DEPLOYING IP/MPLS IN MOBILE NETWORKS

STRATEGIC WHITE PAPER

As mobile service providers prepare for the evolution to wireless broadband, they require a robust packet transport infrastructure that supports CDMA/EV-DO and GSM/UMTS/HSPA today and is well suited to support LTE and fixed-mobile convergence (FMC). Internet Protocol/Multi-Protocol Label Switching (IP/MPLS) has grown to become a foundation for many mobile, fixed, and converged networks. In mobile networks, IP/MPLS consolidates disparate transport networks for different radio technologies, reduces operating expenditures (OPEX), and converges networks on a resilient and reliable infrastructure, while supporting evolution to Long Term Evolution (LTE)

TABLE OF CONTENTS

Introduction / 1

wireless broadband / 1

Paradigm change in mobile transport networks / 1

Mobile transport and all-IP / 2

Key benefits of IP/MPLS for mobile transport / 3

Staged evolution to IP/MPLS in mobile networks / 4

Improving mobile backhaul / 8

Mobile backhaul and IP/MPLS / 9

Strategies for introducing IP/MPLS in mobile backhaul networks / 10

LTE and IP/MPLS / 11

Alcatel-Lucent IP/MPLS portfolio for mobile transport / 13

Summary: IP/MPLS in mobile transport networks / 14

Abbreviations / 14

INTRODUCTION

With mobile networks evolving to LTE wireless broadband, Multi-Protocol Label Switching (MPLS) is being deployed by many mobile service providers to consolidate disparate transport networks for different radio technologies, reduce operating expenditures (OPEX), and converge on a multi-generation highly scalable, deterministic, manageable and resilient infrastructure. This infrastructure supports mobile evolution to Fourth-Generation Mobile Network (4G) technologies, Long Term Evolution (LTE), and full fixed-mobile convergence (FMC).

The Alcatel-Lucent IP/MPLS solutions for mobile service providers allow the creation of cost-effective mobile and converged network architectures intended for voice, video and data delivery that can be deployed today to support existing mobile networks and leveraged as the network evolves to an LTE and 4G-based network architecture.

WIRELESS BROADBAND

The global geographical reach of mobile networks and their seamless roaming abilities make mobile the first choice for communications today. In both the developed and the developing world, more people are relying on mobile networks as their primary method for voice and data communications.

Radio-technology advancements and the development of smaller, versatile handheld devices, smartphones, tablets, and mobile computing devices, are allowing rapid delivery of new, high-speed data and multimedia services. These sophisticated mobile devices can deliver new real-time bandwidth-intensive services with the same Quality of Experience (QoE) historically available only over fixed networks.

PARADIGM CHANGE IN MOBILE TRANSPORT NETWORKS

Hoping to use the market interest in the new, multimedia-rich mobile services to attract new customers, manage subscriber churn and find new revenue sources, mobile service providers are deploying new mobile radio technologies, such as high speed packet access (HSPA) in the Universal Mobile Telecommunications System (UMTS)/Wideband Code Division Multiple Access (W-CDMA) standard track along with Long Term Evolution standard track. This opportunity to solve some key business problems (such as declining average revenue per user (ARPU), by increasing subscriber numbers and rapidly deploying new services) comes with some risks. The increased bandwidth volumes demanded by new services cannot be easily carried across the existing mobile network without incurring major transport costs.

Mobile service providers are evolving their transport networks to all-IP for delivering new services and staying competitive, but they have concerns about abruptly changing their network architecture from the long-serving, proven and reliable TDM-based transport. The biggest drawback to TDM transport is that transport costs are linearly proportional to transported bandwidth, with the increased bandwidth required for new services undermining the overall business case. Therefore, mobile service providers are investigating new business models by using new transport network paradigms, with the aim of lowering the overall cost of transport per bandwidth transferred, as well as decoupling the service delivery cost from the overall operation costs, including the transport.

This new, cost-effective all-packet transport must address all mobile technologies:
- CDMA (3G1X) and EV-DO
- GSM, GPRS, EDGE, UMTS, HSPA and HSPA
- 4G, LTE, and small cells

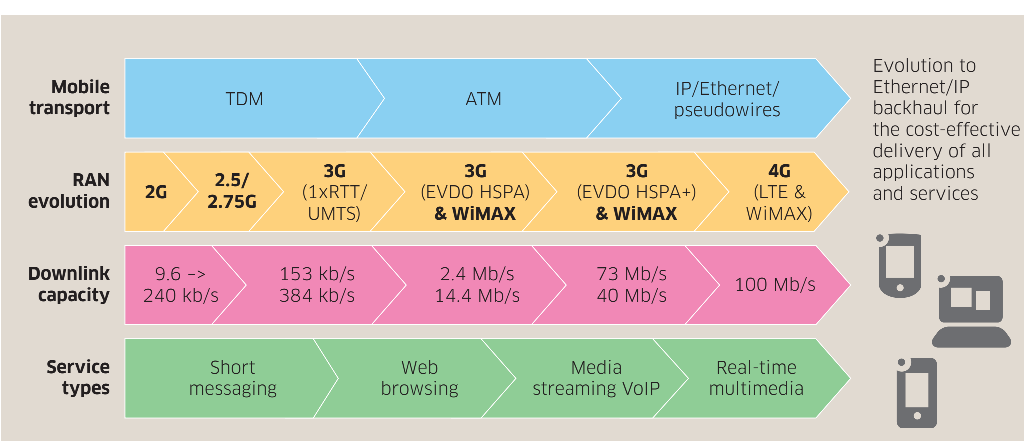
Mobile service providers have realized that any investment in the all-packet transport also must be fully aligned with their strategies for evolution of mobile technologies toward LTE and Wireless Packet Core (WPC).

MOBILE TRANSPORT AND ALL-IP

Over the last decade, radio technologies have rapidly progressed and evolved, introducing new networks, such as HSPA and LTE, which demand new technologies for mobile transport (see Figure 1).

This evolution to HSPA and beyond imposes tremendous changes on the mobile-transport side, with confirmation that bandwidth-per-cell must increase by orders of magnitude to support the new services. At the same time, existing transport models are no longer viable. To address the constant pressure for improving capital expenditures (CAPEX) and operational expenditures (OPEX), mobile transport networks are considered an integral part of the entire mobile network. An increasing number of service providers either already own, or have plans to own, the associated mobile transport network or a larger part of it. This consideration to own the associated transport network makes mobile transport networks subject to the same key principle to clearly separate the cost of introducing new services from the technical requirements for their delivery, including the support for increased bandwidth.

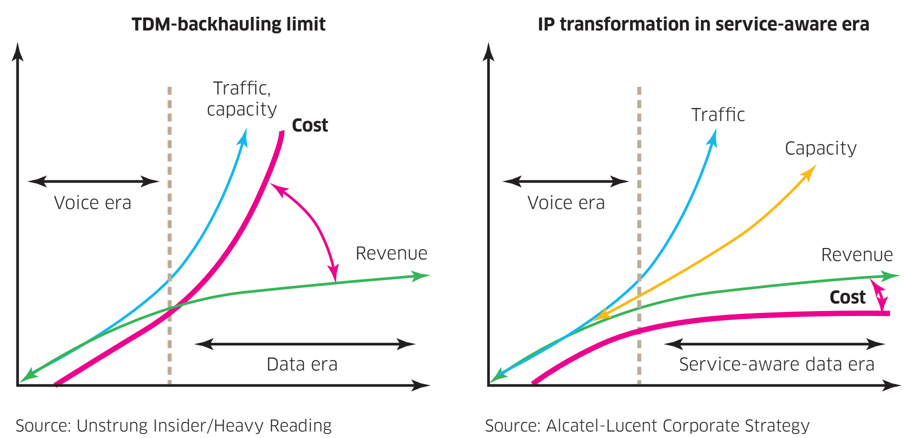
Figure 1. Evolution of the RAN and mobile transport network



Although tremendously important, cost is not the only concern that mobile service providers have about the transport network. The transport network also needs to decouple from the mobile technologies being transported, allow the cost-effective mix of different technologies and support any pace of evolution to the all-IP LTE and 4G network.

The need to change the existing transport paradigm from its TDM-based T1/E1 granularity of leased-lines to a new, cost-effective model also provides an opportunity to create a forward-looking, all-IP transport network that can support evolving and scaling the mobile services for years to come (see Figure 2).

Figure 2. Decoupling transport costs, capacity and revenues



KEY BENEFITS OF IP/MPLS FOR MOBILE TRANSPORT

With lower-cost per bit and smoother granularity steps than those provided by traditional SONET/SDH transport (from T1/E1 to DS3/E3 and OC-m/STM-n), IP/Ethernet provides significant benefits for large-scale deployments of bandwidth-intensive services. While availability of Ethernet at cell towers is increasing, the vast majority of towers continue to connect to the backhaul network using legacy T1/E1 transport or PDH/SONET/SDH. An increasing number of mobile networks also rely on microwave-based systems for very cost-effective and reliable mobile backhaul.

To properly address diverse network requirements for interface types and network protocols, often within a single mobile-service-provider environment, new mobile transport networks must overcome first-mile media restrictions. These networks also must provide common technological and operational frameworks for allowing an arbitrary mix of access media types, such as copper, fiber and microwave, and existing technologies such as TDM and ATM, while being fully capable of addressing the paramount requirement for all-IP readiness.

MPLS has become the technology of choice for many fixed, mobile and converged networks, with an impressive list of advantages:

- Allows mixed deployment of new, low-cost, Ethernet-based transport infrastructures and existing legacy transport networks such as SDH/SONET and PDH
- Provides quick delivery of new, IP-oriented services while allowing a full suite of legacy services by virtue of their emulation using pseudowires, such as ATM, frame relay (FR) and TDM
- Supports disparate network topologies, including linear, star, ring and mesh
- Acts as a unifying layer for upper-layer protocols, with consistent Quality of Service (QoS)
- Offers extensive traffic engineering capabilities that allow implementing multiple and hierarchical QoS and guaranteed service level agreements (SLAs)
- Allows massive scaling of point-to-point and point-to-multipoint connections, using virtual private LAN service (PBB/VPLS/SPBM) and virtual private networks (VPNs), through full Layer 2 and Layer 3 capabilities with Layer 3 routing and connection-oriented traffic flows
- Delivers carrier-grade reliability and resiliency with fast and flexible protection mechanisms
- Satisfies requirements for for reliable IEEE 1588v2 timing distribution over packet-based networks
- Delivers common management and OAM framework for all services
- MPLS-based infrastructure can facilitate service convergence — in cases where service providers are looking to combine their metro Ethernet infrastructure, which is used for business and residential services, with mobile transport infrastructure

While Ethernet availability and cost-effectiveness are the key factors for the mass acceptance of Ethernet-based transport, for true carrier-grade features, pure Layer 2 Ethernet must be enhanced to allow scaling and provide the necessary end-to-end QoS.

Deploying Carrier Ethernet based on IP/MPLS ensures carrier-grade capabilities, high capacity, large-scale network scalability, and end-to-end QoS delivery with comprehensive OAM, and allows full service convergence.

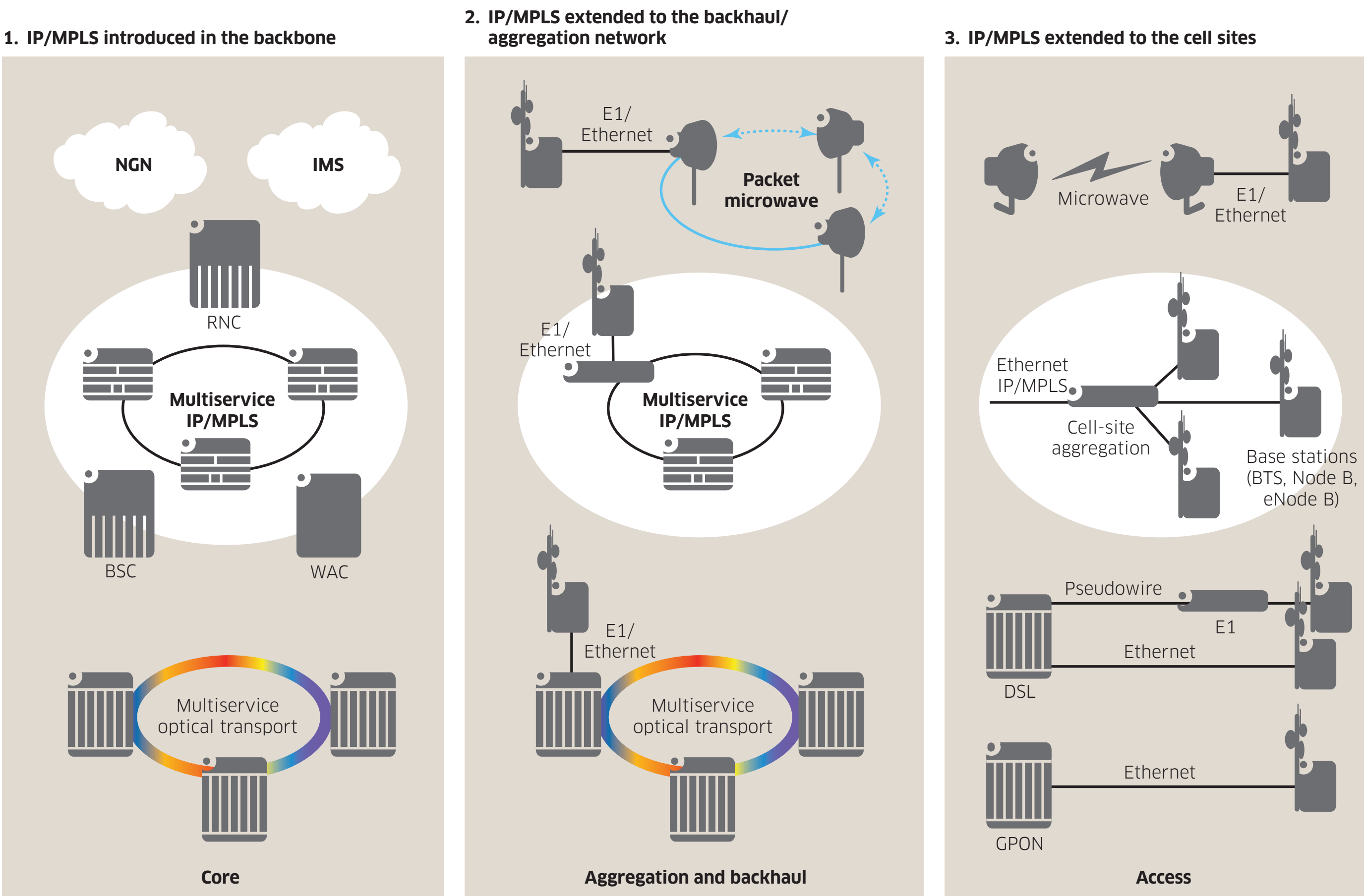
STAGED EVOLUTION TO IP/MPLS IN MOBILE NETWORKS

Evolving mobile transport networks using IP/MPLS has been a multistep process. For most mobile service providers, the first step is introducing the dedicated IP/MPLS mobile backbone as a part of the mobile core, as per the Third-Generation Partnership Project (3GPP) Release 4 specifications. The next steps of mobile transport transformation are in evolving the mobile hub and aggregation sites to IP/MPLS, with extension of IP/MPLS to cell sites (graphically shown on Figure 3).

With the extension of IP/MPLS to cell sites, the entire mobile transport network effectively becomes all-IP, managed end to end with common operational tools and practices.

This evolved mobile transport network can reliably and cost-effectively support all existing and new services, and accommodate any pace of all-IP evolution on the radio side, to to 4G, LTE, and small cells. MPLS is well positioned to address consolidation of Circuit Switched (CS) and Packet Switched (PS) mobile cores into a converged core and the evolution to a common WPC, as well as the end-to-end consolidation around IP.

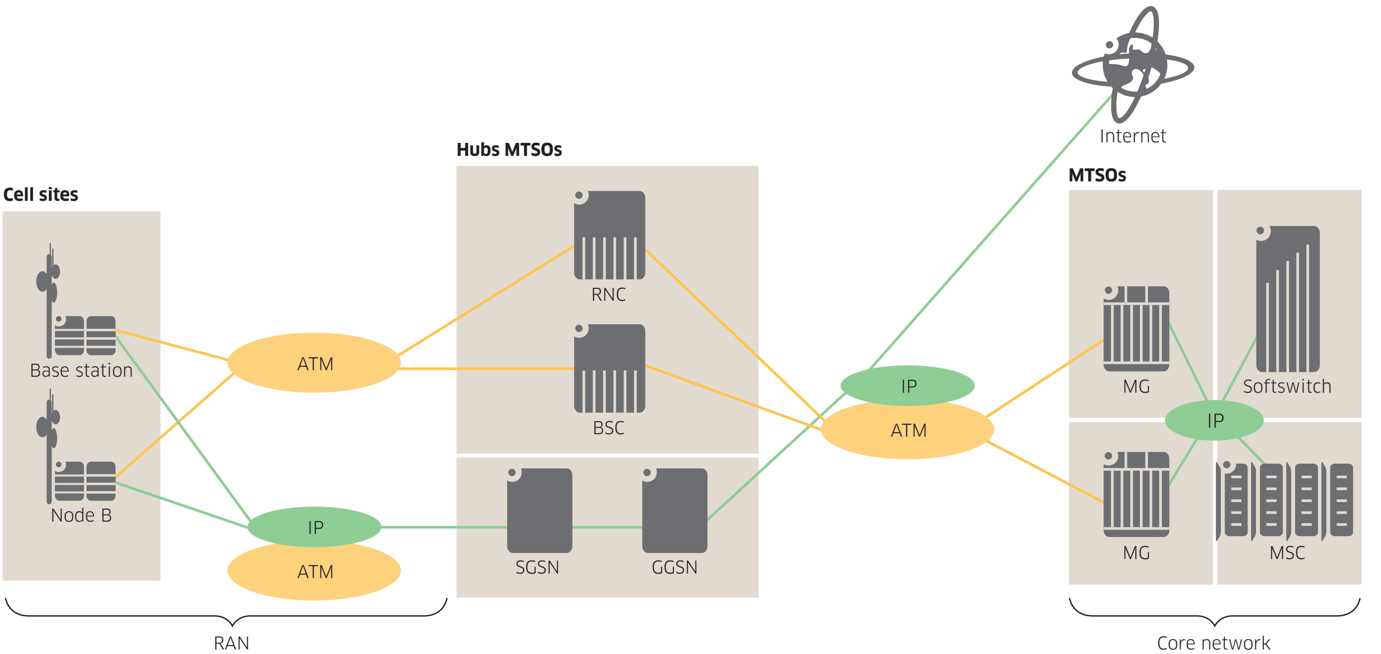
Figure 3. Waves of IP/MPLS transformation in mobile transport networks



MOBILE BACKBONE AND IP/MPLS

Historically, the 3GPP Release 4 set of standards specified the mobile core, or Bearer Independent Mobile Network, and the associated dedicated data backbone network to interconnect Mobile Switching Centers (MSCs), media gateways (MGs) and media gateway controllers (MGCs), or SoftSwitches (see Figure 4).

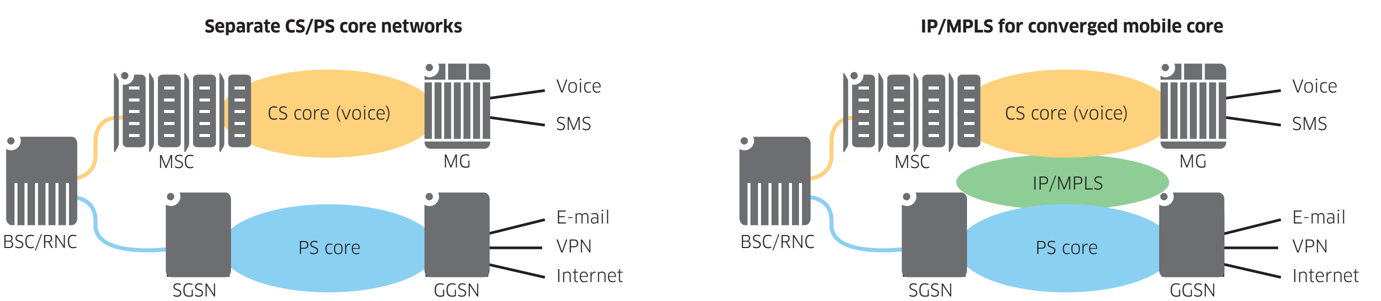
Figure 4. RAN and mobile core network in UMTS



The 3GPP Release 4 specifications provide service providers with the choice between ATM and IP for the core network packet technology, while the subsequent 3GPP Release 5 and IP Multimedia Subsystem (IMS) mandated the use of IP.

With all-IP as the end goal, service providers have opted to go with the IP option for both their mobile core and the associated data backbone, having in mind the evolution to Voice over Internet Protocol (VoIP). This choice was made with the understanding that the actual implementation will be a combination of IP and MPLS, (see Figure 5).

Figure 5. IP/MPLS data backbone convergence on IP/MPLS for CS and PS mobile cores



IP/MPLS fully addresses key requirements for the modern mobile core network architectures. Table 1 shows these key requirements for the mobile core and how IP/MPLS addresses them.

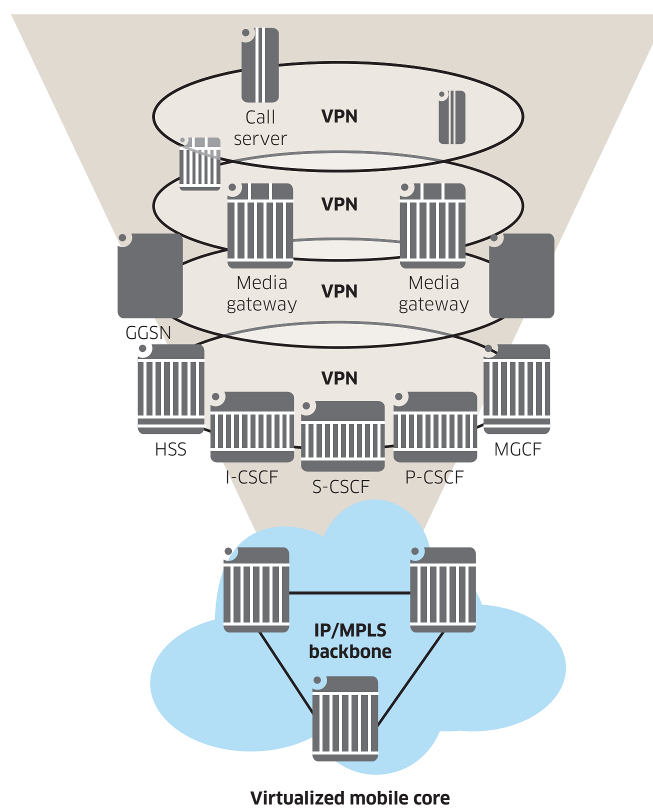
Table 1. Requirements and benefits of deploying IP/MPLS

MOBILE CORE REQUIREMENTS	BENEFITS OF DEPLOYING IP/MPLS IN MOBILE CORE
High reliability and availability	• Matches performance standards set in TDM networks • Allows variable redundant architectures at all levels, supporting no single point of failure • Delivers network-wide reliability and global repair mechanisms for fast recovery
Guaranteed per-service, per-subscriber QoS	• Consolidates transport of existing data services while protecting premium traffic such voice • Introduces new data and multimedia services based on IP with appropriate QoS guarantees, for example, for video streaming and interactive applications • Satisfies the core network QoS requirement for voice transport (transit delays, jitter and packet loss) • Ability to support dynamic control plane mechanisms to help service provisioning without involving external systems
Manageability	• Supports the end-to-end management and engineering tools required for rapid rollout of service and efficient network operations
Proven, scalable solution	• Proven and deployed in largest IP network transformation projects • Smoothly scales with consistent network-wide features • Allows gradual evolution to LTE networks
Service flexibility	• Ability to offer both Layer 2 and Layer 3 services, supporting concurrent deployment of point-to-point and point-to-multipoint service types

With high reliability and resiliency to match the standards set by TDM switching technology, IP/MPLS allows mobile backbones to scale in a controlled and managed way, while delivering guaranteed per-service QoS, full traffic isolation and security in the form of VPNs.

The establishment of VPNs allows traffic and services to be separated and managed independently and results in a virtualized mobile backbone, where different elements and applications in the mobile core are interconnected over separate VPNs, including Layer 2 or Layer 3 VPNs. At the same time, this mobile backbone virtualization allows a smoother evolution to IMS and the ubiquitous delivery of new services over mobile and converged network infrastructures (see Figure 6).

Figure 6. Virtualized mobile core

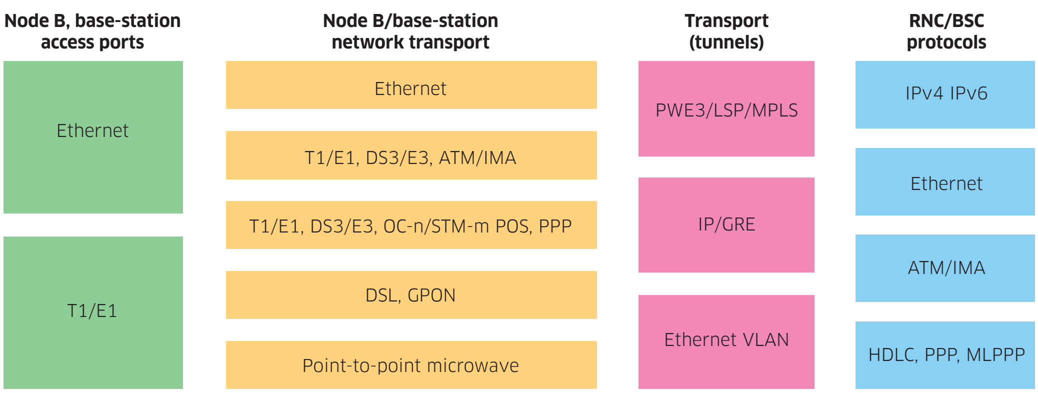


IMPROVING MOBILE BACKHAUL

In size and complexity, the Radio Access Network (RAN) exponentially surpasses the core network. The mobile RAN comes with a rich and varied set of access interfaces and protocol types because each generation of mobile transport technology has brought new network elements tailored to new mobile radio-interface specifications. In addition, mobile service providers strive to incorporate all available transport mechanisms (for example, gigabit passive optical network [GPON], digital subscriber line [DSL] and microwave), to reduce their transport costs and improve the overall business case.

Figure 7 graphically illustrates this RAN complexity by showing the protocol diversity in the RAN.

Figure 7. A snapshot of 2G and 3G backhaul protocols



2G and 2.5G networks commonly use T1/E1 circuits through SONET/SDH transport or over point-to-point microwave links. With 3G networks, ATM/IMA has scaled fairly well as a transport technology for delivering the statistical benefits of ATM multiplexing, along with QoS and traffic engineering capabilities. ATM also allows further traffic optimization and convergence of transport for 2G and 3G.

Increasingly, base stations and their associated controllers now have built-in support for Ethernet and IP. For these evolved elements of the RAN, Ethernet-based transport networks with IP/MPLS architectures provide a better technological complement, because their combined deployment results in end-to-end all-IP environments.

Therefore, a RAN transport network needs to address all important RAN issues, including:

- Diversity of access media: fiber, copper or microwave
- Multiple aggregation technologies: TDM grooming, ATM/IMA and Multilink Point-to-Point Protocol (MLPPP)
- Coexistence of existing 2G and 3G and new technologies, such as WiMAX, small cell and LTE
- Scaling capability to support thousands of network elements with different network requirements

- Cost effectively engineer and deliver the bandwidth required to each cell site
- Support migration to 4G and LTE

Mobile service providers must address all these issues in an extremely reliable manner, matching or exceeding the carrier-grade standards set by fixed service providers and legacy transport technologies.

MOBILE BACKHAUL AND IP/MPLS

While MPLS has by now gained universal acceptance as the networking technology for improving the transport of multiple protocols over diverse transport technologies, it also delivers traffic engineering extensions, allowing end-to-end network management, and offers extensive OAM capabilities for the ideal operation of large networks.

In brief, the key factors for the wide acceptance of MPLS in mobile backhaul networks are:

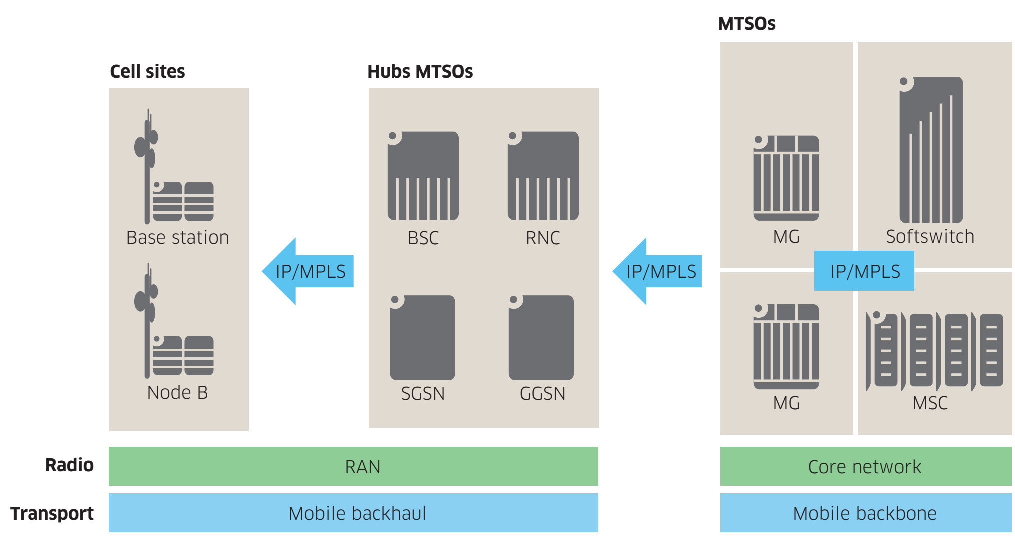
- Suitability for new, IP-based, high-bandwidth multimedia-rich services that require end-to-end QoS
- Ability to evolve to new networking technology with consistent methods of operation, and OAM,
- Ability to reliably distribute timing information over all-packet transport using strict QoS and traffic management

Network-wide deployment of IP/MPLS in mobile networks has become a phased evolution, with MPLS often first being deployed at major mobile telephone switching office (MTSO)/MSC locations, then (with MPLS boundaries and requirements being pushed to the aggregation/hub points) with MPLS eventually being extended all the way to cell sites (see Figure 8).

While perfectly suited for the all-IP and Ethernet-based WiMAX, 4G, and LTE mobile networks, IP/MPLS also supports a range of existing underlying transport infrastructures, based on legacy SONET/SDH, and allows the creation of multigenerational, cost-effective, converged, scalable and multipurpose packet transport networks, supporting 2G, 2.5G, and 3G technologies.

Continued deployment of existing radio technologies, such as 3G and 2G, and transport protocols, such as ATM/IMA, MLPPP and TDM, is enabled by using pseudowire technology, where different types of protocols and technologies are emulated over MPLS in the form of MPLS tunnels. For example, 2G/2.5G traffic is transported over TDM pseudowires, and 3G traffic is transported over ATM pseudowires. Some RAN control/ management traffic is carried in the form of Ethernet pseudowires over MPLS.

Figure 8. Evolution of IP/MPLS in mobile networks



STRATEGIES FOR INTRODUCING IP/MPLS IN MOBILE BACKHAUL NETWORKS

Mobile service providers are embracing two strategies to benefit from more cost-effective IP/Ethernet-based transport. These two strategies are often influenced by the mobile service provider's market position (incumbent or new entrant), or if a corporate-wide IP transformation strategy is underway. Either way, mobile service providers realize that any investment must be benchmarked against their strategic goals for 4G and LTE or Fixed Mobile Convergence.

- One strategy offloads the data traffic originating from new high- bandwidth services onto a dedicated data transport network — either a new or existing data network — while continuing to use the existing transport model, predominantly TDM or ATM-based, for voice traffic
- The other strategy creates a unified, converged transport network, equally suitable for transporting new bandwidth-demanding data services and traditional voice services

These two strategies offer two alternatives for mobile backhaul (see Figures 9 and 10):

- **Hybrid backhaul** – where new, high-bandwidth data services are offloaded onto a parallel and separate transport infrastructure (for example, metro Ethernet, DSL and GPON)
- **Full packet backhaul** – where a converged, data-optimized backhaul network is created

Using MPLS for the associated data transport network has gained equal acceptance in both of these alternative approaches, both for the key technology deployed for alternative back-haul in the hybrid scenario and also as the key technology used in the full packet scenario.

In many networks, the hybrid option can be chosen as the first step to fully evolving to an end-to-end IP/MPLS solution for their mobile backhaul network.

In addition, deploying all-packet transport networks based on IP/MPLS allows mobile service providers and network operators to extend their business to converged networks. For more details on IP/MPLS RAN and pseudowires, please consult the dedicated application notes.

Figure 9. Hybrid backhaul option

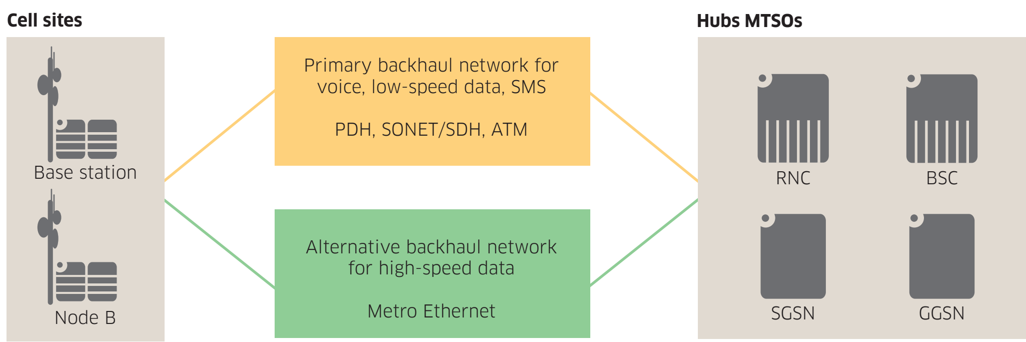
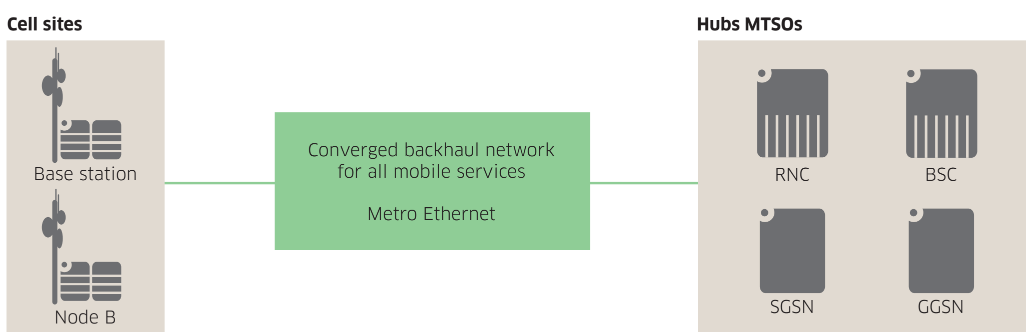


Figure 10. Full packet backhaul option



LTE AND IP/MPLS

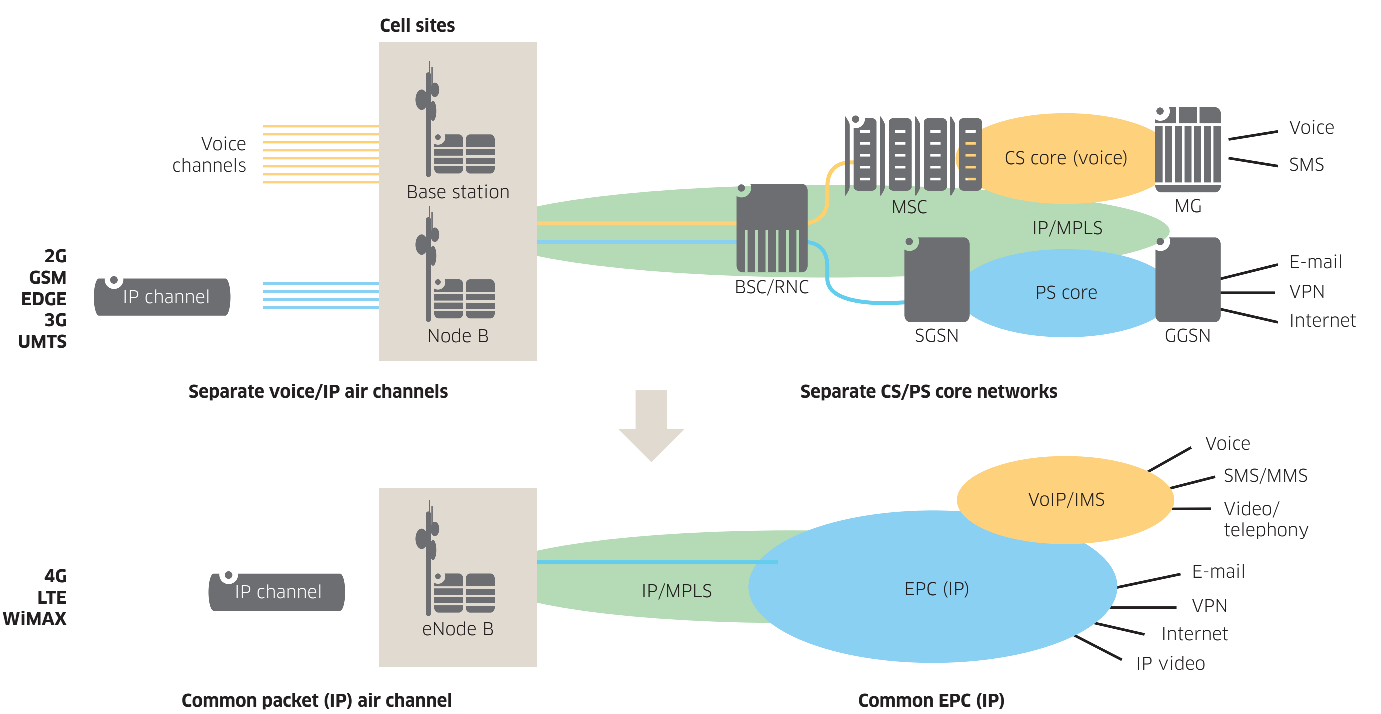
With the formal definition and publishing of the LTE specification in the form of 3GPP Release 8 in January 2008, as well as major LTE deployments by major UMTS and CDMA operators, there is no doubt that the acceleration toward the fully wireless broadband with LTE is underway.

LTE adoption requires major changes in the network architecture and also calls for a seamless coexistence with existing mobile technologies. Mobile service providers are coming to the understanding that with the deployment of 4G and LTE wireless networks they will have the opportunity to evolve their network architecture to fully embrace the attribute and capabilities of IP networking. The strict distinction existing in all previous mobile generations between the radio elements (such as base stations and controllers), the packet data elements (such as Serving GPRS Support Node [SGSN] and Gateway GPRS Support Node [GGSN]) and the transport elements (such as TDM/ATM switches) has come to an end in the LTE world. In particular, introduction of the new wireless packet core, WPC, provides the opportunity to converge the IP backhaul transport network with the wireless packet core into a common highly scalable, flexible, robust and QoE-capable IP packet switched network using MPLS.

By offering the ability to seamlessly and smoothly transition to an LTE-based architecture, MPLS safeguards investments made by service providers today. Using MPLS as a networking protocol now offers the advantage of reusing the same technology in LTE. MPLS allows the seamless coexistence with existing mobile technologies that continue to use MPLS for reliable and efficient bearer and control transport of 2G and 3G mobile traffic.

In addition, MPLS-capable network elements can address the flat-IP requirements by delivering Layer 3-based functionality. These network elements also can extend their functions from the efficient transport of legacy mobile traffic over cost-effective, Carrier-Ethernet transport using pseudowires to fully participating in Layer 3 routing, while allowing full service and network interworking with the pseudowire-based overlay for 2G/3G (see Figure 11).

Figure 11. LTE: Toward flat-IP and EPC



ALCATEL-LUCENT IP/MPLS PORTFOLIO FOR MOBILE TRANSPORT

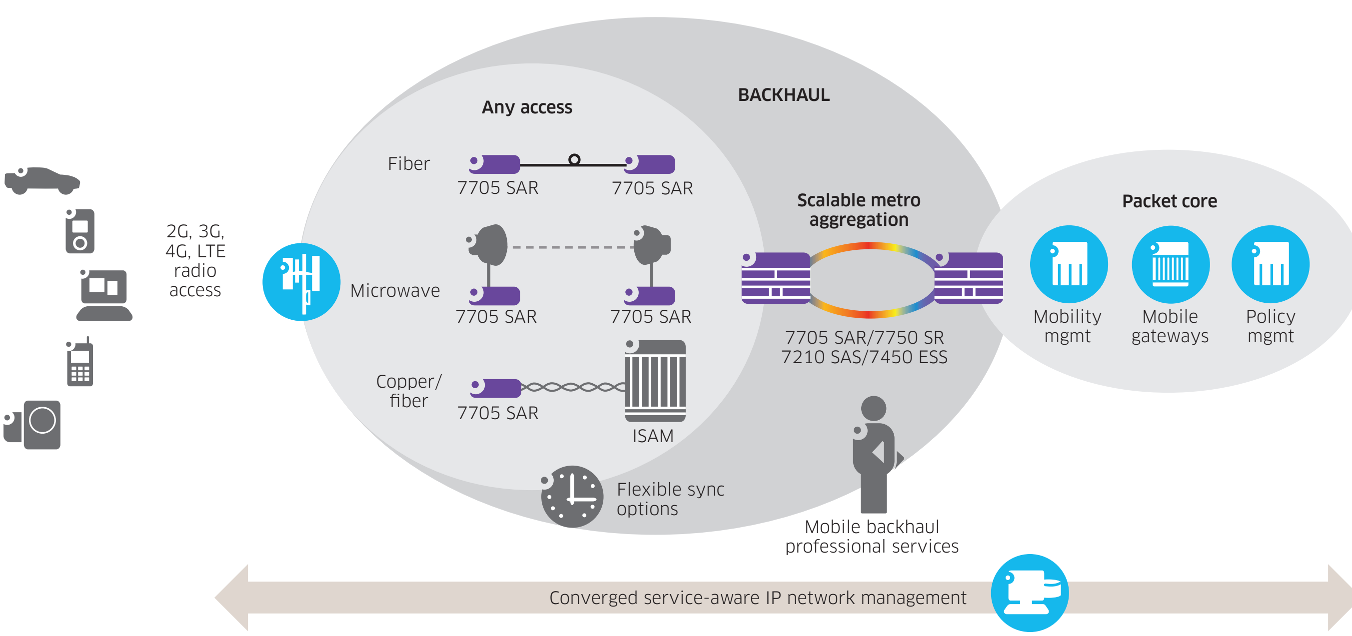
Alcatel-Lucent IP/MPLS solutions for mobile transport are based on deploying the Alcatel-Lucent Service Routers (SRs), 7210 Service Access Switches (SASs), Alcatel-Lucent Ethernet Service Switches (ESSs) and Alcatel-Lucent Service Aggregation Routers (SARs), with end-to-end network and service management by the Alcatel-Lucent 5620 Service Aware Manager (SAM) (see Figure 12).

These industry-leading solutions for cost-effective mobile transport deliver:

- High network reliability and service availability
- Service resiliency with service end-point protection and end-to-end path recovery
- Service awareness: ability to perform flexible correlation to mobile QoS, classify and prioritize traffic and ensure required and guaranteed QoS performance, including delay, jitter and packet loss
- Efficient bandwidth management
- Multiple traffic-flow aggregation and transportation
- Powerful management and engineering tools
- Comprehensive end-to-end OAM and SLA performance and troubleshooting capabilities
- Reliable network timing distribution using packet-based mechanisms for supporting clock distribution to the base stations, including frequency, phase and time synchronization
- Network monitoring and capacity planning tools
- Network security for control and data plane

For more details on the Alcatel-Lucent IP/MPLS solutions and product portfolio, refer to the dedicated application notes and datasheets.

Figure 12. Alcatel-Lucent IP/MPLS portfolio for end-to-end IP/MPLS in mobile transport networks



SUMMARY: IP/MPLS IN MOBILE TRANSPORT NETWORKS

IP/MPLS has become the foundation for many fixed, mobile and converged networks. Its acceptance has been equally driven by the cost-effectiveness of fiber access and Ethernet, as well as by its ability to act as the uniform and unifying layer for many underlying technologies.

MPLS has gained wide acceptance because of its many advantages:

- Adapts to different types of access transmission technologies (including copper, microwave and fiber) and accommodates a flexible mix of access interfaces (for example, E1, STM-1, DSL, Fast Ethernet (FE) and Gigabit Ethernet [GigE]), and technologies (such as PDH, SDH, ATM and ATM/IMA, Point-to-Point Protocol [PPP], HDLC, FR and Ethernet)
- Supports legacy, including TDM, ATM, MLPPP, and IP-based interfaces between base stations and Base Station Controller (BSC)/Radio Network Controller (RNC) complex
- Offers robust traffic engineering capabilities
- Enables end-to-end QoS for all services
- Delivers advanced OAM and troubleshooting capabilities
- Supports the evolution to all-IP and converged deployment of existing mobile technologies as well as WiMAX, small cell, 4G and LTE
- Perfectly addresses FMC

With the evolution to wireless broadband, MPLS is being deployed by many mobile service providers to consolidate disparate transport networks for different radio technologies, reduce OPEX, and converge on a resilient and reliable infrastructure as part of their evolution to 4G, LTE, and Fixed-Mobile Convergence (FMC).

The Alcatel-Lucent IP/MPLS solution for mobile service providers delivers a strong solution set for the evolution to 4G and LTE wireless broadband; Fixed Mobile Convergence; and IP Transformation. The Alcatel-Lucent products and solutions support high capacity, reliable, scalable, cost-efficient and fully managed mobile packet transport, allowing mobile service providers to take full control of their networks to quickly enable the delivery of advanced, revenue-generating services.

ABBREVIATIONS

1850 TSS-5	Transport Service Switch
5620 SAM	Service Aware Manager
7450 ESS	Ethernet Service Switch
7705 SAR	Service Aggregation Router
7710/7750 SR	Service Router
2G	Second-Generation Mobile Network
3G	Third-Generation Mobile Network
3GPP	Third-Generation Partnership Project
4G	Fourth-Generation Mobile Network
AG	access gateway
ARPU	average revenue per user
ATM	Asynchronous Transfer Mode
BSC	Base Station Controller
BTS	Base Transceiver Station
CAPEX	capital expenditures
CDMA	Code Division Multiple Access
CS	Circuit Switched
DL	downlink
DOCSIS	Data over Cable Service Interface Specification
DS	digital signal
DSL	digital subscriber line

E1	E-carrier system
EDGE	Enhanced Data rates for Global Evolution
ESS	Ethernet Service Switch
EV-DO	Evolution-Data Optimized
FDD	frequency division duplex
FE	Fast Ethernet
Femto cells	residential short-range, small-size mobile cells
FMC	fixed-mobile convergence
FR	frame relay
FRR	fast reroute
GigE	Gigabit Ethernet
GGSN	Gateway GPRS Support Node
GPON	gigabit passive optical network; gigabit PON
GPRS	General Packet Radio Service
GRE	Generic Router Encapsulation
GSM	Global System for Mobile Communications
HDLC	High-Level Data Link Control
HSDPA	High-Speed Downlink Packet Access
HSPA	high-speed packet access
HSS	Home Subscriber Server
HSUPA	high-speed uplink packet access
I-CSCF	Interrogating Call Session Control Function
IMA	inverse multiplexing over ATM
IMS	IP Multimedia Subsystem
ISAM	Intelligent Services Access Manager
IP	Internet Protocol
LSP	label switched path
LTE	Long Term Evolution
META	Mobility Evolution Transport Architecture
MG	media gateway
MGC	media gateway controller
MGCF	media gateway control function
MLPPP	Multilink Point-To-Point Protocol
MMS	multimedia messaging service
MPLS	Multi-Protocol Label Switching
MSC	Mobile Switching Center
MTSO	mobile telephone switching office
NGN	next-generation network
OC	optical carrier
OAM	operations, administration, and maintenance
OPEX	operating expenditures
PBB	Provider Backbone Bridge
P-CSCF	Proxy Call Session Control Function
PDH	Plesiochronous Digital Hierarchy
PDSN	Packet Data Serving Node
POS	packet over SONET
PPP	Point-to-Point Protocol
PS	Packet Switched
PSTN	Public Switched Telephone Network
PWE3	psuedowire emulation edge to edge
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
RNC	Radio Network Controller
SAR	Service Aggregation Router
S-CSCF	Serving Call Session Control Function
SDH	Synchronous Digital Hierarchy
SGSN	Serving GPRS Support Node
SLA	service level agreement
SMS	Short Message Service
SONET	Synchronous Optical Network
SPBM	Shortest Path Bridging MAC
SR	Service Router
STM	Synchronous Transport Module
T1	T-carrier system
TDD	Time Division Duplexing
TDM	Time Division Multiplexing
TPSDA	Triple Play Service Delivery Architecture
UL	uplink
UMTS	Universal Mobile Telecommunications System
VLAN	virtual local area network
VoIP	Voice over Internet Protocol
VPLS	virtual private LAN service
VPN	virtual private network
WAC	WiMAX Wireless Access Controller
W-CDMA Access	Wideband Code Division Multiple
WiMAX	Worldwide Interoperability for Microwave Access
WPC	Wireless Packet Core

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