

# Building a Universal Access Network

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Optimizing Service Provider Access Networks with ACX Series Universal Access Routers

## Table of Contents

Executive Summary .....	3
Introduction—Current State of Access Networks .....	3
Challenges for Mobile Operators .....	3
Role of Management in the Access Layer .....	4
The Universal Access Solution .....	4
ACX1000 .....	6
ACX2000 .....	6
ACX4000 .....	6
ACX1100 .....	6
ACX2100 .....	6
ACX Series Universal Access Routers .....	6
ACX Series Features and Benefits.....	7
The Role of Seamless MPLS .....	7
The Role of End-to-End Management .....	8
Junos Space Unified Network Management—From Access to Core .....	9
Conclusion—Emerging Access Networks Unified with the Universal Edge .....	9
For More Information .....	10
Whitepapers:.....	10
Solution Briefs:.....	10
Datasheets:.....	10
About Juniper Networks.....	10

## List of Figures

Figure 1: Cell site backhaul L2 and L3 connection protocols (source: Infonetics Research) .....	4
Figure 2: The Universal Access solution extends edge intelligence to the access layer .....	5
Figure 3: Schematic view of TDM-based RAN .....	5
Figure 4: Schematic view of MPLS-based RAN .....	6
Figure 5: ACX Series Universal Access Routers .....	6
Figure 6: The traditional sets of network segments from the access to the edge and core layers .....	8
Figure 7: The comparatively simple management of an end-to-end seamless MPLS architecture .....	8

## Executive Summary

Convergence and network simplification have been hallmark trends for service providers in recent years, and Juniper has led the way with the Universal Edge—one common platform for business, residential, and mobile subscribers. Access networks could also benefit from consolidation, but this has remained a challenge due to the disparate technologies developed for mobile, residential, and business access. Instead of relying on separate access devices to connect customers, operators want to converge access networks to deliver both a more predictable experience to users and better economics to shareholders.

Juniper's Universal Access solution is based on the high-performance Juniper Networks® ACX Series Universal Access Routers, anchoring the first fully integrated, end-to-end network architecture that combines operational intelligence with capital cost savings. With Universal Access, operators can extend the edge network and its capabilities to the customer, whether that's a cell tower, a multi-tenant unit, or a residential aggregation point. This creates a seamless MPLS architecture that is critical to delivering the benefits of 4G radio and packet core evolution with minimal truck rolls, paving the way for new revenue, new business models, and a more flexible and efficient network.

Universal Access also uses Juniper Networks Junos® Space to offer a single management plane. This enables an open, standards-based management system that allows for rapid provisioning, fault management, Operation, Administration, and Maintenance (OAM), and service monitoring, as well as integration into existing management systems. In addition, proven synchronization technology results in better utilization of assets—more calls added, fewer calls dropped, and more data transported with fewer retransmissions, leading to happier customers and a healthier bottom line.

## Introduction—Current State of Access Networks

Various types of network access have evolved over time, from circuits to packets, from time-division multiplexing (TDM) to IP/Ethernet, and from wireline to wireless. So it is only natural that there are multiple access networks for different applications with many touch points, and this reality leaves operators with an obvious management challenge.

Many of the responses—also logical given the choices available—have been to focus on adding capacity in the form of point-to-point bandwidth from access to aggregation, with the only innovation being to replace TDM with Ethernet. Truck rolls are typically required for minor operational changes, and there is inconsistent quality in telephone calls (jitter, dropped calls) and Internet access connections.

As more and more access connections require wireless support, the challenges facing mobile operators become of paramount concern. These challenges range from the rising tide of packet traffic, to the underlying transport technology, to management of the end-to-end network.

## Challenges for Mobile Operators

The main challenges in optimizing backhaul have to do with the multiple network layers at Layers 1-3. There are many transport technologies and protocols, as well as access infrastructures that span multiple generations. The movement from voice-oriented TDM technology towards data center-oriented IP/Ethernet is part of this trend, as is the presence of many generations of mobile equipment, from voice-oriented TDM technology to data-oriented IP/Ethernet, including 2G and 3G legacy as well as 4G and Long Term Evolution (LTE) adoption.

In addition to the traditional cell sites, there are also many small cell network deployments, and peak backhaul capacities for all locations will be increasing significantly over the next couple of years, including urban and nonurban macrocells, as well as both indoor and outdoor small cell access deployments.<sup>1</sup>

Other large issues include the need to handle diversion of traffic that can be offloaded to either WLAN or Wi-Fi public networks, and to maintain the strong financial and strategic balance that is needed in building access networks. The balance is tipping to IP/Ethernet, as well as to MPLS in the access layer.

According to Infonetics Research, by 2013 a majority of mobile operators and transport providers will have over 90% of their cell sites connected with IP/Ethernet, and 70% of mobile operators plan to use MPLS at their cell sites. Figure 1 illustrates these key trends.

<sup>1</sup> Source: Infonetics Research, Continuous Research Service, Small Cell and LTE Backhaul Strategies: Global Service Provider Survey, November 2011.

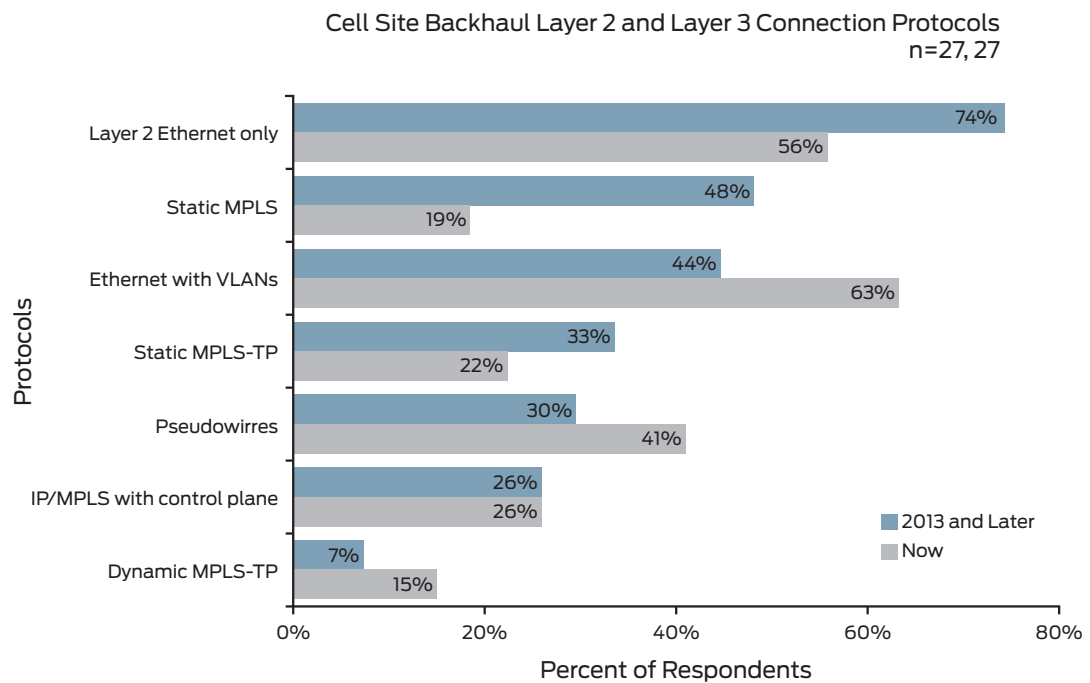


Figure 1: Cell site backhaul L2 and L3 connection protocols (source: Infonetics Research)

To examine the reasons behind these trends, the benefits of MPLS as opposed to pure Layer 2 Ethernet in the access layer were quantified in an integer linear programming exercise conducted by Clemson University—an access network was modeled with varying traffic demands and port sizes (including both 1 Gbps and 10 Gbps interfaces). The results demonstrated that MPLS produced a 30% less expensive network in the access layer.<sup>2</sup>

Clearly, there is a recognized requirement to have more intelligence in the access segment of the provider network. Convergence is a major driver here—independent solutions for mobile, residential, and business are too costly and difficult to manage with today's explosive traffic growth.

Against this backdrop, the rise of packet-oriented data traffic continues at a rapid pace, overloading the existing mobile network infrastructure and causing major bottlenecks in mobile backhaul. The existing architecture will not scale, which leads to the desire for more intelligence in the access layer, especially in mobile backhaul.

### Role of Management in the Access Layer

Access networks are inherently difficult to design and manage, because they are very dependent on geography. There are also many choices of locations and the need for many "satellites" in the field, away from central hub locations that can aggregate the traffic.

A key consideration in the design of access networks is how to manage all of these devices. An ideal solution is to have a single point (hub device) for operating, provisioning, monitoring, logging, and maintenance of the "satellite" devices (which may number into the thousands). The solution to this can come on either the control plane (network element operating system), management plane (a network management system or NMS), or some hybrid of the two.

### The Universal Access Solution

Network convergence has taken hold in core and edge networks, and Juniper's Universal Edge—a single platform for business, mobile, and residential networks—uniquely consolidates disparate edge networks into a single service delivery platform. Access networks, with the diversity of legacy devices for each of these user bases, remain very disparate and challenging to manage.

Juniper's Universal Access solution for mobile backhaul (LTE, 2G/3G, 4G), business Ethernet services, and circuit to Ethernet migration, complements the Universal Edge with a seamless end-to-end service delivery platform. It extends the existing network and all its capabilities to the point where customers are accessing the network. Universal Access also extends the intelligence from edge to access, creating a seamless end-to-end service delivery system, with high scale and financial viability.

<sup>2</sup> See Pietro Belotti, Comparison of MPLS and Ethernet Networks at the Access-Aggregation Level (<http://myweb.clemson.edu/~pbelott/papers/comparison-eth-mpls.pdf>).

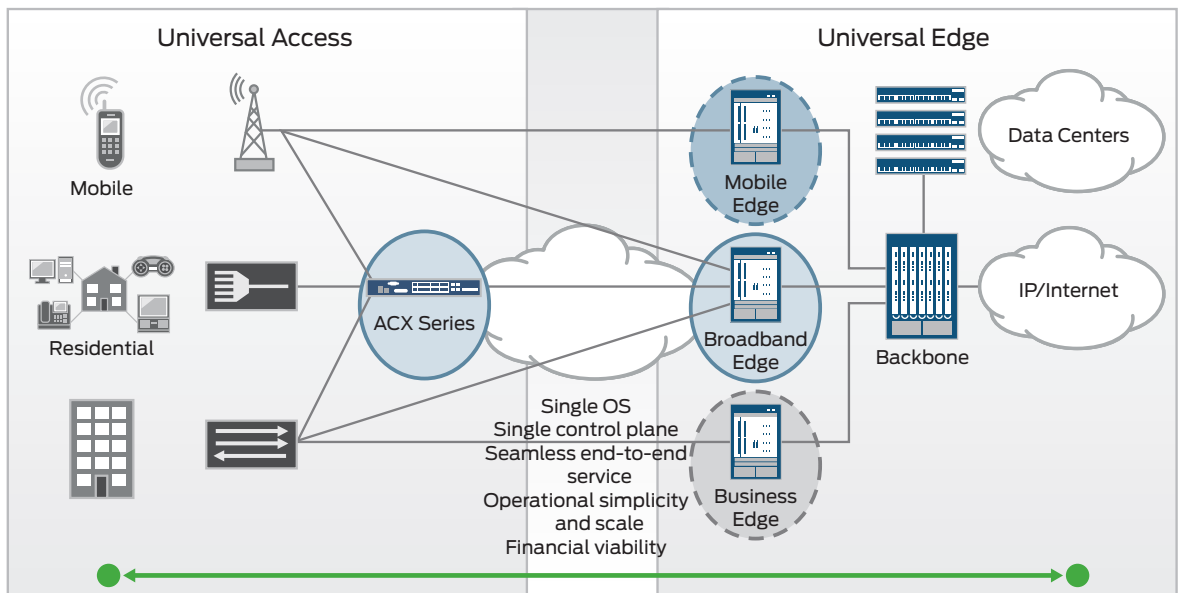


Figure 2: The Universal Access solution extends edge intelligence to the access layer

To give an idea of the topological advantages of MPLS intelligence in the access layer, consider a mobile access example. In the existing TDM radio access network (RAN) shown in Figure 3, the base stations do not connect to each other at all. Instead, dozens of these will be “homed” (assigned) to an existing controller.

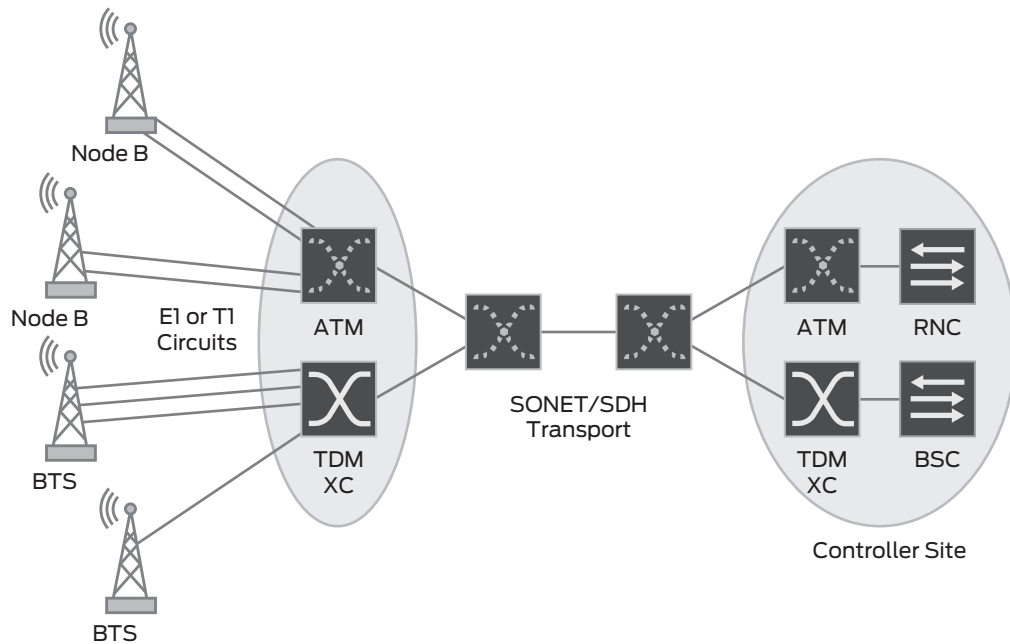


Figure 3: Schematic view of TDM-based RAN

The following example (Figure 4) demonstrates that it is more bandwidth efficient and cost-effective to have MPLS-based network aggregate traffic from multiple base stations and transport it to the controller. This way, if base stations have to be reassigned to a controller, a configuration change can handle the re-homing task.

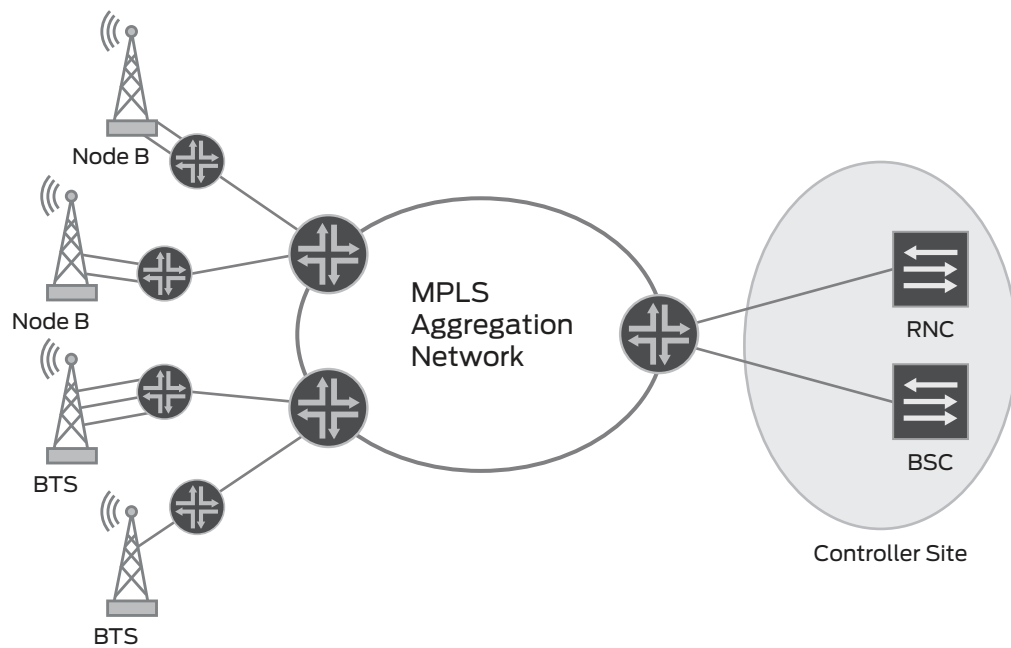


Figure 4: Schematic view of MPLS-based RAN

### ACX Series Universal Access Routers

The ACX Series, a key component of Universal Access, is built to support diverse service architectures. It enables rapid deployment of access services, and it transforms the network to create a seamless end-to-end service delivery architecture.

ACX Series routers enable the Universal Access architecture to run Juniper Networks Junos operating system from access to edge to core, providing a seamless end-to-end service delivery network for all applications and customers. The operational intelligence of IP/MPLS in Junos OS permits traffic steering and makes efficient use of existing bandwidth. Flexible services can be applied at the access layer and optimized per customer. ACX Series routers also incorporate the Juniper Networks TCA Series Timing Appliances' technology to deliver high precision, high bandwidth, carrier-class timing and synchronization.

The ACX Series platforms (Figure 5) include fixed form-factor models in Juniper Networks ACX1000, ACX1100, ACX2000, and ACX2100 Universal Access Routers, and a modular option in the ACX4000 Universal Access Router.



Figure 5: ACX Series Universal Access Routers

The following table illustrates the interface differences (including number of interfaces) between these platforms.

Table 1: Interface Differences Across ACX Series Platforms

Interface	ACX1000	ACX1100	ACX2000	ACX2100	ACX4000 <sup>3</sup>
TDM – T1/E1	8	-	16	16	-
GbE copper	8	8	8 (PoE++ on two ports)	4	-
GbE combination (copper or fiber)	4	4	-	4	8 (PoE++ on two ports)
GbE (small form-factor pluggable transceiver)	-	-	2	2	2
10GbE (SFP+)	-	-	2	2	2

## ACX Series Features and Benefits

The key features and benefits of Universal Access are highlighted in the following table.

Table 2: Key Features and Benefits of Universal Access Solution

Feature	Benefit
High performance access router	<ul style="list-style-type: none"> <li>Industry's only 10GbE capable access router</li> <li>60 Gbps platform: 3x the performance of competition</li> </ul>
Industry's most flexible and adaptable service architecture with seamless MPLS support	<ul style="list-style-type: none"> <li>Most sophisticated MPLS architecture, TE for optimal paths</li> <li>QoS in the access layer on a per-customer basis</li> </ul>
ACX Series with proven and deployed industry-leading timing technology used in the TCA Series appliance	<ul style="list-style-type: none"> <li>Built-in 1588-2008 and SyncE support eliminates dropped calls and data retransmissions</li> </ul>
Juniper Networks Junos Space Unified Management	<ul style="list-style-type: none"> <li>Point-and-click provisioning from a centralized location removes truck rolls</li> <li>Integrated Sync Manager for end-to-end network visibility of latency and jitter</li> <li>End-to-end OAM for service management and fault monitoring</li> </ul>
Only open access system for extensibility	<ul style="list-style-type: none"> <li>Architectural solution that can be augmented by partners to create integrated customized solutions (Juniper Networks Junos SDK)</li> </ul>
Environmentally hardened	<ul style="list-style-type: none"> <li>Survival of system in extreme weather conditions</li> <li>Highly reliable fanless design</li> </ul>

For more information, please see the ACX Series datasheet at [www.juniper.net/us/en/local/pdf/datasheets/1000397-en.pdf](http://www.juniper.net/us/en/local/pdf/datasheets/1000397-en.pdf).

## The Role of Seamless MPLS

MPLS has long taken hold as the transport architecture of choice in both core and edge networks—in the core with high capacity transport label-switched paths (LSPs), and in the edge with Layer 2 and Layer 3 VPN services that include virtual private LAN service (VPLS) and point-to-multipoint LSPs. The access network, however, is more complicated than the core in both size and complexity.

In particular, the mobile RAN has a wide range of interface and protocol types, and there are new network elements introduced with each generation of mobile specifications (2G/3G/4G/LTE, etc.). There are similar (not as diverse) disparities in residential access (ATM and Ethernet). Still, the flexibility of MPLS is attractive in the access network, as it allows a simpler and more flexible end-to-end provisioning model than any previous solution, whether based on TDM or point-to-point Ethernet.

Figure 6 illustrates service provisioning in a traditional network. There are two different segments being provisioned in the access and aggregation layers, and another one in the core. There are multiple control planes controlling these network segments. Even if these were all LSPs, they still might be separately provisioned LSPs held within the boundaries of the regions (clouds) shown within the diagram—multiple provisioning points and more difficult to maintain.

<sup>3</sup> ACX4000 supports two Modular Interface Controller (MIC) slots for additional interfaces.

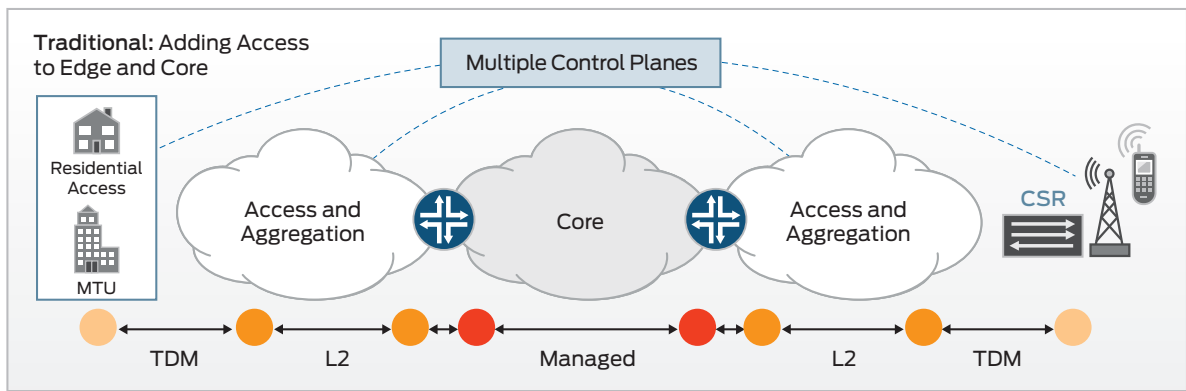


Figure 6: The traditional sets of network segments from the access to the edge and core layers

In a seamless MPLS network, all forwarding of packets within the network, from the time a packet enters until it leaves the network, is based on MPLS. As illustrated in Figure 7, there is a single provisioning point per connection with the notion of a single LSP across the access nodes in a network-wide single MPLS domain. Minimizing the number of service provisioning points further enables decoupling of services architecture from the underlying topology and transport.

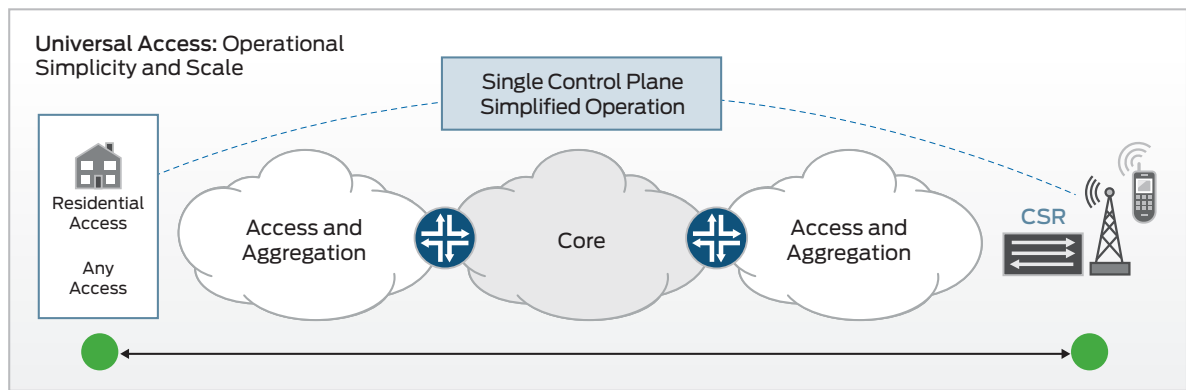


Figure 7: The comparatively simple management of an end-to-end seamless MPLS architecture

With seamless MPLS, the idea is to provision the service end-to-end to minimize the number of provisioning points. The service provisioning is aligned with the network architecture and maintains simplicity in the access network. Achieving this relies on increased capabilities and intelligence on the service nodes (traditional provider edge routers). At the same time, it also simplifies operations and makes efficient use of network resources by reducing the number of provisioning points and relying on a single MPLS-based forwarding in the data plane.<sup>4</sup>

### The Role of End-to-End Management

Service providers have varied challenges in the area of network management. Some choose to use homebuilt management systems for end-to-end discovery and provisioning, and others prefer vendor built solutions. Most will use a combination of the equipment’s control plane(s) and an NMS where appropriate. All service providers would like a more flexible solution, especially one using the same interface in the access layer as in the edge and core of the network.

<sup>4</sup> For more information, see the papers titled, Seamless MPLS ([www.juniper.net/us/en/local/pdf/whitepapers/2000316-en.pdf](http://www.juniper.net/us/en/local/pdf/whitepapers/2000316-en.pdf)) and Building Multi-Generation Scalable Networks with End-to-End MPLS ([www.juniper.net/us/en/local/pdf/whitepapers/2000452-en.pdf](http://www.juniper.net/us/en/local/pdf/whitepapers/2000452-en.pdf)).

## Junos Space Unified Network Management—From Access to Core

Junos Space network management system is an open and extensible network application platform that uses standards-based access to gain network and subscriber intelligence. The platform includes several applications to deliver a complete network management system that addresses the needs of the service delivery network from the access nodes all the way to the core nodes.

Key among these is Junos Space Network Activate, a key component of the Junos Space unified system. Network Activate is a service provisioning application that allows service providers and enterprises to rapidly enable new service offerings. The provisioning elements include:

- Automated and streamlined MPLS/carrier Ethernet service provisioning and autodiscovery
- Ability to design, provision, and deploy point-to-point (P2P) and point-to-multipoint (P2MP) RSVP-signaled and static LSPs
- Control plane and data plane validation to ensure that services are operational
- Improved network service using customized QoS profiles for bandwidth management, traffic shaping, and congestion management

The next component is the Sync Manager that allows network operators to configure, monitor, and manage IEEE1588-2008 and SyncE interfaces across the network. It also provides a detailed view of jitter and latency across the network, a very important operational asset for mobile service providers.

The Junos OS-powered ACX Series supports a wide range of OAM features in the Junos Platform MPLS OAM portfolio. Junos Space offers an OAM toolkit that supports easy configuration of OAM functions such as Ethernet link fault management, connectivity fault management, and Bidirectional Forwarding Detection (BFD). The OAM toolkit also provides performance measurement and troubleshooting integrated into Ethernet OAM.

The Junos Space platform and applications are all accessible through a Representational State Transfer (REST)-based API from northbound systems. This enables operators to build native applications on their operations/business support systems (OSS/BSS), and tap into the rich functionality of the Junos Space platform and applications.

## Conclusion—Emerging Access Networks Unified with the Universal Edge

Network convergence has taken hold in core and edge networks, and Juniper's Universal Edge—a single platform for business, mobile, and residential networks—uniquely consolidates disparate edge networks into a single service delivery platform. The environmentally hardened ACX Series Universal Access Routers provide the only 10GbE access solution in the industry.

Key benefits of the Universal Access solution include:

- Extend intelligence to the access for seamless end-to-end service delivery.
- Highest performance with up to 60 Gbps system throughput and scalability to build seamless MPLS network of the order of 100,000 nodes.
- Superior quality of experience with high-precision, field-proven built-in timing and TE features to mitigate congestion hotspots.
- End-to-end management for automated service provisioning and comprehensive fault management.
- Extensible and open system platform with SDK for device level management extensibility.

The migration to MPLS represents a key trend in the access market. The need for more (and higher) intelligence in the access layer plays into the strengths of MPLS and the rise of converged networks. Juniper's Universal Access solution for mobile backhaul (LTE, 2G/3G), business Ethernet services, and circuit to Ethernet migration, is built on high-performance ACX Series access routers with industry-leading TCA Series timing. Managed by Juniper Networks Junos Space, it is the industry's first converged access solution for mobile, residential, and business subscribers, and it complements the Universal Edge with a seamless, end-to-end, service delivery platform.

## For More Information

For more information, please refer to the following documents:

### Whitepapers:

#### *Seamless MPLS*

[www.juniper.net/us/en/local/pdf/whitepapers/2000316-en.pdf](http://www.juniper.net/us/en/local/pdf/whitepapers/2000316-en.pdf)

Building Multi-Generation Scalable Networks with End-to-End MPLS

[www.juniper.net/us/en/local/pdf/whitepapers/2000452-en.pdf](http://www.juniper.net/us/en/local/pdf/whitepapers/2000452-en.pdf)

Pietro Belotti, Comparison of MPLS and Ethernet Networks at the Access-Aggregation Level

<http://myweb.clemson.edu/~pbelott/papers/comparison-eth-mpls.pdf>

### Solution Briefs:

Evolving Mobile Backhaul to Unleash the Benefits of Evolved Radio Access and Packet Core

[www.juniper.net/us/en/local/pdf/solutionbriefs/3510437-en.pdf](http://www.juniper.net/us/en/local/pdf/solutionbriefs/3510437-en.pdf)

ACX Series Universal Access Routers for Mobile Backhaul Solution

[www.juniper.net/us/en/local/pdf/solutionbriefs/3510336-en.pdf](http://www.juniper.net/us/en/local/pdf/solutionbriefs/3510336-en.pdf)

### Datasheets:

ACX Series Universal Access Routers

[www.juniper.net/us/en/local/pdf/datasheets/1000397-en.pdf](http://www.juniper.net/us/en/local/pdf/datasheets/1000397-en.pdf)

Junos Space Network Activate

[www.juniper.net/us/en/local/pdf/datasheets/1000298-en.pdf](http://www.juniper.net/us/en/local/pdf/datasheets/1000298-en.pdf)

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

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