

# CARRIER ETHERNET SOLUTION FOR SERVICE PROVIDER MOBILE BACKHAUL APPLICATIONS

## Leveraging Carrier Ethernet for Mobile Backhaul to Support Exploding Mobile Data Rates and Services

### Challenge

Today's mobile backhaul network must be designed correctly in order to provide reliable, future-proof, and cost-effective high capacity transport. Otherwise, service providers risk losing the opportunities that broadband mobile services promise.

### Solution

Carrier Ethernet provides a service-agnostic, well known, and relatively simple solution for mobile backhaul. Together, Carrier Ethernet and Juniper's Ethernet services products enable service providers to extract new levels of efficiency from their mobile services network.

### Benefits

- MX Series 3D Universal Edge Routers combines Ethernet services, MPLS, and Layer 3 routing in a single carrier-grade platform ideally suited to the mobile aggregation application while enabling cost savings nearly 30x lower per bit than legacy TDM interfaces.
- BX7000 Multi-Access Gateway allows mobile operators to retain their existing investment in 2G and 3G cell sites while reaping the benefits of IP/MPLS-based transport.
- EX Series Ethernet Switches enables high availability, unified communications, integrated security and operational excellence.

Unwired access to the Internet, our work, personal and family life is reaching new levels of efficiency and enjoyment with the deployment of High Speed Packet Access (HSPA) networks and the new breed of mobile devices. We are seeing the future of broadband converged mobile services through revolutionarily new interfaces enabled by Apple's iPhone, Blackberry's Storm, Google's Android, and the Nokia N95. While the possibilities of converged mobile broadband technologies are seemingly endless, the services that they enable introduce steep and unpredictable bandwidth demands upon the network. Mobile and integrated (fixed and mobile) operators are being challenged to marry profitable business models to a subscriber base that has grown accustomed to flat rate contracts. Doing so requires paying strict attention to the link between mobile devices and core transport domains, known as the mobile backhaul network.

Today's mobile backhaul network must be designed correctly in order to provide reliable, future-proof, and cost-effective high capacity transport. Otherwise, service providers risk losing the opportunities that broadband mobile services promise.

This solution brief provides network design teams with insights into how to deploy Carrier Ethernet from the cell-site base station to the aggregation point of presence (POP) in order to address the mobile backhaul challenges using Juniper Networks Ethernet solutions. After introducing the current mobile backhaul challenges, we then describe Ethernet reference architectures that address these challenges. While a pure Ethernet model is a subset of all mobile backhaul technology deployments, it specifically represents the direction in which 3G and 4G networks are moving, and therefore is relevant to many if not all operators as they migrate from legacy technologies to newly emerging Carrier Ethernet.

### The Challenge

As if the growing disparity between broadband service revenue and associated bandwidth consumption weren't enough, the current global financial conditions make it ever more imperative for service providers to efficiently operate their networks. This is particularly challenging when deploying mobile services because the technologies are still maturing and the operator must invest in new mobile technologies to remain competitive. Today's environment challenges mobile backhaul deployment in the following major categories:

- **Service availability**—How to connect any service to any device over a common transport network
- **Capacity planning**—How to traffic engineer for service availability and efficient dimensioning
- **Profitability**—How to extract new levels of efficiency out of the network

Carrier Ethernet has become a powerful tool for service providers to employ for metro connectivity, providing reliable transport that is cost effective and operationally efficient. Through the efforts of equipment vendors and the Metro Ethernet Forum (MEF), Ethernet technologies have been enhanced to move beyond the LAN as a carrier-grade technology, enabling a growing number of services. Because the cost of Primary Digital Hierarchy (PDH) and PDH over ATM mobile connections is significantly higher than the cost of new Ethernet connections, mobile backhaul has become the latest service to benefit from Carrier Ethernet.

This paper specifically addresses:

- How Juniper Networks® MX Series 3D Universal Edge Routers, EX Series Ethernet Switches with Virtual Chassis technology, and the BX7000 Multi-Access Gateway integrate in helping to solve the challenges of mobile backhaul via Carrier Ethernet
- Cell-site base station and aggregation POP support of Ethernet, common to 3G and 4G mobile standards
- Ethernet transport fabric, aspects of service availability and capacity planning
- Challenges and options associated with high availability, quality of service (QoS), and clock synchronization
- Carrier Ethernet's role in engineering a profitable mobile backhaul network by illuminating its applicability to most Greenfield and service migration build-outs

**Note:** This paper does not address legacy interfaces such as time-division multiplexing (TDM) and Asynchronous Transfer Mode (ATM).

## Juniper Networks Solution Portfolio for Service Providers

### Service Availability—Connecting Any Service to Any Device over Carrier Ethernet

With three generations of mobile technologies all relevant simultaneously, Carrier Ethernet provides a service-agnostic, well known, and relatively simple solution for mobile backhaul. Ethernet is a Layer 2 service that can be transported over many underlying media such as copper, fiber, and microwave. Ethernet adapts to all mobile backhaul transport technologies through TDM and ATM pseudowire circuit emulation services (CES). Example CES technologies include Structure Agnostic Transport over Packet (SAToP), ATM PWE3, MPLS, and IP tunneling (generic routing encapsulation or GRE). Circuit bundling technologies supported over Ethernet include Multilink Point-to-Point Protocol (MLPPP) and ATM IMA that allow the operator to dimension the transport fabric of earlier generation mobile technologies to meet the changing needs of their subscriber base. Cost analysis shows that cost savings continue to be realized with incremental bandwidth increases when compared with legacy transport technologies.

Within the mobile standards framework specifications, the cell-site base station has many configurations and capabilities. Abstracting the specific vendor details, the transport of mobile device content into Ethernet frames for backhaul can be viewed in three categories, as shown on the left side of Figure 1. First, 2G and 3G cell sites that support TDM and ATM respectively require a device that provides transport interworking over Ethernet. The Metro Ethernet Forum (MEF) uses the term Generic Inter-Working Function (GIWF) for this function. 4G and earlier generation

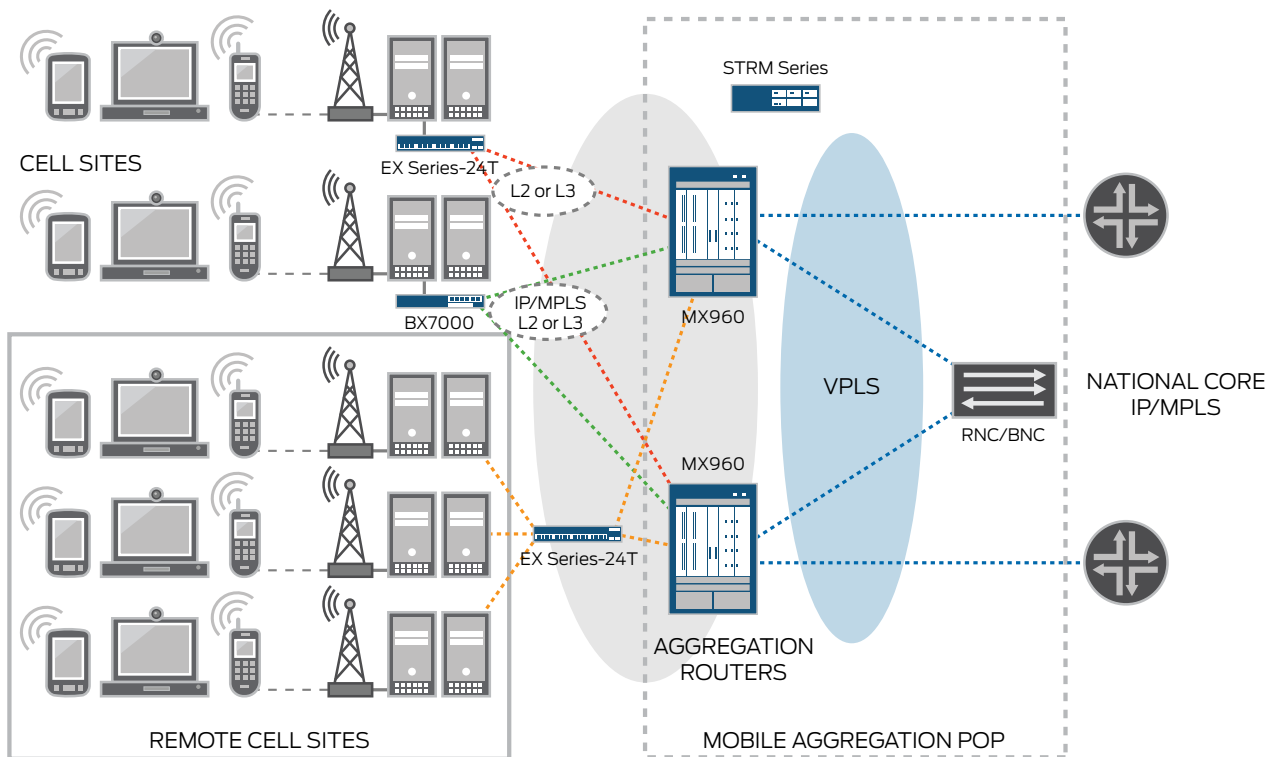


Figure 1: Carrier Ethernet mobile backhaul transport models

base stations that support Ethernet can interface directly to the Ethernet transport device. Many base station equipment vendors have been adding Ethernet interfaces directly into 2G and 3G equipment in order to realize the transport cost saving it enables. The second of these categories has the GIWF embedded within the cell-site router, as in the case of the BX7000 Multi-Access Gateway, while the third category uses a hub-site router to aggregate remote cell-site traffic.

### Scalability—Choosing the Right Topology and Switching Layer

The typical mobile backhaul deployment will have up to two regional aggregation sites connected to thousands of cell sites. The service provider must choose between Layer 2 and Layer 3 transport over the Ethernet service topology. There are many considerations that go into this selection, such as whether the backhaul service is to be layered atop an existing network or not, where and how QoS is to be enforced, and the size of the deployment.

In a Layer 2 network, media access control (MAC) address management must be addressed as the network size increases. The number of MAC addresses has an impact on service availability, as in the case of a link or node failure where the resultant network must relearn the MAC addresses of the resultant topology. The E-TREE (rooted multipoint) Ethernet service topology can reduce the overall number of MAC addresses due to its tree hierarchy structure, while also providing an ideal topology for clock synchronization distribution methods such as IEEE 1588v2.

Layer 3 switching scales up to 500,000 route table entries as compared to 4,000 (VLANs) for Layer 2, and is more secure against MAC spoofing and storming attacks. IP/MPLS and Layer 3 switching are the preferred methods as they eliminate MAC address learning, therefore providing scale and service availability benefits. IP/MPLS represents a mature and reliable mobile backhaul transport service for carrier scale broadband applications through its use in wire-line applications. MPLS fast-reroute enables sub-second link and node recovery times, while it supports sophisticated traffic engineering and VPN models.

### Staying In Sync—Addressing the Clock Distribution Challenge

Another aspect of connectivity that is critical in the mobile backhaul network is timing. Real-time content such as voice and video must be extracted from the data stream in sync with the timing in which it was placed into the data stream at the cell site. There are many clock distribution strategies that can be leveraged to synchronize base stations and the radio network controller, such as adaptive clocking, Synchronous Ethernet, and IEEE 1588v2. When clock synchronization data is transported over the Carrier Ethernet service, packet delay and packet delay variation must be carefully managed, particularly for adaptive clock recovery techniques. The most robust clock distribution strategy provides guarantees that a change in traffic conditions does not negatively impact the transport of its information. In the United States, a common out-of-band clock distribution method is based on placing GPS receivers at the cell-site and aggregation points, while in Europe, T3 and microwave are more common. An out-of-band clock distribution method called IEEE 1588v2 is becoming increasingly popular, along with Synchronous Ethernet.

### Intelligent Mobile Aggregation—Connecting the Backhaul Domain to the Core

Keeping pace with the mobile technology evolution requires agility in service transport, and intelligence in service routing. Connectivity into the core requires smart choices be made around route establishment, maintenance, scalability, and fault tolerance. Extending the backhaul domain into the provider core over virtual private LAN service (VPLS) addresses all of these challenges by creating virtual Ethernet switching domains that allow the provider to segment and manage the routing of mobile services. This model supports the wholesale backhaul operator for serving multiple customers off of a single backhaul complex, as well as the sole mobile operator for managing roaming services. Transport service virtualization also supports service-level agreement (SLA) enforcement and monitoring, as well as privacy and security.

Reducing the number of network elements in a network design is always desirable as it lowers energy costs, reduces real-estate expenses, and improves reliability. The MX Series combines Ethernet services, MPLS, and Layer 3 routing in a single carrier-grade platform ideally suited to the mobile aggregation application. Built on the full feature-set of Juniper Networks Junos® operating system routing and hardware, the MX Series blends Ethernet services into a single platform that collapses the competitor's separation of switching and routing platforms. This allows the Layer 3 switching backhaul links to forward directly into VPLS pseudo-wires according to mission-critical business criteria via integrated routing and bridging (IRB) support. The MX Series supports both Layer 2 VPN and VPLS metro Ethernet services for the mobile aggregation network. Using Juniper's VPLS technology also ensures service reliability through sub-second, mature failure recovery mechanisms built on its MPLS fast reroute and Bidirectional Forwarding Detection (BFD) protocol technology.

### Features and Benefits

#### Capacity Planning—Traffic Engineering for Efficient Dimensioning

With the fundamentals of connectivity established, the service provider must ensure service quality to meet subscriber expectations. Succeeding at this requires the efficient management of bandwidth resources with service growth. A successful SLA enforcement and monitoring strategy at the mobile backhaul UNI is critical to running an efficient network. The MEF has defined service attributes that can be monitored by a performance-monitoring facility such as Juniper Networks STRM Series Security Threat Response Manager. For QoS, the MEF has defined four service classes that can be implemented in three class-of-service (CoS) mappings. The BX7000, EX Series, and MX Series devices can effectively handle a full, four service class implementation at Layer 2 in the 802.1p bits, as well as Layer 3 in the DiffServ code point (DSCP) field and in the EXP field for MPLS backhaul from the BX7000. These CoS mappings associate EVC parameters related to packet delay, jitter, and committed and excess information rates. Using Juniper switches, service providers can enforce QoS with eight queues on a per-interface, EVC, VLAN, or VLAN grouping. For example, the MX Series provides scheduling on per-port and per-unit (such as Ethernet service class) basis. MX Series scheduling

policy also can be organized to a four-level hierarchy, as shown in Figure 2. Because the IP/MPLS backhaul between the BX7000 and MX Series supports sophisticated label-switched-path (LSP) constraint-based traffic engineering constructs, MPLS can be used in the core as well to reach cell sites directly.

When engineering the mobile backhaul network, fault tolerance can be addressed through deployment of multi-homed interfaces of the cell-site switches into the aggregation switches. Layer 2 OAM and BFD features are designed to detect link failures and node outages. After fault detection, a period of MAC relearning occurs as the redundant elements take over the traffic.

### Solution Components

#### EX Series Ethernet Switches:

- Carrier-class reliability - Leverage the same field-proven Juniper technology - including high-performance ASICs, a carrier-class system architecture, and Junos OS -- that powers the world's largest service provider networks.
- Security risk management - Tightly integrate with Juniper's UAC solution, dynamically delivering network protection, guest access and identity-based QoS based on user, device, and location.
- Performance - Deliver wire-speed performance on all ports for any packet size.
- Virtualization - Virtual Chassis technology allows up to 10 switches to be interconnected and managed as a single, logical device, delivering the reliability, scalability, and manageability of traditional chassis-based systems in a cost-effective, compact platform.
- Application control - Support eight QoS queues per port, ensuring proper prioritization of control plane, voice, video, and multiple levels of data traffic—with room to converge other networks, such as building automation and video security systems.
- Lower TCO - Enable new architectures that reduce cost and complexity.

#### BX7000 Multi-Access Gateway:

- Provides transport of legacy T1/E1 circuits across an ATM network.
- Compact form factor (9.45 inches/24 cm deep) ideal for cell site deployments.
- Temperature hardened option for uncontrolled environments.
- Passive cooling design for increased reliability and reduced power consumption.
- Unique expansion slots for additional advanced clocking and backhaul options.
- Feature-rich software support for TDM and ATM pseudowires, ATM-IMA, MPLS, and GRE.

#### MX Series 3D Universal Edge Routers:

- Ideal for IP/MPLS-based mobile backhaul transport with all the benefits of IP/MPLS—fast reroute, resiliency, reliability, operation, and OAM.
- Supports pseudowire interworking with VPLS, in which an access pseudowire from the BX7000 Multi-Access Gateway is cross-connected with a point-to-point VPLS instance in the backhaul network—this feature allows mobile operators to address a number of technical requirements, including multihoming, control plane scaling, and multicasting, as well as segmentation issues that can arise when backhaul components reside in different administrative domains.
- Junos Scope allows network operators to manage the full end-to-end mobile backhaul network from a central location.

### Summary—How to Extract New Levels of Efficiency Out of the Network

Today's mobile services are paving the way for new service revenue models that fuel new economic possibilities and cultural dynamics. Extracting new levels of efficiencies from the mobile network requires that service providers engineer an intelligent and agile mobile backhaul transport network. Taking this approach allows existing services to evolve and meet future expectations based on business models that fuel growth. Leveraging the right set of tools is the first step in addressing this challenge.

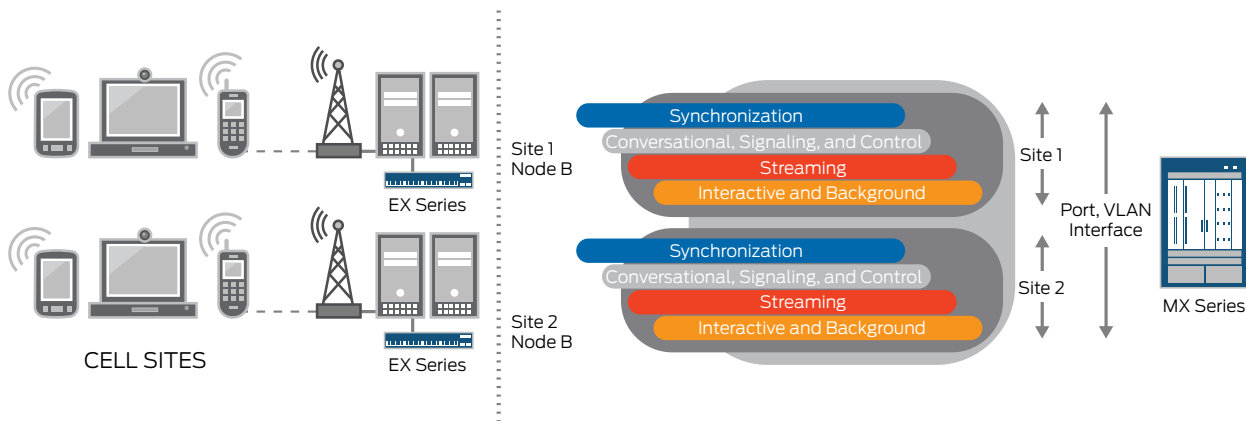


Figure 2: MX Series/EX Series scheduling flexibility

Juniper's cost-effective EX Series cell- and hub-site Ethernet switches provide Layer 2 and Layer 3 feature support on a carrier-grade platform, while the BX7000 adds embedded legacy cell-site interfaces and MPLS into an environmentally hardened chassis. Aggregating the cell and hub sites are MX Series 3D Universal Edge Routers that enable powerful traffic forwarding configurations, such as VPLS and Layer 3 VPN. SLA enforcement on these switches places them in a class of their own, allowing for visibility into network usage for planning, billing, and bilateral agreements.

At a time when the amount of bandwidth per user is increasing significantly, Juniper's Ethernet services routers enable cost savings that are approaching 30 times lower per bit than legacy TDM interfaces. Together, Carrier Ethernet and Juniper's Ethernet services products enable you to extract new levels of efficiency from your mobile services network.

## Next Steps

For more information about Juniper's Carrier Ethernet solution for service provider mobile backhaul applications, please contact your Juniper Networks sales representative or visit [www.juniper.net](http://www.juniper.net).

## 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](http://www.juniper.net).

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### 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](http://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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