



MICROWAVE FOR THE LONG-HAUL

WITH ALCATEL-LUCENT
9500 MICROWAVE PACKET RADIO

APPLICATION NOTE

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INTRODUCTION

The evolving ultra broadband era has placed tremendous pressure on microwave networks to scale capacity to support new IP services and applications. To better compete, operators need to economically extend network reach and capacity, with the flexibility to deploy in a variety of sites to support all services and applications. With the growing demand for high-bandwidth services, microwave networks must also support greater network capacity over any microwave topology, with increased end-to-end network reliability to ensure that end users continue to receive the best quality of experience (QoE) as network demands increase.

Microwave long-haul transport networks are typically used to extend optical transport networks in areas where optical fiber is either too difficult or too costly to deploy. In many cases, these types of networks still leverage time division multiplexing (TDM) technology if there hasn't been a mobile evolution to High-speed Packet Access+ (HSPA+) or Long Term Evolution (LTE) to drive network investment upgrades to packet-based technology. However, even though long-haul microwave networks might be lagging behind mobile backhaul in the transition to packet, that change is imminent as services of all types continue to transition from TDM to packet and increased capacity is demanded from microwave networks to support more IP packet-based services and applications.

Alcatel-Lucent is the global leader in both packet microwave and long-haul microwave networks. Alcatel-Lucent has been the dominant microwave vendor in supporting North America's evolution to LTE with the Alcatel-Lucent 9500 Microwave Packet Radio (MPR). The Alcatel-Lucent 9500 MPR has also become a mainstay of long-haul networks in North America, with the previous introduction of all-indoor transceivers. That same portfolio has been enhanced to meet the unique requirements of long-haul networks around the world. This will enable network operators globally to enhance their microwave networks to support new IP packet-based services and applications, while also efficiently supporting traditional services.

The 9500 MPR offers industry-leading microwave link and network capacity by using features exclusive to packet microwave systems, unique designs to maximize radio frequency (RF) performance, and energy efficient compact indoor devices. This combination supports the efficient and reliable delivery of the most microwave capacity over long distances using the smallest equipment footprint. The 9500 MPR allows microwave operators to address the ultra broadband era using a network with an extremely low total cost of ownership (TCO).

LONG-HAUL MARKET

The microwave long-haul transport market has evolved to serve several types of applications and networks (for example, mobile, DSL, TV broadcast, utilities, and government agencies). Depending on the user and the network application, long-haul networks can range from relatively low capacity (for example, supporting $n \times 100$ Mb/s channels) to extremely high capacity (supporting $n \times$ Gb/s channels). There are common traits, though, such as:

- In most cases radio equipment is installed indoors, both for protection and for ease of maintenance.
- Long distances, often with multiple repeater sites, are required.
- High equipment reliability and path availability are critical.

According to Dell'Oro analysts, the full indoor unit (FIDU) configuration is typically used to transmit multiple microwave channels on long-haul routes. A large percentage of long-haul microwave links still use TDM-based systems to carry Synchronous Digital Hierarchy/Synchronous Optical Network (SDH/SONET) signals, whereas most new deployments of short-haul spans have migrated to packet microwave-based systems. Dell'Oro also forecasts that most service providers (SPs) will upgrade to newer packet microwave for their long-haul links to meet the growing capacity demands (according to Dell'Oro 90 percent of long-haul systems will be packet based by 2016).

ALCATEL-LUCENT LONG-HAUL SOLUTION

Alcatel-Lucent is, and has always been, at the forefront of pushing microwave technology to address SP capacity, reliability, and network TCO needs. Alcatel-Lucent has in-depth and unique expertise and knowledge in the design and implementation of long-haul microwave links and networks. This expertise includes all aspects of the network, such as design and planning, deployment, and optimization, even in the most stringent environments. In addition to microwave leadership, the Alcatel-Lucent authority in the areas of IP/Multiprotocol Label Switching (MPLS) and optical networks enables an investment in network and services management that supports efficient end-to-end network operations across microwave and fiber networks.

The 9500 MPR long-haul solution supports some of the largest LTE networks in the world, and is ready to face new long-haul challenges in terms of capacity growth to support the delivery of new IP services and applications. The 9500 MPR long-haul systems enable:

- Faster, longer, more efficient radio links that support more revenue generating services and/or applications over scarce microwave spectrum
- Advanced networking for reliability and scale, ensuring that end users continue to receive the best QoE as network demands increase
- Lower network TCO using a unique, simplified, end-to-end portfolio that helps support a healthy corporate balance sheet

Faster, longer, more efficient radio links

Faster, longer and more efficient radio links signify more microwave capacity to deliver additional services and applications to more locations. Added capacity also translates to a better service and application end-user QoE to stay ahead of the competition.

RF excellence to support longer distances

When considering long-haul requirements to reach new outlying locations, few parameters are as important as system gain and modem performance. Higher system gain translates directly into specific benefits for the network operator. It can dramatically increase the path distance that can be covered, eliminating the cost of unneeded repeater sites in long linear networks. For shorter paths, higher system gain reduces the amount of antenna gain needed, allowing operators to install smaller diameter antennas. A smaller antenna not only reduces the initial capital expenditure (CAPEX) at deployment, but it also reduces the amount of loading on the microwave tower which further drives down microwave site cost. Higher system gain can also increase the thermal fade margin on the link, improving the path availability performance during times of poor propagation conditions, ensuring that end-user QoE is maintained even under the most adverse weather conditions.

The 9500 MPR transceivers provide high system gain by offering industry-leading transmit power levels, along with extremely low receiver thresholds. In addition, an integrated diversity receiver with a digital combiner provides even greater performance characteristics. The digital combiner provides significant path protection against all types of fading, whereas switched receivers or even intermediate frequency (IF) combiners can only protect against a limited subset of propagation events. The diversity receiver and digital combiner can extend the length of long-haul microwave links to address very difficult propagation conditions frequently encountered when creating long microwave links. This combination of high-transmit gain and receiver sensitivity can be used to address any long-haul deployment scenario.

New approach to efficiently and reliably scale microwave link capacity

Traditional long-haul microwave links often combine several independent RF microwave channels together to scale microwave capacity to required levels. They also use dedicated and costly protection channels to address degradations in capacity when equipment failures occur or when environmental conditions impact microwave RF performance.

The Alcatel-Lucent “multichannel” approach to combine microwave channels together creates faster, more efficient microwave links with higher throughput to address the needs of new IP services and applications. Multichannel can bundle together as many channels as a microwave link design requires. The Alcatel-Lucent multichannel is based on the distribution and balancing of traffic flows over a group of radio channels. Channels operate in parallel; however, they may have different frequency bands, polarizations, and/or channel spacing allowing easier and faster deployments.

Unlike traditional microwave protection mechanisms, multichannel requires no dedicated protection channel (for example, traditional 1:N protection approaches). Rather than having a dedicated protection channel, multichannel links are designed with enough total throughput to handle individual channel failures or reductions in capacity (for example, due to weather impairments) on underlying bonded channels.

Under normal operating conditions, all of the capacity on each of the bonded channels is usable for customer traffic. In the event of a channel failure, the 9500 MPR will automatically reallocate all of the highest priority traffic to the remaining channels. This more efficient utilization of the bundle of parallel channels improves microwave link performance and reduces network TCO when compared to traditional protection mechanisms which leave one channel effectively empty, and incur the cost of one extra radio per microwave site. An extra radio channel dedicated to protection can also be difficult to obtain in frequency congested areas.

Multichannel protection also simplifies microwave network design. Alcatel-Lucent has developed new design tools that take into account the benefits of multichannel. These tools facilitate link availability calculations for services depending on their quality of service (QoS) and service level agreement (SLA) requirements. They also take into consideration the reduction of multichannel link capacity when adaptive modulation is used to meet link availability requirements. These tools enable a smooth evolution from classic microwave link design to packet optimized microwave link design.

Adaptive high order modulation to ensure maximum link capacity

The power efficient 9500 MPR long-haul transceivers are capable of operating at 1024 QAM, while also delivering industry-leading radio transmit power to maximize microwave link distance. These transceivers have the ability to dynamically adjust to optimal modulation levels in changing environmental conditions to ensure maximum channel capacity is always available. Service-aware QoS, coupled with service-driven adaptive modulation, provides optimal utilization of over-the-air bandwidth in all weather conditions.

Packet compression for more link efficiency

The fundamental objective of packet compression is to maximize the amount of traffic payload that traverses a microwave link through the reduction of the required transport protocol overhead. When used in the packet microwave domain, packet compression can take advantage of the fact that microwave is a point-to-point link, hence there is no need for systems to inspect protocol overhead fields such as Ethernet MAC or IP addresses. These overhead elements can be compressed along with other fields that are not encapsulated by IPSec or that do not change from packet to packet in a specific packet flow.

The 9500 MPR advanced packet compression techniques optimize Ethernet and IP headers to increase packet throughput over microwave links by as much as 300 percent without impacting SLAs. The use of packet compression has the added benefit of dramatically increasing capacity without impacting microwave link deployment costs (for example, transceiver power, antenna size).

Cross-Polarization Interference Cancellation (XPIC) to double spectrum capacity

This feature takes advantage of both horizontal and vertical electromagnetic polarizations to double the capacity of a microwave frequency. This allows for more efficient use of scarce microwave spectrum, while also helping to minimize the microwave interference environment. The 9500 MPR transceiver portfolio offers both integrated and add-on XPIC options to flexibly address microwave deployment environments.

Advanced networking for reliability and scale

To support the reliable scaling of network capacity, microwave deployments are evolving from the installation of isolated point-to-point RF links to being deployed as part of an advanced end-to-end network. This evolution places new networking requirements on microwave systems, requirements that the Alcatel-Lucent 9500 MPR portfolio addresses with the support of the following features.

Adaptation of traditional services to packet

Alcatel-Lucent introduced the revolutionary concept of packet microwave with the introduction of the 9500 MPR portfolio. This new category of microwave products has as one of its key values the ability to seamlessly evolve from TDM SDH/SONET networks to all IP and Ethernet packet networks. This transition requires the adaptation of traditional TDM and Asynchronous Transfer Mode (ATM) technologies to packet using standards-based pseudowire technology. It also requires the implementation of advanced packet QoS mechanisms to ensure packetized traditional services can meet existing TDM SLAs.

Packet microwave systems leverage a single Ethernet switching complex for all services, rather than having a TDM switch for voice services and a separate Ethernet switch for packet services as is the case for hybrid microwave systems. This eliminates the operational inefficiency and complexity associated with maintaining two switching domains. Scarce microwave spectrum utilization is also optimized by removing TDM container overhead. New “packet-only” network sites can also be easily added to packet microwave networks, whereas hybrid microwave networks require the extra expense and complexities of having TDM switching at all sites, including the aforementioned packet-only sites.

Scalable microwave sites with minimal indoor footprint

In today’s telecommunications market, many operators are looking for solutions that reduce their impact on the environment and their energy costs. Energy efficiency is becoming more of a priority in order to reduce operators’ utility bills and the drain on resources. In many cases, energy consumption can range from 10 percent to 25 percent of network operating expense (OPEX). Power consumption for microwave equipment cannot be ignored. This is especially true for installations that do not have access to commercial power and have to rely on solar energy or diesel generators for their power supply.

The Alcatel-Lucent 9500 MPR has been designed to maximize transceiver density and packet throughput using a very small indoor footprint. For high capacity long-haul applications, up to 20 transceivers supporting up to 20 Gb/s worth of packet throughput can be deployed in a single rack for use in either nodal and/or repeater configurations. In addition, a full 1 + 1 or 2 + 0 transceiver configuration can be provided in just 2.5 RUs. These industry-leading high capacity and low footprint capabilities reduce the number of network elements to manage in the network, while also cutting down on indoor space requirements by 50 percent when compared to current competitive offers. This leads to lower power consumption and ecological sustainability.

Standards-based Carrier Ethernet and IP/MPLS networking

The 9500 MPR supports standards-based networking features, which allow for the scaling of microwave links and networks in a consistent fashion across an end-to-end microwave network.

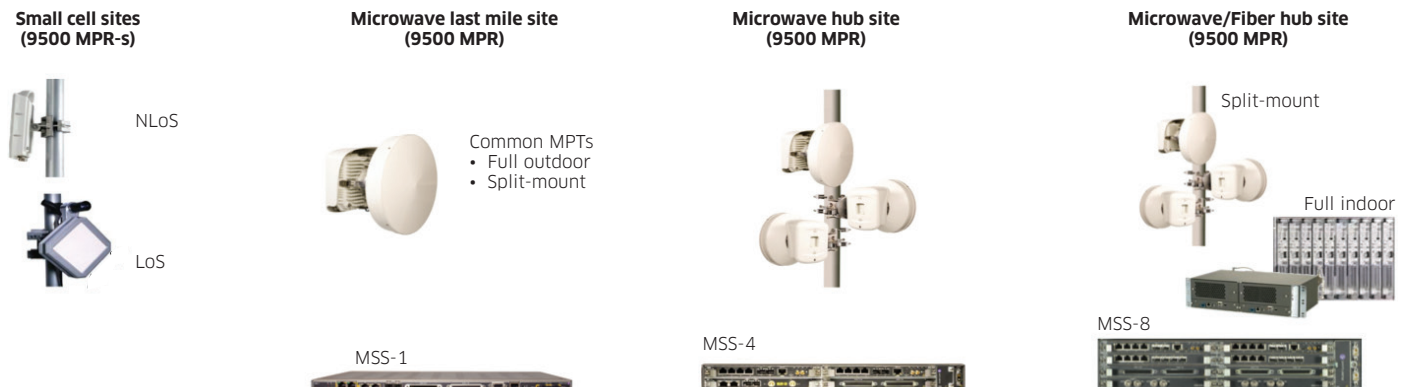
Support for a fully featured ITU-T G.8032v2 implementation allows seamless interworking and scaling between microwave, Carrier Ethernet, and optical networks. Integrated IP/MPLS networking options can also be used to address increasing network capacity demands in IP/MPLS networks. These networking options provide maximum network bandwidth utilization and offer network reliability capabilities to protect against network failures.

To protect traditional services, the 9500 MPR supports protected TDM interfaces to meet all market requirements. These interfaces also enable a smooth migration from the installed base of Alcatel-Lucent traditional long-haul products, such as the Alcatel-Lucent 9600 Long Haul System (LSY) or the Alcatel-Lucent Microwave Digital Radio (MDR) 8000.

Unique, simplified, end-to-end portfolio

The 9500 MPR all-indoor long-haul platform is based on the concept of leveraging common technology to address all microwave deployment and application needs with one single range of products. The indoor transceivers can be used for both short-haul and long-haul applications, or even mixed with outdoor units on the same node. This provides flexibility to offer high-capacity backbone hubs with low-capacity spurs in the most cost-effective manner. Both the indoor and outdoor transceivers share fundamental design parameters so that similar functionality and features can be easily supported.

Figure 1. The Alcatel-Lucent 9500 Microwave Packet Radio portfolio



INNOVATIVE END-TO-END PRODUCT FAMILY EFFICIENTLY ADDRESSING ALL SITES AND APPLICATIONS

- **FEWER SPARES** – Use of common 9500 MPR transceiver (MPT) outdoor units across all applications
- **LESS SPACE AND POWER** – Indoor units optimized to different site sizes and requirements
- **SIMPLIFIED OPERATIONS** – Common software and management across all components (9500 MPR-s – management only), integrated IP and optical options

The 9500 MPR long-haul solution has been designed with enough flexibility to overcome virtually any site constraints and operate in the most stringent environments. The 9500 MPR long-haul solution supports the requirements of different geographical markets. For example, one configuration of the all-indoor solution is mechanically optimized to support the multichannel applications typically used in the ETSI market. However, there is also an optimized solution for N x (1+1) protected channel configurations, which is the primary application used in the North American ANSI market. In addition, there are other configurations available to address different deployment needs in both markets.

Minimizing spares and operational costs

Early in the design of the 9500 MPR, Alcatel-Lucent recognized the power of having common radio products that can support all-indoor, split package, and all-outdoor applications, regardless of the site location or conditions. This fundamental criterion allows operators to minimize the number of spare modules required to support their network and also greatly reduces OPEX.

Minimizing site requirements

Because the 9500 MPR is both modular and scalable, it can be sized to meet the footprint and rack space restrictions of virtually any site.

Service awareness

Very few microwave vendors have the Alcatel-Lucent authority in the areas of IP, optical, and microwave. This end-to-end product and network leadership enables an Alcatel-Lucent investment in network and services management that goes beyond multivendor microwave/wireline partner deployments. This superior management integration delivers additional OPEX savings through the support of end-to-end service provisioning, the ability to monitor the entire network through a single, optimized system, and multi-layer troubleshooting. The Alcatel-Lucent 5620 Service Aware Manager (SAM) platform 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 (FCAPS) management. With service awareness, the 5620 SAM can react to service events to present correlated, relational information to the operator, enabling faster service provisioning, verification and restoration.

Powerful, consistent, end-to-end microwave feature set

The aforementioned 9500 MPR capacity scaling features, which include packet compression, multichannel, XPIC, adaptive high order modulation, adaptation of traditional services to packet, and standards-based Carrier Ethernet networking, can be used in any combination to scale microwave network capacity. In addition, they are all offered through a common hardware technology and software base that is used across the 9500 MPR short-haul and long-haul, end-to-end portfolio of full outdoor, split-mount, and full indoor configurations. The 9500 MPR can also be managed by a single network and service management platform. Together these characteristics combine to simplify SP network operations and lower network TCO.

SUMMARY

Alcatel-Lucent has established an industry leadership position with packet microwave, and has further optimized the 9500 Microwave Packet Radio portfolio to address long-haul microwave deployment requirements around the world. This allows service providers, utilities, and government agencies to enhance their microwave networks to support new IP packet-based services and applications, while also efficiently supporting traditional services.

The 9500 MPR long-haul products are part of an end-to-end 9500 MPR portfolio that provides an advanced combination of high system gain along with microwave link and network capacity-enhancing features. This combination allows network operators throughout the world to create higher capacity, more efficient microwave links, support flexible and scalable network topologies, and achieve low network TCO efficiency to successfully face the ultra broadband era.

ACRONYMS

ANSI	American National Standards Institute	MPLS	Multiprotocol Label Switching
ATM	Asynchronous Transfer Mode	MPR	Microwave Packet Radio
CAPEX	capital expenditures	MPT	Microwave Packet Transport
DSL	digital subscriber line	MSS	Microwave Service Switch
ETSI	European Telecommunications Standards Institute	NLoS	non line of sight
FCAPS	fault, configuration, accounting, performance, and security	OPEX	operating expense
FIDU	full indoor unit	QAM	quadrature amplitude modulation
HSPA	High-speed Packet Access	QoE	quality of experience
IF	intermediate frequency	QoS	quality of service
IP	Internet Protocol	RF	radio frequency
IPSec	IP Security	RU	rack unit
ITU	International Telecommunication Union	SAM	Service Aware Manager
ITU-T	ITU Telecommunication Standardization Sector	SDH	Synchronous Digital Hierarchy
LoS	line of site	SLA	service level agreement
LSY	Long Haul System	SONET	Synchronous Optical Network
LTE	Long Term Evolution	SP	service provider
MAC	media access control	TCO	total cost of ownership
MDR	Microwave Digital Radio	TDM	time division multiplexing
		XPIC	Cross-Polarization Interference Cancellation