

Building Mobile Backhaul Hub 2.0 with MX104 3D Universal Edge Router

Enhance subscriber QoE and reduce the total cost of ownership by flattening the backhaul network through a CE2.0 optimized edge and aggregation router

Table of Contents

Executive Summary	3
Introduction.....	3
CE2.0 Services for Mobile Backhaul.....	3
Mobile Backhaul Hub 2.0 Overview.....	4
Carrier Ethernet Aggregation.....	5
IPsec.....	5
Timing Hub.....	5
Low-Latency Switching/Routing for X2 Interface and CoMP Technology	5
Support for Multigeneration Radio Access and Transport Medium.....	5
SDN-Ready Architecture	6
MX104 as a Mobile Backhaul Hub 2.0	6
CE2.0-Compliant Edge and Aggregation Router	7
Highly Scalable IPsec and Inline Services Implementation.....	7
Highly Reliable and Scalable Hardware-Based Timing	8
High-Capacity Platform with Advanced QoS Engine.....	8
Industry-Leading Port Density and Modularity	8
SDN Architecture Support	8
JunosV App Engine	8
Junos Node Unifier	8
Junos Space Network Management Platform.....	9
Conclusion.....	9
About Juniper Networks.....	9

List of Figures

Figure 1: MEF22.1 reference model for LTE backhaul.....	4
Figure 2: Mobile Backhaul Hub 2.0 architecture for LTE overlay with S1-flex	4
Figure 3: Mobile backhaul hub 2.0 architecture for multigenerational RATs.....	6
Figure 4: Mobile backhaul Hub 2.0 implementation using the MX104 routing platform.....	7

Executive Summary

Mobile operators are looking for ways to provide a remarkable and differentiated user experience while reducing the service delivery cost. Flattening the backhaul architecture by enabling edge services at the mobile backhaul hub is an easy way to achieve this objective.

In addition to the standard carrier Ethernet aggregation, the next-generation hub platforms will also provide additional services such as termination or management of IPsec tunnels, grandmaster clock for the Precision Time Protocol (PTP), low-latency routing for the X2 interface, and support for coordinated multipoint transmission and reception (CoMP) technology, to name just a few. Juniper Networks® MX104 3D Universal Edge Router offers an edge and aggregation platform which enables the aforementioned services to be qualified as the industry-leading mobile backhaul Hub 2.0.

Introduction

There is no doubt that LTE is turning out to be the global mobile standard. Operators around the world are adopting either the frequency-division duplex (FDD) or time-division duplex (TDD) variant of LTE. Some have already taken the leap and the others are preparing for this transition. Associated with the migration to LTE and the evolved packet core (EPC) standard is the migration to packet transport networks from radio access network (RAN) to core.

Migration to packet interfaces and transport provides network simplification but at the same time introduces some challenges, such as network domain security, distribution of precise timing, quality-of-service (QoS) management for delay-sensitive traffic, service-level agreement (SLA) management, etc. The good news is that a number of techniques exist to address these challenges within the next-generation backhaul platforms, which is the main theme of this paper. Since the choice of a next-generation backhaul platform has both technical and commercial implications, the discussion presented here will be relevant to both technical and business decision makers.

Based on the aforementioned challenges, we are witnessing a trend within LTE backhaul. In addition to the advanced carrier Ethernet 2.0 (CE2.0) services, the aggregation (hub) platform is assuming additional functions, such as termination and management of IPsec tunnels, integrated source clock for PTP, advanced inline services, and features to satisfy the most stringent LTE requirements. Some of these next-generation platforms are further differentiated through software defined network (SDN)-ready architecture to enable a service rich, cost optimized LTE backhaul network.

In this paper, we use the term mobile backhaul (MBH) Hub 2.0 to refer to such a next-generation hub platform. The paper first discusses CE2.0 services for mobile backhaul based on the Metro Ethernet Forum (MEF) reference model. The architectural framework for MBH Hub 2.0 with some of the functional requirements follows, and we then make the case for Juniper Networks MX104 3D Universal Edge Router to be the rightful MBH Hub 2.0 edge and aggregation platform through highlighting its differentiated features and CE2.0 services for mobile backhaul.

CE2.0 Services for Mobile Backhaul

CE2.0 is a step in the right direction for the evolution of carrier Ethernet services to address the aforementioned challenges related to design and implementation of mobile backhaul networks. The three fundamental components of CE2.0, multi-class of service (CoS), Ethernet network-to-network interface (E-NNI), and advanced Ethernet Operation, Administration, and Maintenance (OAM) tools for SLA management, are the key ingredients for enabling mobile backhaul services within the LTE network. Within a CE2.0 framework, MEF22.1 implementation agreement specifies the requirements for advanced mobile backhaul services (an example reference implementation is shown in Figure 1 below).

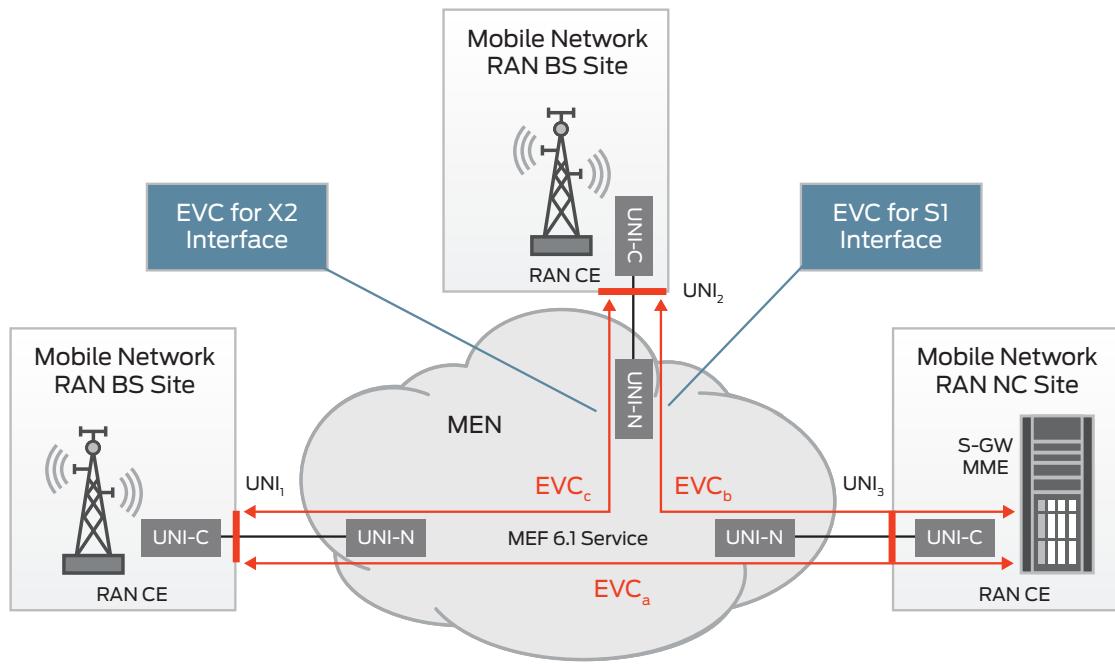


Figure 1: MEF22.1 reference model for LTE backhaul

The model shown in Figure 1 utilizes a number of Ethernet Virtual Connections (EVCs) to provide the backhaul for an LTE network. For example, for S1 backhaul EVCa and EVCb, Ethernet Virtual Private Line (EVPL) service can be used, and for X2 backhaul EVCc, Ethernet Virtual Private LAN (EVPLAN) service can be used. However, if S1-flex architecture is deployed to use mobility management entity (MME) and S-GW pooling, then EVPLAN service can also be used for S1 backhaul.

It should also be noted that the architecture in Figure 1 is equally applicable whether backhaul service is being provided by a wholesale backhaul provider or is being provided by the transport group within mobile operator's RAN or core group. Similarly, the reference architecture does not make any assumptions on the underlying transport technology being used in the Metro Ethernet Network (MEN). For our present discussion, we are assuming that the EVPL and EVPLAN services are implemented through an underlying IP/MPLS network with techniques such as Pseudowire Emulation (PWE) or virtual private LAN services (VPLS).

Mobile Backhaul Hub 2.0 Overview

Within mobile backhaul architecture, the hub sites are strategic locations in the network where the traffic from multiple cell sites is aggregated. For 2G and 3G RAN, carrier Ethernet aggregation was the primary function performed at the hub location. However, for LTE some additional functions are also essential for this location. Therefore, mobile backhaul Hub 2.0, as an essential component of the LTE backhaul network shown in Figure 2, would require the functional components described below.

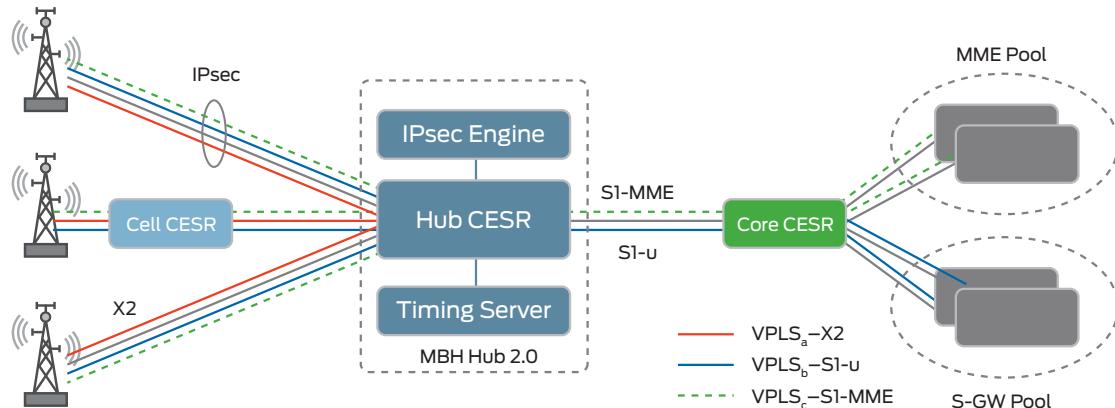


Figure 2: Mobile Backhaul Hub 2.0 architecture for LTE overlay with S1-flex

Carrier Ethernet Aggregation

The basic function of a mobile backhaul hub device is to aggregate various carrier Ethernet services such as EVPL and EVPLAN, also known as E-Line and E-LAN. These services can be provided through Ethernet switches enabled with Carrier Ethernet Transport (CET) capability or IP/MPLS routers. In Figure 2, the term carrier Ethernet switch router (CESR) is shown as a representation of this flexibility. In cases where cell, hub, and core CESRs are based on IP/MPLS infrastructure, PWE and VPLS technologies can be used to implement EVPL and EVPLAN services respectively.

With the introduction of Heterogeneous Network (HetNet) architecture, a hub site may need to aggregate a large number of small cells in addition to the macro cells. Therefore, the hub CESR platform should be scalable to support the future growth in the number of endpoints and the traffic from each of these endpoints.

IPsec

Network domain security is a critical function required in the design of the LTE backhaul. For a distributed IPsec (security architecture) implementation, hub devices should be able to manage or terminate the IPsec tunnels originated from the eNbs. The need for IPsec tunnel setup and management at the MBH hub is critical if the encrypted S1 and X2 interfaces are being routed through the MBH hub and the hub is located at the border of the trusted domain.

One side effect of enabling IPsec on the S1 and X2 interfaces is that intermediate network elements lose visibility to manage these interfaces. Therefore, it is highly desirable that enhancing network domain security should not be at the expense of management visibility.

Timing Hub

Frequency synchronization is a fundamental requirement for normal operation of radio access network, such as voice call handovers, and accurate resource block (RB) assignments for orthogonal frequency-division multiplex (OFDM) downlinks. In some cases, phase synchronization also becomes mandatory, such as CoMP and enhanced inter-cell interference coordination (eICIC) for LTE-Advanced networks. Historically, mobile networks have relied upon the inherent synchronization capabilities of SONET/SDH networks to attain the required frequency synchronization among base stations. Migration to IP/Ethernet-based backhaul requires that the frequency and the phase synchronization be achieved through external technologies such as GPS, and Timing over Packet (ToP) technologies such as Network Time Protocol (NTP), Synchronous Ethernet (SyncE), and/or Precision Time Protocol (PTP-IEEE1588-2008).

The frequency synchronization requirement can be easily satisfied either through SyncE or PTP; however, phase and time of day synchronization will require support of PTP, and deployment flexibility will require that the MBH Hub 2.0 platform support both SyncE and PTP. Furthermore, to minimize the number of components in the solution, it is desirable for the MBH hub platform to act as grandmaster clock (GM) without the need for an external timing server.

In addition to the functional components described above, the MBH Hub 2.0 platform should also have the following features:

Low-Latency Switching/Routing for X2 Interface and CoMP Technology

Within LTE architecture, the X2 interface was introduced to facilitate fast hand-offs between groups of eNbs. Since an X2 interface carries short bursts of delay intolerant data traffic, the optimal place to handle an X2 interface is as close to the cell site as possible. Taking X2 all the way to the core CESR will introduce unnecessary delays and render the existence of an X2 interface almost useless. In cases where cell CESR is not ubiquitously deployed or does not have enough scale to handle the full mesh connectivity requirement of X2, hub CESR becomes the logical place to handle the X2 interface.

CoMP is a critical feature within LTE-Advanced to facilitate cooperative communications across multiple cells within homogeneous or heterogeneous networks (HetNet). Multiple deployment options for CoMP technology are being considered for LTE-Advanced. Within each of these options, the CoMP functionality is dependent on the backhaul characteristics to a great extent, specifically the available capacity and latency. As MBH Hub 2.0 is a pivotal element in connecting multiple neighboring cells, it will need enhanced QoS capabilities to support CoMP technology.

Support for Multigeneration Radio Access and Transport Medium

The architecture shown in Figure 2 assumes that LTE backhaul is a separate overlay. A more common deployment scenario is when multigenerational radio access technologies (RATs) are supported by the same backhaul network. As shown in Figure 3, MBH Hub 2.0 in this case is most likely placed at the mobile telephony switching office (MTSO) and will interface with the base station controller (BSC) and radio network controller (RNC) locally to hand off 2G and 3G traffic, while sending the LTE traffic to core CESR.

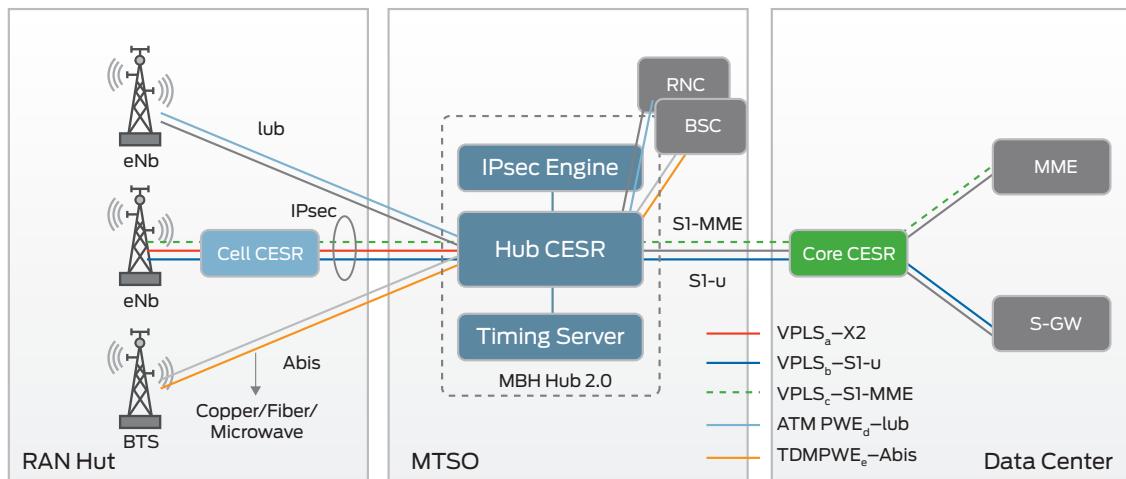


Figure 3: Mobile backhaul hub 2.0 architecture for multigenerational RATs

As shown in Figure 3, MBH Hub 2.0 will be required to aggregate traffic from radios with different interface types—including Ethernet, ATM, time-division multiplexing (TDM), and various transport mediums—including copper, fiber, and microwave. Therefore, MBH Hub 2.0 platforms should be flexible enough to support the mixing and matching of interfaces with varying traffic characteristics.

SDN-Ready Architecture

SDNs are a way to make networks more programmable through software so that they can be reconfigured quickly and functionally extended more easily. Rapid changes in mobile radio and core technologies require that future mobile networks be built on SDN principles. SDN is a broad and loosely defined concept, but the following aspects are important within the context of backhaul networks:

- Ability to offload some services from custom CESR platforms to generic x86 platforms
- Centralized control architecture with the ability to control multiple satellite devices from a single point in the network
- Centralized Web 2.0-based open network management platform

These SDN principles will not only make the MBH Hub 2.0 architecture service rich, but will also reduce the cost of service delivery, both of which are critical for maintaining a sustainable mobile ecosystem.

MX104 as a Mobile Backhaul Hub 2.0

MX104 is a universal edge router optimized for the aggregation of mobile, business, and residential access services. It is based on the central office (CO) optimized MX Series chassis supporting a redundant control plane for high availability. It is environmentally hardened to allow deployment in outside cabinets and remote terminals. A typical implementation of MBH Hub 2.0 using the MX104 platform is shown in Figure 4.

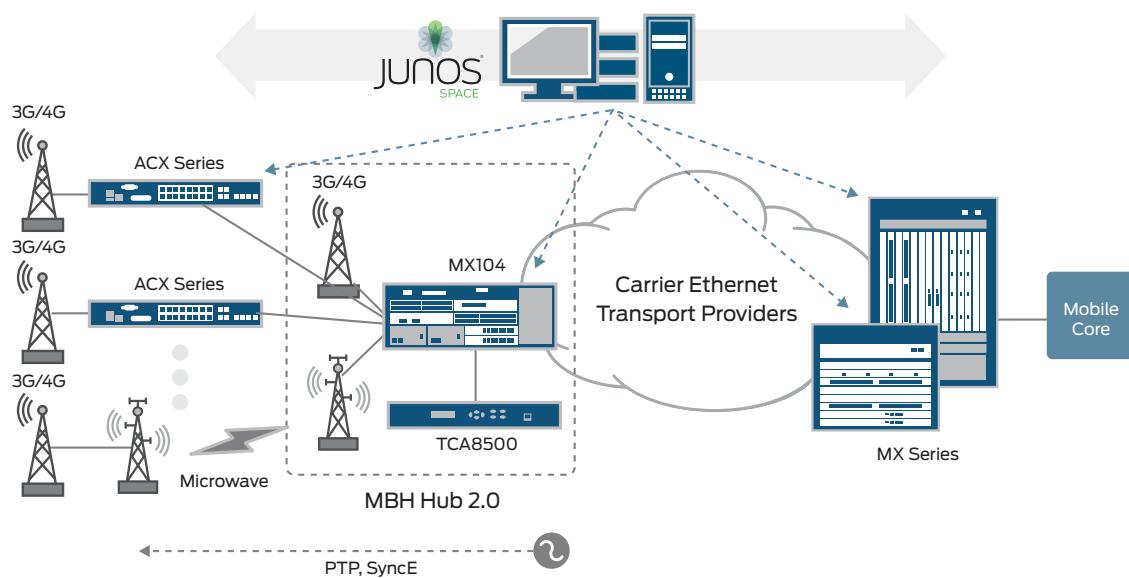


Figure 4: Mobile backhaul Hub 2.0 implementation using the MX104 routing platform

MX104 is Juniper's response to a shift in backhaul network architecture where the aggregation layer is assuming responsibility for being the service provider edge. This simplifies backhaul architecture by eliminating unnecessary layers. Specifically, the following features make MX104 the industry-leading MBH Hub 2.0 platform.

CE2.0-Compliant Edge and Aggregation Router

The MX104 router's CE2.0 certification enables its service provider customers to be assured that their E-Line, E-LAN, and E-Access services are compliant with the CE2.0 specifications. Through the use of Juniper Networks Junos® operating system and the Trio chipset Packet Forwarding Engine (PFE), which are both consistent with the rest of the MX Series family, MX104 can flexibly scale users, services, and bandwidth simultaneously, making it ideal for delivering expanded carrier Ethernet services.

MX104 edge and aggregation router delivers a CE2.0 services solution that enables a future ready, service-rich, converged network for a superior quality of experience to subscribers, and it delivers the lowest TCO to providers by minimizing the cost and maximizing the value per bit delivered.

Highly Scalable IPsec and Inline Services Implementation

With the growth of small cells, it is expected that a typical mobile network will have a few hundred thousand small cells in addition to the tens of thousands of macro cells. For this reason, a distributed implementation of LTE Security Gateway (SeGW) may be required in some cases. In this configuration, MBH Hub 2.0 will be required to terminate the IPsec tunnels, if it is at the border of the trusted domain. In other cases, it may need to act as an IPsec controller to allow the eNbs to establish a full mesh of secured X2 tunnels. MX104 with the Multiservices Modular Interface Card (MS-MIC) can support tens of millions of concurrent IPsec tunnels. This scale is enough to support the most aggressive requirement for network domain security implementation.

Through MS-MIC, MX104 can also support additional security measures such as stateful firewall and intrusion detection and prevention (IDP) for the network domain and subscriber flows. Through the flexible and innovative architecture of MS-MIC and MX104, all of these services can be enabled at full line rate without impacting the forwarding performance of MX104.

In addition to the inline services supported through MS-MIC, MX104 also provides a rich suite of L2-L3 services through the Trio chipset PFE.

Highly Reliable and Scalable Hardware-Based Timing

MX104 incorporates an industry-leading timing solution with all of the necessary components for a robust SyncE and PTP implementation. MX104 with integrated GPS receiver can act as a Stratum-1 level accurate grandmaster (GM) or can rely on an external Juniper Networks TCA8500 Timing Server for a flexible PTP implementation. It utilizes boundary clock (BC), and transparent clock (TC) features to enhance the scalability and accuracy of synchronization, respectively.

The accuracy of the recovery mechanism/clock extraction through PTP protocol is quite sensitive to the choice of algorithms, as not all PTP clock recovery algorithms are the same, and they can vary significantly from vendor to vendor. Through the use of Juniper owned timing and synchronization algorithms and intellectual property, MX104 is capable of meeting the highest level of frequency and phase accuracy required by the time-division duplex (TDD-LTE) mode of operation or frequency-division duplex (FDD-LTE) operation with CoMP and eICIC features enabled in the RAN. The solution has been tested extensively in labs and in field deployments with a chain of more than twelve nodes between PTP GM and slave, maintaining a frequency drift of less than 10 ppb and a phase drift of less than 1 uS using on-path support mechanisms like BC and SyncE for a hybrid mode approach.

High-Capacity Platform with Advanced QoS Engine

As mentioned earlier, support for the X2 interface and CoMP technology requires a high-capacity and low-latency hub platform. For example, Joint Transmission (JT) as one of the implementations of CoMP can be broadly described as a simultaneous transmission of data to an UE from multiple coordinated transmission points (TPs). In order to attain the benefits of JT, it is desirable that a large cluster of TPs be utilized. Typically, the cluster size over which the JT can be performed is limited by the backhaul constraints; hence, the need for a high-capacity and high-performance hub platform.

MX104 provides 80 Gbps of forwarding capacity while supporting the inline services mentioned above. The nonblocking switching fabric with the superior hierarchical QoS implementation scheme allows MX104 to maintain the strictest SLAs required for handling X2 interface or CoMP technology.

Industry-Leading Port Density and Modularity

As shown in Figure 3, support for multiple RATs over different physical interfaces requires the MBH Hub 2.0 platform to be modular. In addition, the traffic on each of these interface types and the number of these interfaces are growing with the introduction of small cells within a macro cellular footprint. Based on these requirements, the MX104 platform has been designed to support a combination of Ethernet, SONET, ATM, and circuit emulation (CE) interfaces through four field-replaceable MICs. The port densities of these MICs combined with built-in 10GbE ports makes MX104 the industry-leading CESR in its product category.

SDN Architecture Support

MX104 platform architecture is grounded in SDN principles and offers several advanced features in this regard:

JunosV App Engine

The JunosV App Engine provides a virtualization platform, support for Junos OS and third-party applications, and an SDK to link to Junos OS-based systems such as MX104. JunosV App Engine provides for hosting of Linux and other applications in a virtualized environment connecting to services and data in Junos OS networking systems. This enables benefits such as greater programmability, scalability, and flexibility, with a solid core of Juniper applications and third-party available and planned applications.

Through JunosV App Engine, the operator has the option to host some or all of the services available on the MX104 platform, including IPsec, stateful firewall, Network Address Translation (NAT), J-Flow, on a virtualized environment hosted on x86 platforms. This flexibility enables MX104 with innovative services to stay ahead of the requirements for MBH Hub 2.0.

Junos Node Unifier

Junos Node Unifier is a Junos OS platform clustering program that increases deployment flexibility of mobile backhaul networks. It centralizes management and automates configuration of switches such as the Juniper Networks ACX Series Universal Access Routers acting as cell CESR and attached to MX104 acting as MBH Hub 2.0. The ability to control and manage a large number of satellite devices through a central point in the network significantly reduces the deployment and operating cost.

Junos Space Network Management Platform

MX104 is managed through Juniper Networks Junos Space Network Management Platform, which is one of the critical components of Juniper's SDN vision. Junos Space Network Management Platform is a unified approach for managing the Juniper network infrastructure and for designing and deploying new services. Junos Space offers a centralized network management and orchestration solution to manage network devices and services through a single pane of glass for real-time visibility.

The Junos Space platform provides a single abstracted network model across the Juniper networking infrastructure, and it extends this to third parties through standards-based Representational State Transfer (RESTful) APIs. The use of a standards-based Device Management Interface (DMI), an XML schema-driven device access API, zero-day support for new devices, and a plug-and-play application environment, allows for in-service device and software upgrades.

Conclusion

Migration to LTE is resulting in upgrades to the backhaul network to provide end-to-end IP transport. This migration creates certain challenges which can be effectively handled through introducing next-generation backhaul platforms that are purposely designed for LTE requirements. In this paper, we have highlighted the essential functional components of the MBH Hub 2.0 platform as a key element of an LTE backhaul network. In addition to CE2.0 services aggregation, such a platform will also need to support control, management, and termination of IPsec tunnels, act as an integrated source clock for PTP to distribute precise timing within the RAN, provide QoS support for handling X2, CoMP, and eICIC technologies, and be built on SDN principles to manage future services requirements while reducing the solution cost. Juniper Networks MX104 3D Universal Edge Router has been purposefully designed to exceed the stated requirements for a MBH Hub 2.0. In this role, MX104 will enable LTE backhaul networks to move beyond the basic transport realm into a rich services realm that greatly enhances the end-user quality of experience.

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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