

## Lab Testing Summary Report

June 2004  
Report 040621

Product Category:  
**Core and Edge  
Routers**

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

Products Tested:  
**Cisco 12810  
Router and  
Juniper T640  
Routing Node**

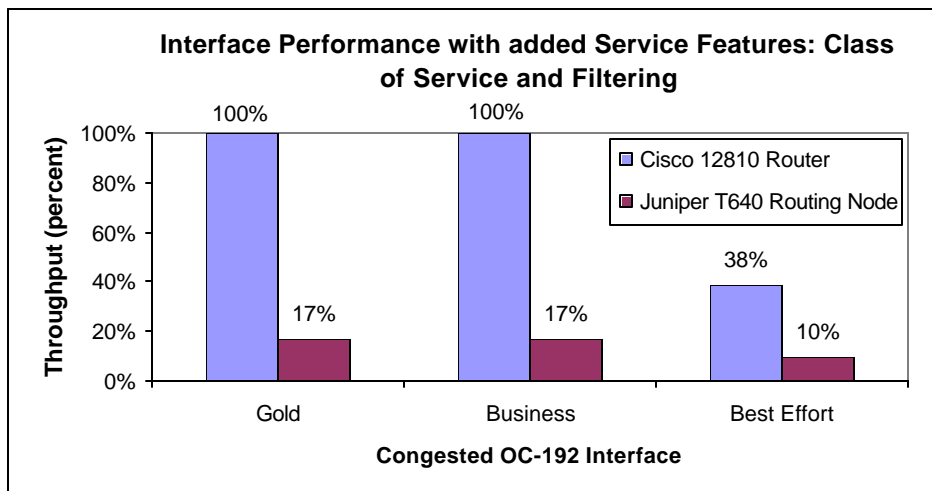


### Key findings and conclusions:

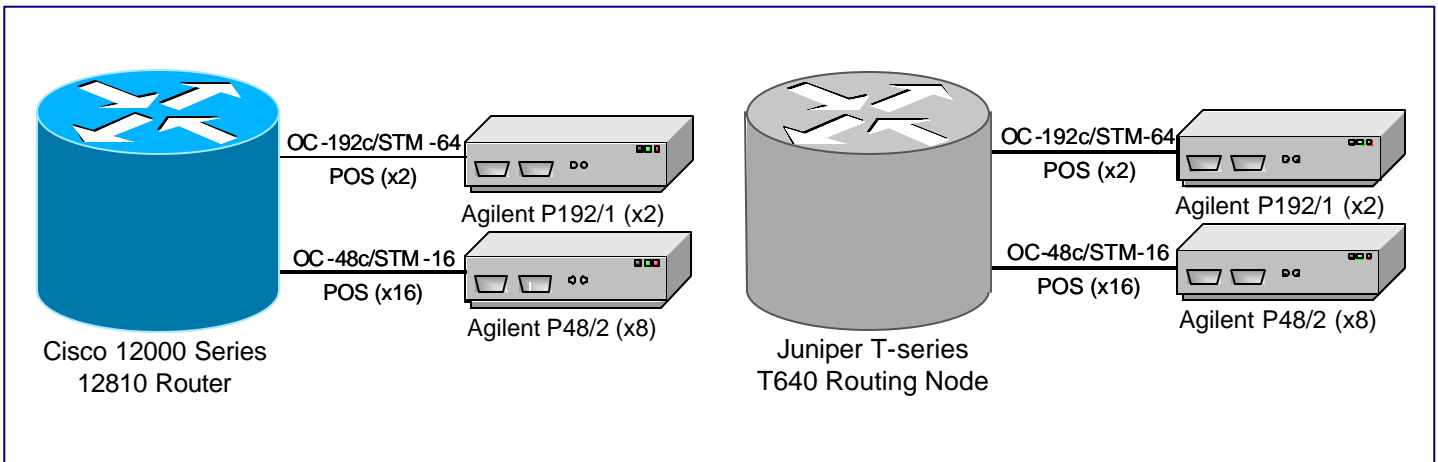
- Only the Cisco 12810 router delivered 100% throughput for real-world tests that include Class-of-Service (CoS), interface filter lists and multicast features
- With a 10-entry filter list, the Juniper T640 routing node dropped throughput to less than 50% of the offered load
- In Class-of-Service tests the Cisco 12810 predictably delivered “priority” traffic, while the Juniper T640 dropped packets in every class
- The Juniper T640 dropped to below 65% of the offered load in multicast tests; the Cisco 12810 delivered 100%

Cisco Systems engaged Miercom to independently assess its 12810 router in a head-to-head comparison with the Juniper Networks T640 routing node. Juniper declined to actively participate in the testing. Performance measurements showed the Cisco 12810's ability to enforce a strict service-level agreement (SLA), while adhering to typical security settings, and forwarding traffic from one to many destinations. Most noteworthy among the findings is the Cisco 12810 router's consistent throughput while under load, unlike Juniper's T640 routing node. Reliability on the Cisco 12810 was demonstrated when employing class-of-service (CoS) queues, interface filter lists, or multicast.

Each router was first baseline tested with basic connectivity settings. As each service feature was enabled router throughput, latency, and packet sequence were carefully measured. The Cisco 12810 router delivered predictable, 100% throughput as each service feature was enabled. Unfortunately when adding CoS queues, as well as a 2,000-entry filter list, serious throughput degradation was caused to Juniper's T640, as seen below. The Cisco 12810 performed as expected, delivering reliable throughput for each Class of Service. This real-world test of SLA enforcement shows that the Cisco router offers consistently predictable performance that is vital for service providers to offer premium services.



## Test-bed Setup



**About the testing...** Cisco Systems presented the Cisco 12810 router (IOS version 12.0(27)S2) for testing versus Juniper's T640 routing node (JUNOS version 6.3R1.3). Agilent P48/2 and P192/1 appliances, both running RouterTester version 5.1.100.4, were used to generate unicast and multicast traffic loads, inject routes, and measure throughput, latency, and packet sequencing. There were a total of eight P48/2 appliances, which provided 16 OC-48c/STM-16 POS interfaces. Two P192/1 appliances provided two OC-192c/STM-64 POS interfaces. HDLC encapsulation was used over all of the POS links. The intended throughput for every interface never exceeded 98.2-percent, to prevent "HDLC bit stuffing" from affecting the measurements, except for the class-of-service tests, which required a congested interface. Therefore, either system under test that achieved 100-percent of the offered load, or approximately 98.2 percent, was considered to perform at 100-percent throughput. All streams ran for 30 seconds. With the multicast testing, test traffic ran for 30 seconds after all receivers had joined all groups.

The Cisco 12810 serviced the 16 OC-48c/STM-16 interfaces on two 8 Port ES Packet Over SONET OC-48c/STM-16 linecards with SFPs that resided in the first two slots of the chassis. The third slot has used for a 2 Port ES Packet Over SONET OC-192c/STM-64 Single Mode/SR linecard with SC connectors, which serviced the two OC-192c/STM-64s. The Juniper T640 serviced the 16 OC-48c/STM-16 interfaces on four 4x OC-48 SONET, SMSR PICs of which two resided in FPC 1. The other two were held in FPC 4 along with two 1x OC-192 SM SR2 PICs serviced the two OC-192c/STM-64s.

To provide a fair testing environment, both routers were configured in the same manner. This base configuration included BGP-4 peering between all Agilent and device-under-test (DUT) ports, totaling 18 peers. The RouterTester injected 10,000 routes across each peering session, thus creating a total of 180,000 unique routes. These routes were used to generate the unicast traffic streams to the peers' 10,000 routes.

The ingress and egress filter testing was baselined using bi-directional traffic in a mesh of all OC-48c/STM-16s and between the two OC-192c/STM-64s. Then ten ingress filters were applied to all interfaces. Next, ten filters were added on the egress of each interface. Finally, 2,000 filters were applied to ingress and egress on each interface.

For the CoS portion of the test, three classes were defined. "Gold" had the highest priority, with a type-of-service (ToS) value of 5, "Business" had the next highest priority with a ToS value of 1, and "Best-effort" traffic had the lowest priority with a ToS value of 0. Unicast "best-effort" traffic was generated from the OC-192c/STM-64 links to the OC-48c/STM-16 links at 81.2-percent throughput. Unicast "best-effort" traffic was also sent from all OC-48c/STM-16 links to an OC-192c/STM-64 each at 48.2-percent throughput. Every OC-48c/STM-16 link generated traffic of each class to another OC-192c/STM-64. "Gold" traffic was sent at 14-percent of the OC-192c/STM-64's throughput, "business" traffic was sent at 28-percent of the OC-192c/STM-64's throughput, and "best-effort" traffic was sent at 152.4-percent of the OC192's throughput.

Multicast performance was tested using PIM Sparse Mode and a single source for 500 groups that were defined on the first OC-192c/STM-64, which generated 23.2-percent throughput of multicast traffic as well as 74-percent of unicast traffic. All other interfaces were receivers for the multicast traffic and the second OC-192c/STM-64 received all unicast traffic.

## Baseline

Before any service features were enabled, baseline measurements were taken on both routers to provide a point of comparison for later tests. Both the Cisco 12810 and the Juniper T640 routers achieved 100-percent throughput on OC-48c/STM-16 and the OC-192c/STM-64 interfaces. They both also had average latencies below 22 microseconds for OC-48c/STM-16 links and 18 microseconds for OC-192c/STM-64 links.

Despite both systems having reasonable average latencies, the Juniper T640 demonstrated out of sequence packets. In our tests 25 percent of all packets traversing the OC-192c/STM-64 links were out of sequence. Depending on the network environment, this can disrupt real-time traffic and cause significant retransmissions, thus adding considerable delay to TCP connections.

## Interface Filtering

As denial-of-service (DoS) attacks proliferate and such traffic-generation exploits occur more frequently, network equipment has to be able to provide defensive measures against such malicious acts. However, certain security features, such as filter lists, may actually hinder the performance of legitimate traffic, creating a self-induced, though unintentional, DoS attack.

Filter lists can permit or block traffic based on IP addresses, protocols, or TCP/UDP ports, separately or in combination. Filters can be applied on an interface's ingress or egress traffic, or on both directions. Both the Cisco 12810 router and the Juniper T640 routing node were tested using these filters in three configurations.

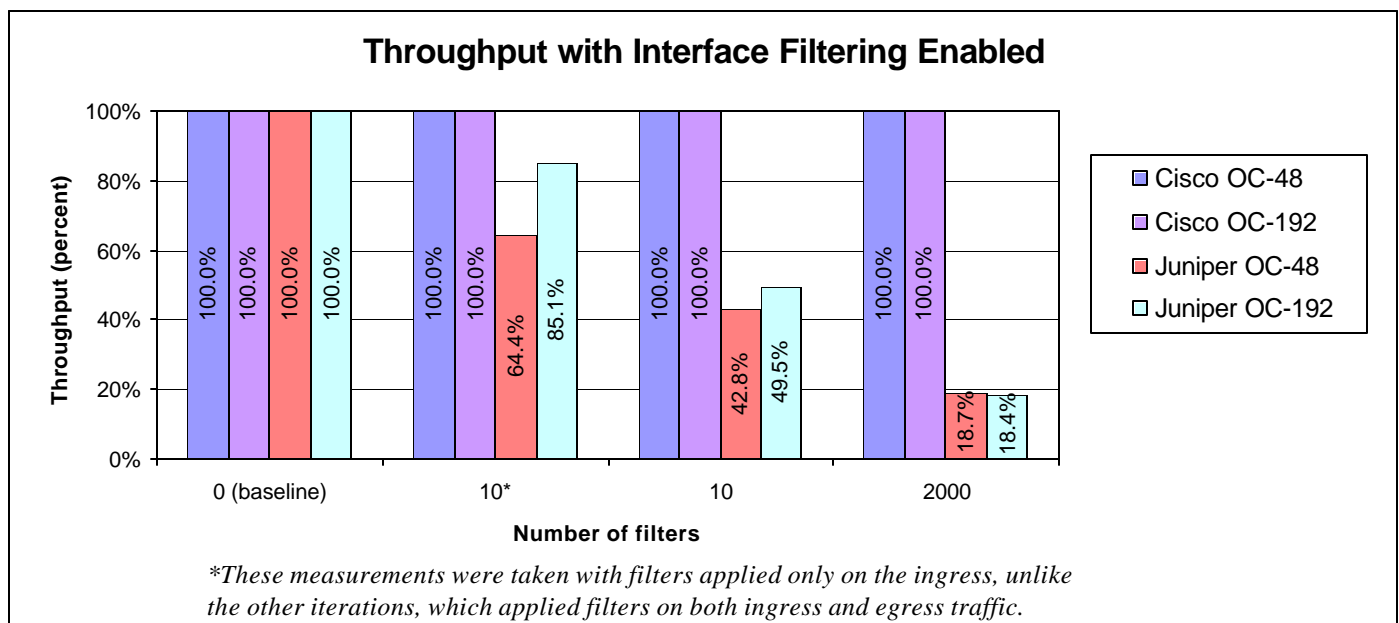
First, ten filters were applied to only the ingress traffic on every interface, which is typically less than standard production network deployments. In this configuration, the Cisco 12810 maintained the 100-percent throughput seen in the baseline measurements (see graph below). The Juniper T640 suffered a drop of 35.6 percent for traffic traversing the OC-48c/STM-16s and a drop of 14.9 percent for the OC-192c/STM-64s.

When the same ten filters were applied to ingress

and egress, Juniper's T640 dropped throughput on the OC-48c/STM-16s 57.2 percent. The T640's OC-192c/STM-64's met a similar fate and dropped throughput 50.5 percent. Meanwhile, Cisco's 12810 continued the 100-percent throughput recorded in the baseline for both interface types.

The number of filters applied to the ingress and egress of all ports was increased to 2,000, not an entirely uncommon number of filters for service provider routers. Inline with the previous tests the Cisco 12810 kept throughput at 100-percent, which is in stark contrast to the Juniper T640 measurements. Neither the OC-48c/STM-16 nor OC-192c/STM-64 interfaces on the Juniper T640 exceeded 18.7-percent throughput.

The Juniper T640 exhibited average latencies that were nearly triple Cisco's 12810, up to 62.72 microseconds for the OC-192c/STM-64s. The OC-48c/STM-16 interfaces of the T640 held an average latency of 60.8 microseconds. Out-of-sequence packets continued to plague the Juniper T640's OC-192c/STM-64 interfaces, increasing to 28.2 percent from the baseline measurement of 24.5, possibly due to the packet loss. The Cisco 12810's had no out-of-sequence packets.

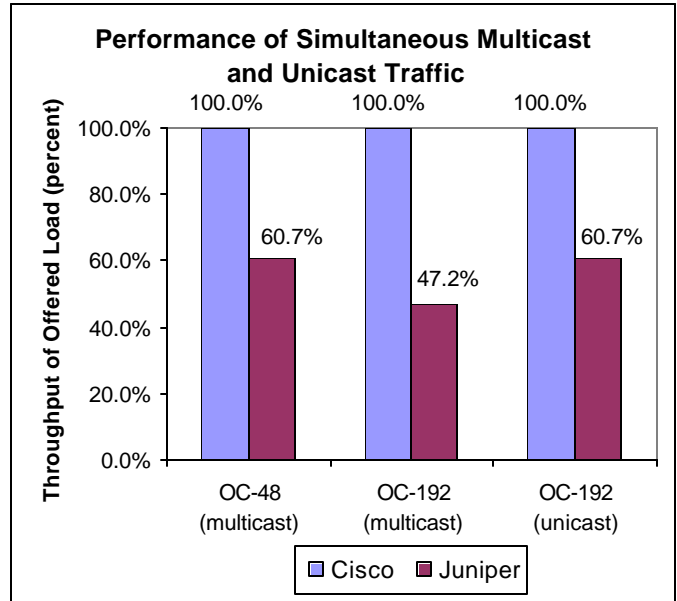
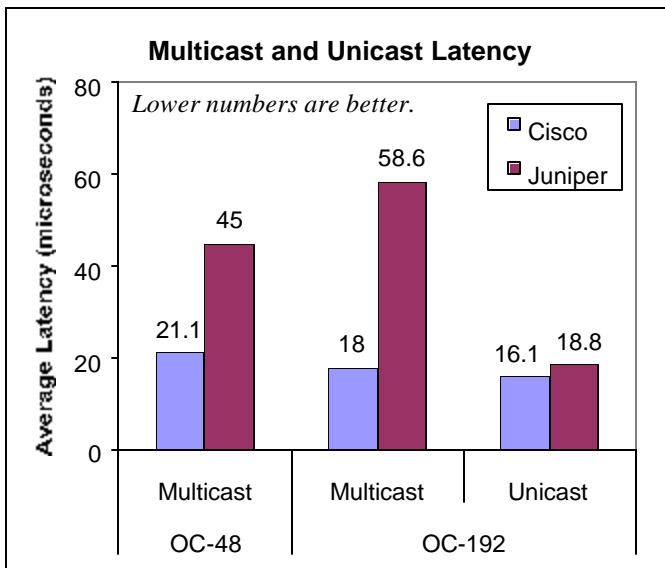


## Multicast

Multicast is known as a transmission technique for dispersing video, from a single source to the masses. But multicast use has spread to numerous other one-to-many business environments, and it is now an important feature of all core and edge routers. The replication of multicast traffic to many receivers can be taxing to the router, but even so, multicast should not appreciably degrade performance, or render it less predictable than the router's unicast traffic performance.

Both the Cisco 12810 router and the Juniper T640 routing node acted as a Rendezvous Point (RP) for a single source of 500 groups and the 17 receivers, which joined each group. They also both passed unicast traffic from the same interface that sourced the multicast traffic, an OC-192c/STM-64 interface, to the other OC-192c/STM-64. However, the two router's performance results were not the same.

The Cisco 12810 achieved 100-percent throughput on the OC48 receiving interfaces for the multicast traffic and 100-percent throughput of the offered load for unicast traffic. On the other hand, the Juniper T640 peaked out at 60.7-percent throughput for the OC-48c/STM-16 multicast receivers. The T640's OC-192c/STM-



64 multicast streams did not exceed 47.2-percent of the offered load. The Juniper T640 delivered the poorest average latencies for all traffic types and across all interfaces (see graph below). However, the Juniper T640's packet loss is of the greatest concern for services like pay-per-view, which would experience choppy audio and video.

Instead of the approximate 25 percent of misordered packets from previous tests, the T640 had misordered packets in the magnitude of 45.8 percent across the receiving OC192 interface for multicast traffic and 15.7 percent for the unicast traffic.

## Class-of-Service

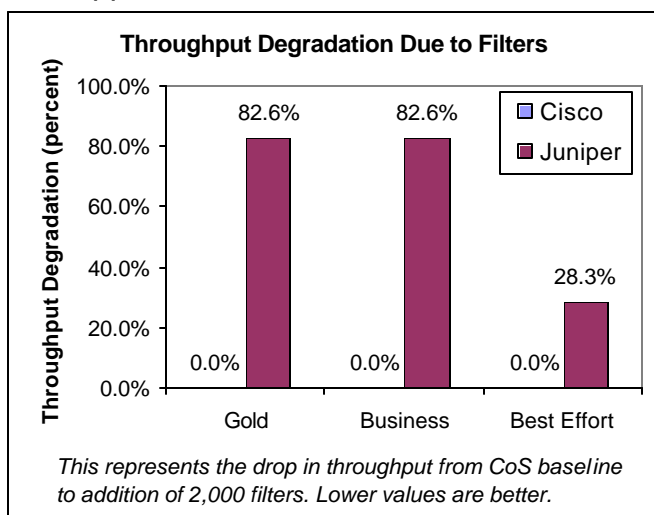
Service level agreements have become standard fare for service providers and are crucial for edge and core routers. This is an area where the strictest predictability plays a critical role and class-of-service features are required to deliver this premium service. CoS queues are typically created and assigned to traffic types or specific interfaces. These queues are given priorities and in times of network congestion, queues with higher priorities are services first to make sure traffic gets to its final destination.

## Class-of-Service (cont.)

The routers were configured with three priorities: gold, business, and best effort. “Gold” traffic should have the lowest latency and at no point have packet loss. Streams prioritized as “business” will only be dropped for the benefit of “gold” traffic, although our traffic rates would not induce any drop in the “business” class. Finally, “best-effort” traffic should be the first to be dropped to facilitate the delivery of “gold” and “business” traffic.

Baseline measurements, without any filters, were taken using a congested OC-192c/STM-64 interface that was induced at a load of 173.4 percent. The Cisco 12810 performed as expected and did not drop any packets that were considered “gold” or “business” class and dropped those necessary in the “best-effort” class. However, the Juniper T640 was close behind with 0.2-percent packet loss in both the “gold” and “business” classes.

Beyond the baseline degradation we saw a significant drop as interface filters were added. In the same fashion as the filter-specific tests, ten filters were added to ingress and egress traffic across the OC-192c/STM-64 interfaces and measurements were taken again. This time the Juniper T640 dropped packets in every class of traffic including “gold”. “Gold” and “business” traffic had almost 58 percent of all packets dropped. This only worsened when more filters were applied.



### Effects of CoS on Uncongested Interfaces

	Cisco	Juniper
Throughput (percent)	100.0%	87.7%
Average Latency (microseconds)	34.5	4122.4
Misordered Packets (percent)	0.0%	1.7%

*This data applies to an uncongested OC-192c/STM-64 interface.*

When the number of filters was increased to 2,000, Juniper’s T640 dropped 82.8 percent of the traffic in the “gold” and “business” classes. Only 9.6 percent of the “best-effort” traffic passed in comparison to the non-filtered traffic measurement of 37.9 percent. This packet loss would directly cause revenue loss due to an inability to preserve an agreed upon SLA.

The Juniper T640’s degradation in performance was actually the worst for “gold” and “business” traffic (see graph below). This is the opposite of the intention of CoS queuing as well as the performance noted on the Cisco 12810.

During all these tests, Cisco’s 12810 router maintained consistent and expected throughput for all classes in the presence or absence of filters.

Surprisingly, performance of an uncongested OC-192c/STM-64 interface was affected on the Juniper T640 (see table above). The traffic traversing an uncongested interface should not be affected by congestion on another interface. This is more harmful than a single congested interface with poorly enforced CoS priorities. Throughput, which should be 100-percent, held on at 87.7-percent on the T640’s uncongested OC-192c/STM-64. Cisco’s 12810 maintained 100-percent throughput on the same interface and had a much lower average latency of 34.5 microseconds in comparison to the T640’s 4122.4 microseconds.

## Conclusion

The Cisco System 12810 router performed 100% as expected and advertised, even as critical service features were enabled such as filtering, multicast, and Class of Service. The Cisco 12810 demonstrated predictable performance with multiple features enabled, while under load, in secure-conscious, one-to-many, and service-level-agreement-sensitive network environments. The Juniper T640's unpredictable performance in the same tests present issues that should be of serious concern, especially to service providers.

In the unanimous opinion of the Miercom testing staff, Cisco Systems 12810 router has been shown to perform in a reliable, predictable manner, while enforcing strict service level agreements, delivering high volumes of multicast traffic, and supporting interface filter lists with thousands of entries. Conversely, under the exact same conditions and during the same period of testing, Miercom testing staff witnessed an unreliable and unpredictable level of performance from the Juniper T640 routing node.



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