



Lab Testing Summary Report

October 2004
Report 041015

Product Category:
Edge Routers

Vendors Tested:
**Cisco Systems
and
Juniper Networks**

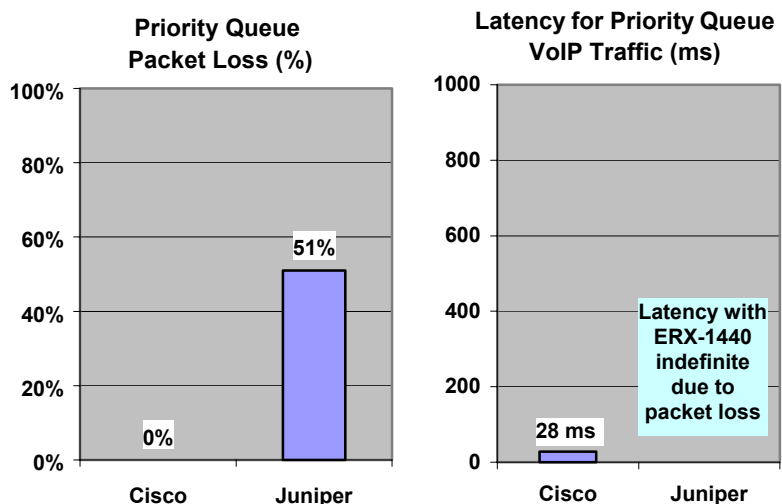
Products Tested:
**Cisco 10000
Series Router
and
Juniper ERX-1440
Edge Router**



Key findings and conclusions:

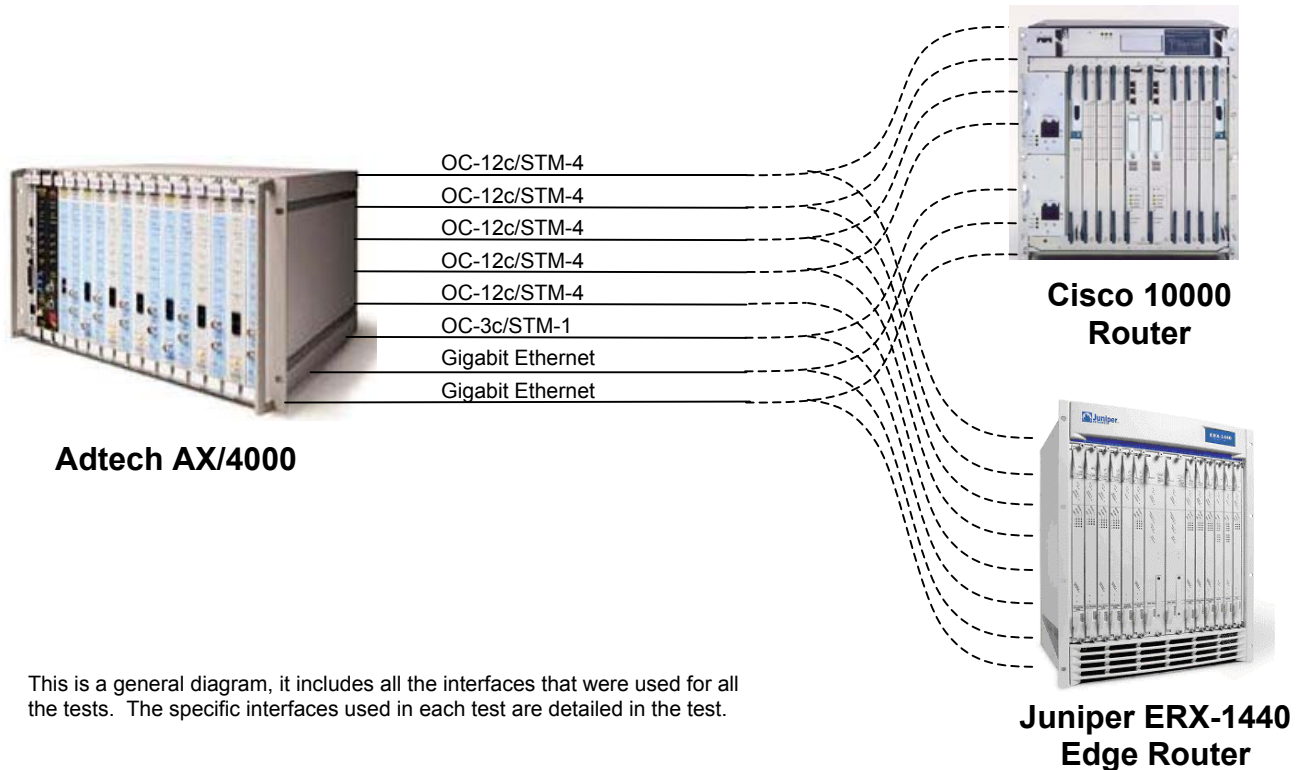
- The Juniper ERX-1440 exhibited 51% packet loss on a VoIP Priority Queue using Hierarchical VP/VC shaping under congested conditions, while the Cisco 10000 Router had no packet loss and low latency
- The Juniper ERX-1440 dropped 83% of high-priority traffic with the OC-12 ATM interface congested with by low-priority traffic, while the Cisco 10000 Router dropped no high-priority traffic
- The Cisco 10000 Router supports 4 times the session capacity and 10 times the call setup rate per ATM line card, as compared to the Juniper ERX-1440
- The Cisco 10000 Router forwards traffic at line rate on OC-12c ATM interfaces, while the Juniper ERX-1440 demonstrated 75% line rate, with basic per-subscriber services turned on
- A single Cisco 10000 Router chassis sustains 61,500 PPPoEoA sessions, while the Juniper ERX-1440 sustains a maximum of 48,000

Cisco Systems engaged Miercom to independently assess its 10000 Series Router in a head-to-head comparison with the Juniper® Networks ERX-1440 Edge Router. Juniper declined to actively participate in the testing. A number of operational and performance aspects were compared in virtually identical test-bed configurations. Our tests showed the Cisco 10000 Router demonstrates better chassis scalability, and performance in many scenarios, compared to the Juniper ERX-1440.



Priority traffic (VoIP) handling with Hierarchical VP/VC Shaping with a Priority Queue for simulated VoIP traffic. For both routers, the VP was congested with "best effort" traffic.

Test Bed Setup



This is a general diagram, it includes all the interfaces that were used for all the tests. The specific interfaces used in each test are detailed in the test.

About the testing ... Great care was taken in the test environment to provide, as much as possible, similar conditions in testing the Cisco 10000 Router and Juniper ERX-1440 Router. The sessions and data streams were created with the same Adtech AX/4000. During the testing, cables were reconnected between tests from the Cisco 10000 Router and the Juniper ERX-1440 Edge Router.

The Cisco 10000 Router was configured with four ATM OC-12c/STM-4, one 4-port ATM OC-3c/STM-1, and two Gigabit Ethernet interfaces. Similarly, the Juniper ERX-1440 was configured with five ATM OC-12c/STM-4 one 4-port ATM OC-3c/STM-1, and two Gigabit Ethernet interfaces. The Cisco 10000 Router was running IOS Version 12.3(7) X11, and the Juniper ERX-1440 Edge Router was running software version JUNOS 5.3.0 release-0.0 [BuildId 2285]. The Adtech AX/4000 ran software versions 4.61.0 and 4.62.0.

The basic configuration of the interfaces for the routers was fairly consistent across the various tests, in most cases some interfaces were not used in some tests. In our Chassis Scaling test, the Cisco used four ATM OC-12c/STM-4 interfaces, while for the Juniper ERX-1440 we needed five ATM OC-12c/STM-4 interfaces and an ATM OC-3c/STM-1 interface (the Gigabit Ethernet interfaces were not needed). In the OC-12c/STM-4 Forwarding Performance test, we loaded 4 ATM OC-12c/STM-4 interfaces on each router, and used 2 Gigabit Ethernet interfaces on each router. The Line Card Subscriber Scaling test focused on only the 4-port ATM OC-3c/STM-1 line card for each router. The ATM CoS Prioritization test used an ATM OC-12c/STM-4 link and a Gigabit Ethernet link on each router. The Hierarchical VP/VC Shaping test used an OC-3c/STM-1 interface and a Gigabit Ethernet interface on each router.

The ATM OC-12c/STM-4, ATM OC-3c/STM-1 and Gigabit Ethernet interfaces from each router were connected, in turn, for each test to the Adtech AX/4000. Except for the configurations of the routers themselves, the testing was controlled and verified from the Adtech AX/4000 GUI. All the sessions established on the routers were created by the Adtech AX/4000; and all sessions and traffic streams were setup and later analyzed using the Adtech AX/4000.

Note: All publicly available documents and materials from Juniper, along with the considerable technical expertise and judgement of the testers, were applied to ensure the Juniper router was appropriately and optimally configured for each test scenario. Juniper declined requests to provide Miercom with direct technical support for this testing.

The Cisco 10000 Router is designed for the large POP environment supporting DSL, ATM and Gigabit Ethernet BRAS applications. The maximum number of sessions, the port performance, and the CoS (Class of Service) and QoS (Quality of Service) handling under numerous conditions were tested.

Hierarchical VP/VC shaping with a Priority Queue was tested simulating how a VoIP stream could be prioritized at the session level when the Virtual Path was congested. ATM CoS prioritization demonstrated high-priority VBR shaping with IP traffic when the ATM link was congested with lower-priority UBR traffic. The VBR traffic for each router was examined to see if it was preserved under congested conditions. The forwarding rates for OC-12c/STM-4 ports were tested and compared between the two routers. The maximum number of supported PPPoEoA sessions (Point-to-Point Protocol, over Ethernet, over ATM) was determined, for the chassis overall and per line card. The rate at which these sessions could be established was also examined.

Hierarchical VP/VC Shaping for Voice

In a test we call “Hierarchical VP/VC shaping,” the Cisco 10000 Router and Juniper ERX-1440 router were configured with an OC-3c/STM-1 interface, and a Gigabit Ethernet interface, over which data load was delivered.

We created a VP (virtual path) shaped at 10 Mbps, configured on the OC-3c/STM-1 interface. Then, within the VP, we created a control VC, with a shaping rate of 1 Mbps. In addition to this control VC, 199 additional VCs were created to carry best effort traffic, also with a shaping rate of 1 Mbps. This results in an over-subscription rate of 20:1. The control VC was configured with a priority queue (PQ).

The Adtech AX/4000 sent one flow, a simulated VoIP connection, on the priority queue at a rate of 100 Kbps, with 80-byte packets (about 78 pps). Then the Adtech was configured to send about 75Kbps on each of the 199 “best effort” queues. This “best effort” traffic (total of 15 Mbps on the VP) when launched created a congested VP.

The test determined whether the traffic in the priority queue (the simulated VoIP connection), could be properly preserved, when its VP was congested. We found that while the OC-3/STM-1 link could handle the total load as the VP congested, priority traffic was dropped.

The latency and packet loss for the priority queue traffic were measured to ascertain whether the Priority Queue (the VoIP traffic) was preserved under VP congestion.

The results (see page 1) show that the Cisco 10000 Router could maintain a 100% forwarding rate for the priority queue traffic, while maintaining acceptably low latency for this high-priority queue. The ERX was unable to preserve the Priority Queue traffic and 51% of the traffic was lost.

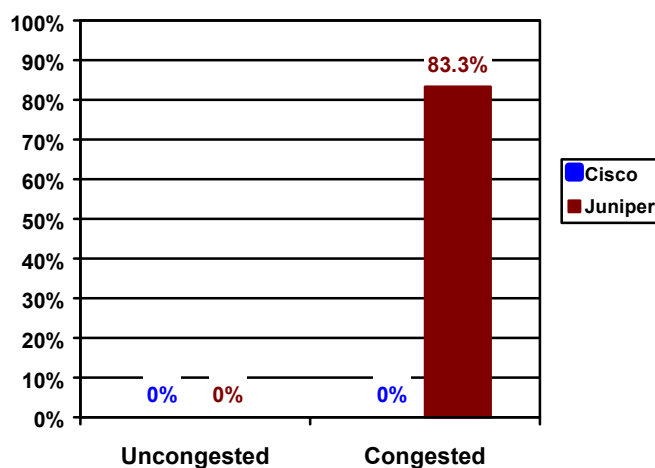
We noted, too, during this testing that only Port 0 out of the 4 available ports on a given Juniper ERX-1440 4-port ATM OC-3c/STM1 ATM line card could be configured for Hierarchical VP/VC traffic shaping.

ATM CoS Prioitization

We ran tests to determine the ATM Class-of-Service (CoS) capabilities of the Cisco 10000 Router and Juniper ERX-1440 router. The Adtech AX/4000 constructed the same set of sessions for the two routers: 4400 subscriber sessions were created, 4000 of which were established on UBR PVCs (with no PCR value) while the remaining 400 used VBR-nrt PVCs (with Peak and Sustained Cell Rates, PCR and SCR values of 512 Kbps each). The UBR PVCs were used to congest the ATM interface and test the effects on the priority VBR-nrt PVCs.

The test was initially run with only VBR-nrt traffic (500 Kbps per VC). We confirmed that no cells were dropped by either router in this environment (no congestion). Then the UBR (200 Kbps per VC) or “best effort” traffic was added to the VBR traffic load. This simulated a congested situation – a situation commonly faced by service providers, who offer premium, priority service for improved profitability.

High-priority Traffic Packet Loss (%)



The test results (see graph above) demonstrate that when the link is uncongested all the VBR traffic is forwarded by both routers. Under congestion, high-priority traffic was unaffected on the Cisco 10000 Router, while the Juniper ERX-1440 dropped over 83% of this high-priority traffic.

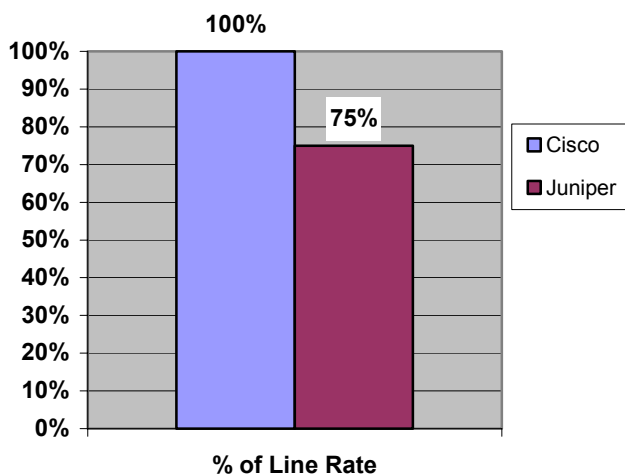
ATM OC-12c/STM-4 Forwarding Performance with Subscriber Services

We measured both routers' ability to forward at line rate downstream on the ATM OC-12c/STM-4 link with per-subscriber services enabled.

For this test we configured four ATM OC-12c/STM-4 links on both the Cisco 10000 Router and the Juniper ERX-1440. The Adtech AX/4000 sent traffic via the two GigE links (with each GigE mapped to two ATM OC-12c/STM4 links for the downstream traffic). The GigE interfaces were configured to send 706,416 packets per second using 40-byte IP packets, which equates to full ATM OC-12c/STM-4 bandwidth (after taking into account the appropriate overhead). During the test we were measuring the routers' forwarding performance of the ATM OC-12c/STM-4 links for downstream data delivery to subscribers, which is the heavy traffic forwarding direction in residential broadband environments.

For this testing the routers were configured to deliver three per-subscriber services. The first was "rate-limiting," which is very popular with service providers. "Rate-limiting" was merely enabled as a service with a rather large value of 1Gbps to ensure that no traffic was dropped due to rate-limiting. The second service was Access Control Lists (ACLs). The ACL list contained seven specific IP subnets that did not match any of the test streams to "deny" and an eighth, which permitted all remaining traffic. Again the idea was to ensure that no traffic was dropped due to ACLs.

Maximum Forwarding Rate on ATM OC-12c/STM-4 link with Per-subscriber Services



The third per-subscriber service was "Unicast Reverse Path Forwarding Check," also known as "Source Address Validation" which is becoming increasingly popular for per-subscriber security purposes. The source address of an incoming packet is checked against the routing table to see if a route exists for the address out the same interface that the packet was received on.

This is used to verify the correct address of subscribers to prevent a subscriber from "spoofing" a valid address to gain access to secured network resources.

The test results show that with 100% load, the Cisco 10000 Router continued to forward all packets, filling the ATM OC-12c/STM-4 links, while the Juniper ERX-1440 began dropping packets, sustaining just over 75% of each of the ATM OC-12c/STM-4 links' capacity. The ability to fill high-capacity links becomes even more important when such links are carefully provisioned by the provider to deliver different "classes" of service – such as "priority" versus "best effort" traffic. This was the focus of other tests we ran, discussed earlier in this report.

ATM OC-3/STM-1 4-port Line Card Session Scaling and Call Setup Rate

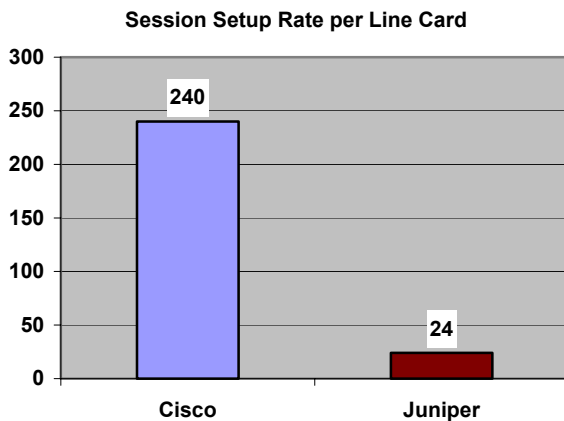
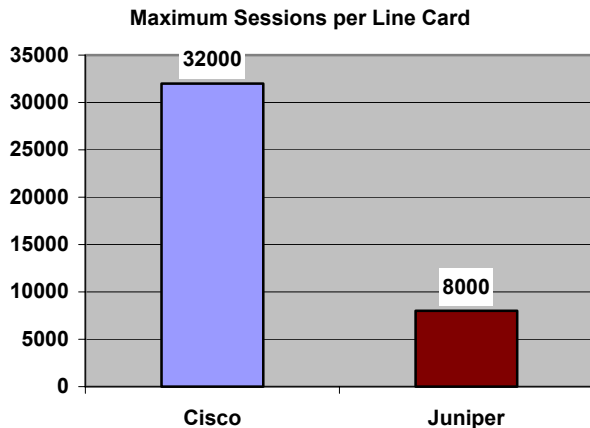
Tests were run to evaluate the scaling of PPPoEoA (Point to Point Protocol over Ethernet over ATM) sessions on a single 4-port ATM OC-3c/STM-1 line card, which we installed in both the Cisco 10000 Router and the Juniper ERX-1440.

The Adtech AX/4000 was reconfigured for this test to provision four ATM OC-3c/STM-1 links to each of the four ports on the routers' ATM OC3c/STM-1 Line Card.

We first tested the Juniper ERX-1440, establishing 8,000 PPPoEoA sessions on the first ATM OC-3c/STM-1 port. These sessions were established at a rate of about 24 sessions per second.

We then moved to the next ATM OC-3c/STM-1 port on the ERX-1440. However, all attempts to set-up additional sessions on this port, and the other remaining two ports on the module, failed. This process verified that a maximum of 8,000 sessions are supported per four-port ATM OC-3 line line module in the Juniper ERX-1440.

We then moved to the Cisco 10000 Router and similarly established 8,000 sessions on the first ATM OC-3c/STM-1 port on the line card. But we were also able to establish an additional 8,000 sessions on each of the remaining ports, a total of 32,000 sessions on the same line card. These sessions were established at a rate of 240 sessions per second. No connection failures were noted.



The results of this test show that the Juniper ERX-1440 supports a maximum of 8,000 sessions per line card, while the Cisco 10000 Router supports 32,000 sessions on a single 4-port ATM OC-3c/STM-1 line card. We also noted, while creating sessions on the two routers, that the Cisco 10000 Router could establish sessions at a much faster rate than the Juniper ERX-1440. The Cisco router set-up sessions at a rate of 240 sessions per second; the Juniper created sessions at a 24 sessions-per-second rate.

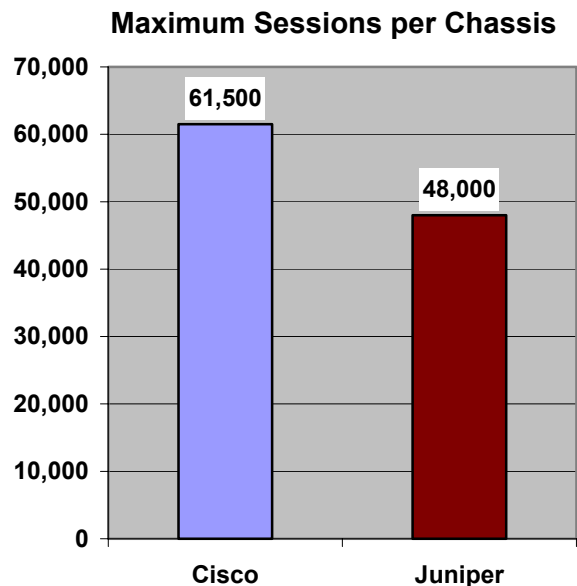
This difference in session-set-up time could affect the recovery time before full service is available after an outage. In a real-world situation, if there were an outage, most subscribers would seek to reconnect at nearly the same time.

Chassis Scaling

To test the maximum number of PPPoEoA (Point to Point Protocol over Ethernet over ATM) sessions supported by the ERX-1440 six line cards had to be installed. We used five ATM OC-12c/STM-4 line cards and one 4-port OC-3c/STM-1 line card. We determined that there is a limitation of 8,000 sessions per Line Card and the chassis (overall) is licensed at a maximum of 48,000 simultaneous interfaces. With this in mind, we configured the Adtech AX/4000 test system to build 8,000 sessions on each of the six line cards.

Cisco recommends that users of the Cisco 10000 Router not exceed 61,500 sessions for a single chassis. In our test we configured the Adtech AX/4000 to build 15,375 sessions on each of four ATM OC-12c/STM-4 line cards.

Our testing verified the maximum 48,000 sessions for the Juniper ERX-1440 Edge Router. We installed the maximum-size license, for 48,000 simultaneous interfaces, and were able to establish 47,997 sessions. The difference is because we configured each of two Gigabit Ethernet interfaces and the management interface with an IP address. The result was 48,000, minus three. We confirmed that, when we attempted to establish 48,000 sessions, the build of the last three sessions failed.



Our testing verified that the Cisco 10000 Router was able to build 61,500 PPPoEoA sessions over four ATM OC-12c/STM-4 line cards. We did this by spreading the session count out over the four line cards, by establishing 15,375 sessions on each line card.

Miercom Verified Performance

Based on Miercom's examination of these systems' configuration, operation and features, as described herein, Miercom hereby attests to these findings:

- The Cisco 10000 Router can support Hierarchical Scheduling for priority traffic shaped at VP, VC and PQ levels. With test VoIP traffic at the priority queue, and a congested VP, the Juniper ERX-1440 had 51% packet loss and the Cisco had no packet loss and low latency.
- The Juniper ERX-1440 dropped 83% of high-priority traffic with the OC-12 ATM interface congested with by low-priority traffic, while the Cisco 10000 Router dropped no high-priority traffic
- A single 4-port ATM OC-3c/STM-1 Line Card on the Cisco 10000 Router can support 32,000 subscriber sessions and 10 times the call setup rate, compared to a maximum of 8,000 sessions for the ERX-1440.
- Running basic per-subscriber services, the Cisco 10000 Router can forward traffic at line rate on ATM OC-12c/STM-4 interfaces. The Juniper ERX-1440, running the same services, forwarded about 75% of line rate
- The Cisco 10000 Router chassis can establish 61,500 PPPoEoA sessions, compared to a maximum 48,000 sessions for the Juniper ERX-1440 chassis.



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