

JUNIPER NETWORKS SOLUTION PORTFOLIO FOR CARRIER ETHERNET

Taking a Multidimensional Approach to Delivering High-Performance Carrier Ethernet

Challenge

New requirements have emerged to extend carrier Ethernet adoption from opportunistic deployment to full-scale implementation. Significant demands have been placed on service provider networks to support such next-generation applications and services as IPTV, VOD, and VoIP.

Solution

Juniper Networks has delivered the industry's first true carrier-grade Ethernet solution. Service providers can leverage the Juniper Networks solution for a variety of network functions including Ethernet transport, aggregation, and offering new Ethernet-based services to increase revenues today and into the future.

Benefits

- Leverages the same Juniper Networks Junos operating system that has powered top service provider networks for more than 10 years
- Provides reliability and performance for various network functions including Ethernet transport, aggregation, and new Ethernet-based services
- Provides ability to more easily roll out new services with required scalability and availability in any environment

Massive demand for bandwidth and pervasive connectivity from both residential and business users is driving service providers of all types to look for innovative ways to increase network capacity in cost-efficient ways, while at the same time enabling new and more sophisticated applications. As part of this trend, carriers have expanded the adoption of carrier Ethernet from its emergence in Metro networks to several other areas of the network for transport, aggregation, and Ethernet-based services. Challenges of early generations of deployment included the lack of carrier-class attributes such as continuous availability, high scalability, and flexible bandwidth control. Today's advanced offerings address these stringent requirements and enable service providers to further leverage carrier Ethernet as the technology of choice for a wide range of progressive applications.

There is little doubt that Ethernet will be an important technology in next-generation networks. carrier Ethernet is being adopted by virtually all service provider types for aggregation, transport, Ethernet-based services, or a combination of these applications. According to IDC, the carrier Ethernet market is expected to grow to almost \$8.5 billion by 2012. This is up from \$3.8 billion in 2007 and represents a five-year compound annual growth rate of more than 17 percent.

The Challenge

With accelerating momentum in the carrier Ethernet market, a new set of requirements has emerged to extend industry adoption from opportunistic deployment to full-scale implementation. While earlier deployments focused primarily on cost optimization, recent emphasis on such areas as network-wide operational consistency, increased service richness, and interdomain service continuity has become critical as the popularity of carrier Ethernet applications grows.

Significant demands have been placed on service provider networks to support next-generation applications and services such as IPTV, video on demand (VOD), VoIP, and others. In addition to increased capacity requirements, service provider networks also must be able to deliver high-quality applications to customers. Networks of all types—whether operated by wireline, wireless, cable, or content service providers (CSPs)—are being pressed to evolve so they can cost-effectively support these applications.

Ethernet can easily provide many service provider requirements (speed, cost-effectiveness, and ease of use), but traditionally has not provided the reliability, scalability, and resiliency service providers need to support applications and services. In fact, service providers often have found that many earlier-generation Ethernet products fail to deliver the features their networks need. This has led to slower-than-expected adoption of Ethernet in service provider networks.

Traditional Ethernet solutions also lack many crucial capabilities that are essential to supporting existing and future network demands:

- Ability to scale cost-effectively
- Ability to support Ethernet-based services
- Efficient space utilization and power consumption
- Decreased network complexity
- Enhanced network resiliency

Only solutions that address all of these challenges can truly be considered carrier-class or carrier Ethernet solutions.

The Juniper Networks Carrier Ethernet Solution

Juniper Networks® understands the importance of robust, scalable Ethernet technology for next-generation carrier-grade networks. Juniper Networks carrier Ethernet solutions portfolio leverages the same operating system—Juniper Networks Junos® operating system—that has powered top service provider networks worldwide for more than 10 years. These solutions provide the reliability and performance required for a variety of network functions including Ethernet transport, aggregation, and the introduction of new Ethernet-based services to increase revenues today and into the future.

Juniper Networks carrier Ethernet solutions also provide the ability to more easily roll out new services with the scalability and availability required in a converged services environment.

Service providers can employ Juniper Networks IP/MPLS-based solutions as an intelligent, more strategic technology to help build global inter-provider relationships that can boost revenues, add subscribers, and expand networks. Juniper Networks techniques for provisioning infrastructure reduce the configuration burden, bring a greater degree of order and simplicity to the network, and diminish the probability of configuration errors.

Juniper Networks MX Series 3D Universal Edge Routers significantly raise the bar of carrier-class Ethernet by offering an innovative feature set based on industry-leading Junos OS with unmatched density and scalability. The Juniper Networks MX960 3D Universal Edge Router, MX480 3D Universal Edge Router, and MX240 3D Universal Edge Router are uniquely designed to provide carrier-grade Ethernet service and transport for all service provider networks.

The MX Series, along with Juniper Networks M Series Multiservice Edge Routers, T Series Core Routers, and EX Series Ethernet Switches, leverage Junos OS to provide consistent features across platforms, greatly reducing training requirements. Service providers also can leverage the high density and increased energy efficiency of the MX Series routers to enable green networking. In addition to the MX Series, Ethernet PICs and line modules are available for Juniper Networks E Series Broadband Services Routers, as well as M Series and T Series routers, to seamlessly and cost-efficiently extend Ethernet through various parts of the network.

Features and Benefits

- Leverages the same Junos OS that has powered top service provider networks worldwide for more than 10 years
- Provides the reliability and performance required for a variety of network functions including Ethernet transport and aggregation, enabling new Ethernet-based services to increase revenues today and into the future
- Provides the ability to more easily roll out new services with the required scalability and availability in a converged services environment

Solution Components

Juniper Networks takes a multidimensional approach to delivering carrier Ethernet service provider solutions. First, Ethernet PICs and line modules are available on E Series, M Series, and T Series routers to allow Ethernet to be seamlessly and cost-efficiently extended throughout various parts of the network. This enables Ethernet to be implemented as appropriate with minimal effort or investment.

Second, the MX Series routers are purpose-built to deliver service providers high-performance, scalable, and reliable carrier Ethernet. MX Series routers are designed to provide the reliability and resiliency required in service provider networks, and to cost-effectively scale to meet ever-increasing bandwidth requirements. Service providers can leverage the MX Series for a variety of network functions including Ethernet transport, aggregation, and offering new Ethernet-based services.

The leading-edge EX Series Ethernet Switches are purpose-built for large CSP data center applications, enabling business processes by connecting users to applications, and delivering everything from traditional file services to telephony, messaging, presence, video conferencing, and Web services.

MX Series routers and EX Series switches leverage Junos OS—the same industry-leading operating system that powers M Series and T Series routers. Service providers benefit from a familiar interface and a proven operating system that currently runs in the top 100 service provider networks worldwide. Figure 1 shows the structure of the solution.

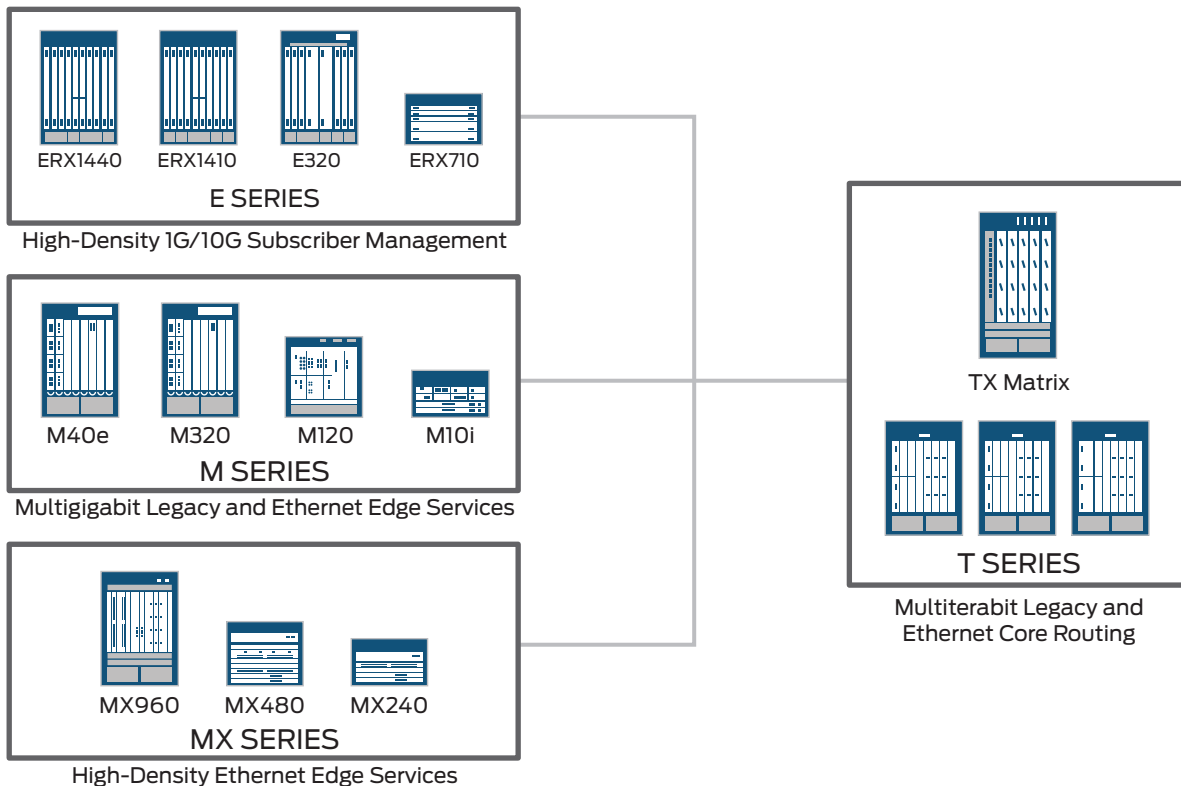


Figure 1: Juniper Networks carrier Ethernet solution

MPLS Plug-and-Play

Operating expenses make up a significant percentage of total network costs—up to 75 percent in some networks. To help alleviate some of these cost concerns, Juniper Networks has developed the industry’s first MPLS Plug-and-Play capabilities, featured in the Junos OS as well as in M Series, T Series, and MX Series routers. MPLS Plug-and-Play is designed to automate certain time-consuming tasks, which significantly lowers operating costs by dramatically reducing the complexities of setting up and maintaining the network.

Through automated address learning and preconfigured protocols that run on interfaces, Juniper Networks has already contributed heavily to the success of Ethernet. MPLS Plug-and-Play takes a similar approach to simplifying the deployment of MPLS in Metro networks by aiming to provide a “zero-configuration” approach to networking. With MPLS Plug-and-Play, the network can proactively adapt to changes, detect potential problems, and choose a correct course of action before problems even occur. MPLS Plug-and-Play helps streamline operations with the following functionality:

- Error-resilient configuration
- Scripts to prevent procedural errors and simplify common configurations
- Auto-discovery and adaptation to network changes

- Automatic response to network conditions
- Proactive system management and preventive services to detect and prevent potential operational issues
- Systematic implementation of diagnostics and repair to speed trouble response and resolution

Industry-Leading Capacity, Port Density, and Media Access Control Addressing Capabilities

Next-generation applications and services can quickly place bandwidth strains on the network. As these applications and services become more prevalent, this challenge will become even more difficult to address. Therefore it is crucial that networks scale to handle these demands—both today and into the future.

As illustrated in Table 1, Juniper Networks MX Series routers provide industry-leading density. In fact, when compared to competing products, there is a clear distinction between the Juniper Networks purpose-built MX Series and older, less-dense products. MX Series routers are designed to provide 10-Gigabit Ethernet today, but are capable of going well beyond this based on customer requirements. Additionally, the MX Series routers are unique in their ability to handle up to 1 million Media Access Control (MAC) addresses, a feature shared across all MX Series platforms. The result is that the MX Series routers are number one in system capacity, port density, and MAC addressing.

Table 1: Juniper Networks MX Series 3D Universal Edge Routers

MX SERIES	MX240	MX480	MX960
Physical dimensions	5 RU (9 per 7-foot rack)	8 RU (6 per 7-foot rack)	16 RU (3 per 7-foot rack)
Capacity	240 Gbps	480 Gbps	960 Gbps
10-Gigabit Ethernet	12	24	48
Gigabit Ethernet ports	120	240	480
MAC addresses	1 million	1 million	1 million

MX Series 3D Universal Edge Routers are powered by Dense Port Concentrators (DPCs) that give service providers flexibility as to how their MX Series routers are implemented and what functions the routers perform in the network. DPCs combine high port density with a distributed architecture and onboard processing to ensure that performance scales with the addition of interfaces.

Three types of DPC cards are currently available for all MX Series routers:

- **DPCE-R**—Provides both Layer 2 and Layer 3 functionality
- **DPCE-X**—Designed for Metro Ethernet transport, provides very-high-density Gigabit Ethernet and 10-Gigabit Ethernet configurations for digital subscriber line access multiplexer (DSLAM) and direct customer aggregation
- **DPCE-Q**—Provides enhanced queuing for per-customer granularity plus additional quality of service (QoS), including per-VLAN treatment with support for 64,000 queues; also provides functionality that allows service providers to offer Ethernet connectivity services with assured quality

The Green Networking Advantage

The industry-leading density of MX Series routers provides an important benefit to service providers beyond scalability: energy efficiency. With energy costs soaring and concern about the global environment growing, service providers must ensure they are doing their part to conserve energy. Juniper Networks helps service providers decrease power consumption and environmental impact by providing environmentally efficient platforms. For example, the MX Series can handle more bandwidth and more subscribers with much less space and power consumption than other products on the market. Service providers can leverage these efficiencies to realize green networking, helping meet expectations for energy conservation and protecting the global environment while also saving significantly on operational expenses.

Flexible Deployment Options

Traditional Metro Ethernet products are only able to perform Layer 2 switching. Service providers implementing these Layer 2 devices often find themselves needing additional functionality such as MPLS, virtual private LAN service (VPLS), or Layer 3 functionality. Service providers in this situation have found that they need to add another Layer 3 network device to address this need—thereby increasing network complexity, CapEx, and OpEx.

The MX Series 3D Universal Edge Routers from Juniper Networks solve this challenge by providing both Layer 2 and Layer 3 functionality in a single device. Service providers can initially implement an MX Series router as a Layer 2 switch in the Metro part of the network. If Layer 3 routing later becomes necessary due to changing network requirements, this only requires the simple addition of a new DPC card. This flexibility enables service providers to offer business Ethernet services such as E-LAN, Ethernet Line (E-Line), or E-Tree within the same MX Series router. This combination of Layer 2, Layer 3, and Ethernet services gives service providers a high degree of flexibility with a single equipment investment.

Summary: Carrier Ethernet Applications

In addition to increased capacity requirements, today's carrier Ethernet solutions must be able to deliver a high level of quality for a variety of service provider network applications. These can include wireline, wireless, cable, and CSP data centers. Service providers of all types can benefit from the benefits shared by MX Series routers:

- Industry-leading capacity, port density, and MAC addresses
- MPLS Plug-and-Play to simplify deployment and reduce operating costs
- Reduced space and power consumption to promote green networking benefits
- Carrier-grade reliability
- Layer 2 and Layer 3 functionality in a single network device

Table 2 shows the wealth of MX Series functionality for multiple service provider network applications.

Table 2: Typical Carrier Ethernet Usage and Network Applications Utilizing the MX Series

MX SERIES CARRIER ETHERNET USAGE AND NETWORK APPLICATIONS	WIREFINE	WIRELESS	CONTENT SERVICE PROVIDERS	MULTIPLE SERVICE OPERATORS/CABLE OPERATORS
Access	<ul style="list-style-type: none"> • TSB Ethernet access • MDU Ethernet access 			<ul style="list-style-type: none"> • M-CMTS access platform (future)
Aggregation	<ul style="list-style-type: none"> • Residential broadband (xDSL, FTTx) • Ethernet business services • Metro Ethernet network (SONET migr) 	<ul style="list-style-type: none"> • WiMAX base transceiver station (BTS) aggregation • Ethernet and IP/Ethernet radio access network (RAN) for third-generation (3G) builds 	<ul style="list-style-type: none"> • L2 aggregation switch • L3 core aggregation switch 	<ul style="list-style-type: none"> • Cable modem termination system (CMTS) aggregation • Ethernet business services • IP data aggregation
Edge	<ul style="list-style-type: none"> • Ethernet services edge (VPLS, VPWS) • Business VPNs (IP/MPLS VPNs) • ATM/ Frame-Relay/ • TDM PWEs 	<ul style="list-style-type: none"> • Mobile core site switching • Mobile Switching Center (MSC) aggregation 		<ul style="list-style-type: none"> • Business services (IP/MPLS-E, VPLS, VPWS) • Digital MPEG video transport • IP backbone (data and voice)
Metro Core	<ul style="list-style-type: none"> • Super-aggregation networks • Hosting video headends and super VHOs 			<ul style="list-style-type: none"> • Video head-end/VOD pooling centers • Distributed VOD centers • High-speed data and VoIP
Data Center	<ul style="list-style-type: none"> • Application hosting centers • Disaster recovery centers • Video headend 	<ul style="list-style-type: none"> • Gateway GSN (GGSN)/ packet data serving mode (PDSN) handoff • Network Operation Center (NOC) 	<ul style="list-style-type: none"> • Application hosting centers • Disaster recovery centers • Data center edge WAN router • L3 aggregation • L2 aggregation switch 	<ul style="list-style-type: none"> • Regional data centers

MX Series 3D Universal Edge Routers can improve almost every part of the typical wireline application for service provider networks, from access to edge to aggregation to Metro core and even in the data center (Figure 2).

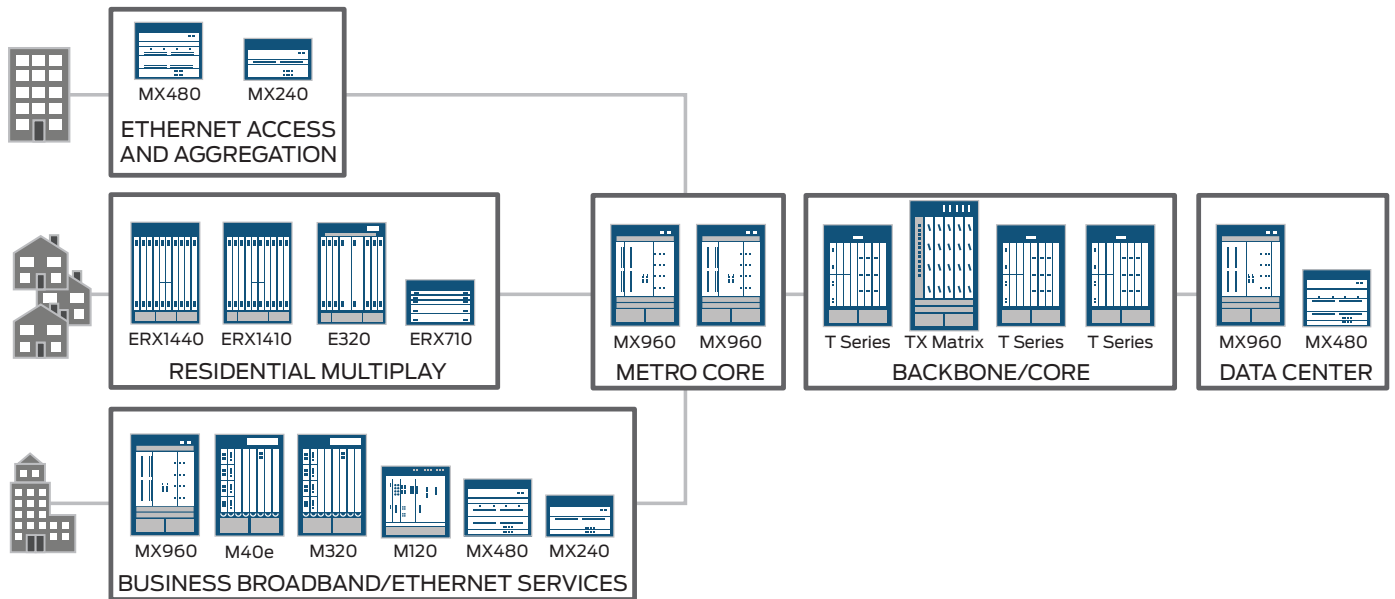


Figure 2: Juniper Networks products in the wireline network

For business services applications, the MX Series can be leveraged to offer revenue-generating Ethernet-based services to business customers, including multipoint services such as VPLS. The MX Series supports both LDP-based and BGP-based VPLS. BGP-based VPLS allows multiple-service-provider VPLS networks to interconnect. MX Series routers also can provide LDP and BGP VPLS interworking. This is very useful for service providers who provide both LDP and BGP VPLS to customers. In addition to VPLS, the MX Series supports point-to-point Ethernet services such as E-Line and pseudowire. The addition of enhanced queuing DPC cards enables wireline service providers to deliver service level agreements for all Ethernet services.

The MX Series also meets the requirements for residential services applications. The rich MPLS feature set present in MX Series routers provides the necessary traffic engineering and QoS to ensure the efficient delivery of video generated through next-generation applications such as IPTV, VOD, VoIP, and others. With these video applications driving the need for extremely high bandwidth, wireline service providers are building centers to bring content distribution closer to the residential customer. These content distribution centers are often referred to as super video head offices and connect to Metro cores to help offload bandwidth demands in the core network. Metro cores are a critical piece of the network for delivering high-bandwidth video services with the appropriate quality of experience.

The MX Series features the same advanced multicast architecture as other Juniper Networks routing platforms, including the Juniper Networks M320 Multiservice Edge Router, T320 Core Router, and T640 Core Router. Multicast replication is performed on the Packet Forwarding Engines (PFEs), keeping the switch fabric simple and allowing it to be as scalable as possible (Figure 3). Each DPC includes 4 PFEs based on I-Chip technology. In addition, the MX Series provides high-density aggregation of residential broadband such as xDSL and FTTx.

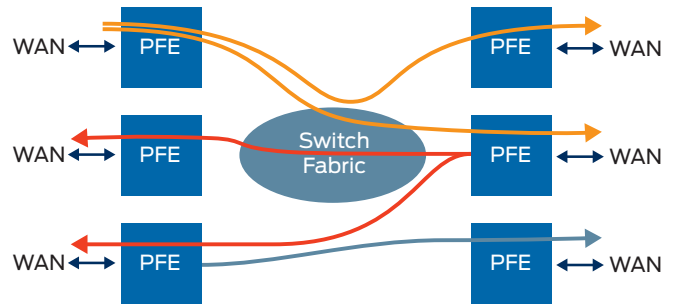


Figure 3: Multicast replication with the MX Series

Wireless Backhaul

For wireless backhaul applications, the MX Series can provide significant cost savings to service providers. Today, backhaul transport within the wireless network is a significant portion of overall OpEx. The majority of backhaul is done with older legacy technology such as ATM, time-division multiplexing (TDM), and microwave. These expensive legacy technologies tend to be more costly and do not scale well when faced with growing data traffic, due to broadband services such as Evolution-Data Only (EV-DO), High Speed Packet Access (HSPA), and Worldwide Interoperability for Microwave Access (WiMAX). MX Series routers provide Ethernet backhaul with high scalability for substantially lower costs. The full MPLS feature set found in the MX Series can be used to provide necessary QoS, traffic management, and resilience.

Many next-generation wireless technologies such as IP Radio Access Network (IP RAN) and WiMAX are based on IP. There will be a growing need for aggregation points as these emerging technologies are more widely deployed. The MX Series provides wireless carriers with a cost-effective way to aggregate multiple WiMAX base stations and IP RANs (Figure 4).

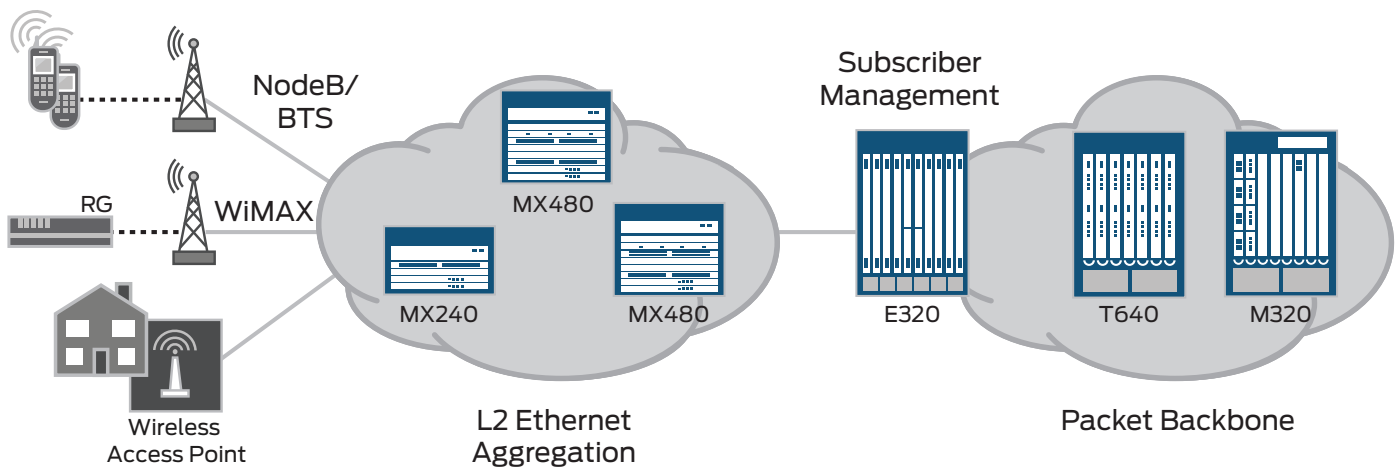


Figure 4: MX Series 3D Universal Edge Routers in a wireless backhaul environment

Mobile Switching Centers

Today's Mobile Switching Centers (MSCs) include logical networks for a variety of network elements including the Serving GPRS Support Node (SGSN), application servers, and media gateways. MX Series routers provide aggregation, switching, routing, and access control between logical networks.

Cable

The enhanced hierarchical multicast functionality of the MX Series is perfectly suited for cable applications, supporting the more efficient Switched Digital Video (SDV) solution that works in any SDV environment. Cable operators use SDV to reduce the bandwidth consumed by broadcast video.

SDV allows the network to deliver to each service group (of approximately 500 digital subscribers) only those programs currently being viewed. If a broadcast video is not requested, the

video is not sent to the service group, representing a significant bandwidth savings considering that most channels are not requested at any given time.

The capacity and density of the MX Series, including the ability to support 40 Gbps per slot, is also very beneficial for high-bandwidth cable applications. The arrival of fiber-based services, the growth in demand for HD video, and the eventual growth of additional high-bandwidth interactive services (such as HD gaming, interactive video, and others) underscores the need for a clear architectural roadmap and for platforms that can support these bandwidth requirements. MX Series routers boast industry-leading capacity while enabling intelligent use of that capacity, in effect further increasing the extensibility of the platform. Figure 5 depicts the MX Series in a typical cable network.

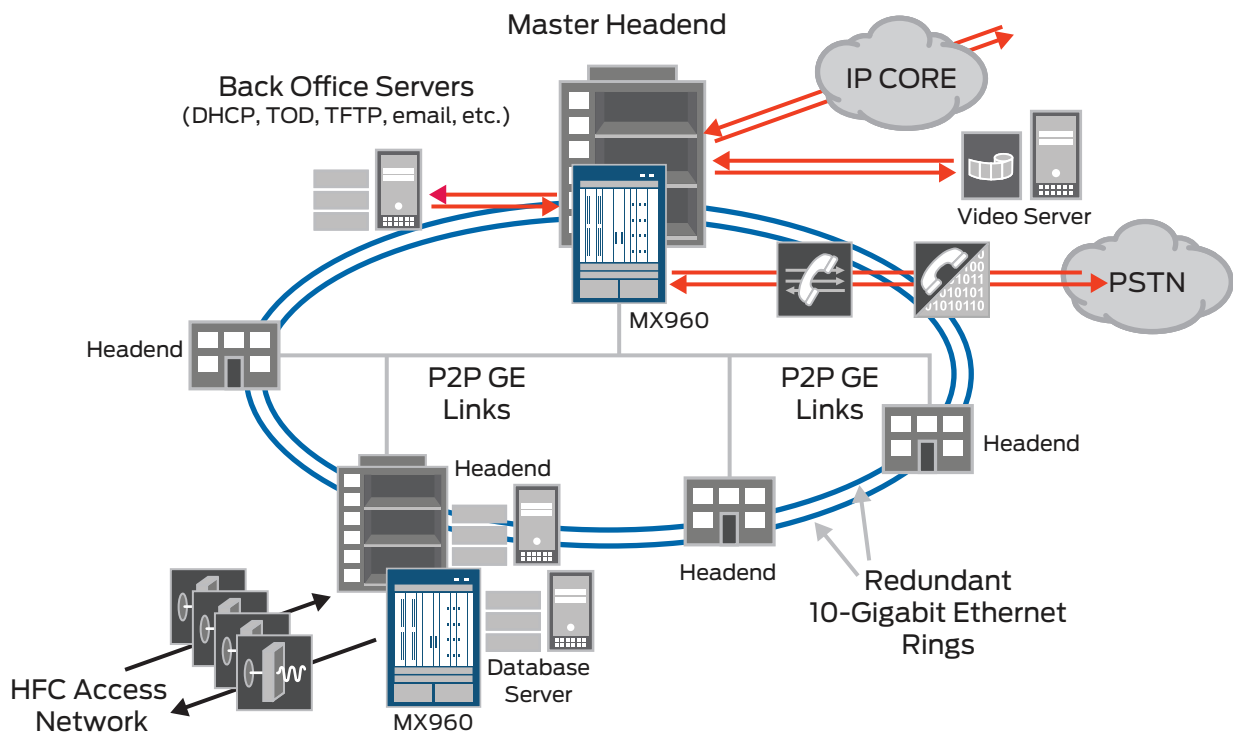


Figure 5: MX Series 3D Universal Edge Router in the cable operator network

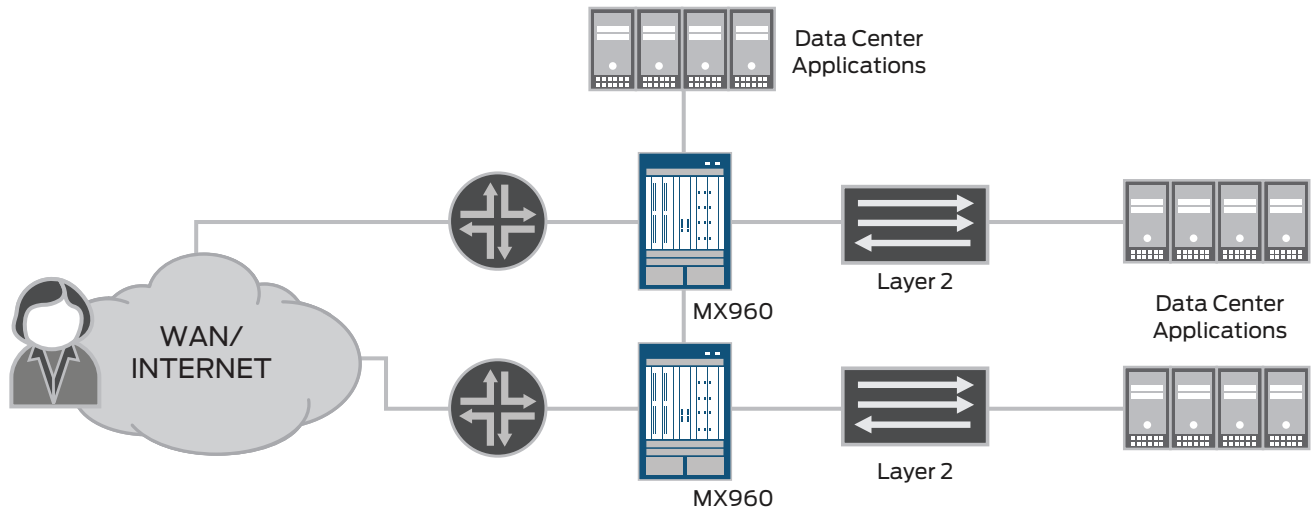


Figure 6: MX Series 3D Universal Edge Routers as data center aggregation switches

MX Series routers also serve as a next-generation networking (NGN) edge routing platform for cable applications, allowing operators to collapse Layer 2 and Layer 3 functionality into a single box to reduce operational complexity in the cable head-end.

Cable operators can extend many of the characteristics of the Juniper Networks best-in-class routing platforms into their Metro Ethernet switching architectures. For example, operators can dynamically provision capacity and QoS in order to efficiently support such applications as multicast video distribution. Resources in the network are allocated when needed, rather than being carved out in advance to support services. This contrasts sharply with solutions from other vendors that mandate static resource provisioning, ultimately stranding these resources.

CSP Data Centers

The MX Series meets the primary requirements for CSP data center networking applications, providing scalability, reliability, and efficient space and power usage. As a data center aggregation switch, MX Series routers provide the scalability required to support high-bandwidth data center needs. For example, the MX960 router supports 48 10-Gigabit Ethernet or 480-Gigabit Ethernet ports in a 16-RU system—a density unmatched in the industry. Providing this much system capacity in a single platform also greatly reduces overall power consumption and space requirements. Fewer MX Series routers are required as compared to competitors' products, which saves on overall rack space, facilities costs, power consumption, CapEx, and OpEx.

CSPs rely on data centers to host the applications and content that drive their business. Data centers deliver a multitude of applications—Web searches, instant messaging, VoIP, gaming, hosted applications, and many others. The success of these applications is crucial to the success of CSPs, as the applications provide the required “stickiness” that motivates users to come back for more. The scalability features of the MX Series routers can handle the very high bandwidth requirements driven by these interactive applications and rich content.

MX Series routers also can leverage the power of Junos OS in providing aggregation switch functionality in the data center. Junos OS provides the reliability, security, and scalability necessary for the most stringent data center requirements. With MX Series Ethernet 3D Universal Edge Routers, MPLS can be extended into the data center to provide traffic engineering (TE). Leveraging MPLS-TE between the data center aggregation switch and the data center edge router provides scalable control along with assurance that packets will be treated appropriately within the data center and through the core and edge domains of the network. This enables prioritization of applications. Figure 6 illustrates how the MX Series can be deployed in the CSP data center as an aggregation switch.

In the data center, the Juniper Networks EX8200 line of Ethernet switches accommodates large numbers of 10-Gigabit Ethernet line-rate uplinks from access layer devices such as the Juniper Networks EX4200 line of switches, offering a scalable solution for supporting more servers with fewer switches, effectively reducing power consumption, heat generation, and footprint.

Summary: High-Performance, Scalable, and Reliable Carrier Ethernet—An Industry First

The service provider network is a strategic asset. Network performance, reliability, and scalability are critical to its success. Next-generation applications and services are straining existing networks and driving the need to replace legacy technologies with Ethernet. Due to its cost-effective scalability, Ethernet is enjoying adoption within multiple service provider segments. However, traditional Ethernet lacks the required reliability and resiliency that high-performance networks require.

Juniper Networks has made a significant investment in new Ethernet products to deliver the industry's first true carrier-grade Ethernet solution. MX Series routers, paired with Ethernet PICs and line modules available for Juniper Networks E Series, M Series, and T Series routers, take a multidimensional approach to delivering a high-performance carrier Ethernet solution. This MX Series solution leverages the same Junos OS that has been powering the top service provider networks for more than 10 years, providing the reliability and scalability required to deliver high-bandwidth applications and services such as IPTV and VOD. In addition, Juniper Networks MX Series 3D Universal Edge Routers provide industry-leading density to reduce overall costs, space requirements, and power consumption.

Service providers can leverage Juniper Networks carrier Ethernet solutions for a variety of network functions, including Ethernet transport, aggregation, and the offering of new Ethernet-based services to increase revenues today and into the future.

Next Steps

To learn more about what Juniper Networks carrier Ethernet solutions can do for your network, contact your Juniper Networks sales team or visit www.juniper.net for additional information.

About Juniper Networks

Juniper Networks, Inc. is the leader in high-performance networking. Juniper offers a high-performance network infrastructure that creates a responsive and trusted environment for accelerating the deployment of services and applications over a single network. This fuels high-performance businesses. Additional information can be found at www.juniper.net.

Corporate and Sales Headquarters

Juniper Networks, Inc.
1194 North Mathilda Avenue
Sunnyvale, CA 94089 USA
Phone: 888.JUNIPER (888.586.4737)
or 408.745.2000
Fax: 408.745.2100
www.juniper.net

APAC Headquarters

Juniper Networks (Hong Kong)
26/F, Cityplaza One
1111 King's Road
Taikoo Shing, Hong Kong
Phone: 852.2332.3636
Fax: 852.2574.7803

EMEA Headquarters

Juniper Networks Ireland
Airside Business Park
Swords, County Dublin, Ireland
Phone: 35.31.8903.600
EMEA Sales: 00800.4586.4737
Fax: 35.31.8903.601

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