy to navigate and use. For instance, if an ACL configuration needed to be made, we knew we could find the page under the security tab.

Netgear GSM7224P Home Screen



Netgear home screen showing system information, and different menu options.

Configuration areas were easy to find. Once a change was made, the configuration could be easily saved under the maintenance tab. CPU usage and switch statistics under the system tab provided simple access to monitor processor utilization and other switch information, such as packets transmitted and maximum VLAN entries. CPU utilization is displayed with three different averages; 5 second average, 60 second average and a 300 second average.

The MAC address table was viewable under the switching tab. The GUI also shows the total number of MAC addresses in the table. Additionally, every single address in the table is displayed. The address table can easily be cleared by selecting the clear option at the bottom right hand of the screen.

6.5 Ease-of-use Summary

All switches in this report came with Web interfaces that are accessible from a Web browser for configuration. Some of the biggest differences between the vendors came into play when dealing with the actual ease-of-use. The Cisco and Netgear switches, overall, were the easiest interface to use, being up-to-date, fast and intuitive. At no point during the configuration process did we have to hunt for an option. Section headings were logically written and made it easy to locate specific features while configuring the switch.

Ease-of-use Summary Table

	Cisco	HP	D-Link	Netgear
GUI ease-of-use	5	3	3	5
ACLs	GUI and CLI	CLI	GUI and CLI	GUI and CLI
Responsiveness	5	4	3	4
MAC Table View	GUI and CLI	V-Series - GUI and CLI E-Series - CLI	GUI and CLI	GUI and CLI
Browser*	IE, FF, Chrome	IE, FF, Chrome	IE, FF	IE, FF, Chrome

Ease-of-use was scored on a 1 to 5 scale, with 1 difficult and 5 the easiest.
GUI responsiveness was scored on a scale of 1 to 5, with 1 the slowest and 5 the fastest.
**IE: Internet Explorer, FF: Firefox.*

While performing the configurations, we logged into the GUI to look up statistics on the switch, such as how many MAC address were currently stored in the table and what the CPU usage was while performing the test.

The D-Link, Cisco and Netgear switches offered the capability to see the number of MAC addresses in the address table, and to which port they were assigned. The HP switches only offered this capability on the V-Series.

When dealing with the E-Series HP switches, we had to use the CLI interface to print a list of MAC addresses through the command line and have it output to a log file. This proved to be very cumbersome when trying to compile a list of MAC addresses and compare it to the advertised table size on the data sheet. Overall, the switches provided a good amount of status updates and logs directly accessible from the GUI.

7.0 Key Features

Information regarding the features and functionalities of each switch were obtained by publicly available vendor datasheets. The details are summarized here.

Switch Features

Features	Cisco		HP		D-Link	Netgear	
	200 Series	300 Series	E-Series	V-Series	DES-3052 Series	GSM7224P	GS724TP
IGMPv3	No	Yes	Yes	V1910	No	Yes	No
Ingress Rate Limiting	Yes	Yes	E2620	V1910	Yes	Yes	Yes
Egress Shaping	No	Yes	No	No	Yes	No	No
VLAN Mirroring	Yes	Yes	No	No	No	No	No
MAC Multicast	No	Yes	No	No	No	No	No
MAC VLANs	No	Yes	Yes	No	No	Yes	No
IPv6	Yes	Yes	E2520G E2620	V1910	No	Yes	No
IPv6 ACL	No	Yes	No	V1910	No	Yes	No
IPv6 to IPv4	Yes	Yes	E2620	V1910	No	No	No
MLD Snooping	Yes	Yes	E2620	V1910	Yes	Yes	No
Granular ACLs	No	Yes	E2620	V1910	Yes	Yes	No
DoS Protection	SG200-26 SG200-26P	Yes	E2520G	V1810* V1910	Yes*	Yes	No

***Note:** These switches have DoS protection. However, GUI became unresponsive during DoS attack.

The Cisco switches supported a variety of features, including IGMPv3, ingress rate limiting, egress shaping, VLAN mirroring, MAC multicast, MAC VLANs, MLD snooping, DoS protection and IPv6 support. IPv6 support included the ability to network IPv6 over IPv4 with Intra-Site Automatic Tunnel Addressing Protocol (ISATAP). Having all of these features and functionalities available on SMB switches helps administrators manage, troubleshoot and secure their networks without having to purchase additional equipment. They are also future proofed by virtue of their IPv6 support.

One Netgear and two HP switches supported DoS protection, which mitigates security attacks that would prevent the switch from functioning. However they did not all support IPv6 in their current firmware version. If a company needs to migrate to IPv6 they would either have to wait for a new firmware version or purchase new equipment.

8.0 Energy Efficiency

All 15 of the switches were measured for power usage under full load. Those switches which had green or energy saving features were tested with and without the green features enabled. This section shows power usage and then compares it with usage when green features were enabled.

Power Usage With and Without Energy Saving Features Enabled

		Power Usage			
Configuration	**Model**	**Without Energy Savings**	**With Energy Savings**	**EEE**	**Lowest Configuration Usage**
24-port 10/100	Cisco SF300-24	15.3	15.3	N/A	✓
	HP E2610-24	27.4	N/A	N/A	
48-port 10/100	Cisco SF300-48P	45.3	45.3	N/A	
	HP E2610-48PWR	43.7	N/A	N/A	
	D-Link DES-3052	20.3	N/A	N/A	✓
	D-Link DES-3052P	55.2	N/A	N/A	
24/28-port Gigabit	Cisco SG200-26	19.3	18.6	17.2	✓
	Cisco SG200-26P	24.4	23.2	15.7	
	Cisco SG300-28P	29.9	28.7	20.7	
	Cisco SG300-28	20.7	20.0	18.7	
	Netgear GSM7224P	43.5	N/A	N/A	
	Netgear GS724TP	47.1	N/A	N/A	
	HP V1910-24G-PoE	34.2	34.2	N/A	
	HP V1810G-24	21.8	20.6	N/A	
	HP E2520G-24	35.8	N/A	N/A	
48/52-port Gigabit	Cisco SG300-52	44.8	43.3	41.1	✓
	HP E2510G-48	102.4	N/A	N/A	
	HP E2810-48G	103.6	N/A	N/A	
8-port Gigabit	Cisco SG200-08	7.4	7.1	N/A	✓
	HP V1810G-8	7.9	7.3	N/A	

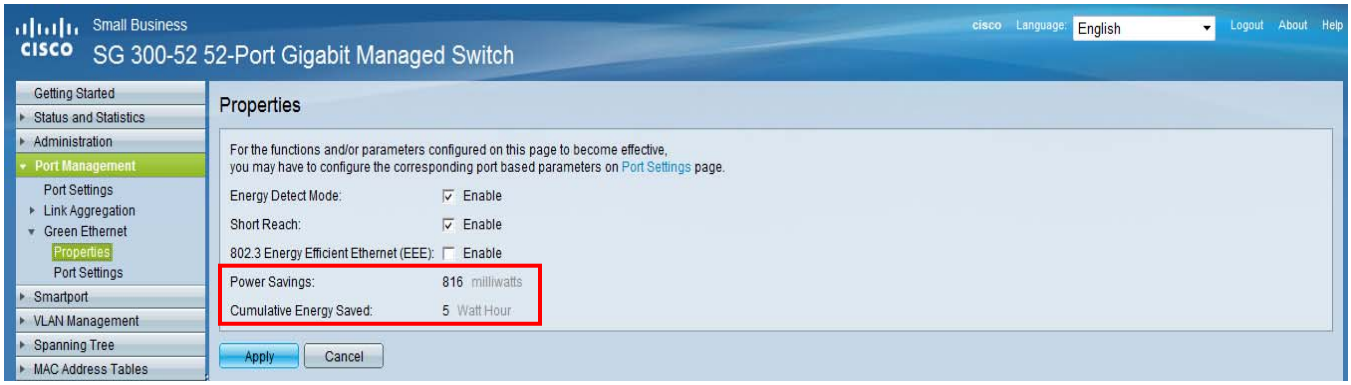
Power used with and without power saving features enabled. Watts were recorded while loading the switch with full mesh throughput traffic at a 512-byte frame size. Power saved ranged from 0 to 1.5 watts. The HP E series switches and two D-Link switches did not support any energy saving features.
** The D-Link DES-3052 was the only switch in this category which is fanless and a non-PoE design.*

Not all switches have energy saving features. All Cisco switches tested do have energy saving features that could be toggled on or off.

The Cisco switches included several features. The first is Short Reach, which saves power when the switch cables are shorter than 10 meters. Our testing was conducted using cable lengths of 4.26 meters, allowing us to utilize the Short Reach feature. The saving is from reducing the amount of power required with shorter cables. Longer cable runs require more power for data transmission.
Another energy saving feature supported by the Cisco switches is Energy Detect mode. Energy Detect mode enables the switch to put ports into sleep mode when they are not in use.
Firmware version 1.2.7.76 supports another feature which disables the LEDs on each port. With port LEDs off, a reduction of .5 watt was observed when compared with the port LEDs on. The power measurement was recorded while running full mesh traffic at 100%.

Note: The LED disable feature was only tested on the Cisco SG200-26P and SG300-28P with firmware version 1.2.7.76. Version 1.1.2.0 did not support the LED disable feature.

Power Saving Calculation



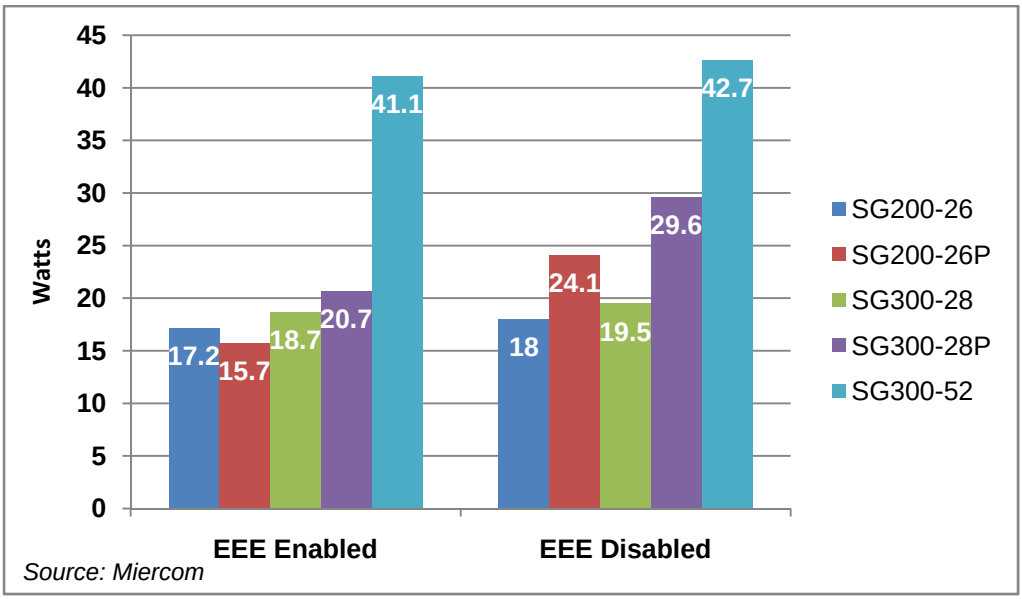
The Cisco switches support a feature that calculates power savings and cumulative energy savings. This feature is not functional while EEE is enabled.

Another Cisco feature is IEEE 802.3az Energy Efficient Ethernet which cuts transmitter power to any interface when the port is either idle or when there is bursty traffic.
This is not a supported feature for the HP ,D-Link and Netgear switches.

The EEE power saving functionality was tested using a recommended configuration from a 2011 Cisco whitepaper. The Ixia traffic generator was configured to simulate laptop/desktop users, which EEE is optimized for. The data pattern consisted of bursty traffic with a low link utilization of 10%. Each burst of traffic consisted of 100,000 64-byte packets, with an inter-packet gap of 100 milliseconds and the bursts occurring every 100 milliseconds.

The Cisco SG200-26, SG200-26P, SG300-28, SG300-28P and SG300-52 supported the EEE feature and were tested to compare power consumption with and without EEE enabled. We found the SG200-26 saved 4.5% power with EEE enabled, the SG200-26P saved 35%, the SG300-28 saved 4.10%, the SG300-28P saved 30%, and the SG300-52 saved 4%.

EEE Power Consumption



Comparison of the Cisco EEE-capable switches showing the reduction in power when EEE is enabled.

HP switches support power saving features that allow LEDs on ports to be turned off after a certain time period. This feature allowed the HP switches to save up to 1.2 watts compared to the energy used when this feature was disabled.

While the D-Link switches did not have any power saving features, the DES-3052 model has a fanless design that reduces the amount of power required to run the switch.
There are other models of D-Link switches available which do support power savings options.

The Netgear switches do not have any energy saving features for the model tested here.

9.0 Scalability and Capacity

The capacity of the switches was compared by focusing on the number of IP static routes, ACLs, configurable VLANs, as well as maximum MAC table size. The capacities varied by switch and vendor. MAC tables, ACLs and VLANs are supported by Layer 2 switches, while IP routes are supported on Layer 3 switches.

Switch Capacity

		Layer 2		Layer 3	
Configuration	**Model**	**MAC Table**	**VLANs**	**ACL Rules**	**IP Routes**
24-port 10/100	Cisco SF300-24	16,000	4,000	512	32
	HP E2620-24	16,000	512	2048	256
48-port 10/100	Cisco SF300-48P	16,000	4,000	512	32
	HP E2620-48	16,000	512	2048	256
	D-Link DES-3052	8,000	200	256	NA
	D-Link DES-3052P	8,000	200	256	NA
24/28-port Gigabit	Cisco SG200-26	8,000	256	NA	NA
	Cisco SG300-28	16,000	4,000	512	32
	Cisco SG200-26P	8,000	256	NA	NA
	Cisco SG300-28P	16,000	4,000	512	32
	Netgear GSM7224P	16,000	1,000	512	16
	Netgear GS724TP	4,000	128	128	NA
	HP V1910-24G-PoE	8,000	256		32
	HP V1810G-24	8,000	64	NA	NA
	HP E2520G-24	8,000	256	NA	NA
48/52-port Gigabit	Cisco SG300-52	16,000	4,000	512	32
	HP E2510G-48	8,000	64	NA	NA
	HP E2810-48G	8,000	256	96	NA
8-port Gigabit	Cisco SG200-08	8,000	128	NA	NA
	HP V1810G-8	8,000	64	NA	NA

The MAC table size ranged from 4,000 to 16,000. ACL rules ranged from 96 to 2,048, VLANs ranged from 64 to 4,000, and IP routes ranged from 16 to 256 across all switches.

The Cisco SG200 series switches and HP E2510, E2520, V1810-Series switches do not support IP routes because they are Layer 2 switches. The lack of ACL support indicates that they fall into the category of smart switches (managed switches with limited features), rather than fully managed switches.

10.0 Cost of Ownership Normalized Pricing

Price per Gigabit was calculated by taking the throughput and dividing it by the list price of the switch.
The switches were grouped in similar categories for comparison. The chart below shows the 20 switches with their price per gigabit easier.

10.1 Price per Gigabit Comparison

Gig non-PoE		Ports	Price per Gigabit
Cisco	SG200-08	8	$1.96
	SG200-26	26	$0.64
	SG300-28	28	$3.06
	SG300-52	52	$3.10
HP	V1810G-08	8	$3.04
	V1810G-24	24	$1.90
	E2510G-48	48	$4.55
	E2810-48G	48	$3.41
Gig PoE		**Ports**	**Price per Gigabit**
HP	E2520G-24-PoE	24	$9.10
	V1910-24G-PoE	28	$3.81
Cisco	SG200-26P	26	$2.89
	SG300-28P	28	$3.92
Netgear	GSM7224P	24	$5.79
	GS724TP	24	$2.60
10/100 non-PoE		**Ports**	**Price per Gigabit**
Cisco	SF300-24	24	$4.98
D-Link	DES-3052	48	$9.50
10/100 PoE		**Ports**	**Price per Gigabit**
Cisco	SF300-48P	24	$16.88
D-Link	DES-3052P	48	$18.10
HP	E2620-24-PPoE	24	$15.35
	E2620-48-PoE	48	$34.70

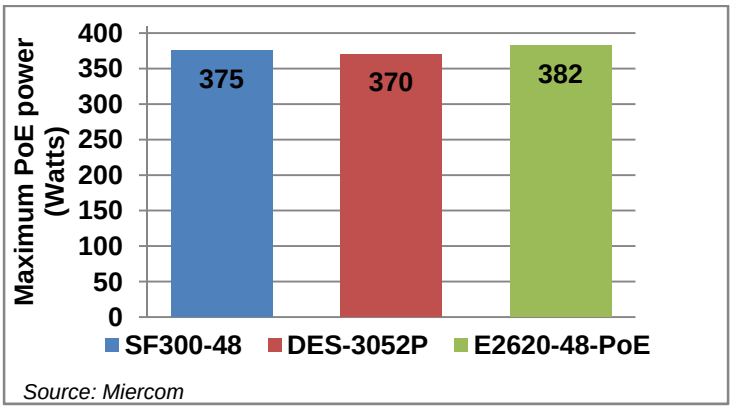
Cost of switch per gigabit ranged from $.64 to $34.70. Using only the price per gigabit, Cisco had the lowest value.

10.2 Cost of Switch per PoE Watt

Cost of Switch per PoE Watt was calculated using the PoE watt from data sheet information and published market prices. To obtain a numerical value, we divided the switch cost by the PoE budget (number of watts allocated for PoE usage). A switch's value increases when more PoE power can
be utilized.

Only switches with 48 and 52 ports were selected for this comparison.
The 24 ports switches from Cisco, HP, D-link and Netgear are not included.

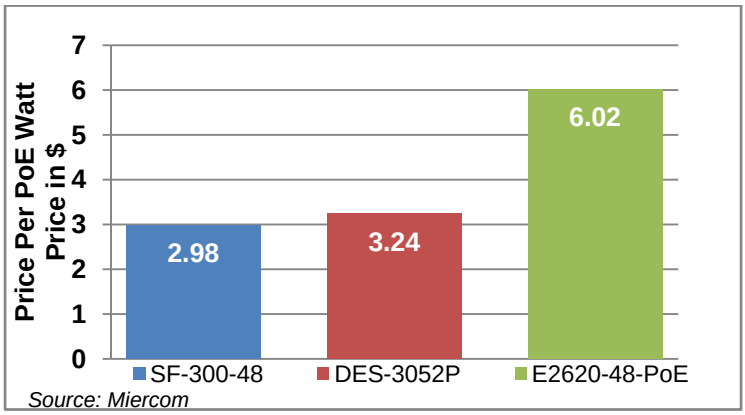
Maximum PoE Power



Maximum PoE power provided by each switch across all ports.

Using switch vendor data sheets, we obtained the published maximum watts a switch can provide for PoE. This was used to calculate the switch cost per PoE watts. This cost price does not reflect any power consumption costs.

Price per PoE Watt



Cisco has the lowest switch price at $2.98 per PoE watt.

11.0 Bottom Line

There was some interesting data collected during this review. Overall, the Cisco switches had better or equal performance then the other switches. When focusing on MAC learning, the Cisco 300 Series switch firmware doubled the MAC address table size to 16,000 while keeping the CPU usage under 11%. The HP E2620 switch series were also advertised to achieve 16,000 MAC addresses, but in our testing they achieved up to 15,931 with CPU usage at 25%. The Netgear GSM model switch was able to learn 16,382 MAC addresses out of the stated 16,384 addresses in its datasheet while keeping CPU utilization under 20%.

Switch Summary

	Cisco		HP		D-Link	Netgear	
Capacity	**200 Series**	**300 Series**	**V-Series**	**E-Series**	**DES-Series**	**GSM**	**GS**
MAC Table Size	8K	16K	8K	E-Series: 8K E2620: 16k	8K	16K	4K
VLANs	256	4K	V1810: 64 V1910: 256	E-Series: 256 E2620: 512	200	1K	128
ACLs	N/A	512	N/A	E-Series: 254 E2620: 2048	256	512	128
IP Routes	N/A	32	V1810: N/A V1910: 32	E-Series: 16 E2620: 256	No	16	No
IPv6 Transition Support	Yes	Yes	No	Yes	No	No	No
Energy							
Specific Energy Saving Features	Yes	Yes	No	No	No	No	No
EEE	Yes	Yes	No	No	No	No	No
Power Consumption	Low	Low	Moderate	High	Moderate	Moderate	Moderate
User Interface							
GUI Consistency	Yes	Yes	Yes	No	Yes	Yes	Yes
Ease-of-use	High	High	High	Medium	Medium	High	High
Browser Compatibility	IE,FF,C	IE,FF,C	IE,FF,C	IE,FF,C	IE,FF	IE,FF,C	IE,FF,C

Summary results of all switches tested in the review.
IE: Internet Explorer, FF: Firefox, C: Chrome.

The Cisco and Netgear switches have an up-to-date GUI making it easy to navigate and configure required parameters. The Cisco and Netgear GUI was able to load on multiple browsers, was extremely responsive with load times, and was very intuitive, requiring almost no idle time while looking for options.

The D-Link switches had the most outdated Web interface of the three vendors. D-Link interface did not display properly when using the Chrome browser, had a very slow load time, and was generally not as intuitive as the Cisco interface.

The HP switches had several web interfaces and did not have a consistent functionality within the E-Series or V-Series switches. The E-series switches also could not display MAC tables within the GUI. That function required accessing the CLI.

Cisco SMB Gigabit and 10/100 switches had no frame loss when sending full mesh throughput traffic. All other switches tested in this report had minimal frame loss ranging between 0% and 0.002%.

More features and functions were supported by Cisco compared to the other vendors. Having built-in features built in eliminates additional equipment purchases. Cisco is also future proofing the switches with IPv6 support.

Additionally, the Cisco switches had the lowest switch cost per gigabit compared to the other competitive switches tested. Hewlett-Packard had the highest switch cost per gigabit at $34.70. The two D-Link switches were mid-range at $9.50 and $18.10.

Finally, the Cisco switches had energy/power saving options available on all the models included in this report, which contributed to lower overall energy consumption. The Cisco switches were able to save power using the Short Reach cable option, as well as with EEE support. The D-Link switches did not include any features that would save power or reduce watts used. However their switch does operate without fans, reducing the amount of power required to run the switch. The Hewlett-Packard switches provided power saving options on the V-Series switches, but not on the E-Series switches.

The Cisco products were generally better overall than the other switches discussed here. They provided a user-friendly and intuitive interface, and included power save options to reduce energy costs while the switches were operational. This combination of feature-rich design and high performance makes them a good value for SMB customers.

12.0 Applicability of These Test Results

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 Device Under Test and test tools used in this evaluation. Miercom recommends that customers conduct their own needs analysis review with us or any other proven network consultancy and test specifically for the expected environment for deploying new equipment.

This report was sponsored by Cisco Systems, Inc., and the data within obtained completely and independently as part of the Miercom Ethernet Switch Industry Assessment in which all vendors have equal opportunity to participate and contribute to the test methodology. All vendors involved in these tests were afforded opportunity to represent their products, and still have an opportunity to actively participate in the Industry Assessment and challenge any findings.