

## Highlights

- Scalable multiservice IP/MPLS, SDN-enabled routers in 4-, 8-, 16-, and 32-slot chassis options
- Fully distributed, non-blocking, and programmable architecture with up to 15.36 Tbps fabric capacity for maximum performance and investment protection
- 64 100 GbE, 128 40 GbE, 768 10 GbE, and 1,536 1 GbE ports in a single router
- Wire-speed forwarding performance for all software features, including Ethernet, VLAN, IPv4, IPv6, MPLS, VPLS, IPsec, MACsec, and OpenFlow capabilities
- High-availability design with redundant management modules, switch fabrics, power supplies, and fans; hitless failover; hitless software upgrades; and non-stop routing
- Delivers integrated hardware support for OpenFlow 1.3 in the industry's only true hybrid port mode, enabling SDN to seamlessly interwork with existing network forwarding
- Ideal for applications in data center core and interconnects, Wide Area Networks (WANs), and campus cores



## ExtremeRouting MLX Series

### Multiservice IP/MPLS SDN Routers

The way organizations communicate and conduct business has changed dramatically in the past decade. Services such as high-definition video streaming, cloud services, and anytime/anywhere mobile connectivity not only consume an enormous amount of network capacity, but also create a greater degree of complexity for network operations. As a result, today's network planners are seeking solutions that provide the right mix of scalability, performance, programmability, and operational simplicity.

The ExtremeRouting MLX Series of high-performance routers, which includes MLXe Core Routers, is designed to meet these requirements and many others. Built with a state-of-the-art, sixth-generation, network processor-based architecture and terabit-scale switch fabrics, the MLX Series provides a rich set of high-performance Layer 2/3, IPv4, IPv6, Multiprotocol Label Switching (MPLS), wire-speed encryption, and Software-Defined Networking (SDN). As a result, these routers address the diverse needs in environments that include the data centers of service provider, enterprise, and public sector organizations; service provider transit and Internet Exchange Points (IXPs); research and education networks; enterprise and public sector campuses; and mobile 4G/LTE service providers.

## Scalability, Without Compromising Performance

The MLX Series is highly optimized for IP Ethernet deployments, providing symmetric scaling with chassis options that include 4-, 8-, 16-, and 32-slot systems. These routers offer industry-leading wire-speed port capacity without compromising the performance of advanced software capabilities.

For example, the MLXe-32 delivers data forwarding performance of 6.4 Tbps and a switch fabric capacity of 15.36 Tbps, enough capacity to future-proof networks for years to come.

However, true router scalability is measured not only in terms of packet forwarding performance, but also in the scalability of the hardware forwarding tables and maturity of the control plane. The MLX Series offers a flexible scale-as-you-grow model with hardware Forwarding Information Base (FIB) capacity options in a wide range of interface modules supporting up to 2.4 million IPv4 routes or 1.8 million IPv6 routes. In addition, the robust control plane has been proven in thousands of missioncritical deployments around the globe.

## SDN Controller and MLX Series

The MLX Series operates seamlessly under the SDN Controller. This controller is a qualityassured edition of the OpenDaylight controller code supported by an established networking provider and its leaders within the OpenDaylight community.

## SDN-Enabled Programmatic Control of the Network

Software-Defined Networking (SDN) is a powerful new network paradigm designed for the world's most demanding networking environments and promises breakthrough levels of customization, scale, and efficiency. The MLX Series enables SDN by supporting the OpenFlow protocol, which allows communication between an OpenFlow controller and an OpenFlow enabled router. Using this approach, organizations can control their networks programmatically, transforming the network into a platform for innovation with the agility to support new business requirements, applications and services.

The MLX Series supports OpenFlow 1.3 via an innovative hybrid port mode which allows simultaneous deployment of traditional switching or routing forwarding with SDN control on the same port. This unique capability provides enables network operators to integrate SDN into existing networks to gain the agility provided by software-based control for specific flows while maximizing their investment in traditional network platforms carrying most network traffic which is switched or routed as before. The MLXe VersaScale packet processor hardware support for OpenFlow enables organizations to apply these capabilities at scale for up to 128,000 flows per chassis with line-rate performance for 100 GbE, 40 GbE, and 10 GbE ports.

## Designed for Non-Stop Networking

Designed to enable reliable converged infrastructures and support missioncritical applications, the MLXe features advanced redundant switch fabric architecture for very high availability. The architecture helps ensure that the system continues to operate at peak performance even in the case of a switch fabric card failure. In the highly unlikely case of additional fabric failures, the advanced architecture allows the system to continue operating in a graceful degradation mode, where the system tunes its performance to the remaining fabric capacity.

The advanced fabric architecture is complemented by comprehensive hardware redundancy for the management modules, power supplies, and cooling system. In addition, the NetTron operating system offers hitless management failover for IPv4 and IPv6 with Open Shortest Path First (OSPF), IS-IS and IP multicast Non-Stop Routing, and Border Gateway Protocol (BGP) Graceful Restart capabilities—as well as hitless (in-service) software upgrades to further enhance both system availability and overall network availability. With LDP Graceful Restart, MPLS traffic loss is minimized if there is an interruption on the network. To maintain continuous operations in data centers and metronetworks, the innovative Multi-Chassis Trunking (MCT) feature provides fast link and node failover protection while simultaneously maximizing network utilization. For example, MCT supports active/standby redundancy for VPLS and VLL pseudowires, providing flexible options for redundancy in network designs that interconnect multiple data centers. For increased redundancy and functionality, dynamic Layer 3 routing over MCT is also supported.

## Advanced Capabilities for a Broad Range of Applications

The MLXe provides a wide range of capabilities to support advanced applications and services in the most demanding network environments, including Wide Area Network (WAN), data center, and campus.

The routers enable scalable and resilient Layer 2 Metro Ethernet services that comply with the Metro Ethernet Forum (MEF) specifications for Ethernet Private Line (EPL), Ethernet Virtual Private Line (EVPL), and Ethernet LAN (E-LAN).

Complementing Layer 2 Metro Ethernet capabilities is a powerful suite of MPLS capabilities and services, including MPLS-TE, Fast ReRoute (FRR), MPLS Virtual Leased Line (VLL), Virtual Private LAN Service (VPLS), BGP/MPLS VPNs (MPLS Layer 3 VPNs), and Dynamic Inter-VRF. Routing over VPLS provides Layer 3 forwarding functionality on the VPLS endpoints, thus simplifying management and operations by allowing a single access point for both switching and routing applications. This is ideal for inter-data center connectivity and Virtual Machine (VM) migration in the cloud. The combination of Layer 2/3 features and advanced MPLS capabilities enables the routers to function in the data center core and connect geographically distributed data centers using standards-based technology such as VPLS. Within the data center, advanced network resiliency features, such as MCT, eliminate the need for spanning tree while enabling efficient usage of network resources through active-active load balancing.

## Data Security Without Compromising Network Performance

The ExtremeRouting MLX 4-port 10 GbE IPsec module for the MLXe provides inline IPsec encryption capabilities at wire speed, ensuring data privacy without compromising performance or complicating deployment models. With support for four additional ports of 10 GbE/1 GbE (combo) and four ports of 1 GbE, it supports an industry leading capacity of more than 44 Gbps encrypted traffic per half-slot module and up to 128 IPsec ports of 10 GbE in a single MLXe system. The inline ports for IPsec deliver unmatched performance by requiring no service module to be used, freeing up slots in the chassis to be used for other routing applications. This programmability enables one of the strongest cryptographic suites for IPsec—Suite B—available in hardware of the MLXe. For additional security, the module supports IEEE 802.1AE (MACsec), which provides 128-bit Layer 2 hop-by-hop encryption for Local Area Network (LAN) use cases.

The ExtremeRouting MLX 20-port 10/1 GbE module for the MLXe provides inline IEEE 802.1AE (MACsec), which provides 128-bit MAC layer hop-by-hop encryption for LAN use cases, with up to 640 10 GbE/1 GbE MACsec ports per chassis.

## Scalable and Intelligent Network Visibility

The MLXe provides visibility capabilities to non-disruptively and transparently tap into a production network with no loss in performance.

It filters and extracts relevant network traffic based on the rules configured statically or dynamically on it. Industry-leading port density, low latency, high throughput, and scalability make the MLXe router a powerful solution for carrier-class environments. By implementing network visibility with the MLXe, network operators can increase efficiency and scale of analytics into network data and traffic, process captured data to evaluate network and application conditions, and generate actionable metrics and reports used for network planning.

## Simplified Service Management

Delivering effective MPLS services on Carrier Ethernet infrastructure requires fast fault identification and isolation. The MLXe supports MPLS Labeled Switch Path (LSP) ping and trace route features to isolate any MPLS-related connectivity issues. In addition, it supports all the capabilities of IEEE 802.1ag (Connectivity Fault Management), including Connectivity Check Messages, Loopback Message/Response, and LinkTrace Message/Response.

IEEE 802.1ag, in conjunction with the MPLS OAM features, provides the capabilities to monitor, isolate, and identify connectivity problems and reduce the time to repair business VPN services. For performance management on Carrier Ethernet infrastructure, the MLX Series supports Y.1731 to measure roundtrip delay and jitter characteristics between two points in the network. To diagnose link layer connectivity issues, the routers also support the IEEE 802.3ah Link OAM feature.

In addition, the MLXe supports standards-based sFlow traffic monitoring technology, which provides unprecedented visibility into network usage. Integrated into the line module hardware, the sFlow technology enables the monitoring of high-speed links without impacting performance.

# MLXe Interface Modules

The MLXe provides a wide range of leading-edge Ethernet modules for 100 GbE, 40 GbE, 10 GbE, 1 GbE that enable organizations to use a single platform for many applications. For more information about these modules, see the tables below.

## Versions Supported

Interface Module	-DM	-M	-X	-X2
24x1 GbE RJ45		•		
24x1 GbE Fiber		•		
4x10 GbE		•		
8x10 GbE		•		
24x10 GbE	•			
20x10 GbE		•		•
20x1 GbE (upgradable to 10 GbE)		•		•
4x10 GbE IPsec		•		
4x40 GbE		•		
2x100 GbE CFP2		•		•

\*Denotes full-slot module, all other interface modules are half-slot.

## Route Table Scalability for MLXe Interface Modules

Interface Module Version	Supported Route Table Scalability
-DM	Up to 256,000 IPv4 routes Up to 64,000 IPv6 routes
-M	Up to 512,000 IPv4 routes Up to 256,000 IPv6 routes
-X	Up to 1 million IPv4 routes Up to 240,000 IPv6 routes
-X2	Up to 2.4 million IPv4 routes Up to 1.8 million IPv6 routes

## Key Features

4-, 8-, 16-, and 32-slot systems for maximum deployment versatility

Up to 9.5 billion packets per second routing performance with non-blocking 15.36 Tbps data capacity

Ideal for demanding, high-density environments with up to:

- 64 100 GbE ports per system
- 128 40 GbE ports per system
- 768 10 GbE ports per system
- 1,536 1 GbE ports per system

Comprehensive, wire-speed, dual-stack IPv4/ IPv6 routing support based on the Multi-Service IronWare OS:

- High-performance, robust routing using Forwarding Information Base (FIB) programming in hardware

- RIP/RIPng, OSPF/OSPFv3, IS-IS/IS-IS for IPv6, and BGP-4/BGP-MP for IPv6
- Secure Multi-VRF routing for supporting virtual routing applications over non-MPLS backbones
- VRRP and VRRP-E
- Connecting IPv6 islands over IPv4 MPLS using IPv6 Provider Edge (6PE) routers
- 6VPE enabling IPv6 multitenancy to the edge of the cloud
- 127-bit IPv6 interface addresses

Industry-leading scalability up to:\*

- 10 million BGP routes
- 2.4 million IPv4 routes in hardware (FIB)
- 1.8 million IPv6 routes in hardware (FIB)
- 153,600 multicast routes
- 2,000 BGP peers per system
- 2,000 BGP/MPLS VPNs and up to 1 million VPN routes
- 48,000 VLLs per system
- 16,000 VPLS instances and up to 1 million VPLS MAC addresses and 64,000 RSVP-TE LSPs
- 4,094 VLANs and up to 2 million MAC addresses
- Large-scale Equal Cost Multi-Path (ECMP); up to 32 paths for unicast and multicast

Software-Defined Networking (SDN):

- OpenFlow 1.3: QoS (for metering and enqueue), Group Table (select and fast failover), QinQ (TAG type autorecognition), Active-Standby Controller, IPv6, Transport Layer Security (TLS) 1.2 (controller interface)
- OpenFlow in hybrid port mode with support for sFlow, IP, and MPLS/VPLS (uplinks) with protected VLAN for additional flexibility
- Up to 128,000 flows supported
- True 12-tuple (Layer 2 and Layer 3) matching for a diverse set of applications

Industry-leading performance for MPLS services, providing several service choices:

- IP over MPLS, IPv6 over MPLS (6PE), IPv6 Layer 3 VPNs (6VPE), MPLS over GRE, Virtual Leased Line (VLL), Virtual Private LAN Service (VPLS), BGP/MPLS VPN, Multi-VRF, routing over VPLS, Max VPLS LSP Load Balance Scale for LER, RSVP TE Link Metric for CSPF Computation, RSVP Auto-Bandwidth with Absolute Threshold

Comprehensive MPLS signaling and path calculation algorithms for both traffic engineered and non-traffic-engineered applications:

- LDP, OSPF-TE, IS-IS-TE, RSVP-TE, CSPF, LDP over RSVP, Point-to-Multipoint (P2MP) RSVP-TE LSP
- MPLS FRR (detour, bypass) and hot standby paths for traffic protection

Superior high-availability design:

- Redundant management modules
- Redundant switch fabrics
- Redundant power supplies and cooling system
- Hitless Layer 2/3 failover with stateful OSPF IS-IS and BGP Graceful Restart
- Hitless (in-service) software upgrades with Graceful Restart

Advanced QoS:

- Hierarchical Quality of Service (H-QoS): Supports up to four levels of hierarchy— port, logical port (optional), customer (optional), and service
- Inbound and outbound two-rate three-color traffic policers with accounting
- Eight distinct priority levels
- WRED support for congestion management and precedence dropping (tunable via configuration)
- Support for hybrid queue servicing disciplines: Mixed, Strict Priority, and Weighted Fair Queuing

Comprehensive hardware-based security and policies:

- Layer 2/3 ACLs (both inbound and outbound)
- Granular ACL accounting (both inbound and outbound)
- Hardware-based packet filtering
- Hardware-based Policy-Based Routing (PBR)
- Unicast Reverse Path Forwarding (uRPF)
- IPv4/IPv6 Receive ACLs
- Extensive sFlow Layer 2-7 traffic monitoring for IPv4, IPv6, and MPLS services
- IPv6 ACL-Based Rate Limiting
- ACL Editing
- Port-based network access control using 802.1x or MAC port security
- Root guard and BPDU guard
- Broadcast, multicast, and unknown unicast rate limits
- ARP inspection for static entries
- Multi-port Static ARP and Static MAC
- 256-bit Suite B Algorithm IP-layer encryption
- 128-bit MAC-layer encryption

Advanced Carrier-grade Ethernet services:

- Ability to reuse VLAN-ID on each port using the Extreme Ethernet Service Instance (ESI) framework

- MPLS Layer 2 VPN services
- IEEE 802.1ad Provider Bridges
- IEEE 802.1ah Provider Backbone Bridges
- IEEE 802.1ag Connectivity Fault Management
- IT U Y.1731 OAM functions and mechanisms for Ethernet-based networks
- Comprehensive set of Layer 2 control protocols: Extreme MRP/ MRP-II , VSRP, RSTP, MSTP, and IT U G.8032 Ethernet Ring Protection (ERP version 1 and 2)
- Multi-Chassis Trunking with support for up to 512 clients (Active/Active mode or Active/Standby mode for Active/Passive access for client ports)
- E-LINE (EPL and EVPL), E-LAN, and E-TREE support
- Protocol tunneling of Bridge Protocol Data Units (BPDUs)
- MEF 9, MEF 14, and MEF 21 certification

Full suite of unicast and multicast IPv4 and IPv6 routing protocols:

- Supported IPv4 protocols include RIP, OSPF, BGP-4, IS-IS, PIM-DM, PIMSM/SSM, IG MP, BGP-MP for multicast, MSDP, Anycast RP, PIM Multicast ECMP, and RPF Shortcut
- Supported IPv6 protocols include RIPng, OSPFv3, IS-IS for IPv6, BGP-MP for IPv6 (BGP4+), PIM-SM/SSM, MLD, VRRPv6, IPv6 Non-Stop Routing (NSR), VRRP-E, PIM Multicast ECMP, and RPF Shortcut

## MLX Series At-A-Glance

Features	MLXe-4	MLXe-8	MLXe-16	MLXe-32
Interface slots	4	8	16	32
Switch fabric capacity	1.92 Tbps	3.84 Tbps	7.68 Tbps	15.36 Tbps
Data forwarding capacity	1.6 Tbps	3.2 Tbps	6.4 Tbps	12.8 Tbps
Packet routing performance	1.19 billion pps	2.38 billion pps	4.75 billion pps	9.5 billion pps
Maximum 100 GbE ports	8	16	32	64
Maximum 40 GbE ports	16	32	64	128
Maximum 10 GbE ports	96	192	384	768
Maximum 1 GbE ports	192	384	768	1,536
Height (inches/rack units)	8.71 in./5RU	12.21 in./7RU	24.50 in./14RU	57.75 in./33RU
Management module redundancy	1:1	1:1	1:1	1:1
Switch fabric redundancy	N+1	N+1	N+1	N+1
Power supply redundancy	1+1	1+1	1+1	1+1
Airflow	Side to back	Side to back	Front to back	Front to back

## Power Specifications

	MLXe-4	MLXe-8	MLXe-16	MLXe-32
Maximum DC power consumption (W)	2,083	4,060	7,107	14,232
Maximum AC power consumption (W) (100-240 VAC)	2,083	4,060	7,107	14,232
Maximum thermal output (BTU/HR)	7,108	13,858	24,255	48,575

# Physical Specifications

Mode	Dimensions	Weight
MLXe-4	17.20 in. W × 8.71 in. H × 23.0 in. D (43.69 cm × 22.12 cm × 58.42 cm)	117 lb (53 kg)
MLXe-8	17.20 in. W × 12.21 in. H × 24.0 in. D (43.69 cm × 31.01 cm × 60.96 cm)	171 lb (78 kg)
MLXe-16	17.20 in. W × 24.47 in. H × 24.18 in. D (43.69 cm × 62.15 cm × 61.42 cm)	351 lb (159 kg)
MLXe-32	17.45 in. W × 57.75 in. H × 26.88 in. D (44.32 cm × 146.69 cm × 68.28 cm)	505 lb (229 kg)

## Specifications

### IEEE Compliance

802.3-2005 CSMA/CD Access Method and Physical Layer Specifications  
 802.3ab 1000BASE-T  
 802.3ae 10 Gigabit Ethernet  
 802.3u 100BASE-TX, 100BASE-T4, 100BASE-FX Fast Ethernet at 100 Mbps with Auto-Negotiation  
 802.3x Flow Control  
 802.3z 1000BASE-X Gigabit Ethernet over fiber optic at 1 Gbps  
 802.3ad Link Aggregation  
 802.3ah Ethernet in the First Mile  
 802.1Q Virtual Bridged LANs  
 802.1D MAC Bridges  
 802.1w Rapid STP  
 802.1s Multiple Spanning Trees  
 802.1ad Provider Bridges; partial support: port-based and S-tagged service interface  
 802.1ag Connectivity Fault Management (CFM)  
 802.3.ba 100 Gigabit Ethernet  
 802.1ab Link Layer Discovery Protocol  
 802.1ah Provider Backbone Bridging  
 802.1ae MAC Security standard

### ITU Compliance

Y.1731 OAM functions and mechanisms for Ethernet-based networks  
 G.8032 Ethernet Ring Protection (ERP version 1 and 2)

### RFC Compliance

#### BGPv4

RFC 1745 OSPF Interactions  
 RFC 1772 Application of BGP in the Internet  
 RFC 1997 Communities and Attributes  
 RFC 2385 BGP Session Protection via TCP MD5  
 RFC 2439 Route Flap Dampening  
 RFC 2918 Route Refresh Capability  
 RFC 3392 Capability Advertisement  
 RFC 3682 Generalized TT L Security Mechanism, for eBGP Session Protection  
 RFC 4271 BGPv4  
 RFC 4273 BGP-4 MIB  
 RFC 4456 Route Reflection  
 RFC 4486 Sub Codes for BGP Cease Notification Message

RFC 4724 Graceful Restart Mechanism for BGP  
 RFC 4893 BGP Support for Four-octet AS Number Space  
 RFC 5065 BGP4 Confederations  
 RFC 5291 Outbound Route Filtering Capability for BGP-4  
 RFC 5396 Textual Representation of Autonomous System (AS) Numbers  
 RFC 5668 4-Octet AS specific BGP Extended Community

#### OSPF

RFC 2328 OSPF v2  
 RFC 3101 OSPF NSSA  
 RFC 1745 OSPF Interactions  
 RFC 1765 OSPF Database Overflow  
 RFC 1850 OSPF v2 MIB  
 RFC 2154 OSPF w/Digital Signature(Password, MD-5)  
 RFC 2370 OSPF Opaque LSA Option  
 RFC 3137 OSPF Stub Router Advertisement  
 RFC 3630 TE Extensions to OSPF v2  
 RFC 3623 Graceful OSPF Restart (helper mode)  
 RFC 4222 Prioritized Treatment of Specific OSPF Version 2  
 RFC 5250 OSPF Opaque LSA option

#### IS-IS

RFC 1195 Routing in TCP/IP and Dual Environments  
 RFC 1142 OSI IS-IS Intra-domain Routing Protocol  
 RFC 3277 IS-IS Blackhole Avoidance  
 RFC 5120 IS-IS Multi-Topology Support  
 RFC 5301 Dynamic Host Name Exchange  
 RFC 5302 Domain-wide Prefix Distribution  
 RFC 5303 Three-Way Handshake for IS-IS Point-to-Point  
 RFC 5304 IS-IS Cryptographic Authentication(MD-5)  
 RFC 5306 Restart Signaling for ISIS (helper mode)

#### RIP

RFC 1058 RIP v1  
 RFC 2453 RIP v2  
 RFC 1812 RIP Requirements

#### IPv4 Multicast

RFC 1122 Host Extensions  
 RFC 1112 IG MP v1  
 RFC 2236 IG MP v2  
 RFC 2362 PIM-SM  
 RFC 3376 IG MP v3

## **IPv4 Multicast (cont.)**

RFC 3569 Overview of SSM  
RFC 3618 MSDP  
RFC 3973 PIM-DM  
RFC 4610 Anycast RP using PIM  
RFC 4611 MSDP Deployment Scenarios  
RFC 4760 BGP-MP

## **General Protocols**

RFC 768 UDP  
RFC 791 IP  
RFC 792 ICMP  
RFC 793 TCP  
RFC 826 ARP  
RFC 854 TE LNET  
RFC 894 IP over Ethernet  
RFC 903 RARP  
RFC 906 TFTP Bootstrap  
RFC 950 Subnet  
RFC951 BootP  
RFC 1027 Proxy ARP  
RFC 1042 Standard for The Transmission of IP  
RFC 1166 Internet Numbers  
RFC 1122 Host Extensions for IP Multicasting  
RFC 1191 Path MTU Discovery  
RFC 1256 IRDP  
RFC 1340 Assigned Numbers  
RFC 1519 CIDR  
RFC 1542 BootP Extensions  
RFC 1591 DNS (client)  
RFC 1812 Requirements for IPv4 Routers  
RFC 1858 Security Considerations for IP Fragment Filtering  
RFC 2131 BootP/DHCP Helper  
RFC 2578 Structure of Management Information Version 2  
RFC 2784 Generic Routing Encapsulation  
RFC 3021 Using 31-Bit Prefixes on IPv4 Point-to-Point Links  
RFC 3768 VRRP  
RFC 4001 Textual Conventions for Internet Network Addresses  
RFC 4950 ICMP Extensions for MPLS  
RFC 4459 MTU and Fragmentation

## **QoS**

RFC 2474 DiffServ Definition  
RFC 2475 An Architecture for Differentiated Services  
RFC 2597 Assured Forwarding PHB Group  
RFC 2697 Single Rate Three Color Marker  
RFC 2698 A Two-Rate Three-Color Marker  
RFC 3246 An Expedited Forwarding PHB

## **Other**

RFC 2474 DiffServ Definition  
RFC 2475 An Architecture for Differentiated Services  
RFC 2597 Assured Forwarding PHB Group  
RFC 2697 Single Rate Three Color Marker

RFC 2698 A Two-Rate Three-Color Marker  
RFC 3246 An Expedited Forwarding PHB  
RFC 1354 IP Forwarding MIB  
RFC 1757 RMON Groups 1, 2, 3, 9  
RFC 2068 HTTP  
RFC 2665 Ethernet Interface MIB  
RFC 2784 Generic Routing Encapsulation (GRE)  
RFC 2865 RADIUS  
RFC 2863 Interfaces Group MIB  
RFC 3176 sFlow  
RFC 4087 IP Tunnel MIB  
RFC 4133 Entity MIB  
RFC 4293 - IP MIB  
RFC 5905 NTP Version 4  
RFC 4741 NET CONF (Partial)  
RFC 5961 TCP Security  
RFC 5880 Bidirectional Forwarding Detection (BFD)

## **IPv6 Core**

RFC 1887 IPv6 unicast address allocation architecture  
RFC 1981 IPv6 Path MTU Discovery  
RFC 2375 IPv6 Multicast Address Assignments  
RFC 2450 Proposed TLA and NLA Assignment Rules  
RFC 2460 IPv6 Specification  
RFC 2462 IPv6 Stateless Address—Auto-Configuration  
RFC 2464 Transmission of IPv6 over Ethernet Networks  
RFC 2471 IPv6 Testing Address allocation  
RFC 2711 IPv6 Router Alert Option  
RFC 3587 IPv6 Global Unicast—Address Format  
RFC 4193 Unique Local IPv6 Unicast Addresses  
RFC 4291 IPv6 Addressing Architecture  
RFC 4301 IP Security Architecture  
RFC 4303 Encapsulation Security Payload  
RFC 4305 ESP and AH cryptography  
RFC 4443 ICMPv6  
RFC 4552 Auth for OSPFv3 using AH /ESP  
RFC 4835 Cryptographic Alg. Req. for ESP  
RFC 4816 Neighbor Discovery for IP version 6 (IPv6)

## **IPv6 Routing**

RFC 2080 RIPng for IPv6  
RFC 2740 OSPFv3 for IPv6  
RFC 5308 Routing IPv6 with IS-IS  
RFC 2545 Use of BGP-MP for IPv6  
RFC 6106 Support for IPv6 Router Advertisements with DNS Attributes  
RFC 6164 Using 127-Bit IPv6 Prefixes on Inter-Router Links

## **IPv6 Multicast**

RFC 2710 Multicast Listener Discovery (MLD) for IPv6  
RFC 3810 Multicast Listener Discovery Version 2 for IPv6  
RFC 4601 PIM-SM  
RFC 4604 IGMPv3 and MLDv2 for SSM  
RFC 4607 Source-Specific Multicast for IP

## IPv6 Transitioning

RFC 3056 Connection of IPv6 Domains via IPv4 Clouds  
RFC 4213 Transition Mechanisms for IPv6 Hosts and Routers  
RFC 4798 Connecting IPv6 Islands over IPv4 MPLS Using IPv6 Provider Edge Routers  
RFC 4659 BGP-MPLS IP Virtual Private Network (VPN) Extension for IPv6 VPN

## MPLS

RFC 2205 RSVP v1 Functional Specification  
RFC 2209 RSVP v1 Message Processing Rules  
RFC 2702 TE over MPLS  
RFC 2961 RSVP Refresh Overhead Reduction Extensions  
RFC 3031 MPLS Architecture  
RFC 3032 MPLS Label Stack Encoding  
RFC 3037 LDP Applicability  
RFC 3097 RSVP Cryptographic Authentication  
RFC 3209 RSVP-TE  
RFC 3270 MPLS Support of Differentiated Services  
RFC 3813 MPLS LSR MIB  
RFC 3815 Definition of Managed Objects for the MPLS, LDP  
RFC 4090 Fast Reroute Extensions to RSVP-TE for LSP Tunnels; partial support  
RFC 4379 OAM  
RFC 4448 Encapsulation methods for transport of Ethernet over MPLS networks  
RFC 4461 Signaling Requirements for Point-to- Multipoint Traffic-Engineered MPLS Label Switched Path(LSR)  
RFC 4875 Extensions to RSVP-TE for P2MP TE LSPs  
RFC 5036 LDP Specification  
RFC 5305 ISIS-TE  
RFC 5443 LDP IG P Synchronization  
RFC 5561 LDP Capabilities  
RFC 5712 MPLS Traffic Engineering Soft Preemption  
RFC 5918 LDP "Typed Wildcard" FEC  
RFC 5919 Signaling LDP Label Advertisement Completion

## Layer 3 VPN

RFC 3107 Carrying Label Information in BGP-4  
RFC 4360 BGP Extended Communities Attribute  
RFC 8092 BGP Large Communities  
RFC 4364 BGP/MPLS IP VPNs  
RFC 4365 Applicability Statement for BGP/MPLS IP VPNs  
RFC 4382 MPLS/BGP Layer 3 VPN MIB  
RFC 4576 Using LSA Options Bit to Prevent Looping in BGP/MPLS IP VPNs (DN Bit)  
RFC 4577 OSPF as the PE/CE Protocol in BGP/ MPLS IP VPNs  
RFC 4760 Multiprotocol Extensions for BGP-4

## Layer 2 VPN and PWE3

RFC 3343 TTL Processing in MPLS networks  
RFC 4664 Framework for Layer 2 Virtual Private Networks  
RFC 4665 Service Requirements for Layer 2 Provider-Provisioned Virtual Private Networks  
RFC 4762 VPLS using LDP Signaling  
RFC3985 Pseudowire Emulation Edge to Edge (PWE3) Architecture  
RFC 4447 Pseudowire Setup and Maintenance using LDP

RFC 4448 Encapsulation Methods for Transport of Ethernet over MPLS Networks

RFC 5542 Definitions of Textual Conventions for Pseudowire (PW) Management

RFC 5601 Pseudowire (PW) Management Information Base

## Encryption

RFC 5996 Internet Key Exchange Protocol Version Version 2 (IKEv2)  
RFC 4303 IP Encapsulating Security Payload (ESP)  
RFC 6379 Suite B Cryptographic Suites for IPsec  
RFC 5903 Elliptic Curve Groups modulo a Prime (ECP Groups) for IKE and IKEv2  
RFC 4868 Using HMAC-SHA -256, HMACSHA- 384, and HMAC-SHA-512 with IPsec  
RFC 4754 IKE and IKEv2 Authentication Using the Elliptic Curve Digital Signature Algorithm(ECDSA)  
RFC 4106 The Use of Galois/Counter Mode (GCM) in IPsec Encapsulating Security Payload (ESP)  
RFC 3602 AES with 128-bit keys in CBC mode  
RFC 4806 Online Certificate Status Protocol (OCSP) Extensions to IKEv2  
FIPS PUB 186-4 Digital Signature Standard (DSS)  
SP800-56A Recommendation for Pair-Wise Key Establishment Schemes Using Discrete Logarithm Cryptography

## Federal Certification

FIPS

- FIPS 140-2 Level 2 with Design Assurance for Level 3 Common Criteria

- Network Device Protection Profile version 1.1

USGv6

- UNH-IOL USGv6 accreditation as Switch and Router JIT C

- DoD UC APL for Assured Services LAN (ASLAN) Layer 2/3 switch with MPLS
- DoD UC APL for Customer Edge Router

## MEF Certification

MEF 9 Certified—Abstract Test Suite for Ethernet Services at the UNI

MEF 14 Certified—Abstract Test Suite for Traffic Management Phase 1

## Network Management

Network Advisor Web-based Graphical User Interface (GUI)

Integrated industry-standard Command Line Interface (CLI)

sFlow (RFC 3176)

Telnet

SNMP v1, v2c, v3

SNMP MIB II

RMON

Support for automated configuration management using NETCONF

Entity MIB (Version 3)

## Element Security Options

TLS 1.1 and 1.2

AAA

RADIUS

Secure Shell (SSH v2)

Secure Copy (SCP v2)

HTTPs

TA CACS/TA CACS+



## Element Security Options (cont.)

Username/Password (Challenge and Response)

Bi-level Access Mode (Standard and EXEC Level)

Protection against Denial of Service (DoS) attacks, such as TCP SYN or Smurf Attacks

## Environmental

Operating temperature: 0°C to 40°C (32°F to 104°F)

Storage temperature: -25°C to 70°C (-13°F to 158°F)

Relative humidity: 5% to 90%, at 40°C (104°F), non-condensing

Storage humidity: 95% maximum relative humidity, non-condensing

Operating altitude: 6,600 ft (2,012 m)

Storage altitude: 15,000 ft (4,500 m) maximum

## Safety Agency Approvals

CAN/CSA-C22.2 No. 60950-1-3

UL 60950-1

IE C 60950-1

EN 60950-1 Safety of Information Technology Equipment

EN 60825-1 Safety of Laser Products—Part 1: Equipment Classification, Requirements and User's Guide

EN 60825-2 Safety of Laser Product—Part 2: Safety of Optical Fibre Communication Systems

## Electromagnetic Emission

ICES-003 Electromagnetic Emission

FCC Class A

EN 55022/CISPR-22 Class A/VCCI Class A

AS/NZS 55022

EN 61000-3-2 Power Line Harmonics

EN 61000-3-3 Voltage Fluctuation and Flicker

EN 61000-6-3 Emission Standard (supersedes EN 50081-1)

## Immunity

EN 61000-6-1 Generic Immunity and Susceptibility (supersedes EN 50082-1)

EN 55024 Immunity Characteristics. Supersedes:

EN 61000-4-2 ESD

EN 61000-4-3 Radiated, radio frequency, electromagnetic field

EN 61000-4-4 Electrical fast transient

EN 61000-4-5 Surge

EN 61000-4-6 Conducted disturbances induced by radiofrequency fields

EN 61000-4-8 Power frequency magnetic field

EN 61000-4-11 Voltage dips and sags

## TELCO NEBS/ETSI

*Designed to meet the following specifications (formal testing under way):*

Telcordia GR-63-CORE NEBS Requirements: Physical Protection

Telcordia GR-1089-CORE EMC and Electrical Safety

Telcordia SR-3580 Level 3

ET SI ET S 300-019 Physical Protection

Part 1-1, Class 1.1, Partly Temperature Controlled Storage Locations

Part 1-2, Class 2.3, Public Transportation

Part 1-3, Class 3.1, Temperature Controlled Locations (Operational)

ET SI ET S 300-386 EMI/EMC

## Power and Grounding

ET S 300 132-1 Equipment Requirements for AC Power Equipment Derived from DC Sources

ET S 300 132-2 Equipment Requirements for DC Powered Equipment

ET S 300 253 Facility Requirements

## Physical Design and Mounting

Tabletop

Rack Mount 19-inch rack mount supporting racks compliant with:

- ANSI/EIA -310-D
- ET S 300 119
- GR-63-CORE Seismic Zone 4

## Environmental Regulatory Compliance

- EU 2002/95/EC RoHS (with lead exemption)
- EU 2002/96/EC WEEE

## Network Equipment Building Standards (NEBS)

- GR-1089-CORE NEBS EMC and Safety
- GR-63 CORE: NEBS Physical Protection
- SR-3580: NEBS Criteria Levels (Level 3)

## Ordering Information

Part Number	Description
BR-MLXE-4-MR2-M-AC	MLXe-4 AC system with one MR2 (M) management module, two high-speed switch fabric modules, one 1,800 W AC power supply, four exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-4-MR2-M-DC	MLXe-4 DC system with one MR2 (M) management module, two high-speed switch fabric modules, one 1,800 W DC power supply, four exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-4-MR2-X-AC	MLXe-4 AC system with one MR2 (X) management module, two high-speed switch fabric modules, one 1,800 W AC power supply, four exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-4-MR2-X-DC	MLXe-4 DC system with one MR2 (X) management module, two high-speed switch fabric modules, one 1,800 W DC power supply, four exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-8-MR2-M-AC	MLXe-8 AC system with one MR2 (M) management module, two high-speed switch fabric modules, two 1,800W AC power supplies, two exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-8-MR2-M-DC	MLXe-8 DC system with one MR2 (M) management module, two high-speed switch fabric modules, two 1,800W DC power supplies, two exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-8-MR2-X-AC	MLXe-8 AC system with one MR2 (X) management module, two high-speed switch fabric modules, two 1,800W AC power supplies, two exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-8-MR2-X-DC	MLXe-8 DC system with one MR2 (X) management module, two high-speed switch fabric modules, two 1,800W DC power supplies, two exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-16-MR2-M-AC	MLXe-16 AC system with one MR2 (M) management module, three high-speed switch fabric modules, four 1,800W AC power supplies, two exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-16-MR2-M-DC	MLXe-16 DC system with one MR2 (M) management module, three high-speed switch fabric modules, four 1,800W DC power supplies, two exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-16-MR2-X-AC	MLXe-16 AC system with one MR2 (X) management module, three high-speed switch fabric modules, four 1,800W AC power supplies, two exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-16-MR2-X-DC	MLXe-16 DC system with one MR2 (X) management module, three high-speed switch fabric modules, four 1,800W DC power supplies, two exhaust fan assembly kits, and air filter. Power cord not included.
BR-MLXE-32-MR2-M-AC	MLXe-32 AC system with one MR2 (M) management module, seven high-speed switch fabric modules, four 3,000W AC power supplies, two power supply fans, eight exhaust fans, two air filters and cable management system. Power cord not included.
BR-MLXE-32-MR2-M-DC	MLXe-32 DC system with one MR2 (M) management module, seven high-speed switch fabric modules, four 3,000W DC power supplies, two power supply fans, eight exhaust fans, two air filters and cable management system. Power cord not included.
BR-MLXE-32-MR2-X-AC	MLXe-32 AC system with one MR2 (X) management module, seven high-speed switch fabric modules, four 3,000W AC power supplies, two power supply fans, eight exhaust fans, two air filters and cable management system. Power cord not included.
BR-MLXE-32-MR2-X-DC	MLXe-32 DC system with one MR2 (X) management module, seven high-speed switch fabric modules, four 3,000W DC power supplies, two power supply fans, eight exhaust fans, two air filters and cable management system. Power cord not included.
BR-MLX-MR2-M	MLX system management module, 4 GB SDRAM, 2 GB internal compact flash, external compact flash slot, RS-232 and 10/100/1,000 Ethernet ports for out-of-band management
BR-MLX-MR2-X	MLXe system management module, 4 GB SDRAM, 2 GB internal compact flash, external compact flash slot, RS-232 and 10/100/1,000 Ethernet ports for out-of-band management
BR-MLX-32-MR2-M	MLX 32-slot system management module, 4 GB SDRAM, 2 GB internal compact flash, external compact flash slot, RS-232 and 10/100/1,000 Ethernet ports for out-of-band management
BR-MLX-32-MR2-X	MLXe 32-slot system management module, 4 GB SDRAM, 2 GB internal compact flash, external compact flash slot, RS-232 and 10/100/1,000 Ethernet ports for out-of-band management
NI-X-4-HSF	MLX 4-slot system high-speed switch fabric module
NI-X-16-8-HSF	MLX 8/16-slot system high-speed switch fabric module
NI-X-32-HSF	MLX 32-slot system high-speed switch fabric module
BR-MLX-10GX4-IPSEC-M	MLX 4-port 10 GbE/1 GbE combo and 4-port 1 GbE (-M) IPsec module with 512,000 IPv4 routes or 240,000 IPv6 routes in hardware
BR-MLX-100GX2-CFP2-X2	MLX 2-port 100 GbE (X2) CFP2 module with extended route table support for up to 2.4 million IPv4 or 1.8 million IPv6 routes in hardware
BR-MLX-100GX2-CFP2-M	MLX 2-port 100 GbE (M) CFP2 module. Supports 512,000 IPv4 routes in FIB.

## Ordering Information (cont.)

Part Number	Description
BR-MLX-40Gx4-M	MLX Series 4-port 40 GbE (M) module with IPv4/IPv6/MPLS hardware support and support for QSFP+ optics, including both LR and SR versions. Supports up to 512,000 IPv4 routes or 128,000 IPv6 routes. Requires high-speed switch fabric modules.
BR-MLX-10GX20-X2	MLX 20-port 10 GbE/1 GbE (X2) SFP+ and SFP combo module with extended route table support for up to 2.4 million IPv4 or 1.8 million IPv6 routes in hardware. Integrated hardware-enabled MACsec.
BR-MLX-10GX20-M	MLX 20-port 10 GbE/1 GbE (M) combo module. Supports SFP+ and SFP with up to 512,000 IPv4 routes or 240,000 IPv6 routes in FIB. Integrated hardware-enabled MACsec.
BR-MLX-10GX24-DM	MLXe 24-port 10 GbE module with IPv4/IPv6/MPLS hardware support—requires SFP optics. Supports 256,000 IPv4 routes in FIB.
BR-MLX-10Gx8-X	MLX Series 8-port 10 GbE (X) module with IPv4/IPv6/MPLS hardware support—requires SFP optics. Supports up to 1 million IPv4 routes in FIB. Requires high-speed switch fabric modules.
NI-MLX-10Gx8-M	MLX Series 8-port 10 GbE (M) module with IPv4/IPv6/MPLS hardware support and up to 512,000 IPv4 routes—requires SFP+ optics and high-speed switch fabric modules.
BR-MLX-10Gx4-X	MLX Series 4-port 10 GbE (X) module with IPv4/IPv6/MPLS hardware support—requires XFP optics. Supports 1 million IPv4 routes in hardware.
BR-MLX-10Gx4-X-ML	MLX/MLXe 4-port 10 GbE (ML) module with IPv4/IPv6/MPLS hardware support—requires XFP optics. Supports 512,000 IPv4 routes in FIB. License upgradable to “X” scalability (1 million IPv4 routes in hardware).
BR-MLX-1GFX24-X	MLX Series 24-port FE/GbE (SFP) module, with IPv4/IPv6/MPLS hardware support. Supports 1 million IPv4 routes in hardware.
BR-MLX-1GFX24-X-ML	MLX Series 24-port FE/GbE (SFP) module, with IPv4/IPv6/MPLS hardware support. Supports 512,000 IPv4 routes in FIB. License upgradable to “X” scalability (1 million IPv4 routes in hardware).
BR-MLX-1GCX24-X	MLX 24-port (X) 10/100/1,000 copper (RJ-45) module with IPv4/IPv6/MPLS hardware support. Supports 1 million IPv4 routes in hardware.
BR-MLX-1GCX24-X-ML	MLX 24-port (X) 10/100/1,000 copper (RJ-45) module with IPv4/IPv6/MPLS hardware support. Supports 512,000 IPv4 routes in FIB. License upgradable to “X” scalability (1 million IPv4 routes in hardware).
BR-MLX-1GX20-U10G-M	MLX 20-port 1 GbE (M) module. Upgradable to 10 GbE using additional software license. Supports SFP with up to 512,000 IPv4 routes or 240,000 IPv6 routes in hardware.
BR-MLX-1GX20-U10GMUPG	MLX 20-port license to upgrade from 1 GbE to 10 GbE (M).
BR-MLX-1GX20-U10G-X2	MLX 20-port 1 GbE (X2) module. Upgradable to 10 GbE using additional software license. Supports SFP with up to 2 million IPv4 routes or 800,000 IPv6 routes in hardware. Integrated hardware-enabled MACsec.
BR-MLX-1GX20-U10GX2UPG	MLX 20-port license to upgrade from 1 GbE to 10 GbE (X2).



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