Miercom

Lab Testing Summary Report

April 2009
Report 090421C

Product Category:
Director Class SAN Switch

Products Tested:

Cisco MDS 9509
Cisco MDS 9513
Brocade DCX

Reliability and Non-Blocking Performance

Key findings and conclusions:

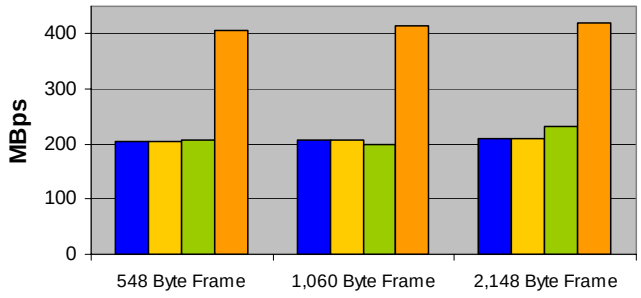
- **Cisco MDS 9509/9513 passed a rigorous battery of performance tests without frame loss or error**
- **MDS proved full line rate and highest throughput for 8-Gbps Fibre Channel port pair tests**
- **MDS proved traffic prioritization with dedicated bandwidth and fair allocation on remaining ports**
- **MDS Passed all resiliency and high availability tests for system and line card failover tests**

Cisco Systems provided the MDS 9509, 9513 Director Class Switches and a Brocade DCX for private competitive analysis. Testing was conducted both in the Miercom West Coast Lab and at Cisco's facility. The methodology for this evaluation was mutually agreed, with the tests focusing on performance differentiators and guaranteed frame delivery. The Cisco MDS proved to offer the most reliable and non-blocking throughput of the products tested.

The MDS 9509 and 9513 outperformed the DCX in fully loaded line card tests with error free throughput. The MDS 9509 and 9513 also proved to be the only products that could handle full 8-Gbps Fibre Channel traffic load without reported error or frame loss during any of the tests conducted regardless of the testing configuration.

Figure 1 below compares the maximum error free throughput per line card on the Brocade DCX and Cisco MDS for this particular test. The switches were connected with maximum port *(continued on page 3)*

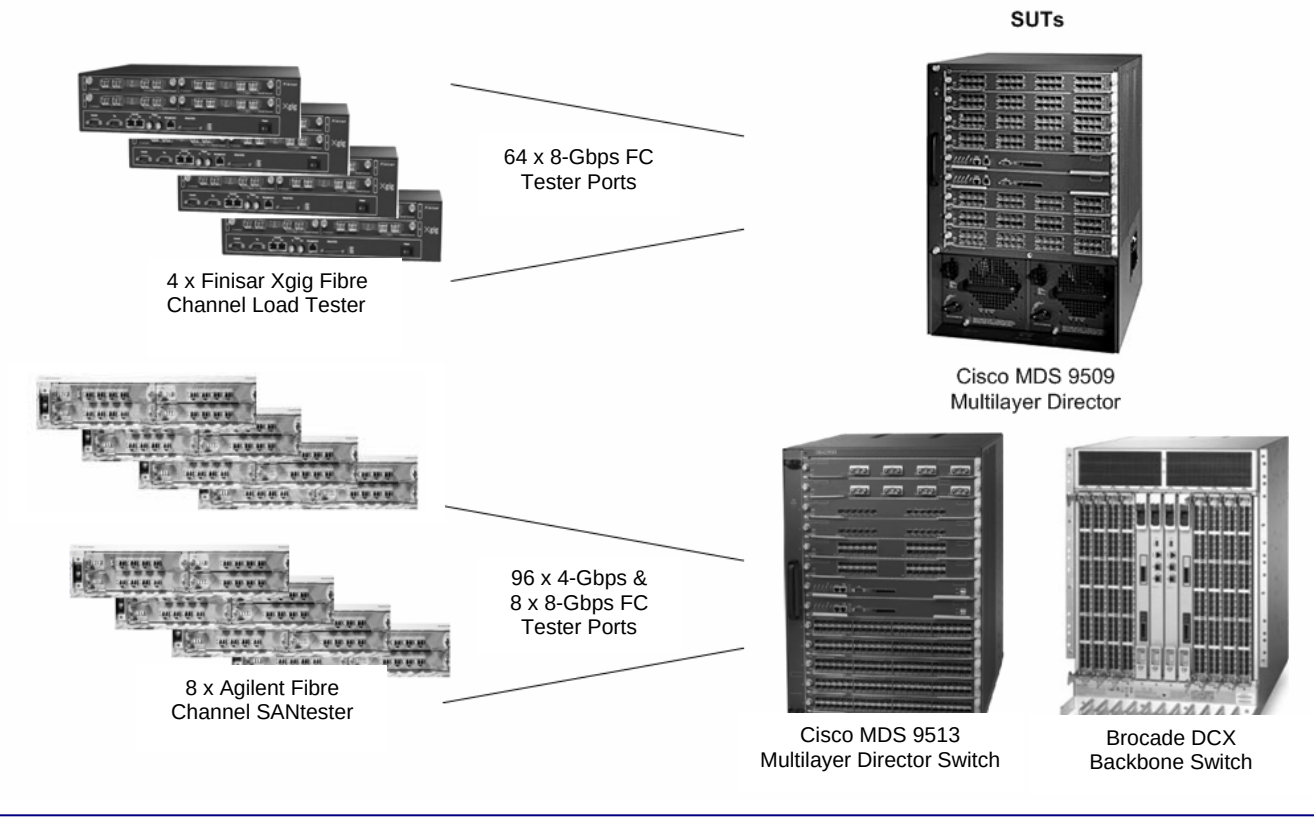
Figure 1: Cisco MDS and Brocade DCX Fully Loaded Line Card Test With No Errors



frame size	548 byte	1,060 byte	2,148 byte
Cisco MDS 9509 and 9513:		**MBps**	
96 ports 2-Gbps – target throughput	203.6	207.8	210.2
96 ports 2-Gbps – achieved throughput	203.6	207.8	210.2
Total card – achieved throughput	9,772.8	9,973.9	10,089.6
Brocade DCX:			
64 ports 4-Gbps – target throughput	407.2	415.6	420.3
64 ports 4-Gbps – achieved throughput	207.4	199.8	232.5
Total card – achieved throughput	6,636.8	6,394.9	7,440.0

Cisco MDS 9509 and 9513 are Rated Best for Reliability and Non-Blocking Performance in the Miercom Director Class Storage Area Networks Switch Industry Assessment December 2008. The MDS provided the best throughput without frame loss or sequence error.

Test Bed Diagram:



How We Did It

Cisco provided the systems under test for this evaluation, and Brocade demonstrated additional tests on a DCX they provided. Miercom confirmed that the operating systems used for all products were generally available at the time of testing. The test systems used in this evaluation were the Agilent Fibre Channel SANtester and the Finisar Xgig Analyzer and Load Tester version 4.2.80565 and Xgig Maestro version 4.0.0.78.335. Engineers from Agilent and Finisar provided technical support during the testing.

The Systems Under Test (SUTs) included:

- Brocade DCX with Fabric OS 6.1.0d. The DCX chassis was equipped with two Core Processor 8 (CP8) and two Core Routing 8 (CR8) modules, (1) 48 port 8-Gbps FC8-48 module, (2) 32 port 8-Gbps FC8-32 modules, and (1) 16 port 8-Gbps FC8-16 module.
- Cisco MDS 9509 and 9513 with NX-OS 4.1.1 were configured with (2) 48-port 8-Gbps Fibre Channel Switching Modules and (1) 24-port 8-Gbps Fibre Channel Switching Module.

Traffic flows included medium and large fixed frame sizes, as well as randomly distributed payload sizes. We used fixed frame sizes to get benchmark throughput data, similar to that obtained from RFC 2544 type tests for networking switches. Test Frames with Random Originator Exchange IDs (OXIDs) were used for the tests when applying the traffic load. This setting was found to be advantageous for performance testing of Brocade's product. The Cisco MDS 9509 and 9513 performance did not vary with random vs. fixed OXID, so most tests for the MDS were conducted using random OXID as fixed mode is not realistic.

Fibre Channel Class 3 traffic passed through each switch at combinations of 2-Gbps, 4-Gpbs and 8-Gbps using several frame sizes. Up to 96 Fibre Channel ports were used with uni-directional or bi-directional traffic flows. Throughput, latency and error statistics were collected for these tests. Each test utilized a single switch with traffic flowing between two line cards, unless otherwise described. Tests for the Cisco products were conducted on both the 9509 and 9513 MDS.

Testing of small frame and zero payload size frames are not included in this report as it was deemed that these tests are too unrealistic relative to real world traffic for storage area networks. Medium and large frame sizes as well as randomly distributed frame sizes were used in benchmark tests.

(*continued from page 1*) density on two line cards and the port speed selected was within the vendors' stated line card capacity. This test is designed to verify the per card switching capacity and determine if the rated capacity per port could be attained. Although the Brocade DCX proved that it could handle more aggregate load than the Cisco MDS, it did so with the test tool reporting sequence and other errors. In this test, only the Cisco MDS attained the maximum throughput per port without frame loss or error. This test was conducted with Brocade's default Exchange Based Routing setting, "aptpolicy=3". We measured the highest achievable throughput without reported frame loss, sequence error, or other error reported by the Agilent Fibre Channel SANtester. Similar results were observed in other tests when a Finisar xGig Load Tester was used. We tested both the Cisco MDS and Brocade DCX with minimal changes from the default settings.

We also tested Brocade's DCX using different variations in advanced settings to achieve the best possible observable throughput including fixed vs. variable OXID and Port Based Routing vs. Exchange Based Routing. Typically, we found the Brocade DCX performed error free with the non-default setting of "Port Based Routing" and with the test tools configured to provide random OXID in the traffic streams. In tests conducted using Port Based Routing, although the sequence errors were eliminated for the DCX, this configuration change resulted in lower port-to-port throughput. Storage manufacturers have published technical notes recommending use of Port Based Routing rather than Brocade's default setting of Exchange Based Routing to ensure certain applications function properly.

Traffic Prioritization

Both Brocade and Cisco products tested could be subjected to oversubscription where traffic demand exceeds the switching capacity of the switches. Standard Fibre Channel flow control implements a buffer credit allocation mechanism to prevent frame loss and limit traffic beyond what the switch or the end point can handle.

The Cisco MDS 9509 and 9513 were the only products that we observed in testing that could offer guaranteed dedicated bandwidth. By using the Rate-Mode-Dedicated command, we found that the MDS accommodates the requirement to provide guaranteed bandwidth to a specific higher priority Inter-Switch-Link (ISL) or Fibre Channel attached endpoint. We proved that using this feature allowed the Cisco MDS 9509 and 9513 to pass our traffic congestion test which measured the throughput to a high priority connection (indicative of a key server or ISL.) Without this prioritization capability, normal Fibre Channel flow control limits the traffic destined for the high priority connection.

Reliability

Both Brocade and Cisco products offer hot swappable power supplies, fan modules or trays, switching fabrics, management control modules and line cards. In testing, both sets of products proved to have very effective high availability capabilities. However, only the Cisco MDS 9509 and 9513 passed the full series of throughput, reliability and failover tests without demonstrating any instances of unusual behavior during testing.

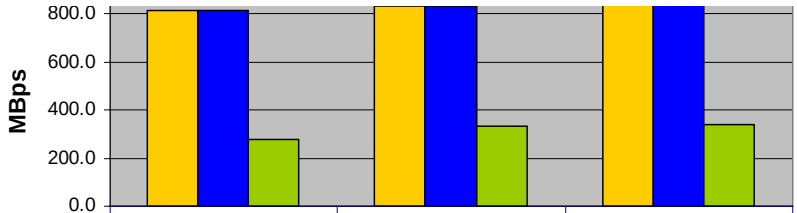
Our testing included removing hot swappable modules while traffic was applied through the Cisco MDS to ensure effective system failover. The Cisco MDS exhibited no performance problems, reported errors, or other issues regardless of the test tool settings or switch configuration applied during any of the testing. Overall, the Cisco MDS 9509 and 9513 performed more reliably in tests discussed in this report by demonstrating error free, non-blocking performance.

Frame Loss Tests – DCX Exchange Based Routing

The Cisco MDS exhibited no frame loss, sequence errors or other anomalies during our testing. Additional stress tests conducted were unsuccessful in causing the Cisco MDS to fail with error conditions or dropped frames. The MDS exhibited predictable performance throughout testing and our engineers described the testing as "uneventful".

When testing the Brocade DCX, frame loss and sequence errors were reported by both the Finisar and Agilent test equipment which was set up with different but similar test tool configurations. This was specifically observed when using the Exchange Based Routing feature, which is the default routing policy for the Brocade DCX. Brocade claims this feature allows the switch to select an optimal routing path based on an FC Originator Exchange ID (OXID) for the frame. We found anomalies

Figure 2: Cisco MDS & Brocade DCX 8-Gbps Throughput Tests Rated Capacity
Throttled Traffic Delivery Rate to Produce No Errors



	548 Byte Frame	1,060 Byte Frame	2,148 Byte Frame
Target throughput	814.3	831.2	840.6
Cisco MDS 9509 and 9513 8 port pairs - achieved throughput	814.3	831.2	840.6
Brocade DCX 32 port pairs achieved throughput	277.3	332.7	336.4

Cisco MDS 9509 and 9513 achieve better per port performance in tests that stressed vendors' stated 8-Gbps port capacity for full line rate per line card. Port pairs of 8-Gbps Fibre Channel utilized in these tests. Exchange Based Routing was used in this testing.

during testing with the DCX under high traffic load conditions in which both test systems reported error conditions pertaining to sequence errors, frame loss and other errors. In response to learning of this condition, Brocade representatives presented to Miercom engineers, a demonstration of a different kind of test using a Brocade DCX configured for Exchange Based Routing and a Finisar Load Generator configured with Fixed Dedicated ISL Mode rather than Random Originator Exchange ID (OXID) setting. Both vendors were asked to provide packet capture detail to further prove their claims.

Figure 2 shows the throughput limitation for the Brocade DCX when configured for Exchange Based Routing. The testing was similar to that described in RFC 2544 with different versions of Fabric OS applied.

The Cisco MDS 9509 and 9513 achieved better per port performance without reported errors in tests that stressed the vendor's stated 8-Gbps port capacity per line card. The Brocade DCX was configured with Exchange Based Routing.

Latency Observed

Latency measurements for all the Cisco MDS tests did not vary significantly based on the volume of traffic applied. In some of the tests conducted on the Brocade DCX, we observed significant latency variations under heavier loaded and mixed traffic conditions. We attribute the differences in performance for latency and overall throughout of the products in these tests to the differences in their architectures.

Product Architecture

Brocade DCX Architecture: Data moves through the DCX from switch ASIC to switch ASIC along multiple paths that route from the ingress port to the egress port. The DCX routing policies determine the path for each frame of data. With Exchange-based routing, the choice of routing path is based on the Source ID (SID), Destination ID (DID) and Fibre Channel originator exchange ID (OXID). With port-based routing, the choice of path is based on the incoming port and the destination domain.

Port-based routing and Exchange-based routing only apply to the DCX because of its internal multi-stage design, which uses multiple interconnected switching ASICs. The routing policy determines the type of load balancing that occurs over interconnecting links.

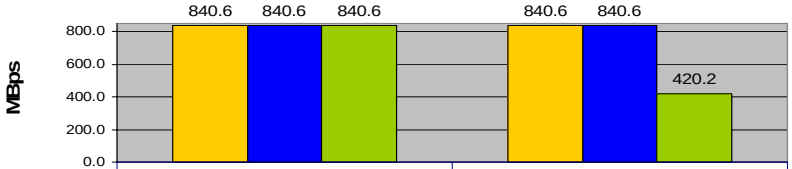
MDS Architecture: All Cisco MDS 9500 Series Director Switches are based on the same underlying crossbar architecture. Frame forwarding logic is distributed directly in ASICs on the line cards, resulting in a distributed forwarding architecture. The MDS architecture, with centralized arbitration and virtual output queues provide fair servicing to all ports together with consistent, predictable and non-blocking performance. The test results obtained validate how well this design performs.

Mixed Speed Tests

Customer deployments for 8-Gbps Fibre Channel (FC) typically are deployed in environments of existing 1-, 2-, and 4-Gbps connected servers and switches. Fibre

Figure 3: Cisco MDS and Brocade DCX 8-Gbps Throughput with Slower Speed Background Traffic

Traffic for 8-Gbps control streams with and without slower speed background load traffic



	Single 8-Gbps stream with no background traffic	Single 8-Gbps stream with slower speed background traffic
Target throughput	840.6	840.6
Cisco MDS 9509 and 9513 up to 48 port pairs achieved throughput	840.6	840.6
Brocade DCX up to 32 port pairs achieved throughput	840.6	420.2

Cisco MDS 9509 and 9513 achieve maximum 8-Gbps throughput even with mixed traffic of slower speeds. Both MDS and DCX were loaded with one 8-Gbps control stream. The DCX was loaded with 31 ports of 4-Gbps background load, the MDS with 47 2-Gbps. Port-based Routing (AptPolicy = 1) was used on the DCX.

Channel Switching products should not perform differently under mixed load conditions. Switching products should not limit the 8-Gbps FC throughput capacity when tasked to simultaneously support other FC speeds on neighboring ports.

The purpose of this test was to determine if the products under test exhibited problems with handling mixed speed traffic. Cisco discovered this anomaly with the Brocade DCX during testing they conducted previously and asked Miercom to reproduce and validate this condition. Miercom conducted further tests on the DCX to examine when the reduced throughput on 8-Gbps links occurs, and also in what cases it does not occur. This testing is designed to push the limit of both products at maximum forwarding capacities and to determine how well mixed traffic speeds are handled.

Cisco MDS proved it could pass all tests with the mixed speed environment, whereas in certain conditions the Brocade DCX would exhibit a reduced throughput by as much as a 50% for the 8-Gbps connection from 840 MBps to 420 MBps when concurrent mixed speed traffic load of 31 ports of 4-Gbps traffic was applied. The DCX also exhibited varying ranges of latency in excess of 100 usec in some of the test iterations. A steady state condition and average observation for this anomaly is represented in Figure 3.

The behavior occurs when the Brocade DCX is configured with Port-based routing (AptPolicy = 1) and background traffic exceeds 31 ports of 2-Gbps line rate traffic.

The condition does not occur when exchange-based routing is used, or when the background load for traffic on the 31 ports is reduced from 4-Gbps full data rates to 2-Gbps.

Miercom applied due diligence in scrutinizing this test to ensure no unfair advantage or disadvantage to either vendor. The applied load to the Cisco MDS was admittedly lower for the Cisco MDS, as the advertised throughput capacity for the product is lower. Both products were tested within the rated specifications for which they were designed. We repeated tests on switches with different firmware loads for the switches, and different port pairs. We attribute the reduced 8-Gbps throughput on the Brocade DCX to a difference in product architecture.

Test bed environment only used Agilent SANtester for this test. All traffic traversed the backplane for the switches tested.

Conclusion

When Fibre Channel switches were compared in extreme environments with mixed speeds (2-, 4-, 8-Gbps FC), and are required to handle close to line rate capacity, only one product passed all mixed speed throughput tests – the Cisco MDS.

From a benchmark testing perspective we feel this is a fair test to conduct, it is very repeatable and there is no doubt that the Cisco MDS proved superior in this specific test case. It should be noted however, that this is benchmark testing, and depending on the customer environment and load, this specific condition may or may not present itself.

Miercom Rated Best

Based on Miercom's hands on testing and validation of capabilities, operation and features, Miercom is pleased to announce the Cisco MDS 9509 and MDS 9513 products are Rated Best of comparable products tested in areas of Reliability and Non-Blocking Performance.

The award is in accordance with the Rated Best Testing Program of Miercom, effective for one year from test certification. The Rated Best program recognizes products that exhibit exceptional qualities in specific test criteria when analyzed in a competitive test review or Miercom Industry Study.

The Cisco MDS 9509 and 9513 are clearly designed to achieve non-blocking performance and proved in testing to exceed the vendor stated scalability and performance specifications.

Reliability and Non-Blocking Performance

Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134
(800) 553-6387

www.cisco.com

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