Alcatel·Lucent

9500 MPR
Release 6.0

Technical Solution Manual

CONTENTS

1 INTRODUCTION

Scope of this document is to describe 9500 MPR platform , the main features supported and its architecture.
Some details on hardware components are provided and their application is explained.

The document is further completed by Technical Summary documents where all main technical caractheristics are reported.
In general for each feature , components and frequencies availability please refer to product roadmap and to customer release note.

2 SYSTEM DESCRIPTION

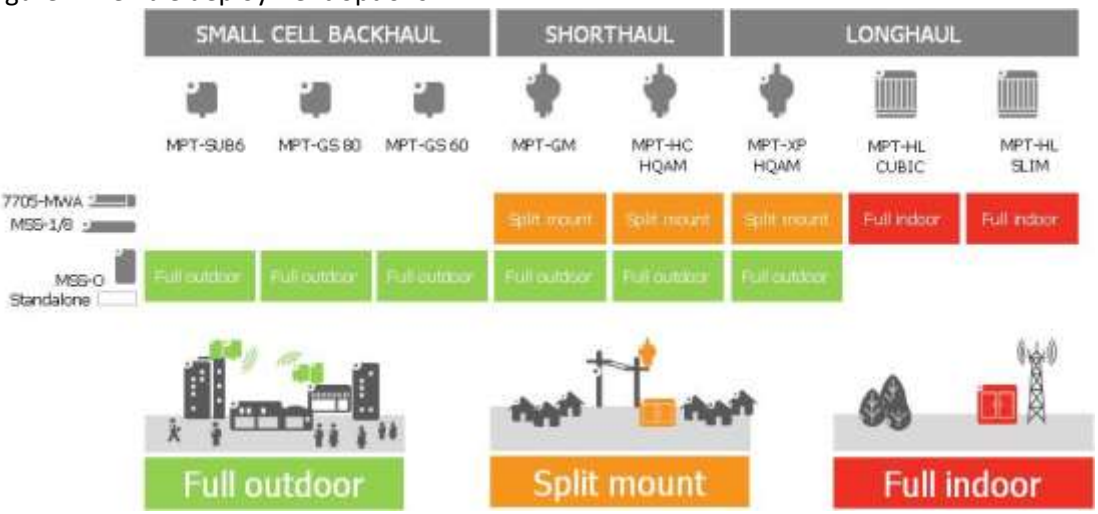
2.1 9500 MPR solution portfolio

Alcatel-Lucent 9500 MPR solution consists of a combination of an radio unit (Microwave Packet Transceiver or MPT) and a networking unit (Microwave Service Switch or MSS) described in Figure 1. Three segments are served: small cell backhaul, shorthaul and longhaul. Several types of wireless cell site connection options are required to support mobile network capacity and coverage expansions. Alcatel-Lucent's 9500 MPR solutions support a full suite of wireless frequency options including 5.8-42GHz solutions for macro cell backhaul, 80GHz millimeter wave (e-band) solutions for both macro and small cells, unlicensed 60GHz millimeter wave (v-band) and sub-6GHz solutions that are typically used to support the backhaul of small cells.

Figure 1. Alcatel-Lucent 9500 MPR portfolio

Depending on the option chosen, the solution can be split-mount, full-indoor or full-outdoor, as shown in Figure 2. The solution can be used in tail, hub and longhaul packet microwave applications.

Figure 2. flexible deployment options



2.2 9500 MPR solution components

2.2.1 Microwave Packet Transport

9500 MPR Microwave Packet Transport (MPT) units all leverage the same software and technologies whether they are deployed in a split-mount, full-indoor, or full-outdoor configuration. This offers operators more deployment flexibility, minimizes spares inventory, and results in lower network TCO.
The MPTs support:

- Advanced packet compression
- Hitless, high order adaptive modulation
- IP along with legacy technologies
- Integrated cross-polarization to double capacity
- N+N hot standby with spatial diversity options
- Both short-haul (less than 20 km) and long-haul (greater than 20 km)

MPTs are available to address distance and availability needs.

2.2.2 Microwave Service Switch indoor units

Full-outdoor MPTs can be deployed independently (for example, connecting directly to an LTE eNode B mobile base station) or together with a Microwave Service Switch (MSS) indoor units that provide advanced Carrier Ethernet networking, aggregation and demarcation functions. Optimized to reduce space and power consumption, the MSS exists in different form factors to address all network sizes and locations, including tail, hub and backbone. The entire MSS family uses the same software and management systems, enabling consistent operations across end-to-end packet microwave networks.

The complete range of right-sized MSS microwave units addresses any site footprint requirement. The units are energy-efficient, extremely scalable and offer deployment flexibility. All indoor units support traditional services such as TDM, and newer Ethernet and IP services over a converged, packet-based, operationally efficient network.
To minimize operational complexity, the various MPTs and MSSs share common technology, software, and network and service management. They can be combined to support any wireless transmission application.

2.2.3 9500 MPR-e

The 9500 MPR-e is a full outdoor MPT solution set optimized for Ethernet-oriented all-outdoor deployments.
The 9500 MPR-e is fully integrated with the Alcatel-Lucent 7705 Service Aggregation Router (SAR) IP/MPLS portfolio, including support for the 9500 MPR-e as a native 7705 SAR microwave interface. Microwave-specific cards have been added to the 7705 SAR to support microwave protection and powering.
This level of integration offers unique capabilities for deploying IP/MPLS networking over microwave links:

- The solution offer is managed as a single network element, under common network management. This unique capability brings a number of OPEX advantages.
  For example, regardless of how many radio instances exist, network element maintenance procedures, such as software upgrades and configuration backups, are done only once to all components.

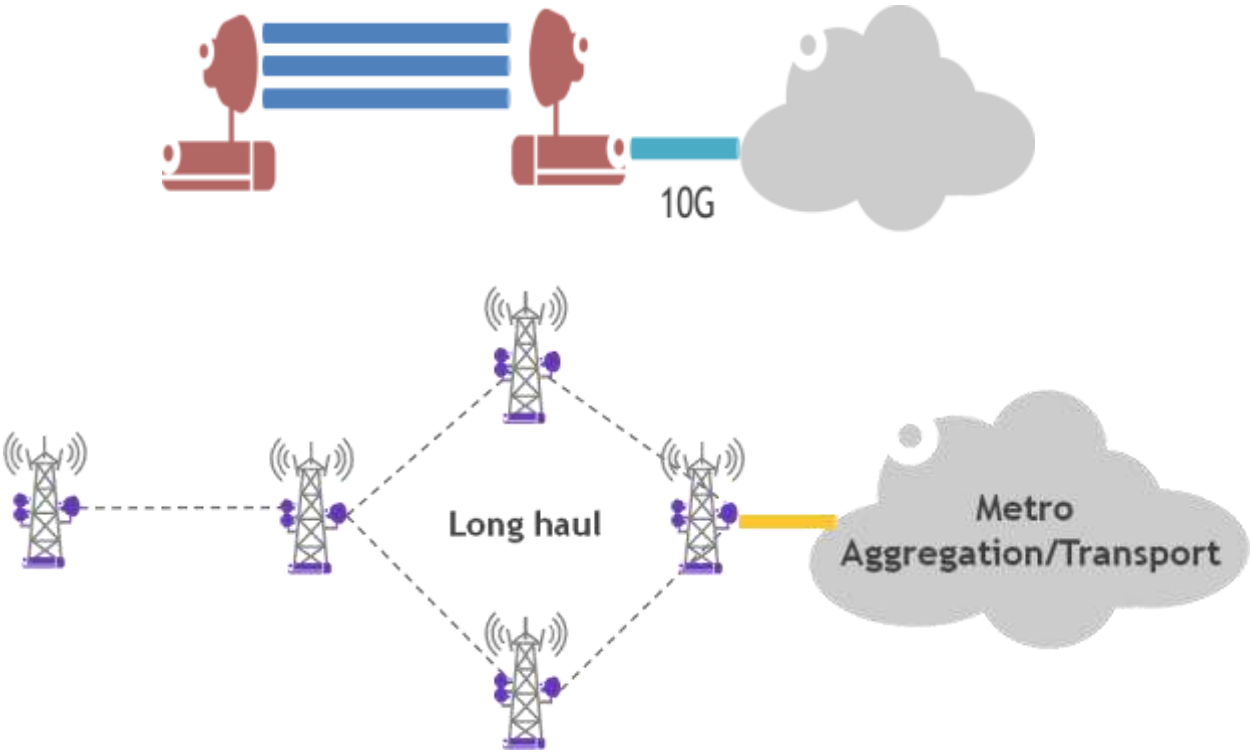
- Microwave radios can be directly powered by IP/MPLS cell site devices, which provide lightning protection and voltage surge suppression. This simplifies and optimizes cell site battery feed planning and installation.
- Collapsing two platforms into a single compact and very flexible platform reduces real estate requirements, operations complexity and energy costs.

3 9500 MPR: Main features

3.1 10G interfaces

9500 MPR does offer full not-blocking 10 Gbit/sec capability. This is achieved using:
corEvo card, that provides 2 x 10 Gbit/sec SFP+ interfaces and that does embedded a traffic matrix of 100 Gbit/sec
MSS-8 10G shelf, having a backpanel with 10 Gbit/sec connection among slot 1-6 and 2.5 Gbit/sec connection for slot 7-8

Typical usage of 10G interfaces is the handoff of aggregated traffic, see here below two use cases.
The first one is representing a split mount system that in a LAG L1 N+0 configuration does provide an air troughput greater than 1 Gbit/sec. In this case the best technical solution is to hand off traffic using a 10Gbit/sec interface. A similar case is represented by a long haul trunking system that usually it is designed and deployed to transport very high capacity, in the range of 4-5 Gbit/sec and above up to 10Gbit/sec: in this case it is abvious that the only reasonable technical solution to deliver this high capacity is through 1x 10G bit/sec interface



In this section we will discuss on the technical reasons for which using multiple 1 Gbit/sec user interfaces to deliver high capacity traffic is not the best technical solution.

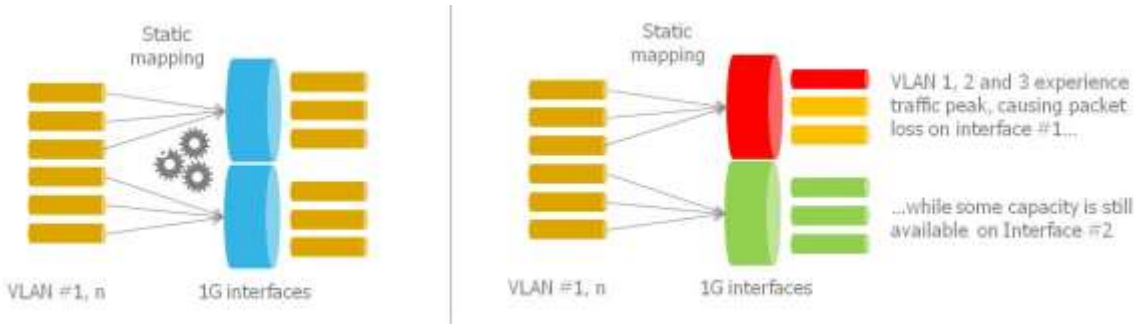
TRAFFIC HANDOFF: MULTIPLE 1G INTERFACES EVENTUALLY LEAD TO PACKET LOSS
Let's imagine to have multiple 1 Gbit/sec interfaces in the indoor unit. This will actually create a number of issues. Let's make a very simple example: let's imagine having a radio throughput of 1.8 Gbit/sec to be handed off using 2 x 1 Gbps ports without a 10 Gbit/sec interface available. How this can be done? Two methods are usually proposed:

- A static assignment of VLAN to the two ports
- Ethernet LAG IEEE 802.3ad/802.1AX.

The first method, consists in assigning, among the whole set of Ethernet flows transported by the radios, a sub-set of VLANs to port #1 and a second sub-set of VLAN to port #2, in a static way through an explicit provisioning by the operator. What does this mean for the operator?

This brings a huge operational complexity - The radios transport an aggregated traffic, made by multiple services and by multiple VLAN. This means that the details of each VLAN labels transported over the radio must be known in order to assign them to a one of the two ports.

This static provisioning can lead to a loss of packet - Let's assume that the VLANs are statically mapped in order to balance the load on the two 1G interfaces. Each interface therefore carries around some 900 Mbit/sec (1 Gbit/sec being the limit is imposed by the physical port speed). As the LTE traffic is extremely bursty by nature, it is highly probable that some VLANs may experience traffic peak, making the overall traffic exceeding the 1Gbit/s. In that case, the egress traffic will be cut above 1 Gbit/sec with the serious consequence of loss of packets (even if the other port may still have available throughput).



Drawbacks of multiple 1G interfaces

The second method is the usage of IEEE 802.3ad/802.1AX Ethernet Link Aggregation for port #1 and port #2

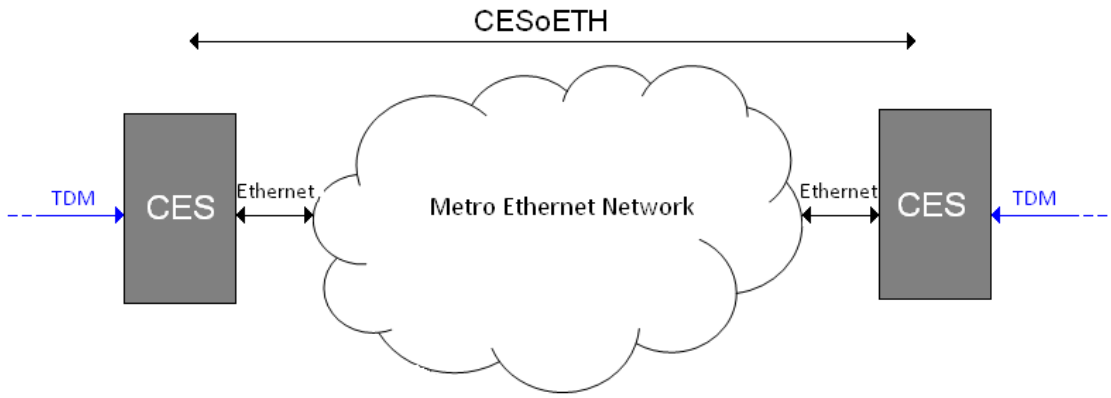
This standard, introduced in mid 1990s consists in combining two (or even more) physical Ethernet links into one logical link via. The logical pipe is equivalent to the sum of the physical Ethernet links. The traffic is distributed "per-flow", since it is not allowed by the standard to send the same Ethernet flow (=VLAN) to different physical interfaces in order to avoid any possible disorder potentially introduced.
Operational complexity is solved - The assignment between VLAN and port is automatically done by a hashing algorithm, that "in average" or "statistically" split up the incoming Ethernet flows.
But Ethernet LAG can still lead to packet loss - While the load balancing is quite effective in the case multiple Ethernet flows (30+) with different MAC/VLAN values, it proves to be less than optimum or simply not effective in case of limited number of VLANs (less than 16). In particular, if only one or a few of the flows have relative higher throughput than the others, one port can be over-saturated by the Ethernet flows, whilst the second one still has spare capacity. In our example, 1.8Gb/s roughly corresponds to a dozen of LTE nodeB maximum.

So again, the bursty nature of LTE traffic will make the algorithm un-effective and will lead to packet loss.

3.2 TDM/SDH traffic management

3.2.1 MEF-8

As described in MetroEthernet Forum, MEF-8 is a standard for "implementing interoperable CES equipment that reliably transport TDM circuits across Metro Ethernet Networks while meeting the required performance of circuit emulated TDM services as defined in ITU-T and ANSI TDM standards". The Circuit Emulation Service (CES) emulates a circuit network, by packetizing, encapsulating and tunneling the TDM traffic over Ethernet.



MEF-8 Service Definitions

Alcatel-Lucent 9500 MPR implements a proprietary technique that reduces the overhead to a low percentage, thus exploiting the maximum bandwidth on air when MEF-8 emulated circuits are transported. The improvement depends on the MEF-8 payload size and frame format: in case of TDM CES implemented inside 9500 MPR the efficiency is practically the same than a traditional TDM radio.

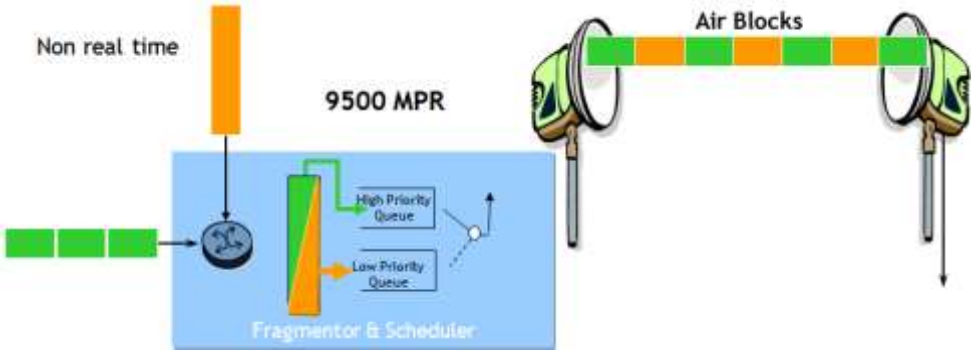
3.2.2 BER performance

When MEF-8 Ethernet frames are transmitted through a noisy medium (e.g. the Radio Physical Layer), bit errors may occur. If an Ethernet frame is affected by one error, this is detected and the entire frame is dropped. This affects the TDM traffic with a worse BER which, if compared with a traditional TDM transmission process, is higher, multiplied by a factor equal to the frame length.
In order to avoid such BER degradation a specific implementation is put in place such as for any reasonable BER on the Radio Channel, the TDM transported by MEF-8 CESoETH is affected by the same BER without any multiplication effect.

3.2.3 Packet Delay Variation control / Fragmentation

Mixing different Packet Based Services over a radio channel introduces a Packet Delay Variation (PDV) that affects TDM/Voice and any other high priority traffic, whatever the queuing mechanism.
Inside 9500 MPR a technique is implemented in order to control PDV affecting Ethernet frames.
Actually this mechanism is available for any kind of traffic (VoIP, TDM, ATM, Ethernet).

Long Ethernet frames are fragmented in fixed small size blocks before being transported into the air, then reassembled at receiver side.
With this technique the waiting time that affects high priority traffic is neither depending on the Ethernet frame length nor on the traffic load.



3.3 Multiservice Ring Protection (ITU-T G.8032v2)

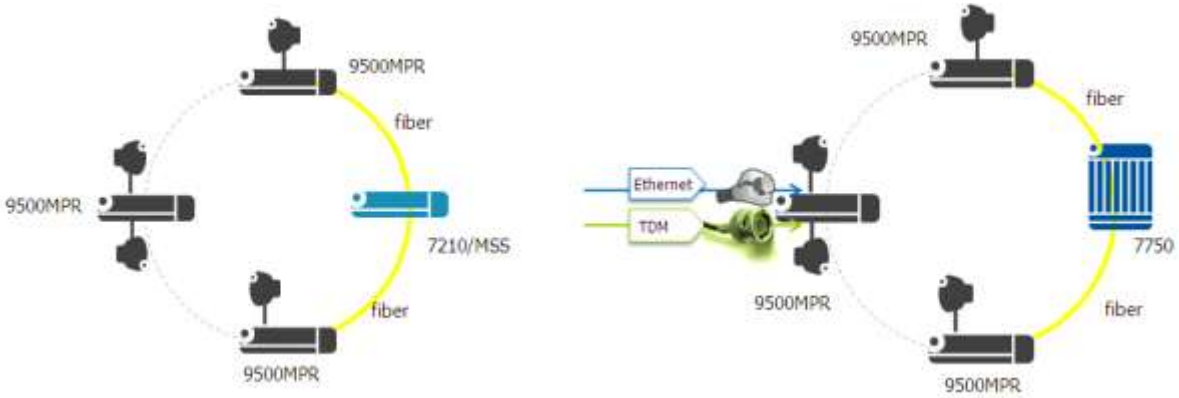
Multiservice Ring Protection is based ITU-T G.8032 ERPS, and providee sub-50ms protection and recovery switching traffic in a ring topology .

Additionally to 8032v2 standard, the Multiservice ring protection implemented in the 9500 MPR offers the capability to protect all type of traffic: Ethernet, TDM E1/DS1 and SDH (planned in a future release)

Each Ethernet Ring Node is connected to adjacent Ethernet Ring Nodes participating in the same Ethernet Ring, using two independent links. A ring link is bounded by two adjacent Ethernet Ring Nodes, and a port for a ring link is called a ring port. The minimum number of Ethernet Ring Nodes in an Ethernet Ring is two.
The fundamentals of this ring protection switching architecture are:
a) The principle of loop avoidance.
b) The utilization of learning, forwarding, and Filtering Database (FDB) mechanisms defined in the Ethernet flow forwarding function (ETH_FF).
Loop avoidance in an Ethernet Ring is achieved by guaranteeing that, at any time, traffic may flow on all but one of the ring links. This particular link is called the Ring Protection Link (RPL), and under normal conditions this ring link is blocked, i.e. not used for service traffic. One designated Ethernet Ring Node, the RPL Owner Node, is responsible for blocking traffic at one end of the RPL. Under an Ethernet ring failure condition, the RPL Owner Node is responsible for unblocking its end of the RPL (unless the RPL has failed) allowing the RPL to be used for traffic. The other Ethernet Ring Node adjacent to the RPL, the RPL Neighbour Node, may also participate in blocking or unblocking its end of the RPL.
The event of an Ethernet Ring failure results in protection switching of the traffic. This is achieved under the control of the ETH_FF functions on all Ethernet Ring Nodes. An APS protocol is used to coordinate the protection actions over the ring.
The ring is implemented by east and west facing radio directions
Traffic can follow on both ring directions: Clockwise direction & Counter-clockwise direction
Protection is triggered by physical criteria (no protocol intervention)

Protection is based on R-APS messages sent on both sides of the ring by the nodes detecting the failure. Traffic is redirected by each node of the ring locally, ensuring parallel processing to speed up protection time.

- G.8032v2 algorithm operates on VLAN, regardless the type of traffic transported: TDM (TDM2TDM and TDM2ETH) and Eth (Multiple CoS and services) traffic types can be protected
- Traffic flows (any type/priority) can be allocated on both ring directions to exploit the maximum ring bandwidth in normal conditions for best effort traffic and to limit packet delay when traffic enters from different points of the ring.
- G.8032v2 is supported on all MSS1/MSS8
- Synchronization is managed through SSM messages.
- Multichannel LAG L1 configuration can be supported inside the ring, with optionally error error free adaptive modulation configured. A LAG L1 link with N channels is declared “faulty” when all the N channels of the link are operationnaly down
- 9500MPR does support ITU-T G.8032v2 in mixed configuration as well, meaning that some links can be microwave and some links can use fiber.
- With corEvo 10G card, the 9500 MPR offers 10G ring capability.(future release)



G.8032 Ring

3.4 Ethernet features

9500 MPR provides several service interfaces and it is also able to provide a wide-assortment of service interfaces by configuring appropriate service interface boards.
Frame size : The LAN interface supports jumbo frames up to 9280 bytes

3.4.1 Level-2 Addressing

The address management function is performed in the switch through the address table (Level-2 Table) that can manage up to 65536 entries in the switch . New entries are automatically learned when packet is received on port.
The aging process periodically removes dynamically learned addresses from the "address resolution table.; default aging time is 300 sec. Aging time might be user configurable.

3.4.2 IEEE 802.3x Flow control

In case of incoming Ethernet traffic leading to exhaustion of buffers on input queues, PAUSE frames are transmitted from the switch to remote peer in order to slow down the traffic (if the peer supports flow control).
In the other direction, when the switch receives a pause frame on a specific port from peer equipment, the switch stops the packet transmission on that port until receives again a pause frame with resume transmission command.
Flow control to be fully effective (no packets lost inside the network) requires that all devices in the end-to-end path support flow control.
The flow control function is supported only when the capability is full duplex.
The flow control setting on the switch ports linked to user Ethernet ports must be consistent with the setting on the user ports.
Flow control is not supported on MPR-e.

3.4.3 VLAN MANAGEMENT

- **Supported services**:
  Ethernet services (EVCs)
  - E-Line (Point-to-Point)
  - E-LAN (Multipoint)

- **Support VLAN** 9500MPR does upport up to 4096 VLANs

- **IEEE 802.1Q**

It allows of partition the switch ports into virtual private domains.
The IEEE 802.1Q tag VLAN feature can be enabled including between the other the stripping or adding of the TAG and VLAN lookups in addition to MAC lookups (this feature between the other can be useful for re-route TMN traffic to the controller).
The IEEE 802.1Q tag VLAN feature can be enabled or disabled (be transparent for the VLAN) including between the other the stripping or adding of the TAG and VLAN lookups in addition to MAC lookups (this feature can be useful to logically break a physical LAN into a few smaller logical LAN and to prevent data to flow between the sub-LAN), dropping NON-VLAN Frames.

- **Stacked VLAN (Q-in-Q): 802.1ad**

The switch supports double tagging according to 802.1ad, in particular:

- adding a service VLAN on the ingress traffic, per port of per service VLAN
- pbits value of service VLAN is a)user configurable b)same value of customer VLAN.

The EtherTypes supported are:
EtherType 0x8100
EtherType 0x9100
EtherType 0x88A8

- **Port based rate limiting**

It is possible, on per port basis, to define an ingress/egress port rate limiting. Per-port ingress rate control is used to meter and limit the rate of data stream input. If the ingress rate exceeds the limit configured, the switch can either transmit flow control or drop the frame. If the egress rate control is enabled, the traffic exceeding the configured threshold is dropped. Granularity is 64 kbit/sec.
Example:
-)it is possible to define an egress rate limiting on user port 1 at 15Mbps
-)it is possible to define an ingress rate limiting on user port 2 at 10Mbps

- **Per flow policer**

Ingress rate limiter per VLAN, dropping the traffic exceeding a given CIR value

- **Per CoS policer**

Ingress rate limiter per Class of service, dropping the traffic exceeding a given CIR value
The rate limiter is applied to a tagged Ethernet flow classified according to the value of VLAN ID and PCP fields of the VLAN Tag. One VLAN ID value and one PCP value identifies the flow.

- **Broadcast storm control**

Ingress rate limiter on broadcast traffic

- **Multicast storm control**

Ingress rate limiter on broadcast frames

- **Destination Lookup Failure (DLF) storm control**

DLF are frames having a unicast destination MAC address, which is not present in any port MAC lookup table. These packets are typically flooded to all switch ports.
The storm control limits the broadcast of such frames.

- **MAC address control list**

Only packet with SA inside a given list are transmitted towards the radio

- **Link Aggregation IEEE 802.1AX**

Link Aggregation allows two or more Ethernet links to be aggregated together to form a Link Aggregation Group (LAG), consisting of N parallel instances of full duplex point-to-point links operating at the same data rate. Link aggregation can be used for two main purposes:

1. Traffic Aggregation, using L2 hashing algorithm and spreading the traffic over multiple interfaces
2. Link Protection, achieved mainly with static LAG, where one link of the group is active and the other(s) is in stand-by condition

Frame distribution. Frame distribution over Ethernet interfaces inside the LAG is based on Ethernet switch hashing function. Two options can be selected for the hashing function:

1. L2 Hash (DMAC, SMAC, VLANID, Ethertype)
2. L3 Hash (IPdst, IPsrc, TCP/UDP dst port, TCP/UDP src port)

Link aggregation protocol. LACP is supported and can be configured in one of two modes: active or passive. In active mode it will always send frames along the configured links. In passive mode however, it acts as "speak when spoken to", and therefore can be used as a way of controlling accidental loops (as long as the other device is in active mode). Following options are

· Disabled, to configure Static Link Aggregation.
· Active :send LACPDUs automatically with the defined periodicity)
· Passive (send LACPDUs only if received by the Link Aggregation Partner).

3.4.4 Quality of Service

QoS management is supported by:
Scheduler queues: 8 queues
Scheduling: Strict priority, WFQ, Combination of Strict priority and WFQ
Frames discard: Tail drop
Buffer Sizes : 32 Mbit per queue, 8x32 Mbit=256 Mbit total

The frame buffer size as a function of the frame size.

- **Priority classification**

The priority to TC queue mapping is based on whether the port is trusted/tagged or not. The following options are supported:
• DSCP value in IP header
• Traffic Class field bits in MPLS header
• Reuse priority bits in C-tag (Q-tag, VLAN) or S-tag.

3.4.5 Ethernet Service OAM - IEEE 802.3ag/Y.1731

Ethernet Service OAM provides network end-to-end Ethernet L2 OAM capabilities. The supported Connectivity Fault Management (CFM) functions are:

- Continuity Check (CC). CC is a proactive OAM used to detect loss of continuity between pair of Maintenance End Points (MEPs). Optionally Port status TLV and Interface status TLV can be used to also supervise the status of the transmitting MEPs interface or switch port.
- Remote Defect Indication (RDI); proactive OAM function used by a MEP to communicate to its peer MEPs that a defect condition has been encountered.

- Loopback (LB) - unicast; on-demand OAM function used to verify connectivity of a MEP with its peer MEP (or a Maintenance Intermediate Point, MIP). A MEP can optionally use Data TLV, e.g. to verify connectivity for jumbo frames.
- Link Trace (LT); on-demand function used for fault localization.

3.4.6 Ethernet Link OAM – IEEE 802.1ah

Ethernet link layer OAM, based on the IEEE 802.3ah specification, enables service providers to monitor and troubleshoot a single Ethernet link.
The following features are supported

- Discovery: Identifies devices in the network and their OAM capabilities. It uses periodic OAM Protocol Data Units (PDUs) to advertise OAM mode, configuration, and capabilities; to advertise PDU configuration; and platform identity.
- Remote Loopback: Puts the remote link partner into loopback mode so that every frame received is transmitted back on the same port. This is used to ensure the quality of links during installation or troubleshooting

3.5 Radio Encryption (AES)

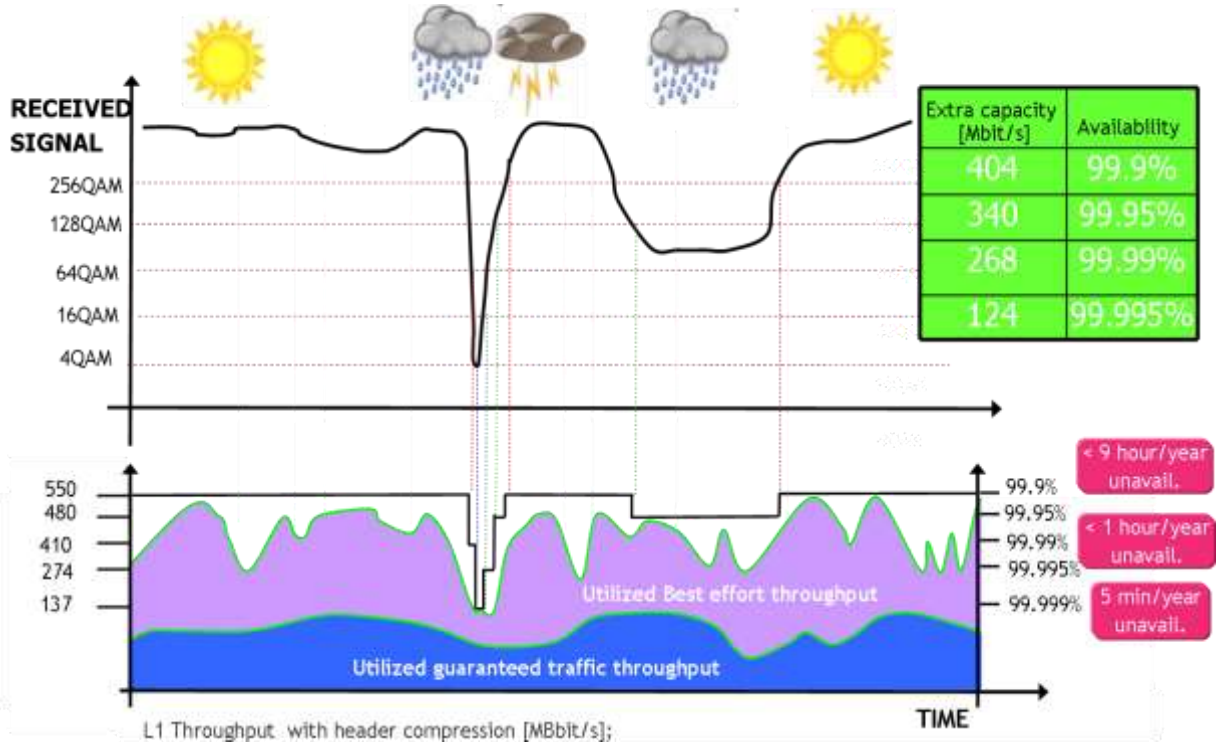
9500 MPR supports 256 Byte AES on the Radio Links, designed to comply with FIPS 197.
Encryption can be supported independently by each Radio direction and each radio direction has a unique AES Key, to be provisioned by the user.
Encryption does not affect the bandwidth transmitted over the radio interface and the ACM, ATPC, QoS and TMN functionalities.
Support for AES is available for the following radios:

- MPT-HCv2 / MPT-HC-HQAM / MPT-XP / MPT-XP-HQAM
- MPT-HLC (cubic)
- MPT-HLS (slim)

AES can be enabled in the following topologies:
MSS 1/8
MPR-e

3.6 ADAPTIVE MODULATION

In order to be able to fulfill the required quality of service (QoS) associated to the specific application, together with the goal of efficient usage of the available frequency spectrum under temporal variable channel conditions, the signal transmission is adapted to the near-instantaneous channel conditions.



3.6.1 Configuration

On the user interface it is possible to select the following parameters:
- modulation schemes in the ACM range (min, max modulations)
- reference modulation

The reference modulation corresponds to the modulation scheme used for identifying the equipment parameters needed for the radio link budget and link coordination, with predefined availability objective.

Minimum modulation scheme can be chosen to be equal but also lower than reference mode, in order to maximize traffic availability for a certain amount of high priority traffic. This is especially useful for LAG configurations, for which excess capacity on one link can compensate degradation of other links (down to minimum modulation scheme). In 1+1 configuration both receivers are measuring the MSE. Both values are reported to the transmitter, which is able to select the best one among the two. This allows the capability to deliver maximum capacity (because maximum possible modulation scheme is chosen) even when one of the two radio hops is degraded. On the user interface it is possible also to

change this strategy, thus forcing the transmitter to select the worst value among the two, switching down modulation scheme as soon as one receiver degrades. This is a conservative configuration which favour high priority traffic availability with respect to higher capacity.

3.6.2 Performances

9500 MPR allows to fully exploit the air bandwidth by changing modulation scheme according to the propagation availability, associating the available transported capacity to the different service quality. In fact the integrated QoS algorithm (with Strict Priority or DWRR scheduler) efficiently distributes input traffic adapting instantaneously to the radio channel conditions.

The ACM modulation switches are "error-less", which means that high priority traffic (PDH, SDH or Ethernet) fitting the capacity associated to the new modulation scheme is transported without errors. This implies that for this kind of traffic the availability is guaranteed for a higher percentage of time, according to predefined SLA (Service Level Agreement).

Instead lower priority traffic is carried with less availability, according to the link propagation performances with respect to QoS parameters.

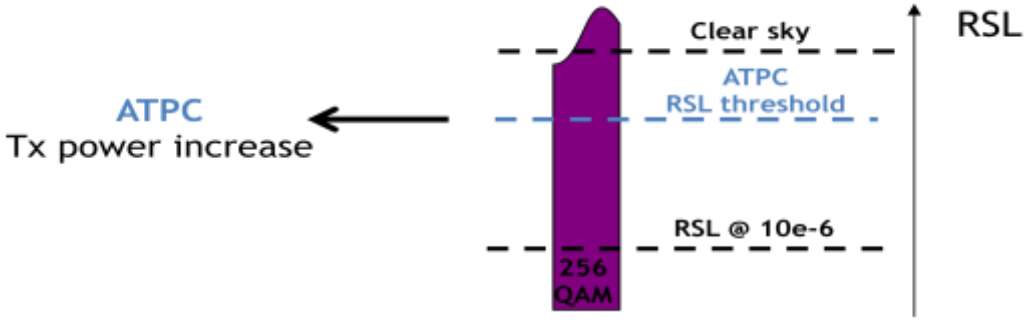
The supported flat fading speed without errors on priority traffic is 100 dB/s.

The adaptive modulation algorithm is fully compatible with the contemporary enabling of XPIC and/or ATPC (see “ATPC” chapter for details on ATPC+ACM). Another powerful capability of 9500 MPR, available for any radio, is to be able to automatically adapt transmitted power to the modulation scheme. Generally higher modulation schemes support lower output power, due to reduced backoff. MPR ACM algorithm is not penalizing lower modulation schemes for this reason, on the contrary is able to increase the Tx power while decreasing modulation scheme, adapting automatically while switching down the modulation scheme. This allows to guarantee maximum system gain (thus availability) when link fading increases.

3.7 ATPC

ATPC is a closed loop algorithm which regulates local transmitted power according to the remote receiver signal level (RSL), obtained through the radio link.
ATPC main objective is to reach a desired RSL value, allowing to keep Tx power as low as possible when field conditions are favourable and increasing Tx power only when needed to compensate for link fading. This enables an easier coordination and frequency reuse during network design phase, thanks to interference mitigation.

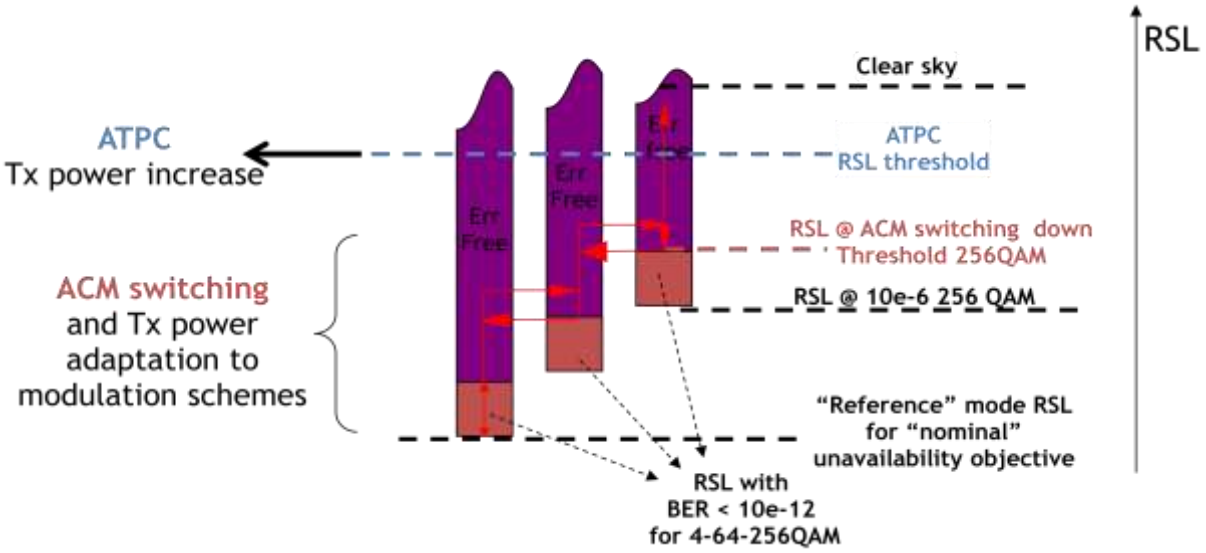
In case of link fading, Tx power starts to increase when "ATPC threshold" is crossed. Here is an example for RSL graph with fixed modulation (FCM):



To summarize, main benefits of ATPC usage are:
better re-use of radio channels in a network, enhancing network density
interference minimization, also as mitigation factor for sharing with other services
to increase system gain as a countermeasure against rainfall attenuation

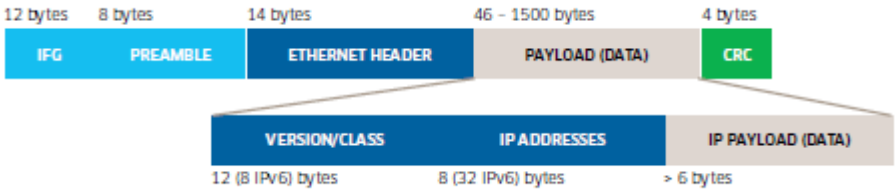
3.7.1 ATPC and ACM

ATPC and adaptive modulation can work together, efficiently regulating Tx power and transmitted modulation scheme at the same time in order to reach any possible advantage available from these features, mainly interference mitigation and guarantee for traffic availability/QoS at the same time.
In fact the two algorithms work on two different RSL ranges: first ATPC compensates for link fading through power increase, then Adaptive modulation (when max power is reached) reduces available capacity maximizing availability of high priority traffic.
Here is an example for RSL graph with adaptive modulation (ACM):


RSL
Clear sky
ATPC
Tx power increase
ATPC
RSL threshold
Err Free
Err Free
Err Free
RSL @ ACM switching down
Threshold 256QAM
RSL @ 10e-6 256 QAM
ACM switching
and Tx power
adaptation to
modulation schemes
"Reference" mode RSL
for "nominal"
unavailability objective
RSL with
BER < 10e-12
for 4-64-256QAM

3.8 Throughput Packet Booster

The fundamental objective behind the Alcatel-Lucent packet throughput boost feature on the 9500 MPR is to maximize the amount of traffic payload that traverses a link. This action is done by reducing the proportion of overhead required to transmit the payload. As most microwave links are point-to-point in nature and are not shared resources, there is significant opportunity to reduce unnecessary overhead. If we examine the content of a data packet, as shown in figure below, it is sometimes surprising to see the amount of overhead when compared to the actual user traffic contained in the IP payload field. The overhead fields are needed for routing, collision, and flow identification in complex topology LAN/WAN networks. But in a point-to-point radio link with full-duplex transmission where the medium is not shared by simultaneous users, overhead can be drastically reduced to improve and increase overall throughput over the air.



Significant benefits can be gained by reducing packet overhead, especially when small packets are considered. Let's take a look at each of the header fields in the basic Ethernet frame .The first two fields, Interframe Gap (IFG) and preamble, are not transmitted over the air and therefore not needed in a microwave transmission, so automatically 20 bytes can be entirely eliminated per Ethernet frame

• Interframe Gap (12 bytes). Ethernet devices must allow a minimum idle period between transmissions of Ethernet frames known as the Interframe Gap. IFG was introduced by IEEE 802.3 to avoid collision over a shared medium, such as the LAN.

• Preamble and Start of Frame Delimiter (8 bytes). These fields were added to the IEEE 802.3 standard to allow devices on the network to easily detect a new incoming frame. The remaining fields that are subject to compression but not automatically eliminated are:

• Ethernet header (14 bytes). This is the information used to switch an Ethernet frame across a network segment:

Destination addresses (6 bytes)

Source addresses (6 bytes)

802.1Q tag (4 bytes): Optional virtual LAN (VLAN) tag

EtherType/length (2 bytes); EtherType is a two-octet field in an Ethernet frame. It is used to indicate which protocol is encapsulated in the payload of an Ethernet frame.

• Payload (46-1500 bytes): Contains user data and/or IP/Multi-Protocol Label Switching (MPLS) frames

IFG and preamble suppression operates automatically even if throughput packet booster is not enabled

Throughput packet booster identifies traffic flows and replaces the header fields with a "flow ID". This is done using an algorithm that learns unique flows and that in RX side is rebuilding the original packet header.

As summary, with the Alcatel-Lucent packet throughput boost feature, operators can transport up to 1 Gb/s of traffic on a single channel. Under the most favorable conditions, the gain achieved by the 9500 MPR exceeds 300 percent.

Throughput packet booster can be activated in presence of full Ethernet traffic or even in the case of mixed /E1/SDH/Ethernet traffic.

3.8.1 Throughput packet booster counters

9500 MPR provides counters when Packet Throughput Booster is enabled. This information can be used by operators to monitor network usage and capacity and to monitor the effectiveness of packet throughput booster algorithm

3.9 Multichannel

In previous chapter we have described techniques such as packet throughput booster aimed to increase channel capacity. However, at a certain point, the only way to get more microwave link bandwidth is to increase the number of radio channels used.
Modern methods that combine 2 or more microwave channels to create a higher capacity virtual link have several names, including channel bonding, radio link aggregation (LAG) and multichannel. Although all methods use multiple channels to scale microwave capacity, implementations and efficiency levels can differ. Here we are describing the multichannel packet microwave system as implemented on 9500 MPR . In particular we would like to show the advantage of this implementation on a real packet radio respect to a hybrid approach; in fact these systems offer a new way to bond microwave channels together in order to create higher capacity and more reliable microwave links.

Multichannel are designed to work with features such as:

- High-order adaptive modulation (AM)
- Carrying legacy time division multiplexing (TDM) services as packet traffic together with IP traffic

Multichannel systems give network operators new flexibility when it comes to designing microwave links and new ways to increase microwave capacity and availability:

- A multichannel approach creates a virtual link from 2 or more underlying channels. The resulting capacity is the sum of every channel's capacity.
- The individual channels in the multichannel bundle can have different profiles for frequency bands, modulation levels and capacities.
- Adaptive modulation can be enabled across all channels in the multichannel bundle. This creates room to increase capacity and service availability according to network design parameters.
- Because modern packet microwave systems packetize legacy TDM traffic, legacy and new IP traffic can use a multichannel virtual link as a whole.
- The rigid association between the capacity a service requires and the capacity a radio channel offers is removed. For example, a packetized synchronous digital hierarchy STM-1/OC-3 circuit can be spread across the channels in a multichannel bundle whose total capacity matches the capacity required.

Microwave link protection can move from a traditional N+1 spare channel approach to a more effective multichannel N+0 approach. An N+0 approach uses the entire virtual link capacity to increase availability.

In contrast, standard LAG techniques suffer from limitations when used in microwave environments:

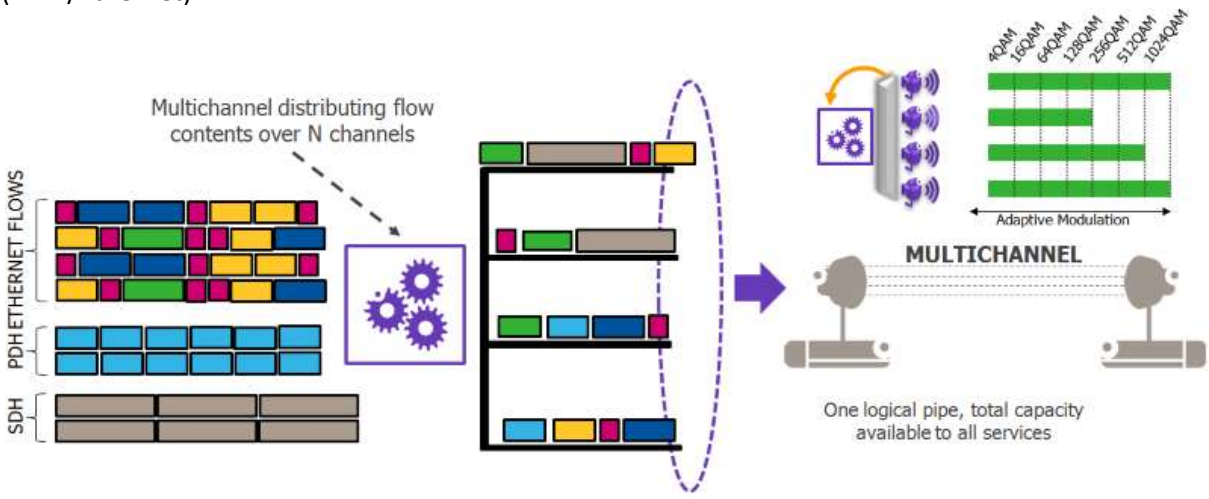
- There is a rigid association between a flow and a specific channel in a virtual link. This is because standard LAG hashing algorithms use IP or Ethernet header fields to consistently map a flow to a channel. If these fields do not vary much in value, some channels in a virtual link can become congested while others are only lightly used. Low utilization is a particular challenge when packets are encapsulated in IPsec. In these cases, there is not enough variety in the fields used for hashing algorithms to optimally spread the load across a bundle of channels. As a result, the same channels in the bundle are always selected, leaving the other channels underutilized.
- Every channel in a virtual link must support the same capacity. In microwave networks, this is seldom possible due to the effects of adaptive modulation on individual channels.

These limitations mean that channel capacity must be equal to, or greater than, the highest flow bandwidth. This constrains link dimensioning because radio capacities are typically not correlated with IP service flow capacities. As a result, in some network environments — LTE backhaul networks, for example — channel bundles are underused.
Multichannel radio LAG eliminates these issues because it:

- Distributes traffic load evenly based on algorithms that do not leave channels underutilized or impact services, even in the event of a channel failure
- Does not require each channel in a bundle to have the same capacity as the most demanding service

9500 MPR multichannel has a unique algorithm which outstands Native TDM or Hybrid technology provided by Alcatel-Lucent MW competitors in long haul. These legacy technologies supported by competitors statically allocate radio capacity per service type (TDM or Ethernet) leading to poor capacity repartition per services and possible waste of throughput. In fact, radio time-slot division implies a fixed granularity while distribute capacity to multiple services.

Instead, 9500 MPR fairly shares the entire radio available capacity of the aggregated channels on a byte per byte basis to all incoming services regardless their nature (TDM/Ethernet).



Service load balancing is so effective that L1 LAG reaches 99.9% of efficiency regardless packet size or TDM circuits bitrate (STM1/OC3 or E1/DS1).

The multichannel engine is aware of traffic flow quality of service (QoS) requirements to ensure that service level agreements (SLAs) are maintained. When multichannel link capacity varies, the multichannel engine uses the real-time status of the entire virtual link to adjust traffic distribution across the channel bundle and improve spectral efficiency.

Spare capacity, not spare protection

Unlike traditional N+1 techniques to scale microwave link capacity, multichannel systems do not require spare protection channels to protect link capacity. Instead, multichannel systems use the concept of spare capacity across a bundle of active channels.

When adaptive modulation is used, a channel does not have to be in an 'on' or an 'off' state; it can be in a partially working state, although at a reduced capacity. In the rare case where the capacity available in the multichannel bundle is lower than requested, high-priority committed traffic is preserved and only best-effort traffic is discarded.

From a network design standpoint, the probability of delivering the committed traffic is very high. That's because the degradation on one channel can be compensated for with the excess capacity available on other channels in the bundle.

On ALU implementation the adaptive modulation changes and the reallocation of traffic from one channel to the other is completely hitless on high priority traffic.

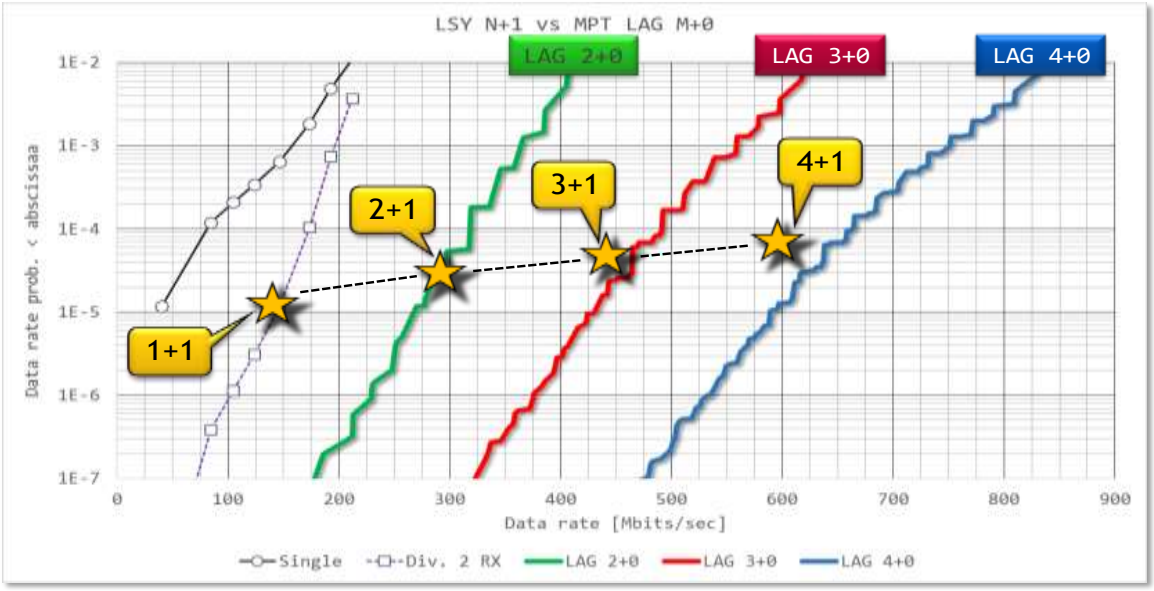
Traditional N+1 link protection mechanisms do not support the spare capacity concept when scaling and protecting microwave links. If channel capacity drops, all traffic is moved to a dedicated protection channel, stranding any remaining capacity on the degraded channel.

Increase microwave capacity and availability

There are 2 ways to take advantage of the benefits that multichannel provides:

- Increase availability and maintain the same capacity as a traditional microwave system
- Increase capacity and maintain the same availability as a traditional microwave system

Figure 2 shows a comparison between multichannel in 9500 MPR and performances of the previous legacy ALU platform where protection is based on a traditional N+1 mechanism.



Source: Alcatel-Lucent analysis

The behavior of a multichannel system is represented by a curve that is associated with the entire set of channel capacity and availability levels. It is not represented by a pre-defined single point as is the case with a traditional N+1 system. Availability in a multichannel system is strongly increased when compared to the capacity of an N+1 system with same number of channels.
If the goal is to maintain the same availability value, the multichannel system offers at least 25% more capacity than a 3+1 system, with the same number of channels used. This extra capacity can potentially lead to link redesign to reduce antenna size requirements, which can further minimize network total cost of ownership (TCO).
Multichannel benefits in case of SDH traffic vs hybrid solution
In 9500 MPR platform TDM and SDH traffic is carried packetized but performances are exactly the same as a native legacy microwave thanks to some proprietary mechanism that allow the radio to be aware about the services carried.
This solution is offering to customer the possibility to have a smooth migration from legacy services to Ethernet or IP without the need of changing the infrastructure when changes are needed.

Basically the main advantages on ALU solution respect to an hybrid approach can be summarize as follow:

- No need of dedicated channel carrying SDH and other carrying packet traffic
- Better efficiency on the usage of all RF resources: all the capacity over the multiple radio can be shared between the different services without need of correspondence between flow and channel.
- All modulations scheme can be used up to 1024 QAM and the hitless mechanism of adaptive modulation is allowing to carry traffic according the correct priority.

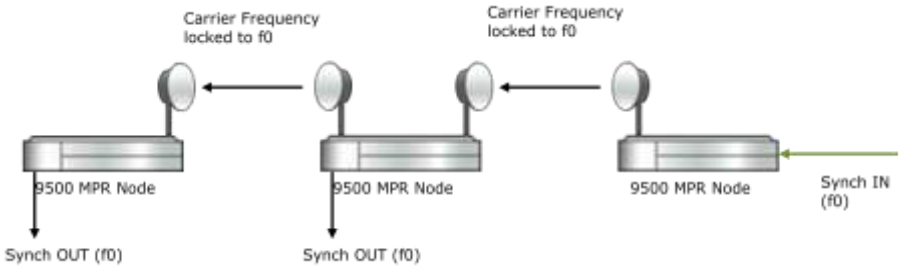
- As all the services can be part of multichannel, the benefits described above are realized also when traditional TDM applications are carried. As already mentioned SDH traffic will have a better availability versus propagation issues. Let's consider the case of 2 RF channels: thanks to multichannel the STM-1 flow can be carried without any error also if fading is not allowing both channels to stay at high modulation scheme (128 QAM). The traffic can be carried by 2 channels at 32 QAM.

3.10 Synchronization

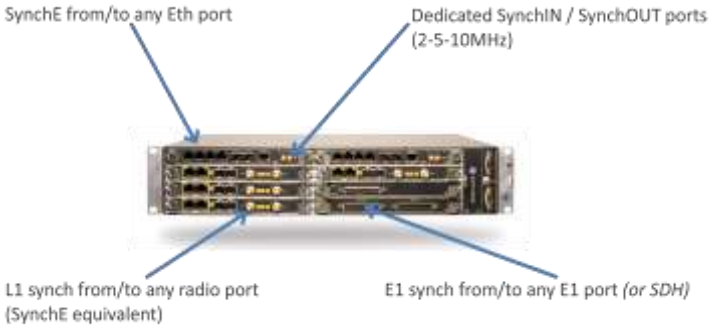
Synchronisation distribution is very often needed in transmission networks. The specific customer need depends on the final application, e.g. in the case of mobile backhauling networks 'frequency' or 'frequency and phase/ToD' synch distribution might be required depending on the RAN technology (e.g. LTE, 3G, 2G, ...). As a matter of facts multiple interfaces and multiple flavours of synch signals must be taken into account in a transmission network.

9500 MPR is fitting synchronisation requirements of any aggregation network (legacy SDH/PDH, Carrier Ethernet, MPLS) and of any base station technology (LTE, 3G, 2G, ...) thanks to the following feature set:

- 9500 MPR has been designed to be a synchronous node where synch signals are exchanged among nodes through the microwave carrier. Synchronization at physical level is a key point in achieving immunity against PDV and/or congestion.

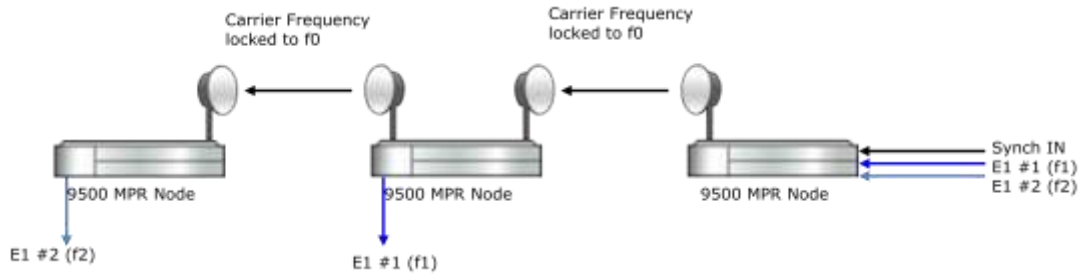


- 9500 MPR has the capability to take any synch input (E1, 2 MHz, 10 MHz, SDH, Synchronous Ethernet, …) and to deliver any synch out independently.



- 9500 MPR Ethernet ports support Synchronous Ethernet (SynchE), a mechanism to transfer frequency over the Ethernet physical layer as specified by G.8261. As SynchE uses the physical layer, it is immune to traffic load and packet delay variation. SSM according to G.8264 is supported.

- Synch distribution via E1s is possible and multiple synchronization domains are supported thanks to differential clock recovery.



- 1588v2 applications:
  - 9500 MPR implements a fragmentation method to support frequency and phase/ToD synch distribution via 1588.
    Mixing different Packet Based Services over a radio channel introduces a Packet Delay Variation (PDV) that affects any low/high priority traffic, whatever the Queuing Mechanism. High Priority Packets transporting Voice, Real time traffic, synch info are interleaved with Ethernet packets bringing Native Data.
    Without fragmentation, if low priority long frames data are present, real time traffic has to "wait" in the schedulers, as long as the length of the data packet.
    With 9500 MPR fragmentation low priority frames are fragmented into fixed small size blocks and scheduled in different priority queues before being transported into the air. In this way high priority 1588 packets are practically not affected by the PDV potentially introduced by long low priority Ethernet frames
  - Transparent Clock (TC) on-path support is supported on 9500 MPR Core10G board: the synch packets correction field is updated with the transit time, so the PDV normally caused by internal queues is removed.
  - 9500 MPR LAG L1 algorithms are 1588v2 aware: 1588v2 packets are recognised and given a preferred path in the LAG L1 packet distribution/rebuilding mechanisms.

4 SYSTEM ARCHITECTURE

4.1 9500 MPR platform

9500 MPR is very comprehensive and flexible platform applicable to all radio configuration keeping the same HW variant in all cases.

9500 MPR is composed by 2 main building blocks:

- **MSS**: indoor unit including all user interfaces, switching capability, multichannel functionalities and radio protection.

- **MPT:** transceiver part including radio and modem . This unit can be installed in indoor (MPT-HL) or in outdoor and can work connected to MSS or in stand alone mode. This change is only requiring a sw configuration.

9500 MPR is able to support the following configurations:

- **Split mount Indoor/Outdoor (IDU/ODU)**: the functions are split into IDU and ODU units; more configurations can be obtained configuring the equipment in a suitable way:
  - Terminal Configuration
  - Repeater Configuration
  - Node Configuration

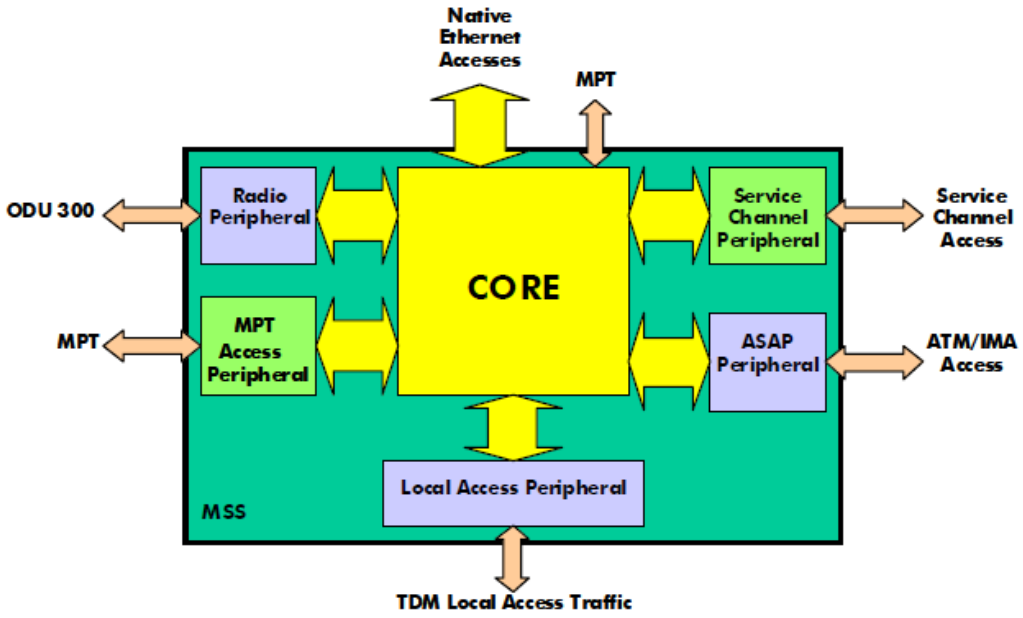
- **Full Outdoor (MPT)**: all the functions are in the outside unit next the antenna; two different configurations are supported:
  - MPT in 1+0 and 2x(1+0) XPIC
  - MPT Repeater

- **Full Indoor (IDU)**: this is not a radio configuration. The radio interface is changed into a gigabit Ethernet lineside interface. It allows aggregation of different type of line-side traffic into a gigabit Ethernet line side traffic; onlyone configuration is forecasted: Stand alone IDU.

4.1.1 MSS architecture

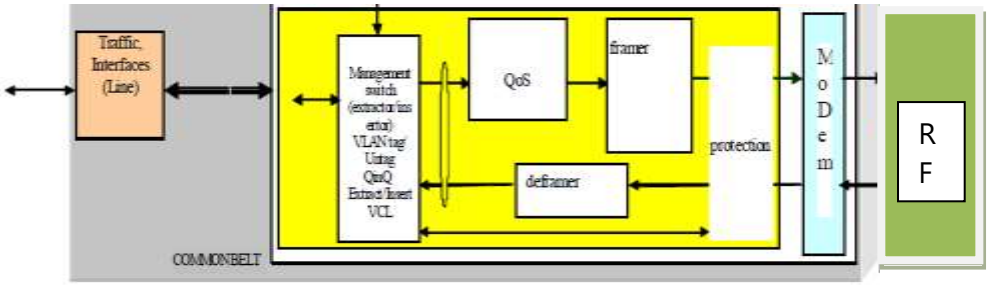
In the attached drawing it is reported the MSS diagram; IDU is able to manage multiple peripherals of different type (for example: local access TDM, Ethernet, radio interfaces towards MPTs) and to connect each of them to a Core. Up to six peripherals are supported in case of MSS-8.

The number and the type of peripherals can change according to the customer configuration.



4.1.1 MPT architecture

MPT scheme is reported in following diagram.



MPT can be connected to dedicated plug in (EASv2 or MPT access plug in) or directly to core card using optical or electrical GEthernet cables according to specific kind of MPTs as described in next paragraphs.

5 MSS-1/8

5.1 MSS

MSS implements functionalities of grooming, routing, switching and protection, exploiting a packet-oriented technology.

The MSS is available in four different versions:

- **MSS-8** 2RU shelf to support up to 24 unprotected links, or up to 12 protected links, or a mix of them.

MSS-8

MSS-8 slots are reserved this way:

- Slot 1 is dedicated to the Core Main Board
- Slot 2 is dedicated to the Core Spare Board or to DC injector card
- Slots 3-8 are universal and can be used for transport and radio plug-ins

Slot 1	Slot 2	Fan
Slot 3	Slot 4	
Slot 5	Slot 6	
Slot 7	Slot 8	

MSS-8 slot scheme

MSS-8 supports a double battery input.

- **MSS-1** ½ RU shelf to support up to 6 unprotected links , or up 3 protected 1+1 links, or a mix of them.

MSS-1

MSS-1 is a compact system, offering E1/DS1 , Ethernet connectivity

The interfaces currently available are:

- 16 ports E1/DS1
- 6 GETH ports, electrical and (2) optical
- 1 port for local craft terminal
- 1 port for housekeeping
- 2 PFoE (power feed other Ethernet) ports for MPT connection

Fan unit is not needed for MSS-1, that is able to operate in the wide range -40°C up to +65 °C.

MSS-1 supports a double battery input.

- **MSS-1c:** 1RU and ½ a rack width shelf to support up to 2 MPT

MSS-1c

9500 MPR MSS-1c is a compact system, offering E1/DS1 , Ethernet connectivity and up to 2 radio directions on a single hardware

The interfaces currently available are:

- 16 ports E1/DS1
- 4 GETH ports, electrical and optical
- 2 ports for NMS chaining
- 1 port for local craft terminal
- 1 PoE(power feed other Ethernet) ports for MPT connection
- 2 optical Gb Ethernet for MPT connection

Fan unit is optional and external to MSS-1c, requested for usage from 50°C to reach 65°C external temperature.

- **MSS-O** : an outdoor power injector and switch

MSS-O

MSS-O is a compact system, part of the MSS-x family, allowing networking and power injector functionalities. Optimised for outdoor usage, it can be also installed in an indoor environment.
It provides 4 user ports:

- 3 x 10/100/1000 Electrical - out of them: 2 with PoE capabilities to deliver data and power on a single cable
- 1 x 1000 SFP Optical

Each user port can be used to connect to:

- small cells, or metro/macro cells: to provide Eth data connectivity
- MPTs: in this case the MSS-O plus the MPTs behave as a standard 9500MPR split mount system
- third party ODUs.

Additional connectivity is assured by a RJ45 connector, supporting a 10/100 management interface for local TMN / debug.

5.2 Core Board

The Core Board provides the key node management, control functions and Ethernet User traffic management by performing the following macro functions:

- MSS Controller to manage all the peripheral modules. MSS has a one layer control architecture implemented by a microprocessor acting as Equipment Controller and Physical Machine Controller.
- Layer-2 Ethernet Switch performing Cross-Connect function between all the peripherals and Ethernet ports. The switch assures to the system a complete interconnections between all the boards connected into MSS node.
- Clock Reference Unit (CRU) with main function to generate the Network Element Clock.
- Ethernet interfaces can be optionally used or as user interfaces or to connect up to 6 MPT (Outdoor unit)

5.2.1 **Core-E**

The Frontal panel interfaces provide:

- 3 x 10/100/1000 Base – T Data Port
- 1 x 10/100/1000 Base – T configurable Data/NMS Port
- 2 x SFP ports (Optical or Electrical GETH)
- 1 x 10/100 Base-T LAN for 9500 MPR Craft Terminal or NMS
- 1 x Local CT Mini USB to upload Pre-Provisioning File (unused)
- 1 x Sync CK input via 1.0-2.3 coaxial connector that can be used as source for the Network Element clock
- 1 x Sync CK output via 1.0-2.3 coaxial connector that provides the NE Clock
- 5 LED indicators for test and status

Core Board Frontal Panel

The core board could be protected through a Core "Spare" (same PN of Core "Main") that can be added to provide Control platform redundancy and protection of aggregated data using an external switch.

5.2.2 CorEvo-10G board

The CorEvo-10G board provides node management, cross-connection between MSS plugins and Ethernet ports at 10 Gbit/sec.The CorEvo-10G board embeds a microSD Card, which among other things stores the terminal SW Configuration and the Node License.

CorEvo-10G Board

The Frontal panel interfaces provide:

- 4 x RJ45 10/100/1000 BaseT electrical ports
- 2 x SFP+ 1/10Gbps optical ports (electrical SFP 1Gbps can also be used)
- 2 x SFP electrical/optical GE ports
- 1 x RJ45 10/100 BaseT for TMN
- reset button and status/activity LEDs

CorEvo-10G provides HW support for 10Gbps user interfaces, 10Gbps ring, 1588v2 on path support and enhanced Ethernet features –pls see 9500MPR roadmap for availability.

5.2.3 CorEvo-1G

CorEvo-1G board is a cost optimised version of CorEvo-10G.

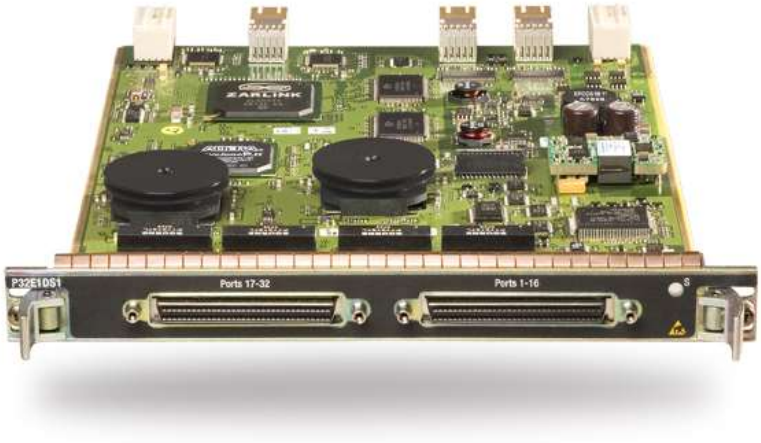
Feature level is the same apart from the 2xSFP+ ports that here are only 1Gbps capable.

5.3 PDH Access Board

The PDH Access Board has the aim to manage the specificities of the related external interface, to implement the adaptation function between the external interface and the boundary internal interface providing the consistency to the established SLA rules.

The PDH Access Board has two main functions:

- Termination or reconstruction of the E1 signal with the original PDH Timing meeting G823/824 Requirements.
- Encapsulation/Extraction of those PDH data flows into/from std Eth packets MEF8 Compliant



PDH Access Board

The Front Panel Interfaces include:

- 32xE1
- One Led indicator for status

In case of EPS line protection two boards will be plugged inside the sub rack and an additional protection panel will perform a 'Y' connection for both Tx and Rx PDH signals.
The card version is 32-port adapter.

5.4 EASv2

EASv2 is a high connectivity board supporting Ethernet access and several radio configurations:

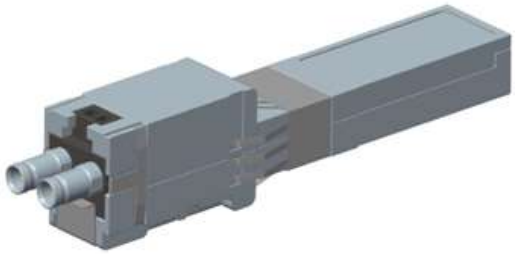
- 1+0 – applicable to MPT-xC, -HL Slim/Cubic
- 1+1 cross-EAS – applicable to MPT-HC optical, HL Slim/Cubic
- LAG L1 N+0 cross-EAS and intra EAS (N up to 8) – applicable to MPT-xC, HL Slim/Cubic
- LAG L1 N+N cross EAS (N up to 4) – applicable to MPT-HC optical, HLv2 Cubic
- Ring of LAG L1 – applicable to MPT HL Slim/Cubic (

Other features:

- Electrical ports with/without PfoE.
- Synchronous Eth on user ports (SynchE SFP, SynchE RJ45)
- SSM

5.5 SFP Synch IN/OUT

MSS can deliver or receive frequency synchronisation to/from an external device –like a BTS- via a dedicated SFP. This dedicated SFP can be plugged into CorEvo and MSS-1 standard SFP ports.
Electrical format can be 2.048MHz G.703 or 5/10MHz sine wave via two 1.0/2.3 coaxial connectors.



SFP Synch IN/OUT

5.6 2E1 SFP

In order to target applications where a few number of E1s are needed, a miniature E1 over GE converter is available. 2E1 SFP is SFP device that provides two G. 703 E1 interfaces, supporting the same functionalities of 32E1 PDH card. In addition, this device is able to generate a “dummy framed” E1 in order to provide synchronization to an external equipment (like a BTS).
This device can be used instead of 32E1 PDH card when the requested E1 connectivity is limited, saving in this way one slot in MSS8 that can be used by other cards.

2E1 SFP

2xE1 SFP can be plugged in one of the two SFP ports of Core card, providing two G. 703 E1 interfaces (up to 4xE1 in case Core Card hosts 2 SFP). EPS protection is available in case Core Card is protected: the secondary SFP is hosted by the stand-by Core, and a Y cable is provided to connect the 2 SFP.

5.6 SDH Access Card

9500MPR SDH Access card is the board that enables 9500 MPR to be connected to a SDH network.

The same board can be used in two different working modes, addressing two different network scenarios:

- STM-1 mux/demux
- STM-1 transparent transport over the radio

SDH Access Board

5.6.1 STM-1 mux/demux application

The STM-1 mux/demux behaves as a terminal multiplexer; it terminates or originates the SDH frame. It multiplexes up to 63xE1 into a STM-1 electrical/ optical line connection. Standard VC4 mapping of lower-order E1 traffic streams to/from STM-1 is applied, that means that a VC4 directly maps up to 63xVC12 into an STM-1 signal (in turn each VC12 contains 1xE1)

Typical application is a direct connection to SDH add-drop multiplexers (ADMs)

5.6.2 STM-1 transparent transport application

In this application the board has the aim to manage the specificities of the related external interface and to implement the adaptation function between the external interface and the boundary internal interface. Up to 2xSTM-1/OC-3 are transparently transported through a single radio link.

The card supports 1xSTM-1 in channelized mode or up to 2xSTM-1 interfaces in transparent transport mode (2 optical interfaces or 1 electrical interface)

The Front Panel Interfaces include:

- 2x SFP (optical LC connector or electrical 1.0/2.3 connector)
- One Led indicator for status

In case of EPS line protection two boards are plugged inside the sub rack. Optional splitter Y-cables are provided for both Tx and Rx SDH signals.

5.7 EoSDH SFP

Ethernet over SDH (EoSDH) SFP is miniature Gigabit Ethernet over STM-1/OC3 converter that bridges between GE networks and SDH networks providing simple and efficient Gigabit Ethernet connectivity over SDH.
The device offers a migration path for connecting future-ready IP devices to existing SDH/SONET networks

EoSDH SFP

EoS SFP supports the following basic features:

- Delivers Gigabit Ethernet traffic over a single STM-1/OC-3 link
- Supports standard GFP encapsulation according to G.7041/Y.1303: Gigabit Ethernet frames are mapped into VC-4 or STSc-3

Physical interface is 1xSTM-1 optical in a SFP cage with LC connector.

EoSDH SFP can be plugged in one of the two SFP ports of Core card (up to 2xSTM-1 in case Core Card hosts 2 SFP). EPS protection is available in case Core Card is protected: the secondary SFP is hosted by the stand-by Core, and an optical splitter is provided to connect the 2 SFP.

5.8 E3 SFP

E3 SFP is a TDM Pseudo wire access gateway extending TDM-based services over packet-switched networks.

E3 SFP

The device converts the data stream from its user E3 interface into packets for transmission over 9500 MPR network; the addressing scheme is MEF8. These packets are transmitted via the SFP port of the Core Board; a remote E3 SFP converts the packets back to TDM traffic.

Physical interface is 1xE3 electrical in a SFP cage with 1.0x2.3 connector.
E3 SFP can be plugged in one of the two SFP ports of Core card (up to 2xE3 in case Core Card hosts 2 SFP.
EPS protection is available in case Core Card is protected: the secondary SFP is hosted by the stand-by Core, and a Y cable is provided to connect the 2 SFP.

5.9 MPT Access Card

The MPT Access Card is dedicated to connect the MPT to MSS,.

Up to two MPT can be connected to the MPT Access Card

Main physical characteristics:

- 2 x 10/100/1000 Base – T Port for electrical data to/from MPT. These ports can also power the MPT through the same CAT5 cable.
- 2 x SFP Optical GETH for optical data connectivity to/from MPT
- Double 50Ω QMA Connectors as an option for MPT Power feeding in case of optical connectivity

MPT Access Card

Main Functions:

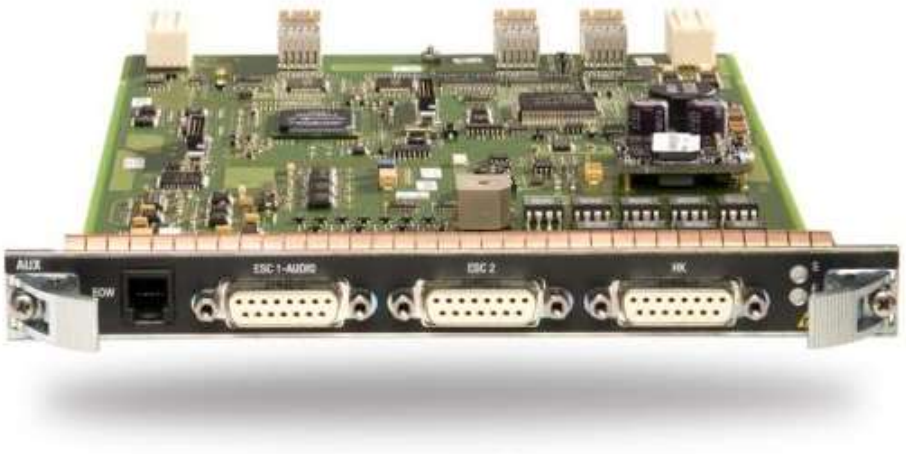
- Provide traffic interface between Core switch and MPT
- Provide the power supply interface to the MPT
- Lightning and surge protection for both electrical GETH and power interfaces that are connected to MPT
- MPT 1+1 protection management
- Clock distribution function
- Radio Link Quality notification through MPR Protection Protocol frames
- Communication with Core controller for provisioning and status report.

5.10 AUX board

Service channels accesses and housekeeping alarm are supported by auxiliary peripheral.

Auxiliary cards support two main functions:

- Auxiliary data channels management (2 x 64 Kbit/s service channels) – available with ODU300 only
- External I/O management



AUX Board

Auxiliary board front panel is equipped with four connectors:

- EOW connector
- Service channel interface #1 (RS422 V11 DCE 64 kbit/s)
- Service channel interface #2 (RS422 V11 DCE 64 kbit/s)
- Housekeeping interface (6 inputs + 7 outputs. The polarity of each alarm is user configurable and a user defined label could be added per each alarm)

Only one auxiliary card per NE can be equipped, and in a fixed position: it can be lodged in slot 8 (bottom right) of MSS-8 .

5.11 Fan Boards

MSS-8 must be always equipped with a fan card; two versions are available: ‘Fan2U’ and ‘Fan Alarm Enh’. The Fan2U has three long-life axial fans, which are controlled and performance-monitored by the controller.

Fan2U Board

To have high reliability 3 fans are used with separate alarms in order to understand the urgency (two or three fans failed) or the not urgency condition (one fan failed).
The Unit is inserted from front side to avoid payload interruptions in case of fan maintenance. The Fan2U board is hot swappable and in-service replacement doesn't affect traffic.

The Fan Alarm Evo card can be plugged into the MSS-8 shelf and is the default choice in case of CorEvo. It hosts 6 long-life axial fans, which are controlled and performance-monitored by the controller. A Sub-D 15 poles connector provides 8 housekeeping IN and 3 housekeeping OUT signals.
6 leds provide equipment alarms and battery/fan module status.
This board is mandatory when +24V DC converter is equipped.

'Fan Alarm Evo' board

5.12 +24V integrated DC/DC converter

An optional +24V DC/DC converter is available for MSS-8 shelf

One or two converters are able to slide on the MSS chassis, side by side, in a single card slot. Unprotected converter kit will be used in configurations where single, non –redundant “A” battery feed is used. Protected converter kit will be used when dual, redundant, “A” and “B” battery feeds are used. In either configurations, the +24VDC to -48VDC converter kits use a single vacant slot of the MSS chassis.

There is no interconnection between the converter(s) and the MSS backplane. Both the +24 VDC input and -48 VDC output are available via 2 position connectors on the front of the unit.

The converter(s) will receive its input(s) from +24 VDC primary power feed(s) and the -48 VDC output(s) will be connected to the MSS -48 VDC inputs located on the right side of the MSS chassis via a short external power cable, providing -48 VDC to the MSS, in the same way the shelf is powered when -48 VDC primary is used as oppose to +24 VDC.

+24V DC/DC converter can power any module in the shelf (and of course related ODU connected to the module) up to a total power consumption of 348 watts.

When + 24V DC/DC converter is used, the ‘Fan Alarm Enh‘ board must be equipped in the rack.

6 MPT

All 9500 MPR radio independently from the application are based on the same architecture called MPT.
In this model MPT contains not only the transceiver part but also the modem board.

MPT Unit is performing the following main five functionalities:

- Data interfaces and RPS protection

- Framing, QoS and modem functions with an integrated microprocessors capable to manage the antenna pointing and local management signal

- RF and IF functionalities

- Separation of radio TX and RX signal with diplexing functionalities. The diplexer is internal or external depending on the frequency : see 6.4 for further informations on diplexer.

- Remote-CPU function, able to control the switch on the MSS-1c access board.

There are four different MPT options :

- MPT-XP-HQAM
- MPT-HC-HQAM
- MPT-MC
- MPT-HL

The four variants are using a common architecture but they have different carachteristics linked to different application. They can work in three modes :

- in split mount : connected to MSS1/8 and MSS-1c,

- or stand alone mode, called MPR-e,

- or integrated : connected to 7705 SAR to address MPLS converged networks.

6.1 MPT-HC-HQAM

6.1.1 Supported features

MPT-HC-HQAM supports the following configurations :

- capacity from 2xE1 to 160xE1
- throughput from 4,5 to 425 Mbps
- modulation rates : QPSK, 16QAM, 32QAM, 64QAM, 128QAM, 256QAM, 512QAM 1024QAM, 2048QAM without hardware change
- all channelization from 3.5 MHz up to 56 MHz
- available for all licensed frequency bands from 6 to 38 GHz : L6GHz, U6GHz, 7GHz, 8GHz, 11GHz, 13GHz, 15GHz, 18GHz, 23GHz, 25GHz, 38GHz
- Note : 5.8GHz & 10.5GHz frequency bands also available but limited to 256QAM modulation

6.1.2 Connectivity

Baseband signal coming from MSS is transported to MPT-HC-HQAM through optical or electrical connectivity.
MPT-HC-HQAM can support both electrical and optical connectivities.

In case of electrical connectivity, a single CAT5e cable connects an MPT to the MSS, which carries transmit and receive baseband signals, telemetry overheads, internal controls and MPT DC power.
In case of optical connectivity, two cables connect an MPT to the MSS:

- one cable is a 50 ohm coaxial cable to send the -48 V power supply to the MPT
- the second cable is an Ethernet optical cable that carries transmit and receive baseband signals, telemetry overheads and internal controls.

6.1.3 Radio Protection Switching (RPS)

Radio Protection Switching (RPS) functionality is used for 1+1 configuration.

This functionality is embedded for MPT-HC-HQAM and is available for all frequency bands. For specific cases, the 1+1 RPS can be implemented in two ways.

- the two mate MPTs can be interconnected through an optical cable to allow the exchange of signals needed or
- the two mate MPTs are exchanged the RPS signals in-band with the user traffic on the IDU-ODU cables between MSS and MPT, without any psysical interconnection between the two mate MPTs

Note : for 5.8GHz & 10.5GHz bands only, RPS function can supported via a module which can be directly plugged onto the outdoor unit.

6.2 MPT-XP-HQAM

6.2.1 Supported features

MPT-XP-HQAM is the version of outdoor MPT-HC enhanced in order to offer in low frequency band higher output power. This is translated in an improvent of system gain making this version suitable for very long links. Output Power increase is compared to MPT-HC-HQAM from 5 to 8dB depending on modulation.
It support the following configurations :

- capacity from 2xE1 to 160xE1
- throughput from 4,5 to 425 Mbps
- modulation rates : QPSK, 16QAM, 32QAM, 64QAM, 128QAM, 256QAM, 512QAM 1024QAM, 2048QAM without hardware change
- all channelization from 3.5 MHz up to 56 MHz
- available for all licensed frequency bands from 6 to 11 GHz : L6GHz, U6GHz, 7GHz, 8GHz, 11GHz

6.2.2 Extended Power

- Except for emission power and for system gain, MPT-XP-HQAM has the same performances than MPT- HC-HQAM.
- The interface is the same between MPT-XP-HQAM and HC-HQAM :
    - All MPT-XP-HQAM are using external diplexers that are compatible with MPT-HC-HQAM and MPT-MC.
    - The installation material is the same between MPT-XP-HQAM, MPT-HC-HQAM and MPT-MC.
- The MPT-XP is also the best in class for power consumption perspectives compared to the competition.
- The MPT-XP-HQAM can be powered with an MPT Extended Power Unit (see further section on this equipment).

6.2.3 Connectivity

Baseband signal coming from MSS is transported to MPT-XP-HQAM through optical or electrical connectivity.
MPT-XP-HQAM can support both electrical and optical connectivities.

In case of electrical connectivity, a single CAT5e cable connects an MPT to the MSS, which carries transmit and receive baseband signals, telemetry overheads, internal controls and MPT DC power.
In case of optical connectivity, two cables connect an MPT to the MSS:

- one cable is a 50 ohm coaxial cable to send the -48 V power supply to the MPT
- the second cable is an Ethernet optical cable that carries transmit and receive baseband signals, telemetry overheads and internal controls.

6.3 MPT-MC

6.3.1 Supported features

MPT-MC stands support the following configurations :

- split mount (connected to MSS-1 / 8), stand alone mode (called MPR-e) or integrated (connected to 7705 SAR)
- capacity from 2xE1 to 160xE1
- throughput from 4,5 to 425 Mbps
- modulation rates : QPSK, 16QAM, 32QAM, 64QAM, 128QAM, 256QAM without hardware change
- all channelization from 3.5 MHz up to 56 MHz
- available for all licensed frequency bands from 6 to 38 GHz : L6GHz, U6GHz, 7GHz, 8GHz, 11GHz, 13GHz, 15GHz, 18GHz, 23GHz, 25GHz, 38GHz

6.3.2 Connectivity

Baseband signal coming from MSS is transported to MPT-MC through electrical connectivity. Optical connectivity is not proposed for this product.
A single CAT5e cable connects an MPT to the MSS, which carries transmit and receive baseband signals, telemetry overheads, internal controls and MPT DC power.

6.3.3 1+1 configuration

Radio Protection Switching (RPS) functionality is used for 1+1 configuration.

This functionality is available for all frequency bands for 1+1 HSB/SD/FD radio protection, the signals needed for RPS are exchanged between two mate MPTs through IDU/ODU cables and through MSS. This is leading to a cost optimized solution not only in term of cost but also in term of operations.

MPT-XP

6.4 MPT-HL

MPT- HL is part of MPT family with specific caractheristics related to the need of long haul and high capacity network. MPT-HL has been designed in order yo be installed in indoor o in outdoor cabinet.

MPT HL supports capacities from 9xE1 to 208xE1 (20 to 553 Mbps) and modulation rates QPSK, 16QAM, 32QAM, 64 QAM, 128 QAM, 256QAM, 512QAM, 1024 QAM without hardware change. All channelization from 28 MHz up to 56 MHz can also be used in the same platform through the usage of dedicated filters. MPT HL covers the full range of frequencies used for long haul application from 4 GHz to 13 GHz.

A single part number covers the full RF band and the frequency can be set by sw. The filters (narrow band) are external to the RT and tuned in factory at the exact frequency.
For the availability of each frequency please refer to the roadmap.

The connectivity between MSS and MPT HL is based on SFP GEth . Optical SFP or SFP cables can be used. MPT HL is powered through the dedicated backplane on the rear part of RT subrack. In a single RT subrack up to 10 RT can be hosted.

6.4.1 Branching and indoor arrangment

4 differents ETSI racks are available for full indoor installation of MPT-HL:

2200 mm able to host up to 20 MPT HL on 2 different RT subracks.

2000 mm, 1700mm and 1300mm able to host up to 10 MPT-HL in 1 RT subrack.

Close to each subrack filters and branching for maximum 10 RT are located. Inside the ETSI rack the connection to antenna circulator positioned on the top is based on waveguide usage increasing the reliability and minimizining the losses.

Branching is based on narrow band filters and circulators.

Narrow band filters allows to use on same branching adjacent channels and offers very good performances in case of adjacent interference.

Inside a single rack repeater and /or nodal configurations can be hosted.

6.5 Radio configurations and protection

The following configurations are available for each radio path.

1+0

1+1

N+0 in multichannel arrangment

Following options are available for protected configuration:

- Hot Stand-by (with or w/o coupler)
- Frequency Diversity
- Polarization Diversity

1+1 Hot Standby

This method offers protection against HW failures providing two independent TX/RX chains. In (1+1)HSby one transmitter is working, while the other one is in stand-by; both receivers are active and the best ODU source is selected.

In case of 1+1 Hot Stand-by on single antenna, both Radio Units are connected to a coupler, balanced or un-balanced.

1+1 Frequency Diversity/Polarisation DIversity

This method offers protection against selective and temporary link quality degradation. In (1+1) Frequency Diversity, both radio paths are active in parallel using different frequencies; this method, based on memory buffer that guarantees the bit to bit alignment, can offer error free protection against fading (via a hitless switch) up to 100dB/sec.

Both two antennas and single antenna (dual polarized) mounting arrangements are available. (However, with FD, the usual arrangement is one antenna SP.)

(1+1) Polarization Diversity adopts the same concepts of FD, but in this case the same RF signal is transmitted on two different polarizations (H/V) by means of a single double polarized antenna.

Adjacent Channel Alternate Polarised (ACAP), Adjacent Channel Co Polarised (ACCP) and Co-Channel Dual Polarisation (CCDP) operations are supported

6.6 XPIC

Thanks to XPIC function, MPTs can provide twice the capacity in one frequency channel (Co-channel Dual Polarized) for any combination of Ethernet, PDH and SDH and for any modulation scheme.
XPIC is supported either in split-mount mode or in full-outdoor configuration (MPR-e).
This functionality is embedded for MPT-HC-HQAM . MPT-XP.HQAM ans MPT-HL and is available for all frequency bands. The two mate MPTs are consequently interconnected through an optical cable to allow the exchange of signals needed to perform XPIC functionality.
XPIC functionality activated by sw through a dedicated licence.

Note 1 : In case MPT HC and XP HQAM for 5.8GHz & 10.5GHz bands only, XPIC function is supported via a module which can be directly plugged onto the outdoor unit.

6.7 Space diversity configuration

Frequency-selective fading is a fade causing amplitude and group delay distortions across the channel bandwidth.
In the time domain it can be defined as the overall path delays between the first to the last pulses reaching the receiver (the multipath echo).
In MPT family an enhanced equalizer has been implemented that allows to have a very high resistance to selective fading.
Another way to counteract selective fading is to implement space diversity, which is based on the simultaneous reception of the transmitted signal at two vertically separated antennas, so that the channel effect on the two signals can be considered uncorrelated.

On MPT-HC-HQAM and MPT-XP-HQAM the space diversity configuration is reaized coupling 2 ODUs connected to 2 different antenna. At receiver side an enhanced RPS mechanism is implemented that allows to select frame by frame the best received signal.

MPT-HL has a a dedicated RT version suitable for space diversity configuration with a second receiver added in factory.

MPT-HL implements baseband digital combiner, thus allowing:

- Better performance in the event of simultaneous impairments on both channels (see next slide)
- Deep selective fading on one channel + flat fading on the other channel
- Deep selective fading on both channels at the same time
- Automatic alignment to recover delay between main and diversity waveguides (up to 40m)

Space diversity option is available in conjunction with XPIC and adaptive modulation.

6.8 Couplers

A coupler is used to connect two ODU to a common antenna for protected or single antenna frequency diversity operation. Two versions are available, an equal-split 3/3dB coupler, and an unequal-split coupler with a nominal 1dB insertion loss to/from the main ODU, and 10 dB insertion loss to/from the standby ODU

. 

MPT Coupler

6.9 Ortho-Mode Transducers (OMT)

Using one OMT and two MPT, it is possible to have double polarization (DP) configurations with integrated antennas. With OMT we are offering the most compact and cost effective solution for double polarization applications.

An OMT is a kind of double polarization coupler. The frequencies can be different (in a same band) or identical (XPIC). By means of an interface, it is attached to the back plate of the antenna's circular waveguide feeder. This interface allows the rotation of the feeder for proper alignment of two facing DP antennas.

There are two OMT shapes depending on the frequency band, identical to couplers :

6L, 6U, 7, 8 GH

11, 13, 15, 18, 23 , 25 and 38 GHz

Insertion loss from antenna to ODU is 0,5 dB, return loss 18 dB, Cross-polar discrimination (XPD) 30 dB, Inter-port Isolation (IPI) 35 dB.

6.10 4+0 or 2x(1+1) HSB dual pol integrated coupler

Mainly for N+0 configurations, a 3+0/4+0 dual pol integrated coupler is offered.

It is a very compact solution, allowing the usage of integrated antennas and avoiding the usage of not-integrated antennas with external couplers and flex twist.

6.11 Power Injectors

6.11.1 Power Injectors : Plug-in and Box

- Used to feed up to 2 MPT-MC / HC / HC-HQAM, with electrical connection (ethernet CAT5e cable), by means of PfoE (Power feed over Ethernet, proprietary)
- when MPT access card is not used on MSS (no PfoE functionality)
- can not be used with MPT-XP / MPT-XP-HQAM (MPT Extended Power Unit is necessary)
- The Power injector is presented in two different ways :

• **Power Injector Plug-in / card** :

  • it can be plugged in any MSS 8 slots, included the one dedicated to core protection

  • when MPT is connected to CORE, Power Injector Plug-In is needed to provide power to the MPT at optimized price,

  • when MPT is connected to 7705SAR, Power Injector Plug-In can be used inside 7705 chassis to power MPT

Power injector plug in

- Power Injector Box :
  - when MPT is used in stand alone : available for all MPR-e applications
  - The Power Injector Box is delivered with a bracket for installation in a rack 19” and the total height is 1U.

Power injector box

6.11.2 Electrical characteristics :

- DC In & DC Out interfaces have the following Voltage range : -48V +/-20%
- Embedded lightning and surge protections are included on each ODU output

NOTE : for inputs, Ethernet lightning protection will be provided by IDU Ethernet access

- Isolation of the Ethernet connectivity between MSS and MPT
- Hot Swap function (current limitation) allowing In Rush / Short Circuit protections
- Reverse polarity protection on the -48V Power In side
- Power O-Ring feature : introduced in order to feed the Power Injector from two independent battery power lines. Even if a battery breaks down, the management of the Power Supplies allows to power the 2 injectors of the Power Injector Unit.

For the PLUG-IN version, both battery power lines are provided through the single backplane connector.

6.11.3 Connectors :

- 2 x RJ45 as input connectors : data to be transmitted
- 2 x RJ45 as output connectors : data to be transmitted + DC battery out (-48V)
- DC connector
  - PLUG-IN : 1 x backpanel / SUB-D connector, located in the back for power from the backpanel
  - BOX : 2 x DC connectors (pairs), located in the front
- RJ45 standard supported : 100 Base-T & 1000 Base-T,
- Also available on the front panel : 2 x LEDs indicating the presence of DC voltage on each Ethernet Output
- Supported CAT5e cable length : 100m
- Power consumption : 1,3W MAX

6.12 MPT Power Unit

6.12.1 Presentation:

- The MPT Power Unit provides a compact solution to power up to 4 MPT-HC or MPT-HC-HQAM even with XPIC option, with integrated lightning arrestor and filters;
- Note: dual battery inputs are available as well:

6.13 MPT Extended Power Unit

6.13.1 Presentation :

- The MPT Extended Power Unit provides a compact solution to power up to 2 MPT-XP (Extended Power) or MPT-XP-HQAM even with XPIC option.
- Note: it can also be used to power MPT-HC (with or without XPIC module) or MPT-HC-HQAM.

- It includes a step-up converter to deliver a stabilized output voltage.

- N connectors are present on the front plate, in order to avoid the usage of pig-tails and allow direct connection of coaxial DC cable.
- The MPT Extended Power Unit is delivered with brackets for installation in a rack 19” and the total height is 1U.

6.14 MPT-GM

"E-BAND", a new frontier of capacity

Most advanced radio and microelectronics technology today permits going beyond the traditional capacity frontier, using a new and really interesting frequency band - from 70GHz up to 90GHz - achieving ultra high capacities based on radio links: this frequency band is called *"E-band"*.

This "E-band" provides some big advantages in terms of radio propagation and telecommunications application:

First of all, the free space attenuation is in the range between $3x10^{-1}$ dB/km up to $5x10^{-1}$ dB/km, which is really comparable with highest *"traditional"* frequency bands attenuation (42GHz: up to $2x10^{-1}$ dB/km)

Second big advantage is that a frequency bandwidth of 10GHz is available for transmission – divided in lower bandwidth from 71GHz up to 76GHz and upper bandwidth from 81GHz up to 86GHz- channelized in steps of 250MHz channel bandwidth (250MHz, 500MHz, 750MHz, 1.000MHz), permitting huge capacities even transmitting with low level modulation schemes (e.g. BPSK, 4QAM)

Last, but definitely not least, to "E-band" light licensing schemes are applied, depending on countries, in order to foster deployments

ULTRA HIGH CAPACITY IP FULL OUTODOOR AND SPLIT MOUNT SOLUTION

MPT-GM is the Alcatel-Lucent solution for ultra high capacity applications in the "E-band" frequency spectrum.

The MPT-GM equipment provides today scalable data rates up to 2.5Gbps.

Modulation range, from BPSK up to 64QAM, with hitless Adaptive Code and Modulation, combines highest throughput with "in field reliability".

MPT-GM provides a full set of Ethernet features and advanced switching capabilities to meet all the Next Generation Networks (4G/LTE) requirements in terms of high-capacity, synchronism transport, compactness and zero footprint, and cost saving.

MPT-GM is also addressing ultra-high capacity split mount solution, with direct connection to 9500 MPR indoor unit (MSS). With such configuration MPT-GM can exploit multi-service aggregation and features (such as G.8032 Ring protection) provided by nodal MSS equipment.

6.14.1 Main characteristics

Two MPT-GM HW versions are available:

- Electrical Gigabit version

- 2x 10/100/1000BaseT traffic/supervision ports with clock and synchronism recovery and PoE
- 1x “interconnection” port for internal communication between MPT-GM in 1+1 protected configuration

- Optical gigabit version

- 2x 1000BaseX traffic/supervision ports with clock and synchronism recovery
- 1x “interconnection” port for internal communication between MPT-GM in 1+1 protected configuration

All ports - electrical and optical - can be used as traffic ports and, in this case, supervision and management can be provided by using In-Band management.

In case that dedicated usage will be required, one of the Ethernet port(s) can be dedicated to supervision and management or to the synchronism transport and the others can be dedicated to traffic transport.

6.14.2 Available Channel Bandwidth and Modulation

MPT-GM can provide following channel bandwidth:

- 250MHz
- 500MHz

In terms of modulation scheme, BPSK-4QAMs-4QAM-16QAM-64QAM are available. 4QAMs is a stronger version of 4QAM, with a different FEC, allowing to improve availability for high priority traffic in case of fading. Below 4QAM modulations, the BPSK is also available for increasing even more the system gain and thus the in-field reliability: this additional profile achieves an even strong maximization of link availability, with a 3dB higher system gain.

MPT-GM implements top class MSE based Adaptive Code and Modulation, combining at the same time higher capacity in good propagation conditions and better availability with tough conditions.

Using the two available user ports, it is possible to reach 2Gbps throughput using 500MHz channel and 64QAM modulation scheme.

6.14.3 Power Supply

MPT-GM power consumption (<50W) is really performing and can be provided by a dedicated power supply cable as well as by a POE+ injector. By consequence, the power supply can be provided directly on the same CAT5 cable through which traffic is incoming in the 10/100/1000baseT port of the equipment.

In case that POE is not provided by the connected equipment (e.g. third party router/switch, eNodeB, etc…) or in case that external dedicated power supply is preferred, additional dedicated Power Supply Port can be used, with standard power supply of -48V ±15%.

Figure 1 - Detail on MPT-GM connectors: two Ethernet IP65 connectors and, in the middle, the dedicated power supply.

6.14.4 Available Configurations

Following configurations are available for MPT-GM:

- 1+0
- 2+0 (LAG), or 2x(1+0)
- G.8032 ring protection (available only in split mount configuration)
- hybrid configurations (mixing traditional microwave and E-band radio), available only in split mount configuration

Split mount configurations implies connection to MSS-8 (Core board) or MSS-1.

6.14.5 Ethernet features

MPT-GM implements a multi-port store-and-forward Layer2 Switch. The embedded Switch supports the following Layer2 functionalities:

- MAC switching
- MAC Address learning and ageing
- Auto negotiation
- Layer 2 Flow Control / Back Pressure: MPT-GM implements flow control based on IEEE 802.3x (full-duplex operation) and Back Pressure (half-duplex operation) to prevent packet loss during traffic peak.
- IEEE 802.1q VLANs and VLAN stacking (Q in Q)
- EVPN profiling
    - Bandwidth limiting per VLAN
    - Bandwidth limiting per priority.
    - Frame fragmentation
    - VLAN rewriting
- Enhanced Ethernet prioritization based on MPLS “Exp bits”
- Selective QinQ based on VLAN and 802.1p priority
- QoS: 8 queues Ethernet scheduler towards radio interface. MPT-GM implementation manages Ethernet traffic classification according to 802.1p, 802.1q, IPv4 TOS or IPv6 TC (Layer3), MPLS “Exp bits”
    - Two scheduling algorithms are available in MPT-GM equipment: strict priority or WRR (SW selectable).
- Layer2 link aggregation
- G.8264 (“Distribution of timing information through packet networks ”) support

6.14.6 Synchronization

Synchronization unit supports following functionalities:

- Synchronism source selection
- Quality estimation based on frequency
- Quality estimation based on information as per G.8264 standard.

Synchronism can be sourced from the incoming Ethernet flows (Synchronous Ethernet) and transported toward remote terminal by using the symbol rate.

Remote terminal can be therefore synchronized with the received symbol rate and synchronism is distributed to all egress Ethernet ports.

6.14.7 Management System

MPT-GM can be reached from network management system perspective either by establishing a DCN data channel over the Ethernet traffic interface (InBand management) or by provisioning a dedicated Ethernet port for management purpose (Out of band management).

InBand management uses a logical separation between payload traffic and DCN traffic using specific VLAN tag dedicated to supervision traffic.

MPT-GM is provided with an embedded SNMP agent fully compatible with existing Alcatel-Lucent's Network Management Systems and relevant management tools.

6.14.8 Mechanical layout - Integrated antenna solutions

The MPT-GM is provided as integrated antenna solution.

Applicable antenna diameters are 1 ft and 2ft. Bigger antennas are not in field applicable for pointing and alignment in field constraints.

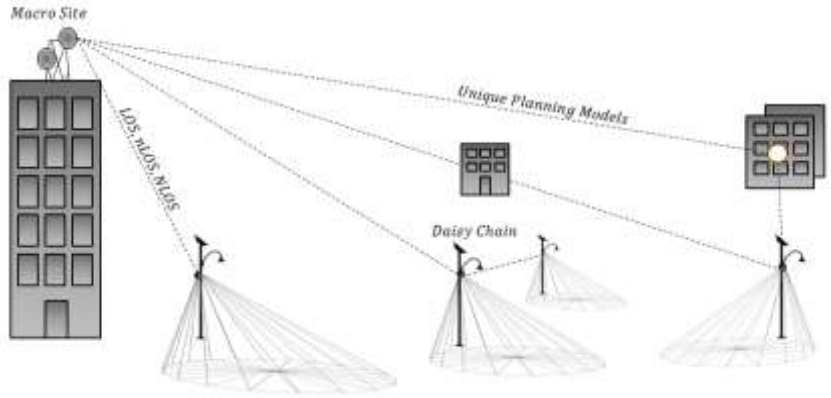
7 SMALL CELLS MPTs

7.1 MPT-SUB6

The MPT-SUB6 is a single carrier, NLOS backhaul platform suitable for small cells bacjhaul applications. It supports a net throughput of up to 350Mbps (aggregate) in a single 40MHz channel.

The MPT-SUB's high quality performance in NLOS conditions is achieved by two layers in the radio:

- MIMO / OFDM based PHY
- Proprietary advanced & robust Air Interface



The core competence of the air-interface is its dynamic adaptation, in a resolution of frame by frame, to the instantaneous changes in the link conditions optimizing the system performance to achieve maximum and stable capacity along with minimum latency.

In addition, the MPT-SUB6 introduces a Smart Antenna enabling the following capabilities:

- Increases system gain (higher fade margin), widens the NLOS deployment cases
- MIMO 3x3
- Beam forming
- Multipath aggregation
- Interference cancellation by spatial filtering
- Automatic alignment.

The smart antenna has a significant impact on the efficient use of the spectrum, the optimization of service quality, higher capacity and improved robustness. The antenna array adjusts its pattern and direction in real time and provides gain while simultaneously identifying and eliminating the interfering signal.

The air-interface controls the Modem and the Smart Antenna and adopts them to the dynamic changes in the channels.

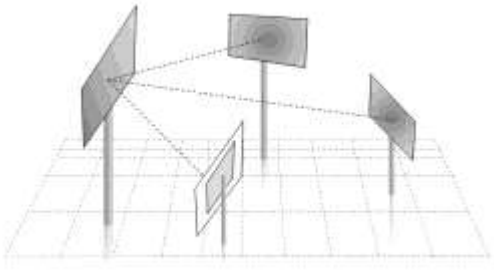
Their combined contributions are essential to overcome the NLOS deployment challenges.

The MPT-SUB6 works in PtMP and PtP mode. A PtP architecture is established using an HBS and a single remote unit (HSU), and can therefore further be scaled to support PtMP configuration by simply adding additional HSUs in the same sector. Using the new smart antenna allows the operator to maintain performance of PtMP similar of having multi PtP. The smart active antenna is aligned towards each HSU to achieve the best performance.

7.1.1 Configurations

The MPT-SUB6 employs a proprietary air interface protocol with unique interference mitigation mechanisms which ensure high quality and reliable delivery of the required services in license-exempt bands in nLOS and NLOS environments.

The MPT-SUB6 supports both PtMP and PtP configurations.



7.1.2 Ethernet traffic interfaces

The MPT-SUB6 has two LAN ports:

- Port 1 – Data & DC in (PoE)
- Port 2 – Local management & Data.

Note: the images above show a LAB radio whose LAN interfaces are without glands. Regular radios are equipped with open gland (LAN port 1) and covered gland (LAN port 2).

The ports are standard copper RJ45 Ethernet interface, supporting 10/100/1000 Base-T Auto-Negotiation (IEEE 802.3u). Configuring the LAN ports is done locally and remotely via the Manager (EMS) and 5620 SAM - Service Aware Manager.

7.1.3 Frequency band

The table below shows the supported frequencies. Additional sub-6 GHz bands can be supported per request.

The term Universal represents bands available under various local regulations, non-FCC and non-ETSI.

Band and Regulation	***Occupied Frequency Range (GHz)***
5.8 GHz FCC/IC	5.725 – 5.850
5.4 GHz FCC	5.480 – 5.715
5.4 GHz IC	5.480 – 5.715
5.4 GHz Universal	5.465 – 5.730
5.3 GHz FCC/IC	5.255 – 5.345
5.3 GHz Universal	5.140 – 5.345
5.8 GHz ETSI	5.725 – 5.875
5.4 GHz ETSI	5.475 – 5.720
5.3 GHz ETSI	5.150 – 5.350
3.6 GHz FCC/IC	3.650 – 3.700
3.5 GHz IC	3.475 – 3.650
3.5 GHz ETSI	3.4105 – 3.7025
3.5 GHz Universal	3.300 – 3.800
2.6 GHz Universal	TBD

7.1.4 Traffic Handling & Quality of Service

Advanced ARQ

It maintains a lossless data connection between the base and the remote unit while maintaining low delay and jitter and ensuring the QoS requirements.

The ARQ fully utilizes the available air interface capacity by avoiding unnecessary retransmission and reducing the feedback overhead.

The ARQ receives the Ethernet frame into the various CoS queues, based on the packet classification (802.1p or DiffServ) and the bridging (each queue is dedicated to a single remote radio and a single priority).

For each new burst dedicated to a remote radio the ARQ scheduler rebuilds the frame based on the data available in each of the queues at that time. The scheduler implements a byte oriented combine strict priority and Weighted

Fair Queuing (WFQ) algorithm based on the QoS parameters as defined by user per queue.

L2 Ethernet properties

MTU	2047 bytes. HW ready to support configurable size
Jumbo Frames	HW ready to support more than 9000 bytes
Buffer Size	32MB: 4 queues, each queue 8Mb 64MB: 8 queues, each queue 8MB (H1 2015)

Queue Drop Mechanisms	Maximum TTL: Enables efficient air channel by dropping packets which are behind the pre-defined QoS level (above defined limit), hence the user saves air bandwidth and in parallel limits the latency per specific queue MIR: The user can limit the Maximum Information Rate of each priority queue. The queue MIR cannot exceed the link MIR. Dynamic Buffer size per queue: Actual buffer size is dynamically set (per queue/buffer) to achieve best performance (high TP with minimum packets drops and minimum latency). The buffer size is set according to the following parameters/attributes: 1. Actual Air Interface 2. Actual TTL 3. Actual Link Conditions (PER, MCS) 4. QoS (number of queues, queue size and scheduler, all are user configured) The dynamics of the buffer is a layer that supports all mentioned mechanisms and enables the radio to track the link fluctuations very fast, while keeping the minimum latency and high TP. This is a unique feature that increases the system robustness, especially in NLOS environment where there are many multipath beams or under interference. There are dedicated algorithms which continuously track channel conditions and quickly adjust the backhaul system radio parameters to provide the best performance possible at any instance
VLAN ID	4096 VLANs
Classification	802.1P or DiffServ
VLAN Support	802.1Q, 802.1P, 802.1ad (QinQ), DiffServ (QoS Layer3)
Number of queues	4 queues 8 queues (H1, 2015)
Scheduler	WFQ, SP
Broadcast, Multicast, etc. flooding Control	Multicast and Broadcast can be limited to 12.5% of downlink to avoid flooding the entire remote radios when a certain user is broadcasting or multicasting (user-configurable) Block interconnection between remote radios within a sector (user configurable)
Handling LTE TCP/IP bursts	1) 8 Byte oriented WFQ (user configurable) queues 2) The offered radio incorporates sufficient memory (64MB, 8MB per queue, H1 2015) to accommodate LTE TCP/IP bursts. 3) Other available mechanisms are :TTL, MIR, Dynamic

	Buffer size

VLAN

The following VLAN functionalities are supported:

- Dedicated VLAN for management traffic
- Transparent mode – in this mode all data is transparently delivered
- Provider mode (QinQ) – in this mode a provider tag is added / removed from the incoming / outgoing frame
- Tag mode – Includes:
  - Ingress - Transparent and Tag modes
  - Egress - Transparent, Tag, Untag all, Untag filter and filter modes.

7.1.5 Network Synchronization

The MPTSUB6 products support the following Synchronization solutions between sites:

- HSSoE (Intra-site TDD)
- Integrated GPS (Inter-site TDD)

The Sub-6GHz SCB products have the capability of distributing the clock over the Ethernet by using the following:

- 1588v2-TC
- SyncE, as required by Sync-E standards (G.8261, G.8262)

The solution supports Sync-E on both directions (Master <--> Slave) and allows to deliver 1588V2-TC and Sync-E simultaneously over the air by the same clock source.

Sync- E will be applicable for Ethernet speed of 1Gbps only.

The MPT-SUB6 implements a 1588 TC (Transparent Clock) of End-to-End type. The design goal of the 1588 V2 solution is to decrease the PVD over the wireless link as much as possible enhancing the clock recovery process of the connected Slaves devices. 1588 V2-TC will keep the same performance under adaptive modulation, packets retransmission and asymmetric configuration.

7.1.6 O&M interfaces

O&M is performed on the MPTSUB6 through the User Ethernet port, supporting in-band method.

Operator may access the equipment through the mentioned interfaces, configuring all the required parameter required for a proper link setup, including the VLAN ID and priority, for the in-band communication protocol.

Once logged-in into the NE, the following protocols can be configured for equipment maintenance:

- Telnet access (enabled/disabled) using the Telnet check-box
- Web Interface access (enabled/disabled) using the Web Interface check-box

SNMP v1/v3 interface is on by default and cannot be disabled; it is the default management interface, used by Manager and 5620 SAM.

7.1.7 Power supply and Consumption

Power is provided over CAT-5e cable using PoE.
Two power injectors are available:

- Outdoor PoE (AC only)
- Indoor PoE (AC and DC)

Type	AC\DC	Detailed Description	Temp. [Celsius]
Outdoor	AC	Outdoor PoE device 10/100/1000Base-T. Input voltage: 100-240VAC Nominal range 90-264VAC max range. The device can provide power of up to 35W	-40 to 60
Indoor	AC	Indoor PoE device 10/100/1000Base-T The device can provide high power of up to 55W. The device is supplied with AC power feeding	-5 to 40
Indoor	DC	Indoor PoE device 10/100/1000baseT interface for RADWIN radios (Includes JET). The device can provide high power of up to 55W. Input voltage is 20-60V	-5 to 40

Note: the MPT-SUB6 radio can be powered also by the 9500 MPR MSS-O.

8 9500 MPR configuration & maintenance (ACTUAL)

8.1 Overview

Taking as reference the suggested layering of the TMN management functions, included in ITU-T M.3010 recommendation, the Network Element Layer doesn't have an explicit model in terms of management functions.

Alcatel-Lucent foreseen the Craft Terminal application and the subsequent evolution of TCO and WebEML, for this purpose; in the following chapters, these applications will be described.

8.2 TCO

The TCO Tool Suite is implemented as an evolution of the Craft Terminal concept for the Alcatel-Lucent Wireless Transmission products.

TCO Software Suite allows the operator to access and configure the NE from its PC without the need of software installation; only Java JRE presence is mandatory. By default, the complete software package is available on the CD-ROM which is needed to start the application.

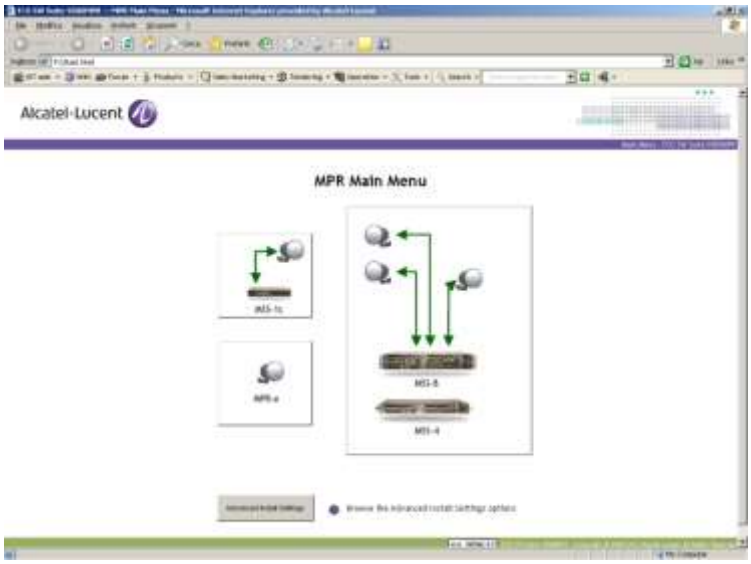
TCO Software Suite now supports the complete set of equipment which are part of the 9500 MPR family: MSS-4/8 based nodes, MSS-1c and MPR-e.

In a unique package, all the WebEML management applications are available, up to the latest software release.

TCO embeds the following tools:

- **Provisioning Tool**: it allows an easy configuration of Network Elements. No need of a device physically connected, allowing back-office activity in standalone mode.
- **Alarms & Settings**: the 'Alarms & Settings' button will connect to the NE Web server, allowing the alarms monitoring and some basic settings directly inside a common web browser. For this reason, the NE must be physically connected with PC running TCO. At this stage, the following configurations may be applied:
  - Date & Time settings
  - Get configuration file
  - Retrieve license info
  - DHCP settings
  - Community string
    - **Operational & Maintenance** tool: it starts the WebEML application (former Equipment Craft Terminal), allowing the complete management of the NE it is connected to.
    - **Advanced Install Settings** menu allows:
      - Install the right version of Sun Java Runtime Environment (JRE), needed to run the TCO package.

- Obtaining a copy of the applications on the local PC (hard disk or USB key).

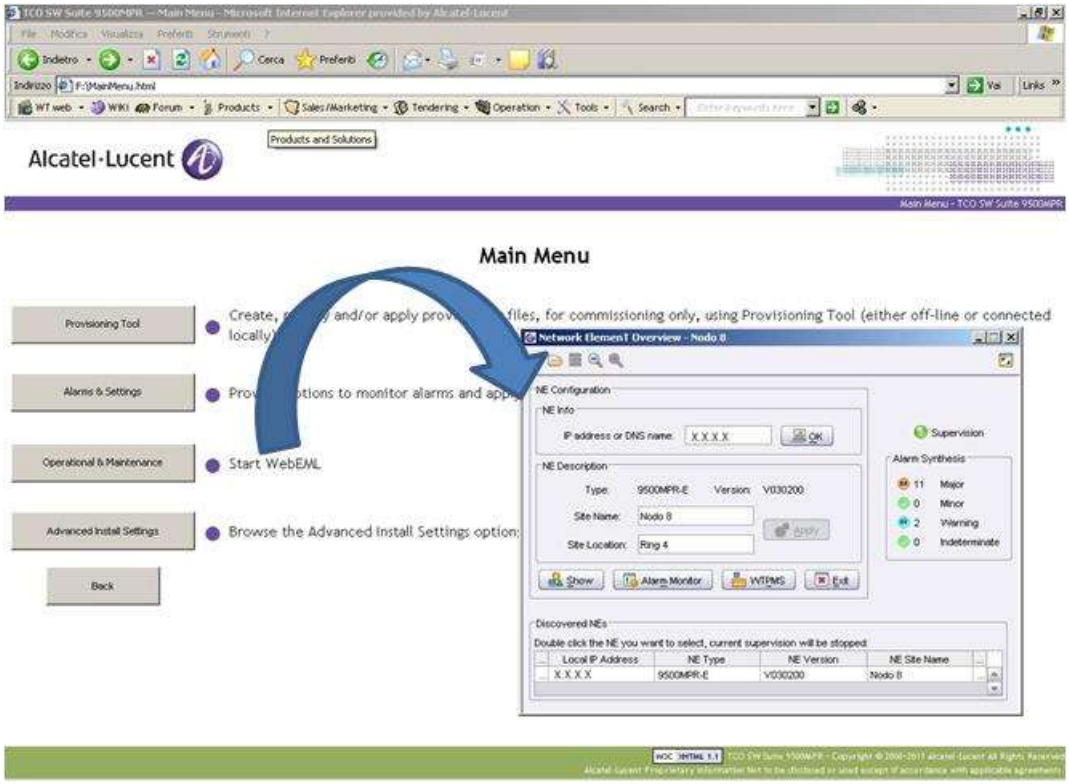


TCO Software Package starting page

Alarms & Settings window – NE connection active

8.3 Network Element Overview – NEtO

The Network Element Overview (NEtO) is the starting point of the Network Element Layer management application, 9500 MPR WebEML.



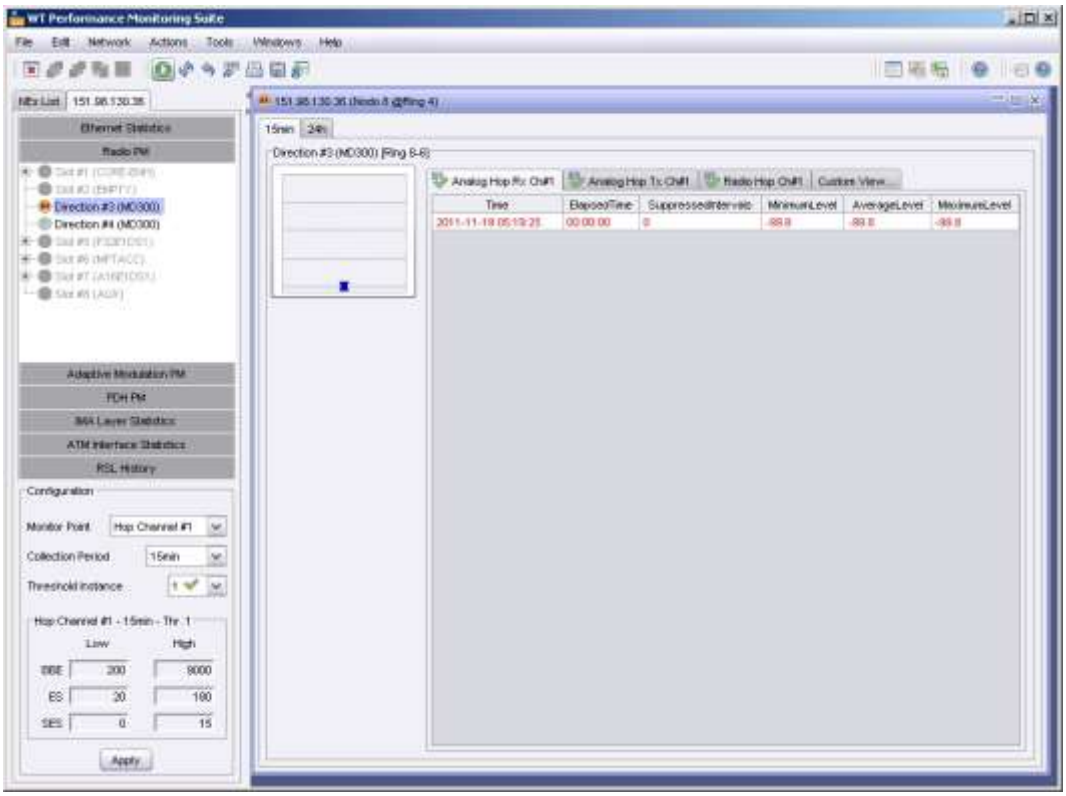
Start WebEML from TCO main menu – NEtO window appears

From NEtO main window is possible to:

- **Show** the equipment – it starts the WebEML applet.
- Start **Alarm Monitor** applet – the Alarm table of the NE under supervision is shown.
- Start the Performance Monitoring Suite (**WTPMS**) applet – allows the visualization/management of the PM data of the NE under supervision.

It's also possible to upload a list of NEs and to start the supervision of one or more of these NEs: in this case, Alarms and PM monitoring will be applied to multiple NEs at the same time.

Current Alarm table – export alarms menu



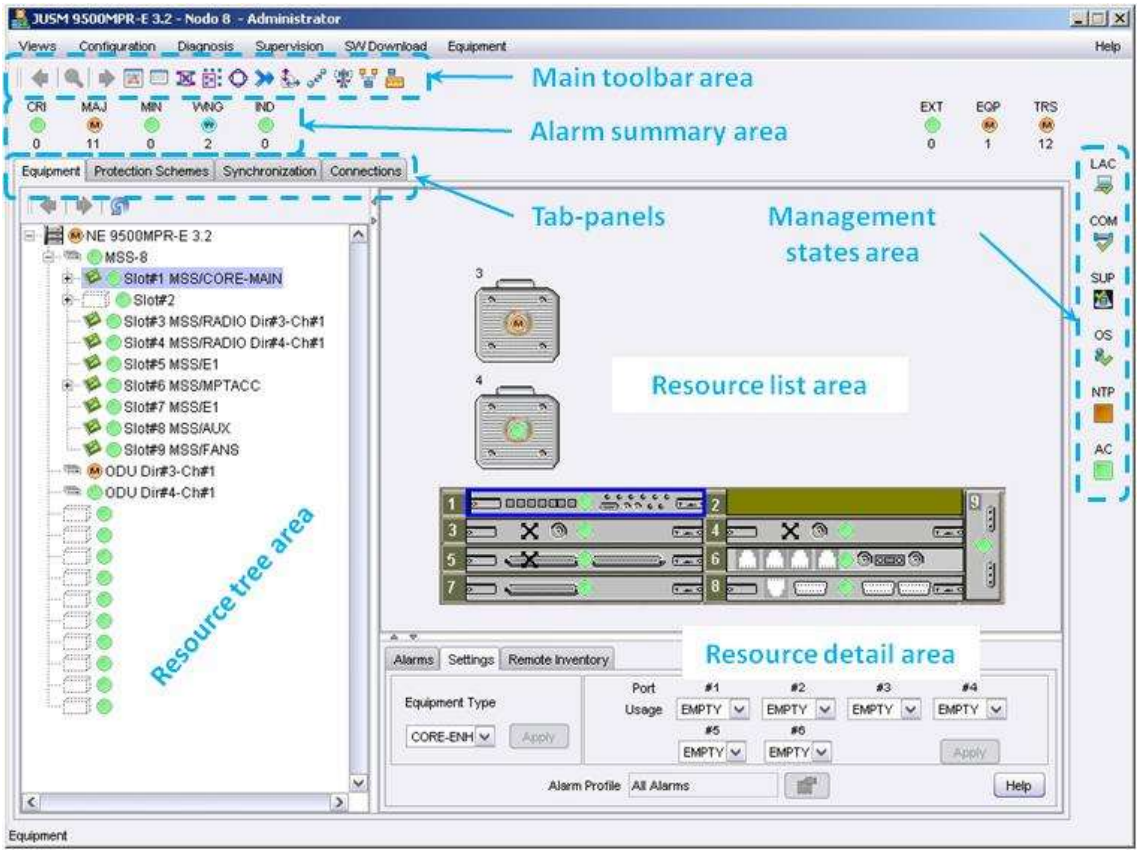
WTPMS – Analog Rx, sample measurement view

8.4 9500 MPR WebEML supported features

9500 MPR WebEML supports the complete Fault, Configuration and Performance Management, performed at Network Element Layer.

In-deep configuration can be performed on NEs from a PC connected both locally or remotely.

WebEML supplies a GUI for all the supported functions, starting with the Main View Area where all the domains and the summary of the Alarm statuses are presented. It is organized with tab panels, e.g. many windows placed one upon another allowing an immediate selection of the required one.



9500 MPR WebEML Main View Area

Tab-panels

All the tab-panels presented in the Main View, represent a set of functions immediately accessible; the choices are:

- Equipment – it allows the management of the equipment configuration
- Schemes – it allows the management of the supported protection schemes
- Synchronization – it allows the management of the synchronization options
- Connections – it allows the management of the cross-connections

The following areas are available for each tab-panel:

- Resource Tree area, displays all the available resources of the NE.
- Resource List area, may be represented by Tabular View or Graphical View, depending on the displayed resource (e.g. by selecting a 32 E1 TDM board, the area will represent a table with the available E1 and relevant configuration options, if any).
- Resource Detail area: displays detailed information of an item, previously selected.

Inside the Equipment view, it's possible to configure all the supported boards with related resources i.e. Radio, PDH, SDH, EAS, ATM, AUX and Core-E views; each of these views, opens a management domain relevant to the selected board.

Main Toolbar Area

From the Main Toolbar is possible to launch the most important configuration applets like:

- Block Diagram View
- Current Configuration View
- Cross-Connections
- Segregated ports
- Ethernet Ring
- LAG Configuration
- QoS Configuration
- AUX Cross Connections
- XPIC Configuration
- VLAN management
- WT Performance Monitoring Suite

Alarm Summary area

The Alarm Summary area gives an immediate view on the general status of the NE under supervision, by indicating the severity of the different alarms in the NE as well as on the number of current alarms.

The meaning of the alarms indication, in terms of status and severity, is listed here below:

- **CRI** – Critical alarm. Red color. Synthesis of alarms that needs immediate troubleshooting, e.g. NE isolation.
- **MAJ** – Major (Urgent) alarm. Orange color. Synthesis of alarms that needs immediate troubleshooting.
- **MIN** – Minor (Not Urgent) alarm. Yellow color. Synthesis of alarms for which a deferred intervention can be decided.
- **WNG** – Warning alarm. Cyan color. Synthesis of alarms due to failure of other NE in the network.
- **IND** - Indeterminate alarm. Blue color. Synthesis of alarms not associated with the previous severities. Not operative.

Management States area

Icons in this area give an immediate view of the management states of the supervised NE. The meaning of the icons is explained here below:

- **LAC** icon: Local Access Control state. Indicates whether the NE is managed by a WebEML or by the OS.

- **COM** icon: Operational state. Indicates whether the communication with the NE is established or not.
- **SUP** icon: Supervision state. Indicates whether the NE is under supervision or not.
- **OS** icon: indicates whether or not the OS is connected.
- **NTP** icon: indicates whether or not the NTP Server is reachable.
- **AC** icon: abnormal condition state. Indicates whether some abnormal conditions have been recognized. The operator can visualize the Abnormal condition through the Diagnosis → Abnormal condition list menu.

8.5 Board-specific managed features

Each board supported by 9500 MPR has a specific set of supported features, starting from the configuration parameters.

8.6 System Configuration options

The configuration options applicable at system level are easily accessible in the main WebEML Toolbar area. The complete list is reported here below:

- Block Diagram View
- Current Configuration View
- Cross-Connections
- Segregated ports
- Ethernet Ring
- LAG Configuration
- QoS Configuration
- AUX Cross Connections
- XPIC Configuration
- VLAN management
- WT Performance Monitoring Suite

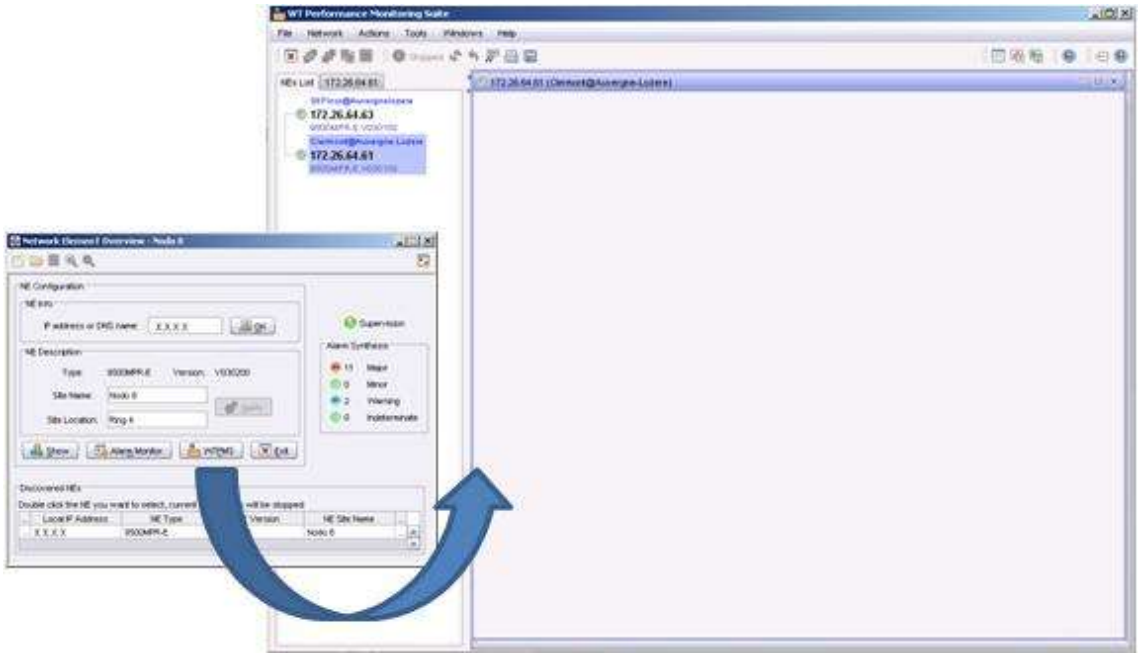
8.6.1 WT Performance Monitoring Suite

WTPMS is a Java based application, specifically designed for the Performance Monitoring handling.

Thanks to his graphical shape, it allows an easy management of all the PM data collected on a single NE or on a small 9500 MPR network.

Starting from NEtO window (from which is also possible to start the Alarm Monitor application) the WTPMS is opened on the NE under supervision.

It's also possible to start the WTPMS from WebEML, by clicking the dedicated icon in the Tool Bar or selecting it through the → Diagnosis → Performance Monitoring menu.

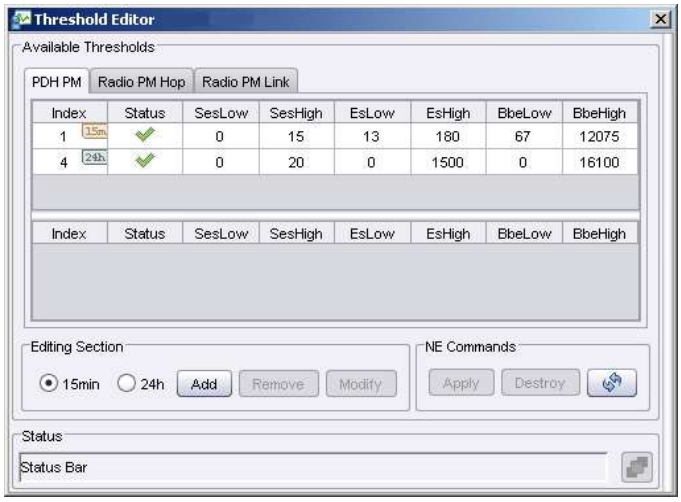


At this point, the starting window appears allowing a wide range of actions; directly from toolbar, amongst the other is possible to:

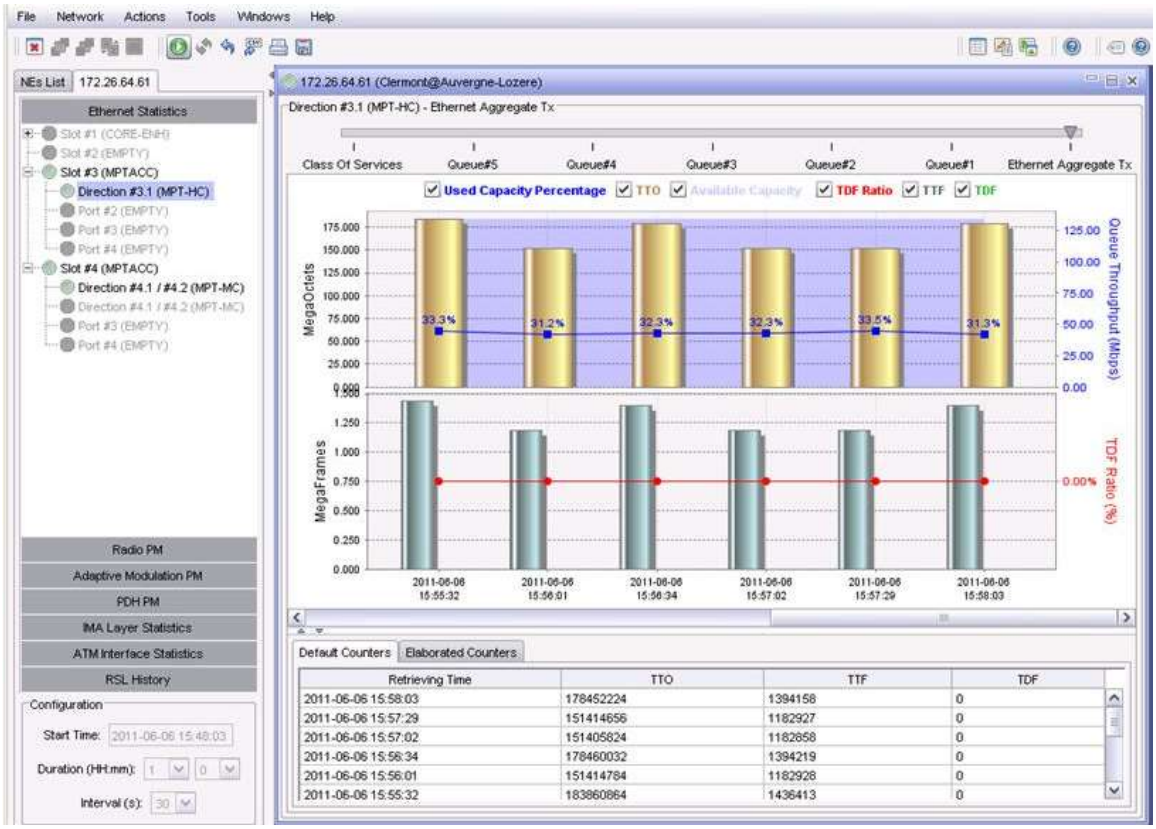
- Start/Stop the counters for the data collection, when the Current Data have been stopped or started;
- Refresh the current PM reports form NE and update the table view and chart view with the recently collected data;
- Reset the data collection and related counters;
- Export the generated reports;
- Print the user selected performance data;
- Turn on the Offline Mode, which allows an offline browsing of the saved PM data;
- Open the List View to display all the PM counters in a tabular format;
- Overview of all the PM counters in a graphic format;
- Open the Bird's Eye View, displaying the selected PM counter in a graphical format with a wide range of visualization and navigation facilities (zoom in/out, auto-range etc.);
- Open the Threshold Editor window, to change the predefined thresholds values for ITU-T G.826 based PM measurements.

  ○Threshold setup triggers the Threshold Crossing Alarm (TCA)

  ○Thresholds can be configured on the following counters: BBE, ES and SES.



Amongst the other, the Bird's Eye View allows browsing and visualizing the Ethernet statistics in an elaborated way (a sample picture is here below); in this windows the Tx Data queues are showed singularly or aggregated, supplying the output throughput in Mbps and the percentage of Tx discarded frames (TDF ratio). The latter value is a clear indication of possible issues in Tx side, due to traffic over commitment or Radio channel capacity saturation.

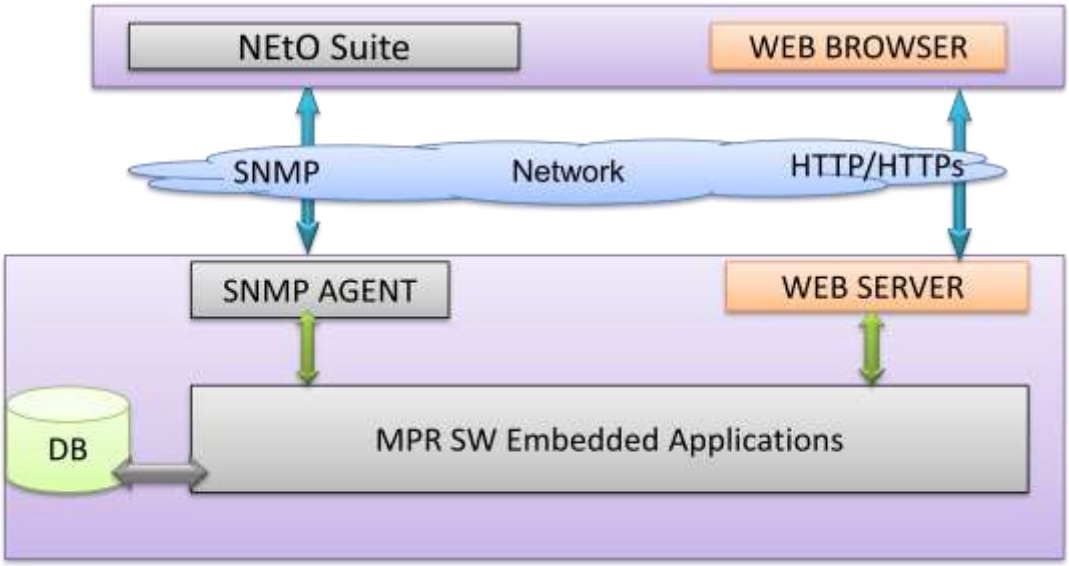


9 9500 MPR configuration & maintenance

A new management architecture allows the A full WEB solution povides the following improvements

- Zero installation on user PC: WEB interface is loaded on Network Element
- JAVA installation not required
- No version compatibility between GUI and Embedded SW
- Performance improvement
- Simplified procedures for daily operation
- Cross-platform: no dependency from OS, device, browser

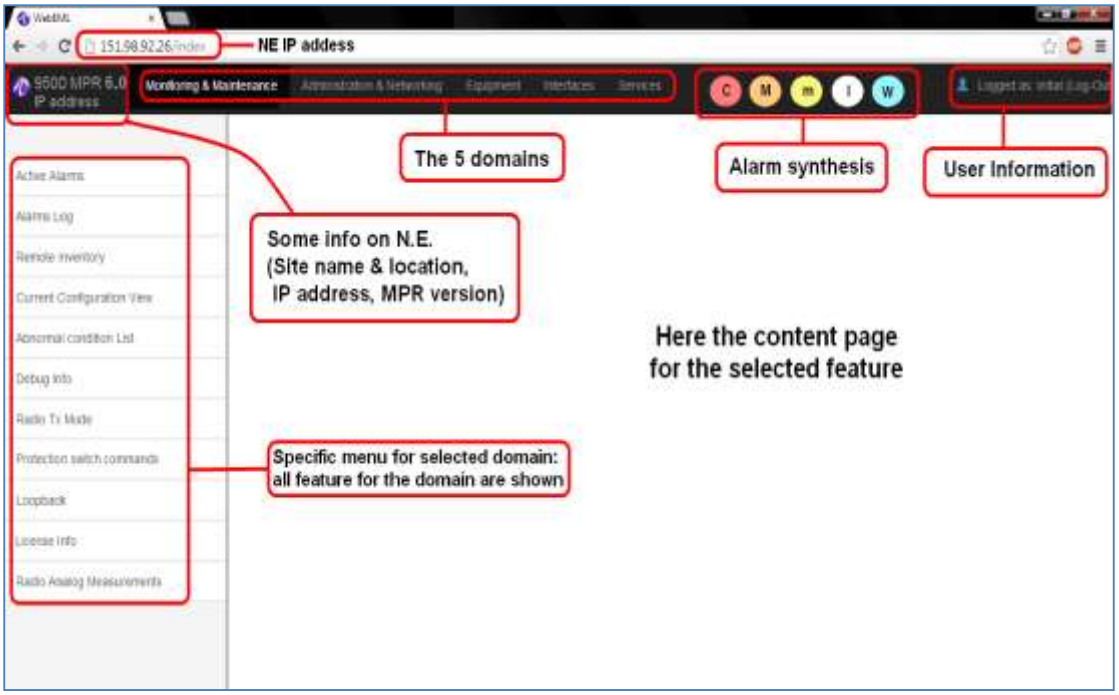
Some of the above feature might be available in the coming releases



General info on NE, Alarm synthesis and Connected User are always visible on top

Navigation is always performed starting from the Domains on the top bar, and then selecting the specific feature from the domain menu on the left.

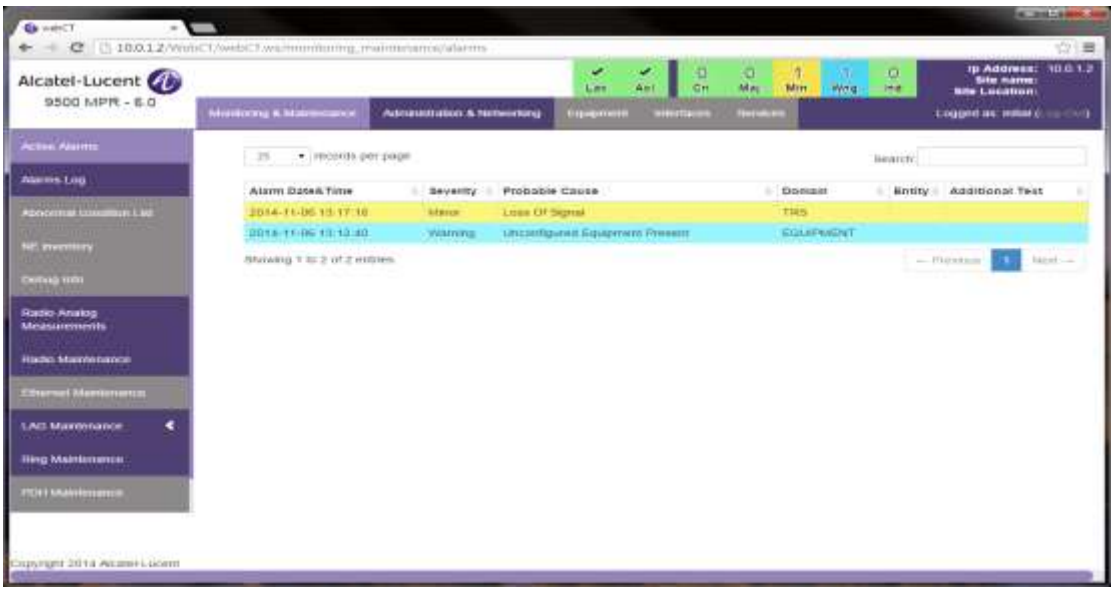
Views and controls for the selected feature are shown in the content page.



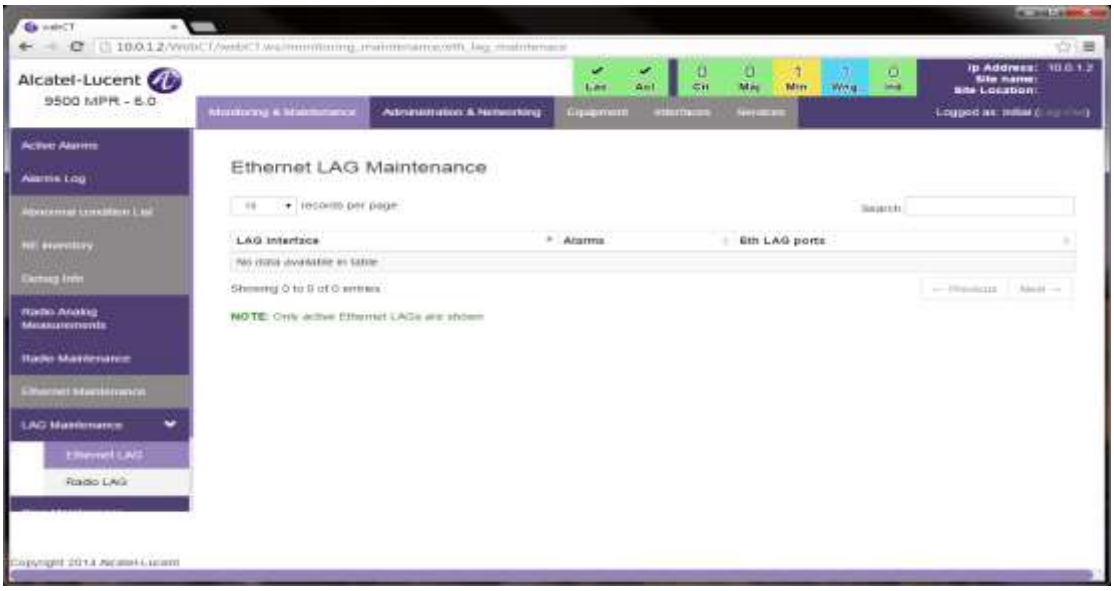
DOMAIN APPROACH

- MONITORING & MAINTENANCE

All the functionalities and tools which are useful to monitor the status of the NE and to operate some actions on interfaces, in order to maintain the working configuration.
Functions: Active Alarms, Alarms Log, Current Configuration View + Remote Inventory, Abnormal Condition List, NE inventory, Debug Info, Radio Analog Measurements, Loopback, Radio Tx Mute, Combiner Squelch, ACM Manual Operation, Protection Switch Commands, Ethernet Maintenance, LAG Maintenance



Monitoring & Maintenance: Active Alarms



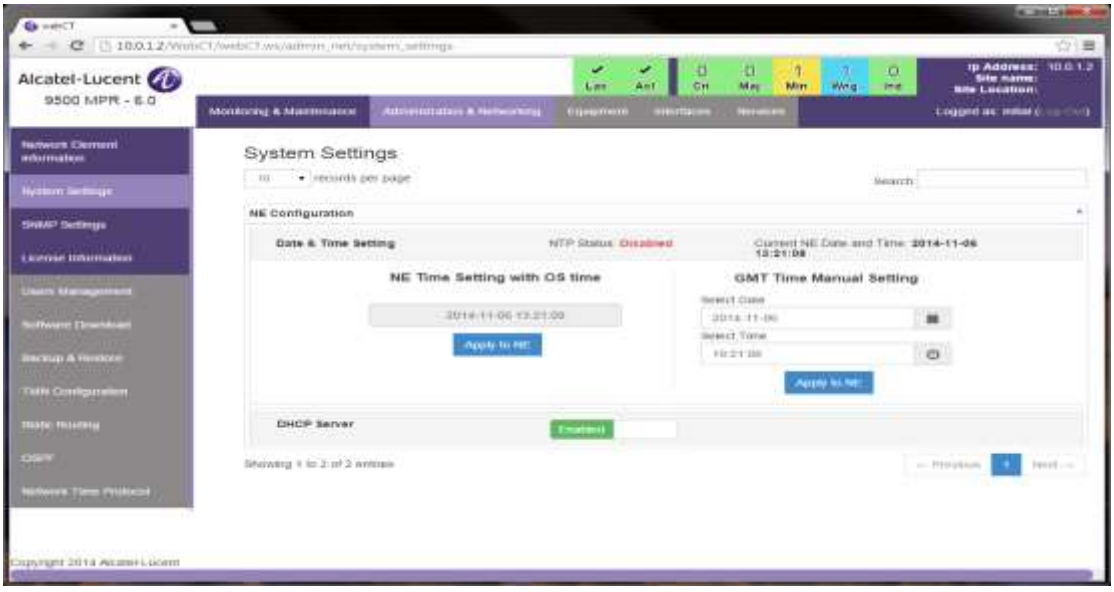
Monitoring & Maintenance: Ethernet LAG Maintenance

- ADMINISTRATION & NETWORKING

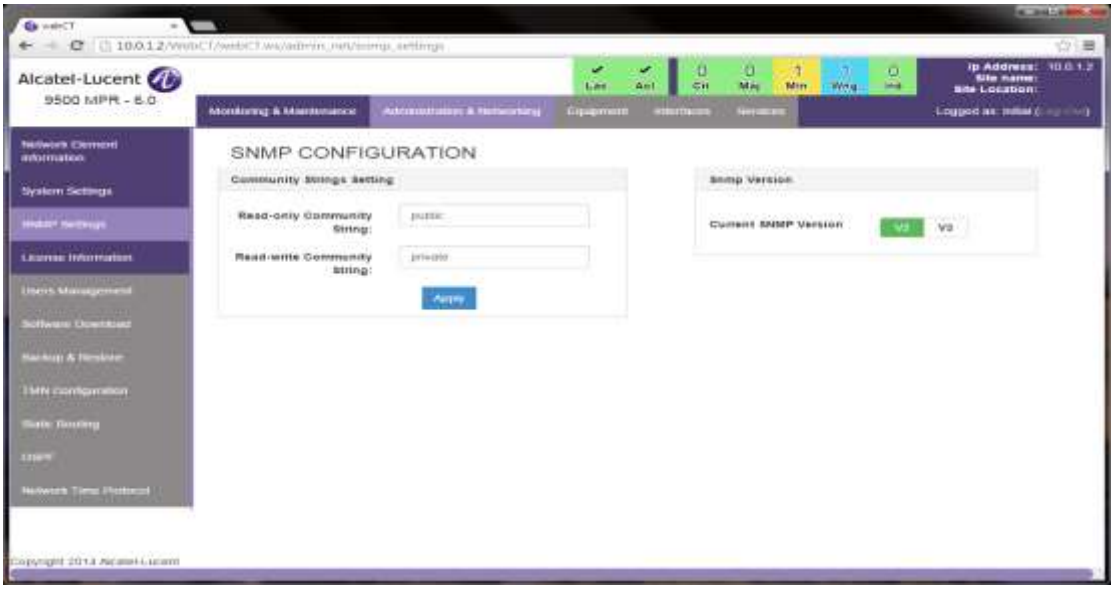
All the general settings on the NE: feature enabling, user and security management, SW downloads, networking configuration (Local IP, TMN, OSPF, Routing).

Administration Functions : Date & Time, DHCP enabling/disabling, SNMP version and community string, License, Users management, Backup & Restore, Alarms Severities, SW Download, System settings

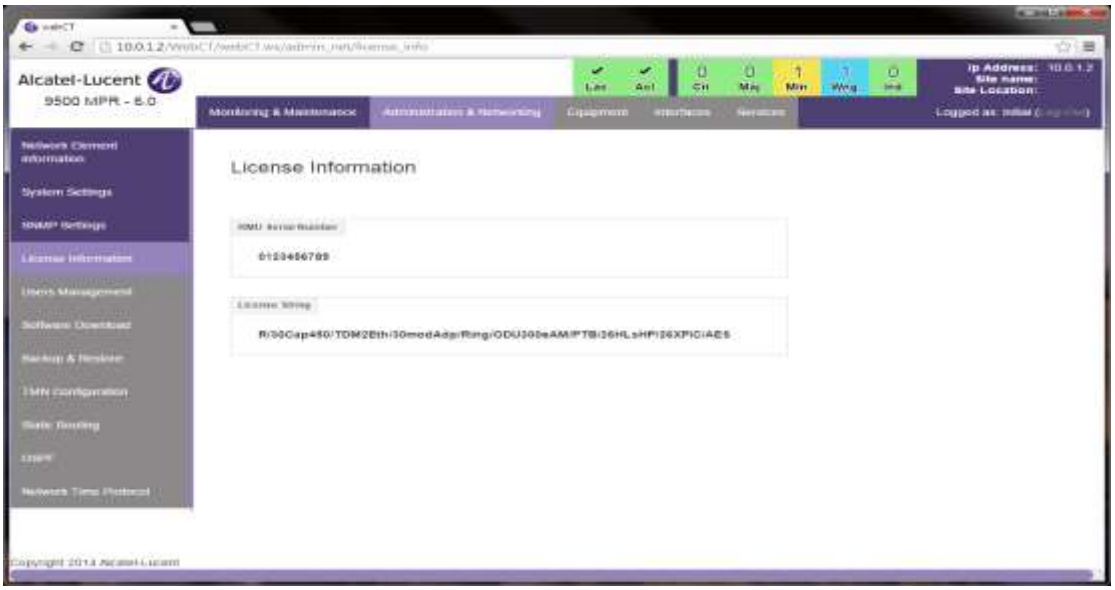
Networking Functions: Local Address Configuration, TMN configuration, OSPF v2/v3, Static Route, NTP, IPv6 management



Administration & Networking: System Settings



Administration & Networking: SNMP Settings



Administration & Networking: License Information

- COMMISSIONING – EQUIPMENT

All features which configure the HW level and make it operative and ready to be configured: Boards, ODUs, protections.
Complete Equipment configuration, protection, synchronization, Power Over Ethernet

- COMMISSIONING – INTERFACES

All the feature which configure the parameters for transmission interfaces
Radio, Ethernet, E1/DS1, SDH, AUX interfaces complete configuration, Ring, LAG

- SERVICES

All the features that make the traffic running through the Network Element interfaces.
Cross-connections, VLAN configuration, Port Segregation

10 RTU

This chapter describes the 9500 MPR Rigth To Use (RTU) policy. 9500 MPR offers a pay as-you-grow concept in which future capacity growth and additional functionality can be enabled through Rigth To Use.
Alcatel-Lucent provides a web-based system for managing activation keys (LKDI). This system enables authorized users to generate activation keys, which are generated per device serial number.
In order to upgrade an activation key, the activation key must be entered into the 9500 MPR. The system checks and implements the new activation key, enabling access to new capacities and/or features.

Here the list of RTU available with the current release

RTU name	RTU Application (Per radio/per node/per card)	Description	Applicability
RTU Packet Throughput Booster	Per node	It enables Packet Throughput Booster feature	Radio: All radios Indoor: MSS-1/8, MSS-1c, MPR-e & MSS-O
RTU encryption (AES)	Per node	It enables encryption AES	Radio: All radios except MPT-MC Indoor: MSS-1/8, MSS-1c, MPR-e & MSS-O
RTU Multi Service Ring Protection	Per node	It enables IEE G.8032 MultiService Ring Protection	Radio: All radios Indoor: MSS-1/8 & MSS-O
RTU SDH Channelized	Per card	It allows configuration of SDH plug-in in channelized (mux/demux) mode	Radio: All radios Indoor: MSS-8
RTU Synchronous Ethernet	Per node	It enables synchronous Ethernet functionalitity for Ethernet ports of : core card, EAS card, MSS1, MSS-O and MSS-1c	Radio : All radios Indoor: MSS-1/8, MSS-1c & MSS-O

RTU Multichannels	Per LAG group	It allows Multichannel LAG L1 up to 2+0 , up to 4+0, up to 8 +0 (using EASv2 card)	Radio : All radios Indoor: MSS-8
RTU Adaptive Modulation	Per radio	It enables the usage of Adaptive Modulation	Radio : All radios Indoor: MSS-1/8, MSS-1c, MPR-e & MSS-O
RTU xx Mbps Capacity	Per radio	It allows a radio throughput (=net bir rate) up to xx Mbit/sec. Please refer to the below table for the association modem profiles vs required RTU	Radio : All radios Indoor: MSS-1/4/8, MSS-1c, MPR-e & MSS-O
RTU XPIC	Per radio	It enables XPIC	Radio : MPT-HQAM/ MPT-XP-HQAM / MPT-HL Indoor: MSS-1/4/8, MSS-1c, MPR-e & MSS-O
RTU xx Mbps Capacity per LAG group	Per LAG group	In case of channel in LAG L1 this licence is allowing to use a globale capacity up to xx Mbit/sec. This licence is used on top of the licence for multichannel features but replace the licence for capacity for each RT.	Radio : All radios Indoor: MSS8, MSS-O
RTU MPT HLs High power version	Per radio	It enables the possibility to reach PTx 35 dBm	Radio : MPT-HL Indoor: MSS-1/8
RTU 1588TC	Per node	It enables 1588 Transparent clock on core10G card and/or on the radios that can support 1588 TC (example: MPT-HQAM,...)	Radio : all Indoor: MSS-1/4/8, MSS-1c, MPR-e & MSS-O
RTU MSSOL1LAG	Per node	It enables LAG 2+0 feature on MSS-0	Radio : all Indoor: MSS-O

Note1: ODU300 not considered; please refer to user manual for details.

Note2: for “indoor” it is intended the boxconnected to the radio; usually it is indoor (hence the name) for split mount/full outdoor configurations, but it can be outdoor as well (MSS-O) or even missing (MPR-e, .i.e. all outdoor radios)

The following table describe the association between capacity RTU and modem profile.
It shall be noted that

- Minimum capacity foreseen for MPT-HLs is 150 Mbit/sec;
- In case of a node with mixed MPT-XC and MPT-HL the capacity licence is related to the specific MPTs.
- In case of adaptive modulation, the capacity RTU defines implicitely the maximum modulation that can be used: as example, in 40 MHz channel spacing, 300 Mbit/sec RTU allows the usage of 1024QAM as maximum modulation scheme (2048QAM can not be used because it does require 350 Mbit/sec RTU)

	QPSK	16 QAM	32 QAM	64 QAM	128 QAM	256 QAM	512 QAM	1024 QAM	2048 QAM
3,5 MHz	40	40	40	40	40	40	x	x	x
7 MHz	40	40	40	40	40	40	60	60	x
14 MHz	40	40	60	60	80	80	100	100	130
28 MHz	40	80	100	130	150	150	220	220	220
30 MHz	40	80	100	130	150	150	220	220	
40 MHz	60	130	150	150	220	300	300	300	350
50 MHz	80	150	220	220	300	350	350	450	450
56 MHz	80	150	220	220	300	350	450	450	500

11 Standards

Product family compliance to international standards and decision is reported in below tables.
For a specific mapping with respect to the different MPR subunits, pls refer to the MPR User Manual.

11.1 ITU-T & ITU-R standards

ITU-R

ITU-R F.382: Radio-frequency channel arrangements for fixed wireless systems operating in the 2 and 4 GHz bands.

ITU-R F.1099: Radio-frequency channel arrangements for high- and medium capacity digital fixed wireless systems in the upper 4 GHz (4 400-5 000 MHz) band.

ITU-R F.635: Radio-frequency channel arrangements based on a homogeneous pattern for fixed wireless systems operating in the 4 GHz (3 400-4 200 MHz) band.

ITU-R F.383: Radio-frequency channel arrangements for high-capacity fixed wireless systems operating in the lower 6 GHz (5 925 to 6 425 MHz) band.

ITU-R F.384: Radio-frequency channel arrangements for medium- and high capacity digital fixed wireless systems operating in the upper 6 GHz (6 425-7 125 MHz) band.

ITU-R F.385: Radio-frequency channel arrangements for fixed wireless systems operating in the 7 GHz (7 110-7 900 MHz) band.

ITU-R F.386: Radio-frequency channel arrangements for fixed wireless systems operating in the 8 GHz (7 725 to 8 500 MHz) band.

ITU-R F.387: Radio-frequency channel arrangements for fixed wireless systems operating in the 11 GHz band.

ITU-R F.497: Radio-frequency channel arrangements for fixed wireless systems operating in the 13 GHz (12.75-13.25 GHz) frequency band.

ITU-R F.636: Radio-frequency channel arrangements for fixed wireless systems operating in the 14.4-15.35 GHz band.

ITU-R F.595: Radio-frequency channel arrangements for fixed wireless systems operating in the 17.7-19.7 GHz frequency band.

ITU-R F.637: Radio-frequency channel arrangements for fixed wireless systems operating in the 21.2-23.6 GHz band.

ITU-R F.746: Radio-frequency arrangements for fixed service systems.
ITU-R F.748: Radio-frequency arrangements for systems of the fixed service operating in the 25, 26 and 28 GHz bands.

ITU-R F.749: Radio-frequency arrangements for systems of the fixed service operating in sub-bands in the 36-40.5 GHz band.

ITU-R F.2006: Radio-frequency channel arrangements for fixed wireless systems operating in the 71-76 and 81-86 GHz bands.

ITU-R F.592 Vocabulary of terms for the fixed service

ITU-R F.1101 Characteristics of digital fixed wireless systems below about 17 GHz

ITU-R F.1102 Characteristics of fixed wireless systems operating in frequency bands above about 17 GHz

ITU-R F.1191-1-2 Necessary and occupied bandwidths and unwanted emissions of digital fixed service systems

ITU-R F.1330 Performance limits for bringing into service the parts of international PDH and SDH paths

ITU-R F.1668 Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections

ITU-R F.1703 Availability objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections

ITU-T

ITU-T G.664 Optical safety procedures and requirements for optical transport systems

ITU-T G.702 Digital hierarchy bit rates

ITU-T G.703 Physical/electrical characteristics of hierarchical digital interfaces

ITU-T G.704 Synchronous frame structures used at 1544, 2048 kbps hierarchical levels

ITU-T G.706 Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in Recommendation G.704

ITU-T G.707 Network node interface for the synchronous digital hierarchy (SDH)

ITU-T G.775 Loss of Signal (LOS), Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) defect detection and clearance criteria for PDH signals

ITU-T G.781 Structure of Recommendations on equipment for the SDH

ITU-T G.784 Management aspects of synchronous digital hierarchy (SDH) transport network elements

ITU-T G.803 Architecture of transport networks based on the synchronous digital hierarchy

ITU-T G.805 Generic functional architecture for transport networks
ITU-T G.806 Characteristics of transport equipment - Description methodology and generic functionality

ITU-T G.808-1 Generic protection switching

ITU-T G.810 Definitions and terminology for synchronization networks

ITU-T G.811 Timing requirements at the outputs of primary reference clocks suitable for plesiochronous operation of international digital links

ITU-T G.812 Timing requirements at the outputs of slave clocks suitable for plesiochronous operation of international digital links

ITU-T G.813 Timing characteristics of SDH equipment slave clocks (SEC)

ITU-T G.821 Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an Integrated Services Digital Network

ITU-T G.822 Controlled slip rate objectives on an international digital connection

ITU-T G.823 The controls of jitter and wander within digital networks that are based on the 2048 kbps hierarchy

ITU-T G.825 The control of jitter and wander within digital networks which are based on SDH

ITU-T G.826 End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections

ITU-T G.828 Error performance parameters and objectives for international, constant bit rate synchronous digital paths

ITU-T G.829 Error performance events for SDH multiplex and regenerator sections

ITU-T G.831 Management capabilities of transport networks based on the Synchronous Digital Hierarchy (SDH)

ITU-T G.957 Optical interfaces for equipments and systems relating to the synchronous digital hierarchy

ITU-T G.7043 Virtual concatenation of PDH signals

ITU-T G.7710 Common equipment management function requirements

ITU-T G.8010 Architecture of Ethernet layer networks

ITU-T G.8011 Ethernet over Transport - Ethernet services framework

ITU-T G.8011.1 Ethernet private line service

ITU-T G.8011.2 Ethernet virtual private line service

ITU-T G.8012 Ethernet UNI and Ethernet over transport NNI

ITU-T G.8021 Characteristics of Ethernet transport network equipment functional blocks
ITU-T G.8032 Ethernet ring protection switching

ITU-T G.8261 Timing and synchronization aspects in packet networks

ITU-T G.8262 Timing characteristics of a synchronous Ethernet equipment slave clock

ITU-T G.8264 Distribution of timing through packet networks

ITU-T Y.1291 An architectural framework for support of QoS in packet networks

ITU-T Y.1541 Network performance objectives for IP-based services

11.2 ETSI

ETSI EN 302 217 – Parts 1,2,3,4 - Fixed Radio Systems; Characteristics and requirements for the use of equipment and antennas in system point-to-point

ETSI TR 101 506 - Fixed Radio Systems; basic definitions, terminology and applicability of the essential requirements given in Article 3.2 Directive 1999/05/EC on the fixed radio systems;

ETSI TR 101 036 - Fixed Radio Systems; basic definitions for standards relating to digital fixed radio systems (DFRS);

ETSI TR 102 243 - Fixed Radio Systems; Representative values for the transmitter power and antenna gain for the analysis of inter-and intra-compatibility and sharing;

ETSI EG 201 399 - Electromagnetic compatibility and ERM; Guidelines for the preparation of harmonized standards for application under the R & TTE Directive;

ETSI EN 300 019 : "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment. Part 1-2-3

ETSI EN 301 126-1 : "Fixed Radio Systems; Conformance testing; Part 1: Point-to-Point equipment - Definitions, general requirements and test procedures

ETSI EN 301 126-3-1: "Fixed Radio Systems; Conformance testing; Part 3-1: Point-to-Point antennas; Definitions, general requirements and test procedures

11.3 EU directive

Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

11.4 ECC

ERC/REC 14-03 E - Harmonized arrangement of channels and blocks designed for low and medium capacity in the band of 3400-3600 MHz;

ERC/REC 12-08 E - Harmonized arrangement of channels and blocks designed for systems of small, medium and large capacity in the band of 3600-4200 MHz;
ERC/REC 14-01 E - Distribution of radio frequency channels for analog and digital radio relay systems in large capacity the band 5925-6425 MHz;

ERC/REC 14-02 E - Distribution of radio frequency channels of digital systems is large, medium and small capacity in fixed service in the band of 6425-7125 MHz;

ECC/REC/(02)06 - Distribution of channels for digital systems in the fixed service in the band 7125-8500 MHz;

ERC/REC 12-05 E - Harmonized radio frequency channel arrangement for digital terrestrial fixed systems in the band 10.0-10.68 GHz;

ERC/REC 12-06 E - Preferential distribution of channels for systems in the fixed service in the band of 10.7 - 11.7 GHz;

ERC/REC 12-02 E - Harmonized radio frequency channel arrangement for analogue and digital terrestrial fixed systems in the band 12.75-13.25 GHz;

ERC/REC 12-07 E - Harmonised radio frequency channel arrangement for digital terrestrial fixed systems in the band 14.5-14.62 GHz GHz paired with 15:23 to 15:35;

ERC/REC 12-03 E - Harmonized radio frequency channel arrangement for digital terrestrial fixed systems in the band 17.7-19.7 GHz;

T/R 13-02 E - Preferential distribution of channels for systems in the fixed service in the band 22.0-29.5 GHz;

REC T/R 12-01 - Preferential distribution of channels for systems in the fixed service in the band of 37-39.5 GHz;

ECC/REC/(09)01 - Use of the band 57-64 GHz for fixed wireless point-to-point systems;

ECC/REC/(05)02 - Use of the band 64-66 GHz for for fixed service;

ECC/REC/(05)07 - Distribution channel systems in the fixed service in the band 71-76 GHz and 81-86 GHz;

2. ECC REP 124 - Coexistence of passive and fixed service in the bands 71-76/81-86 GHz;

IEC Standards

IEC 60153	Hollow metallic waveguide
IEC 60154 Parts1-7	Flanges for waveguides. Part 1-7
IEC 60529	Degrees of protection provided by enclosures (IP code).
IEC 60657	Non-ionizing radiation hazards in the frequency range 10 MHz to 300 000 MHz
IEC 60950-1	Information technology equipment – Safety Part 1: General requirements
IEC 61000-4	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques
IEC 721-3	1,2,3,4 Classes - Classification of environmental conditions including classes: 1K4, 1Z2, 1Z3, 1Z5, 1B2, 1C2, 1S3, 1M2 2K4, 2B2, 2C2, 2M2 3K5, 3Z2, 3Z4, 3B2, 3C2(3C1), 3S2, 3M2 4K2, 4Z5, 4Z7, 4B1, 4C2(4C3), 4S2, 4M5
IEC EN 55022	Information technology equipment — Radio disturbance characteristics — Limits and methods of measurement
IEC EN 60825-1 and -2	Safety of laser Products
IEC EN 62311	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)
IEC EN 60215	Safety requirements for radio transmitting equipment

IEEE standards

802.1ad	Virtual Bridge LAN - Am.4: Provider Bridge
802.1ag	Virtual Bridged LAN - Am.5: Connectivity Fault Management
802.1AX	Standard for Local and metropolitan area networks – Link Aggregation
802.1D	MAC Bridges (rollup of 802.1D-1998, 802.1t, 802.1w, P802.1y, and 802.11c)
802.1p	Traffic Class Expediting and Dynamic Multicast Filtering
802.1Q	Standard for Local and Metropolitan Area Networks---Virtual Bridged Local Area Networks
802.3	
802.3u	100BASE-TX, 100BASE-T4, 100BASE-FX Fast Ethernet at 100 Mbit/s (12.5 MB/s) w/autonegotiation - Media Access Control Parameters, physical layer, medium attachment units and repeater for 100Mb/s operation
802.3x	Full Duplex and flow control. A mechanism for pause-based flow control is also added. Standards for Local and Metropolitan Area Networks: Specification for 802.3 Full Duplex Operation
802.3z	1000BASE-X Gbit/s Ethernet over Fiber-Optic at 1 Gbit/s (125 MB/s)
802.3ac	Frame Extensions for Virtual Bridged Local Area Network (VLAN) Tagging on 802.3 Networ
802.3ah	Ethernet in the First Mile (OAM) Media Access Control Parameters, Physical layers, and Management Parameters for Subscriber Access Networks
802.3as	Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications (Frame format extensions)

IETF standards

IETF RFC 0768	UDP: User Datagram Protocol
IETF RFC 0791	IP: Internet Protocol
IETF RFC 0793	TCP: Transmission Control Protocol
IETF RFC 0826	Ethernet address resolution protocol
IETF RFC 1305	Network Time Protocol (Version 3) Specification, Implementation and Analysis
IETF RFC 2212	Specification of guaranteed quality of service
IETF RFC 2474	Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers
IETF RFC 2475	"An Architecture for Differentiated Services", December 1998.
IETF RFC 2544	Benchmarking Methodology for Network Interconnect Devices
IETF RFC 2597	Assured forwarding PHB group
IETF RFC 2616	HTTP: Hyper Text Transfer Protocol
IETF RFC 2819	Remote Network Monitoring Management Information Base
IETF RFC 3032	MPLS Label Stack Encoding
IETF RFC 3246	An expedited forwarding PHB (Per-hop behavior)
IETF RFC 3916	Requirements for pseudo-wire emulation edge-to-edge (PWE3)