TEST REPORT

Tolly.

#217116

April 2017

Commissioned by
D-Link Systems, Inc.

D-Link DGS-1510-28X Layer 3 Stackable Managed Gigabit Switch

Performance Comparison Versus Cisco SG500X, HPE OfficeConnect 1950 & NETGEAR S3300

EXECUTIVE SUMMARY

Stackable L2/L3 managed switches provide scalability and flexibility in a compact form factor. 10GbE uplink ports provide high-bandwidth connections for server or stacking connections. While high-performance is mandatory for such devices, acquisition cost is an important consideration as well.

D-Link Systems commissioned Tolly to evaluate its DGS-1510-28X switch (24GbE and four 10GbE ports) and compare that to a Cisco Systems SG500X, an HPE OfficeConnect 1950 and a NETGEAR S3300. All switches offer 24 ports of Gigabit Ethernet and four ports of 10GbE. Performance tests were conducted at both layer 2 and layer 3 and included ATIS power consumption measurements and TEER analysis.

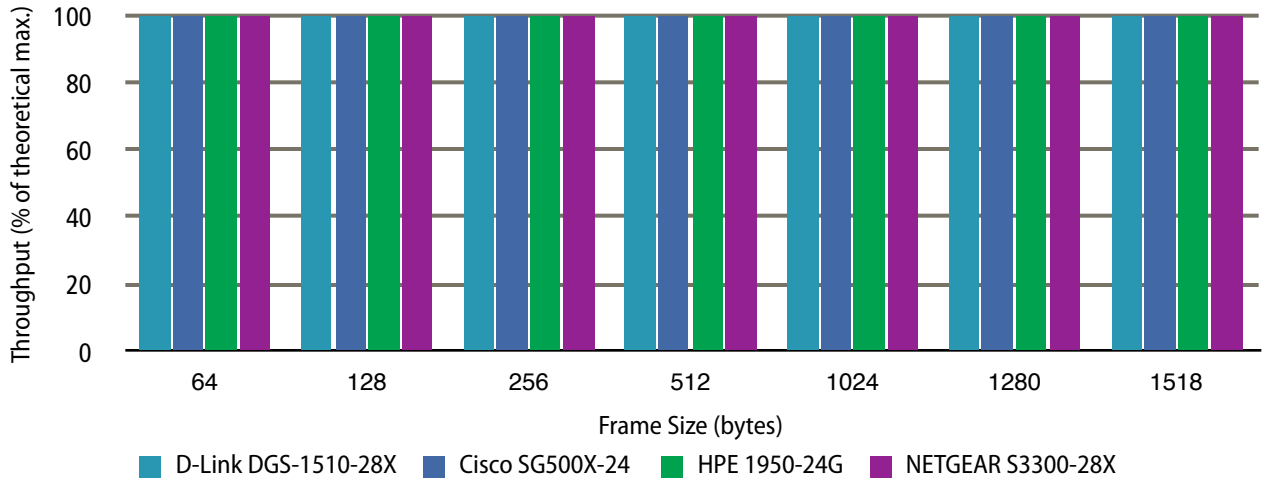
The D-Link Systems switch matched the L2 throughput of the other switches. In addition, the D-Link has a significantly lower purchase price and consumes much less power than the other switches evaluated. ...<continued on next page>

THE BOTTOM LINE

The D-Link DGS-1510-28X delivers:

1. Line-rate L2 throughput across all GbE and 10GbE ports – equivalent to the competing switches
2. L2 and L3 latency that is comparable to the HPE and NETGEAR switches
3. Cost-per-Gigabit that is 62% lower than the Cisco Systems switch and better than HPE & NETGEAR
4. Power consumption that is 51% lower than the Cisco Systems switch using the ATIS model
5. TEER (Gbps/Watt) that is 104% better than Cisco and 50% better than HPE & NETGEAR

Layer 2 Gigabit Ethernet Switch Throughput
Across 24 GbE & Four 10GbE Ports
(as reported by Xena Networks Xena2544)



Note: D-Link and Cisco switches used SFP+ for 10GbE and were tested full-mesh. HPE & NETGEAR used 10GBASE-T for two of their four 10GbE and were tested in snake topology.

Source: Tolly, March 2017

Figure 1

All switches under test provide fixed configurations of 24 Gigabit Ethernet (GbE) ports and four 10GbE ports. The D-Link and Cisco switches implement all of the 10GbE ports as SFP+ connections. HPE and NETGEAR provide two SFP+ connections and two 10GBASE-T connections. All switches offer 64Gbps of total switch throughput.

See the Test Methodology section for additional details about the systems under test and the specifics of the tests.

L2 Throughput and Latency

Industry-standard RFC 2544 Throughput tests of multiple frame sizes, from 64-bytes to 1518-bytes, proved that the D-Link DGS-1510 switch delivers the same line-rate L2 throughput for each port as the competing switches. See Figure 1.

Latency tests showed that the D-Link switch was in line with the HPE and NETGEAR switches. See Figure 2.

L3 Throughput and Latency

Switches under test supported different numbers of IPv4 addresses. As the D-Link switch supports 16 IP addresses, that number was used as the basis for the L3 throughput test. As one IP address was used for management, a maximum of 15 IP addresses/ports were used for testing D-Link, Cisco and NETGEAR. Seven IP addresses/ports were used for testing HPE as it supports maximum eight IP addresses. IP addresses/ports are in different subnets/VLANs. Thus all traffic was forwarded by L3 IP routing. Industry-standard RFC 2544 Throughput tests of multiple frame sizes, from 64-bytes to 1518-bytes, proved that the D-Link switch delivers the same line-rate L3 throughput as the competing switches. See Figure 3.

Latency tests showed that the D-Link switch was in line with the HPE and NETGEAR switches. See Figure 4.

D-Link Systems, Inc.

DGS-1510-28X

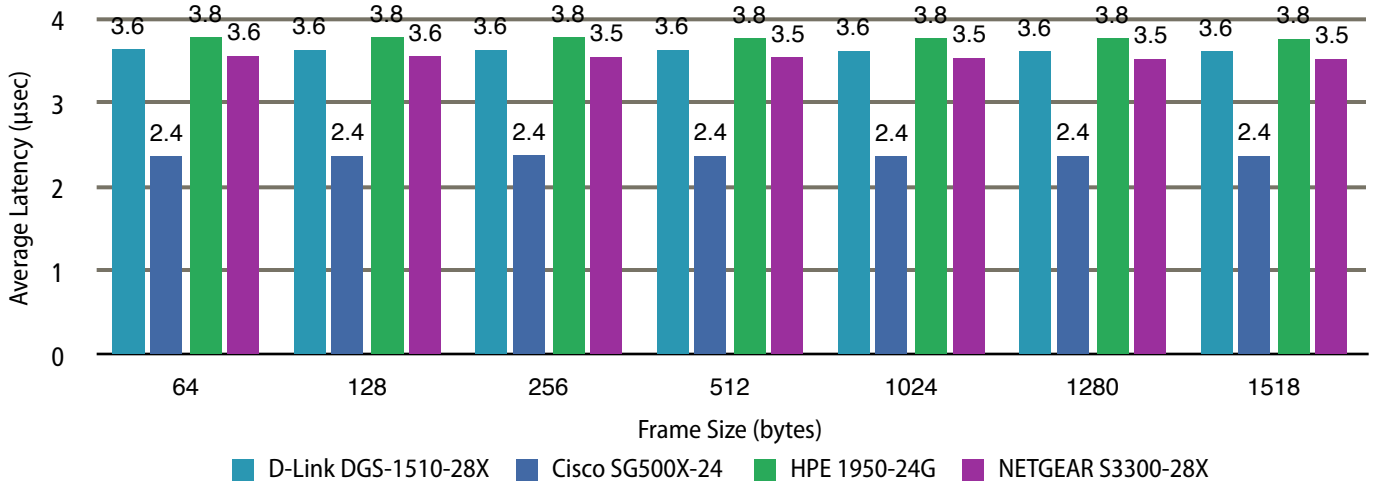
L2/L3 Performance & Power Consumption

Tested March 2017

MAC Address Collision

In order to function properly, switches need to learn the stations addresses, known as MAC addresses, of all the devices communicating across the switch. It is important that switches do not overwrite active addresses and "lose" the address. This could occur if the MAC address storage is not large enough or possibly if the hashing

Layer 2 Gigabit Ethernet Switch LIFO Latency (µsec)
GbE Port-to-Port Configuration
(Lower numbers are better)
(as reported by Xena Networks Xena2544)

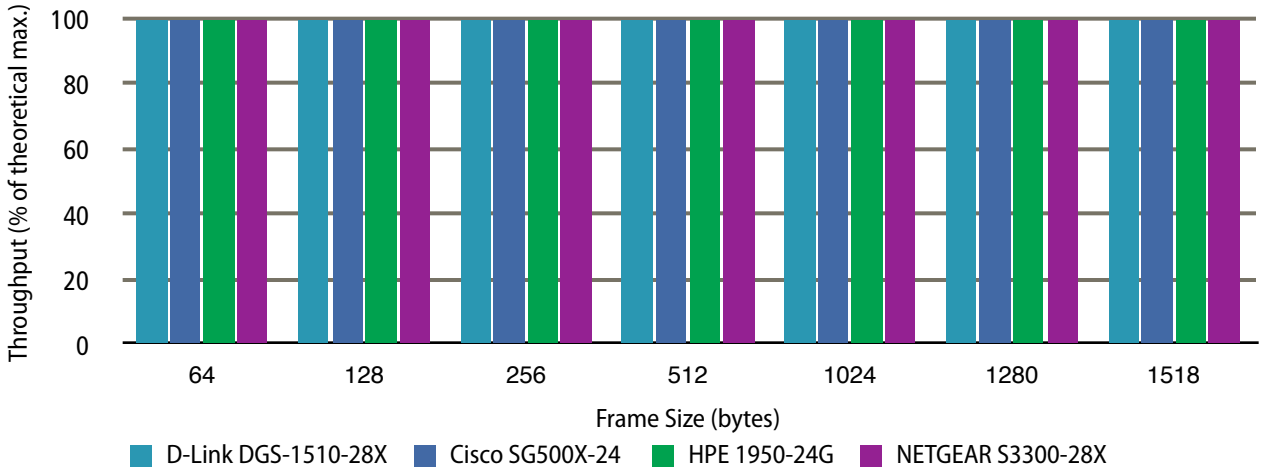


Note: Result is average of port 1 to port 2 and port 2 to port 1. Results do not include time required to store frame/packet.

Source: Tolly, March 2017

Figure 2

Layer 3 IPv4 Gigabit Ethernet Switch Throughput
Across Up to 15 GbE Ports in a Full-Mesh Configuration
(as reported by Xena Networks Xena2544)

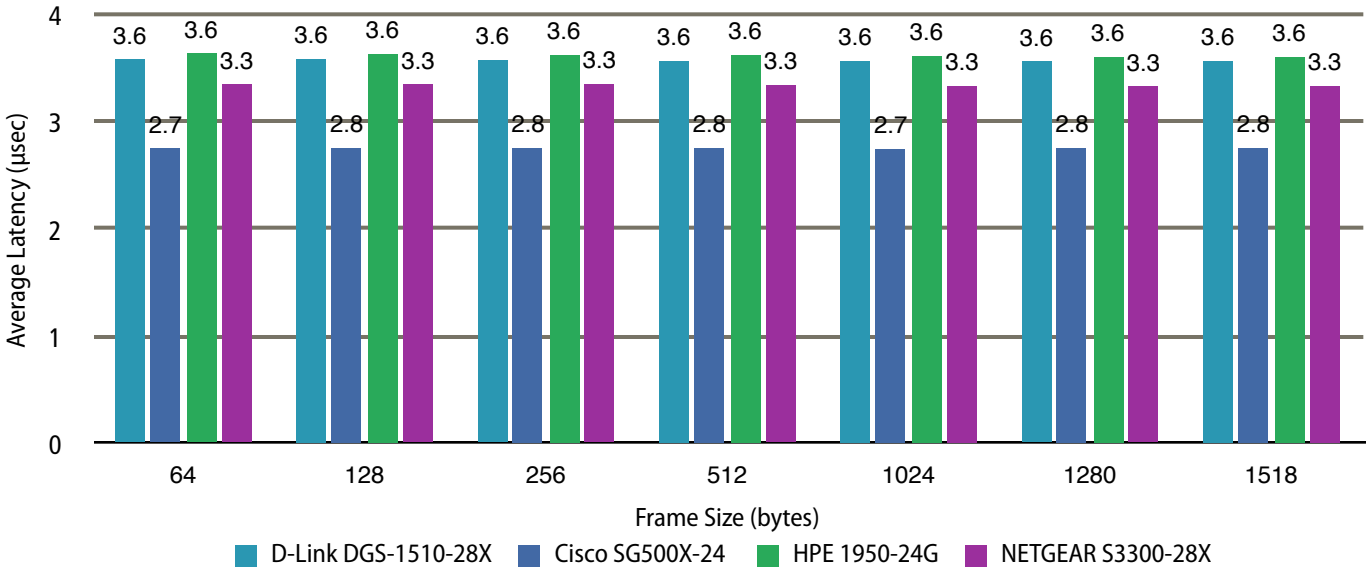


Note: Switches support differing numbers of IPv4 addresses. Test based upon maximum available for D-Link switch. 15 IP addresses/ports in different subnets/VLANs used for D-Link, Cisco Systems and NETGEAR. Seven IP addresses/ports in different subnets/VLANs used for HPE. See Test Methodology section for additional details.

Source: Tolly, March 2017

Figure 3

Layer 3 IPv4 Gigabit Ethernet Switch LIFO Latency (µsec)
GbE Port-to-Port Configuration
(Lower numbers are better)
(as reported by Xena Networks Xena2544)



Note: Result is average of port 1 to port 2 and port 2 to port 1. Results do not include time required to store frame/packet.

Source: Tolly, March 2017

Figure 4

Gigabit Ethernet Switch Power Consumption and Cost Per Gigabit of Throughput

Solution	Power Consumption (W) at ATIS Traffic Loads (lower is better)			ATIS Weighted Average Power (W_{ATIS}) (lower is better)		TEER (Gbps/Watt)		Cost per Gigabit Per Second of Throughput (user ports only)	
	Idle	10%	100%		Percentage (%) Improvement: D-Link vs. Competitor		Percentage (%) Improvement: D-Link vs. Competitor		Percentage (%) Improvement: D-Link vs. Competitor
D-Link DGS-1510-28X	17.2	16.9	17.6	17	N/A	3.76	N/A	$20.42	N/A
Cisco SG500X-24	34.9	34.7	35.7	34.82	51	1.84	104	$53.83	62
HPE OfficeConnect 1950-24G	26.1	25.4	26.8	25.61	34	2.50	50	$37.71	46
NETGEAR S3300-28X	26.6	26.5	27.3	26.59	36	2.41	56	$25.79	21

Note: See pricing information elsewhere in this document for details of system prices. Systems tested with single power supply. ATIS weighted power is calculated by as 80% of the 10% load value plus 10% each of the idle and 100% load values. For idle, ports are active (green LED) but no traffic is running. For TEER, higher numbers are better as it indicates greater throughput per Watt.

Source: Tolly, March 2017

Table 1

algorithm used for storing addresses causes a new address to overwrite an old one.

Switches were tested up to their advertised MAC address table sizes of 16K entries. They were tested first using MAC addresses that were incremented and then tested again with randomly generated MAC addresses.

In the incremental MAC test, the D-Link switch missed only two addresses. This compared with 19 missed for Cisco, nine missed for HPE and 1,540 missed for NETGEAR[1].

With the random test, the D-Link switch missed 2,052 addresses. NETGEAR missed only 1,034 where Cisco missed 2,966 and HPE missed 2,054 addresses.

Cost Per Gigabit

Tolly engineers also evaluated the relative cost of the switches by calculating the cost-per-gigabit-per-second of throughput.

The D-Link switch had a cost of $489.99. The Cisco Systems switch had a cost of $1,291.99, the HPE switch was $904.99 and the NETGEAR switch cost $618.00. These costs did not include any additional features or maintenance.

For the moment excluding the 10GbE uplink ports and dividing the cost by the number of GbE user ports gave a cost per Gigabit per second of throughput value of $20.42 for D-Link.

The D-Link is value 62% better than the Cisco switch that has a cost per Gigabit of $53.93.

Similarly, the D-Link cost is 46% better than HPE's $37.71 and 21% better than NETGEAR's $25.71. See Table 1.

[1] Responding to their results, NETGEAR noted that by adjusting the source addresses of the MAC, NETGEAR saw missed MACs in the range of ~700 to ~1,100 in their lab. Running the test with multiple source ports, they noted, resulted in only 21 missed addresses. NETGEAR confirmed their throughput and latency results. D-Link believes NETGEAR's recommended test approach does not represent a real-world scenario.

Gigabit Ethernet Stackable, Managed, L2/L3 Switches Under Test

Vendor	Product	Vendor SKU	GbE Ports	10GbE Ports	CDW Part #	CDW Price	Firmware	10GbE Connection Notes
D-Link Systems	D-Link DGS-1510-28X	DGS-1510-28X	24	4 (SFP+)	3606864	$489.99	1.0.0.012	All 10GbE ports are SFP+
Cisco Systems	Cisco SG500X-24	SG500X-24-K9-NA	24	4 (SFP+)	2674007	$1,291.99	1.4.7.6	All 10GbE ports are SFP+
HPE	HPE OfficeConnect 1950-24G	HPE 1950-24G-2SFP +-2XGT JG960A	24	4 (2xSFP+ & 2x10GBASE-T)	4360626	$904.99	950_7.10.R3115 P06	Two of the 10GbE ports are 10GBASE-T
NETGEAR	NETGEAR S3300-28X	GS728TX-100NES	24	4 (2xSFP+ & 2x10GBASE-T)	3533850	$618.99	6.6.1.4	Two of the 10GbE ports are 10GBASE-T

Note: CDW (cdw.com) price as of 2017-03-23. Pricing for unit as listed only, no additional maintenance. For the price above, D-Link provides a lifetime/ next-business-day replacement warranty. All switches support one power supply.

Source: Tolly, March 2017 Table 2

ATIS Weighted Power

Finally, Tolly engineers evaluated the power consumption of the switches. The ATIS approach dictates that the power consumption of the switch be measured at different levels of activity. A lower ATIS value is a better result indicating lower power consumption.

The ATIS value for the Cisco Systems Catalyst switch was 34.82W compared to only 17W for the D-Link DGS-1510. This represents 51% lower power consumption for the D-Link switch compared to the Cisco switch.

Similarly, both other switches consumed more power than D-Link with the HPE switch ATIS result being 25.61W and the NETGEAR result being 26.59W. D-Link uses 34% less power than HPE and 36% less power than NETGEAR.

The lower power consumption of the D-Link switch provides long-term benefits to the total cost of ownership for the system.

TEER

The Telecommunications Energy Efficiency Ratio - or TEER - looks at power consumption as it compares to throughput. With TEER, a higher number is better as it indicates more throughput for energy consumed. The D-Link switch

delivered a TEER value of 3.76Gbps/Watt. This was 104% better than Cisco's 1.84Gbps/Watt. D-Link's TEER was also 56% better than NETGEAR's 2.41Gbps/Watt and 50% better than HPE's 2.50Gbps/Watt.

Test Setup & Methodology

Switches under test were managed L2/L3 switches and provided at least 24 ports of Gigabit Ethernet (1000Base-T) connectivity and up to four ports of 10GbE connectivity. See Table 2.

All performance testing used all available GbE and 10GbE ports. Default device configurations were used as the basis for all tests. L3 test required basic IPv4 routing configurations for each device.

In the L3 performance testing, each IP address/port on the device under test acted as the gateway for one subnet. The D-Link switch used as the basis for this comparison supported up to 16 IPv4 addresses. Thus, this number was used as the maximum number of IP addresses/ports for L3 performance testing. The NETGEAR switch also supported up to 16 IPv4 addresses. The HPE switch supported up to eight IP addresses and the Cisco switch support up to 256 IP addresses. Tolly engineers used one IP subnet for management. For D-Link, Cisco and NETGEAR, the L3 test used 15 subnets. For HPE, seven subnets were used. One physical port was assigned to each subnet using VLANs.

Test Equipment Summary

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

Vendor	Product	Web
Xena Networks	**XenaBay C4-12 Chassis, M6SFP & M2SFP+ Test Modules Xena2544 v2.44**	http://www.xenanetworks.com
Siemon	**Cable Infrastructure**	http://www.siemon.com

Performance

Tests were run using Xena Networks test suites in version 72 of the Xena System. A Xena Networks XenaBay C4-12 chassis housed the physical interfaces used in the test. Xena M6SFP and M2SFP+ test modules were used.

L2/L3 Throughput & Latency Tests

The Xena RFC 2544 templates were used for all throughput and latency tests. All tests were run using the following frame sizes: 64-, 128-, 256-, 512-, 1024-, 1280-, and 1518-bytes of full-mesh layer 2 or layer 3 traffic as appropriate. All tests were run three times for a duration of one minute each. The average of the three runs was reported.

For the throughput test, the constant loading traffic profile was used with a loss tolerance of zero frame loss. For all throughput tests, dual-mesh configurations were used whenever possible. Dual-mesh means that all GbE ports were communicating with all other GbE ports and all 10GbE ports were communicating with all other 10GbE ports.

Because the HPE and NETGEAR devices only had two SFP+ ports and the test environment was SFP+, Tolly test engineers used a snake topology for the 10GbE ports and a full-mesh topology for the GbE ports.

For the latency test, the constant loading traffic profile was used and the rate was set to 100%. LIFO (last-in, first-out) latency was measured using two GbE ports. The LIFO measurements do not include the time required to store the frame.

MAC Collision Tests

These tests were designed to illustrate whether the device could accommodate large numbers of MAC (station) addresses in its internal tables. The test had two parts. Incremental: 16K MAC addresses with

incremental values were transmitted into the switch; Random: 16K randomly-generated MAC addresses were transmitted into the switch. At the end of each test, engineers reviewed the MAC address table to determine how many addresses were stored. Ixia IxNetwork was used to generate random MAC addresses.

Cost Per Gigabit

Cost per gigabit per second of throughput was calculated by taking price of the system and dividing it by the system throughput. Since the devices provide different numbers of GbE and 10GbE ports, the total system throughput differed. Calculations done both including and excluding the 10GbE ports.

No maintenance, power, taxes or other costs were included in the calculation. For the cost listed, D-Link includes a lifetime, next-business-day warranty. Prices as listed at CDW website. See Table 2.

Power Consumption

ATIS

Tolly engineers benchmarked the power consumption of each solution using all available ports and one power supply.

Testing was conducted in accordance with ATIS document ATIS-0600015.03.2009 - *Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products.* In the ATIS weighted energy consumption, a lower value is better.

The iMIX profile in Xena: (framesize:weight) as 64:58, 576:33, 1518:9

Power was measured using a WattsUp Pro power meter.

TEER

Telecommunications Energy Efficiency Ratio (TEER) is defined as a ratio of maximum demonstrated throughput (Td) to ATIS weighted power (energy consumption rate) Pw. TEER = Td / Pw. For example, the D-Link DGS-1510-28X demonstrated 64Gbps maximum throughput. So Td = 64Gbps. The ATIS weighted power consumption was 17 Watts. So Pw = 17. As a result, the D-Link DGS-1510-28X switch's TEER is 64 / 17 = 3.76 Gbps/Watt.

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

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Interaction with Competitors

In accordance with Tolly's Fair Testing Charter, Tolly personnel invited representatives from competitors to participate in the testing. HPE and NETGEAR responded and were provided with test plans and reviewed their results. Relevant comments are included in the report.

For more information on the Tolly Fair Testing Charter, visit:

http://www.tolly.com/FTC.aspx

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