

Cisco Nexus 6004 Switch Performance Validation

White Paper

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Contents

What You Will Learn	3
Overview	3
Test Bed	4
How Testing Was Performed	5
Test Results	7
96 x 40-Gbps Overview	7
384 x 10-Gbps Overview	9
RFC 2544: Unicast Port Pair Throughput and Latency for 96 x 40-Gbps Ports.....	11
Overview.....	11
Configuration	11
Test Results.....	11
RFC 2544: Unicast Throughput and Latency for 384 x 10-Gbps Ports.....	12
Configuration	12
Test Results.....	13
RFC 3918: Multicast Throughput and Latency for 96 x 40-Gbps Ports.....	14
Overview.....	14
Configuration	14
Test Results: Accumulated Mode.....	15
Test Results: Distributed Mode	17
RFC 3918: Multicast Throughput and Latency for 384 x 10-Gbps Ports	18
Configuration	18
Test Results: Accumulated Mode.....	19
Test Results: Distributed Mode	21
RFC 2889: Unicast Head-of-Line Blocking for 96 x 40-Gbps Ports	23
Configuration	23
Test Results.....	24
Conclusion	24
For More Information	24

What You Will Learn

Cisco, in partnership with Ixia, conducted performance benchmark tests for the Cisco Nexus® 6004 Switch. The tests evaluated switch performance with various traffic profiles and Cisco® NX-OS Software features up to and including the most stressful testing conditions. This document presents the test results.

Overview

The Cisco Nexus 6004 Switch is a high-performance, high-density, low-latency 10 and 40 Gigabit Ethernet and Fibre Channel over Ethernet (FCoE) switch. This compact four-rack-unit (4RU) 10- and 40-Gbps switch provides line-rate Layer 2 and 3 switching. It runs the industry-leading Cisco NX-OS Software operating system, providing customers with features and capabilities that are widely deployed worldwide.

The Cisco Nexus 6004 offers 48 x 40-Gbps ports on the base of the chassis and 4 line-card expansion module (LEM) slots; 12 x 40-Gbps port LEMs can be plugged into each slot, for a system total of 96 x 40-Gbps ports in an Enhanced Quad Small Form-Factor Pluggable (QSFP+) form factor.

Each 40 Gigabit Ethernet port can be divided into 4 x 10 Gigabit Ethernet ports using a QSFP+ breakout cable, for a total of 384 x 10 Gigabit Ethernet ports.

Figure 1 shows the Cisco Nexus 6004.

Figure 1: Cisco Nexus 6004 with Four LEMs



To fully validate the Cisco Nexus 6004, rigorous testing was performed. IETF RFC 2544¹, 2889², and 3918³ are widely accepted in the industry as standard benchmarking methodologies to evaluate switch performance by measuring throughput, packet forwarding rate, forwarding latency, and jitter at various conditions. Ixia IxNetwork has built-in RFC 2544, 2889, and 3918 test suites, which were used in the tests.

The testing was performed for both the full 40-Gbps configuration (96 x 40-Gbps ports) and the full 10-Gbps configuration (384 x 10-Gbps ports).

Highlights of the Cisco Nexus 6004 performance test results include:

- 100 percent throughput without a single packet drop
- Average latency of 1 microsecond
- Identical latency characteristics for Layer 2 and 3, unicast, and multicast traffic
- Ultra-low and consistent jitter under the most stressful test configurations

¹ IETF Network Working Group: Benchmarking Methodology for Network Interconnect Devices.

² IETF Network Working Group: Benchmarking Methodology for LAN Switching Devices.

³ IETF Network Working Group: Methodology for IP Multicast Benchmarking.

Ixia configured and validated the Ixia IxNetwork configurations. Cisco provided the switch configuration through the standard Cisco NX-OS command-line interface (CLI) during the tests. All test results are based on these validated configurations.

Test Bed

Figure 2 provides an overview of the test bed for the 96 x 40-Gbps configuration.

Figure 2: 96 x 40-Gbps Test Bed Configuration

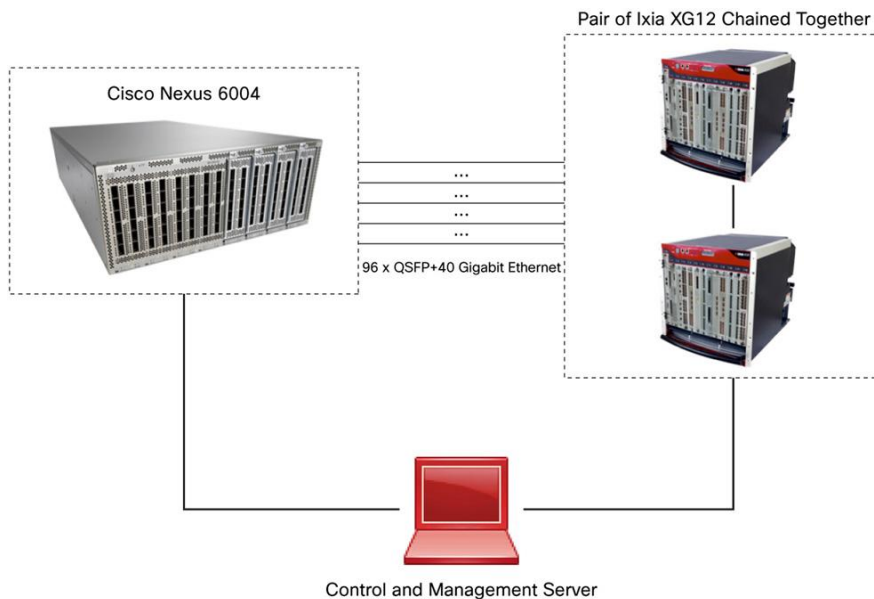
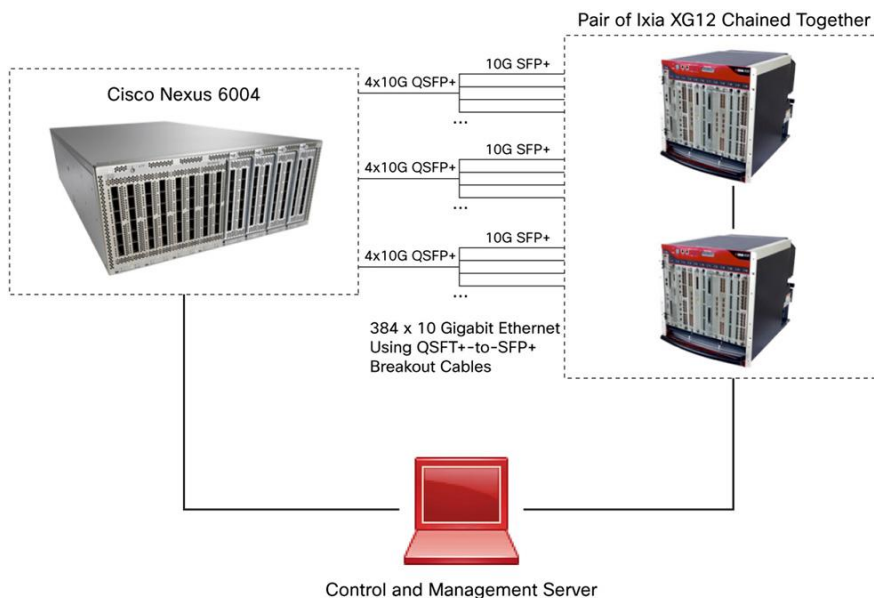


Figure 3 provides an overview of the test bed for the 384 x 10-Gbps configuration.

Figure 3: 384 x 10-Gbps Test Bed Configuration



How Testing Was Performed

The test topology and test bed includes a Cisco Nexus 6004 Switch, Ixia XG12 devices with 96 x 40 Gigabit Ethernet ports, and a control and management server on an out-of-band network. Table 1 shows the software matrix for the test configuration.

Table 1: Test Configuration Software Matrix

Device	Software
One Cisco Nexus 6004 Switch with 96 x 40 Gigabit Ethernet interfaces or 384 x 10 Gigabit Ethernet interfaces	Cisco NX-OS Software 6.0(2)N1(1)
Two Ixia XG12 11RU chassis	• Ixia IxOS 6.30.850.23 EA-SP2 • Ixia IxNetwork 6.30.70.135 EA-SP1

Table 2 shows the hardware matrix for the 40-Gbps test configuration.

Table 2: Test Configuration: 40-Gbps Hardware Matrix

Device	Software	Notes
24 Ixia Xcellon-FlexAP10/4016SQ load modules, each with 16 x 10 Gigabit Ethernet and 4 x 40 Gigabit Ethernet ports	• Ixia IxOS 6.30.850.23 EA-SP2 • Ixia IxNetwork 6.30.70.135 EA-SP1	Total of 96 x 40 Gigabit Ethernet ports or 384 x 10 Gigabit Ethernet ports
96 x 5m 40-Gbps fiber cables	-	For 40-Gbps test
384 x 5m 10-Gbps fiber cables	-	For 10-Gbps test

The Ixia IxNetwork QuickTests for the RFC benchmark test suites were used to test the performance of the Cisco Nexus 6004.

First, the Cisco Nexus 6004 and Ixia IxNetwork were configured to run RFC 2544 test suites to measure switch performance, including throughput and latency, for unicast traffic in a port-pair topology for both Layer 2 and Layer 3 traffic.

Then the multicast performance was measured with RFC 3918 for both Layer 2 and Layer 3 traffic. Again, the throughput and latency were measured in each test.

Next, the jitter was measured for unicast and multicast traffic, for both Layer 2 and Layer 3.

Finally, the RFC 2889 Congestion Control test was used to perform the unicast head-of-line blocking performance test.

The throughput, latency, and jitter tests were conducted to learn the following information:

- Throughput is defined as the maximum forwarding rate that the switch can achieve without losing a single packet. The throughput test measures the number of packets that the switch can move at any given time internally: typically, 1 second. For example, 100 percent line rate for a 10 Gigabit Ethernet interface can move 14 million packets per seconds (mpps).
- Switch forwarding latency is the amount of time it takes for the switch to move a packet from its incoming port to its outgoing port. Essentially, the latency test measures how quickly a switch can forward a packet. For cut-through switches such as the Cisco Nexus 6004, this test uses the First In, First Out (FIFO) method, subtracting the time that the first bit exits the switch from the time that the first bit entered the switch.

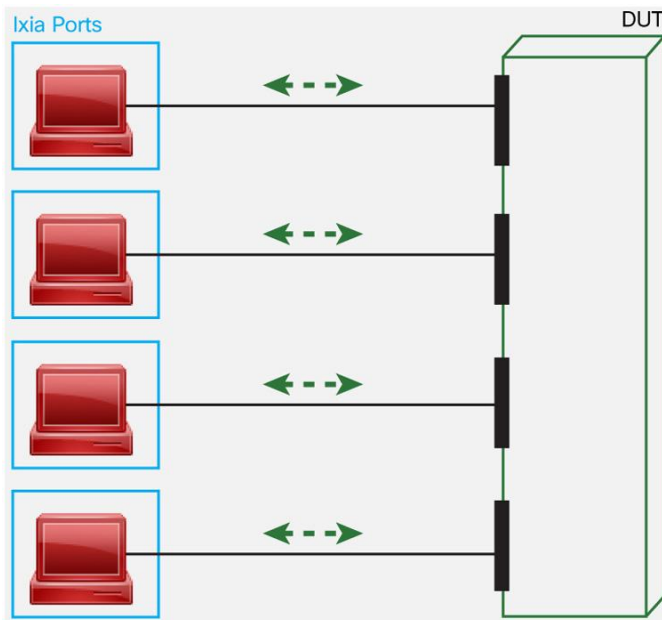
- Jitter is the statistical variance in the packet interarrival time. The lower the jitter value, the better. The jitter test indicates how well the switch can deliver packets at a constant rate at very predictable intervals.

Packet-size, traffic-load, and traffic-pattern metrics were tested in all test cases to help ensure adequate test coverage.

- Packet size (bytes): 64, 128, 256, 512, 1024, 1518, 4096, and 9216 bytes
- Traffic load (percent of interface line rate): 100 percent and 90 percent
- 40-Gbps traffic pattern (96 ports): Port pair for unicast, and 1-to-95 fanout for multicast
- 10-Gbps traffic pattern (384 ports): Port pair for unicast, and 1-to-383 fanout for multicast

In the port-pair configuration for 40-Gbps mode, all 96 ports were configured as 48 pairs; each pair consists of two ports to send and receive bidirectional traffic. In the port-pair configuration for 10-Gbps mode, all 384 ports were configured as 192 pairs. Figure 4 provides an overview of the port-pair topology.

Figure 4: Port-Pair Topology



All tests in this report are intended to be reproducible by customers who want to re-create them in their labs with the same topology, hardware, software, and test application configurations. Current or prospective customers interested in repeating these results can contact their local Ixia and Cisco representatives to obtain additional details.

Test Results

96 x 40-Gbps Overview

Figures 5 through 11 provide an overview of the 40-Gbps test results.

Figure 5: Unicast Throughput Overview for 96 x 40-Gbps Ports

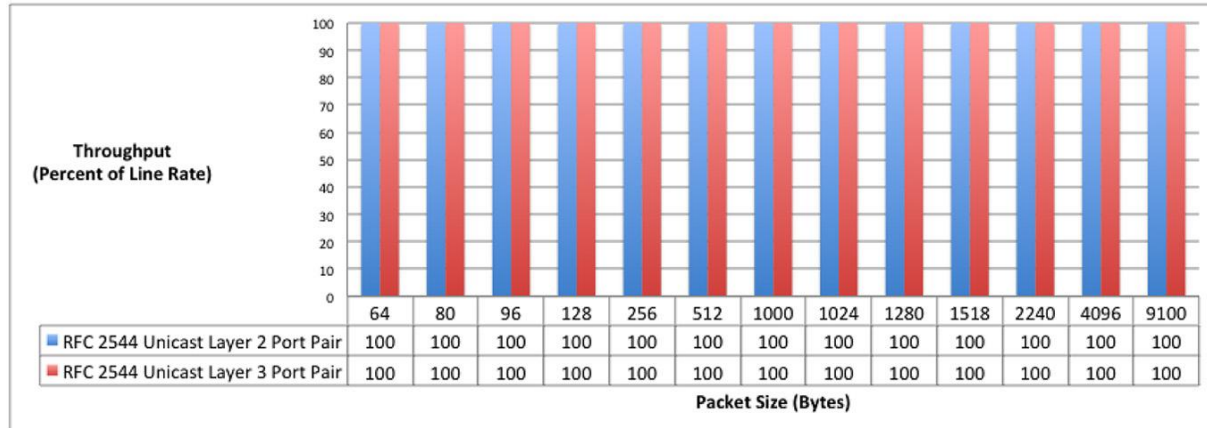


Figure 6: Multicast Throughput Overview for 96 x 40-Gbps Ports

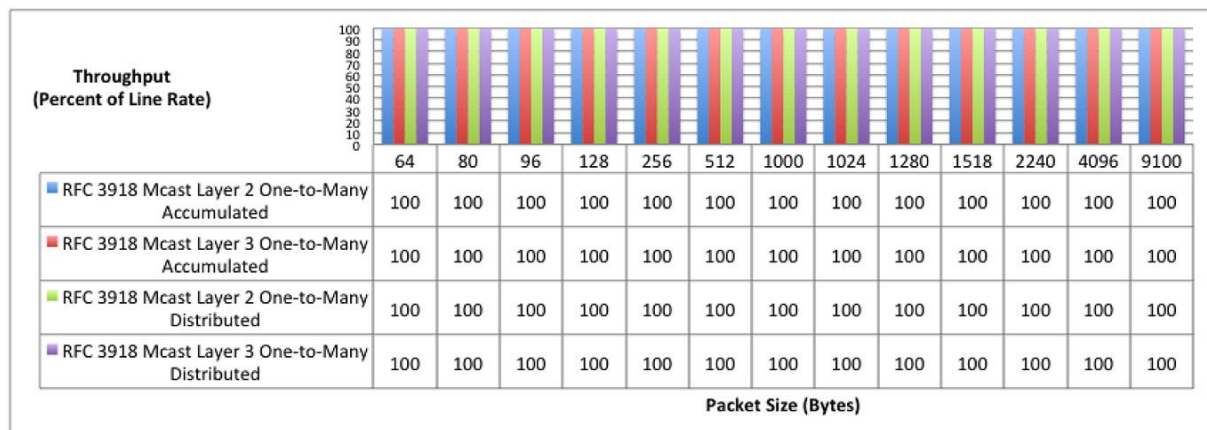


Figure 7: RFC 2544 Unicast 100 Percent Load Latency Overview for 96 x 40-Gbps Ports

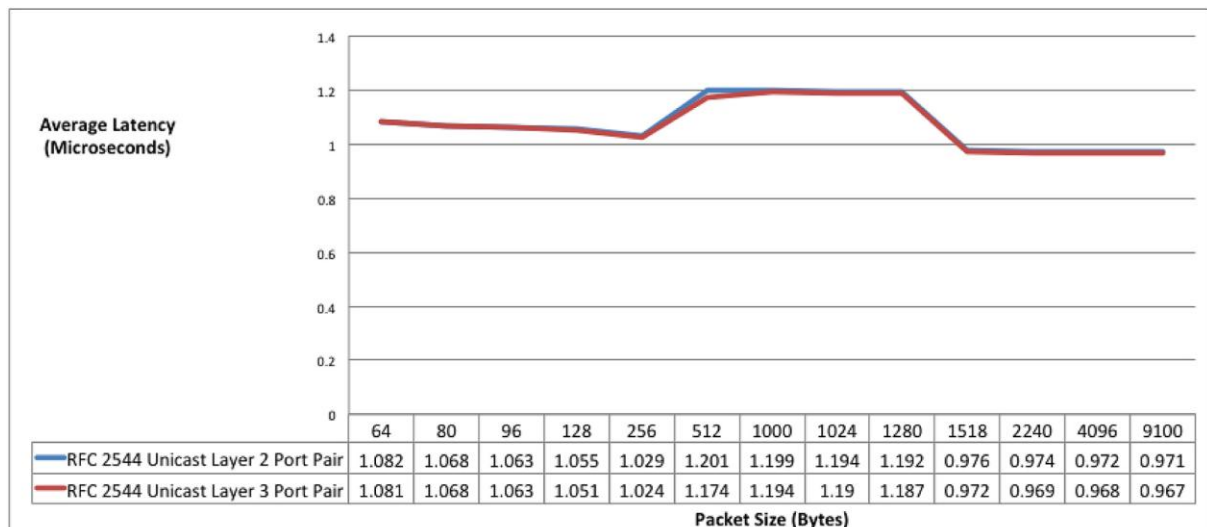


Figure 8: RFC 2544 Unicast 90 Percent Load Latency Overview for 96 x 40-Gbps Ports

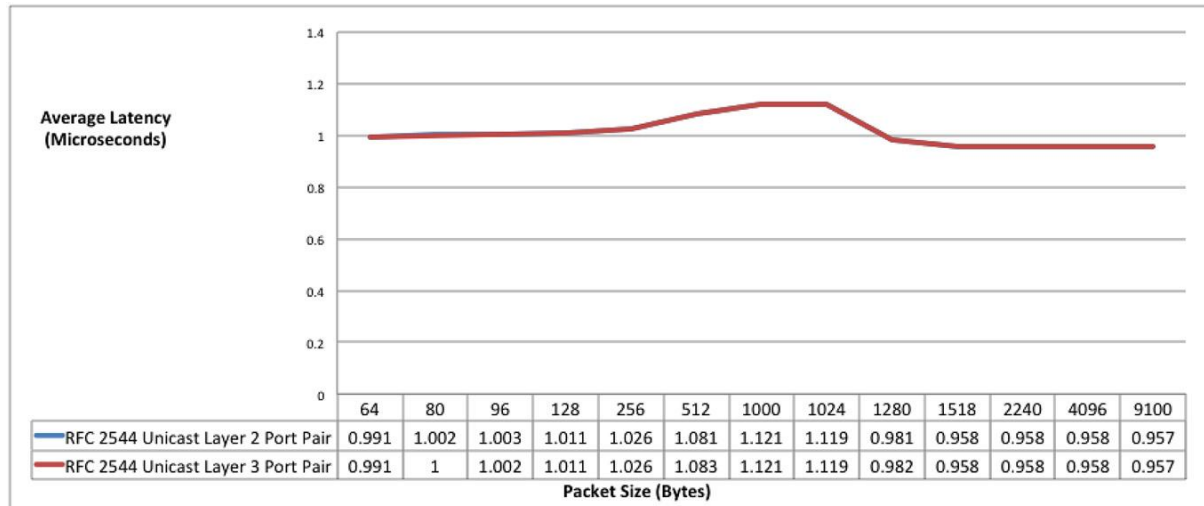


Figure 9: RFC 3918 Multicast 100 Percent Load Latency Overview for 96 x 40-Gbps Ports

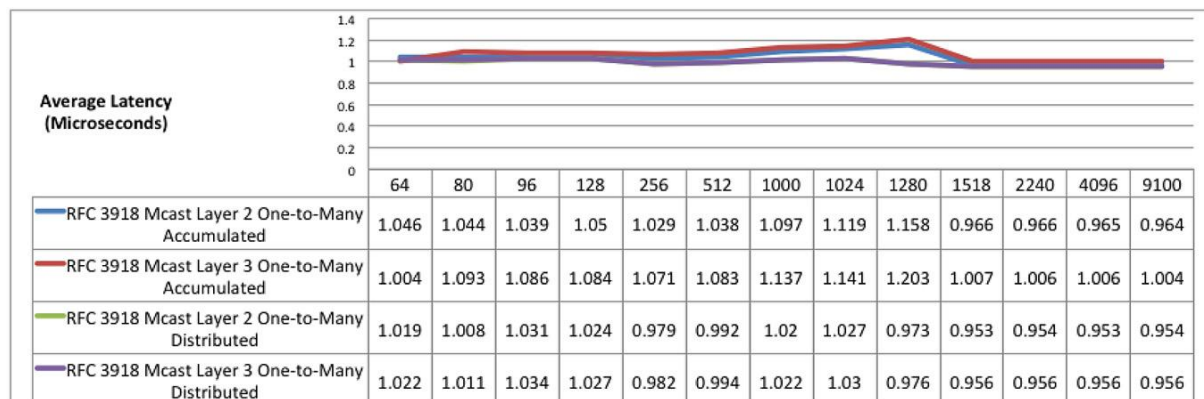


Figure 10: RFC 3918 Multicast 90 Percent Load Latency Overview for 96 x 40-Gbps Ports

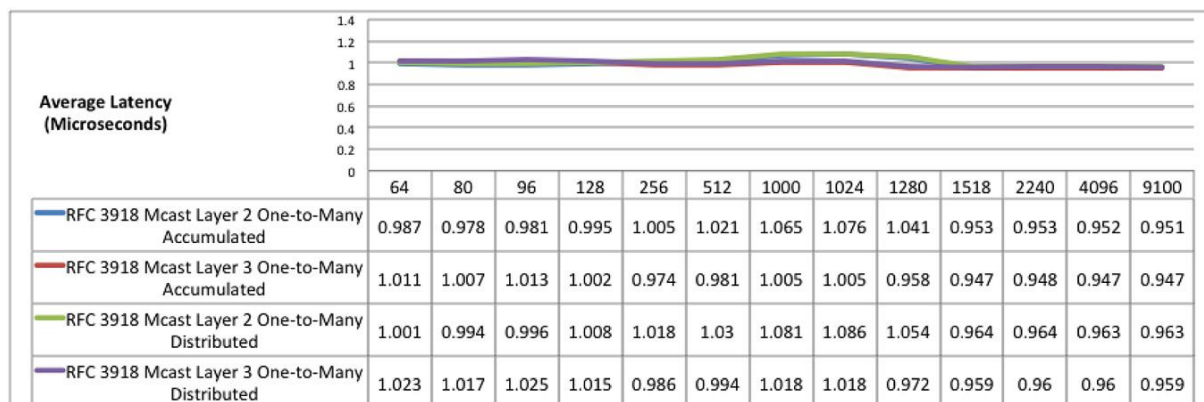
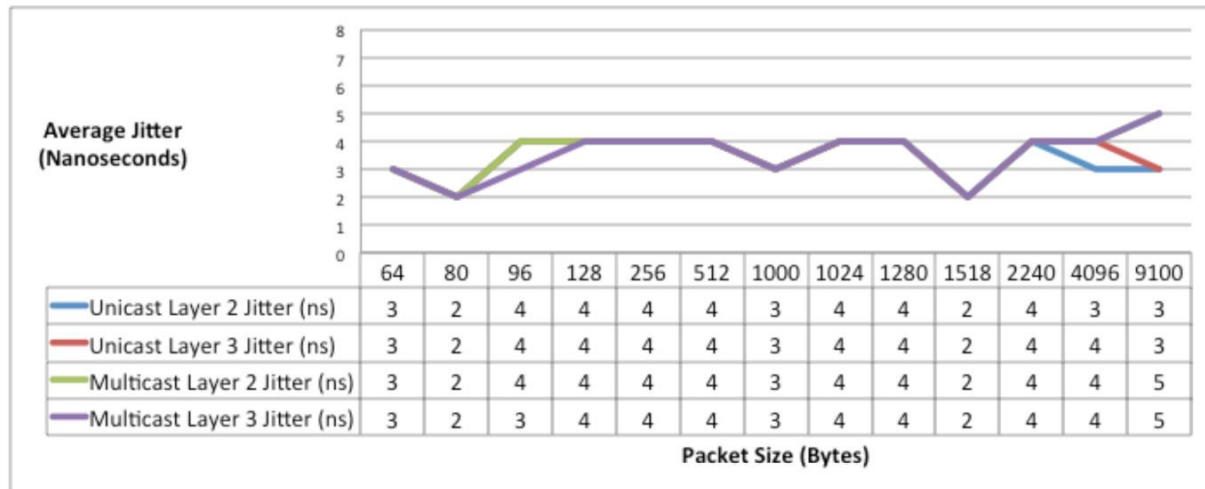


Figure 11: Unicast and Multicast 100 Percent Load Jitter Overview for 96 x 40-Gbps Ports



384 x 10-Gbps Overview

Figures 12 through 16 provide an overview of the 10-Gbps test results.

Figure 12: RFC 2544 Unicast Throughput Overview for 384 x 10-Gbps Ports

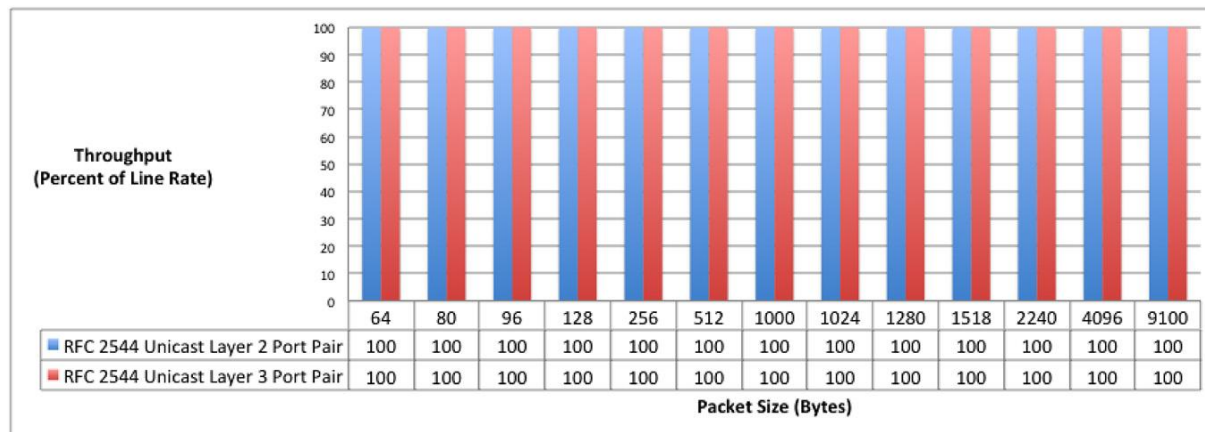


Figure 13: RFC 3918 Multicast Throughput Overview for 384 x 10-Gbps Ports

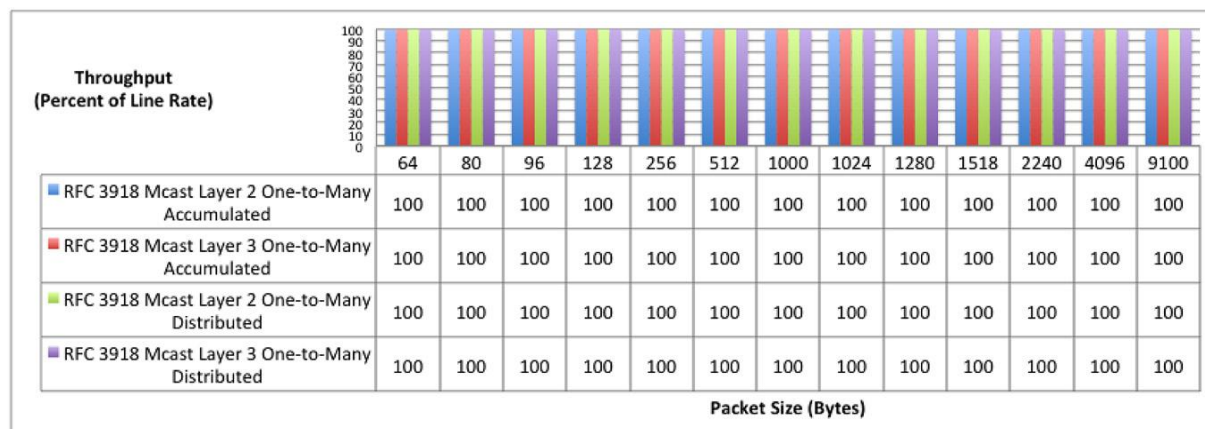


Figure 14: RFC 2544 Unicast 100 Percent Load Latency Overview for 384 x 10-Gbps Ports

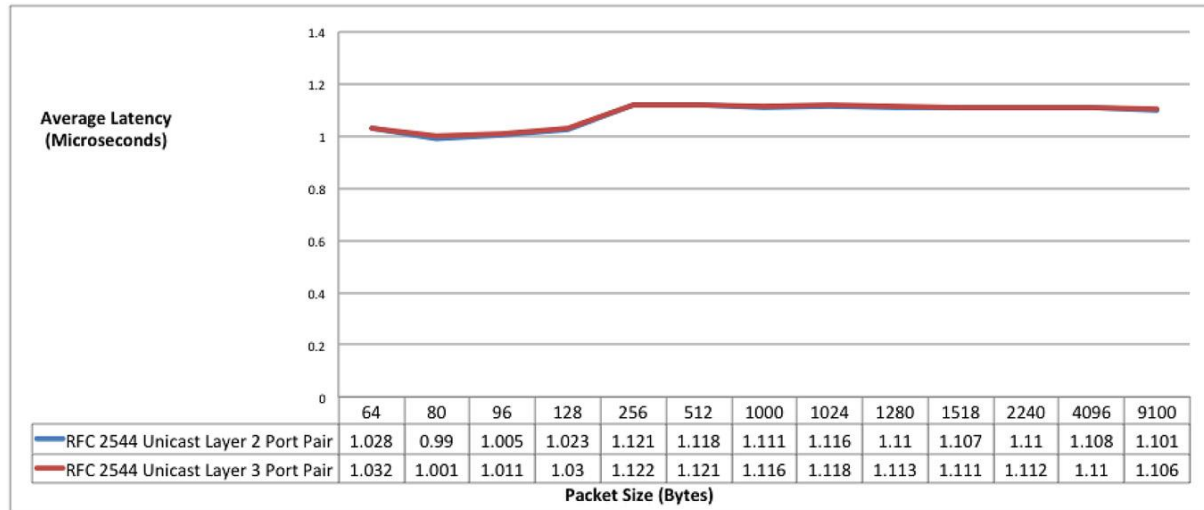


Figure 15: RFC 3918 Multicast 100 Percent Load Latency Overview for 384 x 10-Gbps Ports

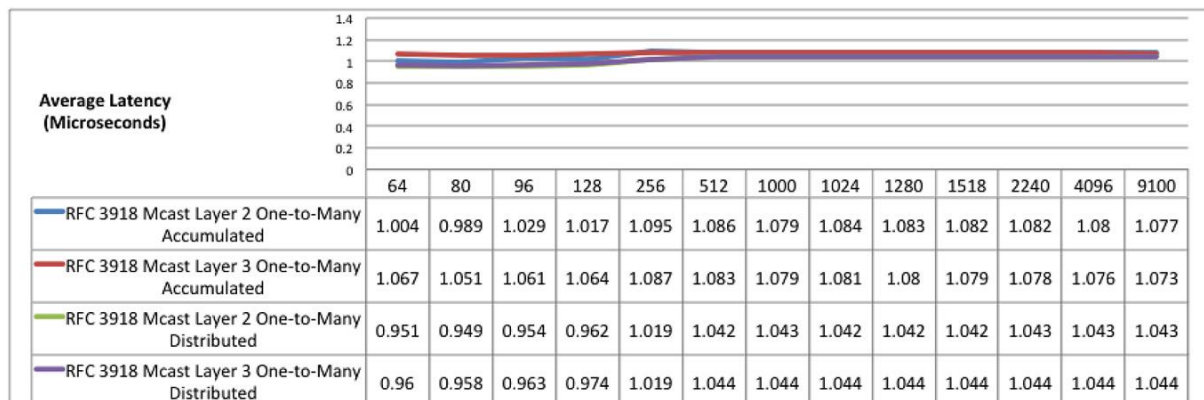
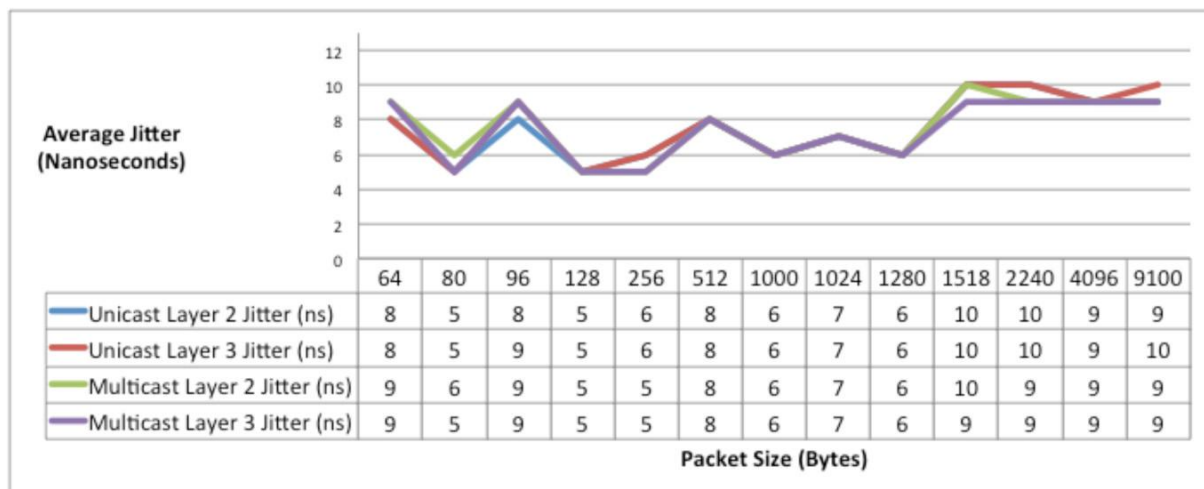


Figure 16: Unicast and Multicast 100 Percent Load Jitter for 384 x 10-Gbps Ports



RFC 2544: Unicast Port Pair Throughput and Latency for 96 x 40-Gbps Ports

Overview

RFC 2544 provides an industry-standard benchmark testing methodology to measure unicast port-pair packet throughput and latency. The Ixia IxNetwork QuickTest has a full-featured RFC 2544 test package to benchmark those measurements for both Layer 2 and Layer 3.

Configuration

The test was configured using Ixia IxNetwork QuickTest RFC benchmarking test suites with the topology and test metrics described earlier in this document. First, Layer 2 switching performance was measured for the port-pair configuration. Then the configuration was changed to Layer 3, and the same measurements (throughput, latency, and jitter) were taken. Ixia engineers confirmed that the Ixia IxNetwork equipment was properly configured.

Test Results

Figures 17 through 20 show the test results.

Figure 17: RFC 2544 Unicast Layer 2 Port-Pair Throughput for 96 x 40-Gbps Ports

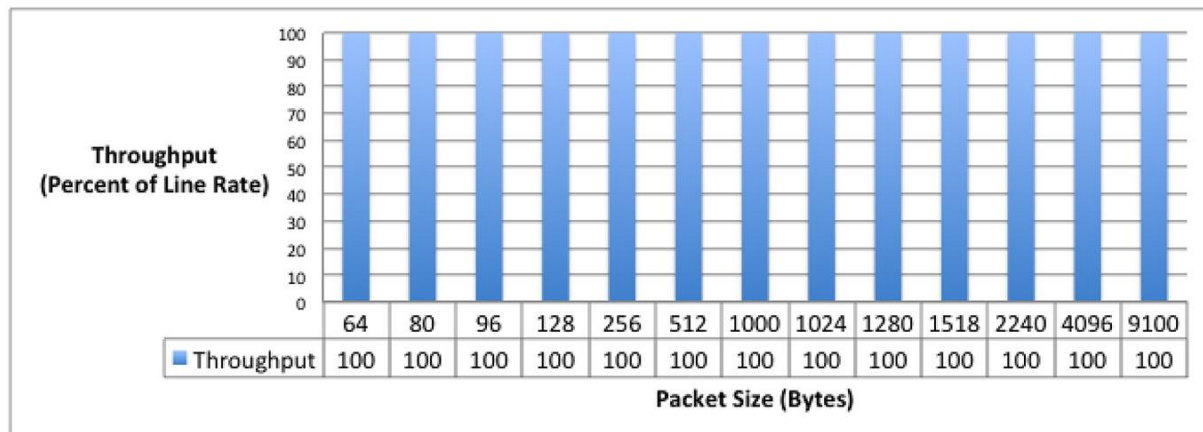


Figure 18: RFC 2544 Unicast Layer 2 Port-Pair 100 Percent Load Latency for 96 x 40-Gbps Ports



Figure 19: RFC 2544 Unicast Layer 3 Port Pair Throughput for 96 x 40-Gbps Ports

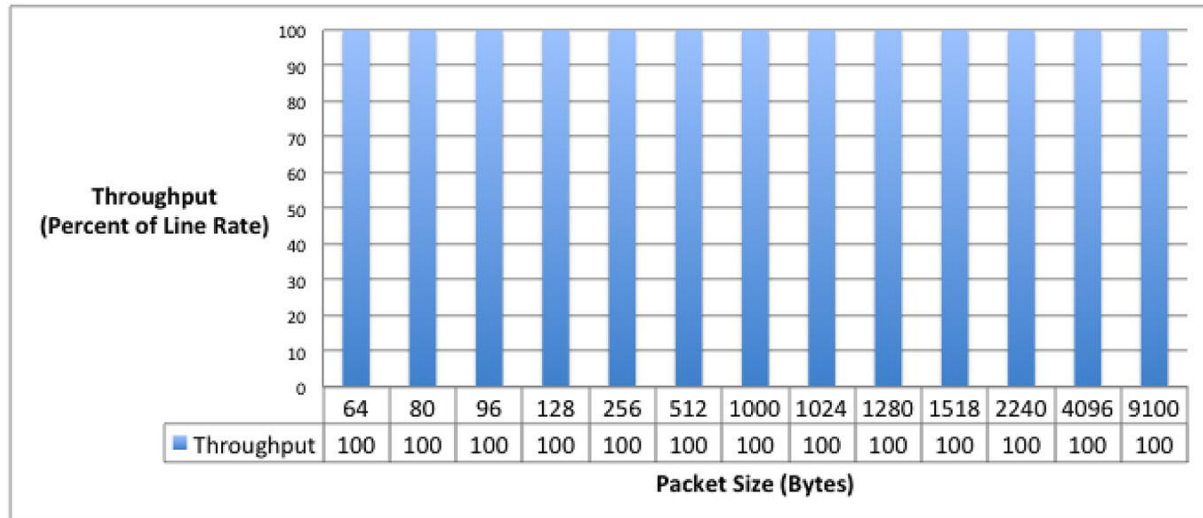
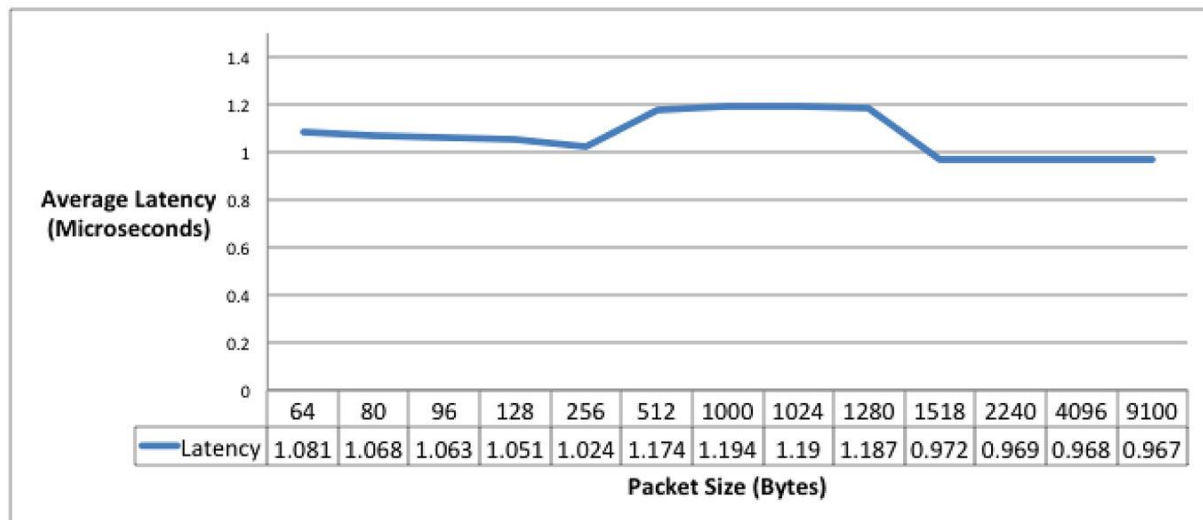


Figure 20: RFC 2544 Unicast Layer 3 Port-Pair 100 Percent Load Latency for 96 x 40-Gbps Ports



RFC 2544: Unicast Throughput and Latency for 384 x 10-Gbps Ports

Configuration

The configuration is similar to that for the 40-Gbps port test, except that QSFP+-to-SFP+ breakout cables are used to divide each 40-Gbps port of the Cisco Nexus 6004 into four 10-Gbps ports. The Ixia XG12 chassis is populated with the Xcellon-FlexAP10/4016SQ modules, which contain both the 10 and 40 Gigabit Ethernet ports.

Test Results

Figures 21 through 24 show the test results.

Figure 21: RFC 2544 Unicast Layer 2 Port-Pair Throughput for 384 x 10-Gbps Ports

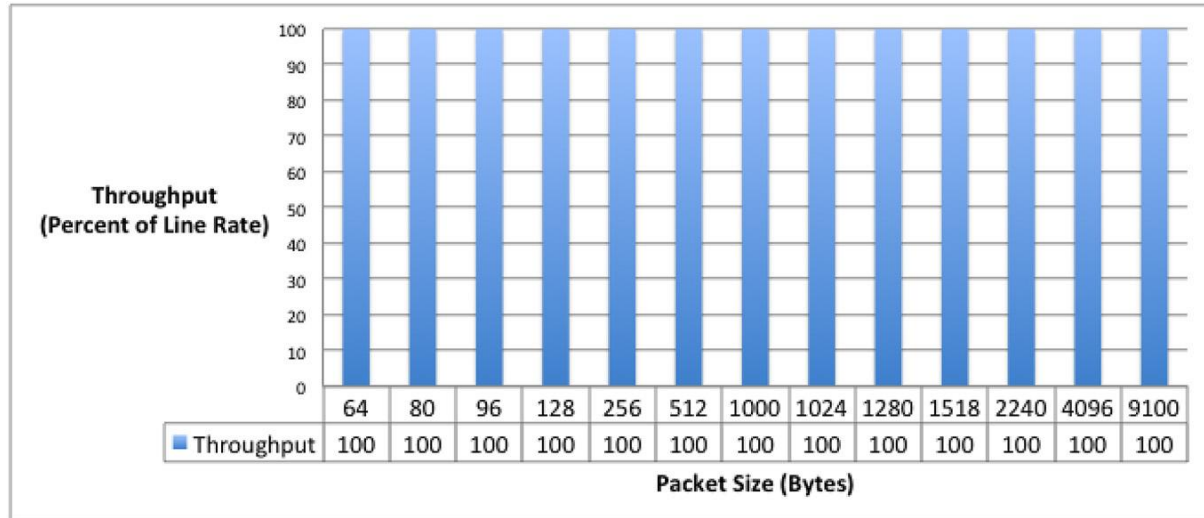


Figure 22: RFC 2544 Unicast Layer 2 Port-Pair 100 Percent Load Latency for 384 x 10-Gbps Ports

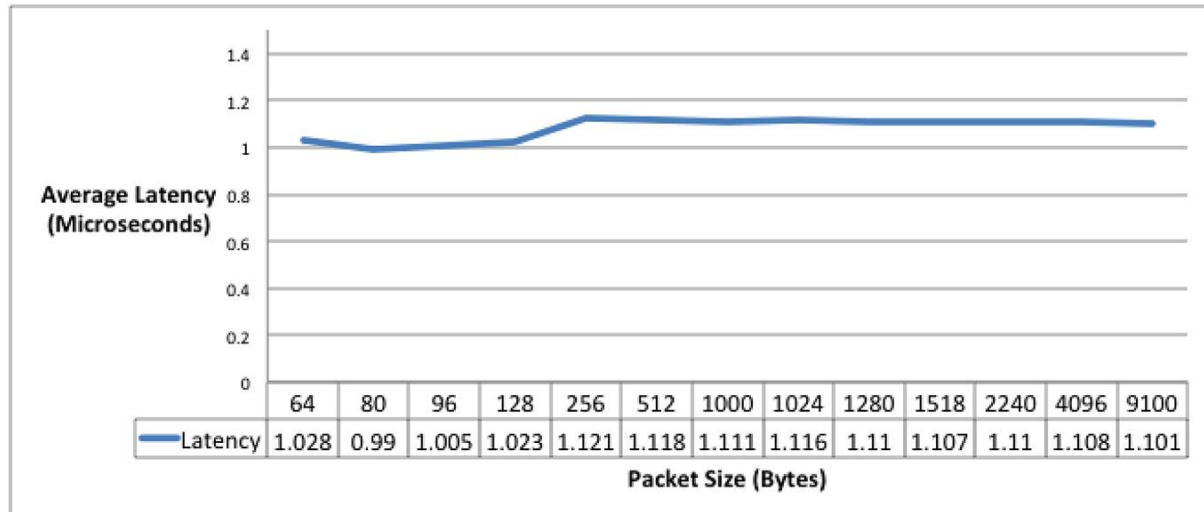


Figure 23: RFC 2544 Unicast Layer 3 Port-Pair Throughput for 384 x 10-Gbps Ports

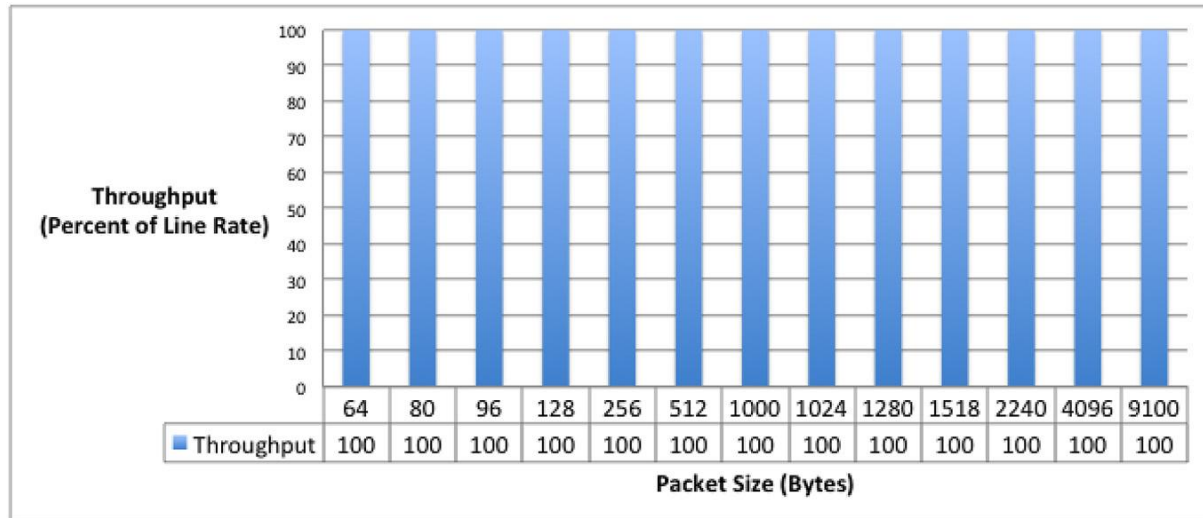
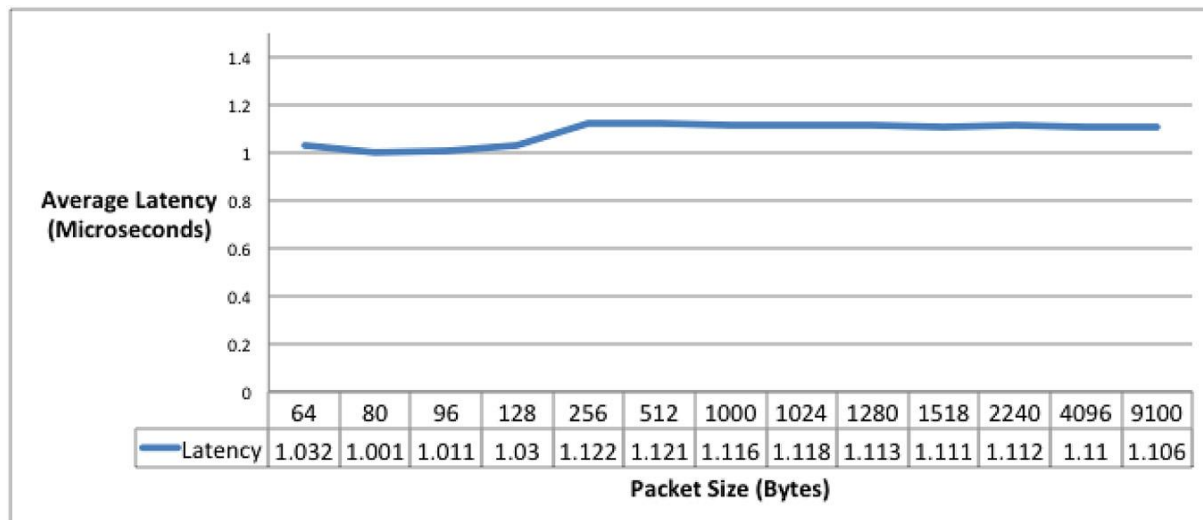


Figure 24: RFC 2544 Unicast Layer 3 Port Pair 100 Percent Load Latency for 384 x 10-Gbps Ports



RFC 3918: Multicast Throughput and Latency for 96 x 40-Gbps Ports

Overview

RFC 3918 provides an industry-standard benchmark testing methodology for measuring multicast throughput and latency. The test can be performed for both Layer 2 and Layer 3 packet forwarding. The Ixia IxNetwork QuickTest has a full-featured RFC 3918 test package capable of running all the tests defined in RFC 3918. Switch throughput and forwarding latency are measured for each test.

Configuration

The test was configured using Ixia IxNetwork QuickTest RFC benchmarking test suites with the topology and test metrics described earlier in this document. First, the switch performance was tested against Layer 2 multicast traffic in a 1-to-95 fanout configuration in which receivers on all 95 interfaces join the multicast groups. Then the configuration was changed to Layer 3, and the same measurements (throughput and latency) were taken. Ixia engineers confirmed that the Ixia IxNetwork equipment was properly configured.

There are two modes for testing multicast traffic: accumulated and distributed. In accumulated mode, each receive port joins every group, with the result that the same multicast traffic goes out multiple ports. In distributed mode, each receive port joins a different set of groups, with the result that different streams of multicast traffic go out different ports of the Cisco Nexus 6004. The Cisco Nexus 6004 was tested using both accumulated and distributed modes.

The tests were performed with 100 multicast groups for accumulated mode and 96 groups for distributed mode.

Test Results: Accumulated Mode

Figures 25 through 28 show the test results.

Figure 25: RFC 3918 Multicast Layer 2 One-to-Many Accumulated Mode Throughput for 96 x 40-Gbps Ports

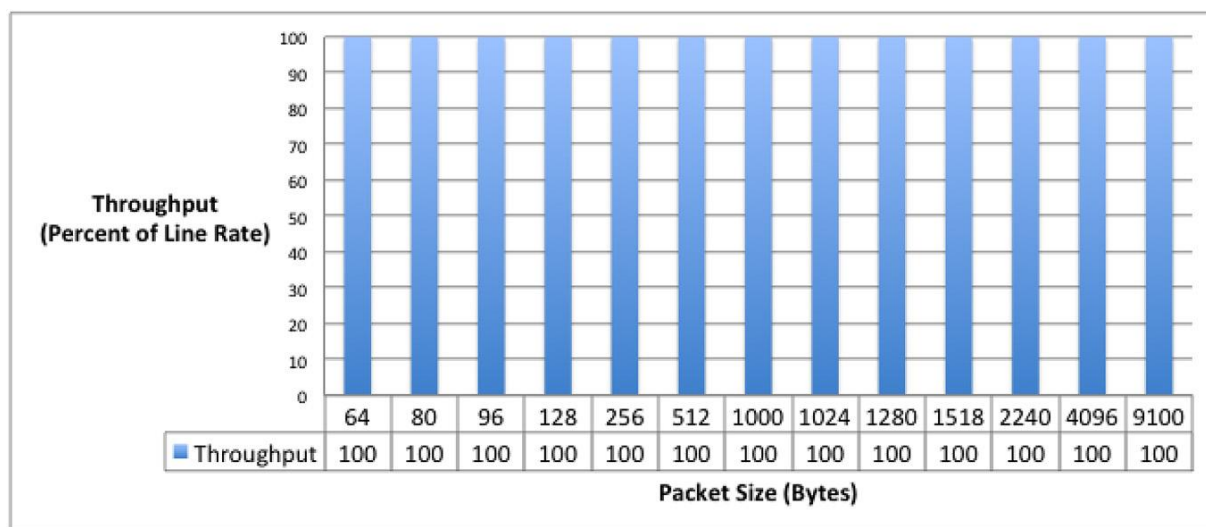


Figure 26: RFC 3918 Multicast Layer 2 One-to-Many Accumulated Mode 100 Percent Load Latency for 96 x 40-Gbps Ports



Figure 27: RFC 3918 Multicast Layer 3 One-to-Many Accumulated Mode Throughput for 96 x 40-Gbps Ports

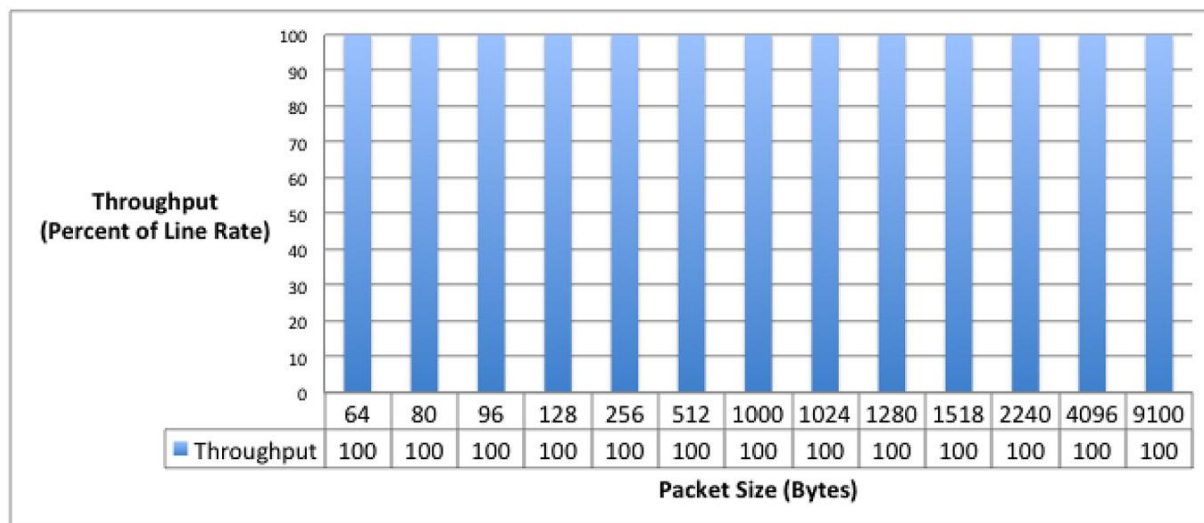
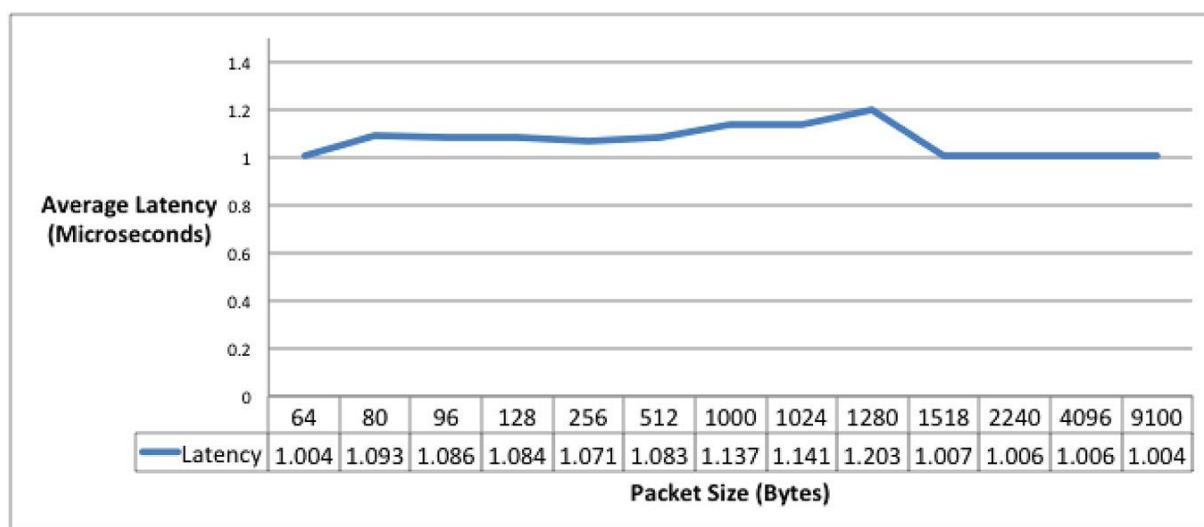


Figure 28: RFC 3918 Multicast Layer 3 One-to-Many Accumulated Mode 100 Percent Load Latency for 96 x 40-Gbps Ports



Test Results: Distributed Mode

Figures 29 through 32 show the test results.

Figure 29: RFC 3918 Multicast Layer 2 One-to-Many Distributed Mode Throughput for 96 x 40-Gbps Ports

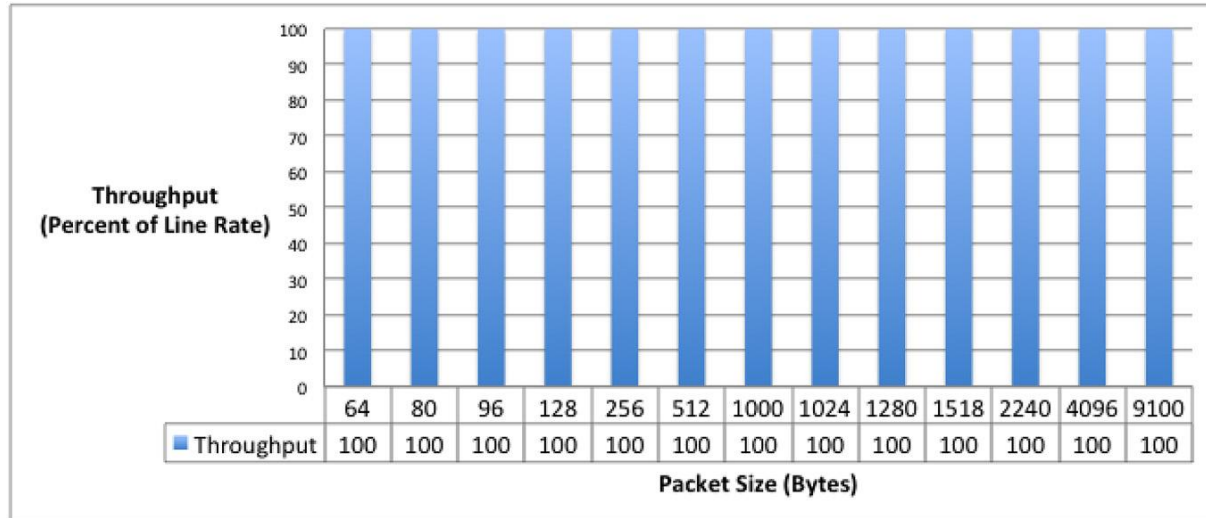


Figure 30: RFC 3918 Multicast Layer 2 One-to-Many Distributed Mode 100 Percent Load Latency for 96 x 40-Gbps Ports

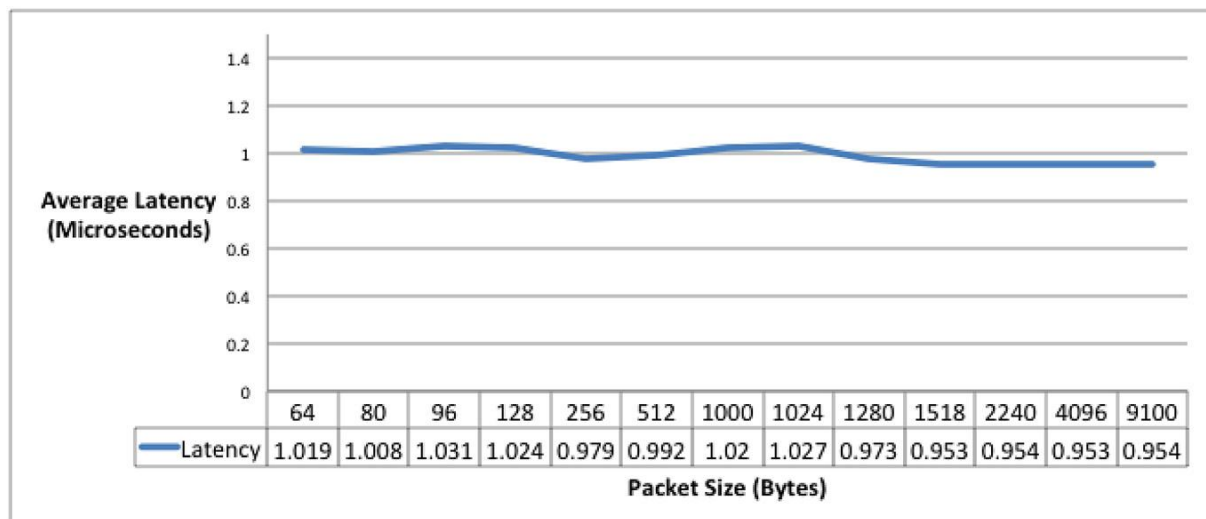


Figure 31: RFC 3918 Multicast Layer 3 One-to-Many Distributed Mode Throughput for 96 x 40-Gbps Ports

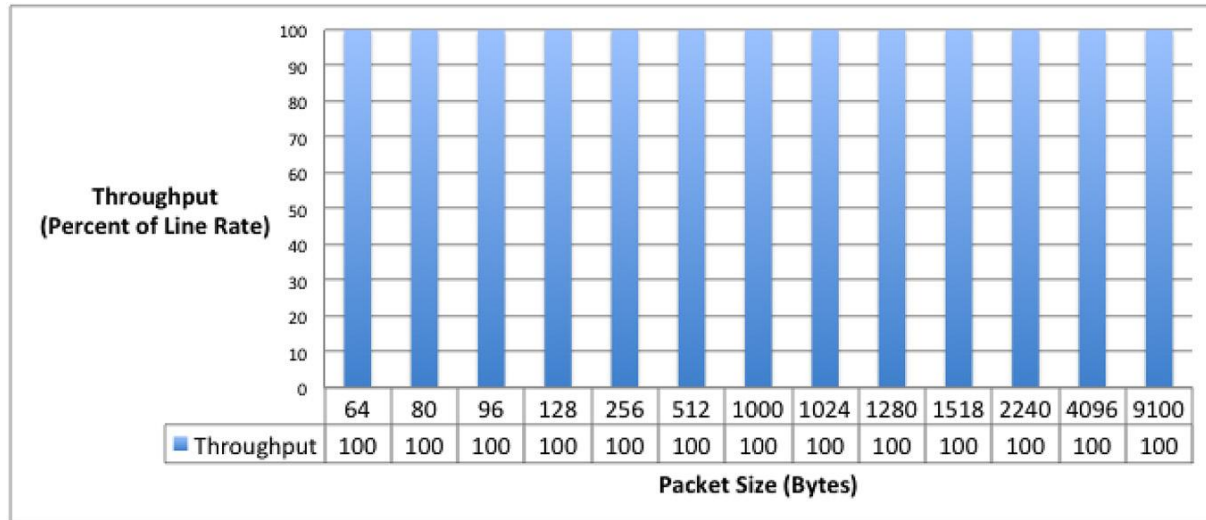
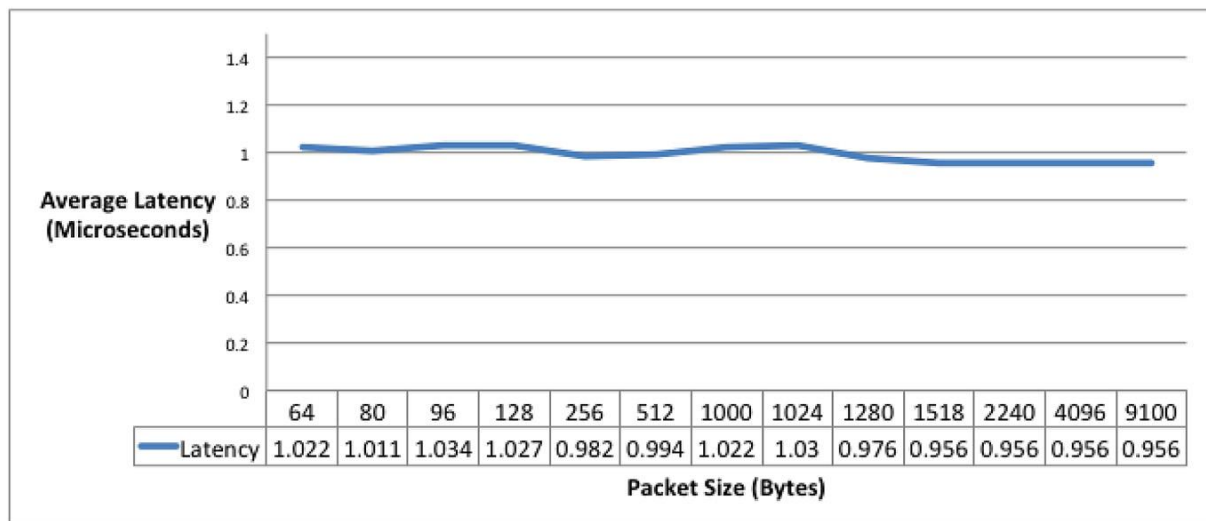


Figure 32: RFC 3918 Multicast Layer 3 One-to-Many Distributed Mode 100 Percent Load Latency for 96 x 40-Gbps Ports



RFC 3918: Multicast Throughput and Latency for 384 x 10-Gbps Ports

Configuration

The configuration is similar to that for the 40-Gbps port test, except that breakout cables are used to divide each 40-Gbps port of the Cisco Nexus 6004 into four 10-Gbps ports. The Ixia XG12 chassis is populated with the Xcellon-FlexAP10/4016SQ modules, which contain both the 10 and 40 Gigabit Ethernet ports.

First, the switch performance was tested against Layer 2 multicast traffic in a 1-to-383 fanout configuration in which receivers on all 383 interfaces join the multicast groups. Then the configuration was changed to Layer 3, and the same measurements (throughput, latency, and jitter) were taken.

Test Results: Accumulated Mode

Figures 33 through 36 show the test results.

Figure 33: RFC 3918 Multicast Layer 2 One-to-Many Accumulated Mode Throughput for 384 x 10-Gbps Ports

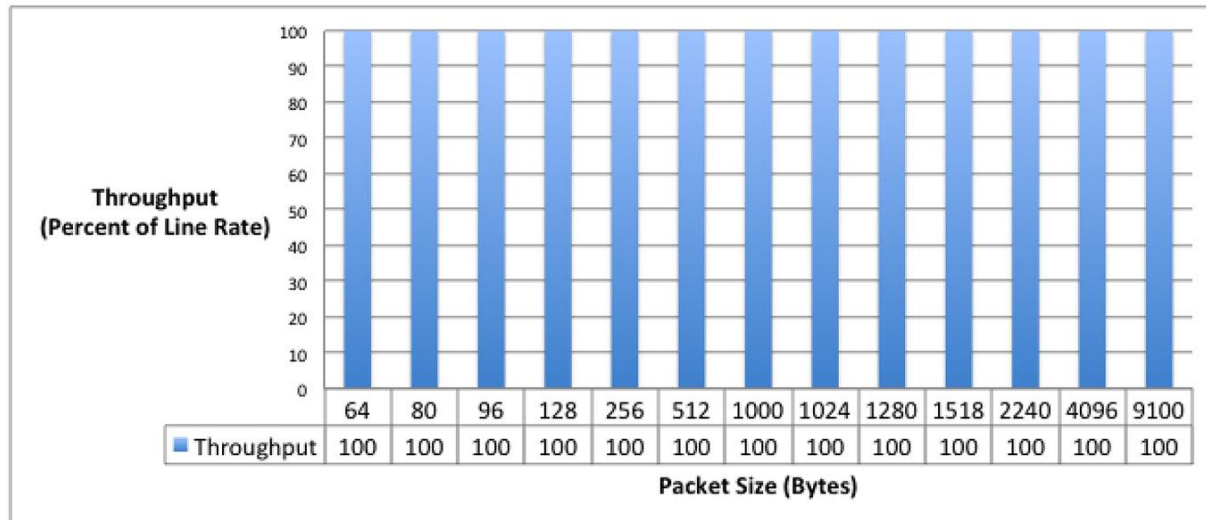


Figure 34: RFC 3918 Multicast Layer 2 One-to-Many Accumulated Mode 100 Percent Load Latency for 384 x 10-Gbps Ports

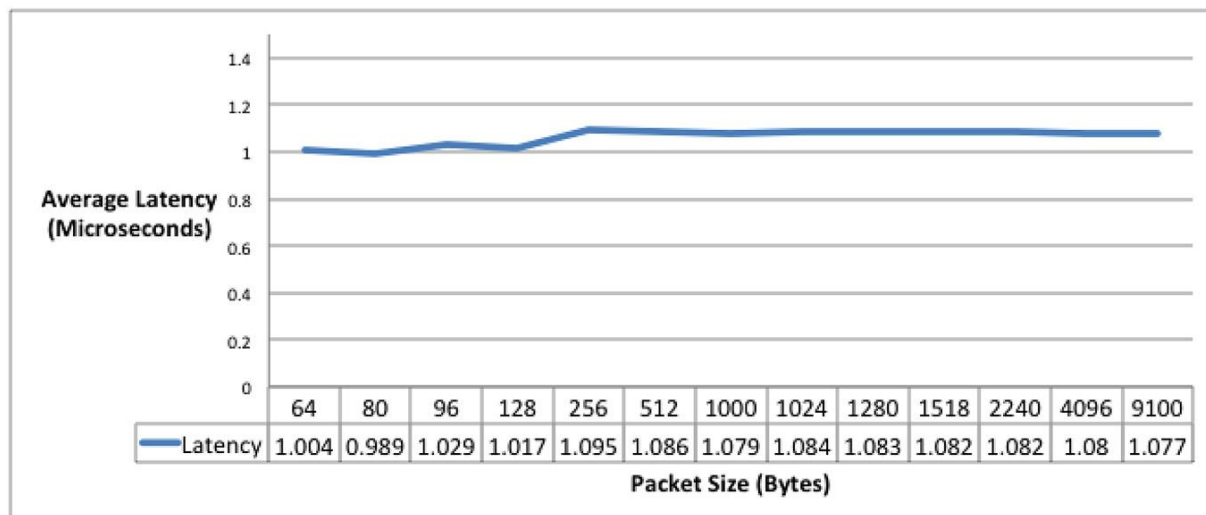


Figure 35: RFC 3918 Multicast Layer 3 One-to-Many Accumulated Mode Throughput for 384 x 10-Gbps Ports

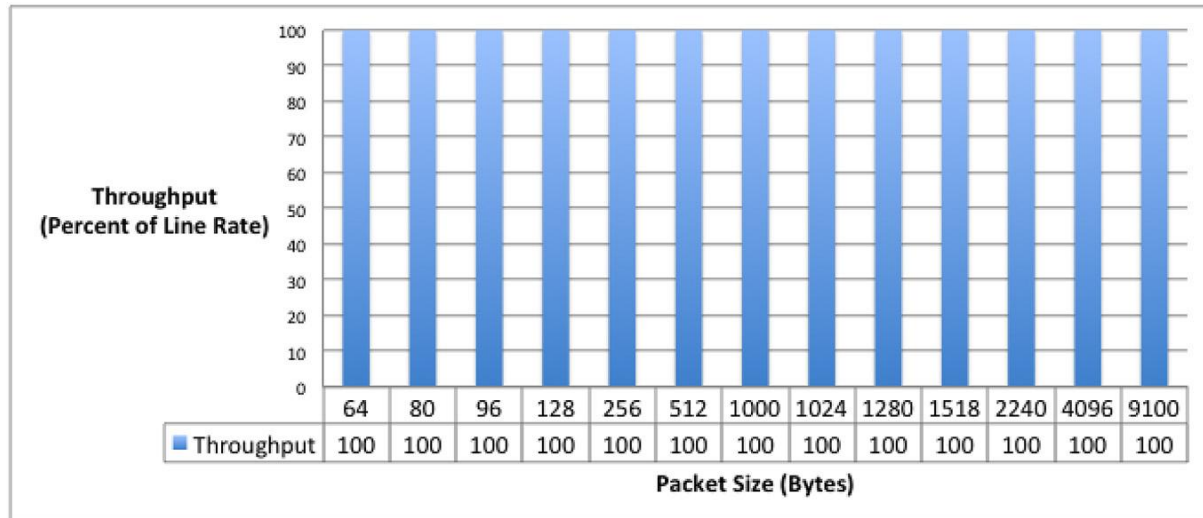
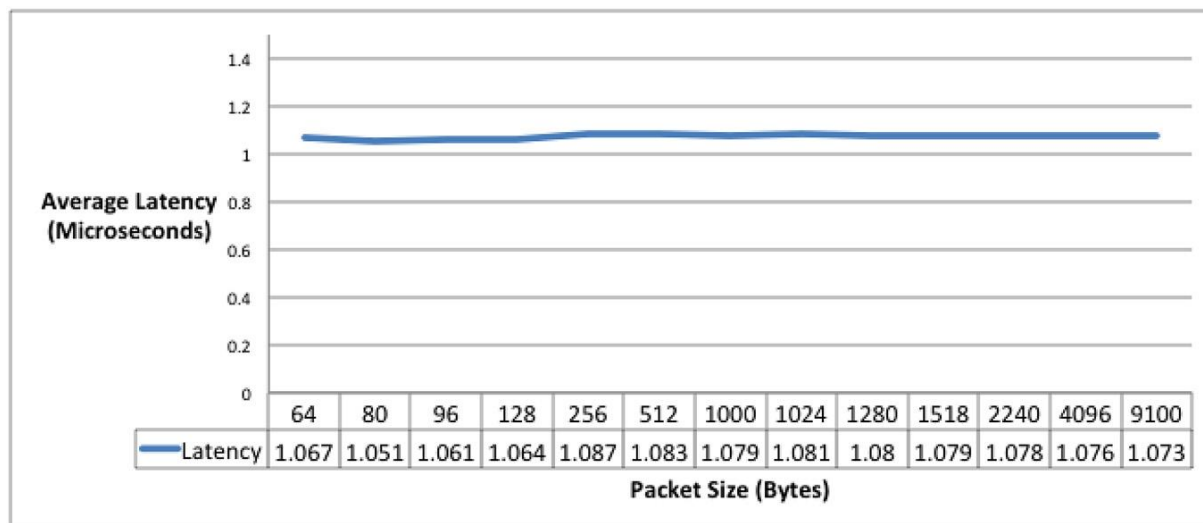


Figure 36: RFC 3918 Multicast Layer 3 One-to-Many Accumulated Mode 100 Percent Load Latency for 384 x 10-Gbps Ports



Test Results: Distributed Mode

Figures 37 through 40 show the test results.

Figure 37: RFC 3918 Multicast Layer 2 One-to-Many Distributed Mode Throughput for 384 x 10-Gbps Ports

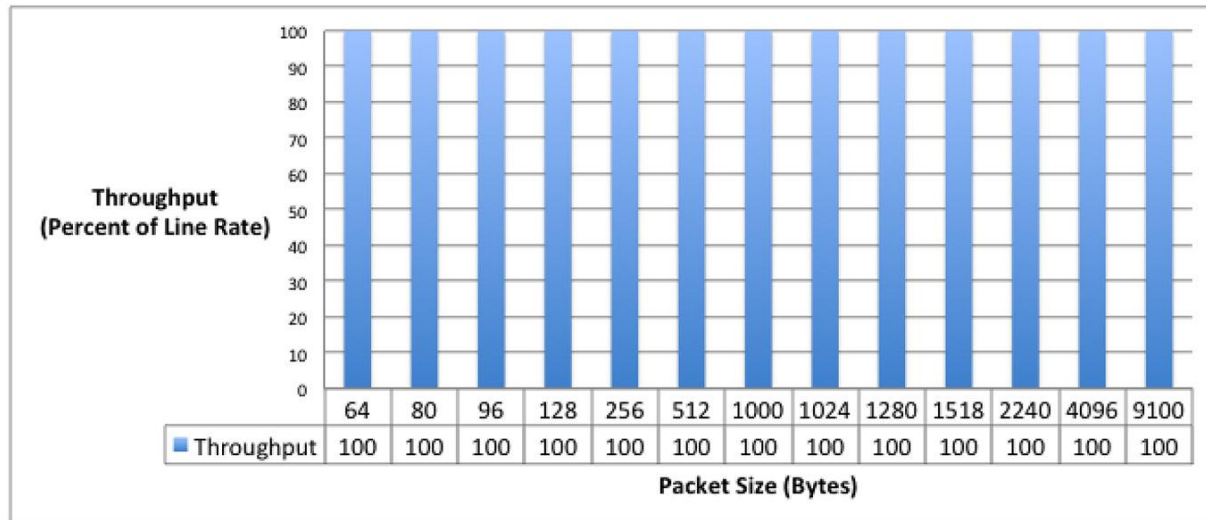


Figure 38: RFC 3918 Multicast Layer 2 One-to-Many Distributed Mode 100 Percent Load Latency for 384 x 10-Gbps Ports

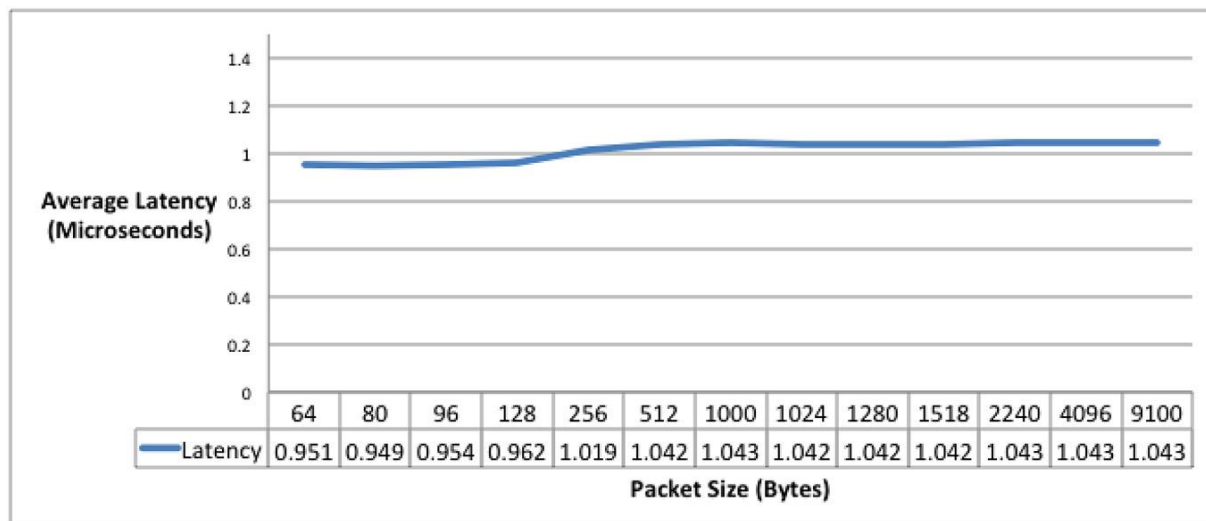


Figure 39: RFC 3918 Multicast Layer 3 One-to-Many Distributed Mode Throughput for 384 x 10-Gbps Ports

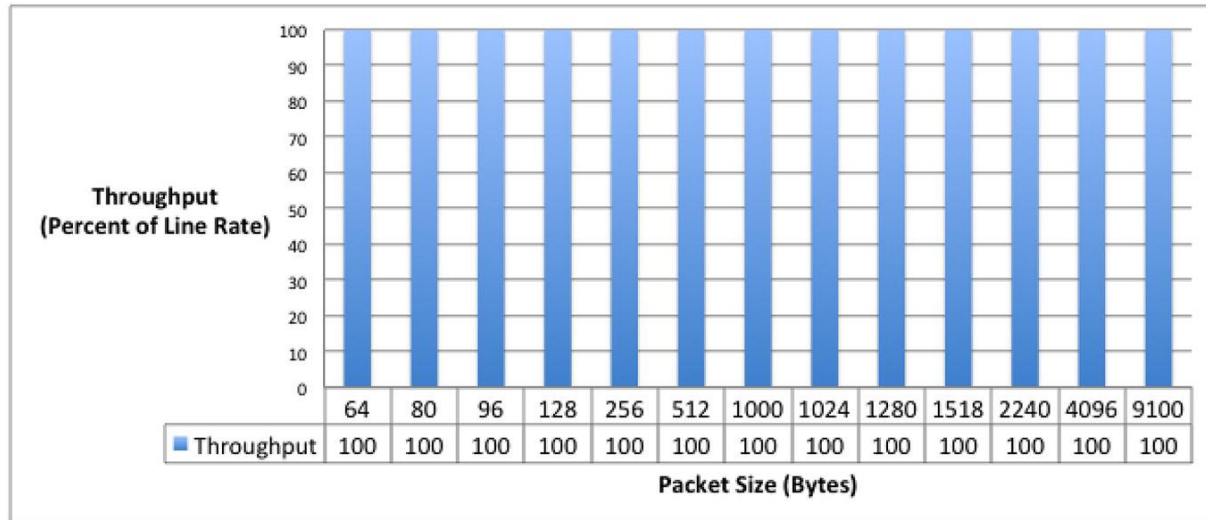
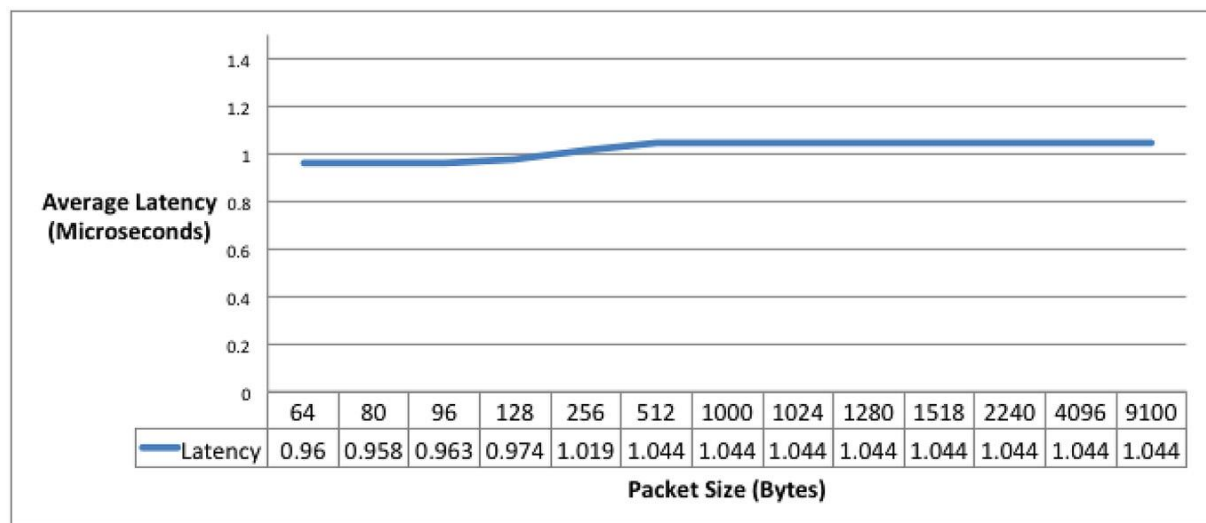


Figure 40: RFC 3918 Multicast Layer 3 One-to-Many Distributed Mode 100 Percent Load Latency for 384 x 10-Gbps Ports

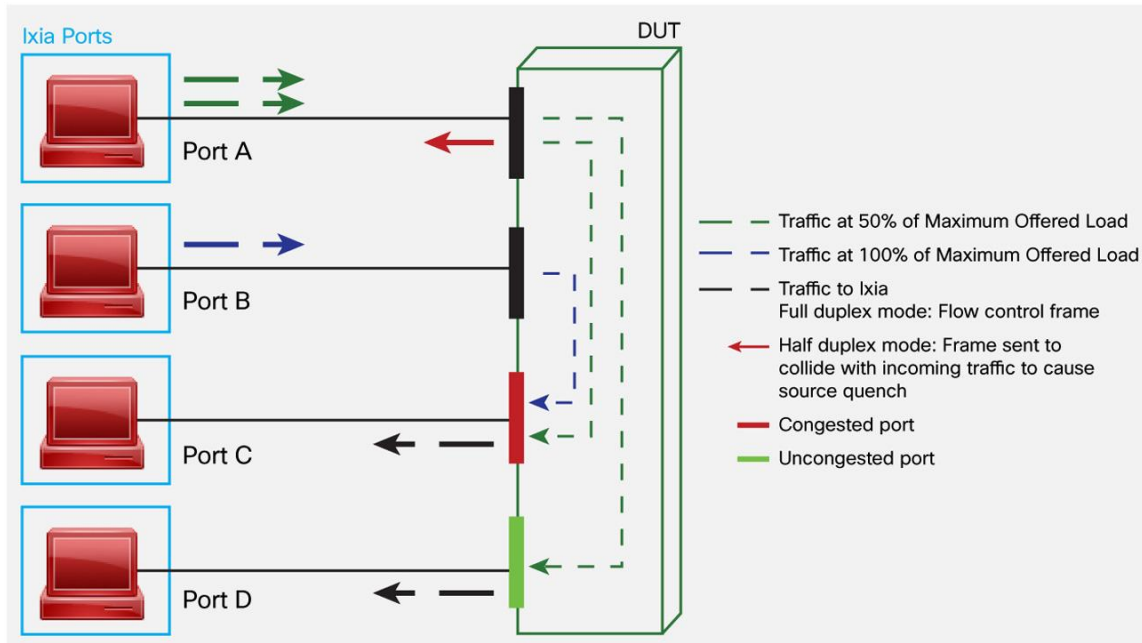


RFC 2889: Unicast Head-of-Line Blocking for 96 x 40-Gbps Ports

Configuration

Figure 41 shows the unicast head-of-line blocking traffic flow.

Figure 41: RFC 2889 Unicast Head-of-Line Blocking Traffic Flow



This test looks for added delay on an uncongested output interface whenever frames are received from an input interface that is also attempting to forward frames to a congested output interface. A fully meshed port mapping with two ports, A and B, transmitting to a third port, C, forms the congested interface, and port A also transmits to port D as an uncongested interface.

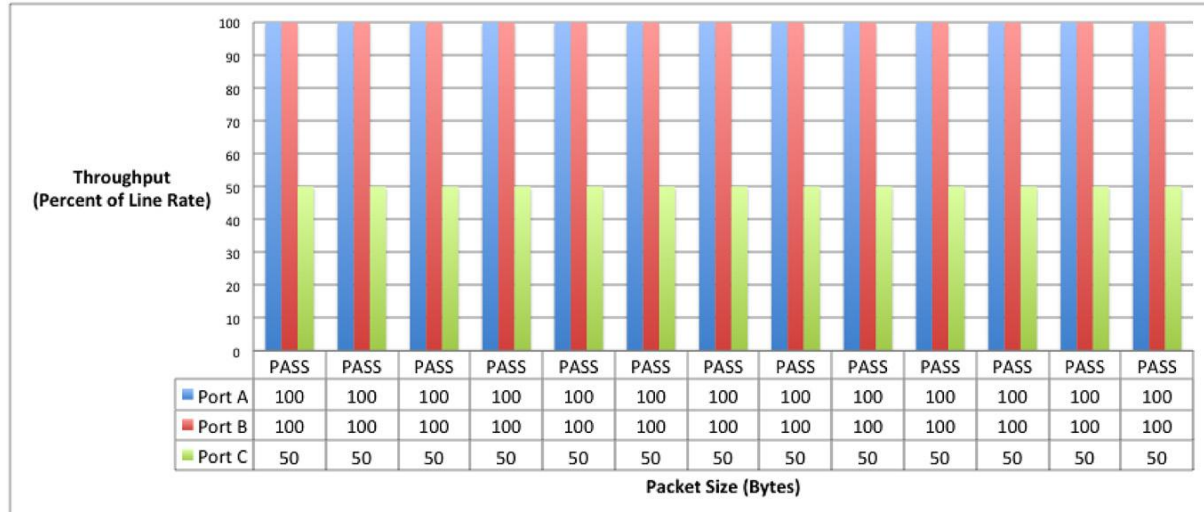
The goal of the test is to verify that the 50 percent offered load is received on port D.

To simulate this scenario, 24 test groups streams were created.

Test Results

Figure 42 shows the test results.

Figure 42: RFC 2889 Unicast Head-of-Line Blocking Throughput



Conclusion

The Cisco Nexus 6004 Switch is a high-performance, high-density, low-latency 10 and 40 Gigabit Ethernet and FCoE switch that can forward packets at line rate in both 96 x 40-Gbps and 384 x 10-Gbps configurations with an average latency of 1 microsecond. It also has extremely low jitter; even at 100 percent of line rate, jitter is always under 10 nanoseconds and is very consistent across the packet sizes.

For More Information

<http://www.cisco.com/go/nexus6000>

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