Dell Networking S6000
High-performance 10/40 GbE Top-of-rack Switch

Hands-on Testing Verifies Excellent End-User QoE and Substantial Scalability in Virtual Desktop Infrastructure Environment

Miercom Lab Testing Report
Contents

1.0  Key Findings ........................................................................................................................... 3

2.0  How We Did It ......................................................................................................................... 4

  2.1  Network Equipment Tested ................................................................................................. 4

  2.2  VDI Topology Diagram ........................................................................................................ 5

3.0  Virtual Desktop Infrastructure (VDI) Environment .............................................................. 7

4.0  VMware Horizon View Desktop Virtualization Solution ......................................................... 8

5.0  About the Dell Networking S6000 Switch ............................................................................... 9

6.0  Two Phases of Testing ............................................................................................................. 10

  6.1  Phase One Testing: End-user Quality of Experience ............................................................. 10

  6.2  Phase Two Testing: Scalability to Support 10,000 Users ...................................................... 18

7.0  Bottom Line ........................................................................................................................... 19
1.0 Key Findings

- Proved switching fabric support for scalability beyond 10,000 desktop VDI sessions and address capacity of 160,000

- Effective as the “spine” in a “leaf spine” topology, the Dell S6000 10/40 GbE high-performance switch delivers excellent performance and services that support quality end-user experience in Virtual Desktop Infrastructure (VDI) environment

- Top-of rack/end-of-row S6000 exhibits high degree of scalability by easily transmitting traffic at line rate with low latency and without any loss

- Verified Virtual Trunk Linking, a proprietary protocol, provides S6000 with Layer 2 multipath redundancy that maximizes network utilization and is simpler to configure and manage than Spanning Tree Protocol
2.0 How We Did It

2.1 Network Equipment Tested

The Ixia XM12 chassis was used with the Ixia IxNetwork application and BreakingPoint FireStorm to drive network traffic through the switches using various test methodologies. Ixia (www.ixiacom.com) is an industry leader in performance testing of networking equipment. Ixia’s exclusive approach employs coordination of energy measurements with network traffic load, allowing energy consumption to be charted 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.

Login Consultants VSI script (www.loginconsultants.com) was used to help automate the launch of Microsoft applications, such as Excel, Word, PowerPoint and Outlook.

The tests in this report are intended to be reproducible for customers who wish to recreate them with the appropriate test and measuring equipment. Contact reviews@miercom.com for additional details on the configurations applied to the system 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 selection.
2.2 VDI Topology Diagram

Source: Miercom, August 2013
Table 1: Network Equipment and Software Featured in Testing

<table>
<thead>
<tr>
<th>Network Equipment</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dell S6000 Spine switches FTOS version 9-0(2-87)</td>
<td></td>
</tr>
<tr>
<td>Dell S5000 Leaf switches</td>
<td></td>
</tr>
<tr>
<td>Dell PowerConnect 6248 Access switch</td>
<td></td>
</tr>
<tr>
<td>Dell PowerEdge R720 VMware vSphere Server for Virtual Desktop</td>
<td>Intel Xeon E5-2690 2.9GHz * 16 CPUs 196GB RAM, RAID10 146GB * 10 SAS Disks</td>
</tr>
<tr>
<td>Dell PowerEdge R710 VMware Horizon View Infrastructure Server</td>
<td>Intel Xeon X5670 2.9GHz * 12 CPUs 96GB, 146GB SAS Disk * 5 Units</td>
</tr>
<tr>
<td>Dell PowerEdge R710 VMware Horizon View Clients</td>
<td>Intel Xeon E5-2690 2.9GHz * 16 CPUs 196GB RAM, RAID10 146GB * 10 SAS Disks</td>
</tr>
<tr>
<td>Dell PowerEdge R710 Horizon View Management Server</td>
<td>Intel Xeon X5670 2.9GHz * 12 CPUs 96GB, 146GB SAS Disk * 5 Units</td>
</tr>
<tr>
<td>Dell Latitude E5530 Packet Capturing</td>
<td>Core i7 Ivy Bridge 2, 9GHz, 16GB, 250GB SSD</td>
</tr>
<tr>
<td>Ixia XM12 Phase 2 Testing</td>
<td>Primary traffic generator</td>
</tr>
<tr>
<td>BreakingPoint FireStorm Phase 2 Testing</td>
<td>Alternate traffic generator</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Software</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESXi</td>
<td>Hypervisor</td>
</tr>
<tr>
<td>vCenter Server</td>
<td>vSphere</td>
</tr>
<tr>
<td>VMware Horizon View 5.2</td>
<td>Virtual Desktop System</td>
</tr>
<tr>
<td>Windows 7 Enterprise SP1</td>
<td>Virtual Desktop Operating System</td>
</tr>
<tr>
<td>Windows 8 Enterprise</td>
<td>View Client Operating System</td>
</tr>
<tr>
<td>LoginVSI</td>
<td>View Client Launcher</td>
</tr>
<tr>
<td>Stratusphere UX</td>
<td>Desktop Monitoring Tool</td>
</tr>
<tr>
<td>WildPackets OmniPeek</td>
<td></td>
</tr>
<tr>
<td>Network Analyzer</td>
<td></td>
</tr>
</tbody>
</table>
3.0 Virtual Desktop Infrastructure (VDI) Environment

In testing, Miercom verified that the Dell S6000 10/40 GbE high-performance, top-of-rack/end-of-row switch can easily transmit the traffic needed to support 10,000 virtual desktop users in a Virtual Desktop Infrastructure (VDI) environment.

A VDI environment consists of servers that host virtual PCs as a central storage repository plus the variety of client devices an end user can utilize to access his/her virtual PC.

A Virtual PC exists on a physical server as a software image that consists of the operating system and applications. The software image operates in conjunction with specialized software called a hypervisor that creates and runs a virtual PC, allowing it to emulate a desktop PC. A virtual PC typically runs on a server, but can run on any compatible hardware.

Users in a VDI environment are location-and hardware-independent. They can access virtual PCs from any compatible client device from anywhere using an Internet and/or network connection as well as a Web browser or a simple client application.

Examples of client devices include laptop computers, tablet computers and thin clients. A common type of thin client is a “dumb” terminal or monitor that provides the user with a graphical interface.

It is not necessary for client devices to have computing power in a VDI environment. Their sole function is to provide users with a conduit to the software image/virtual PC, which is running on a server that could be located hundreds or even thousands of miles away.

In addition to a client device, a user can also have a keyboard and a mouse in order to interact with the virtual PC running on the server. A USB connection on the terminal or monitor can put peripherals at the fingertips of users, such as printer, scanner and Web camera.
4.0 VMware Horizon View Desktop Virtualization Solution

In testing of the S6000, the latest version of a leading software-based desktop virtualization solution, Horizon View 5.2 from VMware, Inc., was utilized. Two Horizon View 5.2 clients that served as virtual-machine hosts ran on two Dell PowerEdge R710 rack servers.

A leader in virtualization and cloud infrastructure solutions, VMware is one of only two companies listed in the Magic (Leaders) Quadrant by IT consultancy Gartner, Inc. in its 2013 Magic Quadrant for x86 Server Virtualization Infrastructure. This is the fourth consecutive year Gartner has positioned VMware in the Magic Quadrant.

Horizon View 5.2 can function as a standalone solution or as part of the VMware Horizon Suite, a comprehensive platform for workforce mobility. VMware announced both Horizon View 5.2 and the VMware Horizon Suite in February 2013.

Horizon View 5.2 is built on VMware vSphere, the industry’s most widely deployed virtualization platform. Although it is a .2 release, Horizon View 5.2 has enhancements and new features that improve performance and scalability as well as the experience for network administrators and end users.

For example, Horizon View 5.2 can benefit network administrators by providing increased performance of desktop provisioning, which is especially important in large VDI deployments. Management of the desktop infrastructure can be improved and provisioning time can be reduced significantly.

Enhancements and new features for end users include Windows 8 support, hardware-accelerated 3-D graphics and Horizon View clients for iOS and Android with Unity. The latter facilitates use of Windows desktop applications on iPhone, iPad or Android mobile devices by transforming them into mobile applications that enable gesturing, swiping and pinching along with other native mobile experiences.
5.0 About the Dell Networking S6000 Switch

The S6000 is a Layer 2 and Layer 3 top-of-row/end-of-rack Ethernet switch designed for use in high-performance cloud and virtual data centers.

All of the following deployment scenarios for the S6000 require a combination of high bandwidth and low latency to maximize network performance:

- Ethernet switch to provide connectivity for traditional Ethernet and Layer 2 fabrics for the cloud and the data center
- Aggregation switch for the enterprise LAN serving mid-sized and large customers or handling high-frequency financial trading, high-performance computing, Web 2.0, big data, OpenStack/Hadoop applications and other heavy workload operations
- Traditional Ethernet switch with redundant connections to 10 GbE rack and blade servers

The S6000 delivers high performance from a compact 1U form factor. The primary configuration is 32 ports of 40 GbE QSFP+. It also can be configured with 96 ports of 10 GbE and eight additional ports of 40 GbE to conserve rack space and provide a path for the migration of speed in the network core to 40 Gbps.

Other key features of the S6000 include:

- 1.28 Tbps of switching I/O bandwidth in half-duplex mode
- Scalable Layer 2 and Layer 3 switching with QoS and a full complement of standards-based IPv4 and IPv6 functionality, including OSPF and BGP routing support
- Layer 2 multipath support via Virtual Link Trunking (VLT), a proprietary Layer 2 link aggregation protocol available in Dell datacenter- and enterprise-class switches

Force10 Networks, a producer of 10 and 40 GbE switches, developed VLT. Dell received VLT in its acquisition of Force10 in 2011.

VLT offers servers connected to different access switches a redundant, load-balancing connection to the network core in a loop-free environment that has benefits beyond that of Spanning Tree Protocol.
6.0 Two Phases of Testing

Testing of the Dell S6000 switch in a VDI environment consisted of two phases. Two S6000s served as spine switches in a leaf frame test fabric that simulated a desktop virtualization environment.

In the first phase of testing, the quality of experience (QoE) for end users was evaluated using a test bed environment with 200 virtual desktop clients.

In the second phase, the scalability of the Dell S6000 was assessed using emulated, stateful, bidirectional traffic representative of the earlier observed VDI transaction in the 200-user environment.

Essentially the same test bed was used in both phases of testing. It is described in detail in the next section, Phase One Testing: End-user Quality of Experience.

Different traffic load generators were used in each phase of testing. Traffic observed in the first phase was captured and replayed in the second phase.

6.1 Phase One Testing: End-user Quality of Experience

In the first phase of testing, the Quality of Experience (QoE) for end users was evaluated using a sample set of approximately 200 virtual desktop clients.

Traffic utilized in the first phase was captured for multiple replays in the second phase. The S6000 proved in the second phase that it can easily support 10,000 virtual desktop clients with low latency as well as no loss of frames or other network anomalies.

The latest version of VMware Horizon View, 5.2, was utilized as the desktop virtualization solution. The Horizon View client ran on two stacked Dell PowerEdge R710 rack servers, which were among six end nodes in the test bed. Of the other four end nodes, two were PowerEdge 710 servers and two were PowerEdge R720 servers.

Horizon View 5.2 was built on VMware vSphere. The two R720 servers use Windows 7 operating system and ran VMware vSphere ESXi hypervisor. Functioning as a "virtual desktop," they housed virtual desktop master images and replicas as well as applications in the Microsoft Office Suite, such as Word, Excel, Windows Media Player, etc., that were used to create traffic for testing.

Two R710s had Windows 8 Enterprise as the operating system and served as Horizon View clients.

Login VSI, a load testing tool for virtualized desktop environments, was installed on each version of Windows 8 Enterprise on these two servers. Each Login VSI launched multiple Horizon View virtual desktops.

Another R710 server, the Management Host, housed the Horizon View Connection Server, the vCenter Server with View Composer, the SQL server and a server that stored user profiles for virtual desktops.

The other R710, the Infrastructure Host, housed non-VMware servers needed to run Horizon View: the Microsoft Active Directory Domain Controller and the Stratusphere UX desktop monitoring tool from Liquidware Labs, Inc.

(VMware View Composer reduces storage requirements for virtual desktop machines by up to 90% and enables organizations to manage desktop images more effectively. With View Composer, a single, parent virtual image can be created and pushed out to multiple users across
the enterprise in minutes. It also allows updating, patching or rolling out hundreds of desktops from a single, master virtual image and refreshing desktop images while retaining user settings during updates and patches.)

The heart of the test bed was a leaf/spine fabric that was composed of Dell top-of-rack 10/40 switches.

The S6000 switches are connected by Virtual Link Trunking (VLT), a proprietary link aggregation protocol available in Dell datacenter- and enterprise-class switches. As mentioned earlier in the report, VLT was originally developed by switch manufacturer Force10 Networks. Dell obtained VLT in its acquisition of Force10 in 2011.

VLT offers servers connected to different access switches a redundant, load-balancing connection to the network core in a loop-free environment. Because all physical links are active, the need for use of Spanning Tree Protocol, as well as advanced and proprietary versions, is eliminated.

(STP creates a spanning tree within a network of connected Layer 2 bridges, which typically are Ethernet switches. Links that are not part of the spanning tree are redundant, leaving a single active path between any two network nodes. Redundant links remain blocked until an active link is disrupted.

The existence of redundant links that are inactive plus the inherent complexity of designing and implementing STP makes VLT an attractive alternative for Layer 2 redundancy.)

Both leaf switches in the test bed were Dell S5000s. They were connected to each other via VLT. Also, each was connected to each vSphere (R720) server and to each spine (S6000) server.

Lastly, a Dell 6248 switch was connected with one of the spine S6000 servers and all three Horizon View servers (Client Host, Management Host and Infrastructure Host). A GbE Layer 3 switch, the 6248 provided a management VLAN for all end nodes housing the servers.

To begin the QoE portion of the test, 16 guest operating systems residing on the two stacked R710 servers functioning as the Horizon View client were launched. Each guest OS had Login VSI, the load testing tool. Each Login VSI generated multiple Horizon View clients.

After a Horizon View clients signed in to the virtual desktops on the vSphere ESXi hypervisor, Login VSI generated a pre-configured script that imitated realistic user activities, such as accessing the Internet, using Microsoft Outlook, writing and editing documents in Microsoft Word, playing video and playing audio (music).

The following Login VSI screenshot shows the simulated activities of virtual users in the VDI environment.

Login VSI repeated the script for the duration of the test, which lasted about 15 minutes, to impose stress on the test network and its hardware components.
During this test, two parameters were changed to simulate conditions in a VDI environment on a real-world network.

One was the level of user activity generated by the Login VSI script for the ESXi load test. Workloads classified as “medium” and “heavy” were imposed on the Horizon View infrastructure.

A medium workload consisted of opening five applications simultaneously of the seven available at a type rate of 160 ms for each character. The applications are replayed in a loop. Approximately two minutes of idle time was included to simulate the behavior of real-world users.

The seven applications were: Microsoft Outlook 2007/2010 (browse 10 messages), Internet Explorer (one Website left open, two Websites browsed), Word 2007/2010 (one instance to measure response time and one instance to review and edit a document), Bullzip PDF Printer and Acrobat Reader, Excel 2007/2010 (open a large spreadsheet), PowerPoint 2007/2010 (review and edit a presentation) and 7Zip.

A heavy workload, of course, provided a greater challenge to memory and CPU consumption because more applications are running in the background.

The heavy workload is based on the medium workload. The differences are that in the heavy workload, eight applications are running simultaneously; the type rate is 130 ms per character; the idle time is only 40 seconds.

The second parameter was desktop resolution, which assessed network utilization during testing. High resolution was Full HD, 1080p, with p referring to the numbers of vertical lines displayed on the screen. “Low resolution” was XGA (Extended Graphics Array), a high-resolution video display...
mode that provides screen pixel resolution of 1,024 x 768 in 256 colors or 640 x 480 in high (16-bit) color.

Four combinations of workload and resolution were run to determine the impact on end user experience. They were medium workload with low resolution, heavy workload with low resolution, medium workload with high resolution, and heavy workload with high resolution.

To ascertain a complete picture of end-user Quality of Experience (QoE), two tools were used. The Stratusphere UX virtual appliance, a software-based desktop monitoring tool housed on the Infrastructure Host, made a visual recording of desktop activity that allowed subjective evaluation.

Installed on a golden image of a virtual desktop, the Stratusphere agent pushed all data related to end-user experience to the Stratusphere UX for rating Quality of Experience. The overall quality was rated in the upper right (best) quadrant, indicating both best interactive experience and best quality of display rendering.

Figure 2: Stratusphere End User Experience Data from Virtual Desktop Clients

In addition, an objective evaluation of end-user experience was made using the OmniPeek network analyzer from WildPackets, Inc., which monitored network utilization during the test of the S6000 switches and the ESXi hypervisor resource. OmniPeek was placed on the link between a S6000 switch and the 6248 switch. It monitored traffic passing through the S6000 switches from the vSphere servers via the S5000 switches.
Tests Combining Workload and Screen Resolution

A short description of each of the four tests follows. The combination of workload and screen resolution is in bold.

Test One used the combination of medium workload with XGA (1,024 x 768). 16 Login VSIs launched multiple Horizon View clients, which logged into the virtual desktop at 60-second intervals. CPU capacity was verified to be near maximum. 203 virtual users ran concurrently on a subnet, which had a single S6000 switch as the backbone.

Figure 3: Login VSI Simulates Realistic Desktop Activity of 203 Virtual Users
Desktop experience of all 203 users was rated fully satisfactory by Stratusphere UX.

Test Two used the combination of heavy workload with XGA (1,024 x 768). Again, Horizon View clients logged into the virtual desktop at 60-second intervals. The sample set was 203 clients. Stratusphere UX, which carried out real-time monitoring, scored the user experience of all as best. The image from the Stratusphere interface is shown below.

The quality of images visible on the desktop was excellent. Desktop operation was observed even while video was playing.
Figure 5: Viewing Video during Heavy Workload with XGA

Two hundred current users accessing video over VDI sessions. The Dell S6000 proved to handle current VDI sessions with video with excellent QoE.
Medium and Heavy Work Load with Full HD Desktop

The charts below show the resource monitor of one of the ESXi hypervisors. Because of nearly 100% load on the CPU at peak time, 190 of View Client with Heavy Work Load sessions were running concurrently without losing user experience. As Kernel latency of Disk IO is below one millisecond, bottleneck of scalability of VDI system depends on the CPU of the test bed.

Maximum network utilization is about 11 Mbps, nearly twice the speed of the single ESXi host. It is equal to 88Mbps. Network traffic was about 460 kbps per each View Client. It is categorized as Knowledge Worker, using multiple monitors in terms of criteria of VMware Horizon View Architecture Planning Guide. Because VMware estimates 50 to 150kbps per typical user in a general deployment scenario, the stress that each View Client imposed on the S6000 was more than enough for testing purposes. Similar testing characteristics were observed throughout the scenario of Medium Work Load with Full HD resolution desktop. Because of lesser CPU demand on Medium Work Load, we were able to launch 206 concurrent VDI clients.
6.2 Phase Two Testing: Scalability to Support 10,000 Users

The objective of testing the S6000 switch was to verify scalability to support up to 10,000 users in a VDI environment.

The traffic scenarios generated by Login VSI in the first part of testing were captured and re-used multiple times in a loop.

The traffic generation equipment used in scalability testing was the Ixia XM12 and the BreakingPoint FireStorm.

VMware has different descriptions and traffic consumptions for types of users. A Power User, who consumes 2 Mbps of traffic, is at the top of the list. Another example is an Average User, who consumes between 50-150 Kbps.

So for example, for 10,000 virtual desktop Power Users, the S6000 would in theory, have to generate at least 20 Gbps of traffic.

In testing, the S6000 provided 63.2 Gbps of fully meshed traffic at 99.5% line rate with low latency from seven 10 GbE ports with similar distribution of frame sizes in as the VDI sessions. There was no frame loss and no network anomalies. See the chart below.

Table 2: Throughput of Seven 10 GbE ports, Full Meshed Traffic with Similar Frame Sizes in VDI Session

<table>
<thead>
<tr>
<th>Tested Ports</th>
<th>Traffic type</th>
<th>Line rate [%]</th>
<th>Throughput [Gbps]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10Gbps * 7 ports</td>
<td>Fully Meshed</td>
<td>99.5</td>
<td>63.20</td>
</tr>
<tr>
<td>10Gbps * 7 ports</td>
<td>Fully Meshed</td>
<td>99.5</td>
<td>63.20</td>
</tr>
<tr>
<td>10Gbps * 7 ports</td>
<td>Fully Meshed</td>
<td>99.5</td>
<td>63.20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>63.20</td>
</tr>
</tbody>
</table>

The 10,000 Horizon View sessions created a large number of local MAC addresses. The sum of each virtual desktop MAC, each Horizon View client MAC and each Horizon View infrastructure MAC was approximately 20,000.

However, this is not an issue since the MAC address table of the S6000 was verified to exceed the vendor-stated capacity of 160,000. In testing, Miercom verified maximum capacity of 163,836. The S6000 learned all of the MAC addresses in less than 15 seconds.

The following screen shot showing the MAC address capacity is from the management interface of the S6000.

Figure 6: Maximum MAC Address Count

Maximum MAC address count for the S6000 switch was verified in testing using the default configuration.
7.0 Bottom Line

The Dell S6000 high-performance 10/40 GbE Layer 2/3 switch offers exceptional performance and scalability, making it well suited for a data center or cloud networking infrastructure for years to come. A compact 1U top-of-rack/end-of-row switch, the S6000 can be just as important as an aggregation switch for an enterprise LAN and in a traditional Ethernet environment in which it is connected to 10/40 GbE rack and blade servers.

As the maximum speed in the network core continues to climb toward 40 Gbps, the S6000 is ready now with 32 ports of 40 GbE or 96 ports of 10 GbE and eight additional ports of 40 GbE. The latter configuration is available to save rack space and simplify the migration to 40 Gbps in the core.

The other built-in functionality that future proofs the S6000 is the massive MAC address table. In testing, Miercom validated the capacity to be 163,836 addresses, higher than the vendor-stated capacity of 160,000.

Also in testing, the S6000 admirably met two objectives in a Virtual Desktop Infrastructure (VDI) environment. The switch used a tiny fraction of its horsepower to provide excellent end-user Quality of Experience to approximately 200 virtual desktops.

The same traffic then was re-used for emulation in scale to validate substantial scalability, that the S6000 can support 10,000 virtual desktops in a VDI environment.

We proved in testing the Dell S6000 could handle 10,000 VDI users, however, scalability testing indicates the switch is capable of 16 times that capacity.
About Miercom

Miercom has hundreds of product comparison analyses published in leading network trade periodicals including Network World, Business Communications Review - NoJitter, Communications News, xchange, Internet Telephony and other leading publications. Miercom’s reputation as the leading, independent product test center is unquestioned.

Miercom’s private test services include competitive product analyses, as well as individual product evaluations. Miercom features comprehensive certification and test programs including: Certified Interoperable, Certified Reliable, Certified Secure and Certified Green. Products may also be evaluated under the NetWORKS As Advertised program, the industry’s most thorough and trusted assessment for product usability and performance.

Other Notes and Comments

Product names or services mentioned in this report are registered trademarks of their respective owners. Miercom makes every effort to ensure that information contained within our reports is accurate and complete, but is not liable for any errors, inaccuracies or omissions. Miercom is not liable for damages arising out of or related to the information contained within this report. Consult with professional services such as Miercom Consulting for specific customer needs analysis.

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 customers conduct their own needs analysis study and test specifically for the expected environment for product deployment before making a product selection.