WHITE PAPER

MIDRANGE MX SERIES 3D UNIVERSAL EDGE ROUTERS EVALUATION REPORT

Demonstrating the high performance and feature richness of the compact MX Series

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Executive Summary

Juniper Networks MX5, MX10, MX40 and MX80 3D Universal Edge Routers create a scalable and flexible upgrade path for growing enterprise or service provider needs. Extending the battle-hardened capabilities of Juniper Networks MX Series 3D Universal Edge Routers (MX240, MX480 and MX960) from service provider networks to the enterprise, MX Series midrange routers are designed to provide the 3D scaling necessary to address today's advanced Ethernet requirements even in the smallest of environments.

Juniper Networks conducted a range of tests to demonstrate the capabilities of the MX80 and the MX Series midrange router portfolio. This testing expanded on the service provider focused test (www.juniper.net/us/en/local/pdf/validation-reports/eantc-mx-marketing-report.pdf) Juniper commissioned with the European Advanced Networking Test Center (EANTC) on the MX80, MX480 and MX960. This paper provides a preview of the MX80 router's functional maturity, leading performance, and scale for typical enterprise services involving deployments such as the WAN core, campus core, data center interconnect, Internet edge, and WAN aggregation. This testing does not stress the box to its theoretical limit in all areas, but it is relevant to enterprise applications, and it validates the midrange MX Series capabilities in the following areas:

- Platform forwarding performance and scalability
- Service resiliency of the recommended solution
- Functional demonstration of midrange MX Series routers for typical enterprise applications

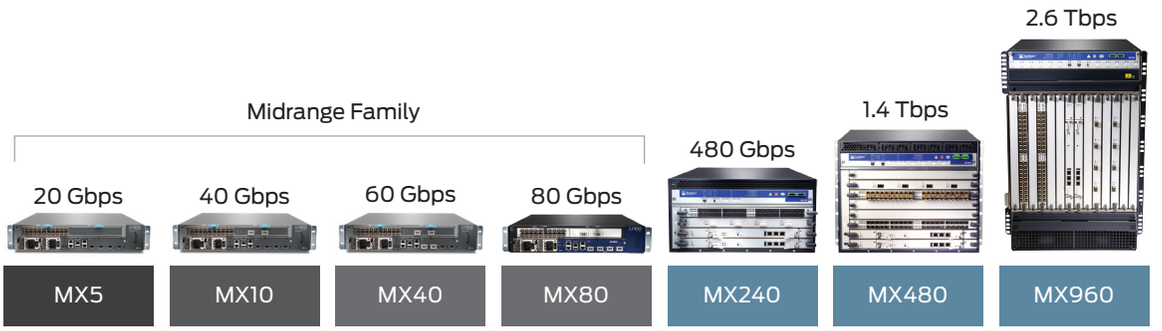

Figure 1: Midrange MX Series routers

Introduction

Juniper's universal WAN is comprised of several compact form factor additions to the **MX Series routing portfolio**[1]. Based on Juniper Networks Junos® Trio chipset, these additions include the carrier class MX5, MX10, and MX40 3D Universal Edge Routers, optimized to deliver new levels of scalability and performance in a compact, "pay as you grow" platform.

The latest additions to the MX Series can scale up to the full functionality of an MX80—the industry's most powerful compact edge router—without a chassis change, using software license upgrades (see Table 1 below).

Table 1: New Additions to MX Series Routing Portfolio with Easy Upgradability

MIDRANGE ROUTER	FIRST MIC SLOT	SECOND MIC SLOT	10GBE PORT	SOFTWARE LICENSE UPGRADEABLE
MX5	✓	X	X	✓
MX10	✓	✓	X	✓
MX40	✓	✓	✓ (2)	✓
MX80	✓	✓	✓ (4)	N/A

The MX5, MX10, MX40, and MX80 provide full featured routing capabilities in a compact form factor (2RU) based on the Junos Trio chipset. The MX Series midrange routers are state of the art for WAN edge, Internet edge, data center aggregation, data center interconnect, and the campus core. Because of their advanced functionality and design, these midrange routers are ideal for all enterprise applications requiring high performance and high scale.

MX80 Highlights

- Density, throughput, and scale: 70 Gbps and 55 Mpps in a compact form factor 2RU router
- Up to 8 ports of 10GbE, or 40 x GbE and 4 x 10GbE ports

Testing Highlights

- IPv4 and IPv6 forwarding performance (70 Gbps and 55 Mpps sending traffic to 1.6 million IPv4 and IPv6 routes)
- Multicast replication (3,500 multicast receivers over 500 multicast groups)
- Large-scale services support for L3VPN and virtual private LAN service (VPLS) (500 L3VPNs and 500 VPLS instances)
- Generic routing encapsulation (GRE) tunnel scale (1,000 GRE tunnels)
- Large media access control (MAC) address table (500,000 MAC addresses)
- Fast MAC learning rate (40,000 per second)

The MX80 model has the highest 10GbE and 1GbE port density of any enterprise router in its class. MX Series routers for the midrange are capable of forwarding 70 Gbps of full duplex traffic, and the packet processing rate is 55 Mpps. The intent of performing these tests was to highlight the scalability and forwarding performance of the MX Series midrange routers and to demonstrate their advanced functionality in various applications. All of the test cases in this report utilize the modular MX80 chassis with four fixed 10GbE ports and two 2-port 10GbE Modular Interface Cards (MICs) for a total of eight 10GbE ports for testing.

Multiple tests were completed to demonstrate the MX80's functional maturity and processing power. The range of tests conducted were based on typical enterprise customer requirements and included:

- Forwarding performance—IPv4 unicast, IPv6 unicast, and mixed IPv4 and IPv6 throughput testing
- Multicast testing
- Mixed unicast and multicast testing
- L3VPNs and VPLS functionality at large scale
- MAC address scalability and MAC learning
- GRE tunneling and performance at large scale

Test Scenarios

IPv4 and IPv6 Forwarding Performance

Forwarding table capacity and throughput are two important routing factors that both service provider and enterprise customers benchmark to ensure investment protection against growing bandwidth and service requirements. Support for large-scale route tables is critical for both IPv4 and IPv6 in dual-homed or multi-homed scenarios to receive multiple BGP feeds from different Internet service providers (ISPs), for example for an Internet edge router. Route scalability is also important when Layer 3 virtualization is achieved with MPLS VPNs in the case of WAN core and data center interconnect applications.

This test measured the IPv4 and IPv6 forwarding performance with large-scale BGP routes on the MX80 using the RFC2544 test methodology. Figure 2 shows the simulated network with internal and external BGP (EBGP and IBGP) peers advertising 1 million IPv4 prefixes and 640,000 IPv6 prefixes. A full traffic mesh is created between all of the 10GbE ports (traffic from one port to every port) to all BGP route destinations, thereby exercising complete forwarding table lookup. The test was performed for a range of packet sizes (per RFC2544) for frame lengths—64, 128, 256, 512, 1,024, 1,280, 1,518, and IMIX[2].

[1] MX Series 3D Universal Edge Routers include the MX80, MX240, MX480, and MX960. Latest additions include the MX5, MX10 and MX40. More details at **www.juniper.net/us/en/products-services/routing/mx-series**.

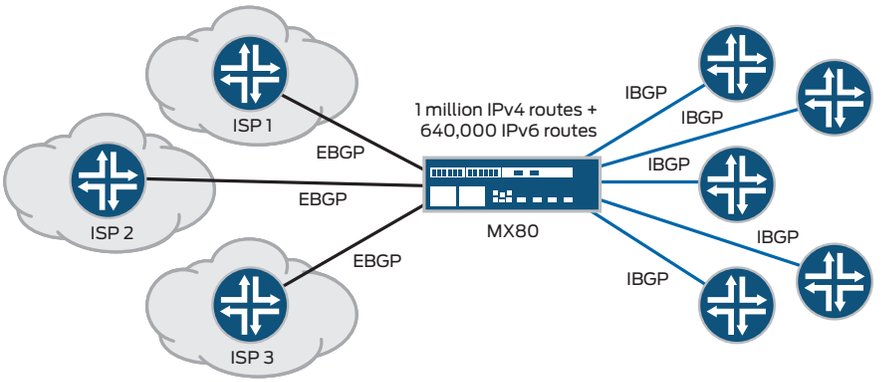

Figure 2: IPv4 and IPv6 test topology

Test result—individual IPv4 and IPv6 testing, as well as mixed IPv4 and IPv6 testing demonstrated that the MX80 was gracefully processing packets as expected at greater than 55 Mpps with no packet loss.

Test Scenario—IPV4 Multicast Replication/Forwarding Performance

As video applications, video conferencing, distance learning, video on demand (VOD), content distribution, and real-time streaming become more prevalent in enterprise networks, multicast capabilities are considered baseline features for enterprise customers.

Current enterprise requirements for multicast go well beyond basic functionality. In the financial sector, for example, support for large-scale multicast at low latency and a large number of replication points are required even in low- to medium-sized locations. We tested both multicast only replication and forwarding and mixed class forwarding (unicast and multicast). This test demonstrates the multicast forwarding performance per RFC2432 and involved multiple 8 x 10GbE ports (1 x 10GbE as source and 7 x 10GbE as receivers) on the MX80. One of the ports acted as a multicast source while the remaining seven ports were configured as Internet Group Management Protocol (IGMP) hosts to act as multicast receivers.

In this test, we defined the first port as the multicast source for 500 multicast groups on each of the remaining seven ports configured as receiver ports. Protocol Independent Multicast (PIM) was enabled on the source port and IGMPv2 for the remaining seven receiver ports (IGMP joins for the multicast group 225.0.0.1 through 225.0.1.250 — a total of 500 groups). The tests were performed for the same mixture of frame sizes as in the forwarding performance test above.

Test result—the MX80 replicated traffic for all packet sizes for all groups on all of the seven receiver ports *with zero packet loss*.

Mixed Class (Unicast and Multicast) Forwarding Performance

This test demonstrated the mixed class (unicast and multicast) forwarding performance. This test was performed with 8 x 10GbE ports connected to tester ports. One of the ports acted as a multicast source, while the remaining ports were configured as IGMP hosts to act as multicast receiver. We set up 500 PIM groups and received IGMP joins for all 500 groups on all receiver ports. We also created fully meshed unicast traffic between all of the tester ports.

Once the IGMP joins were enabled on all interfaces, we increased the traffic to 99.9% on all ports (this was evenly divided between multicast and unicast traffic) and recorded the performance. We observed that the MX80 forwards at its full capability of 70 Gbps and 55 Mpps with zero packet loss. There was no performance impact for one type of traffic over the other. The tests were performed for the same mixture of frame sizes as in the forwarding performance test above (IPv4 only).

Test result—the MX80 processed both unicast and multicast traffic at line rate with *no packet loss for either traffic type*.

[2]IMIX, for both IPv4 and IPv6, consists of 55% 64-byte packets, 5% 78-byte packets, 17% 576-byte packets, and 23% 1518-byte packets.

BGP Convergence Testing

Convergence performance of a router determines how fast the router can relearn the state and proceed with forwarding in case of failures. In this example, after losing connectivity to the preferred ISP, the secondary ISP's 1 million BGP routes are immediately populated from the routing table to the forwarding table

Two ISPs were simulated with IXIA, each advertising BGP routes for 1 million prefixes. ISP 1 was the preferred route with a lower BGP autonomous system (AS) path, and installed in the forwarding table as the preferred next hop.

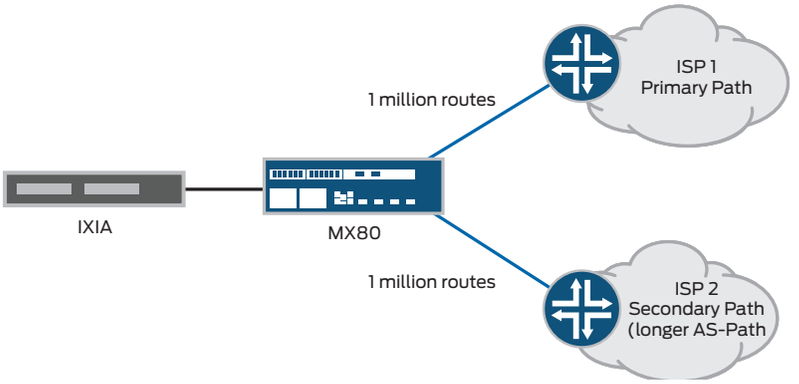

Figure 3: Test topology for BGP convergence test

ISP 2 also advertises 1 million prefixes with a longer AS path; and hence 2 million entries are stored in the routing table for the 1 million advertised prefixes from both ISP1 and ISP2. Traffic is sent to all 1 million prefixes, and a failure is simulated on ISP 1. The convergence time includes the time it takes the router to withdraw the active routes from the forwarding table while installing the routes from ISP 2 as the new active routes. This test conducted a number of times, with the average convergence time measured at 35 seconds.

Juniper Networks Junos operating system supports a rich feature set for traffic engineering and fast convergence with support for features such as graceful restart for routing protocols and MPLS fast reroute.

Service Virtualization (L3VPN and VPLS Services)

For simple management and security, enterprise customers are increasingly deploying MPLS-based VPN services for L3 segmentation or VPLS to extend L2 islands beyond campuses and geographical regions (predominantly to interconnect data centers).

In this test, we investigated the performance of the MX80 with L3VPN and VPLS services at large scale. For the L3VPN setup, on the IXIA tester ports, two core facing interfaces were configured with OSPF, BGP, MPLS, and LDP, simulating a provider (P) router and a provider edge (PE) router behind every core facing interface using OSPF and BGP. On the two customer edge (CE) facing ports on the MX80 to Ixia, 500 L3VPNs were configured with BGP as the PE-CE protocol (see Figure 4). Simultaneously advertising 1,000 routes on each L3VPN for a total of 500,000 L3VPN routes, we sent bidirectional traffic between the two sets of ports (CE to PE and PE to CE).

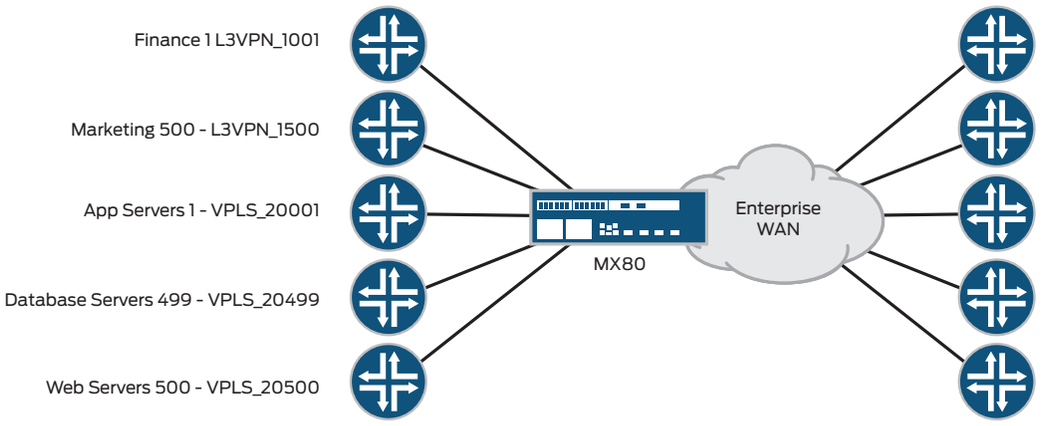

Figure 4: Virtualization at L3 with MPLS VPNs and at L2 with VPLS instances

For L2 virtualization, 500 VPLS instances on the MX80 were added. By configuring the MX80 with two core facing interfaces with protocols OSPF, BGP, MPLS, and LDP, we simulated a P router and a PE router behind every core facing interface with OSPF, BGP, and LDP on Ixia. IBGP was configured between the MX80 and the simulated PE behind the Ixia port, with family "l2-vpn signaling."

500 VPLS (250 unique VLANs on each of the two 10GbE CE interfaces) were then configured, with each VLAN representing a business unit for an enterprise or data center server group. Each VPLS carried traffic for 1,000 MAC addresses (500 from CE and 500 from remote PE) with an aggregate total of 500,000 MAC addresses. Bidirectional traffic was then sent between every pair of CE and remote PE from the Ixia.

Here is a summary of test results with 500 L3VPNs, 500 VPLS instances, and line rate traffic:

- All BGP, OSPF, RSVP, LDP sessions and VPN sessions were stable and running.
- Observed the aggregate route/forwarding table scaling with all of the L3VPN services at scale.
- The L3VPNs had complete route information, and no route flapping was observed.

MAC Address Scalability and MAC Learning Rate

MAC address scalability for an enterprise router determines the number of directly connected Layer 2 devices it can support. This capability is required specifically in data center applications where virtualization is a key requirement and is implemented with L2 stretch virtualization technology such as VPLS.

In this test, we tested and measured MAC address scale to support 500,000 MAC addresses. The MAC learning rate was measured at 40,000 addresses per second.

GRE Tunneling

As enterprise networks span over multiple geographical locations, direct connectivity among those locations becomes more costly and challenging. As an alternative, enterprises are increasingly deploying tunneling mechanisms, which can transport multiprotocol and IP multicast traffic between two sites for global reach. GRE tunneling also serves as a virtualization method for data centers and other applications requiring direct connections between locations.

In this testing, 1,000 GRE tunnels were configured on the MX80 with line rate traffic for various packet sizes and IMIX with no packet loss.

Conclusion

Midrange MX Series routers are compact members of the MX Series product family powered by the Trio chipset and Junos OS, Juniper's high-performance operating system for advanced routing and switching. Only 2RU or 3.5-inches high, the midrange MX Series routers help customers drive down the total cost of ownership and increase operational efficiencies in both enterprise and service provider deployments without service compromise. The flexibility (mix and match interface types) and upgradability (scalable upgrades from MX5 all the way up to MX80, as required) make the midrange MX Series routers ideal for campus, data center interconnect, and service provider WAN connectivity deployments.

The wide range of applications enabled by the MX Series family of routers and supported in the midrange systems include:

- L2 stretch required for data center consolidation and data center mobility (VPLS, pseudowires, MPLS fast reroute, Bidirectional Forwarding Detection protocol)
- L2 and L3 end-to-end network segmentation (using L2/L3VPNs)
- Service provider router with separate control and forwarding functions to provide maximum scale and intelligent service delivery capabilities along with hierarchical quality of service (QoS)
- Campus core router requiring subnet mobility, L2/L3 segmentation, and QoS
- Video distribution for IPTV services with advanced capabilities such as multicast MPLS VPNs
- Cloud computing, providing the perfect platform for connectivity to and between clouds

Throughout these tests, midrange MX Series routers have demonstrated functional maturity and best-in-class performance for control plane operations and data plane forwarding. The extensive feature support at large scale documented here position the midrange MX Series as the optimum choice for service provider and enterprise WAN applications.

For More Information

For more information about how your organization can benefit from midrange MX Series routers, visit Juniper Networks on the Web at **www.juniper.net/us/en/products-services/routing/mx-series**.

About Juniper Networks

Juniper Networks is in the business of network innovation. From devices to data centers, from consumers to cloud providers, Juniper Networks delivers the software, silicon and systems that transform the experience and economics of networking. The company serves customers and partners worldwide. Additional information can be found at **www.juniper.net**.

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2000412-001-EN Apr 2011 Printed on recycled paper