Miercom

Lab Testing Summary Report

August 2001
Report 140801

Product Category:
Optical Routers

Vendor Tested:
Cisco SystemsÒ

Product Tested:
Cisco 7600 Internet Router

MIER Communications
Performance Verified

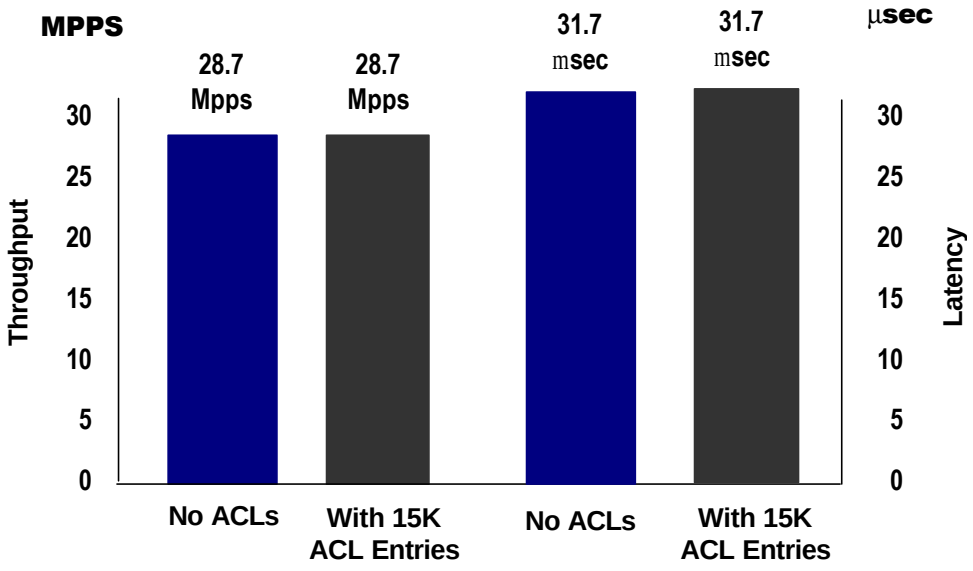
Key findings and conclusions:

- **Cisco 7600 achieved a 28.7 Mpps maximum no-drop throughput with no out-of-sequence packets**
- **Supported ACL scalability with no impact on performance, latency or packet sequencing**
- **Peaked at processor utilization of only one percent while traffic was filtered and forwarded**
- **Delivered excellent performance overall**

Cisco Systems engaged Miercom to conduct analysis and performance validation tests of its Cisco 7600 Internet Router and its Optical Service Modules (OSMs). The goal of testing was to validate Cisco's architected 30-Mpps forwarding rate to show that using the Access Control List (ACL) feature had little or no impact on throughput and latency. In our tests, the Cisco 7600 delivered a maximum throughput rate of 28.7 Mpps when tested with 40-byte IP packets. The same rate was achieved with no ACLs and with 15,000 ACL entries applied in both directions on each port. (See Table 2.) This performance was achieved with an average latency of only 31.7 microseconds (µsec). ACLs were implemented with no impact on the Cisco 7600 processor utilization.

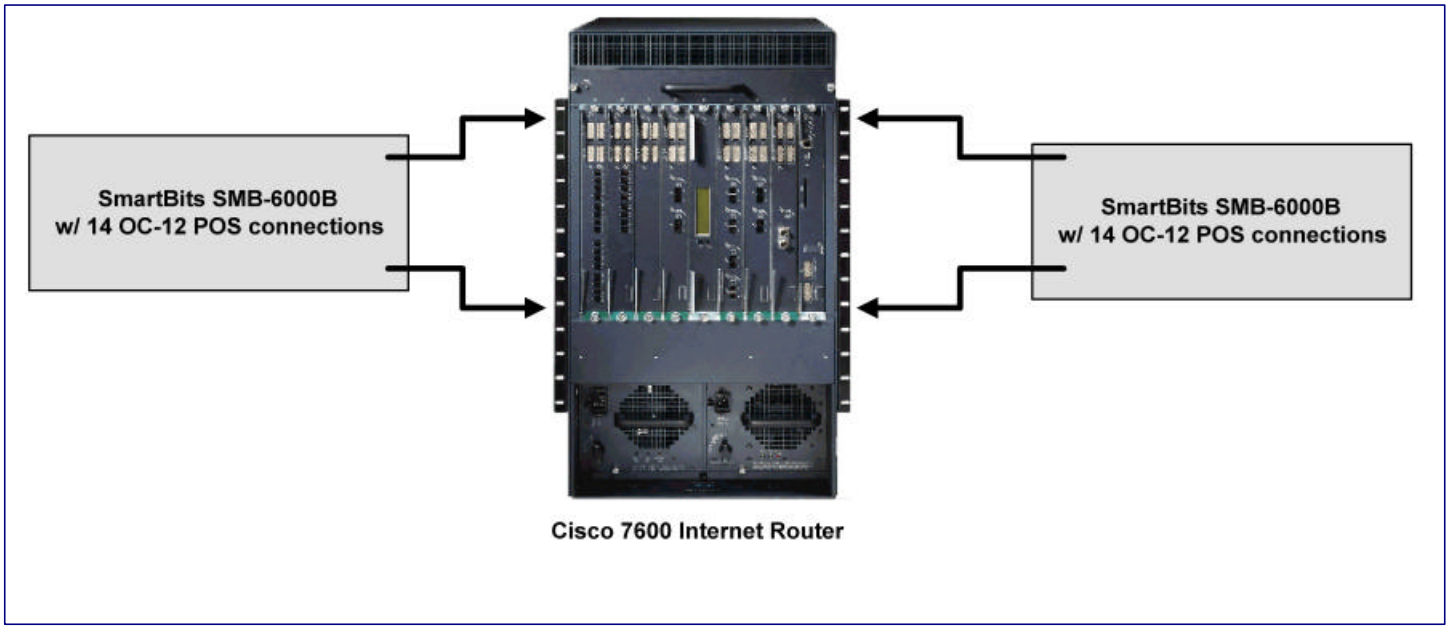
We tested at Cisco's laboratory in Research Triangle Park, NC in July 2001. The Cisco 7600 was tested with Cisco IOS® version 12.1(8a)E and Catalyst Software Release 6.2(2).

Aggregate Throughput vs. Latency*



*Tests were conducted with 40-byte IP packets.

Test Bed Set-up and Methodology



About the testing… We tested the Cisco 7600 in a nine-slot NEBS-compliant chassis; it contained one Supervisor Engine 2 with the Policy Feature Card 2 (PFC2) and Multilayer Switching Feature Card 2 (MSFC2), one 256-Gbps Switch Fabrice Module (SFM), and seven 4-port OC-12c/STM-4 POS Optical Service Modules (OSMs).

The test configuration consisted of port pairing, whereby traffic on one port was matched with one other port. Traffic flowed bi-directionally on the paired ports. For example, the traffic received on port 2/1 was routed to port 4/1, and vice versa. The SmartBits SMB-6000 generated traffic in all the tests. The Script Automation Interface (SAI) scripting language (version 1.11.019) with SmartFlow API, version 2.11.10.02, was also used.

Baseline testing determined the maximum no-drop forwarding rate of the Cisco 7600. This test stressed the frame-handling and packet-buffering on the OSM line cards, the forwarding capabilities of the PFC2, and the switching capabilities of the SFM. The SmartBits Throughput Test was executed for three trials of 30 seconds each.

Packet filter testing demonstrated the effect of packet filtering on the baseline forwarding rate, as well as its effect on latency. In addition to those areas stressed by the baseline testing, this testing stressed the PFC2's filtering capabilities. Using the no-drop rate results of the baseline testing, the SmartBits ran three iterations of the Frame Loss Test for 120 seconds for each IP packet size on the following Cisco 7600 configurations: with no Access Control Lists (ACLs) on any of the 28 OC-12c/STM-4 ports; and with a large ACL (containing 15,000 unique entries) applied in both directions on each of the 28 OC-12c/STM-4 ports. The results contained the average latency of all frames transmitted during the three iterations of the test.

Only the last entry of the ACL permitted the traffic to pass; therefore, each packet had to be compared to all 15,000 entries on the ingress port and again on the egress port. Each ACL entry was defined to deny packets between a specified pair of hosts. Each "deny" entry included a specific host source and destination address, a range of UDP ports and a specific IP precedence value. The SmartBits traffic pattern was configured so that no "deny" entry would match. Only the final entry in the ACL ("permit ip any any ") allowed forwarding of traffic. Therefore, the Cisco 7600 could not permit a packet to forward until all ACL entries had been compared to the packet. We verified this by modifying the last entry to match only a single stream; therefore, that stream was permitted, and all other traffic was dropped.

We also tested processor utilization to demonstrate that the PFC2's forwarding and packet filtering did not affect the MSFC2's control-plane performance or the Supervisor Engine 2's Network Management Processor (NMP). We conducted a SmartBits frame-loss test twice with 40-byte IP packets. The first test did not have the ACL applied to any ports, while the second test had the ACL applied to each port in both directions. We measured NMP and MSFC2 processor utilization with the SNMPc Enterprise Edition, v5.0.11e, from Castle Rock Computer. We polled the processors for their five-second average utilizations and reported the results.

Summary of results

The Cisco 7600 is an optical router targeted for wide-area network (WAN) and metropolitan area network (MAN) applications in which the focus is on high-speed IP services at the edge of a service-provider network.

Each Cisco 7600 incorporates the Supervisor Engine 2 control module, which contains the Policy Feature Card 2 (PFC2) and the Multilayer Switching Feature Card (MSFC2). The Supervisor Engine 2 provides connections to the 32-Gbps bus and the 256-Gbps crossbar switch fabric—allowing classic line cards, such as the FlexWAN module, to be integrated with fabric-enabled line cards such as the Optical Service Modules (OSMs), in the same chassis.

On the Cisco 7600, packet forwarding, packet filtering, and many Quality of Services (QoS) features are implemented in Application Specific Integrated Circuits (ASICs). Having processing done in hardware allows the Cisco 7600 to perform those processes with no effect on processor utilization. In addition, the Cisco 7600 implements distributed IP services in the Parallel eXpress Forwarding (PXF) IP Services Processor contained on the OSM line cards. The PXF IP Services Processor provides high speed processing like ASICs, but is software upgradeable for future IP service delivery.

We designed a series of baseline-forwarding and packet-filtering tests to determine how closely the Cisco 7600's measured throughput came to the vendor's advertised Mpps rate of ~30 Mpps when the product was fully loaded with seven OSMs. (Each OSM supports four ports of OC-12c/STM-4 for a total of 28 ports.) Subsequent tests showed that the Cisco 7600 could perform packet filtering and forward with little or no effect on the router's performance, latency, or ability to transmit packets in sequence. (See Tables 1 and 2 for specific results at various IP packet sizes.)

Table 1: Cisco 7600 – Baseline Throughput (Measured as Forwarding Rate)

IP Packet Size (in bytes)	Actual vs. Max. Theoretical (%)	Forwarding Rate (Mpps)
40	95.6*	28.7
46	95.6*	28.7
64	91.2	26.9
128	99.7	15.5
256	100	7.97
512	100	4.04
1024	100	2.03
1500	100	1.39

**The maximum forwarding rate on the Cisco 7600 is 30 Mpps and the aggregated line rate of 28OC-12c interfaces exceeds that rate for 40- and 46-byte IP packets. The numbers shown represent how close the Cisco 7600 came to the 30-Mpps rate for the 40- and 46-byte IP packet sizes.*

Table 2: Cisco 7600 – Packet Filtering Performance at the No-Drop Rate

IP Packet Size (in bytes)	Throughput (Mpps)		Average Latency (msec)		Frames Lost	Packets out of Sequence
	No ACLs	15K ACL Entries	No ACLs	15K ACL Entries		
40	28.7	28.7	31.7	31.7	0	0
46	28.7	28.7	32.8	32.7	0	0
64	26.9	26.9	34.6	34.7	0	0
128	15.5	15.5	32.2	32.2	0	0
256	7.97	7.97	37.7	37.7	0	0
512	4.04	4.04	42.2	42.2	0	0
1024	2.03	2.03	53.9	53.9	0	0
1500	1.40	1.40	69.7	69.8	0	0

Performance Results – continued

Baseline throughput test results (shown in Table 1, page 3) show that the Cisco 7600 delivered 28.7 Mpps when tested at 40-byte and 46-byte IP packets. (Note: the 46-byte packet size is equivalent to a 64-byte Ethernet frame size.) This is based on traffic being delivered bi-directionally on each of the 28 OC-12c ports. The result is close to the 30-Mpps forwarding rate attainable with the Supervisor Engine 2 architecture.

The Cisco 7600 is targeted to the WAN and MAN service-provider environments in which security is a top concern. The ability to support ACLs—which enable controlled access to critical network applications, data and services—is extremely important.

It's important that a router be able to handle ACLs with minimal impact on performance. This allows the control-plane resources to focus on routing protocol management, a typically CPU-intensive task. To determine whether the Cisco 7600 could support ACLs accordingly, we conducted packet-filtering tests with no ACLs and then again with 15,000 ACL entries. (See "About the testing" for complete details on how the ACL tests were conducted.) Results showed that there was no impact on throughput or latency, whether the Cisco 7600 was tested with no ACLs or implementing 15,000 ACL entries. (See Table 2, page 3, for full results.)

In the packet-filtering tests, only the final entry on the 15,000 ACL list was allowed to forward traffic (on all other entries it was configured to deny traffic). This forced the router to look at the entire list before forwarding traffic.

In another test, we showed that packet forwarding and filtering had no impact on the Cisco 7600's processor utilization. On both the NMP and the MSFC2 processors, utilization peaked at 1 percent when run with and without the ACL feature enabled. (See Table 3.)

Cisco 7600 Internet Router: Key Features

Configuration tested	Nine-slot NEBs-compliant chassis; one Supervisor Engine module; one Switch Fabric Module; seven four-port OC-12c/STM-4 OSMs
LAN interfaces supported	Ethernet, Fast Ethernet, Gigabit Ethernet (10 Gigabit Ethernet planned)
WAN interfaces supported	Leased-line T1/E1 through OC-48c/STM-16; channelized T1/E1 through STM-1 to DS-0; channelized OC-12 through OC-48 to DS-3; ATM T3/E3 through OC-12c; GE WAN
Operating system	Cisco IOS® 12.1E
Redundancy	Redundant Supervisor Engine, switch fabric, and power supplies; SONET APS, SDH MSP
Hot swapping	Supervisor Engine, Switch Fabric, line cards, power supplies
Management	Cisco Element Management Software; Cisco VPN Solution Center; SNMP MIBs and SSH
Price (US list)	Varies widely; starting price for Cisco 7600 router is $12,000; OSMs range from $45,000 to $180,000

Table 3: Cisco 7600: Processor Utilization

IP Packet Size (in bytes)	# ACL Entries	NMP Peak Processor Utllization (%)	MSFC2 Peak Processor Utilization (%)
N/A	Idle	1	1
40	No ACL	1	1
40	15,000	1	1

Processor utilization tests showed that forwarding and packet filtering had no affect on the performance of the Multi-layer Switching Feature Card 2 nor the Supervisor Engine 2 Network Management Processor.

Conclusions

Performance testing conducted by Miercom demonstrated that the Cisco 7600 Internet Router delivers a maximum throughput of 28.7 Mpps, which is near the ~30 Mpps architectural limits of the product. Furthermore, the addition of ACL entries has no impact on performance or latency. We also found that since all processing on the Cisco 7600 is done in ASICs, there is minimal impact (only one percent) on the control of the switch while traffic is filtered and forwarded.

MIER Communications
Performance Verified

Cisco 7600 Internet Router

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