

Lab Testing Summary Report

February 2009
Report 090115B

Product Category:
**Backbone Class
SAN Switch**

Products Tested:
**Brocade DCX
Cisco MDS 9509
Cisco MDS 9513**



**Scalability, Throughput
& Energy Efficiency**

Key findings and conclusions:

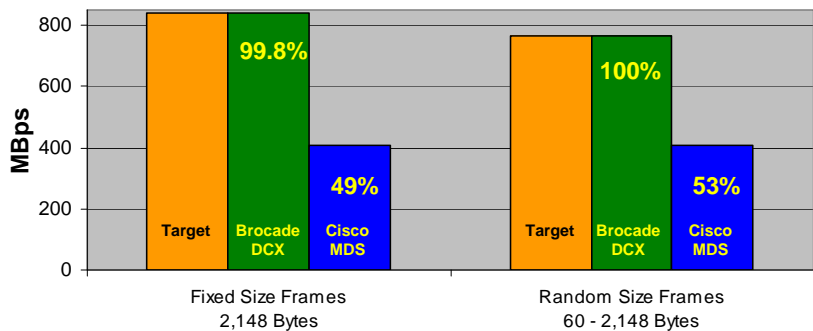
- Brocade DCX passed the industry's first 128 port full 8-Gbps Fibre Channel test without frame loss
- Proved most efficient in power consumption and system cooling during environmental lab testing
- Achieved 256 Gbps per blade throughput to the backplane and 384 Gbps per blade with local switching (48 ports at line rate 8-Gbps)
- DCX provided four times the number of ports that could handle dedicated 8-Gbps line rate traffic

Brocade submitted the DCX Backbone Class Switch for an independent analysis and competitive comparison to the Cisco MDS Director Class Switch. The methodology for this evaluation was mutually agreed upon, with the tests focusing on maximum aggregate throughput and scalability using full 8-Gbps Fibre Channel line rate loads and high port density per line card. An analysis of power consumption, reliability and management was also conducted in this review.

The Brocade DCX proved more capacity than the Cisco MDS 9509 and 9513 on tests for overall aggregate throughput on all performance tests that exceeded 100 Gbps load per line card. The Brocade DCX also proved higher scalability per chassis when considering ports that could pass 8-Gbps line rate traffic simultaneously. [Figure 1](#) below illustrates the performance for the Brocade DCX (*continued on page 3*)

Figure 1 Switch Throughput - Port Average of 128 Ports

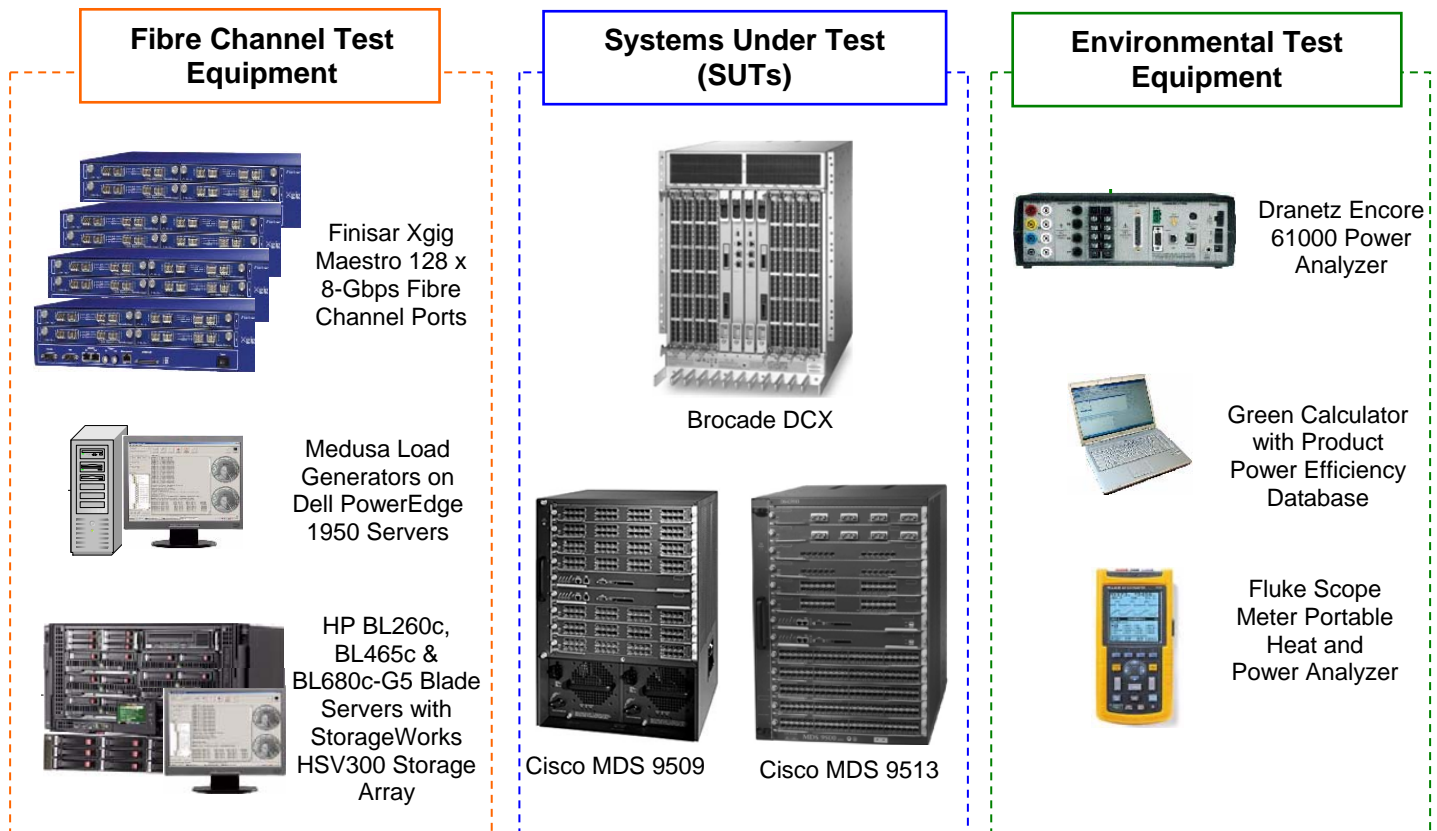
Using four 48-port 8-Gbps Line Cards with 128 ports (64 port pairs) maximum throughput measured with no frame loss



	frame size	2,148 bytes	60 – 2,148 bytes
128 Ports 8-Gbps – Target Throughput (Mbps)		840.6	767.5
Brocade DCX:			
Achieved Throughput Per Port (Mbps)		839.2	767.5
Total Switch Achieved Throughput (Mbps)		107,418	98,240
Percentage Line Rate		99.8%	100%
Cisco MDS 9509 and 9513:			
Achievable Throughput Per Port (Mbps)		409.4	409.4
Total Switch Achievable Throughput (Mbps)		52,400	52,400
Percentage Line Rate		49%	53%

The Brocade DCX is Rated Best for Overall Scalability, Aggregate Switching Throughput and Energy Efficiency in the Miercom Storage Area Networks Switch Industry Assessment January 2009.

Test Bed Components



How We Did It

The Systems Under Test included the Brocade DCX, Cisco MDS 9509 and MDS 9513. The DCX was tested with Fabric OS 6.1.1a and equipped with two Core Processor (CP8) and two Core Switching (CR8) blades, (4) 48-port 8-Gbps FC8-48 blades, and (2) 32 port 8-Gbps FC8-32 blades. The Cisco MDS 9509 and 9513 were tested with NX-OS 4.1(1c) and the switches were configured with (2) 48-port 8-Gbps Fibre Channel Switching Modules.

The test system used in this evaluation included: the Finisar Xgig Analyzer and Load Tester version 4.2.8 and Xgig Maestro version 4.0.0.78 www.finisar.com for 8-Gbps Fibre Channel traffic load generation and monitoring; Finisar's Medusa Test Tool Suite version 2.5.15 for disk storage performance monitoring and realistic traffic load generation; and the Dranetz Encore 61000 www.dranetz-bmi.com for environmental analysis testing including power consumption and heat dissipation. Engineers from Finisar and Medusa Labs provided technical support for this testing.

The test bed was also equipped with HP Blade Servers models BL260c-G5, BL465c-G5, and BL280c-G5 in a CP C3000 enclosure. Dell PowerEdge 1950 servers with Brocade, Emulex, and Qlogic HBAs were utilized in testing. An HP StorageWorks HSV300 Storage Array, with 2 controllers and 12 146-GB Hard Drives (Dual port 15K Fibre Channel) was also used in testing.

Tests mentioned in this report include 8-Gbps Fibre Channel performance on a per port basis for 48-port line cards. We verified load performance on the local port to port traffic as well as the traffic routed from card to card across the backplane. We verified load capabilities on a per port and per card basis. For these tests we used 32 ports per 48-port line card per the maximum system design and to ensure similar port density cards between the vendors. We also tested maximum load capabilities on the Brocade DCX line cards. With Finisar Medusa Labs test software, installed on both the HP blade servers and Dell servers, we generated traffic that included disk read/write tests from Fibre Channel attached servers while the background traffic load was generated by the Finisar Xgig Load Generators. We also measured power

(How We Did It – continued)

consumption and temperature during different stages of the testing with equipment from Dranetz-bmi. We performed availability and survivability tests on the Brocade DCX by removing power supplies, line card blades, and fan units. We measured the cooling fans capabilities by removing one cooling fan at a time as we monitored temperature.

Traffic flows included both fixed large frame sizes (2,148 Byte frames), as well as randomly distributed frame sizes. We used fixed frame sizes to get benchmark throughput data, similar to that used in benchmark tests for networking switches. Test frames were generated from the Finisar Xgig Load Generator with random and unique Originator Exchange IDs (OX-IDs).

Testing of back-to-back high volume of small frame or zero payload size frames are not included in this report as it was deemed that these tests are too unrealistic to real world traffic for storage area networks. A reasonable amount of small size frames are included in the random frame size load tests which is a more realistic traffic load distribution and therefore a more meaningful test.

The tests in this report are intended to be reproducible for customers who wish to recreate them with the appropriate test and measurement 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.

(continued from page 1) which handled 128 ports of 100% line rate load with randomized 60 - 2,148 byte frames tests using 8-Gbps Fibre Channel traffic. The DCX also achieved 99.8% throughput for fixed large frame (2,148 byte) tests – which is an extreme and near maximum load only achievable in a lab environment. The 128 port density used in testing, although substantial, was limited by the amount of load generation equipment we could acquire, not the capacity of the Brocade DCX. A single DCX handled 128 ports of traffic load which is one third of the available port capacity and a fraction of the manufacturer's stated 3.07 Tbps system capacity. Data integrity tests reported no errors or frame loss by the disk read/write test systems.

Testing of the Cisco MDS 9509 and 9513 verified the maximum observable bandwidth per line card to be 104.8 Gbps. This value proved higher than the conservative 96 Gbps stated number in Cisco's documentation. The aggregate switching capacity of the MDS 9509 and 9513 can accommodate the bandwidth required for the switch to be fully configured with modules at the stated 96 Gbps capacity. Per blade bandwidth of the Brocade DCX has a vendor stated capacity of 256 Gbps which was also verified in testing.

The port density for DCX was tested up to 128 ports. Since there were insufficient 48-port 8-Gbps modules for the Cisco MDS, the data for Cisco MDS test is a projection based on lower capacity tests. This test results are in agreement with the vendor stated capacity of the product.

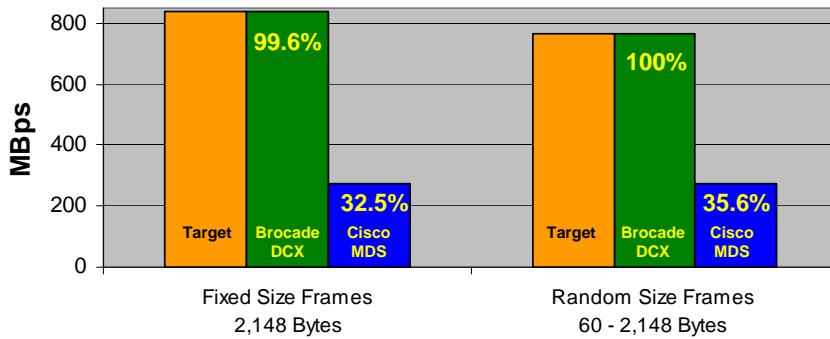
The test in [Figure 1](#) represents each product configured with four partially populated 48-port 8-Gbps FC line cards. Ports connected were distributed evenly across the line cards but in a fashion to allow both vendors' products the benefit of architectural advantages using port groupings. For the test conducted shown in [Figure 1](#), all traffic was forced to traverse the backplane and none of the traffic flows made use of local switching on the line cards.

Additional tests were conducted on the Brocade DCX that proved additional aggregate switching capacity is available if we utilize local (same blade) switching. The Brocade DCX local switching ability is due to an architectural difference between the products and can not be achieved with a Cisco MDS 9509 or MDS 9513.

Data Integrity Verified – data integrity tests were simultaneously conducted with the 128-port "Switch Throughput" test shown in [Figure 1](#). These additional tests proved there was no impact on real world data transfers despite the high volume, multi-port traffic load applied. These tests consisted of disk read/write activities from servers connected via Fibre Channel host bus adapters (HBAs) to storage arrays. While applying the 128-port 8-Gbps aggregate load from the Finisar Xgig Load Generator, we conducted read/write tests using the Finisar Medusa Test Suite. Disk I/O, file transfer speed, latency and other data pertaining to the test data transfer was recorded and compared before and after the Xgig generated load test was launched.

Figure 2 Line Card Test - Maximum Load

Using (2) 48-port 8-Gbps Line Cards with 96 ports (48 port pairs) maximum throughput measured with no frame loss



The Brocade DCX achieved line rate 8-Gbps performance using two fully loaded 48-port line cards with no frame loss.

Randomized and mixed frame size traffic was utilized in testing in order to better replicate customer environments' traffic distribution.

frame size	2,148 bytes	60 – 2,148 bytes
96 Ports 8-Gbps – Target Throughput (Mbps)	840.6	767.5
Brocade DCX:		
Achieved Throughput Per Port (Mbps)	837.0	767.5
Total Switch Achieved Throughput (Mbps)	80,347	73,680
Percentage Line Rate	99.6%	100%
Cisco MDS 9509 and 9513:		
Achievable Throughput Per Port (Mbps)	272.9	272.9
Total Switch Achievable Throughput (Mbps)	26,200	26,200
Percentage Line Rate	32.5%	35.6%

The data transfer between the remote servers and storage arrays remained unaffected with consistent performance and latency as expected despite the 128-port full line rate load applied to the Brocade DCX.

Line Card Performance

The Brocade DCX achieved line rate 8-Gbps performance for mixed frame size tests using a pair of fully loaded 48-port line cards with no frame loss (see Figure 2 above). The DCX also achieved near perfect throughput of 99.67% line rate with fixed size frames (2,148 byte) which is an extreme load even for a lab test environment.

The DCX with two 48-port 8-Gbps blades delivered full line rate performance using the 256 Gbps slot-backplane bandwidth available combined with local switching. For this test, traffic from 48 port pairs was forced to traverse the backplane while 16 port pairs made use of local switching.

The Cisco MDS 9509 and 9513 data is based on the switches configured with two fully populated 48-port 8-Gbps modules. The test results for the Cisco MDS 9509 and MDS 9513 are within the vendor's rated capacity of 96 Gbps per line card.

Optimized Exchange Based Routing

Tests were conducted that specifically stress and verify "in order sequence delivery" for traffic within a given exchange. Our first test was an overnight attrition test; the second test stressed the switch with a large number of unique OX-IDs. A Finisar Xgig Load Tester was configured to run in Fixed/Unique test mode. The system under test (Brocade DCX) was configured in the default configuration of "aptpolicy=3" which is also called Exchange Based Routing.

The Brocade DCX passed the overnight attrition test in which load was applied consisting of 16 ports of line rate traffic with 256 unique OX-IDs defined within the traffic streams. The test configuration was a 16-port full mesh topology from the Finisar Xgig Load Tester connected to the Brocade DCX. Each port sent traffic to every other port including itself. Every Load Tester port had 16 streams, each stream with a unique OX-ID. Each port also received 16 streams, with a unique OX-ID. The total load applied with 16 Load Tester ports simultaneously delivering traffic through the switch, comprised of 16 x 16 = 256 streams (256 unique OX-IDs). The overnight attrition test ran for 18 hours with no frames dropped.

The *maximum OX-ID test* utilized 16 ports to stress the DCX with 15,360 unique OX-IDs. The Finisar Xgig was configured to transmit 960 streams and simultaneously receive from 960 other streams. This produced a system total of 15,360 streams equivalent to 15,360 pending OX-IDs or exchanges. The theoretical maximum number of OX-IDs is 65,536 but it would have required additional test equipment to reach this density. The Brocade DCX proved to deliver traffic in the proper sequence, with no frames dropped even with a high number of OX-IDs used and Exchange Based Routing enabled.

According to documentation from Finisar, using the Fixed/Unique test mode on the Finisar Xgig FC Load Tester (similar to how production servers and storage assign OX-IDs when sending Fibre Channel frames), the Fixed/Unique test mode assigns each exchange and all frames within the exchange a unique OX-ID. Using this mode Miercom engineers verified that the Brocade DCX delivered frames in sequence when the frames were configured within exchanges for these tests.

Advanced Traffic Flow Tests

Head-of-Line Blocking Test – We tested the impact on throughput to an uncongested port with traffic destined for both the uncongested target port and a second port which was congested (busy). Throughput tests ran for 30 seconds at line rate while frame loss and latency were monitored. We observed a fair allocation of service and no head of line blocking.

Many-to-One and Many-to-Few Tests - We tested for architectural blocking between components within the Brocade DCX by applying a combination of traffic flows. A 15-to-1 ratio of ingress to egress ports was applied with 100% intended load. The ideal load per ingress port was approximately 6.66%. No blocking of traffic or other anomaly was observed in these tests.

8-Gbps ISL Tests – We tested inter-switch links, which are used to join Fibre Channel switches using E_ports. We determined frame-based trunk groups can be built from one card to another line card. Two chassis, with four 48 port line cards were used in testing. We built 8 x 8-Gbps trunks using the 48-port blades. Traffic was sent from card1/chassisA through the trunk between card2/chassisA to card2/chassisB out card1/chassisB. No issues or problems with ISL functionality were observed in testing.

ICL Trunking - The Brocade DCX has a unique expansion ability. Using four Inter-Chassis Link (ICL) ports to connect two Brocade DCX chassis allows for system expansion while preserving the equivalent of up to 64 8-Gbps E_Ports per chassis for server and storage connectivity. The test conducted confirmed that using ICL trunking does not impede non-trunked local ports. Our test configuration consisted of 2 x 48-port blades, with ICLs between core switching blades on two DCXs. ICL trunks were built from CR1/chassisA to CR1/chassisB. Available traffic from all ports on card1/chassisA was sent to a port on card1/chassisB. This was repeated using all ports on card2/chassisA to card1/chassisA. We interrupted an ICL trunk connection and observed the remaining connections maintained connectivity with no noticeable down time.

Power Efficiency

Power consumption and power efficiency under load for the Brocade DCX were measured. Observations were recorded with the switch in idle state and with 128 ports of full line rate load applied. The Brocade DCX with (8) 48-port 8-Gbps blades powered on with 128 ports connected but idle consumed 977 Watts. With full line rate of 128-port test load applied, the DCX only consumed 1,091 Watts which is an addition of only 114 Watts.

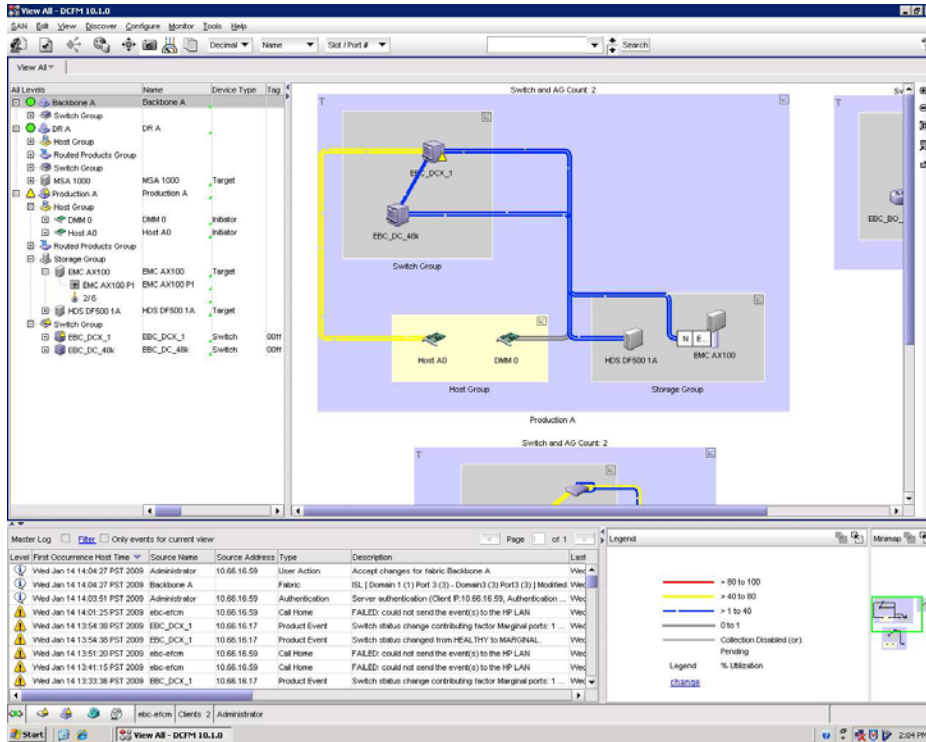
The power consumption of the Brocade DCX is impressive when compared competitively. A Cisco MDS with (8) 48-port modules consumes 3,242 Watts according to the vendor's specifications. The Brocade DCX for this configuration measured 1,091 Watts consumed, which reflects an almost three times reduction in power consumption when compared to the Cisco MDS 9513.

A Brocade DCX 48-port 8-Gbps blade consumes 96 Watts (DC) according to specifications for power consumption available for download: <http://www.brocade.com/power>. The Cisco MDS 48-port 8-Gbps module consumes 298 Watts (DC) according to specifications located at: https://www.cisco.com/en/US/docs/switches/data_center/mds9000/hw/9500series/installation/guide/techspec.html.

System Cooling Resiliency – We conducted a series of tests to determine resiliency of the DCX by forcing a failure of its cooling system. We simulated fan module failures by removing them

Figure 3 DCFM Monitors System Uptime

Brocade DCFM allows for centralized management and administration of the Fibre Channel connected equipment



Brocade Data Center Fabric Manager shown here is an effective tool to assist administrators to optimize storage resources, maximize performance of the system and help maintain security. The Graphical Interface offers a straightforward and centralized view of all system activity and any significant events.

while monitoring the internal temperature of the DCX. Upon removing all fan modules, the system will monitor the multiple temperature sensors and allow for maximum up time until an unsafe temperature is reached. The switch will then shut down to prevent system damage. Brocade demonstrated that with effective ambient cooling the DCX could continue to function without the cooling fans. In our testing of the cooling system, we ran over 10 minutes with no fans while the system accurately monitored the internal temperature and sent necessary alerts for the condition. Logging and alarm activity was verified accurate for the fan removal (simulated failure) events.

Standard Compliance

Miercom confirmed the DCX Backbone Switch participates in SANmark Conformance Tests developed by the Fibre Channel Industry Association, to ensure their product conforms to Fibre Channel Standards. According to records Miercom reviewed, Brocade's Fibre Channel switching products conform with SMI-S by subjecting its software components to SMI CTP tests developed by the Storage Networking Industry Association.

Management

Our review of the Brocade DCX included an analysis of Brocade's Management GUI. We found the DCFM (Data Center Fabric Manager) shown above in Figure 3 is an effective tool to assist administrators to optimize storage resources, maximize performance of the system and maintain security. The graphical interface offers a centralized view of system activity.

Once selected, the details of a switch are displayed in a device map. An Administrator can right click to show end devices attached to the current object and the overall fabric topology. For ease of use you can zoom-in to part of the fabric, zoom-out to see a wider view, and adjust the screen size. Additionally, when elements are moved around, the software remembers the updated layout for future use. The Master Log displays information on all events. To simplify and expedite investigations, a filter can be applied so that only specific types of events are listed; e.g. authentication events.

The application was found to be very scalable with the capability of real time monitoring for up to 9,000 ports in 24 fabrics. Performance data for each port of a device and utilization of

network links are reported with the ability to create tables and graphs of these activities. Threshold settings with different color displays can be configured to provide a dashboard monitoring utility. Excellent historical and trend information is made available through the DCFM graphical interface.

The element manager (called Web Tools) is launched by clicking on a switch in the Organizational Tree. Using this facility the Administrator can investigate specific physical and environmental issues with the device, its overall status, power supplies, etc. The element manager is also used to carry out major administrative tasks such as changing the IP address, enabling long distance support for ISLs, and creating and modifying users and licenses for the software.

DCFM has fully customizable thresholds, for example a threshold for fan speed can be set, and notification only occurs if this is exceeded (although other fans would increase in speed to compensate in this case). DCFM also manages zones, to control access within and between fabrics. Right click on a fabric to select zoning options. This facility includes a function that allows the Administrator to plan specific zone changes but without actually applying these and affecting the production fabric. Instead, the software shows the Administrator a "what if" scenario if the modifications were applied.

Brocade's Data Center Fabric Manager provides an easy to use and comprehensive management tool for multiple networks and devices.

Scalability

Brocade's local switching ability on the line cards was proven in testing to afford Brocade a unique advantage, in that it allows the product to scale with switching not limited to the slot-to-backplane bandwidth. In the test illustrated in [Figure 2](#) the Brocade DCX demonstrated an extra 16 8-Gbps ports at line rate speed using local switching capacity, in addition to more than double the slot-to-backplane bandwidth compared to the Cisco MDS 9509.

The Brocade DCX has a manufacturer stated capacity of 3.07 Tbps. We load tested 128 of the 384 8-Gbps Fibre Channel ports possible for a single chassis DCX. The tests scaled linearly as we applied additional port density of traffic load. CPU utilization did not exceed 10% even during

the heaviest of load tests. We could easily achieve more aggregate throughput with a Brocade DCX by applying more test tool load on other ports with traffic traversing the backplane. Even higher aggregate capacity can be realized if local switching (per blade) is utilized.

The DCX offers flexibility in that it can be configured with 4-Gbps or 8-Gbps Fibre Channel SFPs in a single chassis to provide up to 384 Fibre Channel ports. The DCX has four Inter-Chassis Link (ICL) ports that are used to connect two Brocade DCX chassis and preserve the equivalent of up to 128 8-Gbps E_Ports for server and storage connectivity. Two DCX switches connected with four ICLs can provide up to 768 8-Gbps ports. ICLs support both open systems and mainframe environments.

Our test confirmed that two DCX switches could interconnect using up to four ICLs with no ports sacrificed to provide capacity for up to 768 ports of 8-Gbps Fibre Channel. The DCX can scale with no port/blade penalty.

The Cisco MDS 9513 physically accommodates more ports per chassis with 528 total ports (11 usable slots of the 13-slots can provide up to 11 48-port 8-Gbps line cards in a chassis). This compares to the Brocade DCX with 384 ports (8 usable slots of the 12-slots that can provide up to 8 48-port 8-Gbps line cards). Even with less port density, the Brocade DCX proved in testing to offer four times the number of ports that can be used for dedicated 8-Gbps line rate traffic simultaneously compared to the Cisco MDS 9513 (dedicated bandwidth mode or for ISLs).

Reliability

Both Brocade and Cisco products offer a number of hardware components to ensure high availability. These include hot swappable power supplies, fan modules or trays, switching fabrics, management control modules and line cards. In applying our standard set of criteria for evaluating reliability, both products proved to have very effective high availability capabilities.

Brocade passed failover tests on the hardware components listed above. Our testing included removing hot swappable modules while traffic was applied through the Brocade DCX to ensure effective system failover. The Brocade DCX exhibited no component failures during the tests conducted, and is clearly designed to exceed data center customers' reliability expectations.

Miercom Rated Best

Based on hands-on testing and validation of capabilities, operation and features, the Brocade DCX is Rated Best in Overall Scalability, Aggregate Switching Throughput and Energy Efficiency of comparable products tested. This rating is based on the specific testing in those areas described in this report as well as other tests that were conducted.

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 Assessment.

The Brocade DCX is clearly designed for high density scalability and high aggregate switching capacity. It is well designed and exceeds expectations for the data center storage market.



Scalability, Throughput & Energy Efficiency



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