Alcatel·Lucent

TECHNOLOGY WHITE PAPER

Mobile Backhaul Evolution Using Microwave Packet Radio

Communications service providers want to support escalating capacity demands from customers with network architectures that support data services as well as traditional voice at sustainable cost. By deploying packet microwave in the access network, service providers can quickly reach more consumer and enterprise customers while delivering multiple services over a single Ethernet connection. With the Alcatel-Lucent 9500 MPR, native packet microwave can be deployed in TDM networks to support a smooth transition to the full-packet network without deploying a hybrid system while TDM and data services coexist. The Alcatel-Lucent 9500 MPR features multiservice aggregation, radio-bandwidth optimization, service-aware traffic management, service-driven adaptive modulation, and synchronization distribution — all implemented on one LTE-ready platform that supports TDM-based and hybrid architectures during the evolution cycle.

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1. Introduction

Despite today's wide availability of broadband access technologies, one of the constraints limiting massive deployment of wireless broadband services is confusion about the best way to interact with legacy networks. Communications service providers are being challenged to:

- Reduce backhaul transport costs while meeting escalating demands for bandwidth-intensive mobile multimedia data services
- Evolve to packet-optimized networks that are capable of supporting Fourth Generation (4G) wireless
- Ensure service availability to retain and grow their customer bases

Communications service providers are seeking mobile-backhaul networks that can meet capacity demands with architectures that support data services as well as traditional voice at a sustainable cost.

One solution to these challenges is to increase the use of microwave. Worldwide, microwave is used for half of the total connections in the access network, representing a valid and complementary alternative to wireline technologies such as copper and fiber. Ethernet-based microwave connections are replacing legacy Plesiochronous Digital Hierarchy (PDH) E-carrier system/ T-carrier system (E1/T1) microwave connections at an increasing rate.

This paper describes the advantages of using the Alcatel-Lucent 9500 Microwave Packet Radio (MPR) for mobile backhaul. For communications service providers that want to deliver feature-rich mobile services at attractive rates and with profitable operating margins, the Alcatel-Lucent 9500 MPR, unlike hybrid microwave systems, supports Second Generation/Third Generation (2G/3G) networks and is Long Term Evolution (LTE) ready today.

The Alcatel-Lucent 9500 MPR is capable of operating in hybrid mode — to support current TDM-based architectures and help service providers to progressively migrate their backhaul networks to packet — and full-packet mode, to service the new generations of packet-based Evolved High-Speed Packet Access (HSPA+) and LTE services.

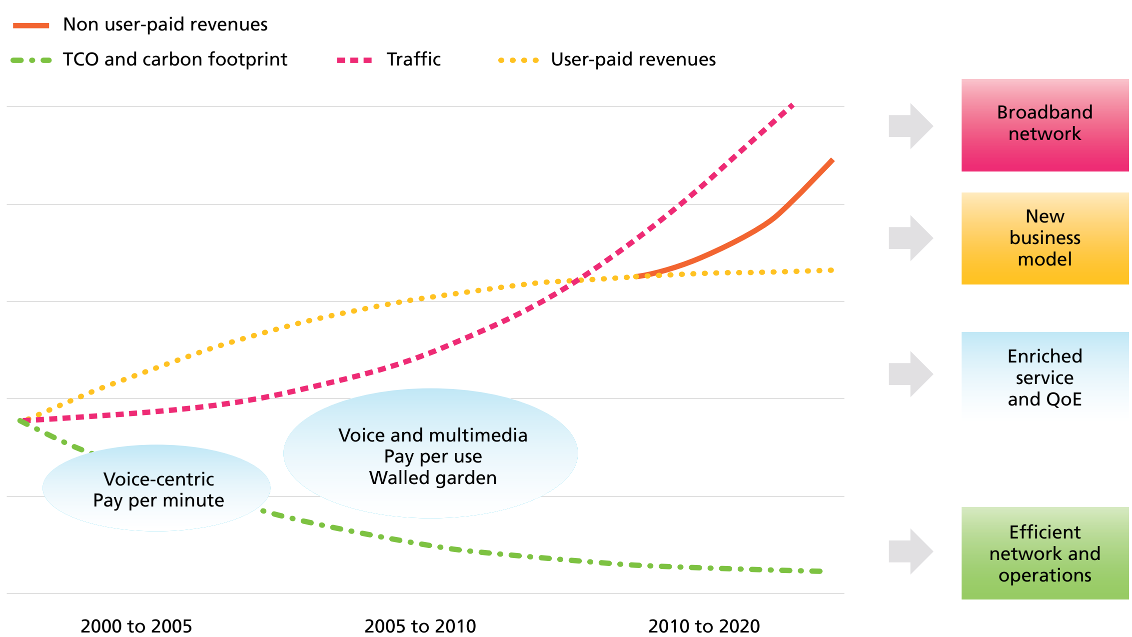
The Alcatel-Lucent 9500 MPR fully supports all the mobile-backhaul scenarios defined in MEF 22 *Carrier Ethernet for Mobile Backhaul Implementation Agreement* (MBIA), giving service providers a wide variety of choices to move their backhaul networks away from legacy infrastructures. A key capability of the Alcatel-Lucent 9500 MPR is the integrated Generic Inter-Working Function (GIWF), defined in MEF 22, to carry TDM and ATM services as pseudowires or circuit emulation:

- Pseudowires (RFC 4717: *Encapsulation Methods for Transport of Asynchronous Transfer Mode (ATM) over MPLS Networks)*
- *Circuit emulation:*
  - MEF 8: *Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks*
  - RFC 4553: *Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP)*
  - RFC 5086: *Structure-Aware TDM Circuit Emulation Service over Packet-Switched Network (CESoPSN)*

2. Market drivers — challenges and opportunities

Driven by consumer demand for seamless multimedia experiences, a diversified competitive landscape and level subscription revenues, wireless communications service providers need a new business model to increase profitability. As shown in Figure 1, mobile-data usage continues to escalate, fueled by the success of 3G-enabled laptops, ultra-mobile PCs, innovative handsets, online video and social-network applications. Consumer and enterprise customers continue to demand enriched, personalized services with guaranteed Quality of Experience (QoE).

Figure 1. Next-generation wireless broadband requires new business models, services and infrastructure



Service providers can strengthen user-paid revenues with IP services, such as multiscreen video and location-based services, and supplement these with revenues from non-traditional services, such as targeted advertising, content brokering and e-commerce transactions.

An innovative business model is needed to address these market conditions, one that can generate additional revenue from content providers, application providers and other sources. The next-generation wireless broadband network must be able to support escalating demands for bandwidth and QoE while reducing total cost of ownership (TCO).

2.1 Ethernet and MEF 22

Historically, mobile-backhaul networks have been implemented using TDM and ATM technologies. However, these networks cannot keep pace with the bandwidth capacity and reliability requirements of increasingly popular voice, data and video broadband applications on mobile devices.

To meet these demands, next-generation mobile equipment and networks are evolving to Ethernet, which is optimized for packet-data traffic. Ethernet is becoming increasingly available at sites because of its flexibility to be transported over a multitude of transport media (fiber, copper and microwave).

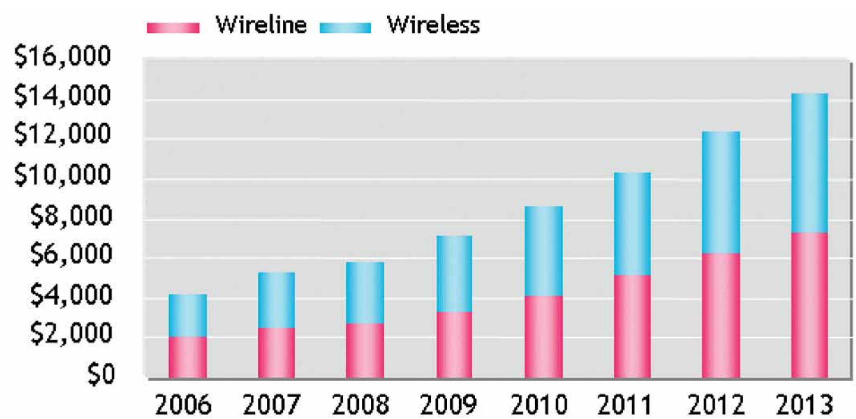
As a guide, the MEF (formerly known as Metro Ethernet Forum) issued MEF 22 *MBIA* to explain how existing MEF specifications can be applied to Ethernet backhaul architectures for 2G, 3G and 4G mobile networks. MEF 22 explains how to successfully and cost-effectively implement Carrier Ethernet for mobile backhaul, including how to apply MEF specifications and industry standards to meet Radio Access Network (RAN) backhaul requirements. MEF 22 enables the deployment of profitable, data-driven mobile services, describing both the benefits and technical-implementation details.

This specification assists mobile service providers as they prepare their RAN backhaul networks to meet current dynamic market and economic conditions. Key to the MBIA is preserving voice-based service revenues with a transition path that supports legacy technologies and an evolution to 3G and 4G. The MBIA includes recommendations for the network design, architecture and operation of packet-based mobile-backhaul networks.

2.2 Ethernet-based microwave

In the access network, microwave is used for half of the total connections worldwide, demonstrating its acceptance as a valid alternative that complements wireline technologies such as copper and fiber (see Figure 2).

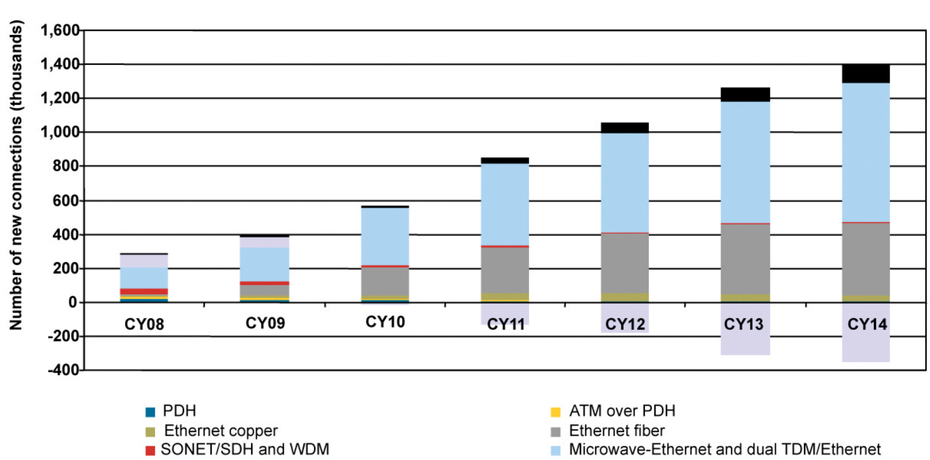
Figure 2. Global equipment forecast by media type



Source: *Wireless Backhaul: Opportunities for Optical and Switching/Routing Vendors*, Ovum, October 2009

Ethernet-based microwave connections are expected to increasingly replace legacy PDH E1/T1 microwave connections — a trend expected to take hold in 2011, as shown in light blue in Figure 3.

Figure 3. Worldwide mobile-backhaul new connectivity by technology



Source: *Mobile Backhaul Equipment and Services* market size, share and forecast report, Infonetics Research, April 2010

Confidence in using packet microwave for mobile backhaul is growing because it addresses:

- The economic push to maintain and reuse existing microwave access networks, avoiding the deployment of expensive fiber connections in the last mile
- Support for LTE and 4G services that demand packet-based transport while continuing to support fixed services

3. Microwave for mobile backhaul

Today's transmission networks are still designed to backhaul voice service from the Base Transceiver Station (BTS, Node B) to their controller — Base Station Controller (BSC) or Radio Network Controller (RNC) — using TDM circuit-based connectivity. This is a common approach, thanks to low operational complexity when capacity remains low and the wide availability of technologies such as PDH/Synchronous Digital Hierarchy (SDH) microwave radio.

TDM is extremely effective when the traffic is predominantly voice, requiring one or two E1/T1 connections per base station. Above all, the capital expenditures/operating expenditures (CAPEX/OPEX) cost model behaves consistently with traffic and operators' revenues.

With the first launch of broadband services, communications service providers maintained TDM backhaul because voice traffic was still predominant. However, traffic growth and service penetration highlight the limitations of this technology:

- Extra E1/T1 connectivity needed to support the growth of base stations, requiring site visits at every site from the access to the point of aggregation
- Optimization of link capacity for existing transport protocols (for example, 2G Abis) with new ones, such as ATM for 3G
- Impact of capacity on aggregation links

Microwave vendors reacted to these requirements by improving their TDM platforms with:

- Integrated E1/T1 cross-connect to solve E1/T1 connectivity
- Super-PDH systems, with more than 32 E1/T1s, to accommodate capacity requirements in aggregation links
- High spectral efficiency to mitigate OPEX increases — for example, 40 E1/T1s instead of 32 E1/T1s using the same radio-frequency channel/modulation

This approach worked well for the first operators who launched data services. However, when the market adopted these ultimate TDM platforms, it became clear that they could not provide a long-term solution: TDM platforms cannot effectively and economically scale to support the data explosion.

Hybrid microwave solutions represent the first attempt to tackle this issue. They were introduced to natively carry TDM using a dedicated switch, enabling the transport of data services by means of a second Ethernet switch. This approach solved the off-loading of data services from the TDM E1/T1s but soon proved unable to scale when coping with the new generation of mobile broadband services such as HSPA+, WiMAX® and LTE. Limits in scaling bandwidth and the lack of packet capability, such as the absence of an integrated GIWF and the impossibility of mixing Voice over Internet Protocol (VoIP) service together with packetized TDM, motivated the introduction of full-packet microwave solutions.

3.1 Mobile evolution from TDM to full-packet

The TDM present mode of operation (PMO) must evolve to support full-packet in the future. As shown in Figure 4, PDH/SDH microwave supports 2G/3G TDM voice and 3G data by introducing an ATM switch in the transmission path.

Hybrid networks keep TDM traffic in the TDM network and transport Ethernet data in a separate packet network. Hybrid microwave works in the same way, handling TDM and packet traffic separately with two different physical units, but it still needs ATM switches for the 3G TDM data, as shown in Figure 5.

How will this hybrid microwave approach evolve to support a full-packet network? How will the remaining 2G and 3G voice be transported across the network? Indications are that service providers are retaining T1/E1s at their cell sites for Ethernet backhaul synchronization, at least until 2013.[1]

Packet microwave uses Ethernet as the only native radio-transmission protocol, as shown in Figure 6. Ethernet signals such as Fast Ethernet (100 Mb/s) and Gigabit Ethernet (GigE; 1 Gb/s) are natively transmitted while TDM/ATM signals such as T1 and E1 are transmitted by pseudowire (PWE3; Pseudowire Emulation Edge-to-Edge) and Circuit Emulation Service (CES) as integrated functionalities.

3.2 Mobile evolution with packet microwave

The Alcatel-Lucent 9500 MPR is designed to cost-effectively support the launch of data services without impact on traditional voice services. For the first time, native packet microwave is capable of being deployed in TDM networks to support a smooth transition from the PMO to a full-packet network, without extra steps such as hybrid systems while TDM and data services coexist.

The Alcatel-Lucent 9500 MPR can shorten the amount of time it takes operators to evolve from their PMO to full packet. As shown in Figure 7, the Alcatel-Lucent 9500 MPR can be deployed in a TDM, hybrid or full-packet network, supporting evolution based on communications service providers' business needs.

Figure 4. TDM present mode of operation

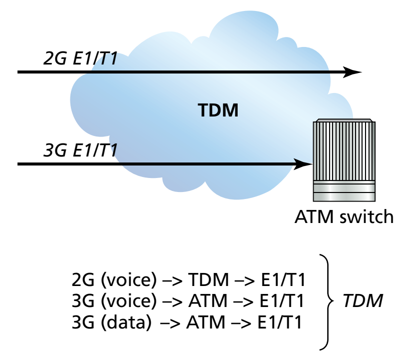


Figure 5. Hybrid network

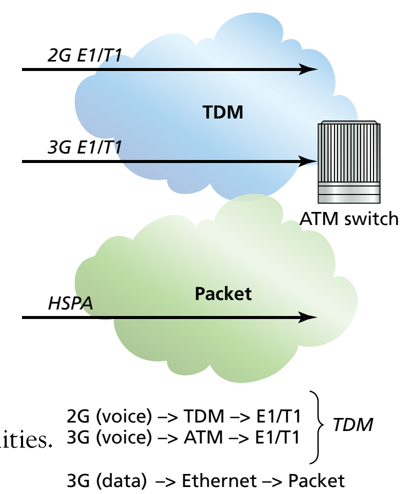
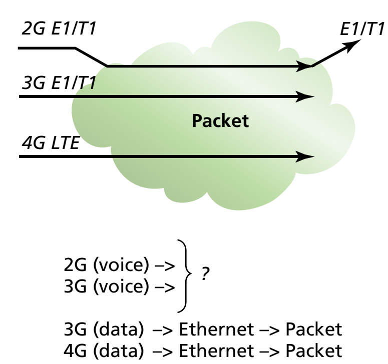


Figure 6. Future mode of operation



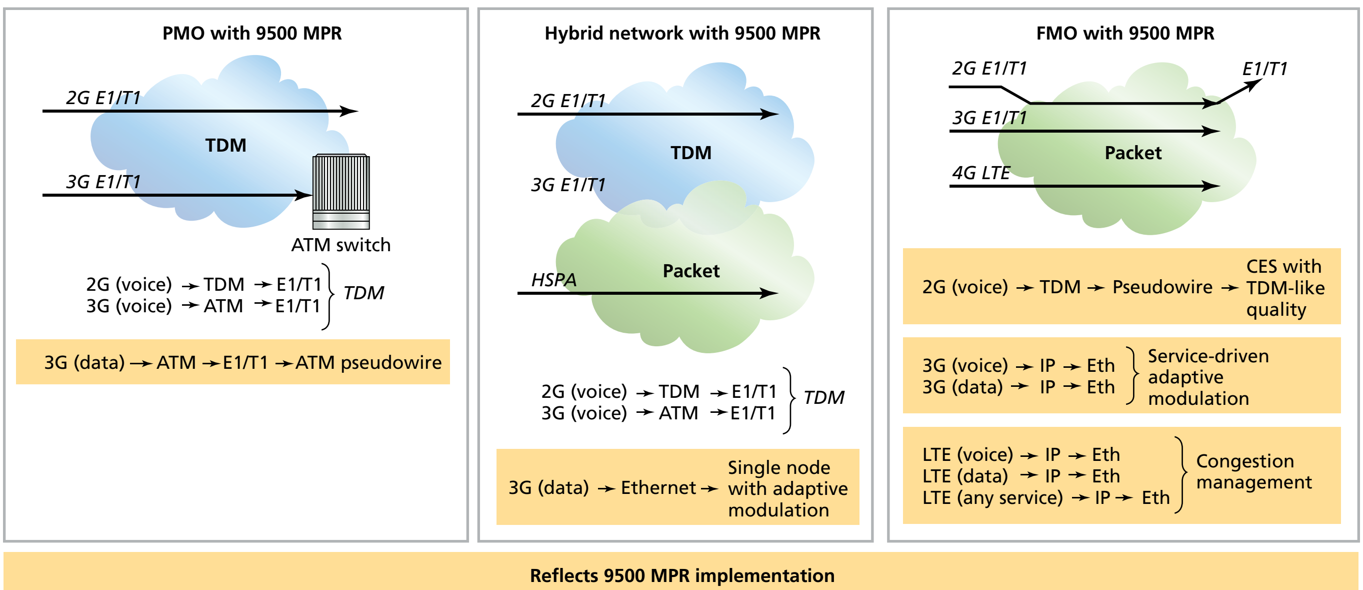
[1] Patrick Donegan, "Ethernet Backhaul Quarterly Market Tracker", *Heavy Reading*, August 2010. Operators will continue to support T1/E1 as they adopt SyncE and IEEE 1588v2.

In Figure 7, the text in peach-colored boxes highlights how the Alcatel-Lucent 9500 MPR supports the network as it evolves. An ATM switch is not needed in the PMO because the Alcatel-Lucent 9500 MPR encapsulates the ATM signal in a pseudowire. In a hybrid network, Ethernet is used for data services, using one node with adaptive modulation for best-effort Ethernet over TDM. For a full-packet network in future mode of operation (FMO), the Alcatel-Lucent 9500 MPR can transport all traffic using one piece of equipment:

- 2G voice is transported using CES, with TDM-like quality and with the same performance.
- 3G IP voice is prioritized over 3G best-effort data. As such, 3G data is handled through service-driven adaptive modulation.
- LTE congestion management is supported for Quality of Service (QoS) and traffic handling.

Appendix A provides a summary comparison of hybrid microwave to packet microwave.

Figure 7. Mobile evolution with the Alcatel-Lucent 9500 MPR



4. Alcatel-Lucent 9500 MPR for mobile backhaul

Communications service providers are evolving their TDM connectivity to work over packet in the backhaul and are discovering the limitations posed by hybrid microwave: limited Ethernet scalability and QoS handling and the need for synchronization distribution in pure packet applications.

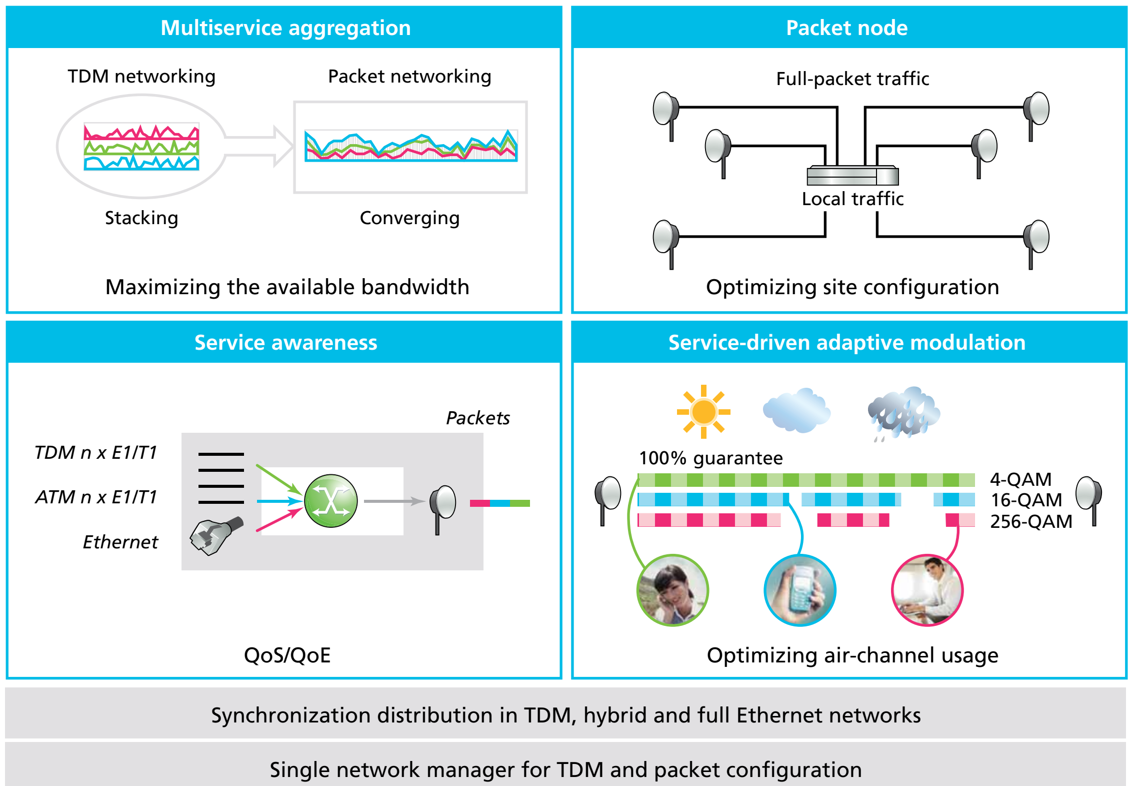
The Alcatel-Lucent 9500 MPR addresses mobile-backhaul transformation, providing a fully scalable platform — from the last mile, with zero additional footprint for pure Ethernet base stations or Ethernet full-outdoor base stations, to one of the industry's most compact indoor-unit solutions, addressing hybrid connectivity and radio protection.

The Alcatel-Lucent 9500 MPR, which is part of the integrated mobile-backhaul transport solution supported by the Alcatel-Lucent High Leverage Network™ (HLN) architecture, is based on the following concepts, as shown in Figure 8 and discussed in the subsections that follow:

- Multiservice aggregation
- Radio-bandwidth optimization
- Service-aware traffic management
- Service-driven adaptive modulation
- Synchronization distribution

The Alcatel-Lucent 9500 MPR implements all these innovations on one LTE-ready platform that also supports current TDM-based and hybrid architectures during the evolution cycle. Provisioning and monitoring of all services (2G/3G/LTE) are provided through either the Alcatel-Lucent 1350 Optical Management Suite (OMS) or the Alcatel-Lucent 5620 Service Aware Manager (SAM) system. Both systems support end-to-end QoS across the Ethernet backhaul network and mobile core.

Figure 8. Alcatel-Lucent 9500 MPR differentiators



4.1 Multiservice aggregation

With multiservice aggregation, Ethernet is used as a common transmission layer to transport any kind of traffic. Ethernet becomes the convergence layer: regardless of access technology, interface type and transmission layer, the Alcatel-Lucent 9500 MPR can converge all traffic over a single packet network using industry-standard pseudowire and circuit-emulation technologies (MEF 8, ATM PWE3, SAToP/CESoPSN). The Alcatel-Lucent 9500 MPR is MEF 9 and MEF 14 certified to support Ethernet Private Line (EPL), Ethernet Virtual Private Line (EVPL) and Ethernet LAN (E-LAN) service functionality and performance, enabling the acceleration of full interoperability in multivendor environments.

Multiservice-aggregation layers remove the need for intermediate E1/T1 connectivity, enabling unique traffic management regardless of ATM/TDM/Ethernet traffic type.

4.2 Radio-bandwidth optimization

The Alcatel-Lucent 9500 MPR is a packet node that supports multiple radio directions and local access, handling all traffic over a common multiservice-aggregation layer. This permits service overbooking across different technologies. The same services, in terms of Class of Service (CoS) generated by an ATM source and an IP source, can now share the same bandwidth resource. The resulting benefit is optimization of radio-bandwidth resources in conjunction with tremendous switching capacity and very high scalability.

4.3 Service-aware traffic management

Service awareness enables the categorization of different traffic types carried over the converged Ethernet stream. The transmitted data stream can come from different sources and may therefore have different requirements. For example, ATM traffic from a 3G base station can carry voice (high priority, real-time service) and data (lower priority and possibly non-real time with a high-variability load, such as Internet browsing, music downloading or video streaming). Service awareness identifies the different traffic types for Hierarchical QoS (H-QoS) and guaranteed QoS/QoE.

Service awareness also includes "genuine TDM transport" options, enabling E1/T1 transmission with TDM-like performance in terms of spectral efficiency and jitter/wander and avoiding the typical quality degradation caused by the packetization process.

4.4 Service-driven adaptive modulation

In the Alcatel-Lucent 9500 MPR, service-driven adaptive modulation operates in conjunction with service-aware traffic management. This approach enables full exploitation of the entire air bandwidth by changing the modulation scheme according to propagation availability, consequently providing sufficient transport capacity. Flow control is service-aware and can adapt the traffic throughput to the new available bandwidth by discarding the packet traffic according to the QoS marking performed at the PWE3/MPLS/Ethernet level. When full bandwidth is restored on the air interface, packets are not discarded.

The Alcatel-Lucent 9500 MPR provides a full set of protection methods with no single point of failure, including the Ethernet switch, Ethernet traffic ports, E1/T1 ports, equipment controller and radio transceivers. Moreover, if the Alcatel-Lucent 9500 MPR is connected to a packet network, link aggregation is supported within the same access card or on two different cards to maximize redundancy of the system.

4.5 Synchronization distribution

To transport real-time services over a packet network, an operator must provide a precise time signal to synchronize the traditional TDM services in the packet network without compromising service quality.

With native TDM traffic, the synchronization signal can be recovered from the traffic itself, for example, from the E1/T1 or Synchronous Transport Mode level 1/Optical Carrier level 3 (STM-1/OC-3) line signal; alternatively synchronization is delivered to site using a sync-out port.

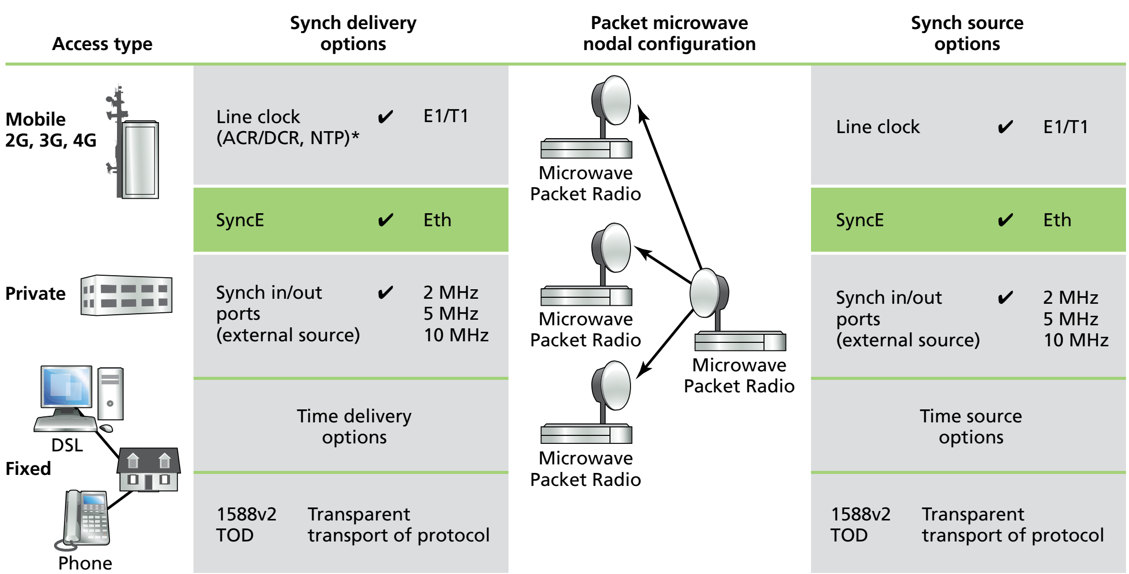
For packet traffic, other techniques must be implemented to achieve the same performance as in a circuit-based network. Synchronous Ethernet (SyncE) and Institute of Electrical and Electronics Engineers (IEEE) 1588v2 are suitable mechanisms for this.

On the air, synchronization distribution using packet radio consumes no bandwidth, being based on radio symbol rate, and is totally immune to the network load. Synchronization-delivery options are independent of the synchronization source.

As shown in Figure 9, the Alcatel-Lucent 9500 MPR implements a number of mechanisms for transporting and distributing synchronization in the network, including:

- SyncE
- IEEE 1588v2
- Packet-microwave synchronization
- STM-1 (SDH)/OC-3 (SONET)

Figure 9. Synchronization distribution for TDM and packet



* Adaptive and differential clock, recovery, node timing protocol

5. Network management with the Alcatel-Lucent 5620 SAM

Network operations are simplified with the Alcatel-Lucent 5620 Service Aware Manager (SAM). The Alcatel-Lucent 5620 SAM facilitates the delivery of advanced network services based on the Alcatel-Lucent converged IP, Ethernet and Multi-Protocol Label Switching (MPLS) portfolio by managing cell sites that provide microwave access using the Alcatel-Lucent 9500 MPR.

The Alcatel-Lucent 5620 SAM enables the provisioning of an end-to-end service using wizards or point-and-click configuration from a single application, eliminating the need to individually configure each device in the service path. The Alcatel-Lucent 5620 SAM greatly reduces the complexity and risk associated with provisioning complex services and provides comprehensive support for Fault, Configuration, Accounting, Performance and Security management (FCAPS). With service awareness, the Alcatel-Lucent 5620 SAM can react to service events to present correlated, relational information to the operator, enabling faster service provisioning, verification and restoration.

6. Meeting real-world challenges with the Alcatel-Lucent 9500 MPR

The Alcatel-Lucent 9500 MPR has the versatility to be successfully deployed by more than 70 customers around the globe, supporting mobile transport in Layer 2 and Layer 3 networks. The following subsections provide some examples of customer deployments and management comments.

6.1 Globalive Wireless, Canada

Globalive Wireless wanted to build a high-speed 3G mobile network able to smoothly transition to LTE. The company deployed the Alcatel-Lucent 9500 MPR and Alcatel-Lucent service routers and service-aggregation routers.

> *"Our commitment is to provide Canadian consumers with unmatched value. For that we need future-ready technology that enables the delivery of high-capacity, cost-effective IP-based services. We look to the experience, expertise and forward-thinking technology of Alcatel-Lucent to support our commitment to building an advanced, high-speed mobile network that will support economic development and jobs creation throughout Canada."*
>
> **KEN CAMPBELL, CHIEF EXECUTIVE OFFICER, GLOBALIVE WIRELESS**

6.2 Digicel Antilles

A mobile telecommunications operator in the Caribbean and Latin America, Digicel Antilles faces the challenges of the island terrain and weather that affects radio transmissions. The company selected the Alcatel-Lucent 9500 MPR for its IP mobile-network transformation.

> *"To meet the increase in traffic and satisfy the growing demand for high-speed mobile data services, we needed to progressively transform our infrastructure towards a simpler network architecture that could ensure the highest level of quality in all circumstances. The Alcatel-Lucent microwave packet radio solution allows us to optimize our network's radio bandwidth, regardless of the signal propagation conditions, which is a particularly important factor in the island's latitude."*
>
> **FRANCK ROGIER, TRANSMISSION MANAGER, DIGICEL ANTILLES FRENCH GUIANA**

6.3 TIM Brasil

Telecom Italia® Mobile Brasil wanted to transform its network to enable the reliable, cost-effective transport of its existing 3G traffic as the company transitions to support LTE and WiMAX-based services. To transform the mobile network, TIM Brasil deployed the Alcatel-Lucent 9500 MPR and Alcatel-Lucent 1850 Transport Service Switch (TSS).

> *"The success of our 3G services is driving the demand for new and higher-speed services. To meet the resulting traffic growth, we needed to transform our infrastructure into a simpler network architecture ensuring cost-effectiveness and the highest quality in service delivery. With Alcatel-Lucent's state-of-the-art packet transport solution, we evolve profitably towards the next generation of wireless broadband, while preparing for LTE and WiMAX-based services."*
>
> **MARCO DI COSTANZO, NETWORK DIRECTOR, TIM BRASIL**

6.4 Indosat, Indonesia

In Indonesia, Indosat wanted to converge its mobile and fixed-line services to improve mobile-backhaul capacity and optimize their CAPEX and OPEX. In view of the extraordinary growth in both the number of subscribers and the traffic volume, the company deployed the Alcatel-Lucent 9500 MPR, the Alcatel-Lucent 7705 Service Activation Router (SAR) and the Alcatel-Lucent 5620 SAM. Deploying the Alcatel-Lucent solution is helping Indosat prepare for emerging next-generation wireless network services and to scale to meet bandwidth demand for High Speed Downlink Packet Access (HSDPA) and eventually 4G.

7. Conclusion

Communications service providers can reduce backhaul transport costs, evolve to scalable packet-optimized networks, and ensure service availability that fosters customer loyalty. The Alcatel-Lucent 9500 MPR is a true packet wireless-transmission system that natively handles packets and efficiently transports feature-rich mobile services, enabling the launch of data services at attractive rates and with profitable operating margins.

Using Ethernet as the only native radio-transmission protocol, Fast Ethernet (100 Mb/s) and Gigabit Ethernet (1 Gb/s) are natively transmitted while TDM/ATM signals are transmitted as pseudowire and CES. The Alcatel-Lucent 9500 MPR supports 2G and 3G services and is LTE-ready today.

8. Abbreviations

1350 OMS	Alcatel-Lucent 1350 Optical Management Suite
1850 TSS	Alcatel-Lucent 1850 Transport Service Switch
5620 SAM	Alcatel-Lucent 5620 Service Aware Manager
7705 SAR	Alcatel-Lucent 7705 Service Aggregation Router
9500 MPR	Alcatel-Lucent 9500 Microwave Packet Radio
2G, 3G, 4G	Second Generation, Third Generation, Fourth Generation
ATM	Asynchronous Transfer Mode
BSC	Base Station Controller
BTS	Base Transceiver Station
CAPEX	capital expenditures
CES	Circuit Emulation Service
CESoPSN	Structure-Aware TDM Circuit Emulation Service over Packet-Switched Network (RFC 5086)
CoS	Class of Service
DDF	digital distribution frame
E-LAN	Ethernet Local Area Network
E1	E-carrier system
EPL	Ethernet Private Line
EVPL	Ethernet Virtual Private Line
FCAPS	Fault, Configuration, Accounting, Performance and Security management
FMO	future mode of operation
GigE	Gigabit Ethernet
GIWF	Generic Inter-Working Function
H-QoS	Hierarchical QoS
HLN	Alcatel-Lucent High Leverage Network™ (architecture)
HSPA	High-Speed Packet Access
HSPA+	Evolved HSPA
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
L2	Layer 2
LTE	Long Term Evolution

MBIA	Mobile Backhaul Implementation Agreement (MEF 22)
MEF	formerly known as Metro Ethernet Forum
MPLS	Multi-Protocol Label Switching
OC-3	Optical Carrier level 3
OPEX	operating expenditures
PC	personal computer
PDH	Plesiochronous Digital Hierarchy
PMO	present mode of operation
PWE3	Pseudowire Emulation Edge-to-Edge
QAM	quadrature amplitude modulation
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
RNC	Radio Network Controller
SAToP	Structure-Agnostic TDM over Packet (RFC 4553)
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
STM-1	Synchronous Transport Mode level 1
SyncE	Synchronous Ethernet
T1	T-carrier system
TCO	total cost of ownership
TDM	Time Division Multiplexing
VoIP	Voice over Internet Protocol
WDM	wavelength division multiplexing
WiMAX	Worldwide Interoperability for Microwave Access

9. Contacts

For information about Alcatel-Lucent mobile-backhaul solutions and the Alcatel-Lucent 9500 MPR, please visit www.alcatel-lucent.com or contact your Customer Team representative.

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11. Appendix A: comparison of packet and hybrid microwave

Table 1 summarizes the primary differences between hybrid microwave and packet microwave.

Table 1. Comparison of packet microwave and hybrid microwave

PACKET MICROWAVE	HYBRID MICROWAVE
• Supports 2G, 3G and 4G • LTE-ready	• Supports 2G and 3G • Not LTE-ready
• Ethernet is the common transmission layer that can transport any kind of traffic (TDM, ATM, Ethernet) • TDM and ATM are converted to packet streams using industry standards (MEF 8, ATM PWE3, TDM CES) • Ethernet provides scalability	• Ethernet, TDM and ATM are each natively transported • Limits scalability
• Aggregates traffic from multiple radio directions and local access, handling all traffic (ATM, TDM, Ethernet) over a common multiservice aggregation layer (Ethernet)	Traffic handled differently: • TDM and ATM require a digital distribution frame (DDF) for aggregation • Ethernet can be aggregated from multiple radio directions and local access
• Service-aware traffic management uses QoS mechanisms (classification, policing, shaping, metering, scheduling) to grant high priority traffic appropriate treatment • Can discriminate different traffic flows (ATM, TDM, Ethernet), including transmission of CES, with the same performance as native TDM traffic	Traffic handled differently: • ATM and TDM are treated natively to be directed to the radio channel • Ethernet traffic is service-aware, with the ability to discriminate traffic by requirements and CoS to grant high-priority traffic the appropriate treatment
• Optimized radio transmission, in which the nature of incoming traffic (TDM voice, VoIP, real-time services or best-effort data) is recognized to perform optimal transmission	Traffic handled differently: • Optimized radio transmission for Ethernet traffic • TDM and ATM do not have optimized radio transmission
• Service-driven adaptive modulation, which can increase radio throughput by scaling modulation when propagation conditions are appropriated • Applies for Ethernet, ATM and TDM traffic	Traffic handled differently: • Service-driven adaptive modulation for Ethernet traffic • TDM and ATM do not support service-driven adaptive modulation
• Carrier-grade protection provides protection methods to avoid service failure	• Carrier-grade protection provides protection methods to avoid service failure for TDM only
• Synchronization distribution provides timing/synchronization to network elements in the access and aggregation networks • Packet microwave uses a number of mechanisms for transporting and distributing synchronization that can be freely mixed (for example, SyncE at ingress, E1/T1 line clock at egress) • E1/T1 line clock is decoupled at ingress and egress (for example, one line at ingress, *n* lines at egress)	• Synchronization distribution with limitations • Legacy and packet-based methods cannot be mixed • E1/T1 line clock is transported one-to-one (for example, *n* lines at ingress, *n* lines at egress)

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