

7705 SAR 7705 SR
Mobile Backhaul

Student Guide

TER36075_V3.1-SG Edition 1

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Terms of use and legal notices

TERMS OF USE AND LEGAL NOTICE

Alcatel-Lucent provides this training course to you subject to these Terms of Use and Legal Notice. Your use of this training course and/or this site constitutes your acceptance of and agreement to these Terms of Use and Legal Notice. These Terms of Use and Legal Notice, as well as the contents of this training course, may be updated or amended by Alcatel-Lucent from time to time without prior notice to you. Your use of the Alcatel-Lucent training materials after such update or amendment constitutes your acceptance of and agreement to said updated or amended Terms of Use and Legal Notice.

SAFETY WARNING

Alcatel-Lucent training materials can be for products or refer to products that have both lethal and dangerous voltages present. Always observe all safety precautions and do not work on the equipment alone. The user is strongly advised not to wear conductive jewelry while working on the products. Equipment referred to or used during this course may be electrostatic sensitive. Please observe correct anti-static precautions.

PERMISSION TO USE CONTENT

The information, communications, scripts, photos, text, video, graphics, music, sounds, images and other materials provided in this training course (collectively the "Content"), is intended for the lawful use of employees of Alcatel-Lucent and other authorized participants in this Alcatel-Lucent training course. You are hereby granted a non-exclusive, non-transferable permission to access and use the Content solely for your personal training and non-commercial use. This permission may be terminated by Alcatel-Lucent at any time for any reason or no reason, with or without notice. You must immediately cease use of the Content upon such termination.

COPYRIGHTS AND TRADEMARKS

The unauthorized copying, displaying or other use of any Content from this training course is a violation of the law and Alcatel-Lucent's corporate policies. The Content is protected in France, the U.S. and other countries by a variety of laws, including but not limited to, copyright laws and treaty provisions, trademark laws, patent laws and other proprietary rights laws (collectively, "IP Rights"). In addition to Alcatel-Lucent's IP Rights in the Content, in part and in whole, Alcatel-Lucent, and any of the third parties who have licensed and/or contributed to the Content, owns a copyright in the formatting and presentation of the Content.

Alcatel-Lucent does not grant you any permission to use the Content other than the permission expressly stated in these Terms of Use and Legal Notice. All other use of Content from this training course, including, but not limited to, modification, publication, transmission, participation in the transfer or sale of, copying, reproduction, republishing, creation of derivative works from, distribution, performance, display, incorporation into another training course or presentation, or in any other way exploiting any of the Content, in whole or in part, for uses other than those expressly permitted herein is strictly prohibited and shall not be made without Alcatel-Lucent's prior written consent. All characters appearing in this training course are fictitious. Any resemblance to real persons, living or dead, is purely coincidental.

There may be a number of proprietary logos, marks, trademarks, slogans and product designations found in the Content. Alcatel, Lucent, Alcatel-Lucent and the Alcatel-Lucent logos are trademarks of Alcatel-Lucent. All other trademarks are the property of their respective owners. Alcatel-Lucent does not grant you a license to use any of the foregoing logos, marks, trademarks, slogans and product designations in any fashion. Granting of the right to access and use the Content for training purposes does not confer upon you any license under any of Alcatel-Lucent's or any third party's IP Rights.

DISCLAIMER

ALCATEL-LUCENT DISCLAIMS ALL WARRANTIES REGARDING THE TRAINING COURSES OR THE CONTENT, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THE ALCATEL-LUCENT WILL NOT BE RESPONSIBLE OR LIABLE FOR ANY INJURY, LOSS, CLAIM, DAMAGE, OR ANY SPECIAL, EXEMPLARY, PUNITIVE, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND (INCLUDING WITHOUT LIMITATION LOSS PROFITS OR LOSS SAVINGS), WHETHER BASED IN CONTRACT, TORT, STRICT LIABILITY OR OTHERWISE, THAT ARISES OUT OF OR IS IN ANY WAY CONNECTED WITH (A) ANY USE OR MISUSE OF THE CONTENT OR THE TRAINING COURSES BY YOU, OR (B) ANY FAILURE OR DELAY BY ALCATEL-LUCENT, ITS OFFICERS, DIRECTORS, AGENTS OR EMPLOYEES IN CONNECTION WITH THE CONTENT OR THE TRAINING COURSES (INCLUDING, WITHOUT LIMITATION, THE USE OF OR INABILITY TO USE ANY COMPONENT OF THE CONTENT OR TRAINING BY YOU). SOME JURISDICTIONS LIMIT OR PROHIBIT SUCH EXCLUSION OF WARRANTIES OR LIMITATION OF LIABILITIES AND SO THE FOREGOING EXCLUSION OF WARRANTIES OR LIMITATION OF LIABILITY MAY NOT APPLY TO YOU.

GOVERNING LAW

These Terms of Use and Legal Notice are governed by the laws of France. The operation and use of the training course is governed by the laws of the country that governs your employment contract, if applicable. If any provision of these Terms of Use and Legal Notice, or the application thereto to a person or circumstance, is held invalid or unenforceable by law, statute or a court of competent jurisdiction, for any reason, then such provision shall be modified and/or superseded by a provision that reflects the intent of the original provision as closely as possible. All other provisions of these Terms of Use and Legal Notice shall remain in full force and effect. You may not assign these Terms of Use or any permission granted hereunder without Alcatel-Lucent's prior written consent. Nothing herein shall be deemed an employment agreement or an offer of employment or an alteration in any way of a user's terms of employment with or within Alcatel-Lucent.

Copyright © 2013 Alcatel-Lucent. All Rights Reserved

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Course outline



1. Overview

Welcome to 7705 SAR 7705 SR Mobile Backhaul

1. Overview
    1. Backhaul Solutions and Architectures
    2. IP MPLS SR-OS Product Family
    3. 7705 SAR Product Overview
2. System Operation
    1. System Initialization and CLI
    2. Basic System and Hardware Configuration
3. Synchronization
    1. Synchronization Techniques for TDM Networks
4. IGP Routing
    1. IGP Routing
5. MPLS and GRE
    1. MPLS and GRE
6. High Availability
    1. High Availability
7. Ethernet OAM
    1. Ethernet OAM
8. QoS
    1. Quality of Service
9. Services
    1. Overview
    2. ePipe
    3. iPipe
    4. cPipe
    5. aPipe
    6. QoS Policies for VLL Services
    7. VPLS
    8. IES
    9. VPRN

Appendix 1-1 Seamless MPLS Overview

Appendix 1-2 Seamless MPLS Lab Exercise

Appendix 2 VSM Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Course objectives

7705 SAR 7705 SR
Mobile Backhaul

Upon completion of this course, you should be able to:

- Describe the 7750 SR , 7705 SAR, and 7210 SAS hardware and architecture
- Explain the 7705 SAR operating system
- Explain the routing protocols and MPLS used by the 7705 SAR and 7750 SR
- Describe the types of Ethernet and IP Backhaul services
- Explain the OAM tool types

Your feedback is appreciated!
Please feel free to Email your comments to:

training.feedback@alcatel-lucent.com

Please include the following training reference in your email:
TER36075_V3.1-SG Edition 1

Thank you!

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 1
Overview

Module 1
Backhaul Solutions and Architectures

TER36075_V3.1-SG-English-Ed1 Module 1.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to:

- Be familiar with several Mobile Backhaul network solutions

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 Different backhaul configuration options	**5**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Different backhaul configuration options

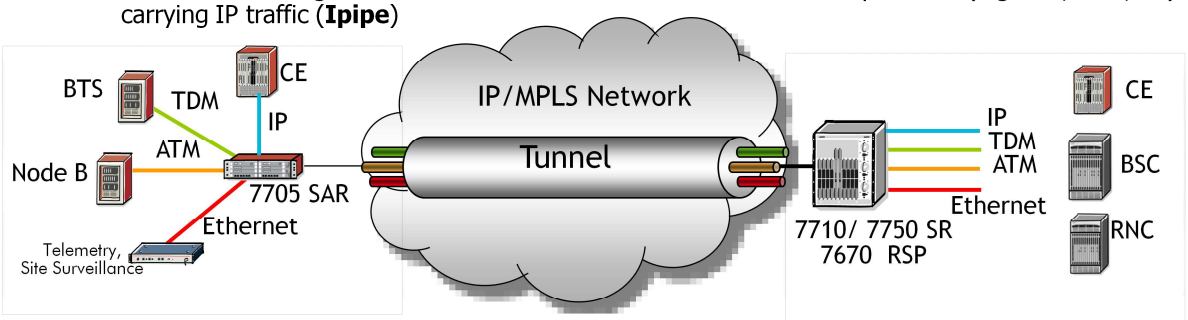
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Traditional backhaul configuration

Pseudo Wire

A layer-2 service that provides a point to point connection between two nodes

- To the access points, a pseudowire behaves as though a leased link exists between the two locations (the IP/MPLS core is invisible to the customer)
- A pseudowire can deliver:
  - ATM traffic (**Apipe**)
  - TDM traffic (**Cpipe**)
  - Ethernet traffic (**Epipe**)
  - Frame Relay traffic **(Fpipe)**
  - An internetworking combination between Ethernet and another encapsulation (e.g. PPP, ATM, FR) carrying IP traffic (**Ipipe**)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This type of service is called Virtual Private Wire Service (**VPWS**) or Virtual Leased Line (**VLL**).

Mobile Telephone Switching Office (MTSO) - The switching office to which all base station cell sites connect.

Base Transceiver Station (BTS) - The name for the antenna and radio equipment necessary to provide wireless service in an area. Also called a base station or cell site.

Radio Network Controller (RNC) - The Radio Network Control is the central control entity of Radio Network System in UMTS (Universal Mobile Telecommunications System) it is in charge of the overall control of logical resources provided by the Node Bs.

Base Station Controller (BSC) - The part of the wireless system's infrastructure that controls one or multiple cell sites' radio signals.

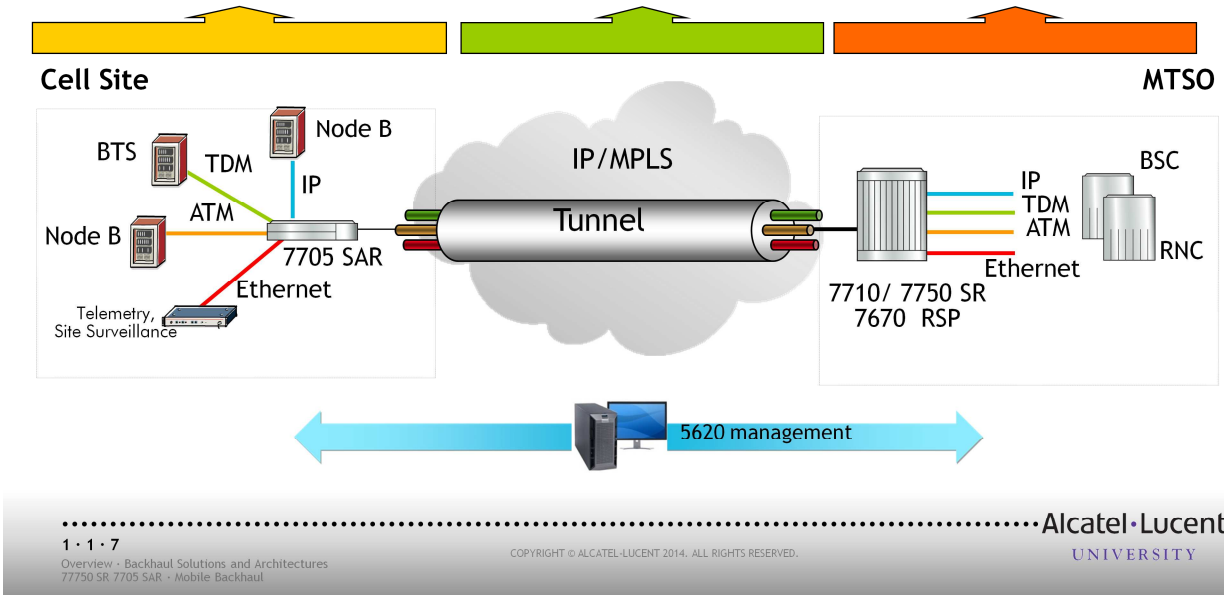
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Backhaul Overview: Pseudowires

7705 SAR used to terminate:
- TDM (T1/E1) (CESoP and SAToP)
- ATM IMA (N:1 Cell Mode)
- Ethernet (10/100/1000)
- IP (PPP/ML-PPP)

Aggregation:
- VLLs from the 7705 SAR traverse the MPLS/GRE network

Groomed Traffic Egress:
- Encapsulation is removed and the traffic is put on the wire



Using Pseudowires, operators may continue to use existing equipment and at the same time upgrade their network with highly scalable IP capabilities. This phased approach is preferred for some operators who have lots of CapEx already invested in traditional UMTS (Universal Mobile Telecommunications System) backhaul technologies.

The Pseudowires supported by the 7705 SAR include:

- TDM Pseudowire: CESoPSN SAToP
- ATM Pseudowire: rfc-4717 N:1 Cell Mode
- Ethernet Pseudowire rfc-4448 Aggregate or per-VLAN

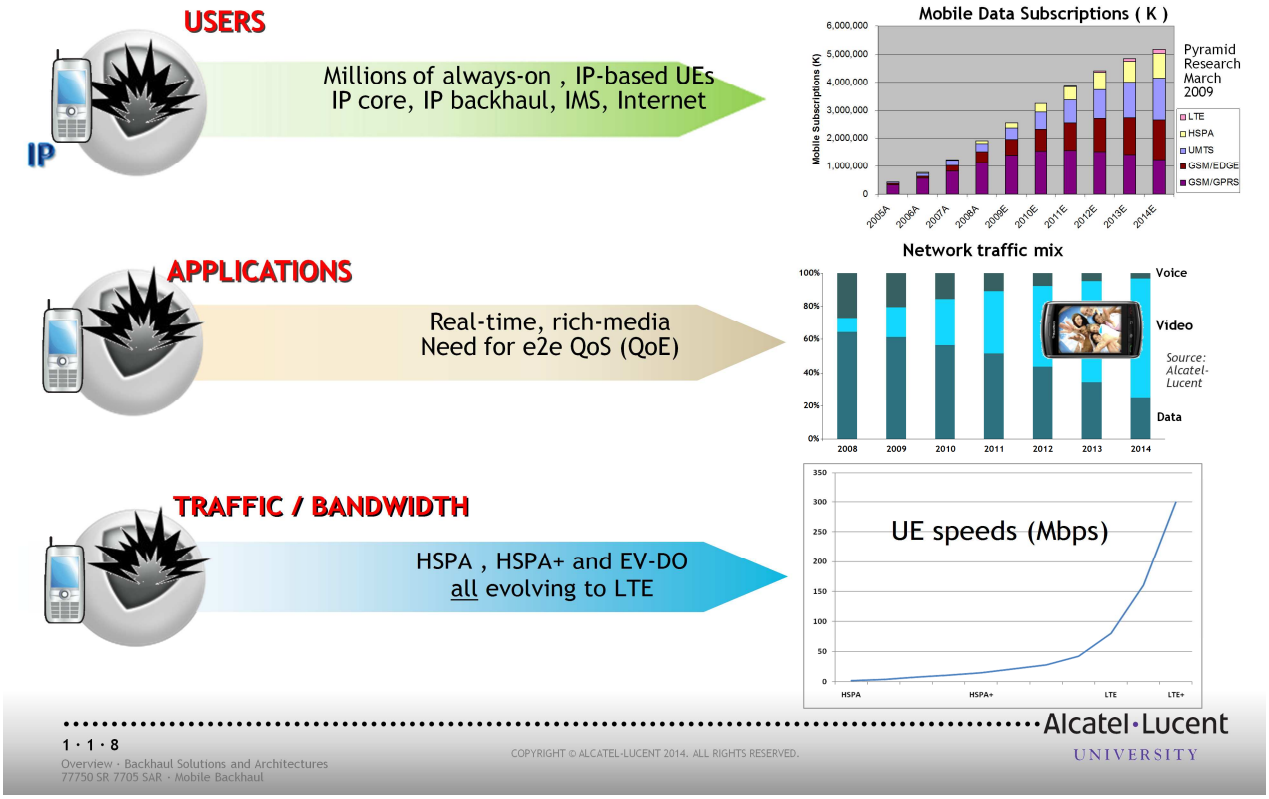
The MPLS PWE3 pseudowires are used to backhaul Ethernet, ATM & TDM traffic over packet transport:

- Minimizes premature obsolescence of embedded mobile infrastructure
- Eliminates underutilized links/channels for ATM (3G) and TDM (2G)
- Dynamic bandwidth “sharing” eliminates wasted bandwidth from multiple, low efficiency links rounded up to the next T1/E1
- Efficient transport of increasingly bursty data traffic
- Combines statistical gain with support for higher instantaneous peak rate
- Managing converged backhaul LSP tunnel reduces OPEX vs separate links/channels for 2G and 3G. Simplified reconfiguration as subscriber and bandwidth requirements shift provides further savings
- PWE3 preserves ATM stats gain, service differentiation and QoS

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Mobile operators become IP centric

Wireless operators are at a critical transition point: on the way to LTE, 4G, and "all-IP"



Nowadays, we can say that wireless operators are at a critical transition point. Some of them are still using the 2G, most of them are moving to 3G and all of them are thinking to move to LTE which is the 4G and all-IP solution.

From a user point of view, we have more and more users which are always on, with devices that are IP based and they expect to see an IP core and IP backhaul, an integration with IMS and the internet.

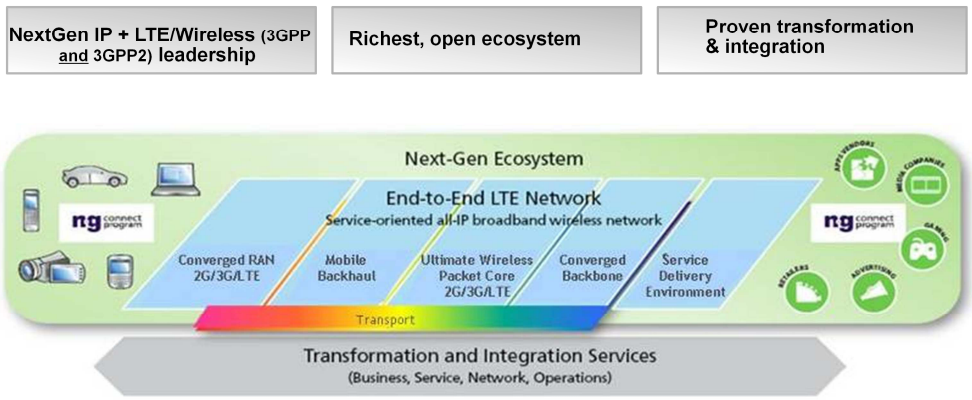
When we look to the chart about the evolution regarding the number of subscriptions we see more and more high-speed internet appearing. UMTS is finally entering in the game, HSPA is also booming and we do expect to see LTE quickly taking some place in the hierarchy.

From an application point of view, users are now looking for something else than simple telephony or simple text exchange. They would like to have real-time applications and, with the introduction of the smartphone, we see more and more people expecting to see rich media content. So they need to have an end-to-end QOS available just to carry this new mix of traffic. On the chart we see that the data part will probably decrease compared to the rest. The video part is booming.

This new set of applications has a direct impact on the traffic and on the bandwidth. With the introduction of new protocols like HSPA, HSPA+ and EV-DO, which are all evolving to LTE, the expectation is to see more and more throughput, more and more bandwidth expected out of the mobile network.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Alcatel-Lucent's End-to-End LTE Solution
A Cornerstone of the Wireless IP Evolution



Market-leading end-to-end LTE solution,
paving the way to a new wireless broadband business model

Alcatel-Lucent offers service provides a service-oriented partnership to evolve their wireless business model, their operational model and their network from end-to-end with a comprehensive set of:

- an open ecosystem of devices, content and application partners.
- transformation and integration services,
- LTE and IP products, integrated into an end-to-end network solution

Open LTE ecosystem

An open ecosystem of devices, content and applications enables innovative business and operational models — and speeds the launch of new services. The ng Connect Program, led by Alcatel-Lucent, brings together a non-traditional mix of partners, including device, content and application developers from the telecommunications, Web, media and consumer electronic industries. By working together on innovative new services, proof of concept development and integration with the end-to-end LTE network, you benefit from:

- Innovative service creation and new business models
- Reduced time to market

IP transformation and integration services

A full suite of IP transformation and integration services promotes smooth evolution to LTE, while minimizing risk. With these consulting, project management, multi-vendor integration, operations and managed network services, you can:

- Minimize the duration and cost of transforming to all-IP wireless
- Maximize LTE operational efficiency

End-to-end LTE network

Integrated LTE and IP products meet growing demand for bandwidth cost effectively, while supporting an enriched end-user experience. The Alcatel-Lucent solution combines flexible, software-defined LTE radio access with a flat-IP service-aware network — including a rich-IP Evolved Packet Core (EPC), IP transport solution, and field-proven Service Delivery Environment (SDE). You gain:

- Unprecedented scalability, cost efficiency, service agility and QoE for end users
- Smooth evolution and seamless service continuity from any wireless access technology (GSM, UMTS, CDMA, EV/DO, TD-SCDMA and LTE) this E2E solution approach is relevant for operator.

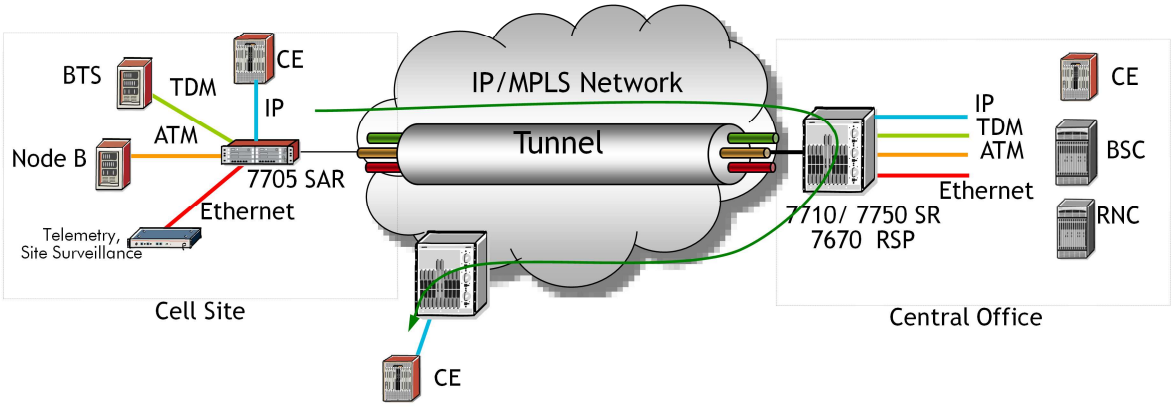
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Mobile operators become IP centric - continued

In the traditional backhaul, all traffic is transported from the cell site to the central office

Routing decisions for IP traffic would have to be made at the central office

This can introduce sub-optimalities (longer paths for packets)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

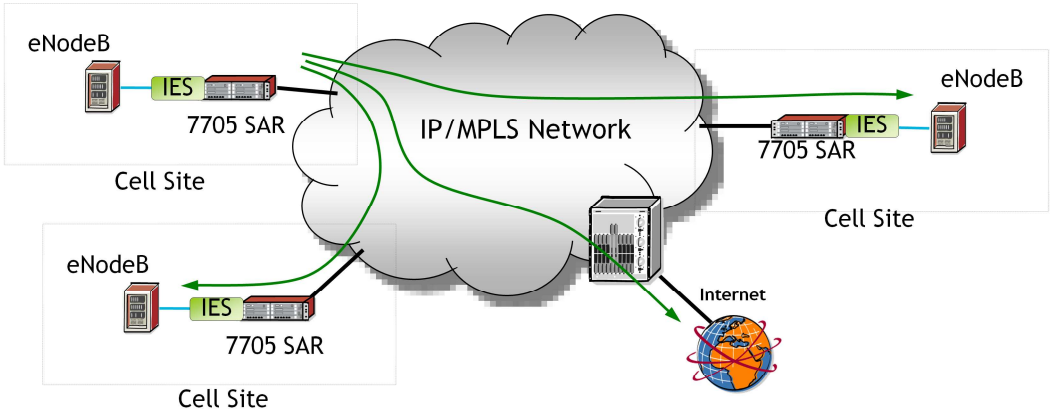
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Mobile operators become IP centric - continued

It makes sense to create layer-3 services at the cell site

- Packets can be forwarded from cell site based on destination IP address
- Shorter path than going to a centralized site first

- Option 1: IES



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

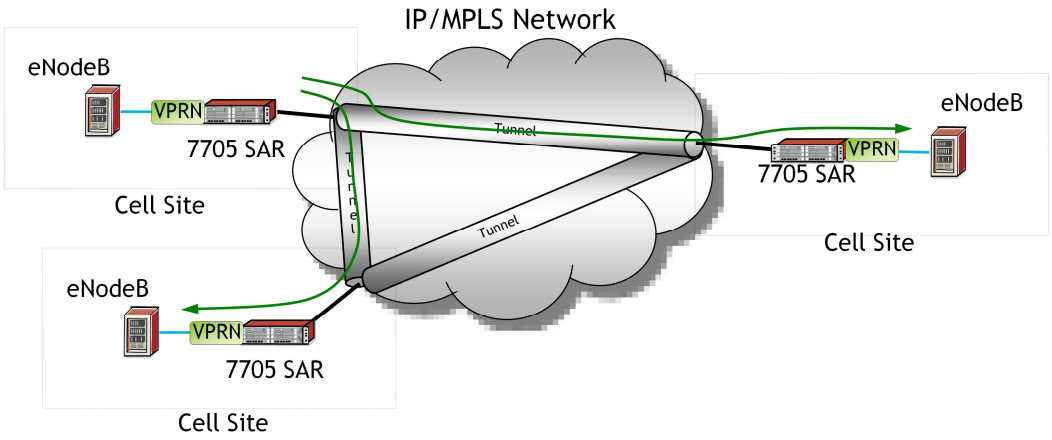
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Mobile operators become IP centric - continued

It makes sense to create layer-3 services at the cell site

- Packets can be forwarded from cell site based on destination IP address
- Shorter path than going to a centralized site first

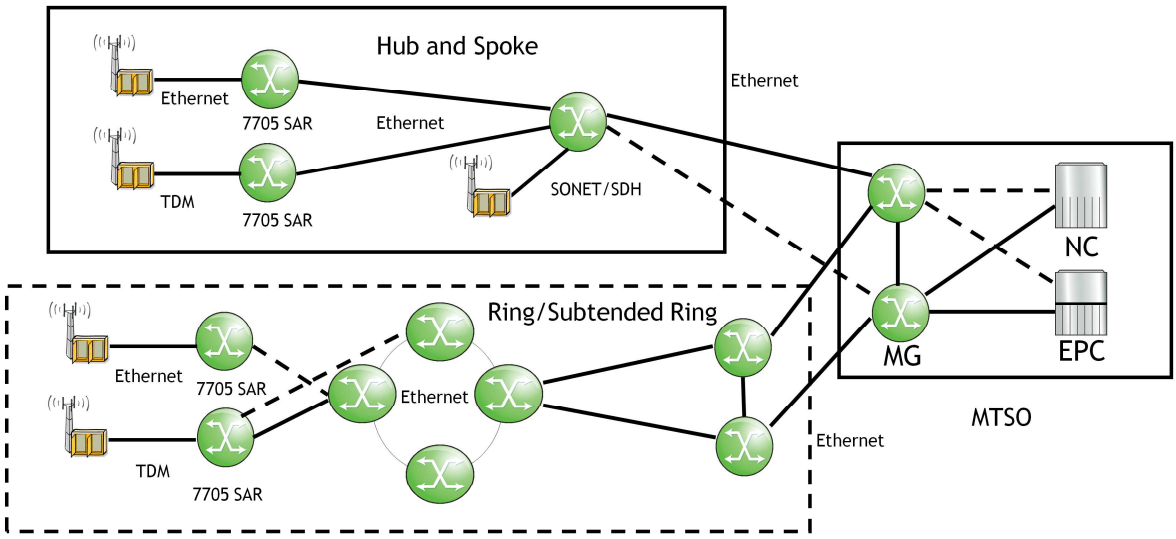
- Option 2: VPRN



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Backhaul Network Physical Topologies



Backhaul physical topologies:
- Hub and Spoke
- Ring/Subtended ring –partial or full mesh

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Hub and Spoke

●Virtual Leased Line (VLL) services transporting cell site traffic into 7750 SR local VPLS and VPRN Services

●The MG routers become the hub sites, aggregating traffic for potentially thousands of cells. This model uses VLL services, ePipes, cPipes, and others, with end points on the 7705 SAR and the 7750 SR routers. The 7750 SR routers route traffic onto the NC elements .

Ring and Subtended Ring

●VLL services transporting cell site traffic into Distributed Virtual Private Routed Network (VPRN) services

●The ring and subtended ring topologies require partial or full mesh service connectivity for high reliability and resiliency. Here we see distributed services deployed, such as Layer 3 VPN Virtual Private Routed Network (VPRN) services from 7750 SR to the 7705 SAR.

However, for better scalability, the service provider could break its routing domain into areas, and deploy distributed and point-to-point services at different aggregation, or concentration, levels.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service Connectivity by Technology

	Connectivity	BS/NodeB to Network Controller (NC)			BS-BS
Wireless Technology	Transport type	TDM (cPipe/ iPipe)	ATM (aPipe)	IP/Ethernet (ePipe/VPLS/ VPRN/IES)	IP/Ethernet (ePipe/VPLS/ VPRN/IES)
GSM		X		X	
UMTS			X	X	
CDMA 1x Voice		X	X	X	
CDMA 1x Data				X	
LTE				X	X

Connectivity and technology determine the type of service used between the Base Station/NodeB and the Network Controller

TDM, ATM, and IP Inter-working VPWS for legacy 2G and 3G services

Ethernet VPWS/VPLS/VPRN or IES for Ethernet connected BS, NodeB, and eNodeB

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Service Connectivity by Technology

In both the Hub and Spoke and Subtended Ring topologies, the type of Base Station, NodeB, and wireless technology determine the service deployed. Additionally, the service provider type, BTP (Backhaul Transport Provider) or MSP (Mobile Service Provider) also influences the services used to carry traffic through the transport network.

TDM Base Stations

GSM (Global System for Mobile Communication) base stations may use DS1 or E1 links to carry traffic to the 7705 SAR router. These could either be individual links, or bundles. In the case the Base Station uses individual links, a cPipe service may be employed to carry traffic from the 7705 SAR to the 7750 SR routers. Where MP bundled links are deployed, an iPipe may be used. Ethernet-capable Base Station use ePipe services, which can be terminated either at a 7750 SR.

TDM NodeB

CDMA (Code Division Multiple Access) NodeBs use bundled DS1s or E1s to carry traffic to the 7705 SAR or directly to the NodeB. Where terminated on the 7705 SAR, an iPipe provides the transport. Where terminated on the 7750 SR directly, an IES or VPRN provides the MTSO Layer 3 interface. Ethernet-capable NodeBs use ePipe services.

ATM NodeB

An ATM NodeB uses IMA bundles to carry ATM traffic to the 7705 SAR. The 7705 SAR could transport this traffic via an aPipe or an iPipe service. Ethernet capable base stations use ePipe services.

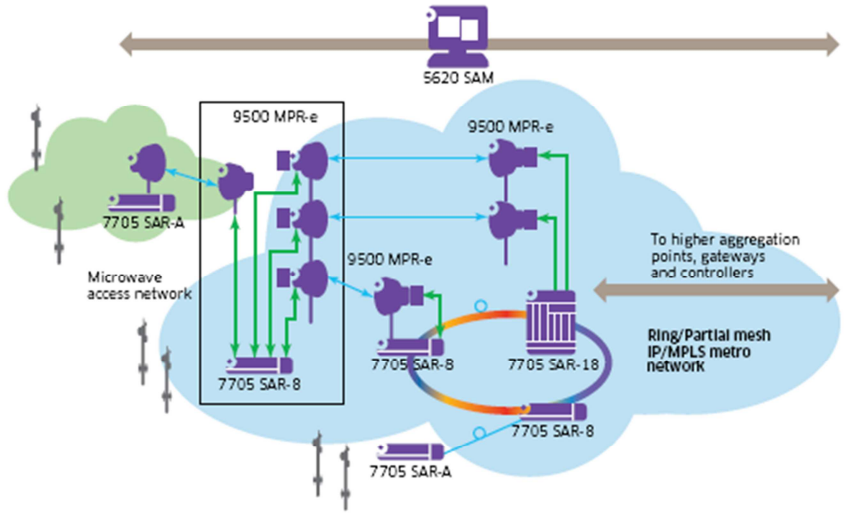
Ethernet BTS, NodeB, or eNodeB

The network could use any Ethernet service, L2 or L3, depending on the design.

ePipes can BS traffic to the downstream L3 services or the 7705 SARs could terminate VPLS, VPRN, or IES, depending on the customer's needs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Packet Microwave and IP/MPLS Backhaul



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

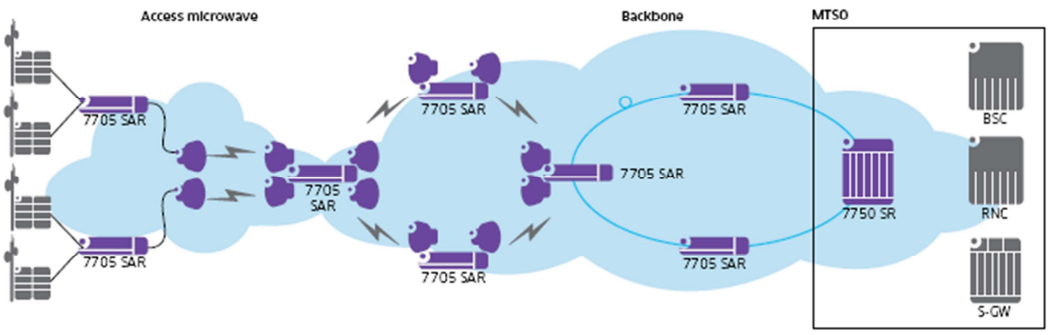
The Alcatel-Lucent 9500 Microwave Packet Radio (MPR) provides an effective transport option, especially for base stations located where cost-effective fiber is not available, for example, at the access portion of the network.

The 9500 MPR-e is the zero-footprint outdoor unit with Ethernet access that can be used either in standalone configurations and directly connected to the base station, or integrated to associated indoor networking equipment, such as the 7705 SAR, which is shown in the diagram above. At higher points of aggregation 7705 SARs can be used to aggregate traffic over fiber or microwave links in various topologies.

7705 SARs can additionally adapt directly connected base station traffic into the IP/MPLS metro network. The Alcatel-Lucent 5620 SAM supports an end- to-end management capability across the network components that comprise the packet microwave and IP/MPLS backhaul architecture.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Backbone Microwave Ring Topology



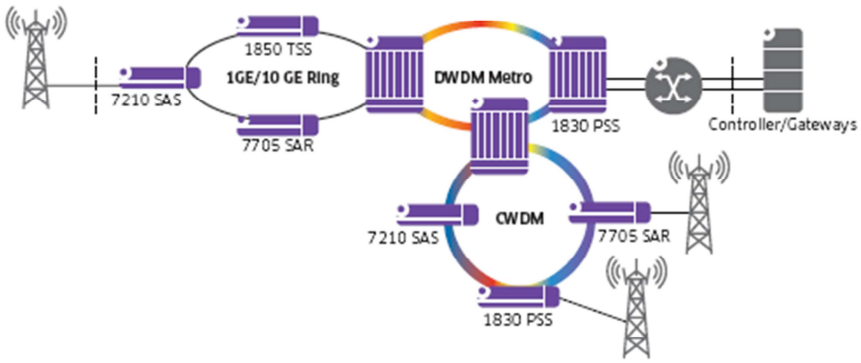
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

In a typical backhaul network, the backbone portion, due to its high resiliency requirement, is often deployed in a ring or mesh topology, using a combination of microwave and fiber media, depending on the terrain. This is depicted in the figure above.

MPLS is a network technology that is well suited to take advantage of such a ring/mesh topology. With its network media-agnostic nature, it can be run seamlessly end to end across a range of media in the backbone.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Packet-Optimized WDM Solution for Ethernet/IP Mobile Backhaul



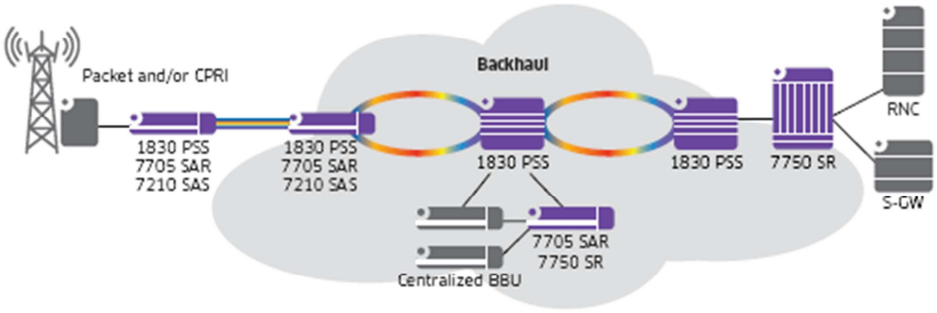
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Alcatel-Lucent 1830 Photonic Service Switch (PSS) is a highly scalable packet and wavelength solution for packet optical mobile backhaul that addresses operators' scaling needs today and into the future. Today, mobile network operators, from incumbents to wholesalers to fixed/mobile operators, are using the 1830 PSS to achieve improved total cost of ownership (TCO) with optimal efficiency and ease of use.

As a highly integrated packet-optimized WDM solution, the Alcatel-Lucent 1830 PSS simplifies the network by consolidating or reducing the number of multiple function-specific or traditional multiservice provisioning platform (MSPP) network elements. This reduces the need to interwork and manage numerous elements. The 1830 PSS also aggregates packet traffic from multiple access/ cell sites and efficiently packs wavelengths to offer massive scalability and networking efficiency. The 1830 PSS provides cell site aggregation for pure-packet mobile backhaul. The combined consolidation and aggregation delivers significant capital and operational savings. The 1830 PSS is part of the Alcatel-Lucent Mobile Backhaul solution, which leverages a unified Alcatel-Lucent 5620 Service Aware Manager network management platform across IP and Optics for further operational simplification and efficiency.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1830 PSS in a CPRI infrastructure



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Mobile traffic growth is accommodated by:

- Expanding the number of cell sites and coverage
- Adding bandwidth capacity per cell site with scalable, high-density access platforms

For multiple-operator sites, growth is accommodated in terms of:

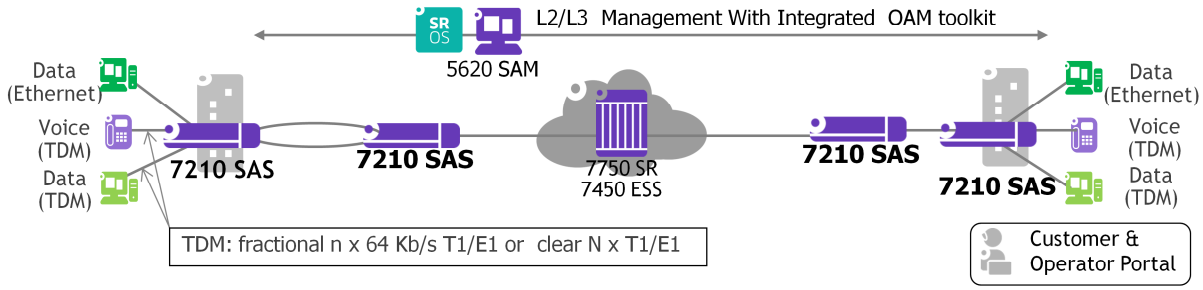
- Capacity allocated per operator
- Number of backhaul connections per cell site
- Support for Carrier Ethenet VPNs
- The ability to support the bandwidth and connection scale required

In early LTE rollouts, sites are equipped with 50-100 Mb/s per operator at sites and much of the equipment is provisioned with 10 GE ports to allow for growth beyond typical 1 GE uplinks. While operators cannot predict LTE's impact on capacity requirements, they do foresee the need to support not only smartphone traffic but also mobile broadband, which will overcome fixed broadband by 2015. These dynamics, along with the increasing number of sites being "fiber-ized", indicates a strong need for the scalability, flexibility and performance of packet-optimized WDM – from the mobile backhaul aggregation site to the access network. Additionally, new centralized base band unit architectures, with remote radio heads using Common Public Radio Interface (CPRI) backhaul over fiber, place yet higher demands on wavelength capacity and performance criteria like delay and jitter.

Wavelength Division Multiplexing (WDM) enables operators to cost-effectively scale their services. It also gives them the ability to maximize fiber utilization and performance. The scalable 1830 PSS multi-reach WDM portfolio offers right-sized platforms designed to efficiently meet traffic capacity and diversity needs ranging from access to metro/aggregation and core backbone applications. The Alcatel-Lucent solution also provides a scalable end-to-end 100G/400G solution across IP and Optics.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Backhaul TDM-Based Services using the 7210 SAS

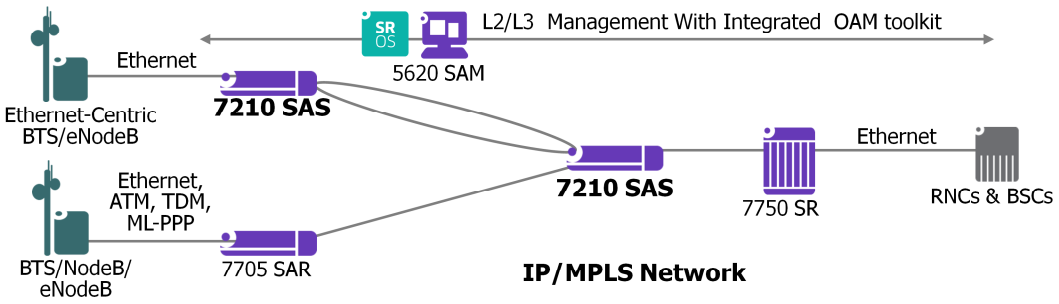


Leverage Circuit Emulation Services (CES) to enhance business VPNs

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- Create further service differentiation by bundling TDM services with Carrier Ethernet VLL services over a single uplink
- Fractional T1/E1 service using structured mode using CES over Packet-Switched Networks (CESoPSN) to transport one or more n x 64 kb/s timeslots between sites over MPLS PWs
- Clear T1/E1 service using structure agnostic transport over packet networks (SAToP) to transport full T1/E1 link between sites over MPLS PWs

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



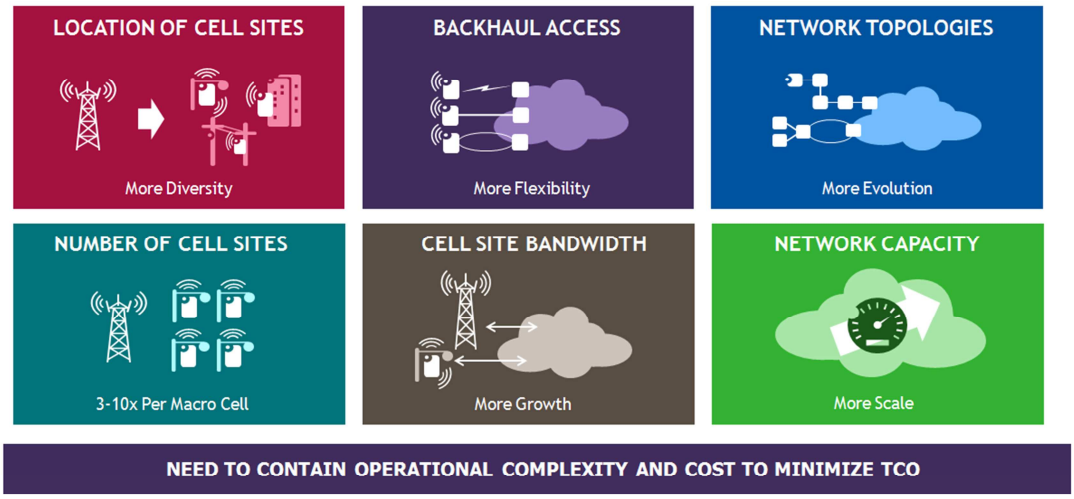
Cost-optimized mobile backhaul using Carrier Ethernet

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- 7210 SAS is part of a comprehensive mobile backhaul and RAN aggregation solution along with the 7705 SAR, 7450 ESS and 7750 SR
- 7210 SAS provides a cost-effective cell site device option for Ethernet-centric base stations
  - The 7210 SAS provides support for MPLS (PW, FRR, etc.), ITU-T Sync-E and IEEE 1588v2

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Examining Metro Cell Challenges



TCO: Total Cost of Operation

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

What are the metro cell backhaul challenges?

First, there is more cell site location diversity.

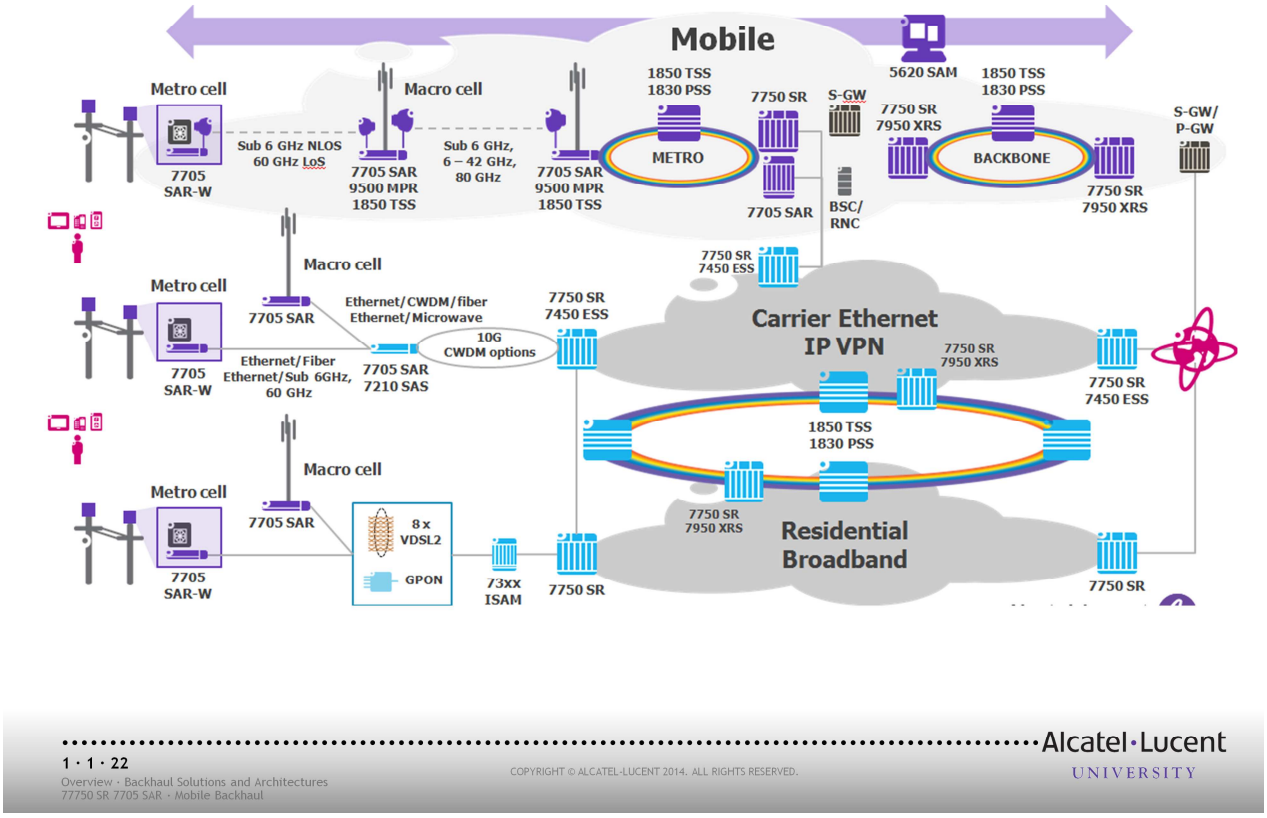
- To deliver optimal mobile subscriber Quality of Experience (QoE) metro cells have to take advantage of both indoor and outdoor locations. Outdoor sites will need to take advantage of street furniture such as: sides of building, lamp post, and poles. This introduces backhaul challenges in terms of backhaul equipment size and weight, cost, look, and ability to withstand harsh environmental conditions
- To reach optimal metro cell options Mobile Network Operators (MNOs) will look to take advantage of the most cost effective backhaul access to the metro cell site be it DSL, GPON, P2P fiber, or microwave based, however, this access diversity must not lead to costly cell site customization
- Metro cells will be incrementally added as coverage and/or capacity needs arise, these metro cell must then be reliably networked with rest of the backhaul network, especially in the cases where metro cells are providing the only coverage, or if a number of metro cells providing capacity share a common backhaul network connection

Then there are thebackhaul scaling challenges as more and more metro cells are added to the network:

- Estimates range from 3 to 10 metro cells per macro cell, this leads to many more backhaul connections to handle
- Backhaul bandwidth associated with increasing numbers of connections also has scaling impacts, metro cell sites need to support the bandwidth of a macro cells sector, multiple RAN technologies 3G, 4G, and WiFi access, this leads to significant bandwidth demands on the mobile backhaul network.
- As metro cell backhaul connections are aggregated to corresponding gateway and control sites, there are increasing pressures on the scaling of the end-to-end backhaul connection. Bandwidth must scale, and the support for carrying more backhaul connections must scale, but they must reliability scale as well. It's ok is a single metro cell backhaul connection is lost, but loosing all metro cells is an issue, all of this scale has to reliability handed as more and more backhaul connections are aggregated.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Alcatel-Lucent Metro Cell Networks and Beyond



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Backhaul networks can be quite involved, they can take advantage of both MNO owned and leased infrastructure.

A high level backhaul network diagram is shown on the slide.

- At the top there is an MNO self-build backhaul network depicted with purple icons.
- Below this is an MNO leasing backhaul services from a Backhaul Transport Provider (BTP) or affiliated wireline organization with equipment depicted in light blue icons in the lower right of the diagram.

Common backhaul operations over this diversity is critical for the MNO to optimize heterogeneous network backhaul Total Cost of Ownership (TCO). It is critical for the BTP as well.

Alcatel-Lucent equipment is at all points in the backhaul network, we are unique in the industry with our mobile backhaul solution support, and address the end-to-end heterogeneous backhaul needs of both MNOs and BTPs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
Backhaul Solutions and Architectures

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 1
Overview

Module 2
IP MPLS SR-OS Product Family

TER36075_V3.1-SG-English-Ed1 Module 1.2 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

1. 7750 SR and 7450 ESS in the service provider network 4
2. 7750 SR and 7450 ESS features 10
3. 7750 SR overview 17
4. 7450 ESS overview 55
5. SR OS capabilities 76
6. Application scenarios with the 7750 SR and 7450 ESS 79
7. 7210 SAS Overview 88

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

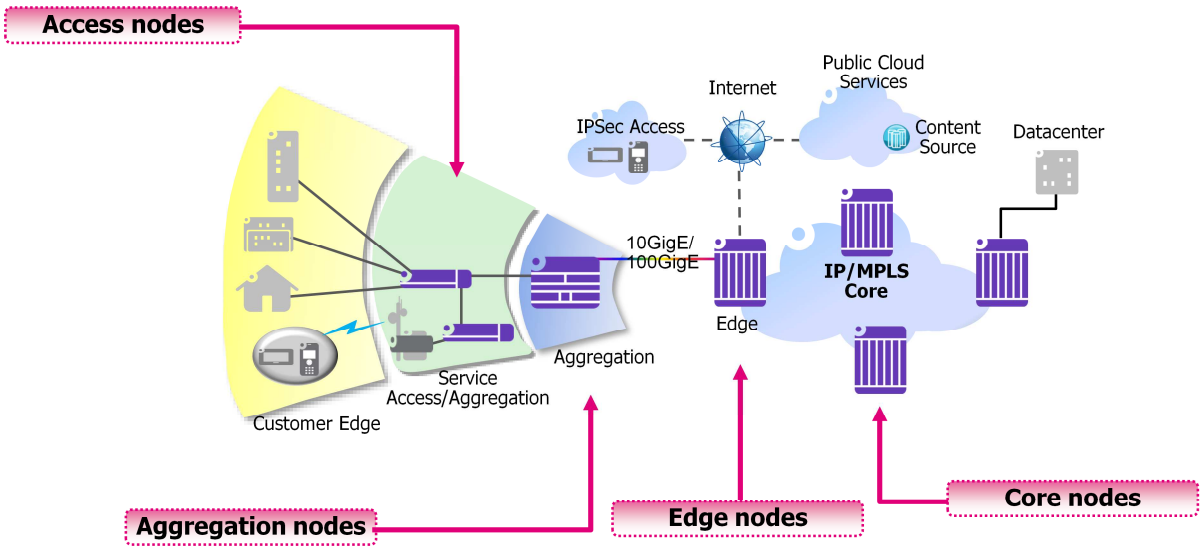
Select the chapter you are interested in, or click on the Next button to follow the recommended learning path.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 7750 SR and 7450 ESS in the service provider network

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service provider network



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Alcatel-Lucent 7750 Service Router and 7450 Ethernet Service Switch are designed to function in the service provider network. A typical service provider network contains access nodes, aggregation nodes, edge nodes, and core nodes.

The **access nodes** need to be compatible with the customer technology. In general, an access nodes does not need to have very high capacity because it is processing a reduced volume of traffic for a reduced number of configured services.

The **aggregation nodes** improve scalability at the edge and the core of the network. An aggregation node needs to have higher capacity because it is processing a large number of traffic streams.

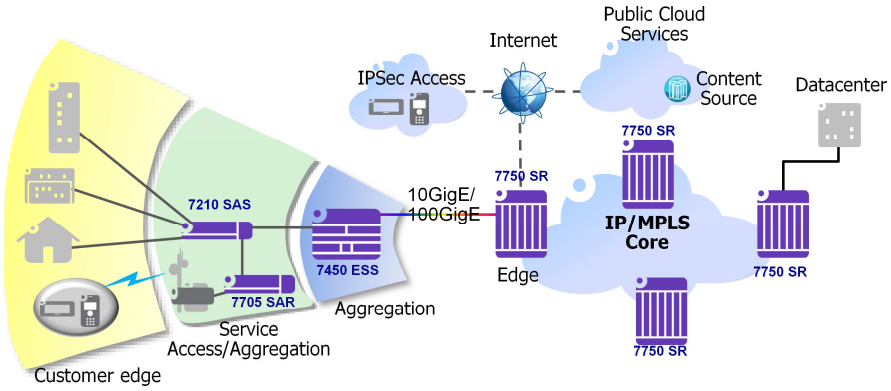
The **edge nodes** provide a rich set of services, including layer-2 and layer-3 services, including Internet Enhanced Services and Virtual Private Network services. An edge node needs to have a very high capacity and processing power to handle a large number of configured services.

The **core nodes** need to be very high-capacity, high-speed devices to carry traffic from one location to one or more remote sites. A core node needs to be able to carry large amounts of traffic, and to quickly recover from failures.

In this application, a core node provides Internet Protocol Multiprotocol Label Switching services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR and 7450 ESS in the service provider network



The Alcatel-Lucent Service Router and Ethernet Service Switch Portfolio includes the 7750 SR, the 7450 ESS, the 7210 SAS, and the 7705 SAR.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Where are 7750 SR and the 7450 ESS in the service provider network?

The 7750 SR delivers services in edge nodes, and the 7450 ESS enables the delivery of Ethernet services in aggregation nodes.

The 7750 SR and the 7450 ESS belong to the Alcatel-Lucent Service Router and Ethernet Service Switch Portfolio that also includes the 7210 Service Access Switch and the 7705 Service Access Router, which deliver services in the access nodes.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR highlights

The 7750 SR delivers high-performance, high-availability routing with service-aware operations, administration, management, and provisioning.



The 7750 SR is available in four chassis options that are suitable for flexible deployments from large ISP core applications to small POPs: SR-12e, SR-12, SR-7, SR-c12 and SR-c4.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR is a multiservice edge router designed to deliver high-performance, high-availability routing with service-aware operations, administration, management, and provisioning.

The 7750 SR supports all industry-standard routing protocols: Open Shortest Path First, Intermediate-System-to-Intermediate-System, Border Gateway Protocol, and Routing Information Protocol. The 7750 SR also supports layer-3 services such as multicast, Multiprotocol Label Switching and Label Distribution Protocol, and Virtual Private Networks, including Virtual Private Wire Service, Virtual Private LAN Service, and Virtual Private Routed Network.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS highlights

The 7450 ESS is a high-performance MPLS-enabled Carrier Ethernet platform dedicated to Ethernet service delivery at maximum scale. The 7450 ESS provides Layer-2 services: VLL and VPLS.

For increased flexibility, greater scale, and more services, the 7450 ESS can be extended to support 7750 SR interfaces and features while preserving its value for the installed base.

The 7450 ESS is available in four chassis options that allow for deployment in various scenarios, depending on the port density and aggregation technologies that are required: ESS-12, ESS-7, ESS-6, ESS-6v.

The 7450 ESS uses the same technology as the 7750 SR, but there are key differences between the two products.

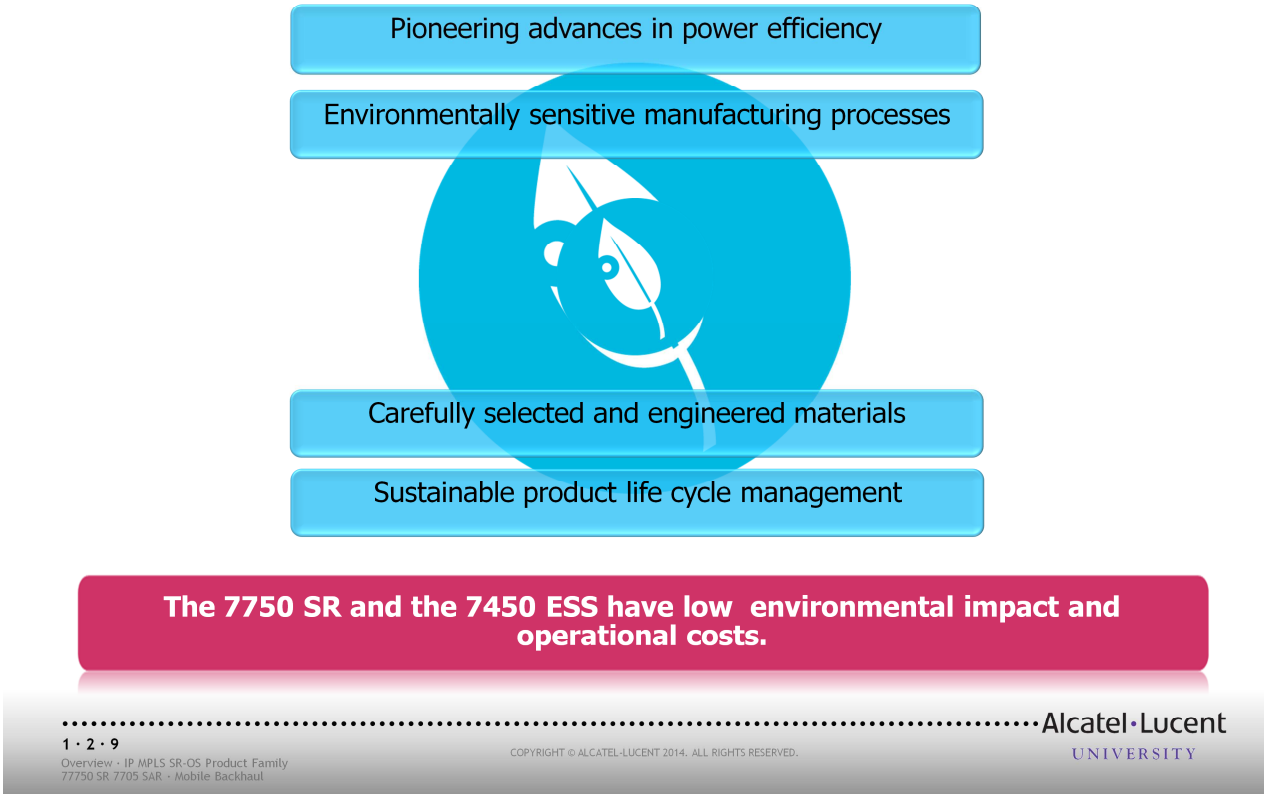


The 7450 ESS has the flexibility to support both Ethernet and IP services, and can be configured to provide advanced IP services.

The 7450 ESS uses the same technology as the 7750 SR, but there are key differences between the two products. The 7450 ESS and 7750 SR have different chassis and modules, separate part numbers and list prices, distinct product feature roadmaps, and separate software loads.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR and 7450 ESS—environmentally friendly systems



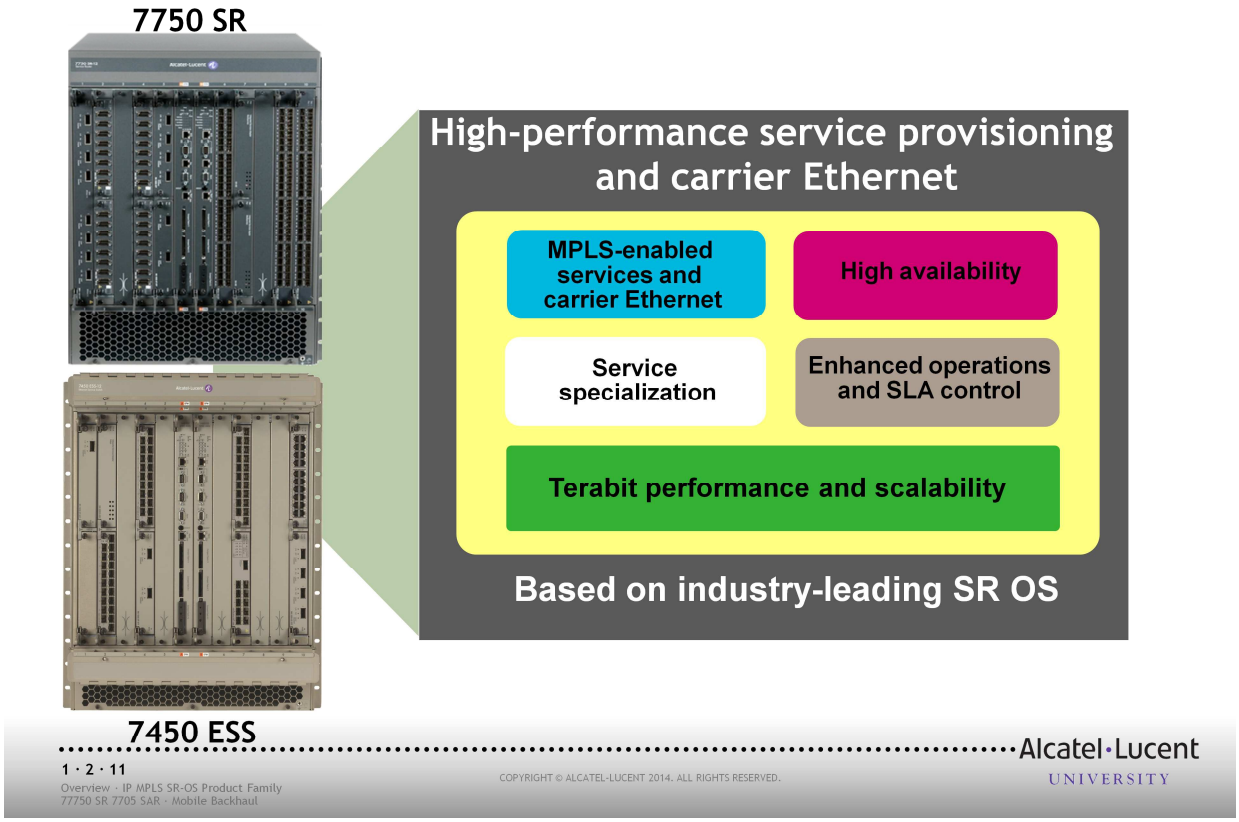
Alcatel-Lucent is committed to supplying environmentally friendly solutions. The 7750 SR and the 7450 ESS are highly efficient systems with very small carbon footprints.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 7750 SR and 7450 ESS features

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR and 7450 ESS features—overview

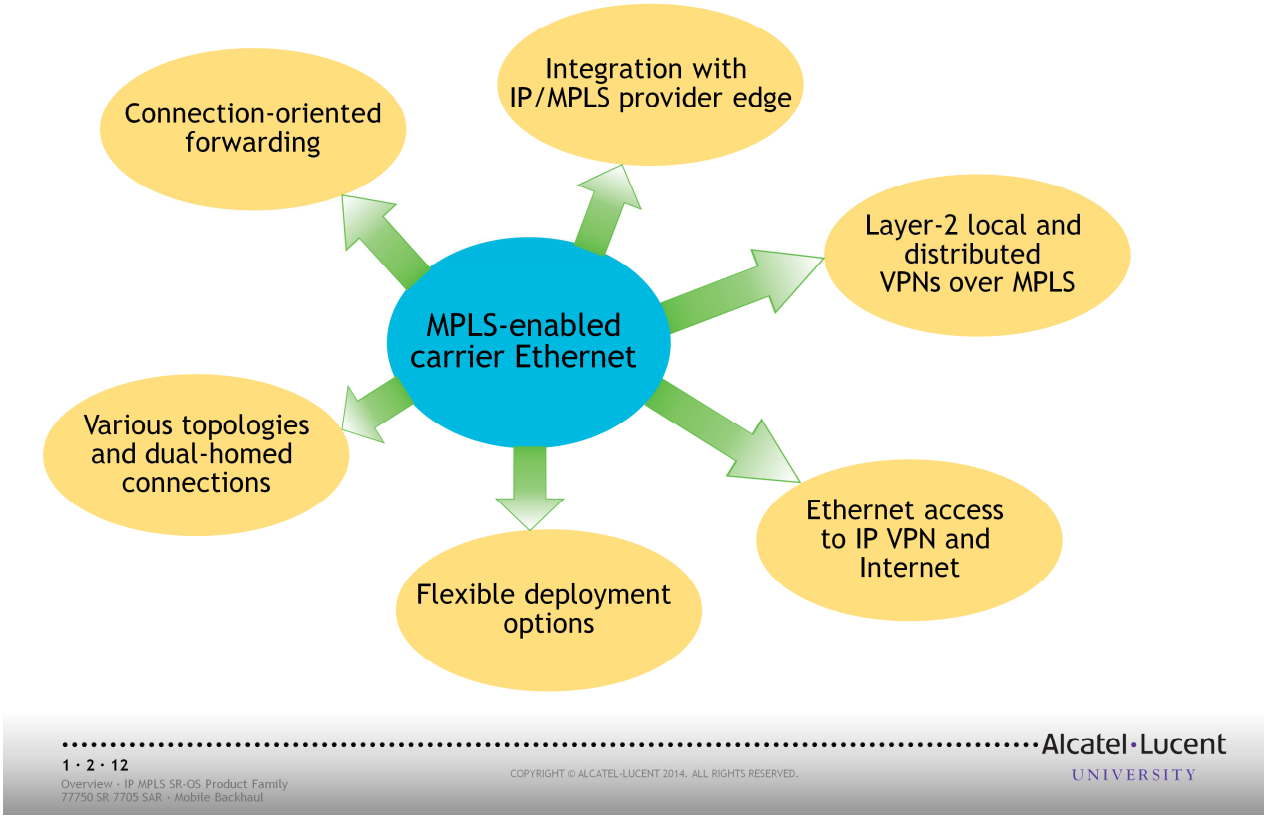


The 7750 SR and 7450 ESS solution provides a rich set of service provisioning and carrier Ethernet.

The 7750 SR and 7450 ESS are based on the Service Router Operating System, a reliable operating system that you can use when deploying services and applications in a service provider network.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

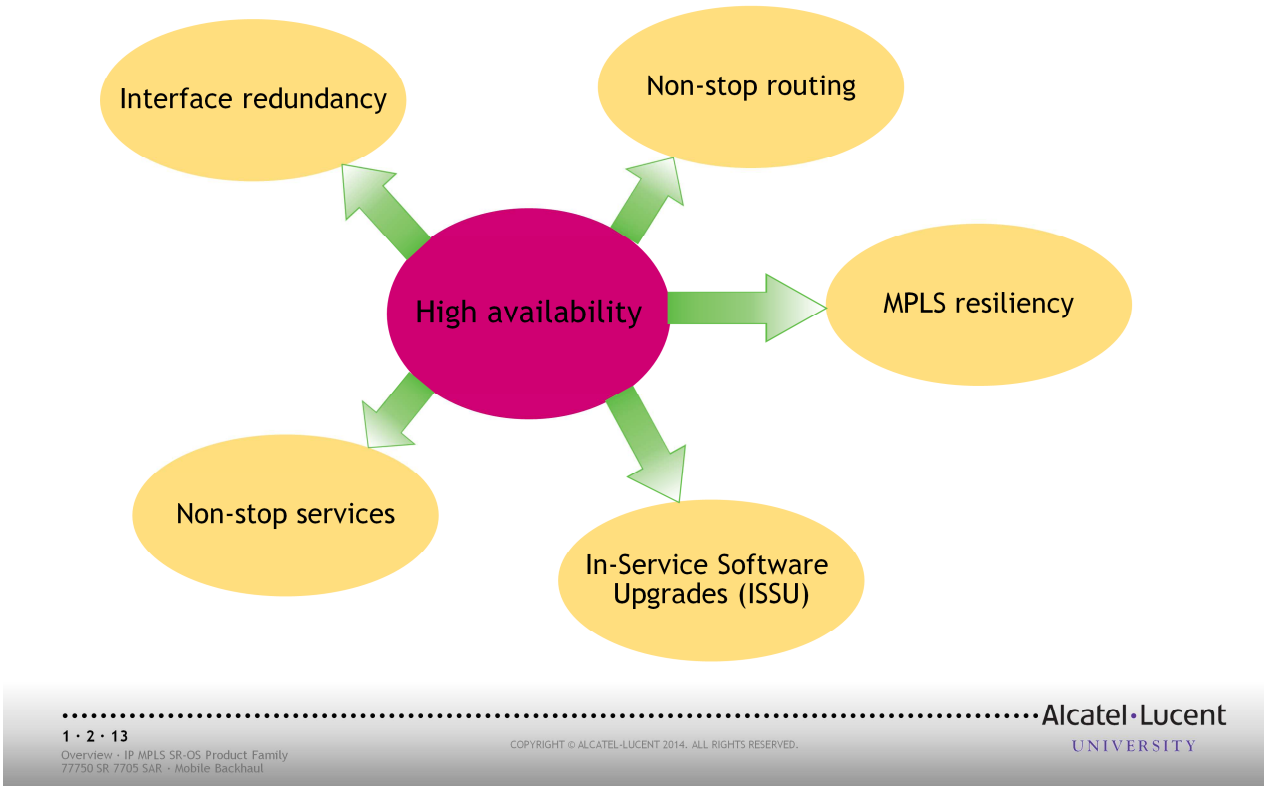
MPLS-enabled services and carrier Ethernet



The 7750 SR and 7450 ESS provide connection-oriented forwarding on an MPLS platform that can include the following: Resource Reservation Protocol with Traffic Engineering, Label Distribution Protocol, static Label Switched Paths, bandwidth reservation, Fast Reroute, and Pseudowire Emulation Edge to Edge. The two devices contribute to a service model that simplifies the provisioning of Layer 2 and Layer 3 services and the integration with the IP/MPLS provider edge. The 7750 SR and 7450 ESS solution promotes flexible deployment for metro, national and international reach, and supports full mesh, point-to-point, and ring topologies, as well as dual-homed connections.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

High availability



The 7750 SR and 7450 ESS use Link Aggregation Groups, Multi-Chassis Link Aggregation Groups, and Automatic Protection Switching to implement interface redundancy.

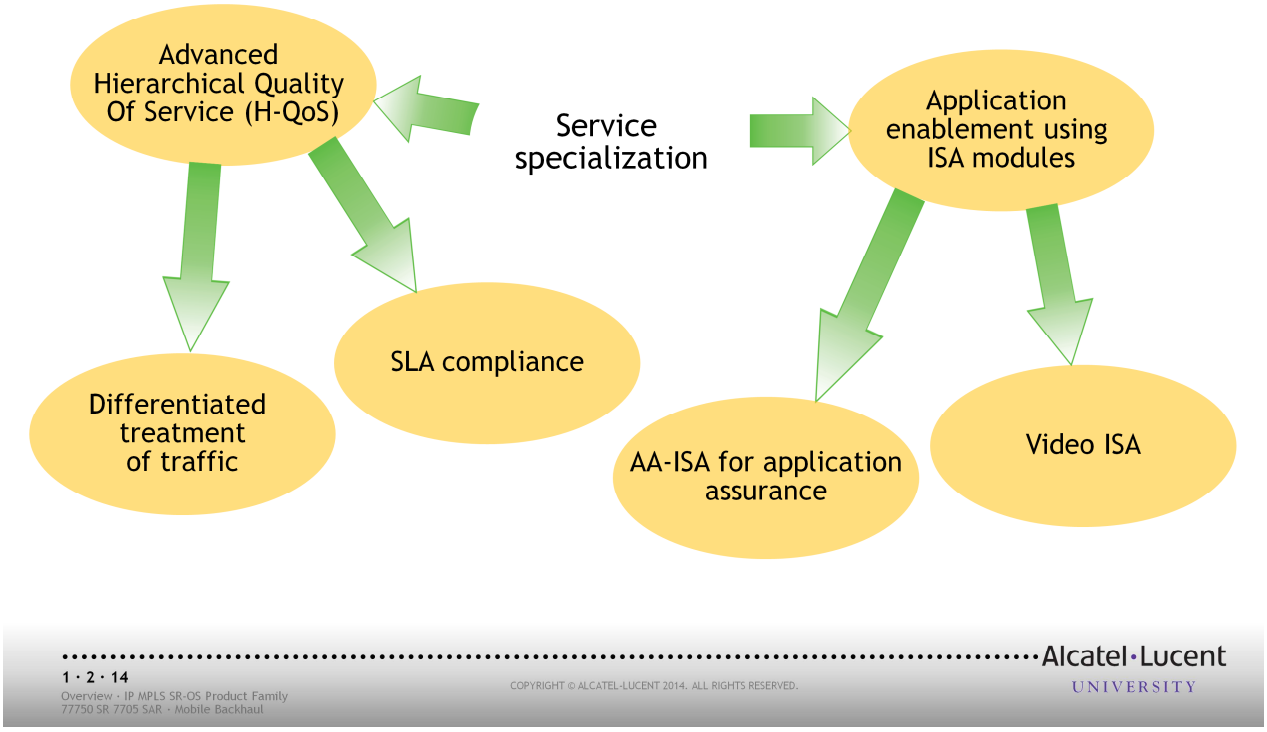
The Redundant Switch Fabric and Control Processing Modules ensure that the MPLS signaling protocols are being performed during a control plane failure. All services and applications are running during a control plane failure due to the pseudo-wire redundancy.

The MPLS resiliency feature includes secondary paths and fast rerouting to provide link and node level protection.

The 7750 SR and 7450 ESS support in-service software upgrades with minimal disruption to service operation due to the non-stop services and non-stop routing capabilities.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service specialization

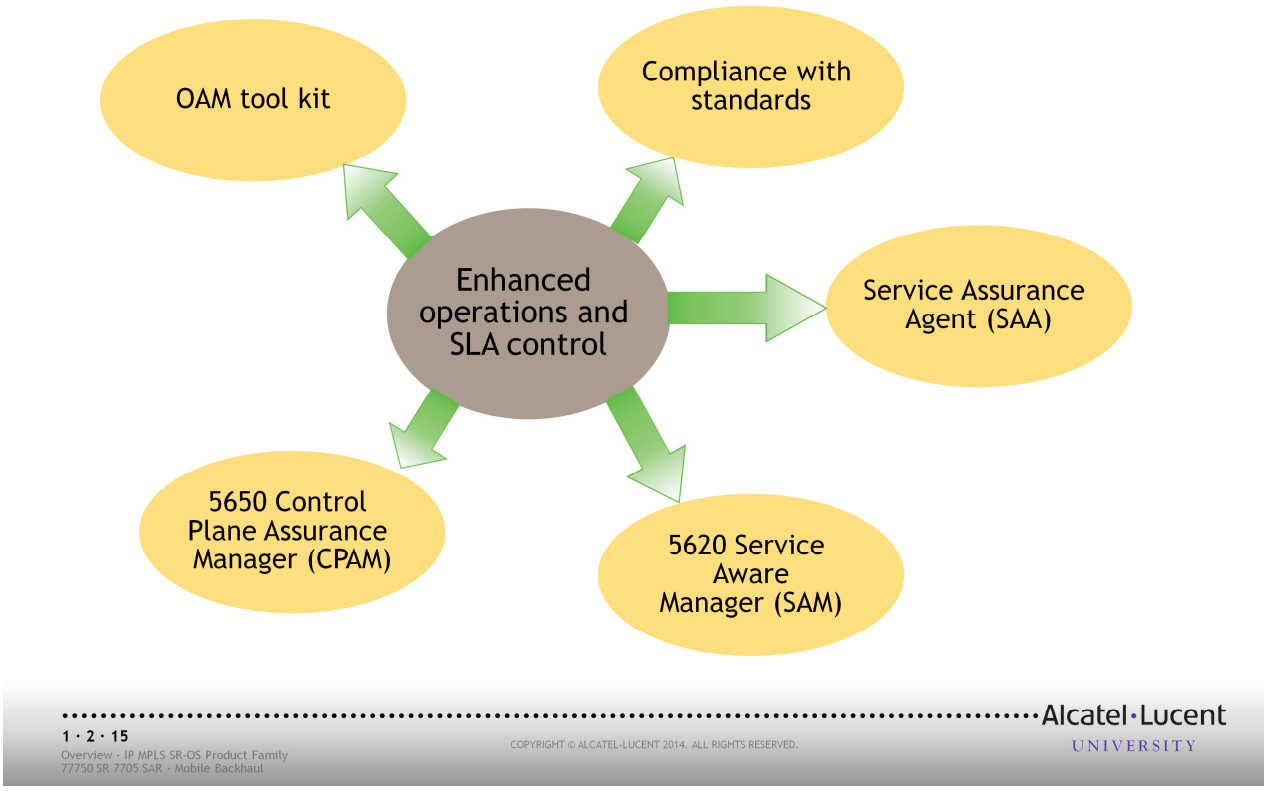


The 7750 SR and 7450 ESS are designed to offer specialized services. Both products have Advanced Hierarchical Quality of Service capabilities; as a result, they can offer services with differentiated treatment of traffic, according to Service-Level Agreements.

The 7750 SR and 7450 ESS can be equipped with Integrated Service Adapter modules, which support application enablement. The application assurance ISA modules use deep packet inspection to provide application-level traffic reporting and traffic management. The video processing ISA modules support assured linear TV service specialization and local ad insertion.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Enhanced operations and SLA control



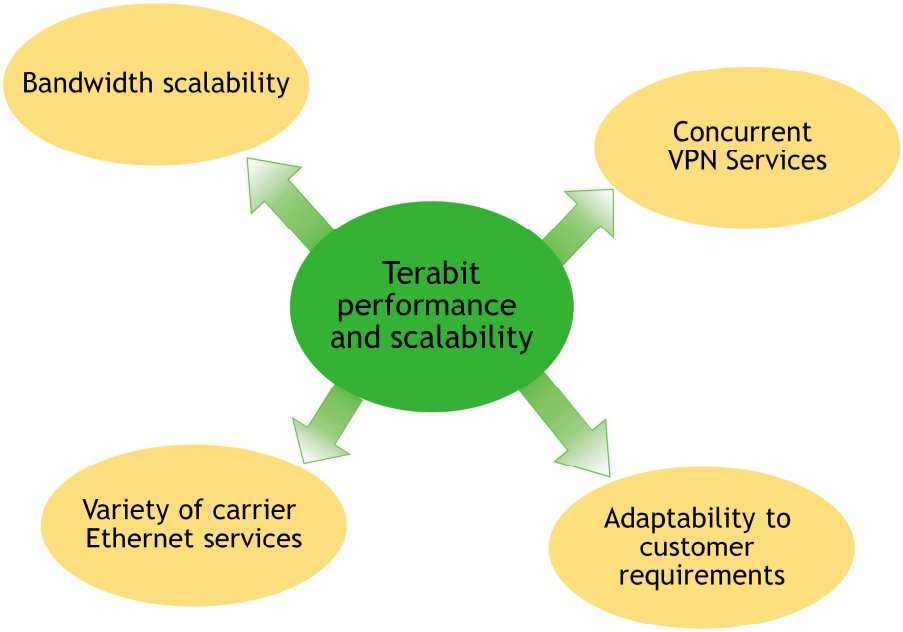
The 7750 SR and 7450 ESS have a service-aware Operations, Administration, and Maintenance tool kit that supports enhanced operations and SLA control. Both products are compliant with established industry standards.

The 7750 SR and 7450 ESS benefit from the Service Assurance Agent, a troubleshooting tool consisting of OAM and debugging tools that allow network operators to gather service quality statistics.

The 7750 SR and 7450 ESS are supported by the 5620 Service Aware Manager and by the 5650 Control Plane Assurance Manager. The 5620 SAM simplifies the provisioning, management and troubleshooting of IP/MPLS networks, and the 5650 CPAM delivers real-time visualization, surveillance and troubleshooting for dynamic IP/MPLS networks and services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Terabit scale and performance



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR and the 7450 ESS provide terabit switching and routing performance, superior Gigabit Ethernet port density, and flexible deployment options.

The 7750 SR and the 7450 ESS support concurrent VPN services such as Carrier Ethernet E-Line VLL services and E-LAN VPLS services, Ethernet pseudowires, business data, internet, voice, and video.

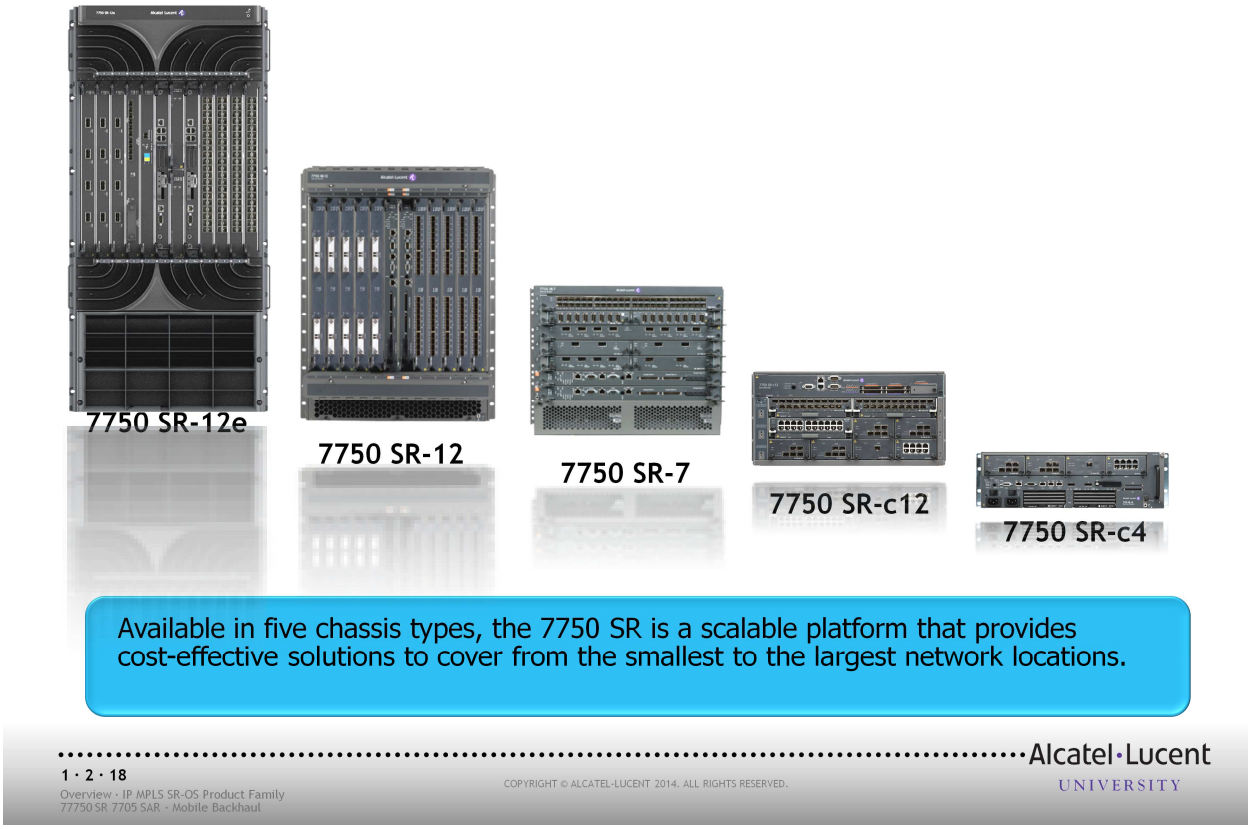
The 7750 SR and the 7450 ESS can be deployed in multi-point, point-to-point, and routed multi-point topologies. The 7750 SR and the 7450 ESS reach metro, national and international geographies.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 7750 SR overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The 7750 SR product family



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Alcatel-Lucent 7750 SR multiservice edge routers are designed to provide high-performance and high-availability routing with service-aware operations, administration, management, and provisioning. Leveraging the Alcatel-Lucent 400 Gbit/s FP3 silicon technology, the 7750 SR delivers exceptional performance and scale to a wide range of IP services, with service intelligence to further drive operational efficiency.

The 7750 SR offers an advanced and comprehensive feature set, and can serve as a Broadband Network Gateway for residential services, as a Multiservice Edge for Carrier Ethernet and IP VPN business services, as the aggregation router in mobile backhaul applications, or as a mobile packet core for second generation, third generation and long-term evolution wireless networks.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR capacity and components at a glance

7750 SR model	Capacity Redundant/ non-redundant	Slots	Components	Slot capacity
7750 SR-12e	9.6 Tb/s 7.2 Tb/s	12	2 SF/CPMs 2 half-slot mini-SFMs 9 IOMs or IMMs	400 Gb/s (redundant)
7750 SR-12	**4 Tb/s** **2 Tb/s**	12	2 SF/CPMs and 10 IOMs or IMMs	**200 Gb/s**
7750 SR-7	**2 Tb/s** **1 Tb/s**	7	2 SF/CPMs 5 IOMs or IMMs	**200 Gb/s**
7750 SR-c12	90 Gb/s (redundant)	**3 full** **(6 MDA or 12 CMA)**	2 CFMs Interface blocks containing MDAs and CMAs	**9.4 Gb/s**
7750 SR-c4	90 Gb/s	4 CMA	Integrated CCM/CFM Separate interface block containing CMAs	**4 Gb/s**

CPM – Control Processing Module
SFM – Switch Fabric Module
IMM – Integrated Media Module
CMA – Compact Media Adapter
MDA – Media Dependent Adapter
CFM – Control and Forwarding Module
CCM – Chassis Control Module
IOM – Input Output Module

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

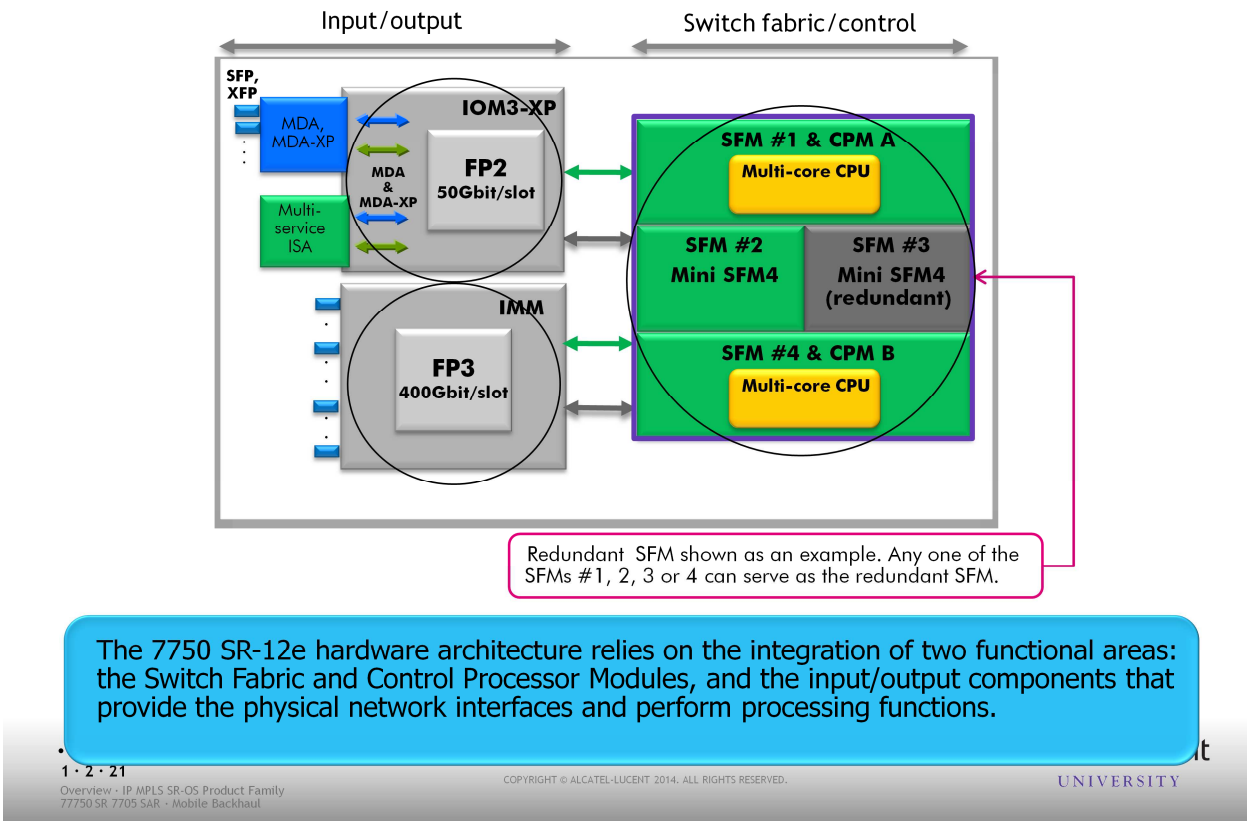
This table summarizes the capacity and components of the 7750 SR models that are currently available. The differences in capacity indicate that the 7750 SR-12e, 7750 SR-12 and SR-7 are suitable for large core applications, while the 7750 SR-c12 and SR-c4 are appropriate for small Point-of-Presence deployments.

The following slides will describe in greater detail all the 7750 SR components: Switch Fabric and Control Processing Modules, mini Switch Fabric Modules, Input Output Modules, Integrated Media Modules, Control and Forwarding Modules, Chassis Control Module, Media Dependent Adapters, and Compact Media Adapters.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3.1 7750 SR-12e architecture and hardware overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



The 7750 SR-12e is a new, high-end addition to the 7750 SR product family, and provides high-scale capacity for future expansion The 7750 SR-12e has been designed to deliver differentiated, high-performance, and high-availability services. It supports specialized service-aware application processing, advanced quality of service, and a wide range of Ethernet and multi-service interfaces and protocols. The 7750 SR-12e provides industry-leading scale and intelligence to deliver residential, business, and wireless broadband IP services on a converged edge routing platform.

A fully equipped 7750 SR-12e integrated chassis contains two Switch Fabric and Control Processor Modules and two Mini Switch Fabric Modules and provides a fully redundant fabric.

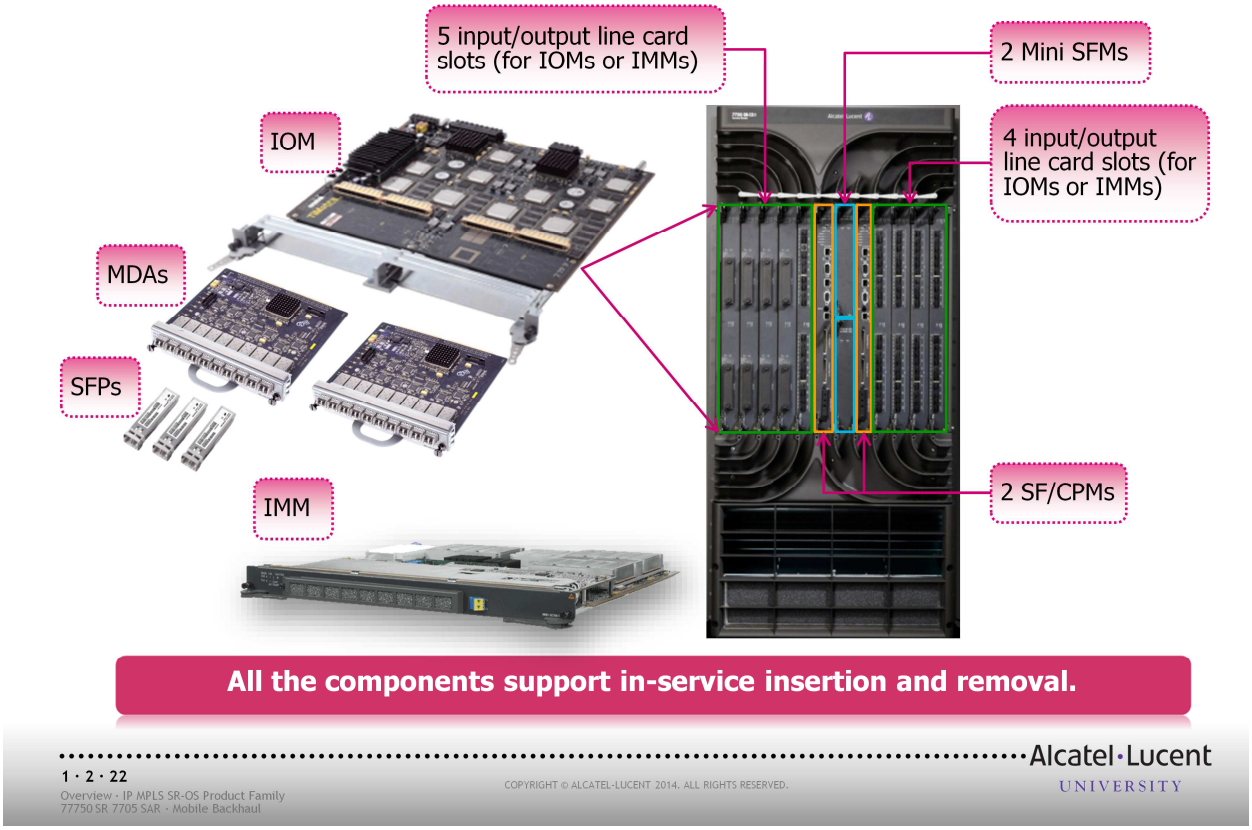
The SF/CPM is a combined control processing (CPM) and switch fabric (SFM) module. The control processing function operates in a 1+1 active/standby redundancy model when two SF/CPM cards provide a fully redundant and hot synchronized control plane. Each SF/CPM integrates the central processing unit and switch fabric, controls the routing and switching functions, and provides the management and console interfaces, as well as the interface for the external synchronization signal.

The Mini Switch Fabric Modules are required (along with the switch fabric function of the SF/CPM card) to provide a fully redundant fabric for the 7750 SR-12e platform.

The input output section can contain Input Output Modules or Integrated Media Modules, or both.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-12e chassis with components



The 7750 SR-12e has a vertical slot layout with two slots for Switch Fabric and Control Processor Modules, two half-slots for mini SFMs, and nine slots for input output modules or integrated media modules.

Each IOM card can accommodate Media Dependent Adapters, which provide physical network interfaces through the Small Form-factor Pluggable units. The IOM can also accommodate Integrated Service Adapters, which provide specialized application processing and buffering.

The IMM cards integrate the processing and physical interfaces on a single board. The 7750 SR-12e introduces support for a series of IMMs based on the new FP3 multi-core CPU.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-12e components at a glance



Switch Fabric and Control Processor Module (SF/CPM)
Multi-core control processor that runs routing, switching and OAM protocols



Mini Switch Fabric Module (SFM)
Multi-core control processor that runs routing, switching and OAM protocols



Input Output Module (IOM)
Full slot module that can accommodate up to two MDAs or two ISAs, or one MDA and one ISA



Media Dependent Adapters (MDA)
Half slot module that provides various Ethernet adapter types, interface options and advanced services with SFPs and XFPs



Integrated Media Module (IMM)
Full slot module based on the new FP3 multi-core CPU. The IMM is equipped with integrated physical ports



Integrated Service Adapter (ISA)
Half slot resource blade without physical ports that inserts into an input/output module and provides specialized services

1 · 2 · 23
Overview · IP MPLS SR-OS Product Family
7750 SR 7705 SAR · Mobile Backhaul

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Alcatel·Lucent UNIVERSITY

This slide provides brief descriptions of the 7750 SR-12e components. You will find out more information about each component later in the course.

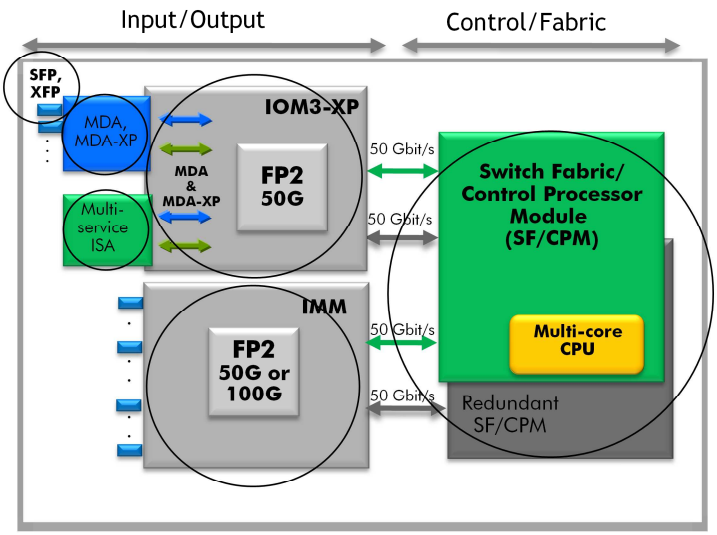
With the exception of the mini SFM, the 7750 SR-12e chassis accommodates the same component types as the 7750 SR-12 and SR-7. However, the characteristics of the components supported by the 7750 SR-12e can be different. For details, see the Release Notice document that applies to your equipment.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3.2 7750 SR-12 and SR-7 architecture and hardware overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-12 and SR-7 hardware architecture



The 7750 SR-12 and SR-7 hardware architecture relies on the integration of two functional areas: the Switch Fabric and Control Processor Modules, and the input/output components that provide the physical network interfaces and perform processing functions.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

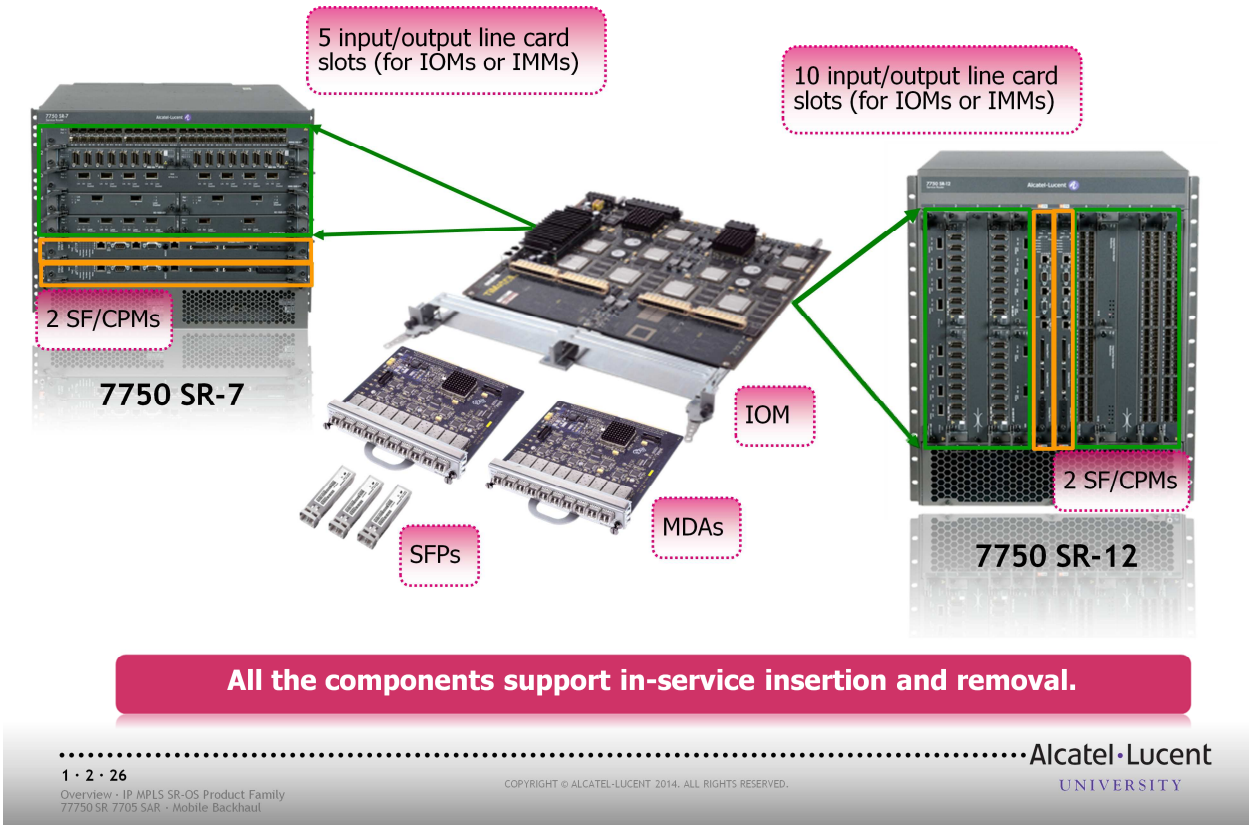
Each 7750 SR-12 and SR-7 unit contains two Switch Fabric and Control Processor Modules. Each SF/CPM card integrates the central processing unit and switch fabric, controls the routing and switching functions, and provides the management and console interfaces, as well as the interface for the external synchronization signal. The two SF/CPM cards share the traffic load and provide system redundancy.

The input output section can contain Input Output Modules or Integrated Media Modules, or both. Each IOM card can accommodate Media Dependent Adapters, which provide physical network interfaces through the Small Form-factor Pluggable units. The IOM can also accommodate Integrated Service Adapters, which provide specialized application processing and buffering.

The IMM cards integrate the processing and physical interfaces on a single board.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-12 and SR-7 chassis with components



The 7750 SR-7 has a horizontal slot layout with two slots for Switch Fabric and Control Processor Modules and five slots for input output cards. The 7750 SR-12 chassis has a vertical layout with two slots for Switch Fabric and Control Processor Modules and 10 slots for input output cards. The greater capacity makes the 7750 SR-12 router the perfect choice for high-end multi-service edge or core applications. The 7750 SR-7 model is better suited for mid-range multi-service deployments.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-12 and SR-7 components at a glance



Switch Fabric and Control Processor Module (SF/CPM)
Multi-core control processor that runs routing, switching and OAM protocols



Input Output Module
Full slot module that can accommodate up to two MDAs or two ISAs, or one MDA and one ISA



Media Dependent Adapters
Half slot module that provides various Ethernet adapter types, interface options and advanced services with SFPs and XFPs



Integrated Media Module
Full slot module with FP2 network processor complex equipped with integrated physical ports



Integrated Service Adapter
Half slot resource blade without physical ports that inserts into an input/output module and provides specialized services

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

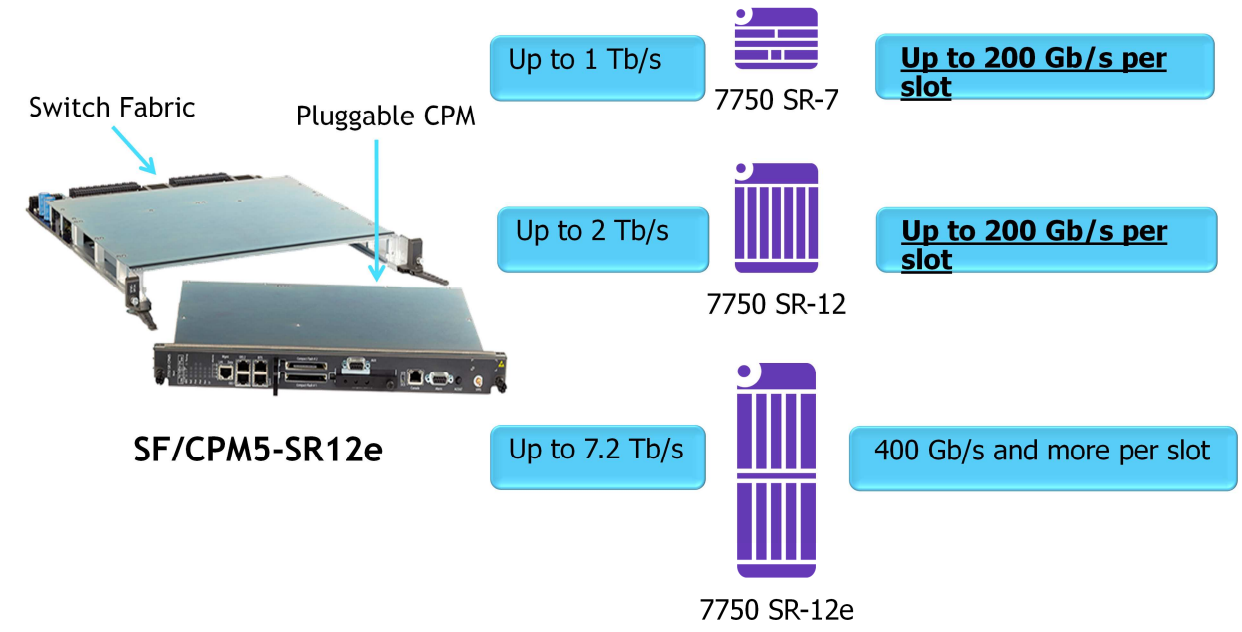
This slide provides brief descriptions of the 7750 SR-12 and SR-7 components. You will find out more about each component later in the course.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3.3 7750 SR-12e, SR-12 and SR-7 components

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Switch Fabric and Control Processor Modules



The Switch Fabric and Control Processor Module integrates the switch fabric and control functions into one module. Each SF/CPM has three slots for compact flash cards: cf1, cf2, and cf3. A new SR system is supplied with a compact flash card that contains the files required to start the system; this is typically inserted in the cf3 slot. You can use the cards in the cf1 and cf2 slots to store debugging and accounting logs.

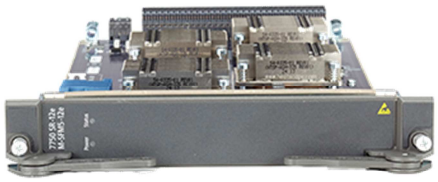
An 7750 SR-7, SR-12 or SR-12e system requires one SF/CPM to function. When two SF/CPMs are installed, the switch fabrics are active on both cards and operate in a load-sharing arrangement, doubling the throughput of the chassis switch fabric.

The performance of the 7750 SR-12e is even more stunning due to the presence of the mini SFMs, which add more capacity to the switching fabric. The next slide describes the mini SFM.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-12e Mini Switch Fabric Module

The Mini SFM module is a smaller form-factor card compared to the SF/CPM module, containing only the SFM unit, controlling the switching functions for the 7750 SR-12e system.



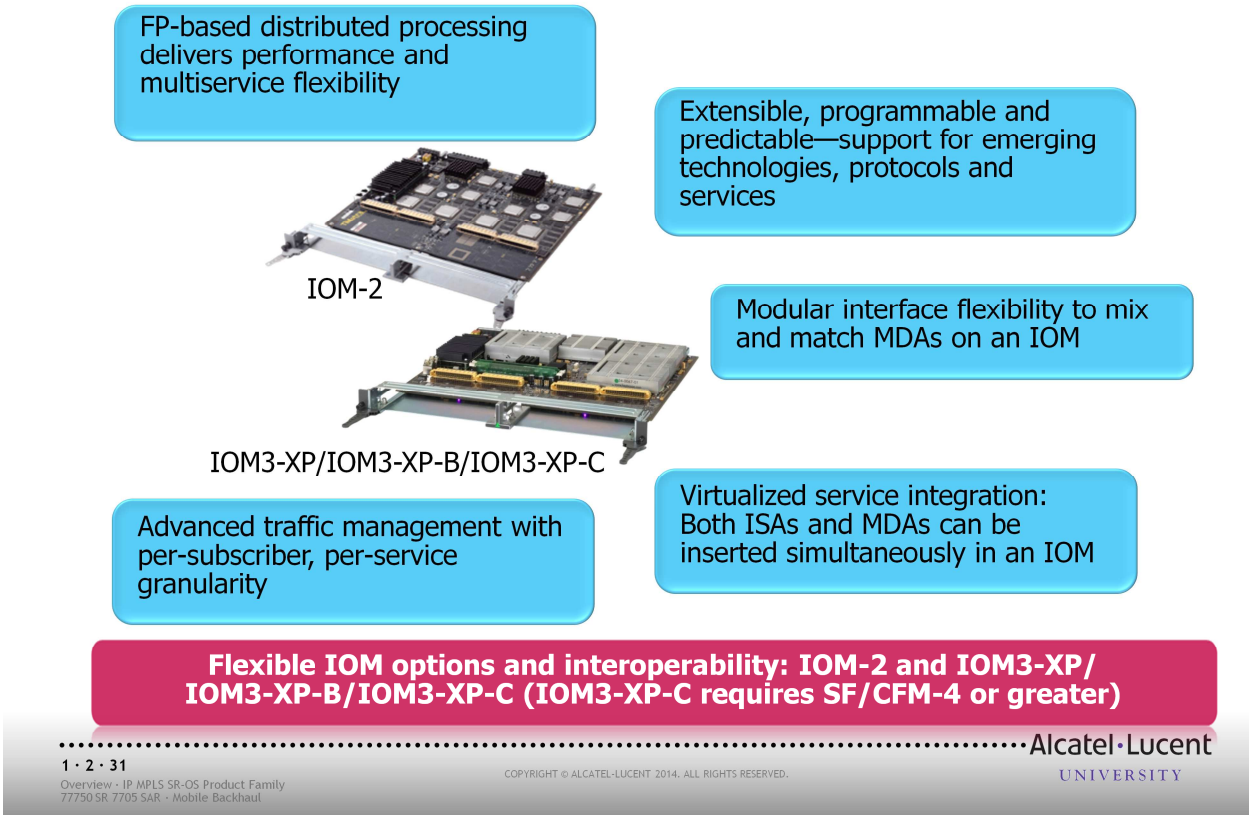
The Mini SFM connects directly to the router backplane and carries traffic between line cards. The backplane provides high-speed access to the modules and chassis components.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Two Mini Switch Fabric Modules are required (along with the switch fabric function of the SF/CPM card) to provide a fully redundant fabric for the 7750 SR-12e platform. The switch fabric in the 7750 SR-12e operates in a 3+1 redundancy scheme when two of the fabric elements are present on each of the SF/CPMs, and the other two are present on the Mini SFM4 modules. A configuration with two SF/CPM modules and two **Mini-SFM5** modules delivers a fully-redundant performance of **400 Gbit/s** per slot in full-duplex mode.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Input/Output Modules

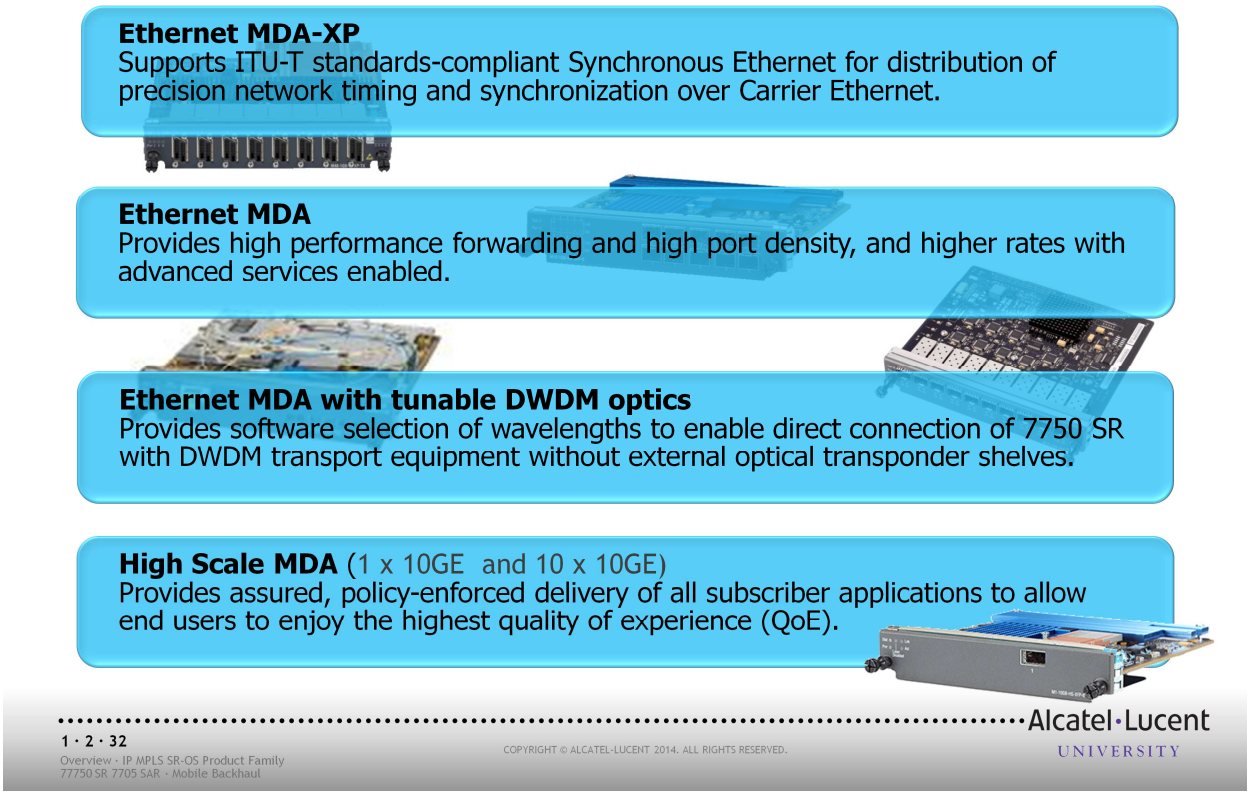


The Input Output Module is a full-slot module that inserts into a 7750 SR-12 or SR-7 chassis slot. Each IOM supports up to two Media Dependent Adapters, or up to two Integrated Service Adapters, or a combination of both. The IOM is the distributed forwarding and packet services engine, while the Media Dependent Adapter provides the physical network interfaces, and the Integrated Service Adapters provide processing resources for integrated advanced services.

The 7750 SR IOM supports Layer 2 and Layer 3 IPv4 and IPv5 routing services, IP/MPLS, Ethernet over MPLS, IP VPN and VPLS.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Media Dependent Adapters—part 1 of 3



The 7750 SR supports a wide range of Media Dependent Adapter types, interface options, and advanced service delivery capabilities. As a result, the 7750 SR provides the flexibility, performance and scalability to meet the full range of service routing and service requirements.

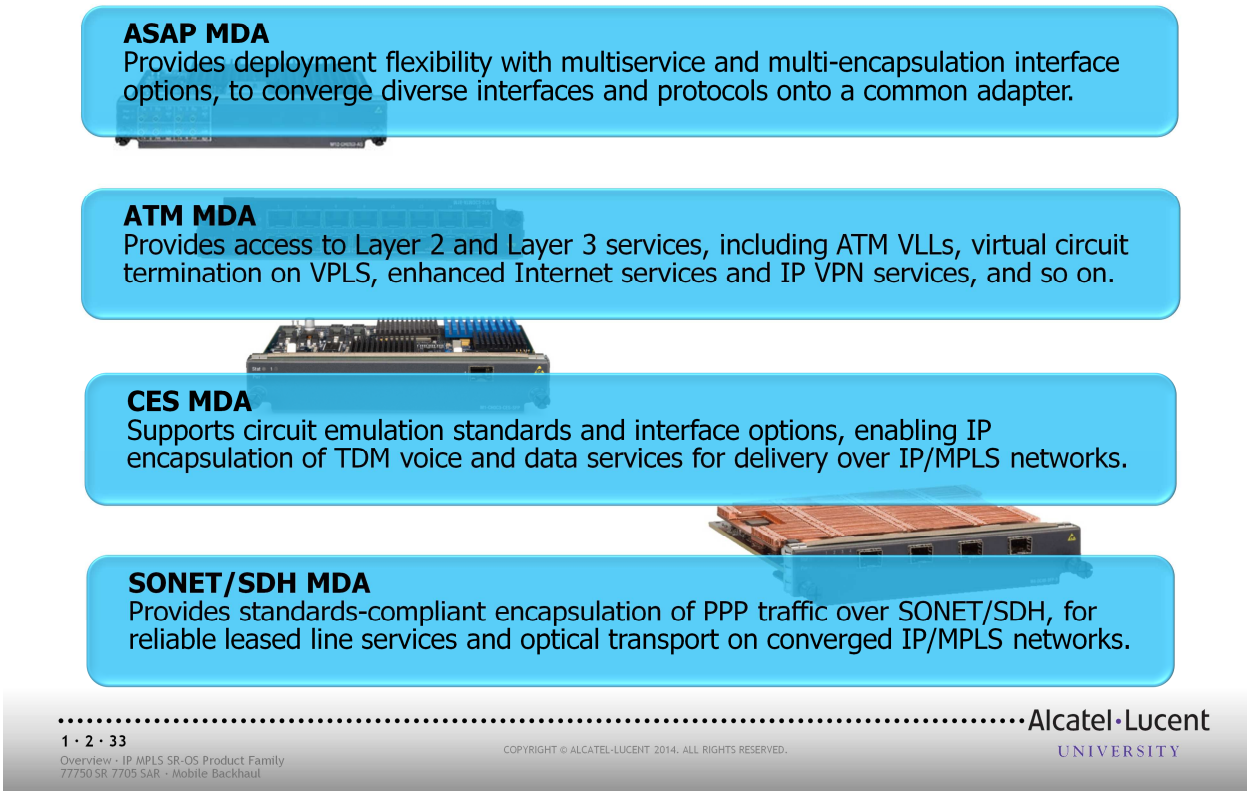
The Ethernet MDAs support Carrier Ethernet applications and services, including mobile core and backhaul aggregation, Layer 2 and Layer 3 business virtual private networks and broadband residential services and content delivery networks, as well as traditional IPv4 and routing applications.

The Ethernet MDA-XP, Ethernet MDA, Ethernet MDA with tunable Dense Wavelength Division Multiplexing optics, and High Scale MDA deliver high-density, high-performance Carrier Ethernet for business, mobile and residential applications.

All Ethernet MDA types support a wide range of SFP and XFP optical modules, and include variants with tunable optics to interface with DWDM transport equipment.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Media Dependent Adapter (MDA)—part 2 of 3



The 7750 SR supports the following multiservice MDAs: Any Service Any Port MDA, Asynchronous Transfer Mode MDAs, Circuit Emulation Services MDA, and SONET/SDH MDA. These MDAs are available in multiple interface options to support next-generation applications, including Broadband Network Gateways for residential services, multiservice edge for Layer 2 and Layer 3 business VPN services. The Multiservice MDA interface options also support mobile backhaul and mobile packet core for second generation, third generation and fourth generation long-term evolution wireless services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Media Dependent Adapter (MDA)—part 3 of 3

VSM-XP
Enables the creation of new services by internally interconnecting services. Multiple VSM-XPs can be installed in a chassis and logically grouped, increasing the overall interconnect capacity through load sharing across VSM-XPs in the group.





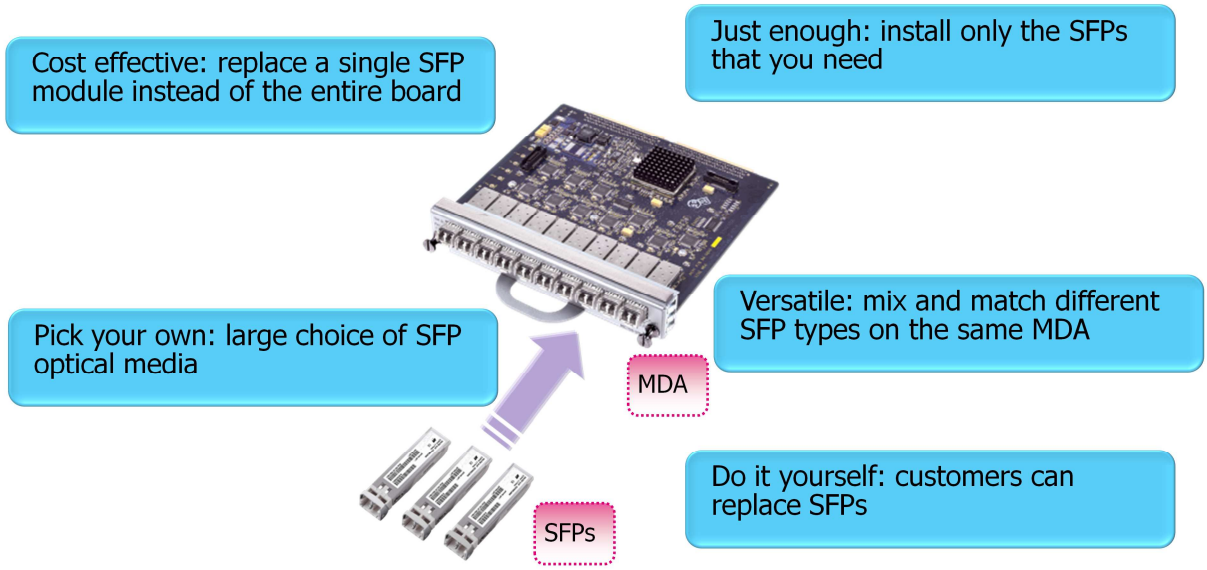
Each VSM-XP occupies half a slot in an IOM and can interconnect up to 25 Gbit/s (half-duplex) of services when installed in an IOM3-XP/IOM3-XP-B and 10 Gbit/s when installed in an IOM2 or IOM1.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR Versatile Services Module XP provides high-performance, inter-service connectivity within a single chassis with advanced Quality of Service features. You can use the VSM XP to interconnect pairs of services internally and to create new service offerings. For example, you can interconnect a Layer 2 service and a Layer 3 service to create a “routed” Layer 2 service.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Small Form-Factor Pluggable transceivers



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SFP transceivers are available in a variety of formats. Alcatel-Lucent recommends you use the SFPs that have been tested, verified and validated for the 7750 SR. Alcatel-Lucent programs its SFPs with a type and a part number. As a result, the operator can easily determine the SFP type and replacement part number when troubleshooting.

The use of SFPs allows you to populate the MDAs with the required features on a per-port basis. The combination of MDAs and SFPs means that carriers can defer much of the capital expense of each point-of-presence customer interface until a firm order for service is received.

To differentiate them from the Gigabit Ethernet transceivers, the 10-Gigabit Ethernet transceivers are commonly referred to as XFPs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Integrated Media Modules

High-performance routing applications, such as edge service aggregation, IPv4/IPv6 peering and multicast, IP transit services, edge-core connectivity

Synchronous Ethernet support available on all optical-based Ethernet IMM cards to enable the distribution of precision network timing and synchronization.

Seamless interoperability with existing combinations of Input/Output Modules equipped with Media Dependent Adapters.

Extensive Operations, Administration and Maintenance tool set, providing integrated visibility, management and control of platform, network and services.



Flexible, tiered feature licensing allowing for in-place feature upgrades without changing the IMM hardware and added costs

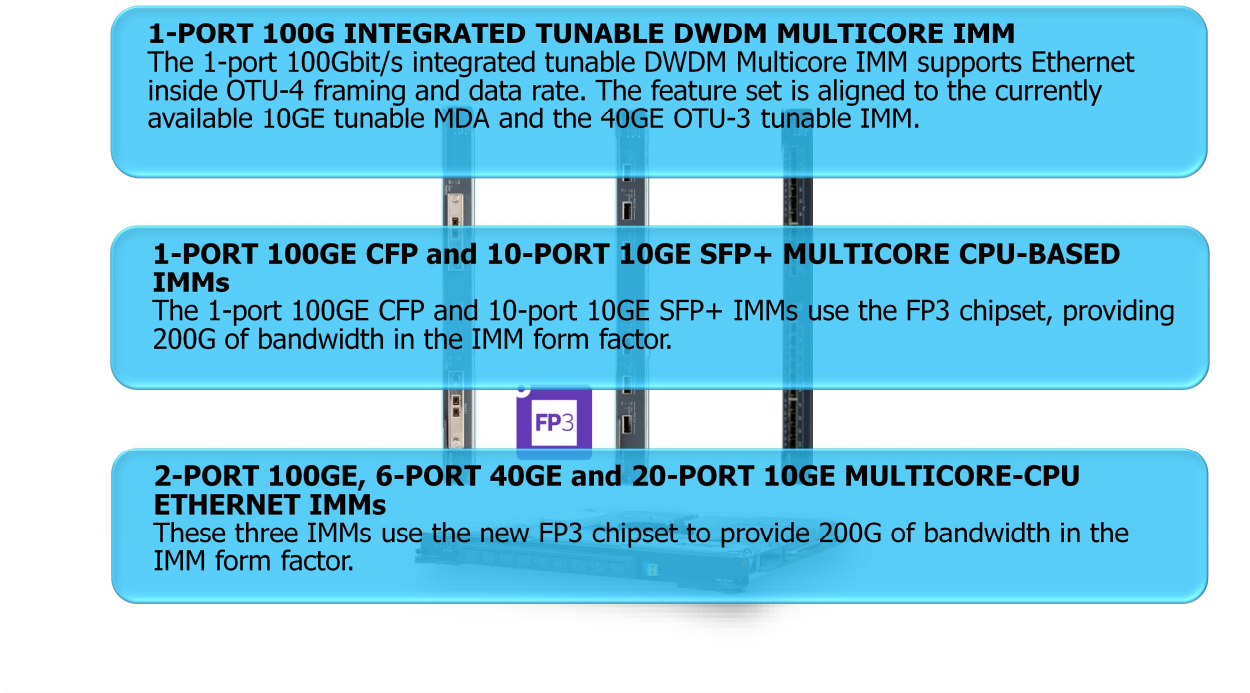
1 · 2 · 36
Overview · IP MPLS SR-OS Product Family
7750 SR 7705 SAR · Mobile Backhaul
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.
Alcatel·Lucent UNIVERSITY

The IMM is a full-slot module with an FP2 or FP3 network processor complex, equipped with integrated physical ports. An IMM combines the functionality of an IOM board equipped with MDAs on a single interface module that you can install in the 7750 SR. The IMMs provide high-density Gigabit Ethernet and 10 Gigabit Ethernet, high-speed 40-Gb/s and 100-Gb/s interfaces, and high-performance IP/MPLS routing and services. The IMMs support advanced traffic management with Hierarchical Quality of Service, a full range of Layer 2 and Layer 3 routing capabilities, Layer 2 and Layer 3 VPN services and residential services.

The IMM is also available in variants with tunable DWDM optics with Fixed Optic—LC connector interfaces. Refer to the product datasheet for details about the available IMMs for each chassis type.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR FP3 Integrated Media Modules



The most recent SR-OS release introduces support for FP3-based IMMs on 7750 SR-7, SR-12, and SR-12e chassis equipped with the latest SF/CPM.

• The one-port 100 Gigabit per second integrated tunable D-W-D-M multicore IMM extends optical reach in long-haul applications without requiring optical signal amplification or dispersion.

• The one-port 100 Gigabit Ethernet C-F-P and ten-port 10 Gigabit Ethernet SFP+ multicore IMMs provide flexible interface options for MDA-like capabilities.

• Each of the two-port 100 Gigabit Ethernet, six-port 40 Gigabit Ethernet and twenty-port 10 Gigabit Ethernet multicore IMMs support 200 Gbit per second throughput when two SF/CPM-4 cards are installed and operational.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-12E IMM

4 X 100GE CXP IMM
400 Gb/s (full duplex) per slot capacity
4 x 100GE enables up to 36 ports per SR-12e



40 X 10GE SFP+ IMM
400 Gb/s (full duplex) per slot capacity
40 x 10GE enables up to 360 ports per SR-12e



Powerful 400G FP3 silicon chip

- Supports the full range of edge services
- No sacrifice of queuing for scale
- Low power consumption
- Enhanced traffic burst absorption

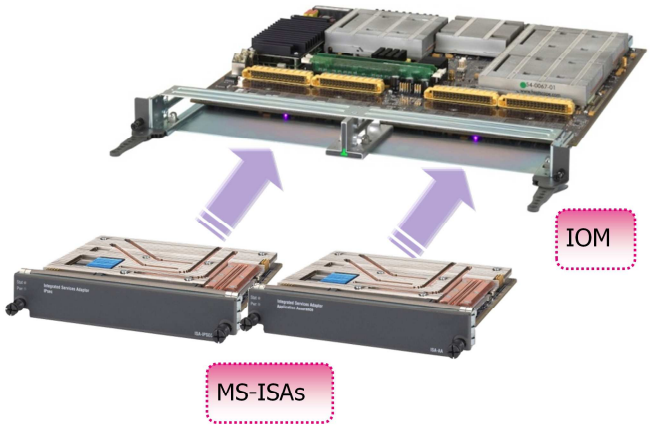
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR-12E Supports the 4 X 100GE CXP IMM and 40 X 10GE SFP+ IMM. The 4 x 100GE enables up to 36 ports per SR-12e and the 40 x 10GE enables up to 360 ports per SR-12e. The FP3 chip supports the full range of edge services with no sacrifice of queuing for scale. It has a low power consumption and enhanced traffic burst absorption.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Integrated Service Adapter—description

The Multiservice Integrated Service Adapter is a half-slot resource blade that inserts into a 7750 SR Input/Output Module



A single Multiservice Integrated Service Adapter is equivalent to multiple external servers, offering scalability and resiliency advantages while reducing costs.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Alcatel-Lucent Multiservice Integrated Service Adapter delivers advanced business and residential services on the 7750 SR, eliminating the need for expensive external platforms to support these services. The MS-ISA virtualizes the services and makes them available to all the ports across the 7750 SR chassis. The MS-ISA reduces the need for standalone network elements, the space and cabling requirements, the power consumption, the topology churn and the network latency.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR Integrated Service Adapter—services

- Application Assurance—including identification and reporting
- L2TP Network Server (LNS) with support for IPv4 and IPv6 features
- Advanced video services—superior Internet Protocol Television QoE
- Network Address Translation (NAT) services—high transaction rates



- MS-ISA Threat Management System (TMS) DDOS Mitigation
- Dual-Stack Lite Address Family Transition Router (AFTR) services
- IPsec services—including Layer 3 VPN connectivity
- WLAN Gateway services with tunneled traffic aggregation

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

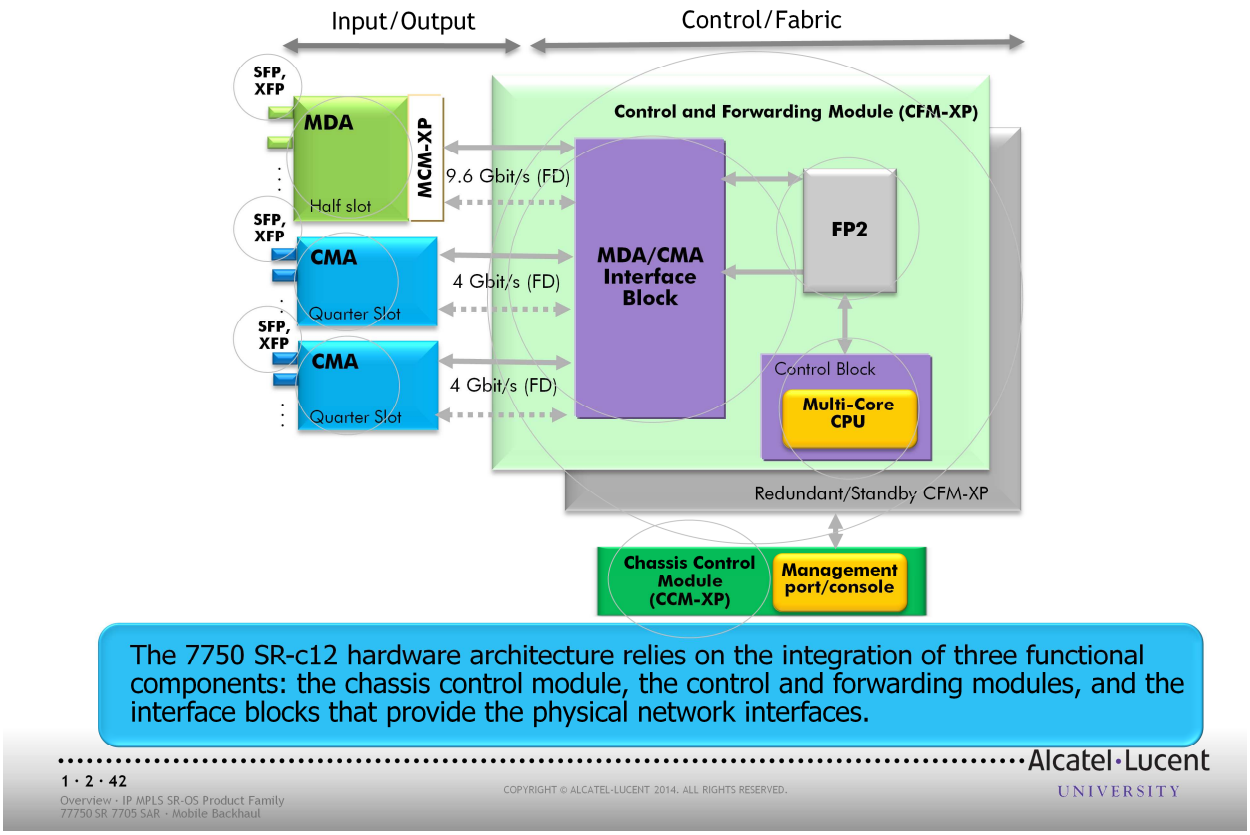
The Alcatel-Lucent MS-ISAs provide purpose-built, extended functionality, and enable deeper levels of integrated services. For details about all supported services and ordering information, refer to the 7750 SR MS-ISA datasheet.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3.4 7750 SR-c12 and SR-c4 architecture and hardware overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

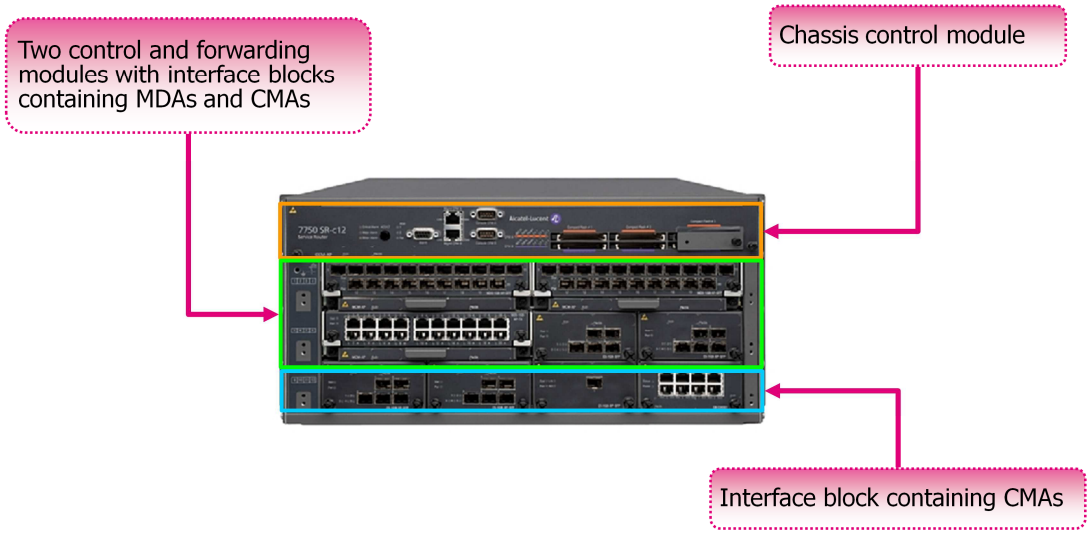
7750 SR-c12 hardware architecture



Each 7750 SR-c12 unit contains a Chassis Control Module XP, which provides control ports, connectors, and three compact flash card slots. The CCM XP is connected to two Control and Forwarding Modules XP for active and standby redundancy. Each CFM XP card integrates an FP2 unit for packet processing, traffic management and advanced Quality of Service, and a 10-core CPU for system control, centralized protocol processing, and management. The CFM XP cards are connected to interface blocks, which accommodate Media Dependent Adapters or Compact Media Adapters, or a combination of both. The MDAs and CMAs provide the physical interface connectivity. An MDA carrier module is necessary to adapt an MDA for use in the SR-c12.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c12 with components



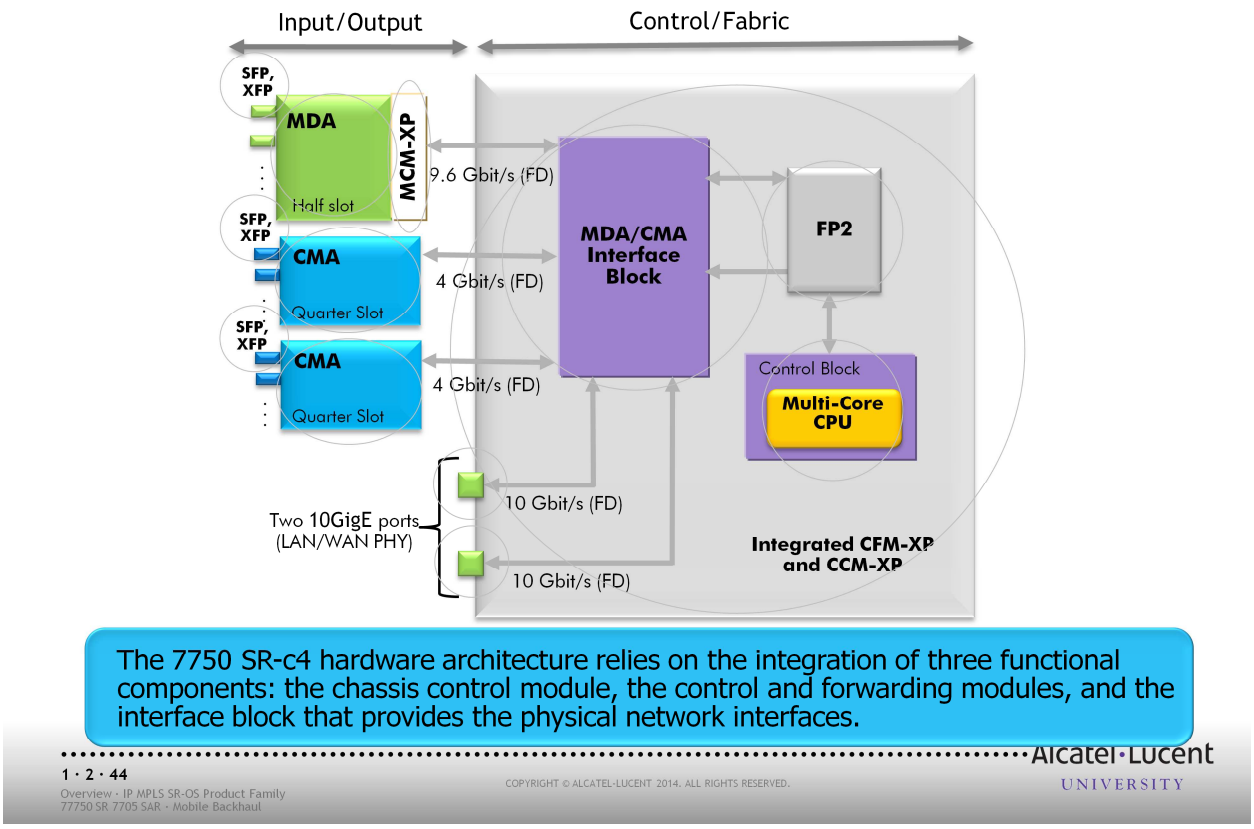
All the components support in-service insertion and removal.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR-c12 has a horizontal slot layout with the top slot dedicated to the chassis control module, two middle slots for the control and forwarding modules with interface blocks, and a slot for a third interface block. The chassis control module provides control ports, connectors, and three compact flash card slots; redundant systems have two sets of three compact flash card slots, for a total of six slots.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c4 hardware architecture

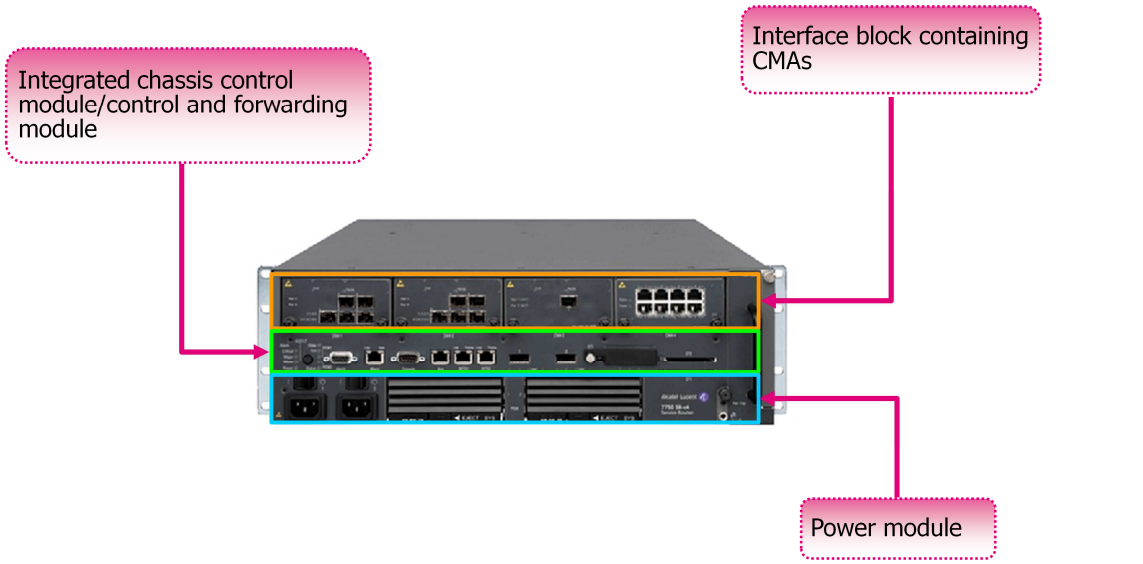


Each 7750 SR-c4 unit contains a CCM XP, which provides control ports, connectors, and compact flash card slots, integrated with a CFM XP. The CFM contains an FP2 unit for packet processing, traffic management and advanced Quality of Service, and a 10-core CPU for system control, centralized protocol processing and management. The integrated CCM XP CFM XP module is connected to an interface block, which can accommodate MDAs or CMAs, or a combination of both. The MDAs and CMAs provide physical interface connectivity for SFP or XFP units. An MDA carrier module is necessary to adapt an MDA for use in the SR-c4.

The 7750 SR-c4 also provides two built-in 10-Gigabit Ethernet physical ports.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c4 with components



All the components support in-service insertion and removal.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR-c4 has a horizontal slot layout with an integrated CCM and CFM module. The integrated module provides control ports, connectors, and three compact flash card slots, and connects to an interface block, which can accommodate MDAs or CMAs, or a combination of both. In this slide, the interface block contains four CMAs. The bottom unit of the chassis is the power module.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3.5 7750 SR-c12 and SR-c4 components

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c12 and SR-c4 components at a glance



Chassis Control Module-XP (CCM-XP)
The CCM-XP provides the console and management interface, as well as alarm information for the CFM and power supplies.



Control and forwarding module (CFM-XP)
The CFM-XP controls the routing and switching functions for the entire system.



Compact Media Adapters (CMA)
Quarter-slot card providing physical layer termination—supported options: Ethernet, POS, ATM, ASAP, TDM and CES



Media Dependent Adapters
Half slot module providing various Ethernet adapter types, interface options and advanced services with SFPs and XFPs



MDA Carrier Module-XP (MCM-XP)
Half-slot module required to adapt an MDA for use in the SR-c12 and the SR-c4—support for subset of SR-12 and SR-7 MDAs

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The CCM is located at the front of the chassis, and has three slots for compact flash memory cards that store system boot images, software images, and configuration files and logs.

The CFM units are located at the back of the chassis, and carry traffic between the MDAs or the CMAs. The switch fabric portion of a CFM receives and directs traffic to the appropriate destinations according to the routing information.

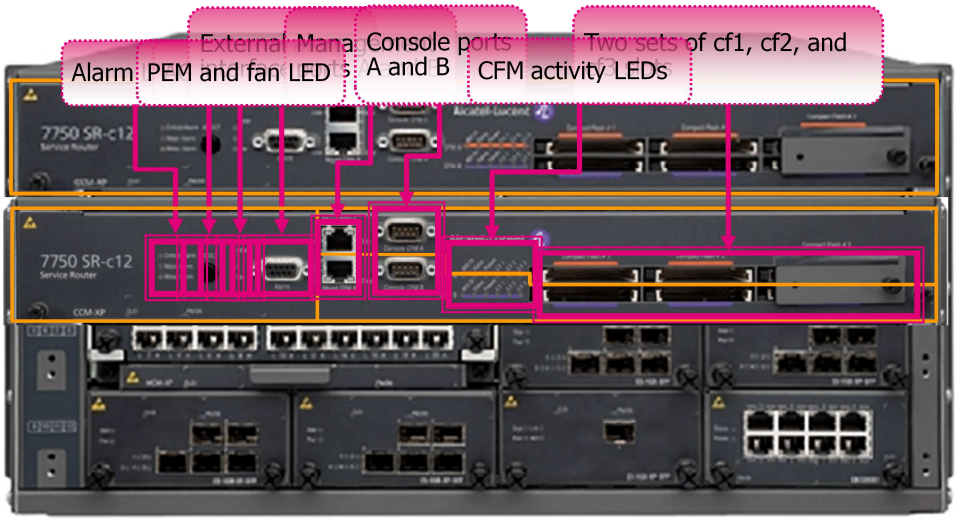
The CMAs support lower-speed, lower-density applications for maximum interface flexibility.

A 7750 SR-c12 or SR-c4 system supports up to two MDAs of types ASAP, ATM or CES .

Each MDA requires an MDA Carrier Module to function in a 7750 SR-c12 or SR-c4 system.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c12 Chassis Control Module XP



A group of specific components associated with a CFM XP are active when that CCM XP is active.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR-c12 has a dedicated Chassis Control Module XP, connected to redundant Control Forwarding Module XPs.

The CCM includes indicators and interfaces that serve the entire chassis, and two duplicated groups of components: one for each CFM.

The CCM-specific elements are: alarm indicators an audible alarm cutoff lamp test button, a power entry module indicator and a fan operation indicator, as well as an alarm port.

The CFM-specific components are: management ports console ports activity LEDs and compact flash card slots.

A group of specific components associated with a CFM are active when that CCM is active.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c4 Chassis Control Module XP



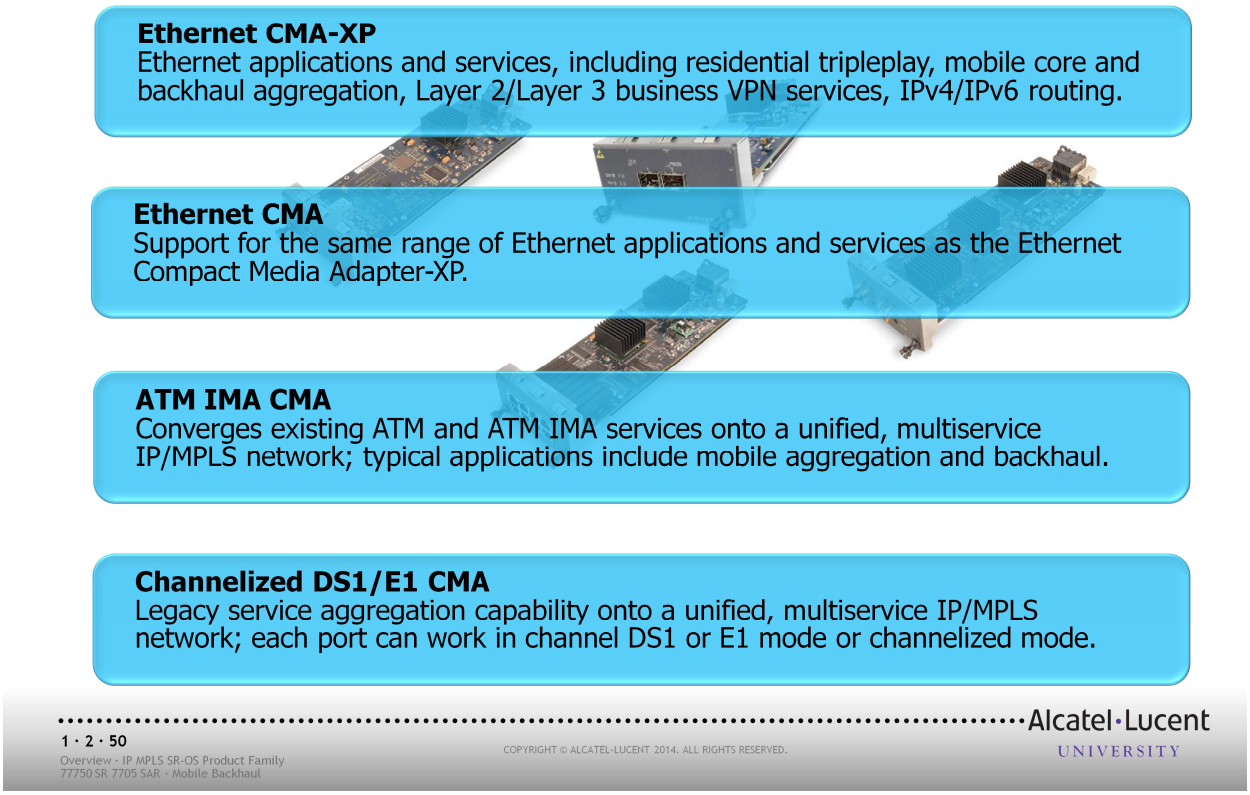
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR-c4 has an integrated Chassis Control Module and Control Forwarding Module.

The integrated module includes the following components: alarm indicators an audible alarm cutoff lamp test button, a power entry module and fan operation indicators, an alarm port a management port a console port an auxiliary port two BITS ports two 10 Gigabit Ethernet ports, and three compact flash card slots.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c12 and SR-c4 Compact Media Adapters—part 1 of 2



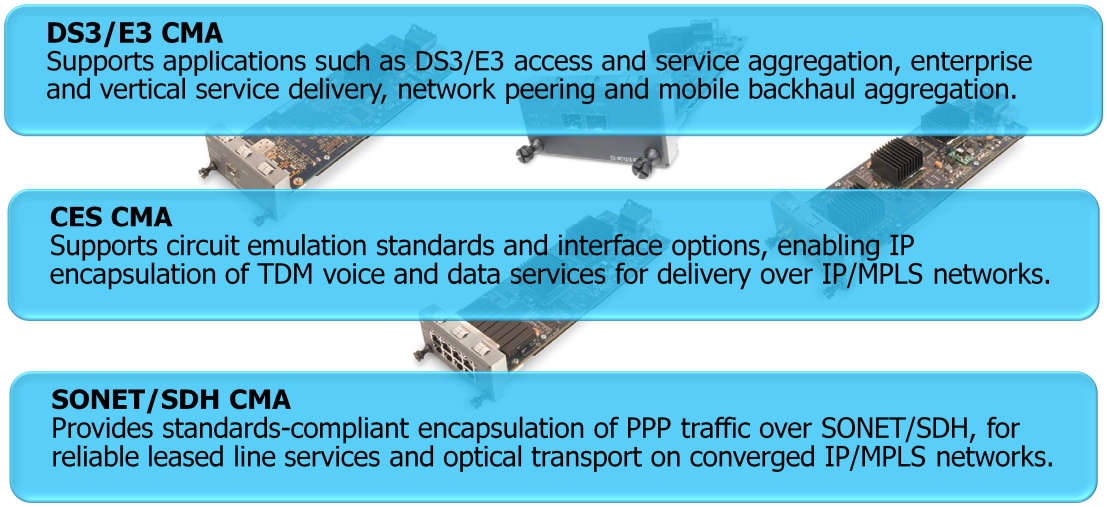
The CMA and CMA XP modules provide service-rich interface options for the 7750 SR-c12 and 7750 SR-c4. The 7750 SR-c12 can accommodate up to eight CMAs in addition to two MDAs and the 7750 SR-c4 can accommodate up to four CMAs.

The CMA XP modules are available for Ethernet applications, and the CMA modules are offered for Ethernet, ATM, SONET/SDH, CES, DS1/E1 and DS3/E3 services. You can mix CMA-XP and CMA modules on the same chassis for flexible configuration options.

The CMA XP and CMA modules that accept SFP transceivers support a wide range of pluggable optics with Digital Diagnostic Monitoring for improved installation, activation and troubleshooting capabilities.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c12 and SR-c4 Compact Media Adapters—part 2 of 2

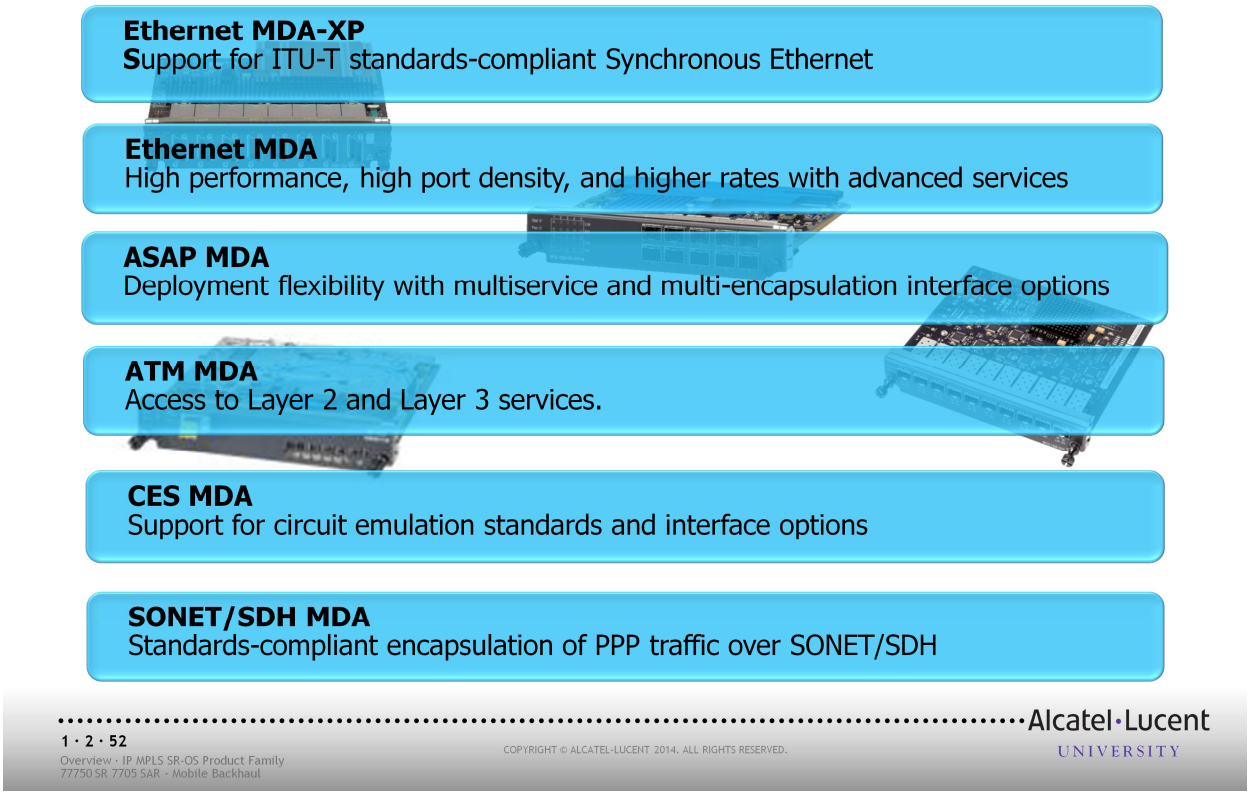


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

For details about all the features and applications that the CMA and CMA XP modules support and for ordering information, refer to the product datasheet.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c12 and SR-c4 Media Dependent Adapters

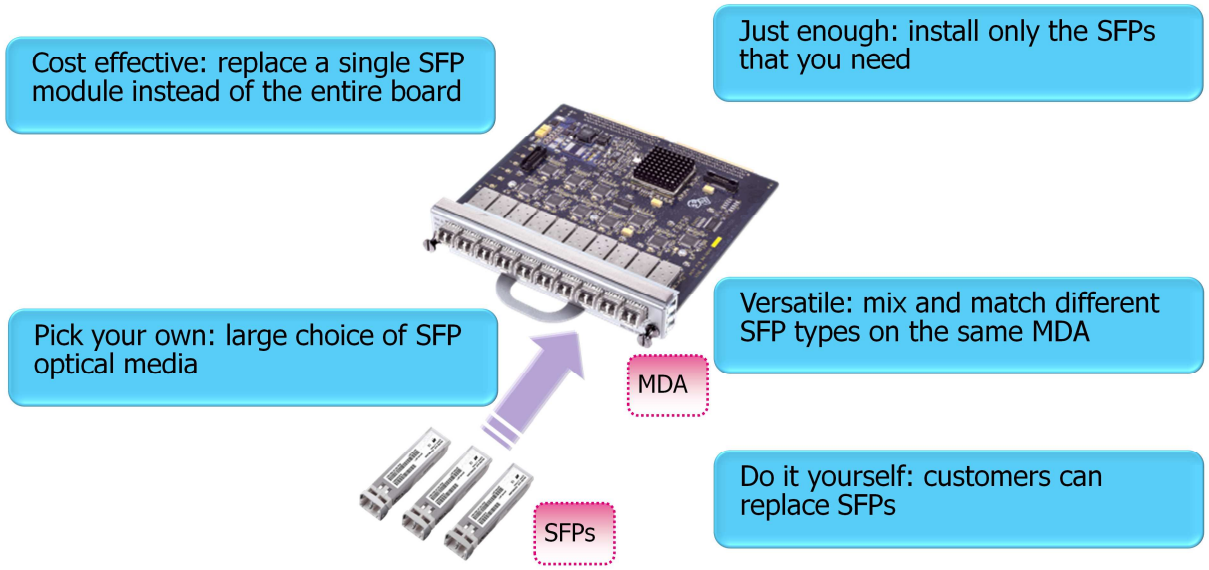


The 7750 SR-c12 and SR-c4 support most of the MDA types that are supported by the 7750 SR-12 and SR-7 systems, with the following exceptions: Ethernet MDA with tunable DWDM optics, High Scale MDA, and Versatile Services Module XP.

The Ethernet MDA types support a wide range of SFP and XFP optical modules. Some SFPs and XFPs provide tunable optics to interface with DWDM transport equipment.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c12 and SR-c4 Small Form-Factor Pluggables



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR-c12 and SR-c4 support most of the SFP and XFP transceivers that are supported by the 7750 SR-12 and SR-7 systems, with the exceptions of the units that apply to the unsupported MDAs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 SR-c12 and SR-c4 Integrated Service Adapter

The MS-ISA is a half-slot resource blade that is equivalent to multiple external servers, offering scalability and resiliency advantages while reducing costs.





The 7750 SR-c12 supports up to two MS-ISAs in each chassis, for up to 20 Gbit/s of wire-speed processing and application recognition.

The 7750 SR-c4 supports one MS-ISA in each chassis, for up to 10 Gbit/s of wire-speed processing and application recognition.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Multiservice Integrated Service Adapter provides extended functionality and enables deeper levels of integrated services. The 7750 SR-c12 supports the Application Assurance and IPsec services MS-ISAs, and the 7750 SR-c4 supports the Application Assurance MS-ISA.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 7450 ESS overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



7450 ESS-12 | 7450 ESS-7 | 7450 ESS-6 | 7450 ESS-6v

Ethernet access and aggregation for high-performance MPLS-enabled carrier networks

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7450 ESS provides Ethernet access and aggregation services over high-performance MPLS-enabled carrier networks of various sizes. The 7450 ESS-12 offers the high capacity required to cover an international or national reach, while the 7450 ESS-7, ESS-6 and ESS-6v models can be deployed in metro or national reach networks.

A 7450 ESS system consists of a physical chassis with slots that house cards. The cards provide the intelligence of the system and the physical interfaces with the network.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS capacity and components at a glance

7450 ESS model	Capacity	Slots	Components	Slot capacity
7450 ESS-12	2 Tbit/s	12	2 SF/CPMs and 10 IOMs or IMMs	Up to 100 Gbit/s
7450 ESS-7	1 Tbit/s	7	2 SF/CPMs and 5 IOMs or IMMs	Up to 100 Gb/s
7450 ESS-6	320 Gbit/s	6	2 SF/CPMs and 4 IOMs	Up to 40 Gbit/s
7450 ESS-6v	320 Gbit/s	6	2 SF/CPMs and 4 IOMs (vertical configuration)	Up to 40 Gbit/s



The table on this slide summarizes the capacity and components of the 7450 ESS models.

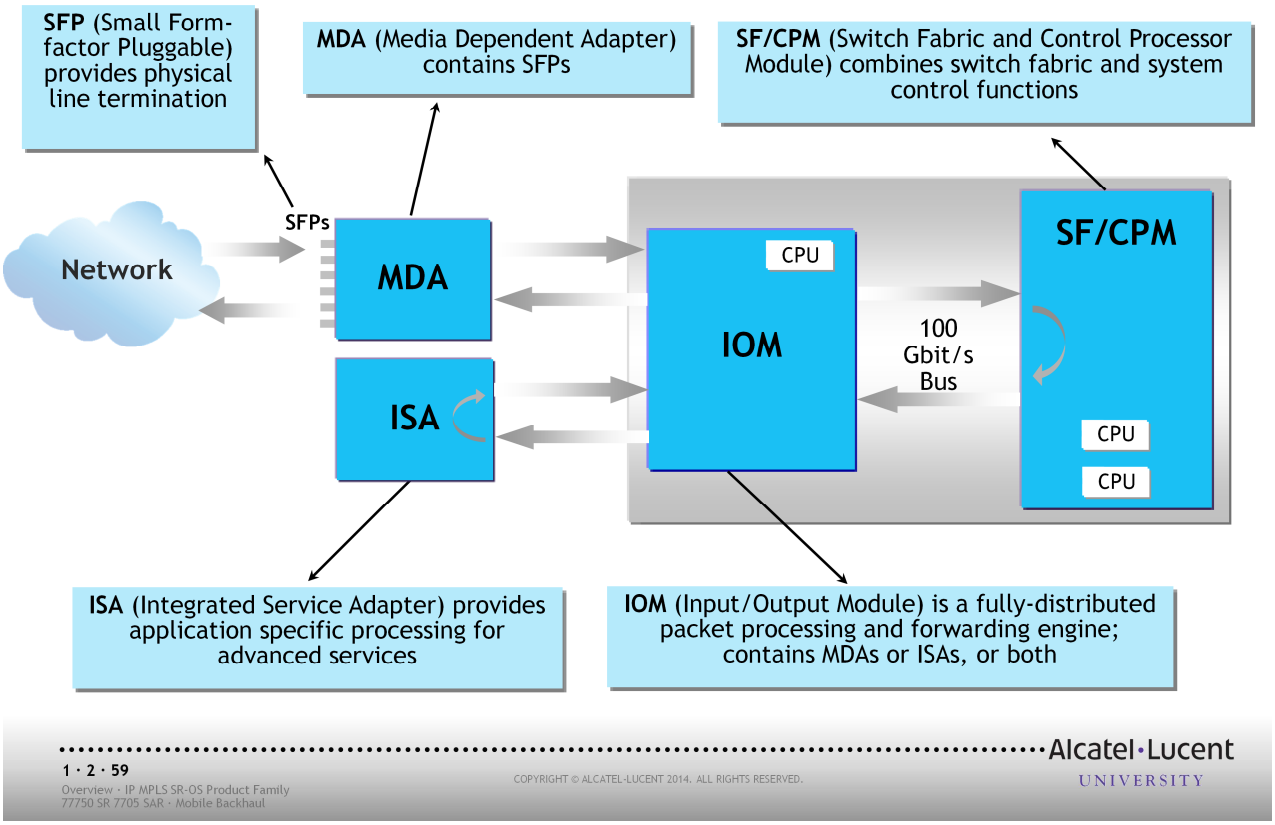
There is no capacity difference between the 7450 ESS-6 and the 7450 ESS-6v models. The 7450 ESS-6v has a vertical slot configuration.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4.1 7450 ESS architecture and hardware overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS with IOM components



This diagram illustrates the structure of the 7450 ESS with Input Output Modules.

The Switch Fabric and Control Processor Module controls the routing and switching functions for the entire system and provides the management and console interfaces, as well as an interface for the external synchronization signal.

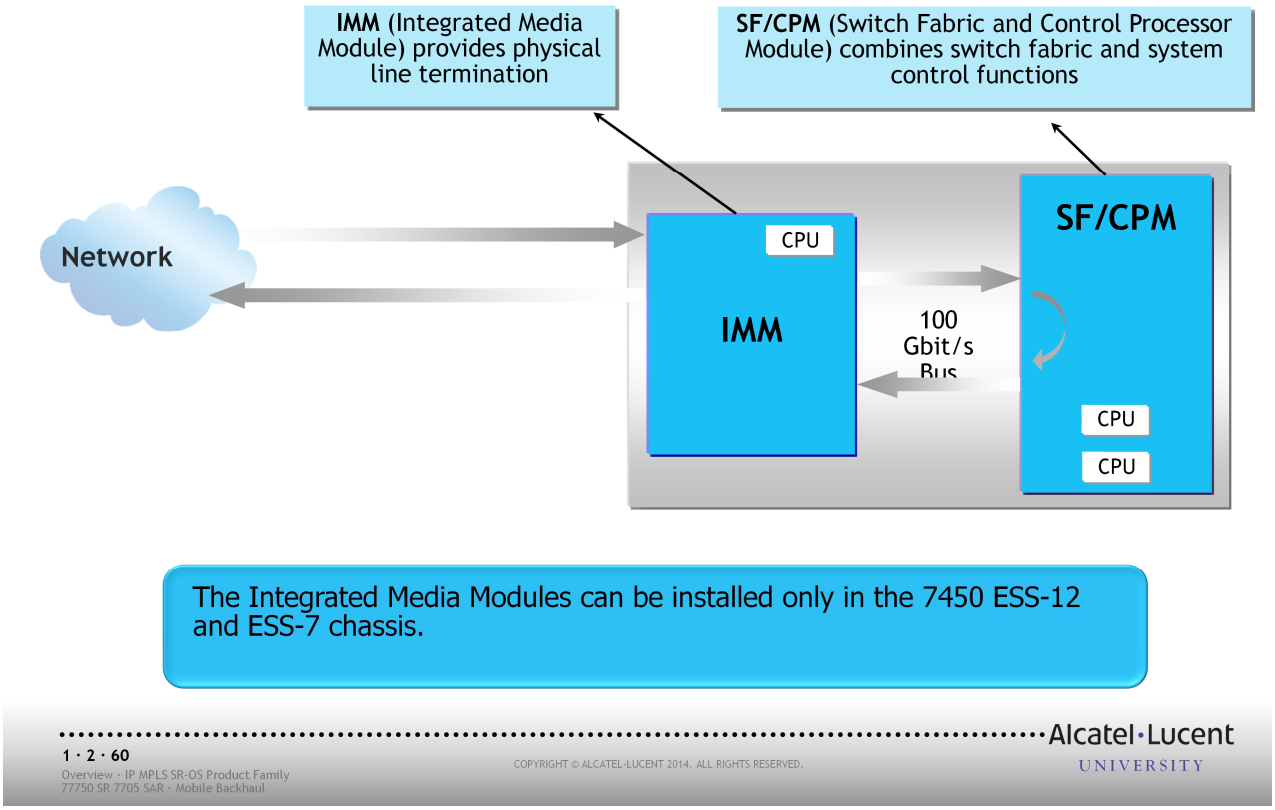
The IOM is a fully-distributed packet processing and forwarding engine, which receives and processes packets to accomplish switching and routing tasks. The IOM provides connectivity to the switch fabric module to move each packet from the ingress interface to the egress interface.

The Media Dependent Adapter contains Small Form-factor Pluggable units that provide the physical network interfaces. The 7450 ESS supports the mixing and matching of different SFP types on the same MDA.

The Multiservice Integrated Service Adapter provides application-specific processing for advanced services such as Application Assurance and Video Processing. The MS-ISA module can be plugged into the IOM cards like the MDAs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS with IMM components



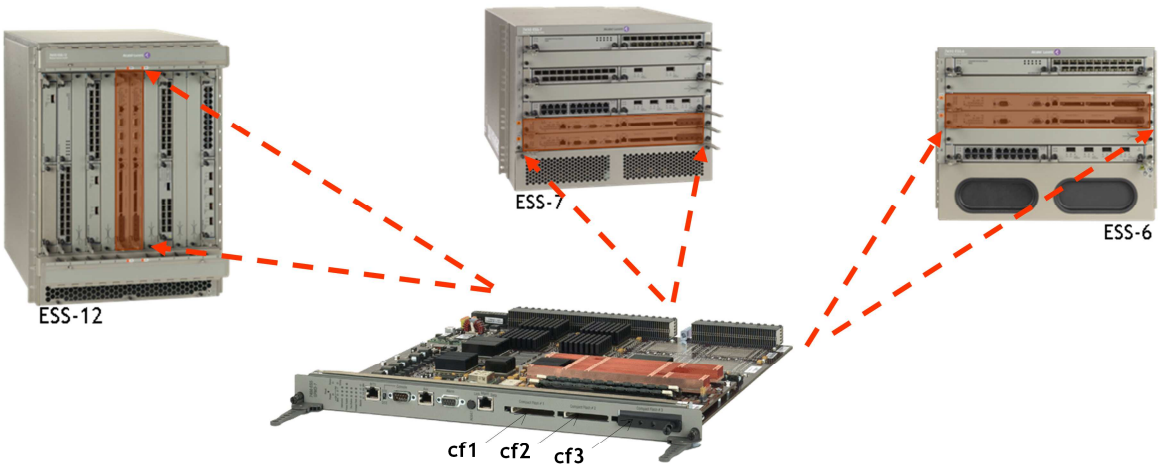
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This diagram illustrates the structure of the 7450 ESS with Integrated Media Modules.

The IMM integrates IOM, MDA and SFP functionality onto a single full-slot, high-density, high-capacity interface module.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS—SF/CPM description



The two load-sharing, redundant Switch Fabric and Control Processor Modules, located in slots A and B, provide full redundancy.

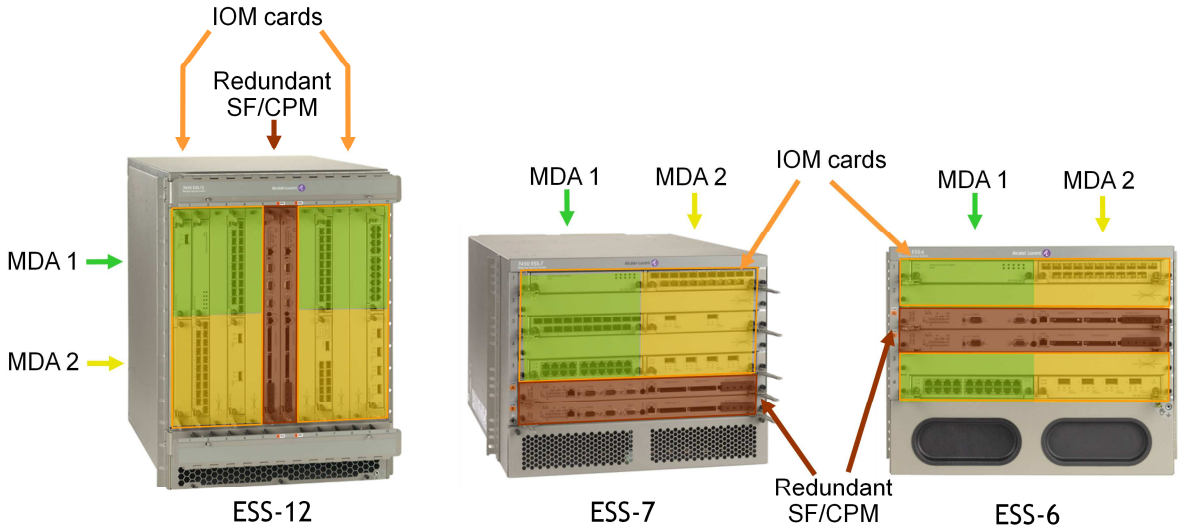
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Each SF CPM contains two central processors. The SF CPM supports hitless switchover using non-stop routing and non-stop service capabilities, as well as routing, switching and Operations, Administration, and Maintenance protocols.

Each SF CPM has three slots for compact flash cards: cf1, cf2, and cf3. Each new system is supplied with a compact flash card that contains the files required to start the system; this is typically inserted in the cf3 slot. You can use the cards in the cf1 and cf2 slots to store debugging and accounting logs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS-12, ESS-7 and ESS-6 with IOM cards



All the components support in-service insertion and removal.

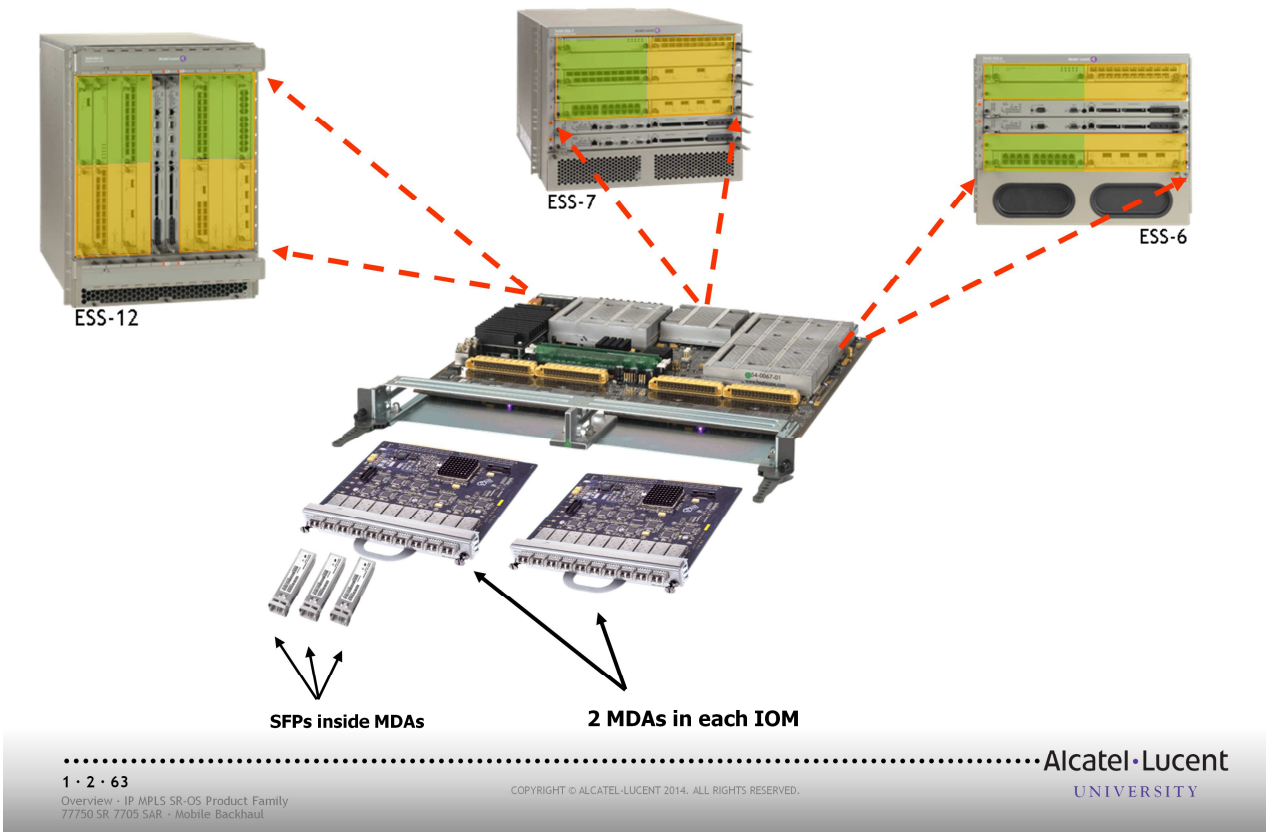
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This is where the SF CPMs, IOMs and MDAs are located in the 7450 ESS-12, ESS-7 and ESS-6 models.

The slide does not show the 7450 ESS-6v, which has the same capacity and accommodates the same components as the ESS-6 model in a vertical form factor that looks like the ESS-12 chassis.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS-12, ESS-7 and ESS-6 with IOMs, MDAs and SFPs



The IOMs are responsible for the queuing, processing and forwarding of data. The 7450 ESS-12 can accommodate 10 IOMs; the ESS-7, 5 IOMs; and the ESS-6 or ESS-6v, 4 IOMs.

Depending on the chassis type and the cards inserted in the IOMs, you can configure multiple operating modes with various feature sets and slot capacities.

The MDAs provide one or more physical interfaces, such as Ethernet or SONET/SDH. The wide variety of MDAs assures the flexibility to populate the 7450 ESS system according to your needs.

The SFPs are small optical or copper modules available in a variety of formats that can be installed in the MDAs.
The 7450 ESS can even have some 7750 SR MDAs installed, as long as the system is properly configured to function in mixed mode.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS components at a glance



Switch Fabric and Control Processor Module (SF/CPM)
Multi-core control processor that runs routing, switching and OAM protocols



Input Output Module
Full slot module that can accommodate up to two MDAs or two ISAs, or one MDA and one ISA



Media Dependent Adapters
Half slot module that provides various Ethernet adapter types, interface options and advanced services with SFPs and XFPs



Integrated Media Module
Full slot module with FP2 network processor complex equipped with integrated physical ports



Integrated Service Adapter
Half slot resource blade without physical ports that inserts into an input/output module and provides specialized services

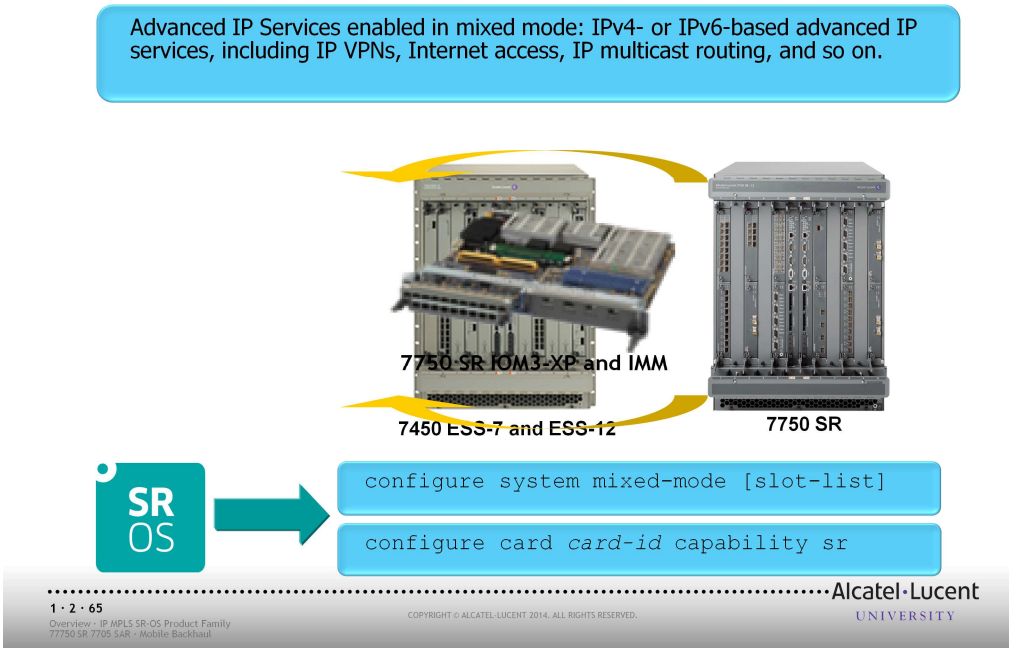
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7450 ESS uses the same types of components as the 7750 SR, but there are key differences in component support and functionality.

The 7450 ESS-7 and ESS-12 can be configured in a mixed mode of operation to support some of the 7750 SR components and services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS mixed mode and advanced IP services



The 7450 ESS-7 and ESS-12 can operate in two modes: standard mode and mixed mode. The standard mode is the default mode of operation. In standard mode, the 7450 ESS uses the components designed to be used in a 7450 ESS and delivers the standard features and services. In mixed mode, the 7450 ESS can use some 7750 SR components that extend the 7450 ESS functionality to support 7750 SR features and services. The 7750 SR features are called Advanced IP Services, and can be enabled only on 7750 SR IOM3-XP cards.

The Switch Fabric and Control Processor Modules do not require an upgrade for the 7450 ESS to function in mixed mode.

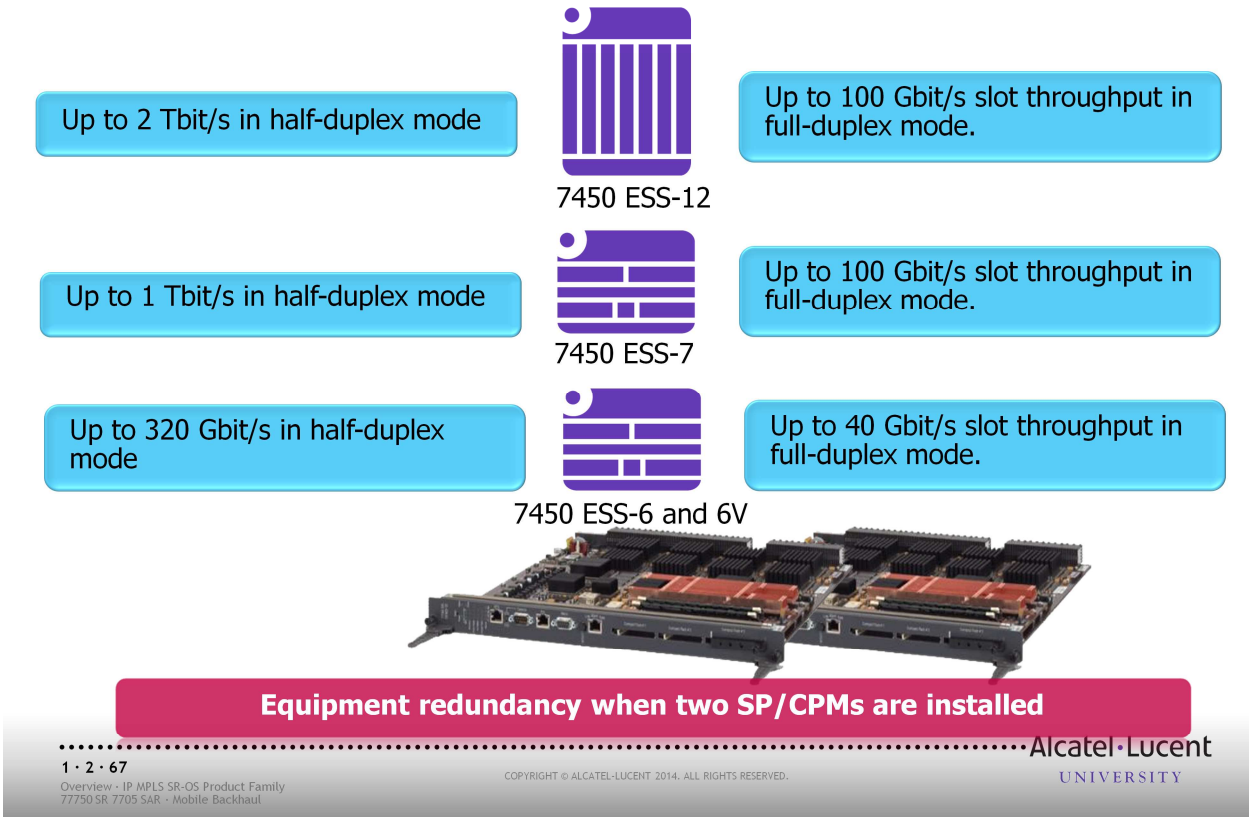
To enable the mixed mode of operation, you need to configure the 7450 ESS and change card capabilities for the system to accept 7750 SR components and provide Advanced IP Services. You perform these tasks in the Service Router Operating System.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4.2 7450 ESS components

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS Switch Fabric and Control Processor Module

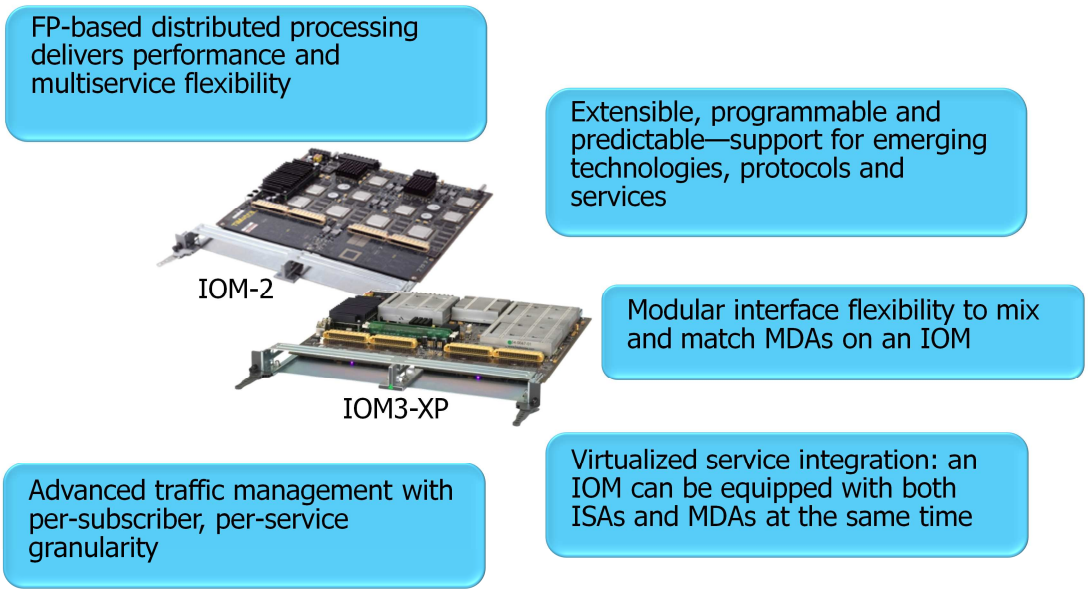


The Switch Fabric and Control Processor Module integrates the switch fabric and control functions into one unit. All 7450 ESS models require one SF CPM to function. When the 7450 ESS is equipped with two SF CPMs, the switch fabrics are active on both cards and operate in a load-sharing arrangement, doubling the chassis switch fabric throughput.

Each SF CPM contains ten 750-MHz core processors. The software that supports the SF CPM is enhanced for symmetric multi-processing. In a redundant configuration, the SF CPM allows for hitless switchover using non-stop routing and non-stop service capabilities.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS Input/Output Module

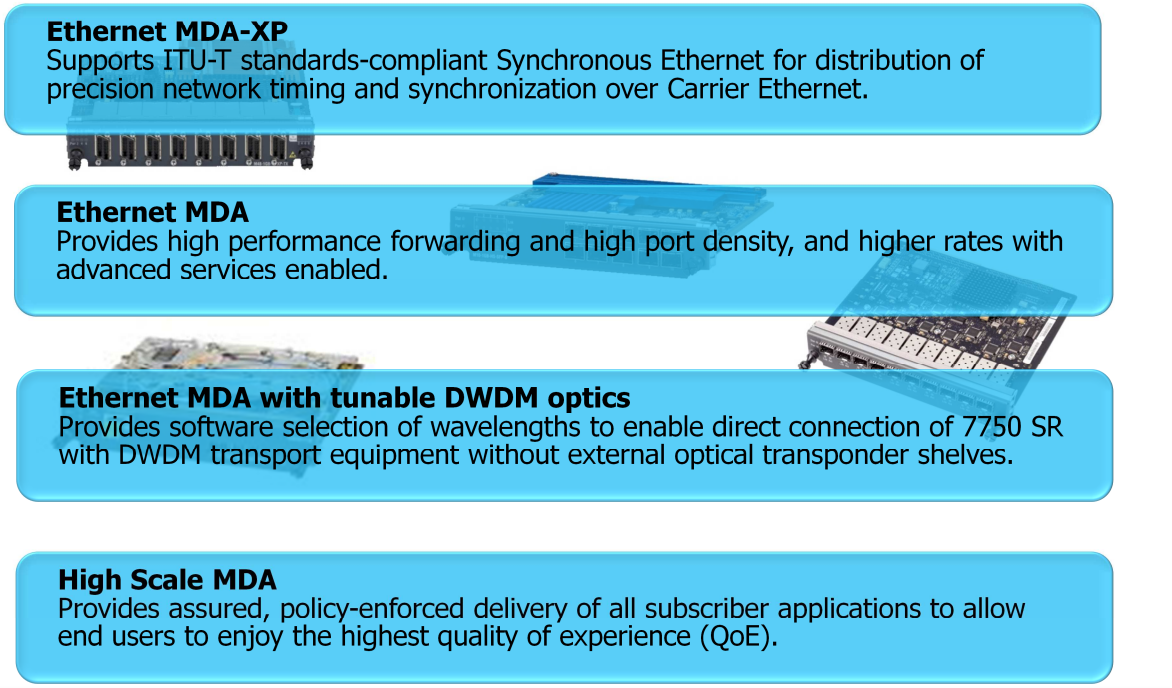


The IOM is a full-slot board that inserts into a 7450 ESS chassis slot. Each IOM supports up to two MDAs or two ISAs, or a combination of both. The IOM is the distributed forwarding and packet services engine, while the MDA provides the physical network interfaces, and the two ISAs provide processing resources for advanced services.

The 7450 ESS supports some 7750 SR MDA types only when the 7750 SR IOM3-XP is installed, and the mixed mode is enabled in the SR OS.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS Media Dependent Adapters—part 1 of 3



The 7450 ESS supports a wide range of MDA types, interface options and advanced service delivery capabilities.

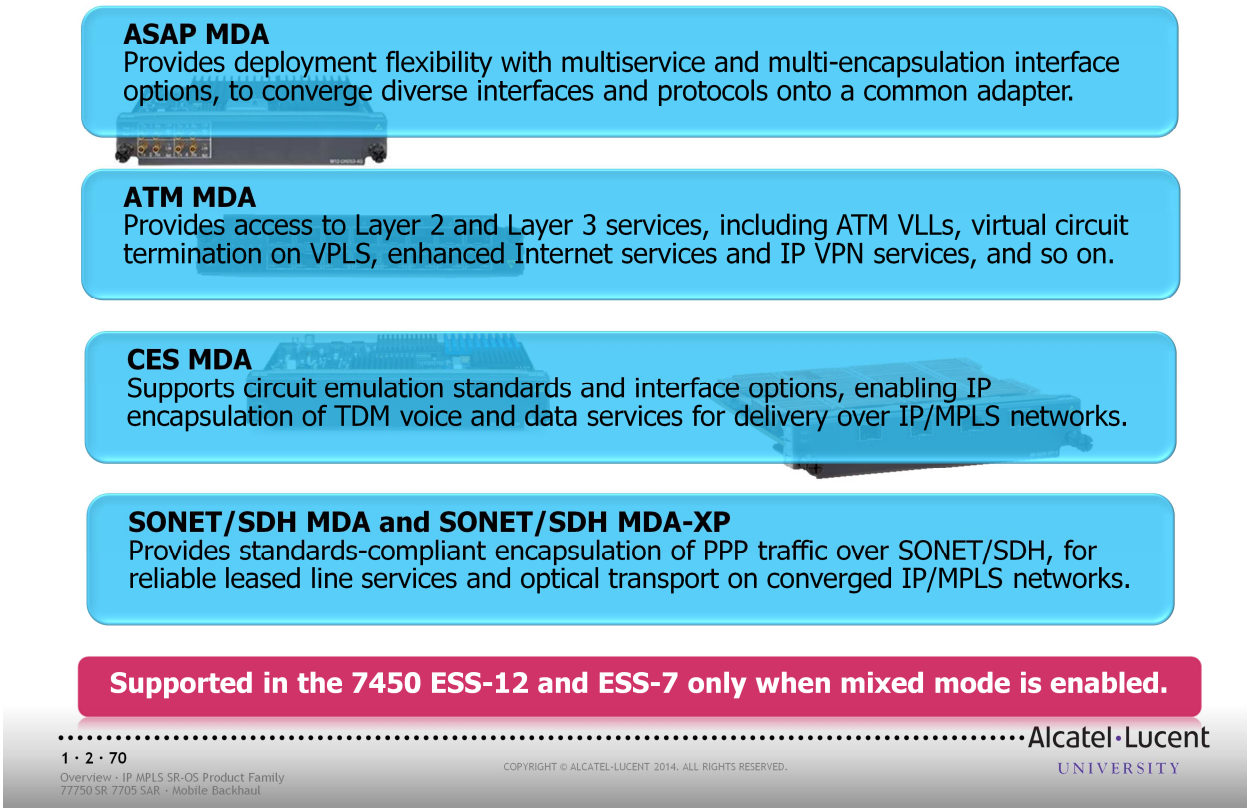
The Ethernet MDAs support Carrier Ethernet applications and services, including mobile core and backhaul aggregation, Layer 2 and Layer 3 business virtual private networks and broadband residential services and content delivery networks, as well as traditional IPv4 and routing applications.

The Ethernet MDA-XP, Ethernet MDA, Ethernet MDA with tunable DWDM optics and High Scale MDA deliver high-density, high-performance Carrier Ethernet for business, mobile and residential applications.

All Ethernet MDA types support a wide range of SFP and XFP optical modules, and include variants with tunable optics to interface with DWDM transport equipment.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS Media Dependent Adapters—part 2 of 3



The 7450 ESS-12 and ESS-7 support the ASAP, ATM, CES, and SONET/SDH MDAs only when the 7750 SR IOM3-XP is installed and the mixed mode of operation is enabled. As a result, the 7450 ESS supports Advanced IP Services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS Media Dependent Adapters—part 3 of 3

VSM-XP
Enables the creation of new services by internally interconnecting services. Multiple VSM-XPs can be installed in a chassis and logically grouped, increasing the overall interconnect capacity through load sharing across VSM-XPs in the group.





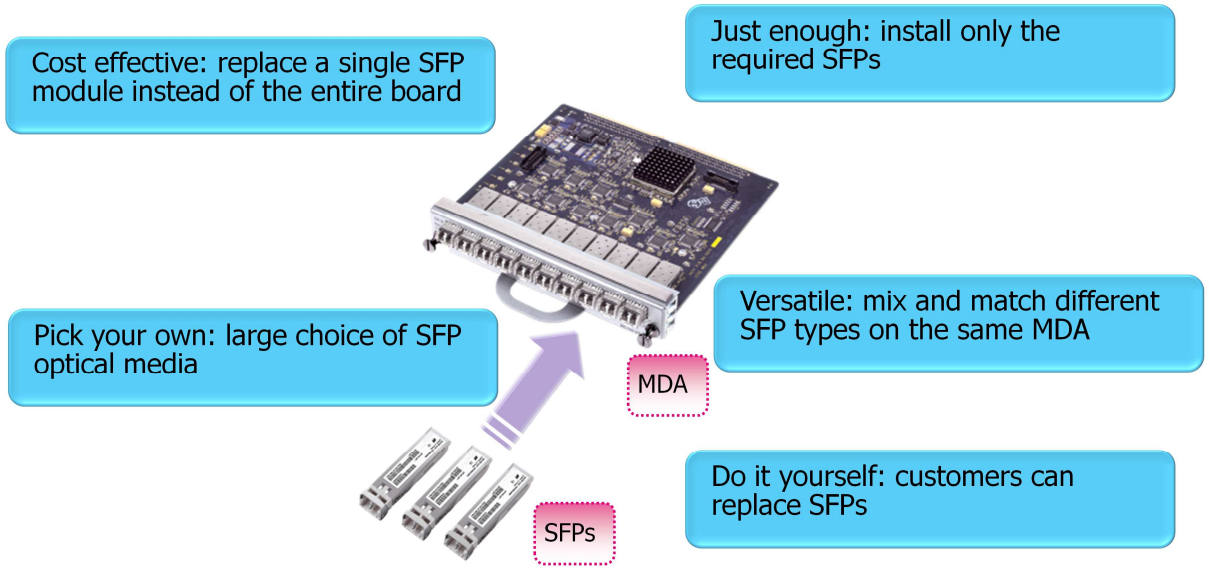
Each VSM-XP occupies half a slot in an IOM and can interconnect up to 25 Gbit/s (half-duplex) of services when installed in an IOM3-XP/ IOM3-XP-B and 10 Gbit/s when installed in an IOM-20G.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7450 SR Versatile Services Module-XP provides high-performance, inter-service connectivity within a single chassis with advanced Quality of Service features. You can use the VSM XP to interconnect pairs of services internally and to create new service offerings. For example, you can interconnect a Layer 2 service and a Layer 3 service to create a “routed” Layer 2 service.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS Small Form-Factor Pluggable transceivers



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SFP transceivers are available in a variety of formats. Alcatel-Lucent recommends you use the SFPs that have been tested, verified and validated for the 7750 SR. Alcatel-Lucent programs its SFPs with a type and a part number. As a result, the operator can easily determine the SFP type and replacement part number when troubleshooting.

The use of SFPs allows you to populate the MDAs with the required features on a per-port basis. The combination of MDAs and SFPs means that carriers can defer much of the capital expense of each point-of-presence customer interface until a firm order for service is received.

To differentiate them from the Gigabit Ethernet transceivers, the 10-Gigabit Ethernet transceivers are commonly referred to as XFPs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS Integrated Media Modules

High-performance routing applications, such as edge service aggregation, IPv4/IPv6 peering and multicast, IP transit services, edge-core connectivity

Synchronous Ethernet support available on all optical-based Ethernet IMM cards to enable the distribution of precision network timing and synchronization.

Seamless interoperability with existing combinations of Input/Output Modules equipped with Media Dependent Adapters.

Extensive Operations, Administration and Maintenance tool set, providing integrated visibility, management and control of platform, network and services.



Flexible, tiered feature licensing allowing for in-place feature upgrades without changing the IMM hardware and added costs

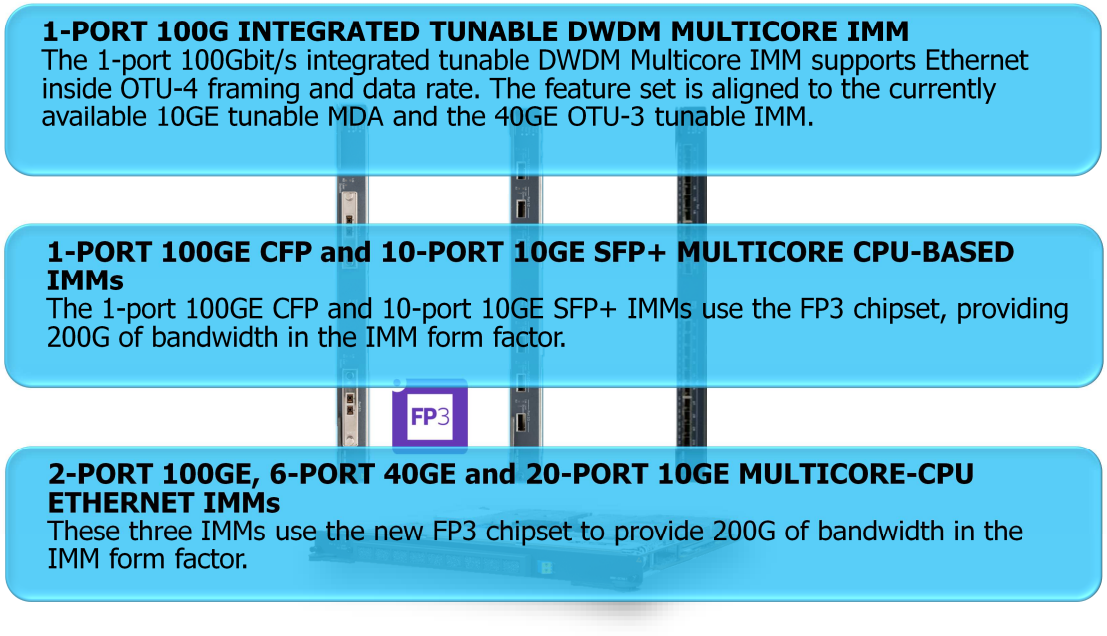
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The IMM is a full-slot module with an FP2 network processor complex, equipped with integrated physical ports. An IMM combines the functionality of an IOM board equipped with MDAs on a single interface module that you can install in the 7450 ESS. The IMMs provide high-density Gigabit Ethernet and 10 Gigabit Ethernet, high-speed 40-Gb/s and 100-Gb/s interfaces, and high-performance IP/MPLS routing and services. The IMMs support advanced traffic management with Hierarchical Quality of Service, a full range of Layer 2 and Layer 3 routing capabilities, Layer 2 and Layer 3 VPN services and residential services.

The IMM is also available in variants with tunable DWDM optics with Fixed Optic—LC connector interfaces. Refer to the product datasheet for details about the available IMMs for each chassis type.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS FP3 Integrated Media Modules



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The most recent SR-OS release introduces support for FP3-based IMMs on 7450 ESS-7 and ESS-12 chassis equipped with the latest SF/CPM.

• The one-port 100 Gigabit per second integrated tunable D-W-D-M multicore IMM extends optical reach in long-haul applications without requiring optical signal amplification or dispersion.

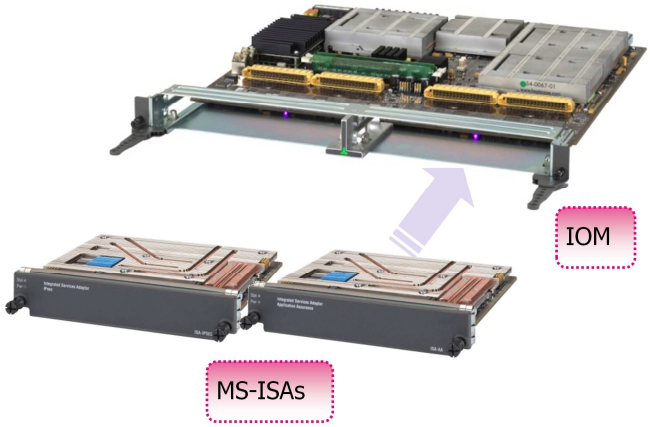
• The one-port 100 Gigabit Ethernet C-F-P and ten-port 10 Gigabit Ethernet SFP+ multicore IMMs provide flexible interface options for MDA-like capabilities.

• Each of the two-port 100 Gigabit Ethernet, six-port 40 Gigabit Ethernet and twenty-port 10 Gigabit Ethernet multicore IMMs support 200 Gbit per second throughput when two SF/CPM-4 cards are installed and operational.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7450 ESS Integrated Service Adapter—description

The Multiservice Integrated Service Adapter is a half-slot resource blade that inserts into a 7450 ESS Input/Output Module



A single Multiservice Integrated Service Adapter is equivalent to multiple external servers, offering scalability and resiliency advantages while reducing costs.

No support for the MS-ISAs when the advanced IP services are enabled.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Alcatel-Lucent Multiservice Integrated Service Adapter delivers advanced business and residential services on the 7450 SR, eliminating the need for expensive external platforms to support these services. The MS-ISA virtualizes the services and makes them available to all ports across the 7450 ESS chassis. The MS-ISA reduces the need for standalone network elements, the space and cabling requirements, the power consumption, the topology churn and the network latency.

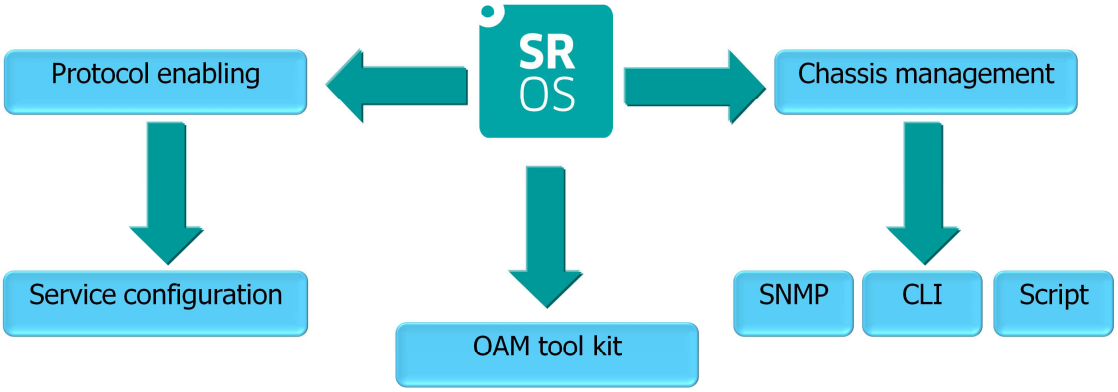
The 7450 ESS supports the MS-ISA Application Assurance and some Video Services when equipped with the IOM-20G or IOM3-XP.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

5 Service Router Operating System capabilities

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SR OS software architecture



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Service Router Operating System is a reliable and feature-rich operating system that functions across the entire Alcatel-Lucent Service Router portfolio. A single operating system used on all platforms enables you to consistently and reliably perform operations and management tasks when deploying Ethernet, legacy, and mobile services and applications in a network that includes the 7750 SR and the 7450 ESS.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SR OS capabilities



7750 SR support: Ethernet, POS, ATM, Frame Relay, TDM interfaces; routing protocols; dual stack IPv4 and IPv6; IP multicast routing and forwarding (PIM and IGMP); MPLS; traffic engineering; local and distributed VPN services; IES services; advanced H-QoS; high-availability features, including In-Service Software Upgrade.



7450 ESS native support: Ethernet and POS interfaces; routing protocols; MPLS; traffic engineering; local and distributed VPN services; advanced H-QoS; high-availability features, including In-Service Software Upgrades.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR supports a wide range of SR OS capabilities that translate into a solid feature and service set.

The 7450 ESS was primarily designed to support Ethernet aggregation services. Its primary focus has been on providing Layer 2 services, such as VLL and VPLS. However, to provide greater flexibility, deliver greater scale, and drive revenue with new services while preserving value for the installed base, the 7450 ESS can be extended to support 7750 SR interfaces and features.

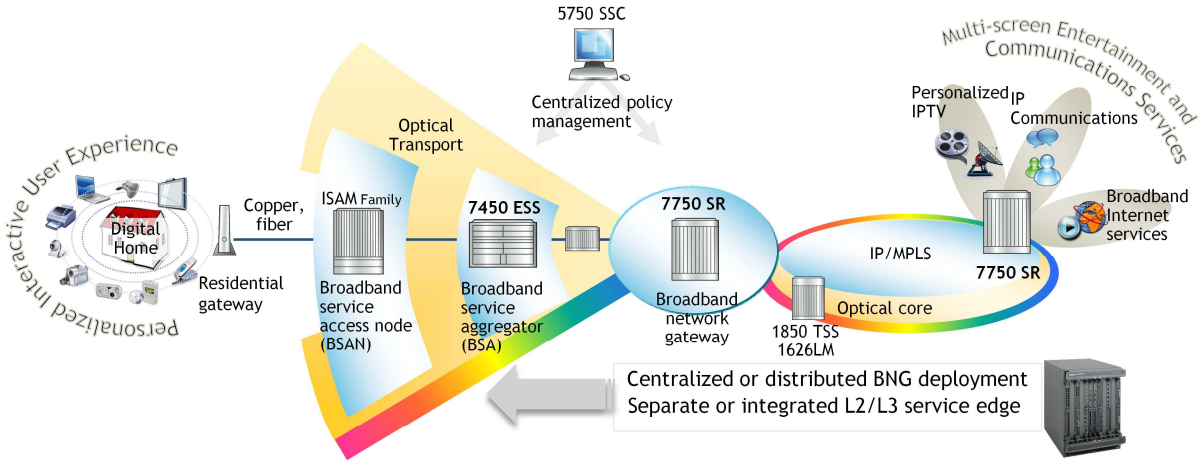
When the mixed-mode is enabled in the SR OS, the 7450 ESS can also support the following 7750 SR capabilities: ATM, Frame Relay and TDM interfaces; Layer-3 services such as full IES and VPRN; BGP for routing (all address families); IPv6 routing; IP Multicast routing and forwarding.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6 Application scenarios with the 7750 SR and 7450 ESS

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Broadband network gateway residential service delivery



End-to-end solution that includes flexible and rich access options, Ethernet aggregation and subscriber management, and service routing (including video core routing).

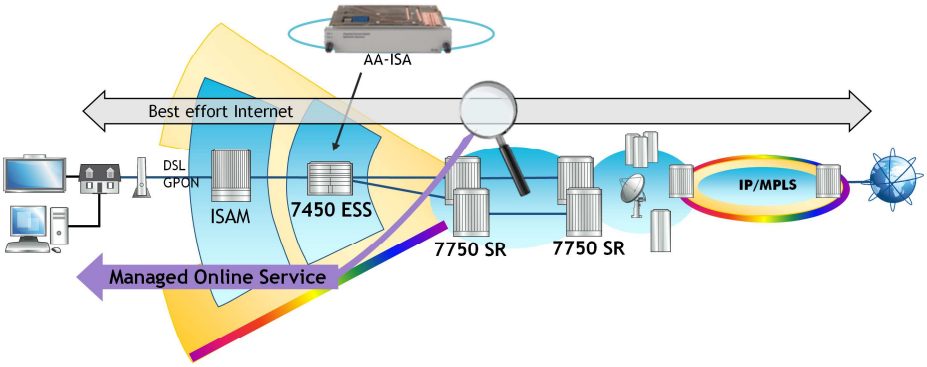
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7750 SR plays a central role as the BNG in the Alcatel-Lucent's Triple Play Service Delivery Architecture, which offers premium residential video, voice services, and HSI services. The 7450 ESS functions as a broadband service aggregator using Carrier Ethernet to deliver next generation services

The TPSDA advantages are: high availability through redundancy and resiliency mechanisms at all levels, hierarchical Quality of Service, distributed policy resource control, centralized network, service and subscriber management, secure network access and content.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Residential broadband service specialization with AA-ISA



Application assurance provides a positive, value-centric approach to over-the-top content, facilitating a new portfolio of managed online services and emerging business models

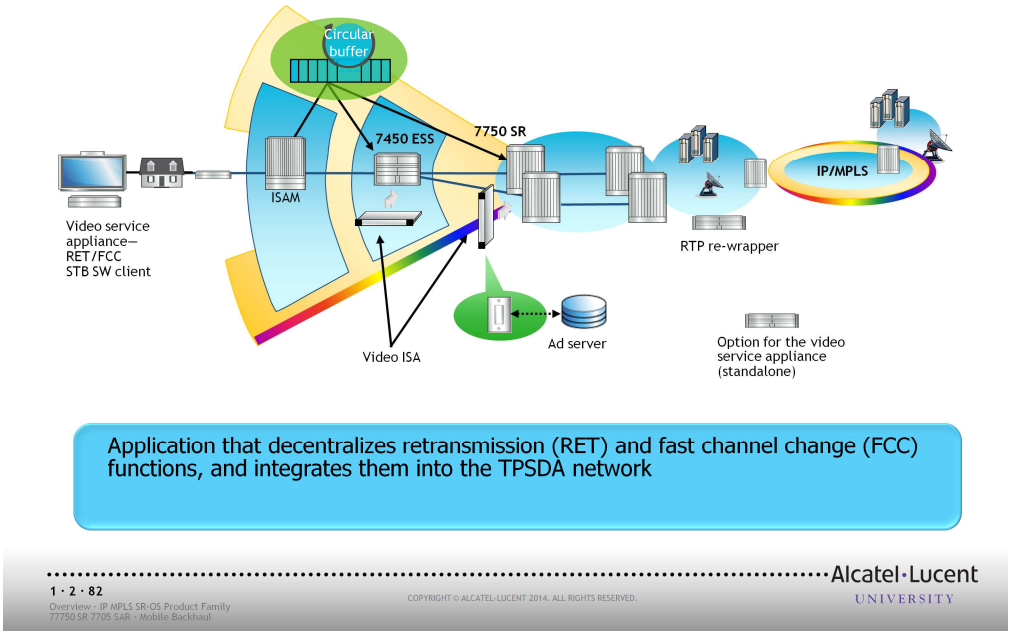
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Both the 7750 SR and the 7450 ESS can be equipped with the Application Assurance Integrated Service Adapter. The AA-ISA scans IP flows and marks specified, per-subscriber application flows for extraction into an SLA-managed online service queue. The combination of application assurance and service router attributes results in specialized managed online services.

Over-the-top content means on-line delivery of video and audio without the Internet service provider being involved in the control or distribution of the content.

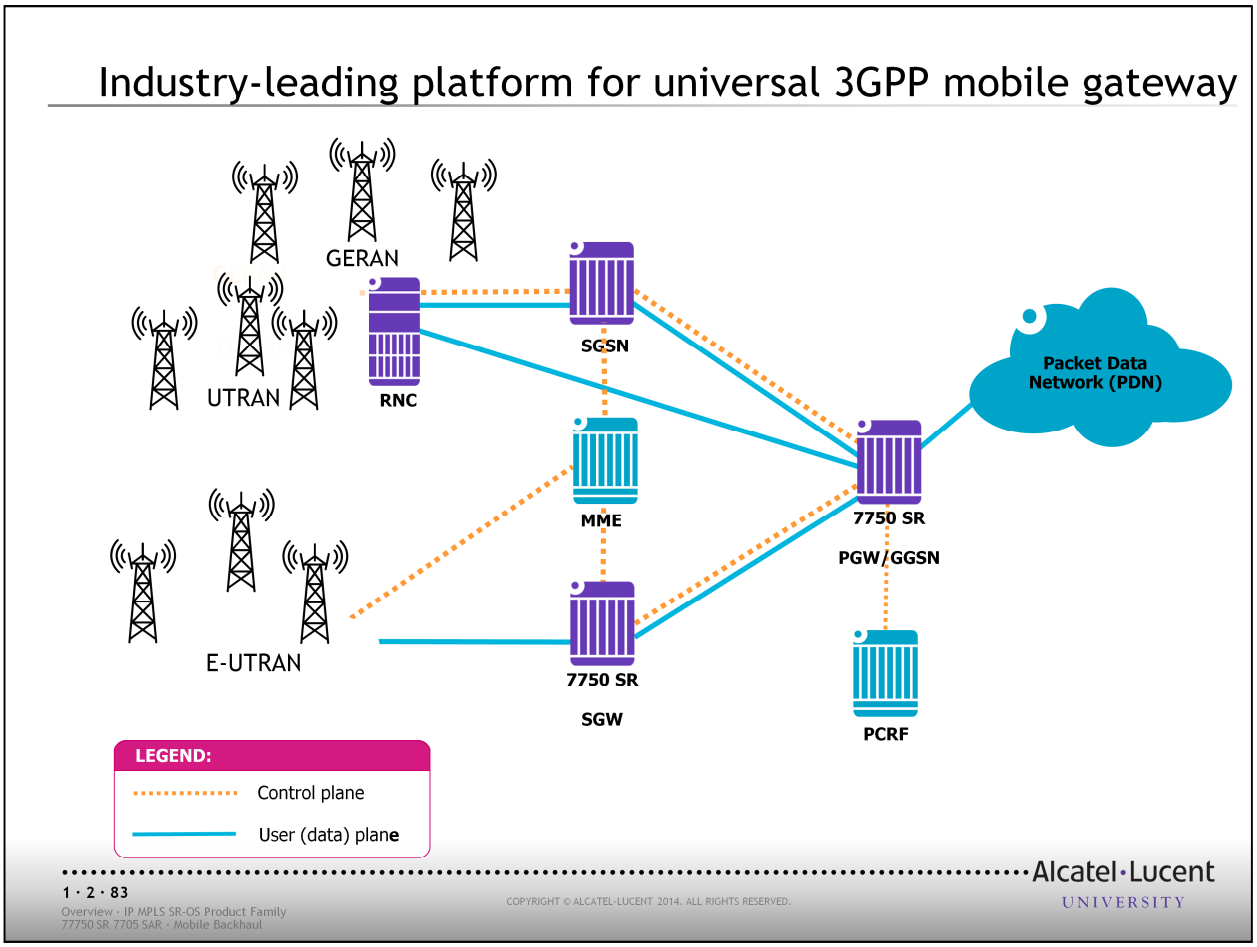
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Assured linear TV delivery and ad insertion with video ISA



This scenario includes assured linear TV delivery and ad insertion with video ISA. The application reduces costs and generates additional advertising revenue. It increases performance and scalability, and supports flexible deployment options. This application is a standards-based and middleware-independent solution. video service appliance

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



This application scenario combines second-generation, third-generation, and fourth-generation network architectures.

The Global System for Mobile communications EDGE Radio Access Network, shown in the drawing as GERAN, belongs to second-generation networks. This terminology is maintained by the Third-Generation Partnership Project as part of the combined Universal Mobile Telecommunication System and GSM networks.

The Universal Terrestrial Radio Access Network, shown in the drawing as UTRAN, includes the base station in the LTE system and the corresponding Radio Network Controller that make up the third-generation UMTS radio access network.

The Evolved UTRAN, shown in the drawing as E-UTRAN, is the air interface of the fourth-generation Long Term Evolution network derived from the 3GPP.

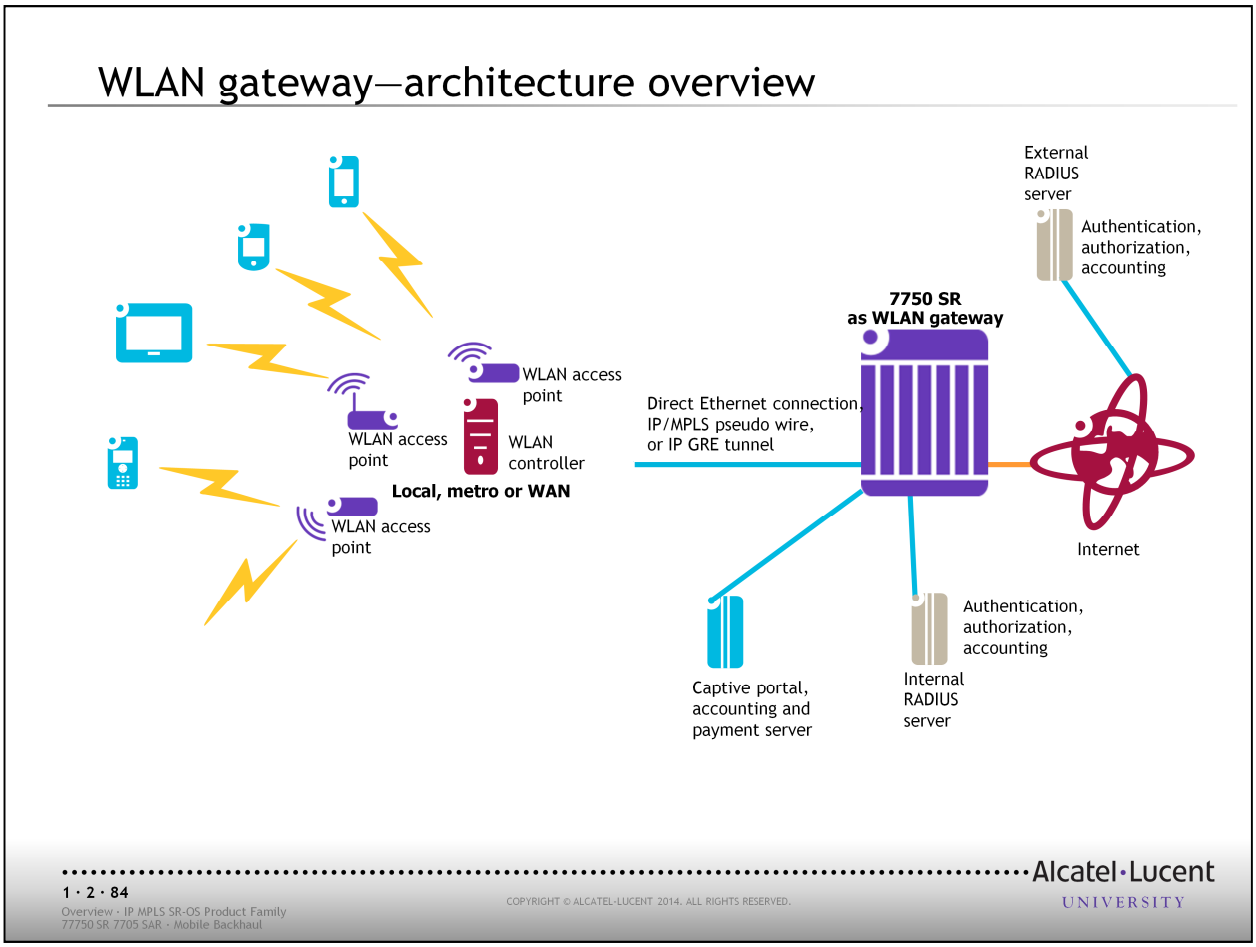
The 7750 SR functions as a Serving Gateway, part of the Evolved Packet Core used in the LTE fourth-generation networks, in charge of forwarding data packets between mobile stations within a given geographical service area. The 7750 SR also acts as a PDN Gateway between the LTE and the external packet data networks, similar to the role of a Gateway GPRS Service Node.

This application scenario also includes a Serving GPRS Support Node, part of the GPRS architecture. The SGSN is responsible for the delivery of data packets between mobile stations within a given geographical service area.

There is also a Mobility Management Entity, which keeps track of mobile devices.

The Policy and Charging Rules Function node determines in real-time the policies that need to be applied to a specific customer connection.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



In this application scenario, the 7750 SR serves as a WLAN gateway. You can deploy a 7750 SR WLAN in one of the following models:

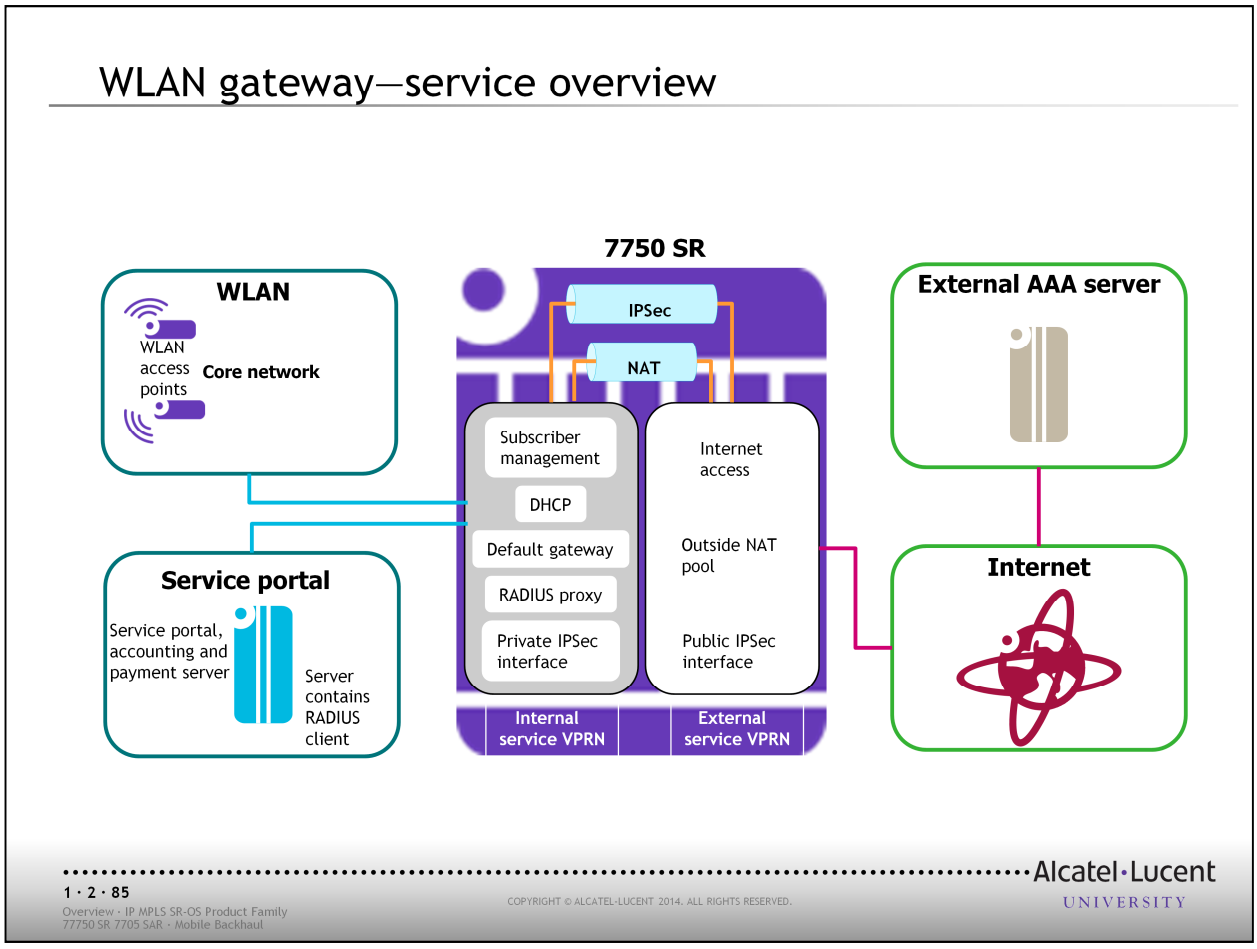
- Wi-Fi community
- Wi-Fi offload
- Mobile Wi-Fi

The Wi-Fi community model provides free or paid Wi-Fi Internet access for a carrier to complement its services, outdoor Wi-Fi access service, and wholesale Wi-Fi Internet access for partner carriers.

The Wi-Fi offload model expands the 2G, 3G or LTE wireless network capacity by enabling a carrier to offload cellular traffic (its own or of roaming subscribers) to Wi-Fi networks. In this context, it is worth mentioning that the Alcatel-Lucent 5780 Dynamic Services Controller — DSC — supports the Access Network Discovery and Selection Function for intelligent and quality-of-service assured subscribers that are roaming between cellular and Wi-Fi networks.

The mobile Wi-Fi model provides Wi-Fi services on trains, buses, and ferries with LTE wireless backhaul.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



The 7750 SR is a service oriented platform. Each service has its own configuration entity from which routing, interfaces, security and other parameters are configured in the SR-OS. Each service is identified by a service type and a service ID. In general, a service provides layer 2 (switching) or layer 3 (routing) functions.

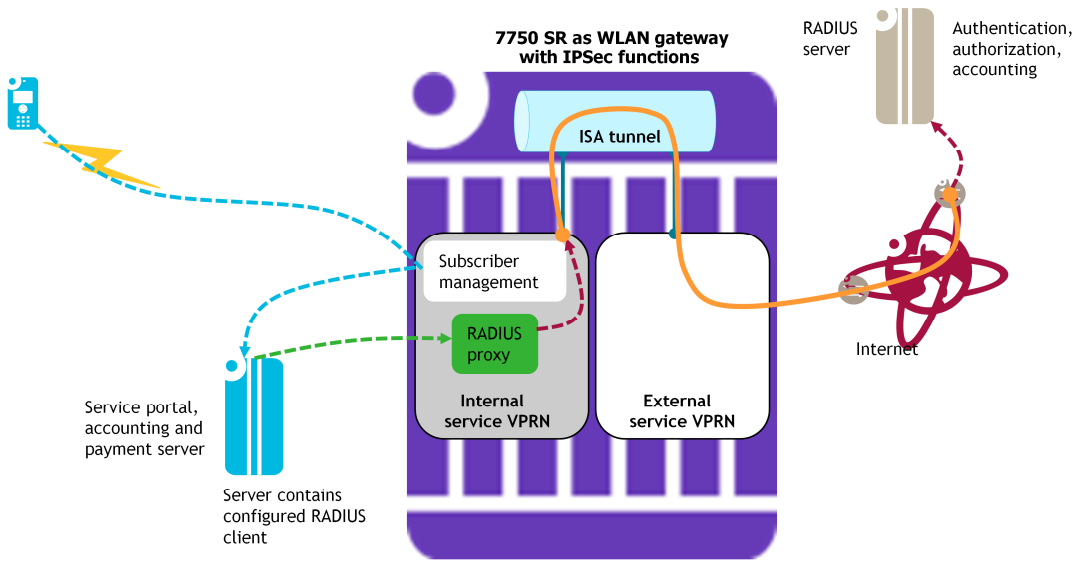
A Virtual Private Routed Network (VPRN) is a layer 3 service that provides its own routing context (for example, a routing table). A Virtual Private LAN Service (VPLS) is a layer 2 service that provides functions at the Ethernet layer, such as MAC learning and spanning-tree.

The core service component of the WLAN gateway solution is the VPRN. Two VPRNs need to be configured. One VPRN connects internal hosts such as subscribers and service portal servers. Another VPRN connects to the external interfaces and services. The separation of interfaces and traffic into VPRNs is required so that the 7750 SR can perform functions such as Network Address Translation and IPSec protection for specific traffic. Policies in each VPRN determine if traffic is translated through NAT, routed natively, or protected by IPSec.

The slide describes the service components provided by the 7750 SR. The internal network consists of the WLAN and he service portal server. The external network components consist of the Internet and the external authentication, authorization and accounting servers.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

WLAN gateway with IPSec functions

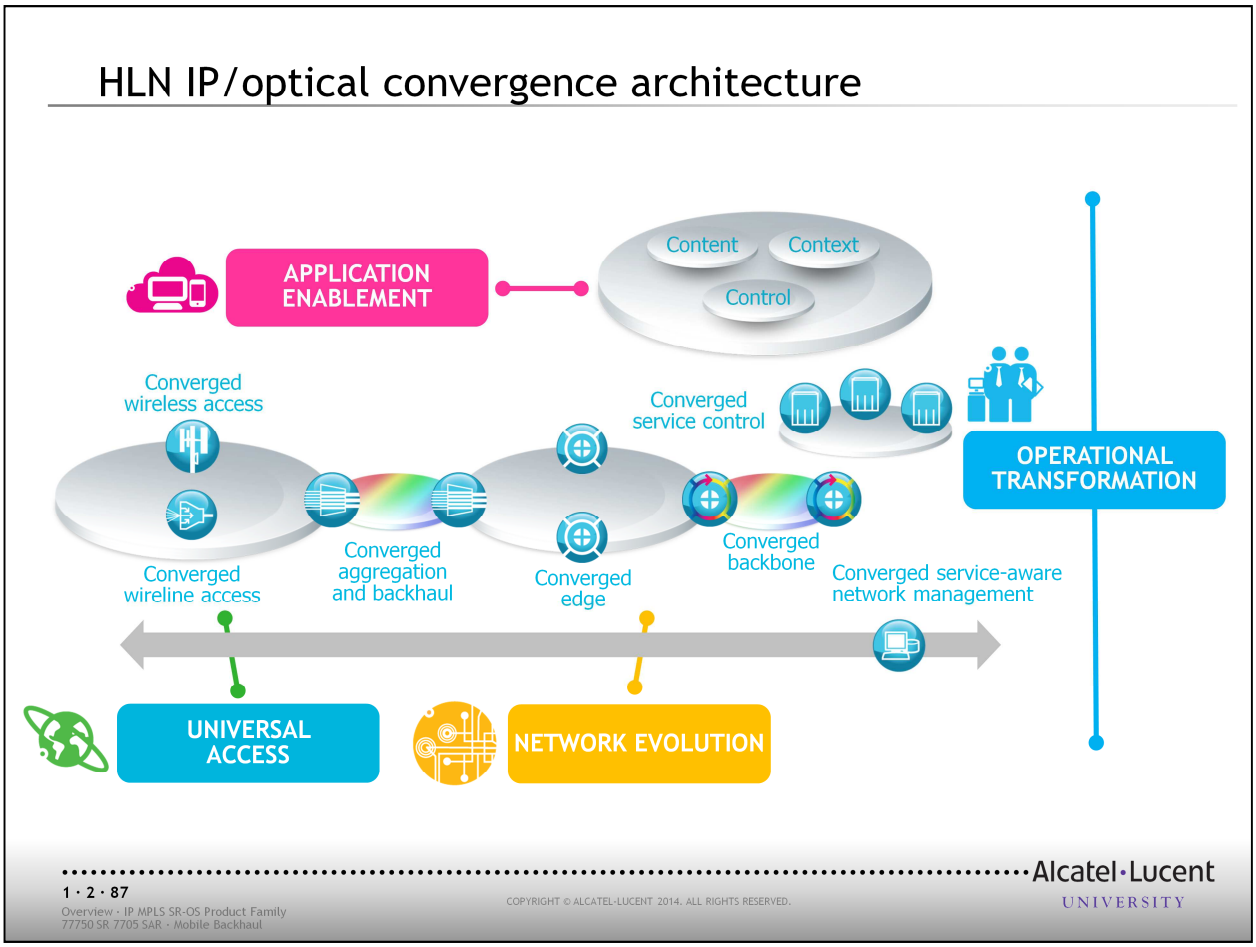


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This slide describes in greater detail the application scenario in which the 7750 SR serves as a WLAN gateway with IPSec functions. The slide illustrates the traffic flow in a configuration in which IPSec is used to protect access transactions. The client device sends the login credentials to the service portal server, which sends an access request to the 7750 SR network element. The 7750 SR proxies the access request and sends it through the IPSec tunnel to the remote termination point, which decrypts the request and sends it to the RADIUS AAA server. The 7750 SR uses IPSec to protect the communication that takes place over the public Internet.

The 7750 SR uses a Multiservice Integrated Service Adapter card to perform the functions required by IPSec. The MS-ISA card must be provisioned before an IPSec tunnel can be configured.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



The High Leverage Network is a converged, scalable and intelligent all-IP network. The HLN offers distributed service intelligence, broadband access, and scalable, efficient IP transport, at the lowest bit cost. At the same time, the HLN supports innovative revenue generating services and business models.
The HLN incorporates the following features: application enablement, universal access, network evolution, and operational transformation.
Application Enablement is about delivering more value to end users through new services that enhance the user experience.
Network Evolution is about leveraging the intelligence in the network to enhance services, increase revenues and develop new business; for example, by delivering enhanced multimedia and multi-screen services.
Universal Access brings broadband to more people and to more devices; that is, to everyone and everything, wired or wireless, anywhere and on any device.
Operational Transformation is about transforming network, IT and business operations to reduce cost and complexity.

For simplicity and for modular evolution, convergence to the single common platform can be split up into seven distinct domains: converged wireless access, converged wireline access, converged aggregation and backhaul, converged Edge, converged backbone, converged service control and converged service-aware network management.
Each of these domains provide a specific set of capabilities and functions.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7 7210 SAS Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 Service Access Switch (SAS)



7210 SAS-D	7210 SAS-E	7210 SAS-M	7210 SAS-X
Low-cost Ethernet demarcation switch	Cost-effective Ethernet edge switch	MPLS-enabled Ethernet edge & aggregation switch	High performance MPLS-enabled aggregation switch
Wirespeed - 20 Gb/s (half duplex)	Wirespeed - 48 Gb/s (half duplex)	Wirespeed - 124 Gb/s (half duplex)	Wirespeed - 88 Gb/s (half duplex)
Fixed configuration: 6 x GigE (SFP) ports or 4 x 10/100/1000BASE-TX (copper) ports	Fixed configuration: 12 x GigE (SFP) ports 12 x 10/100/1000BASE-TX (copper) ports	Fixed configuration + expansion slot: 24 x GigE (SFP) ports 2 x 10GigE (XFP) ports 4 x T1/E1 CES access ports	Fixed configuration: 24 x GigE (SFP) ports 2 x 10GigE (XFP) ports

A family of compact, Ethernet edge and aggregation devices

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Designed for the customer edge, smaller central offices and distributed hub sites, the Alcatel-Lucent 7210 Service Access Switch portfolio of compact Ethernet-edge, demarcation and aggregation devices provides cost-effective Carrier Ethernet service delivery to the customer edge and extends the reach of MPLS-enabled Carrier Ethernet aggregation networks into smaller network locations.

The SAS is available in different compact form factor options.

The 7210 SAS-D is an intelligent Ethernet-edge demarcation device that extends retail and wholesale SLA-based VPLS and VLL services to the customer edge. For service demarcation applications in 3G and LTE wholesale mobile backhaul service delivery networks, it is also available in a variant that supports ITU-T Synchronous Ethernet (Sync-E) and extended temperature ranges (ETR).

The 7210 SAS-E is an Ethernet edge access device with a fixed configuration twelve 10/100/1000BASE-T copper ports and twelve 100/1000BASE fiber ports, and is designed for VPLS and VLL services delivery in multi-tenant offices.

The 7210 SAS-M is an MPLS enabled Ethernet-edge and aggregation device. It supports IP, MPLS, Ethernet, PBB, 10GigE ports and is available in an ETR variant. As a customer edge device, it provides a common platform to enable VPLS, VLL and IP VPN services. It comes with a fixed amount of interfaces and one expansion slot for additional flexibility.

The 7210 SAS-X is a high performance MPLS-enabled aggregation device. Designed for more service intensive smaller network location applications, its powerful CPU is suitable where higher scale switching and routing capabilities are essential. In addition to supporting all the IP, MPLS and Ethernet capabilities of the Alcatel-Lucent 7210 SAS-M, the 7210 SAS-X supports a larger number of service queues, packet buffers, label switched paths (LSPs), counters, MAC addresses, routing table entries and ACLs for increased service scale.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 Service Access Switch (SAS) [cont'd]



7210 SAS-T

Demarcation switch for VPLS and VLL services managed to the customer edge

Wirespeed – 124 Gb/s (half-duplex)

4 x 10GigE + 12 x GigE + 10 copper ports (includes 4 Power over Ethernet (POE) capable ports

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Alcatel-Lucent 7210 SAS-T is designed for 10GigE access and aggregation applications for business virtual private network (VPN) and mobile service delivery. It features 10GigE, GigE, and 10/100/1000Base-TX copper interfaces (including support for Power over Ethernet [PoE]), advanced synchronization, and an optical port to manage WDM passive filter systems.

The 7210 SAS-T is available in two variants, ETR and non- ETR.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 Service Access Switch (SAS) [cont'd]



7210 SAS-R6

***Demarcation switch for VPLS and VLL services managed to the customer edge

**Wirespeed - 120G (HD), 10G (FD) per slot throughput

*** SF/CPM redundancy, 6 x 10GE/GE IMM slots

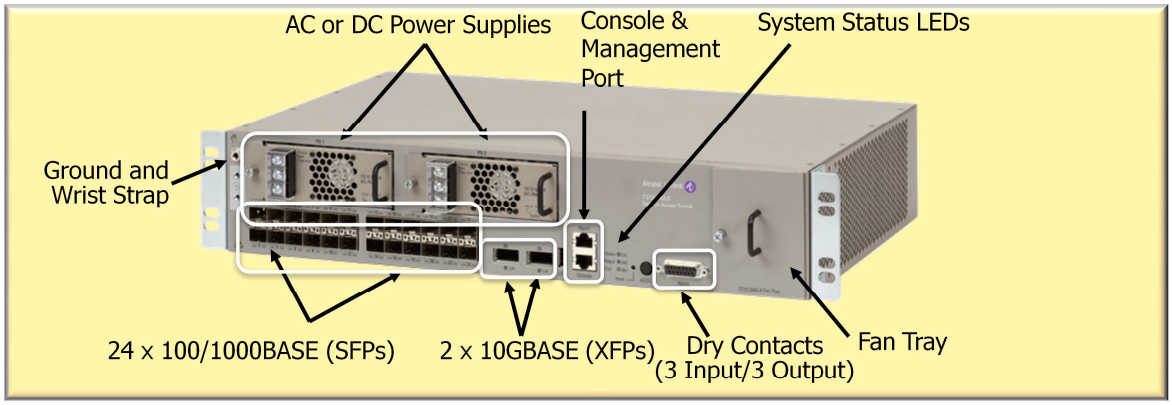
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Alcatel-Lucent 7210 SAS-T is designed for 10GigE access and aggregation applications for business virtual private network (VPN) and mobile service delivery. It features 10GigE, GigE, and 10/100/1000Base-TX copper interfaces (including support for Power over Ethernet [PoE]), advanced synchronization, and an optical port to manage WDM passive filter systems.

The 7210 SAS-T is available in two variants, ETR and non- ETR.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 SAS-X: Hardware Overview



High performance MPLS–based device provides aggregation for more service-intensive smaller network locations

- Aggregates VPLS, VLL and IP VPN services over 10 GigE uplinks with burst capabilities
- Wirespeed (88 Gb/s half duplex), SR OS-based device, 2.0 RU, NEBS3 compliant
- Synchronization: ITU-T Sync-E, IEEE 1588v2 (future), stratum 3E (OXCO) clock

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

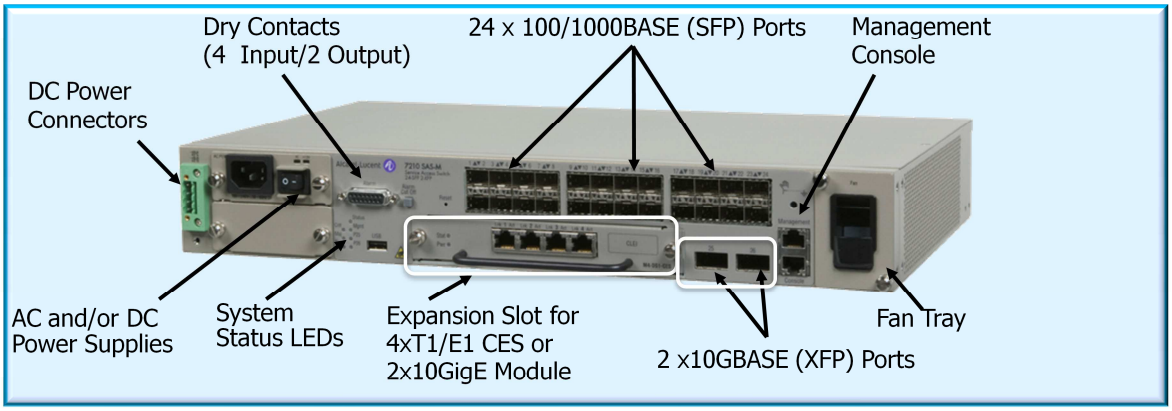
The SAS-X is the most feature rich product of the 7210 SAS product range and is MEF 9 and MEF 14 certified, the defining certification body for Ethernet. All interfaces are integrated. 24 SFPs can be installed to connect 100 or 1000 Base Ethernet. 2 available XFP based slots are available to connect 10 Gig Base Ethernet. AC or DC redundant power supplies are of modular design. Next to 3 input and 3 output connections for dry voltage contacts, the SAS-X is equipped with a console and management port for outbound management. The SAS aggregates VPLS, VLL and IP VPN services over 10 Gig uplinks with burst capabilities.

Burst capabilities are made possible with advanced H-QoS with ingress and egress queuing and shaping. The 7210 SAS-X also supports dynamic buffer allocation, allowing buffers to be allocated on a per-service basis for added SLA flexibility.

The SAS-X supports 888 Gigabits per second in half duplex and synchronization features that comply to the ITU-T Synchronous Ethernet and IEEE 1588v2 standards.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 SAS-M (10GigE w/ETR option): Hardware



MPLS-based device for Ethernet-edge CPE and service aggregation

- CPE/aggregation device supports VPLS, VLL and IP VPN services over GigE/10GigE uplinks
- Wirespeed (128 Gb/s half duplex), SR OS-based MPLS device, 1.5 RU, NEBS3 compliant
- ETR variant supports Extended Temperature Ranges (ETR) - 40°C to +65°C
- Service expansion slot options: 4-port T1/E1 CES and 2 x 10GigE (XFP) modules
- Synchronization: ITU-T Sync-E, IEEE 1588v2 (future), stratum 3 (TXCO) clock

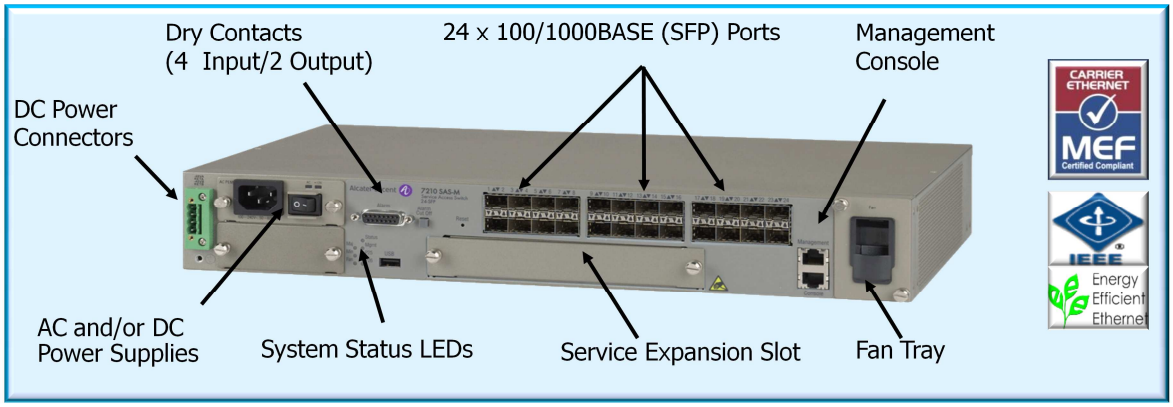
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAS-M as a customer edge device provides a common platform to enable VPLS, VLL and IP VPN services. It also supports the configuration of VPLS and VLL services using PBB. As an aggregation device, it extends the reach of the MPLS-enabled Carrier Ethernet network into smaller offices and distributed hub sites and supports provider edge (PE) functionality to aggregate customer edge (CE) routers in IP VPN service delivery. The SAS-M is an SR-OS based MPLS device working at a wirespeed of 128 Gigabits per second. The extended temperature range variant supports temperatures of -40 to + 65 degrees Celsius.

For added flexibility, the 7210 SAS-M offers optional service expansion modules to support circuit emulation services (CES) over T1/E1 interfaces and two 10GigE ports for higher speed uplinks, larger 10GigE mesh configurations and support for 10GigE CPE. Both standards of synchronization, ITU-T Sync-E and IEEE 1588v2 are supported.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 SAS-M: Hardware Overview



MPLS-based device for Ethernet-edge CPE and service aggregation

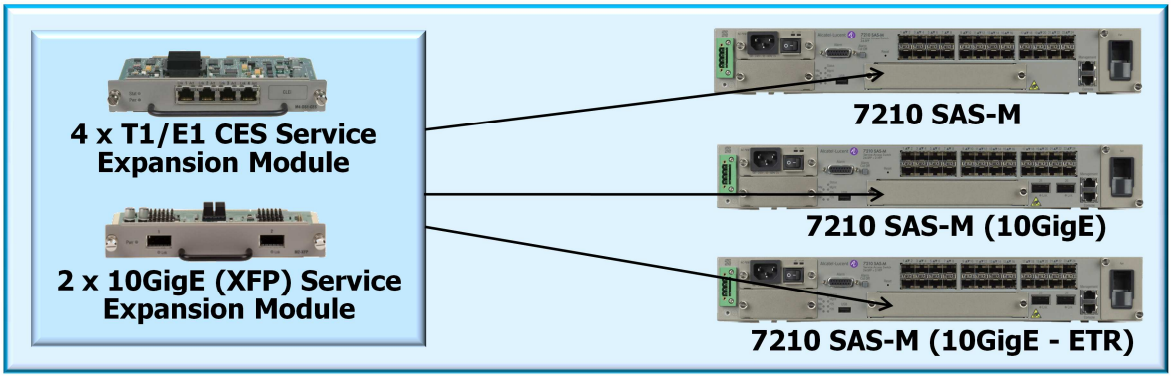
- CPE/aggregation device supports VPLS, VLL and IP VPN services over GigE/10GigE uplinks
- Wirespeed (88 Gb/s half duplex), SR OS-based MPLS device, 1.5 RU, NEBS3 compliant
- Service expansion slot options: 4-port T1/E1 CES and 2 x 10GigE (XFP) modules
- Synchronization: ITU-T Sync-E, IEEE 1588v2 (future), stratum 3 (TXCO) clock

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This is the standard SAS-M, without any integrated 10 Gig interfaces supported and operating in temperatures from 0 to 50 degrees Celsius.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 SAS-M (All Variants): Service Expansion Modules



- **4 x T1/E1 CES module enables new business VPN revenue streams, transitions business services off SONET/SDH metro networks**
  - Allows an enterprise to run several services concurrently such Ethernet VPNs along with fractional nxT1/E1 services or clear T1/E1 services over a single physical connection
- **Scale service delivery to meet emerging 10GigE requirements**
  - Deploy 10GigE module to scale uplink toward 10GigE as required; add additional 10 GigE ports; use as access (customer) interface

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This slide shows all the options of the expansion modules with the available SAS-M variants.

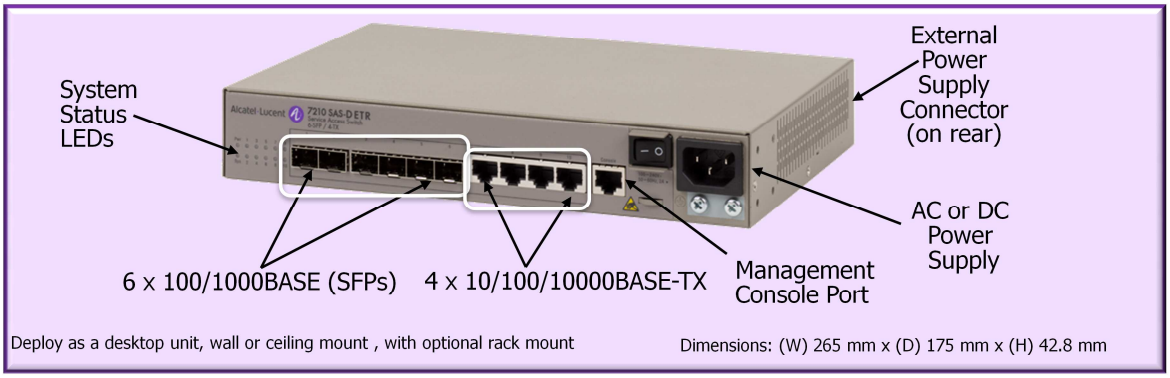
The 4 times T1/E1 CES module allows an enterprise to run several services concurrently such as Ethernet along with fractional n times E1/T1 over a single physical connection.

The 2 times 10 Gig expansion module offers additional 10 Gig ports to be used as access or customer interface.

Any of the two expansion modules can be plugged into the expansion slot of any of the three SAS-M variants.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 SAS-D (with ETR option): Hardware Overview



Intelligent Ethernet-edge demarcation device

Wirespeed (20 Gb/s), non-blocking, SR OS-based device, 1 RU, NEBS level 3 compliant

ETR variant allows for ITU-T Sync-E, IEEE1588v2 (future), 24 VDC or -48VDC power and redundancy option with external power supply (Note: any AC or DC combination between internal and external power supplies is supported)

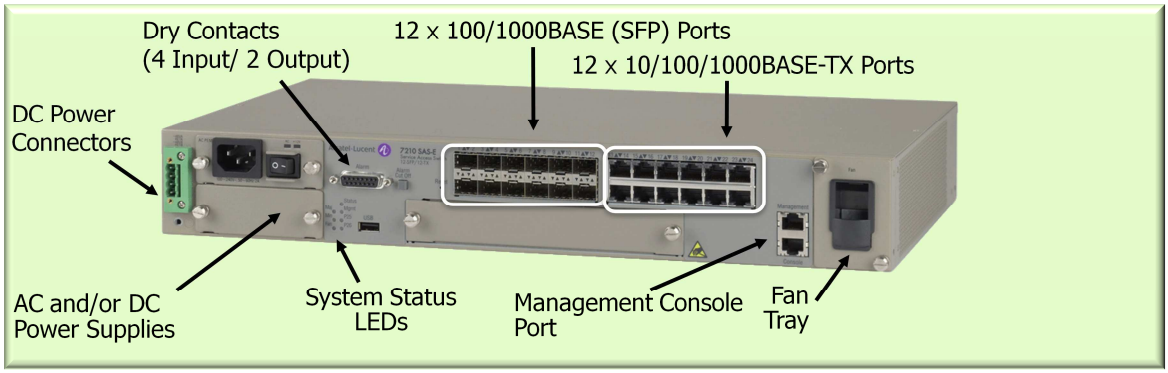
AC or DC power supply with fan-less operation

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAS-D is a low cost 20 Gigabits per second ethernet switch with a fixed amount of interfaces. It supports 6 GigE ports and 4 10/100 or 1000 BaseT copper ports. The D variant of the SAS family works at speed of 20 Gigabits per second half duplex. This picture shows the variant with ETR. There is no MPLS implemented, so the uplink is solely ethernet.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 SAS-E: Hardware Overview



Cost-effective Ethernet-edge device

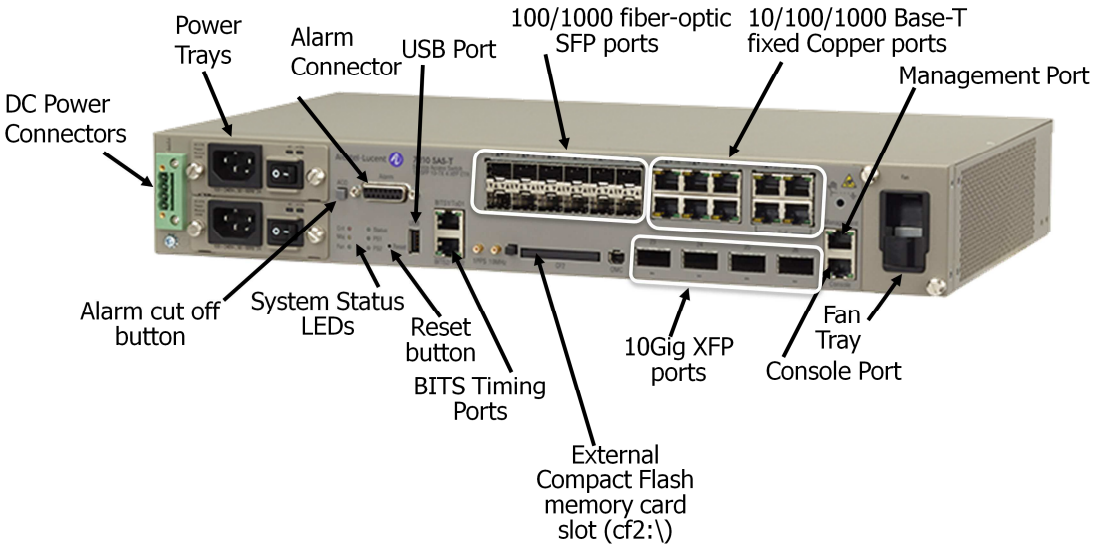
- Wirespeed (48 Gb/s HD), SR OS-based Ethernet switch (1.5 RU)
- Hot swappable AC and/or DC redundant power supplies and fan tray

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAS-D is very similar to the SAS-E, except that it works at a wirespeed of 48 Gigabits per second in half-duplex and supports up to twelve 100/1000 Base SFP ports and twelve 10/100/1000 Base-T ports.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 SAS-T (non-ETR Variant): Hardware Overview



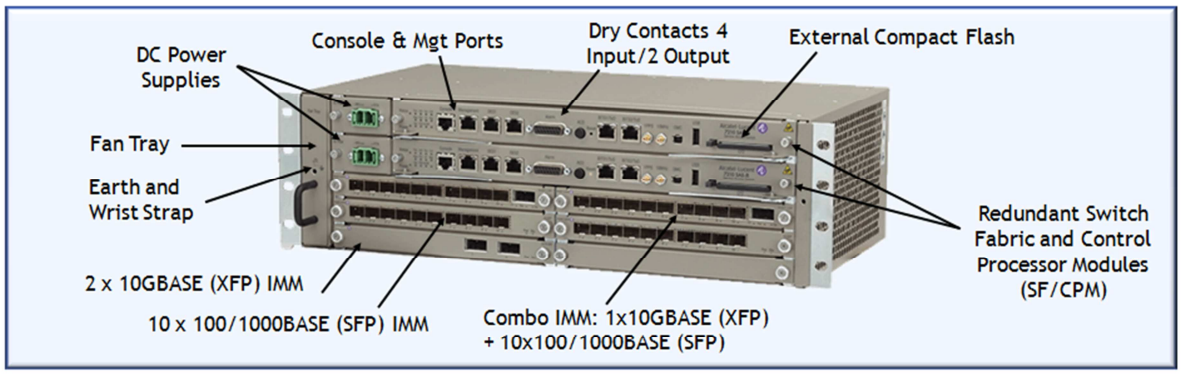
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Feature Highlights

•4 x 10GE (XFP) + 12 x 100/1000 (SFP) + 10 x 10/100/1000BASE-TX (w/ 4 x POE/POE+ capable)
•ETR variant option adds POE/POE+
•VPLS and VLL
•H-QoS and advanced OAM, with flexible buffer allocation
•ITU-T Sync-E, IEEE 1588v2
•Optical management port for Alcatel-Lucent 1830 VWM passive OADM filter
•Redundant, load sharing, hot swapable AC/DC power and fans, NEBS3 compliant
•Tunable DWDM XFPs, copper and CWDM SFPs, SFPs & XFRs w/DDM
•5620 SAM management

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7210 SAS-R6: Hardware Overview



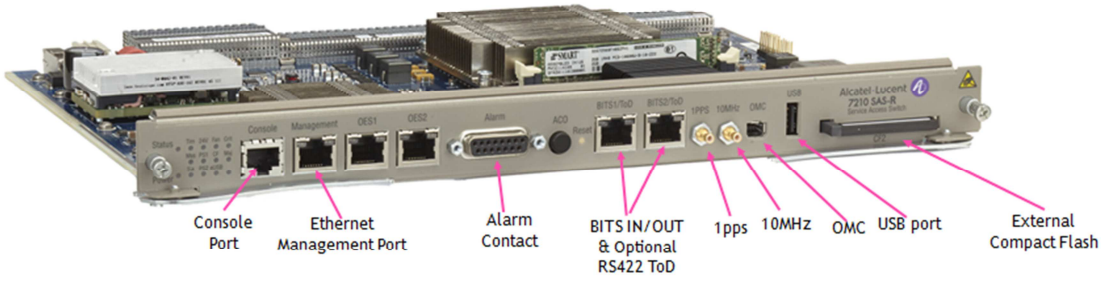
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Feature Highlights

- 120 Gb/s (HD) capacity, 10Gb/s (FD) per slot throughput, 3.0 RU (ETSI 300mm design), NEBS3 compliant
- System hardware architecture similar to 7x50 SR platforms – SF/CPM redundancy and 6 x IMM slots
- Timing and synchronization: stratum 3 (TXCO) clock, ITU-T Sync-E, IEEE 1588v2
- Optical modules: Tunable DWDM XFPs, copper SFPs, CWDM SFPs and SFPs/XFPs with DDM
- 5620 SAM Management

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

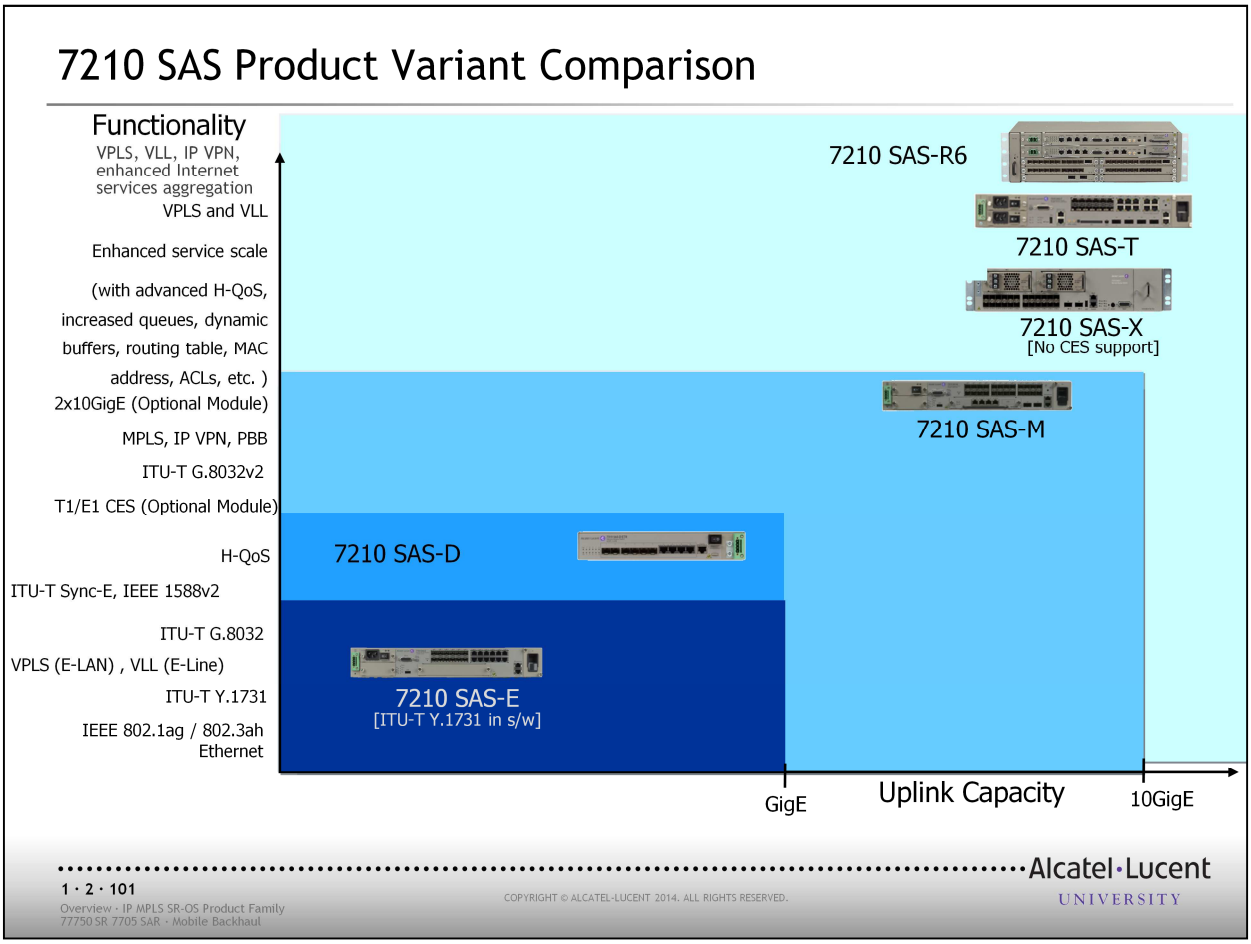
7210 SAS-R6 Switch Fabric/Control Processor Module (SF/CPM)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- RS-232 Console Port for management
- Out-of-band Ethernet Management Port is protected by packet processor on CPM/SF card.
- External replaceable compact flash + USB port
- Dry Contacts – Alarm Output pins and Alarm Input pins
  - Option to supply power to external devices connected to Alarm Input pins (+24VDC)
- Timing and synchronization - Synchronous Ethernet and IEEE 1588v2
- Timing and synchronization - Bits In/Out, Option for RS422 ToD interface
- Optical Management Console (OMC) to manage 1830 VWM Passive Optical Devices

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



With platform capabilities that include IP, Multiprotocol Label Switching (MPLS), hierarchical quality of service (H-QoS), advanced operation, administration and maintenance (OAM) tools, leading resiliency and synchronization capabilities, and 10GigE interface support, the Alcatel Lucent 7210 SAS is an integral component, delivering value-added MPLS-enabled Carrier Ethernet services including Virtual Private Line Service (VPLS) and Virtual Leased Line (VLL) services. With Release 4.0, the required functionality and uplink capacity, the 7210 SAS product family offers the perfect solution for the customer edge, smaller central offices and distributed hub sites.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module summary

- The four major SR-OS product families are the 7750 service router, the 7450 Ethernet service switch, the 7705 service access router and the 7210 service access switch.
- The IP/MPLS products run at 9 Gigabits per second for the 7750 SR-c4 up to 400 Gigabits per second for the 7750 SR-12.
- The complete portfolio is managed by the 5620 Service Aware Manager (SAM).
- The key differentiators are the enormous service scale and performance, the high availability features like non-stop routing and non-stop service, the huge queue buffer space available and the deep packet inspection that allows a flexible way of forwarding.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

In conclusion, this module has given an overview of the SR-OS product families. The 7750 SR with a focus on the new compact variants, the C4 and C12, the 7450 ESS, 7705 SAR and the 7210 SAS. This module highlighted also the key differentiators like high availability features, non-stop routing and non-stop service. At the end the network management platform was introduced.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
IP MPLS SR-OS Product Family

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 1
Overview

Module 3
7705 SAR Product Overview

TER36075_V3.1-SG-English-Ed1 Module 1.3 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to:

- To define the roles of the 7705 SAR in the aggregation and backhaul applications of the service provider network
- To describe how the 7705 SAR is used in the service provider network
- To identify the components and functionality of the 7705 SAR

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

7705 SAR Network Solutions	5
7705 SAR Features Overview	10
7705 SAR Family of Products Overview	18
7705 SAR-18 System Overview	20
7705 SAR-8 System Overview	29
7705 SAR-8/18 Microwave Radio Connectivity	41
7705 SAR-8/18 Interface Adapter Cards	45
7705 SAR-8/SAR-18/SAR-M: CWDM/OADM Adapter Cards	81
7705 SAR-M System Overview	89
7705 SAR-F System Overview	99
7705 SAR-A System Overview	107
7705 SAR-W System Overview	113
7705 SAR-O Passive Optical Module Overview	122
7705 SAR-H System Overview	128
7705 SAR-Hc System Overview	148
7705 SAR System Provisioning and Management	164
7705 OAM and Diagnostics	166

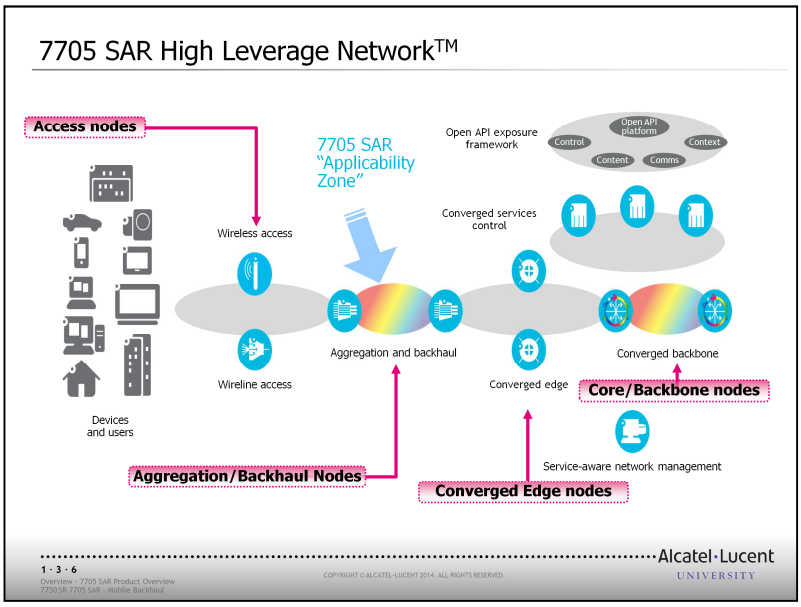
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Select the section you are interested in, or click on the Next button to follow the recommended learning path.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 7705 SAR Network Solutions

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Most networks today have been converged to all-IP/MPLS networks that can provide telephone, video, and data communication services within a single network. An Internet Protocol/Multiprotocol Layered Switching (IP/MPLS) network supports many different types of traffic, including IP packets, native Asynchronous Transfer Mode (ATM), Synchronous Optical Networking (SONET), and Ethernet frames.

To meet demand for high-quality, high-bandwidth, low-cost delivery of services over the converged network, operators must provide “high-leverage” networks that offer distributed service intelligence, broadband access, scalability, and efficient IP transport at the lowest bit cost.

The high-leverage, converged network infrastructure includes backbone or core nodes, edge nodes, aggregation and backhaul nodes, and access nodes.

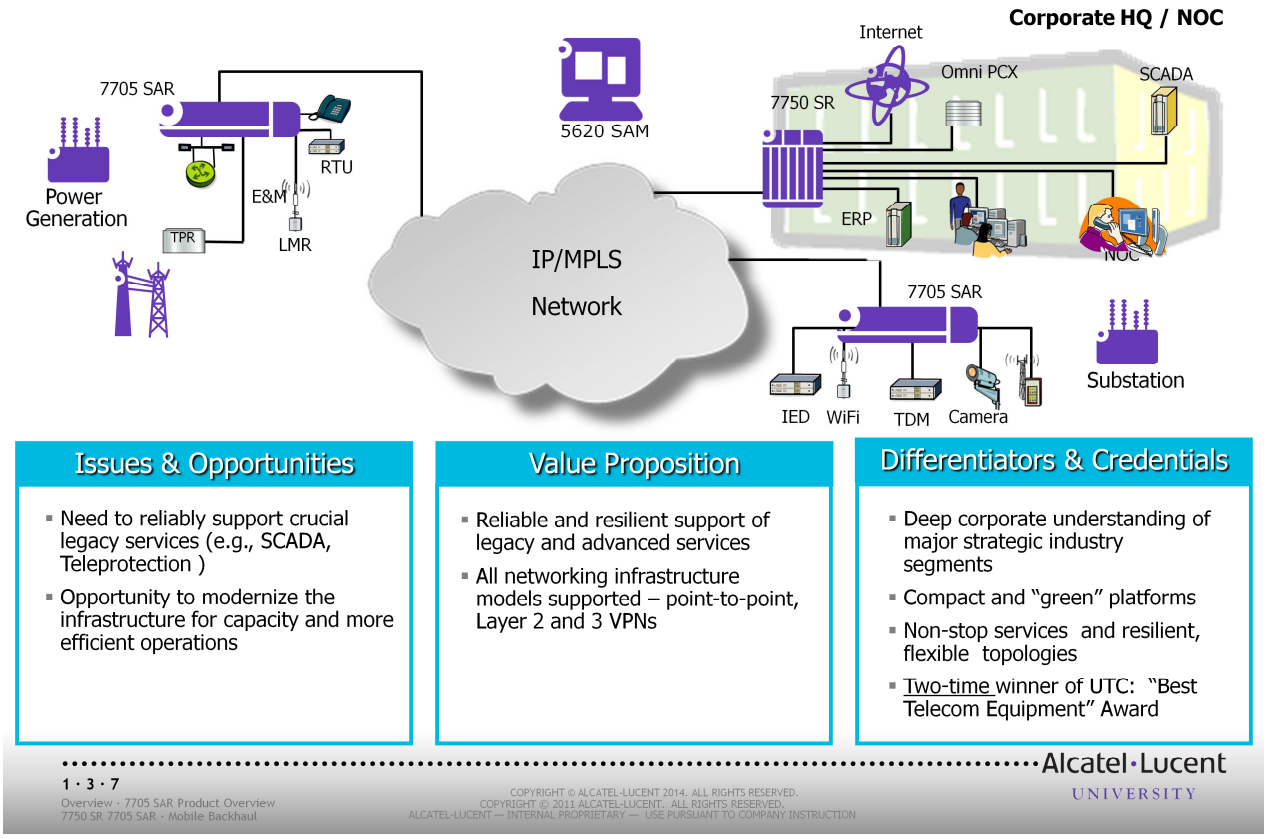
The Alcatel-Lucent 7705 SAR is found in the aggregation and backhaul zone of the high-leverage converged network.

The 7705 SAR adapts and aggregates traffic onto the modern, Ethernet-centric infrastructure.

It provides flexible aggregation and backhaul capabilities for maximum leverage across both wireless and wireline infrastructures in the access part of the network.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR Utilities Network Solution



Many utilities around the world are implementing smart grids to deliver energy.

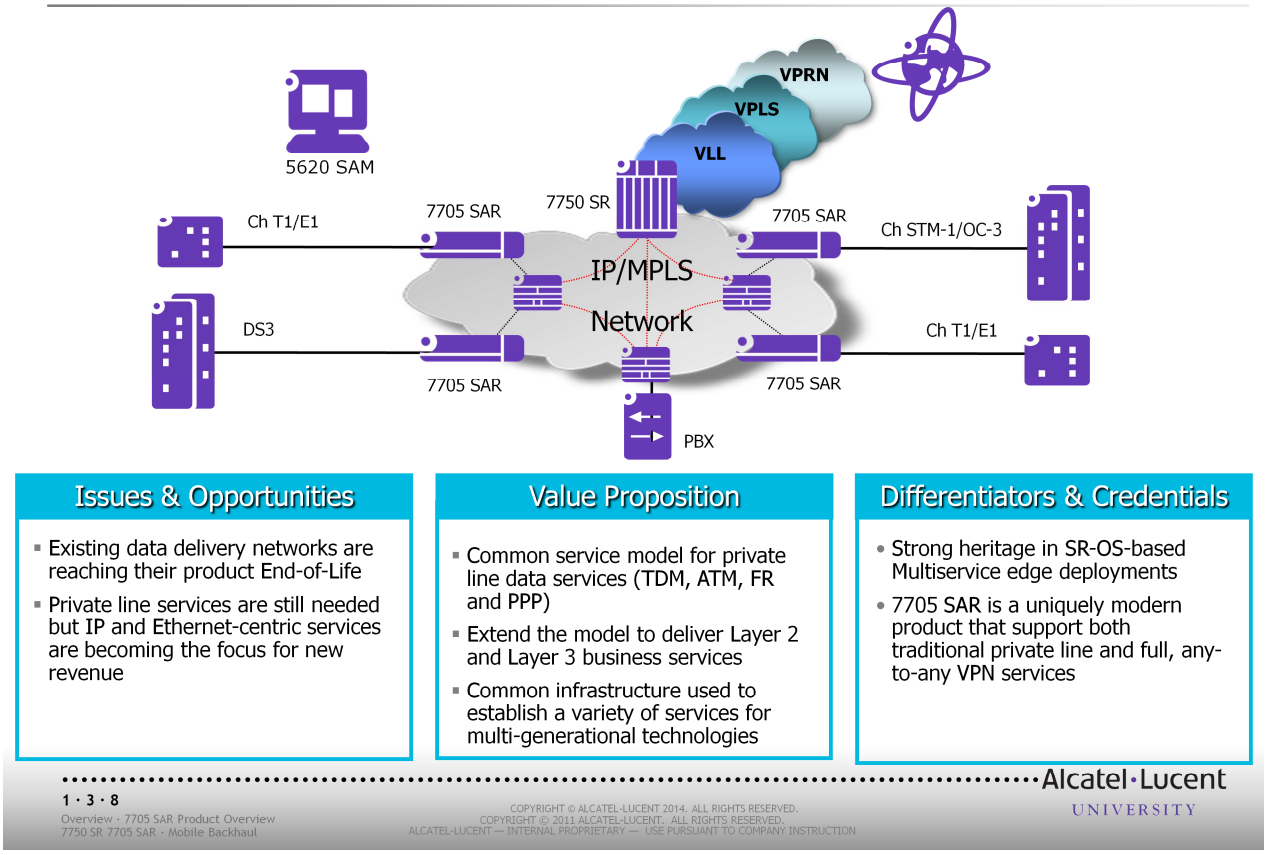
Smart Grid applications provide utilities with better automation, reduced operating costs, increased power quality, and improved outage response.

A highly available IP/MPLS infrastructure that delivers mission-critical network communications is a necessary foundation for the Smart Grid architecture in a communication network.

The Alcatel-Lucent 7705 solution supports critical legacy services such as tele-protection, while transporting legacy and advanced applications over a reliable and resilient IP/MPLS network.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L2/L3 VPN Business Services



Network operators must address the Private Line Business Services market.

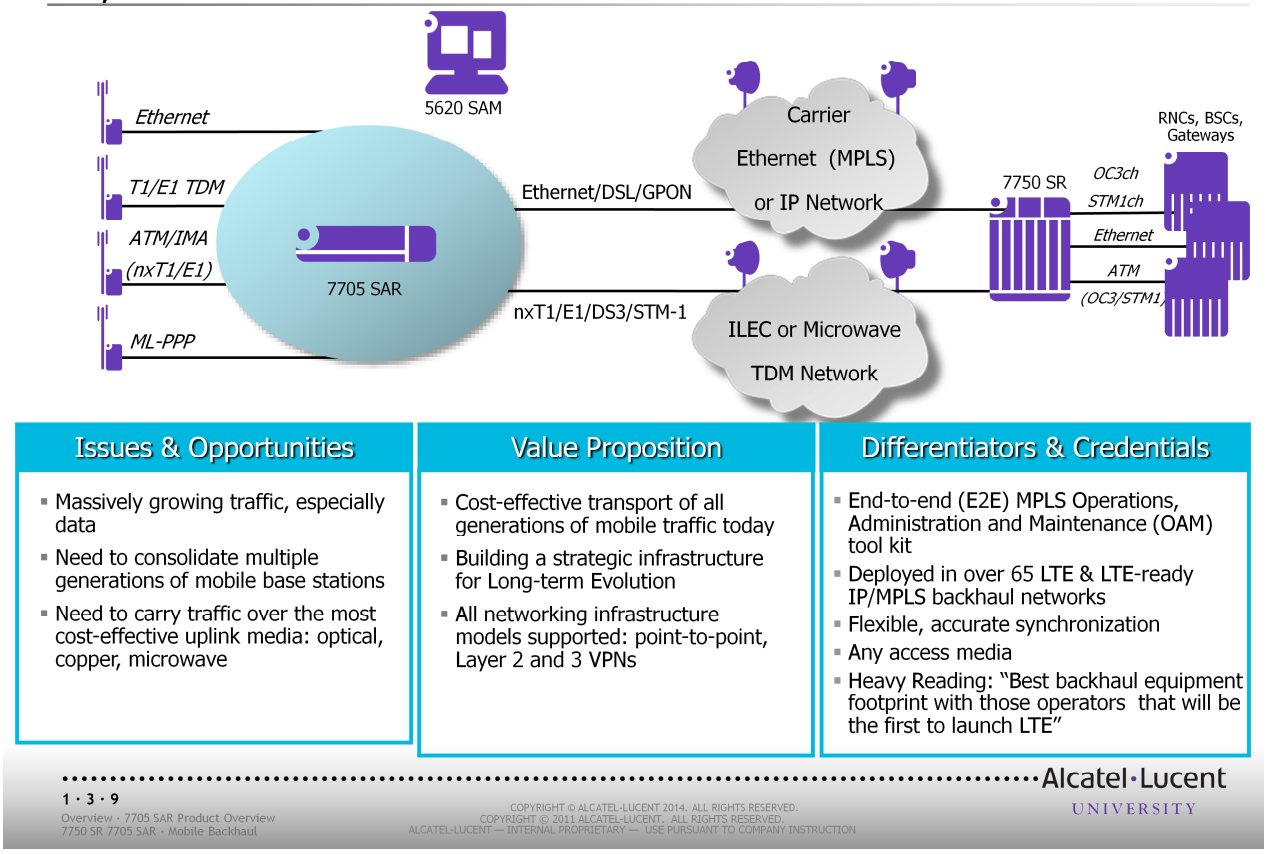
These markets have typically used point-to-point TDM circuits, to provide secure, predictable, and fixed bandwidth applications to deliver voice and data services from small offices or remote locations to office headquarters.

As IP/MPLS network technologies mature, they deliver the same quality of experience and level of predictability as existing TDM network infrastructures, at a reduced cost of ownership.

The 7705 SAR is a unique product that supports both traditional private line and full, any-to-any L2/L3 VPN services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR IP/MPLS Mobile Backhaul Transport Solution: 2G, 3G and LTE



As mobile networks evolve to mobile broadband, MPLS is being deployed by many service providers to consolidate disparate transport networks for different radio technologies, reduce operating expenditures, and converge on a resilient and reliable infrastructure.

This infrastructure is ready for further evolution to Fourth-Generation Mobile Network (4G) technologies, such as Worldwide Interoperability for Microwave Access (WiMAX), Long Term Evolution (LTE), and full fixed-mobile convergence (FMC).

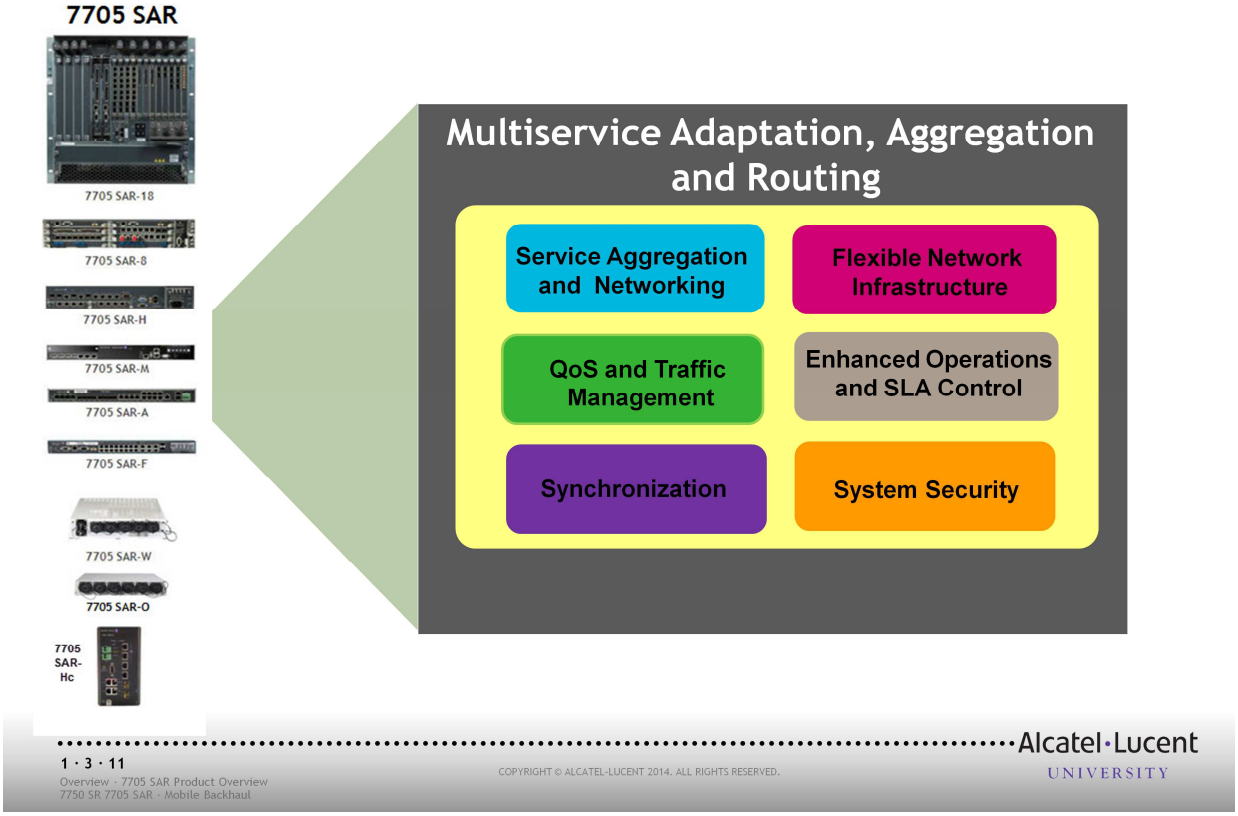
The Alcatel-Lucent IP/MPLS solutions enable mobile service providers to create cost-effective mobile and converged network architectures for voice, video and data delivery, that can be effectively leveraged as the network continues to evolve to LTE-based architectures.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 7705 SAR Features

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR features: overview



The 7705 SAR provides multiservice adaptation, aggregation and routing.

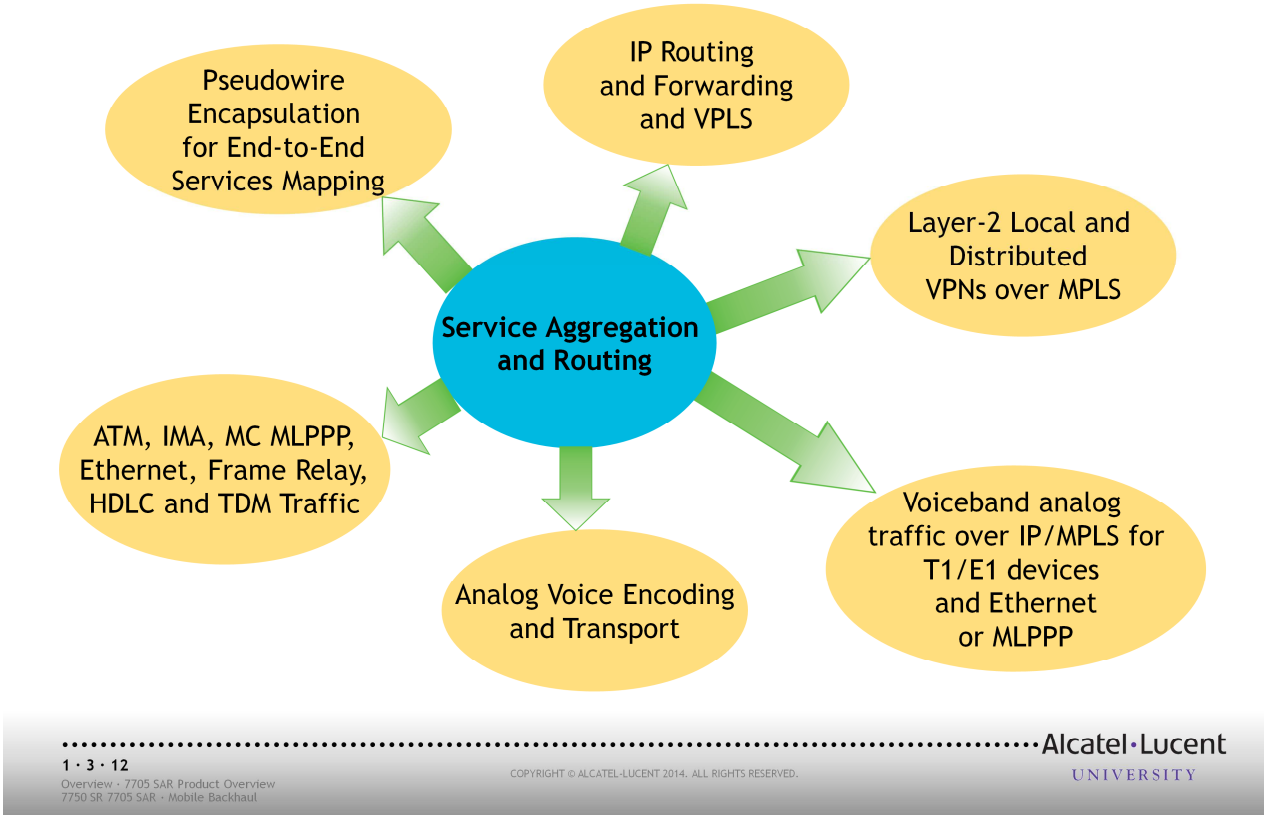
It supports flexible infrastructure and networking for any access, scale aggregation and backhaul, service aggregation and networking, Quality of Service (QoS) and traffic management, synchronization, and enhanced operations.

When combined with the 9500 microwave packet radio, the 7705 SAR extends legacy traffic and network support to provide world-class layer 3 microwave networking solutions.

This includes a full range of packet-to-packet (P2P) any-to-any PW, Virtual Private LAN Service (VPLS), and Virtual Private Routed Network (VPRN) services, IPv6 dual stack backhaul, synchronization solutions, multi-layer end-to-end (E2E) Operations, Administration, and Maintenance (OAM), per service TM and QoS and traffic and network support.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service Aggregation and Networking



The 7705 SAR employs pseudowire encapsulation to map services end to end.

A cost-effective packet environment aggregates and maintains attributes of services.

IP routing and forwarding and Virtual Private LAN Service are supported.

The 7705 SAR supports ATM, inverse multiplexing over ATM, Multi-chassis (MC) multi-link point-to-point protocol (MLPPP), Ethernet, Frame Relay, high-level data link control (HDLC) and Time Division Multiplexing (TDM) traffic.

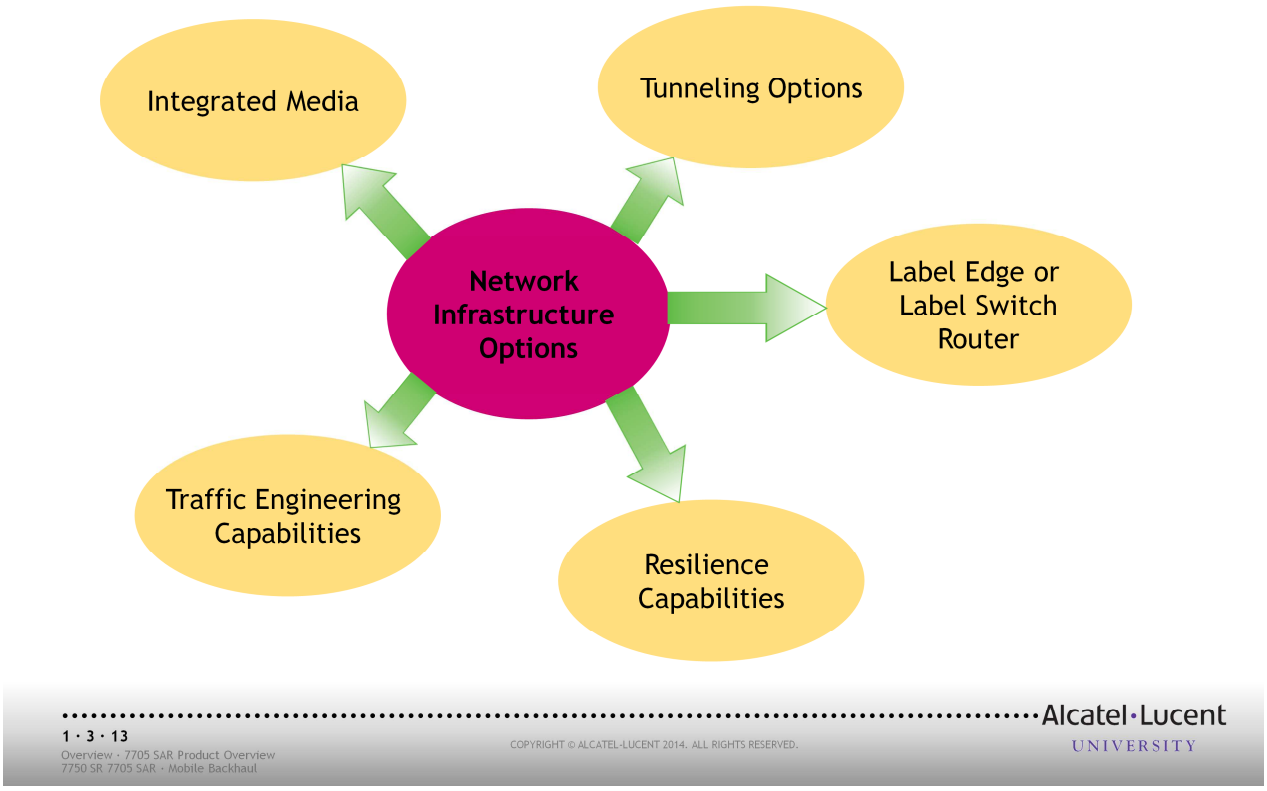
IP VPNs enable separation of Layer 3 traffic among different groups of users or organizations.

The SAR-8 and the SAR-18 provide analog voice encoding and transport.

Voiceband analog traffic is carried over the IP/MPLS network infrastructure between two analog devices using traditional T1/E1, Ethernet, or MLPPP interfaces.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Flexible Network Infrastructure



The 7705 SAR portfolio supports a broad range of integrated media, including fiber, copper, and microwave.

Tunneling options include the use of MPLS, IP, or Generic Routing Encapsulation (GRE) for aggregated traffic.

LDP-based dynamic signaling, static provisioning of MPLS tunnels, and pseudowires are also supported.

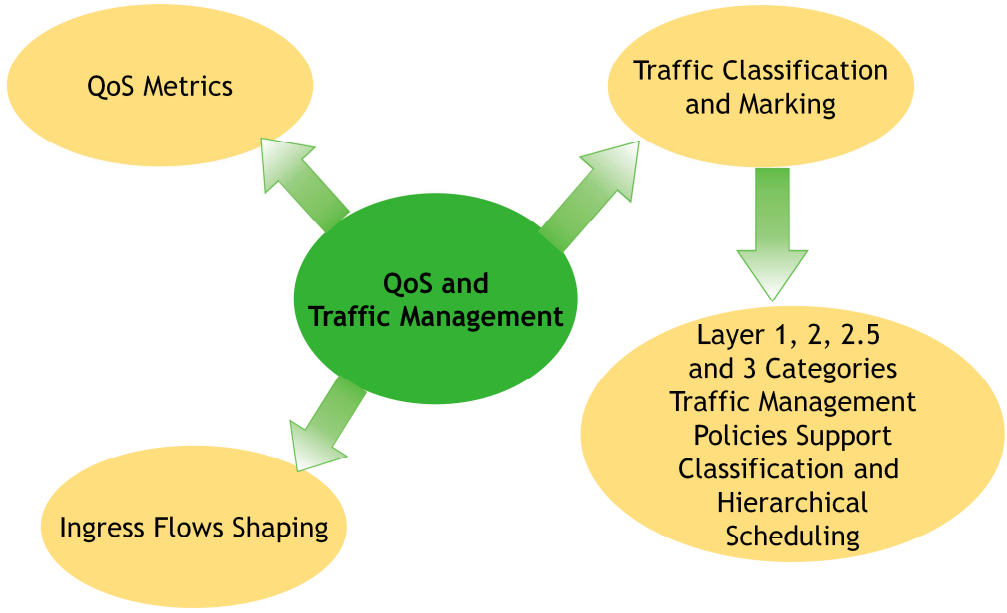
GRE and IP tunneling allow low-cost, ubiquitous IP networks to be used for backhauling.

For example, High Speed Packet Access off-loaded traffic is transported using DSL access media.
The 7705 SAR can be configured as either a Label Edge Router or a Label Switched Router.

The 7705 SAR also includes a strong suite of traffic-engineering and resiliency capabilities, using functions such as constraint-based Shortest Path First, routing, Fast Reroute, primary and secondary LSPs, and redundant pseudowires.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Quality of Service and Traffic Management



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR identifies traffic flows with different QoS requirements at the access, and marks them in-line with the appropriate QoS metrics.

Traffic classification and marking are based on a wide range of categories at Layer 1, Layer 2, Layer 2.5 and Layer 3.

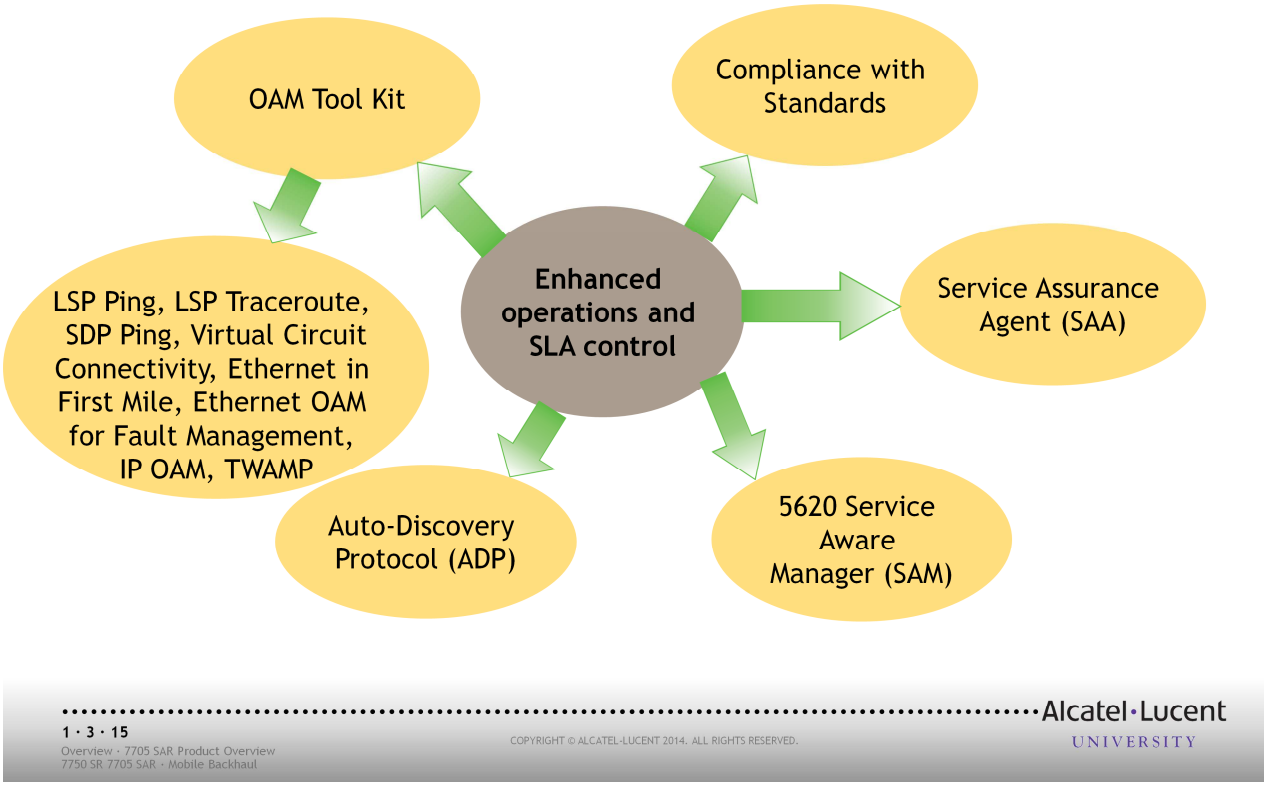
To ensure fairness, the 7705 SAR traffic management policies use detailed classification and hierarchical scheduling mechanisms. These include: minimum and maximum, queue type-based weighted round robin, and strict priority and profiled scheduling.

It also uses multi-tier policing to differentiate and prioritize individual services and flows.

Burst ingress flows can be selectively shaped to improve application throughput and optimize resource usage.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Enhanced Operations, Administration and Maintenance



The 7705 SAR supports a full set of enhanced OAM features and functions. These include:

LSP ping,

LSP traceroute,

Service distribution path ping,

Virtual circuit connectivity verification,

Ethernet in the First Mile,

Connectivity Fault Management,

Ethernet OAM mechanisms for fault and performance management, and

IP OAM functions using Two-Way Active Measurement Protocol.

These OAM features, when used in conjunction with the 5620 Service Aware Manager portfolio, ensure rapid fault detection and efficient troubleshooting.

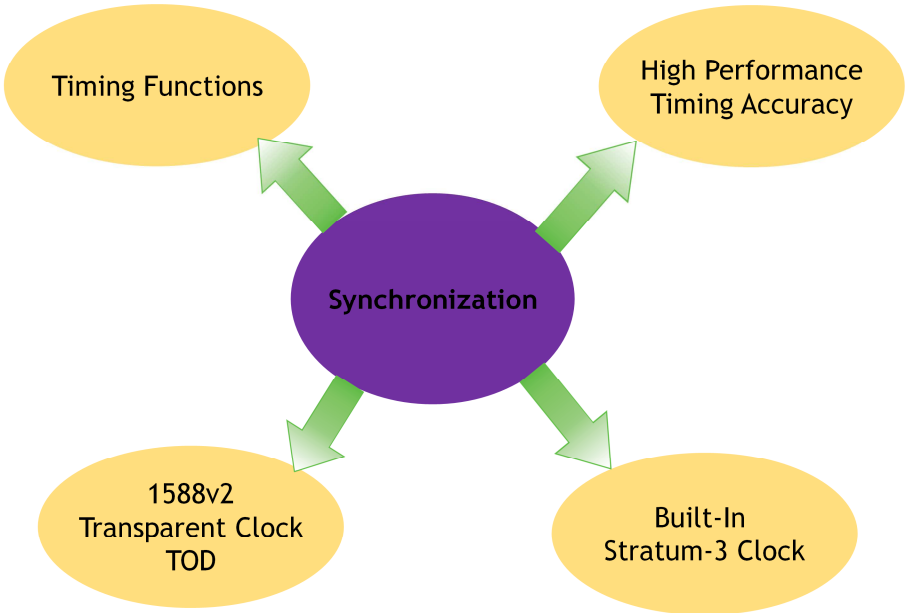
Service Level Agreements (SLAs) can be proactively monitored by the service-aware agent. For example, high-accuracy, one-way delay measurements can be used to closely assess ongoing network latency.

The SAA capability allows the specification of test suites, policies and schedules. Tests are created, and results are compared automatically to predefined SLA metrics.

An auto-discovery protocol can provide rapid automated commissioning of remote devices.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Synchronization



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

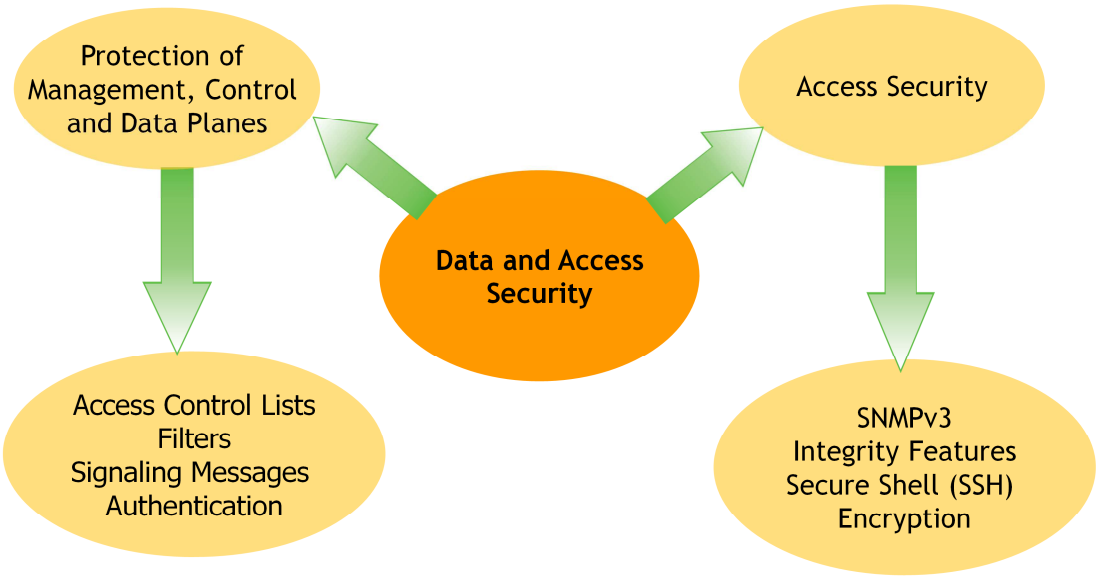
The 7705 SAR portfolio supports external reference timing, line timing, adaptive clock recovery (A-C-R) and differential clock recovery (D-C-R) timing, synchronous Ethernet, and timing distribution using 1588v2.

The 1588v2 Master Clock and Boundary Clock functions are supported. The 7705 SAR-M, 7705 SAR-W and 7705 SAR-A also support Transparent Clock and Time of Day capabilities.
Timing accuracy and high performance over packet solutions are enabled with a combination of built-in architectural features, proprietary algorithms and powerful QoS mechanisms.

A built-in Stratum-3 clock assists with synchronization maintenance if a primary source is unavailable.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

System Security Features



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR incorporates security features to maintain network integrity in the face of cyber-attacks.

Access control lists, filters, and authentication of signaling messages are mechanisms that protect management, control and data planes, and help to prevent session hijacking, spoofing, denial of service attacks, and other malicious behaviors.

Strong access security is provided by Simple Network Management Protocol (SNMP) v3 confidentiality and integrity features, as well as Secure Shell (SSH) encryption.

The 7705 SAR supports dynamic source NAT/PAT for IPv4. Source NAT/PAT allows scaling of IPv4 networks by separating private IP addresses from the public network. All private IP addresses can be reached via a single public IP address or a small range of public IP addresses. In addition, source NAT/PAT can provide additional security to a private network by hiding internal private IP addresses.

Source NAT is supported on the following platforms and adapter cards:

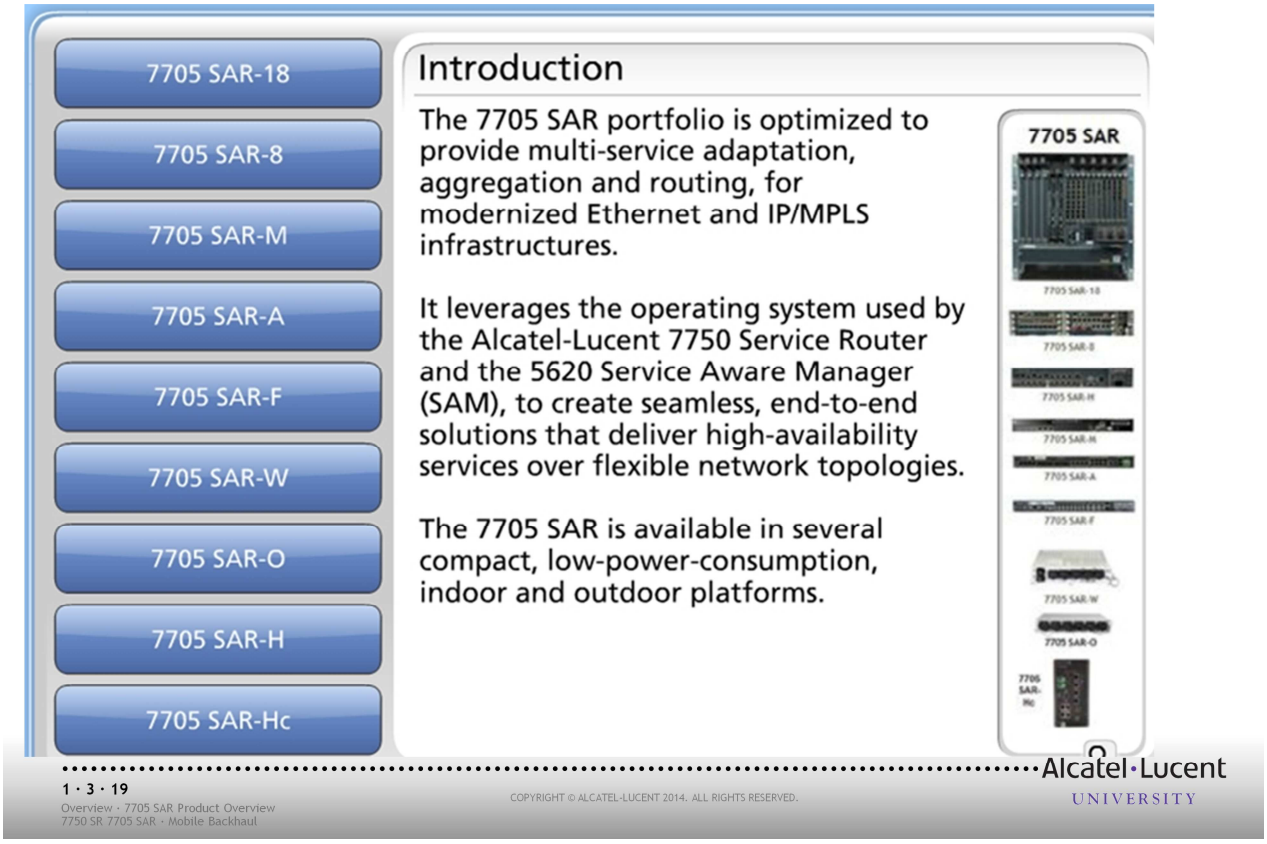
- 7705 SAR-8 with CSMv2 or 7705 SAR-18 configured with any combination of the following adapter cards only:
- 8-port Gigabit Ethernet SFP Adapter card, 8-port Gigabit Ethernet SFP Adapter card v2
- 8-port Gigabit Ethernet SFP Adapter card v3, Packet Microwave Adapter card
- 2-port 10GigE (Ethernet) XFP card, (7705 SAR-18 only) 10-port 1GigE/1-port 10GigE X-Adapter card, (7705 SAR-18 only) 10-port 1GigE/1-port 10GigE X- Adapter card v2
- 7705 SAR-H
- 7705 SAR-Hc

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 7705 SAR Family of Products Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR Family of Products



The 7705 SAR portfolio is optimized to provide multiservice adaptation, aggregation and routing, for modernized Ethernet and IP/MPLS infrastructures.

It leverages the operating system used by the Alcatel-Lucent 7750 Service Router and the 5620 Service Aware Manager (SAM), to create seamless, end-to-end solutions that deliver high-availability services over flexible network topologies.

The 7705 SAR is available in several compact, low-power-consumption, indoor and outdoor platforms.

The SAR-18 provides 10 gigabit SCALABILITY and flexibility across many media, with a full set of interface adapter cards.

The SAR-8 is a compact solution with modular flexibility and full set of interface adapter cards.

The SAR-M is a flexible, modular platform optimized for IP/MPLS over any access to provide multiservice support.

The SAR-A is an Ethernet scalable platform with full IP/MPLS and TDM features.

The SAR-W is an outdoor platform for backhaul and industries; it provides IP/MPLS features similar to those provided by the SAR-M.

The SAR-O add-drop multiplexor adds coarse wave division multiplexing capability in a robust outdoor platform.

The SAR-H positions Alcatel-Lucent in the Distribution Network arena and Field Area Network (FAN), and provides benefits for deployment in smaller transmission substations. It supports the same features as other 7705 SAR products in the R6.1 stream, and also incorporates new technologies, such as fanless operation, that meet IEEE 1613 Class 1 and IEC 61850-3 specifications for utility substation critical electrical relaying components.

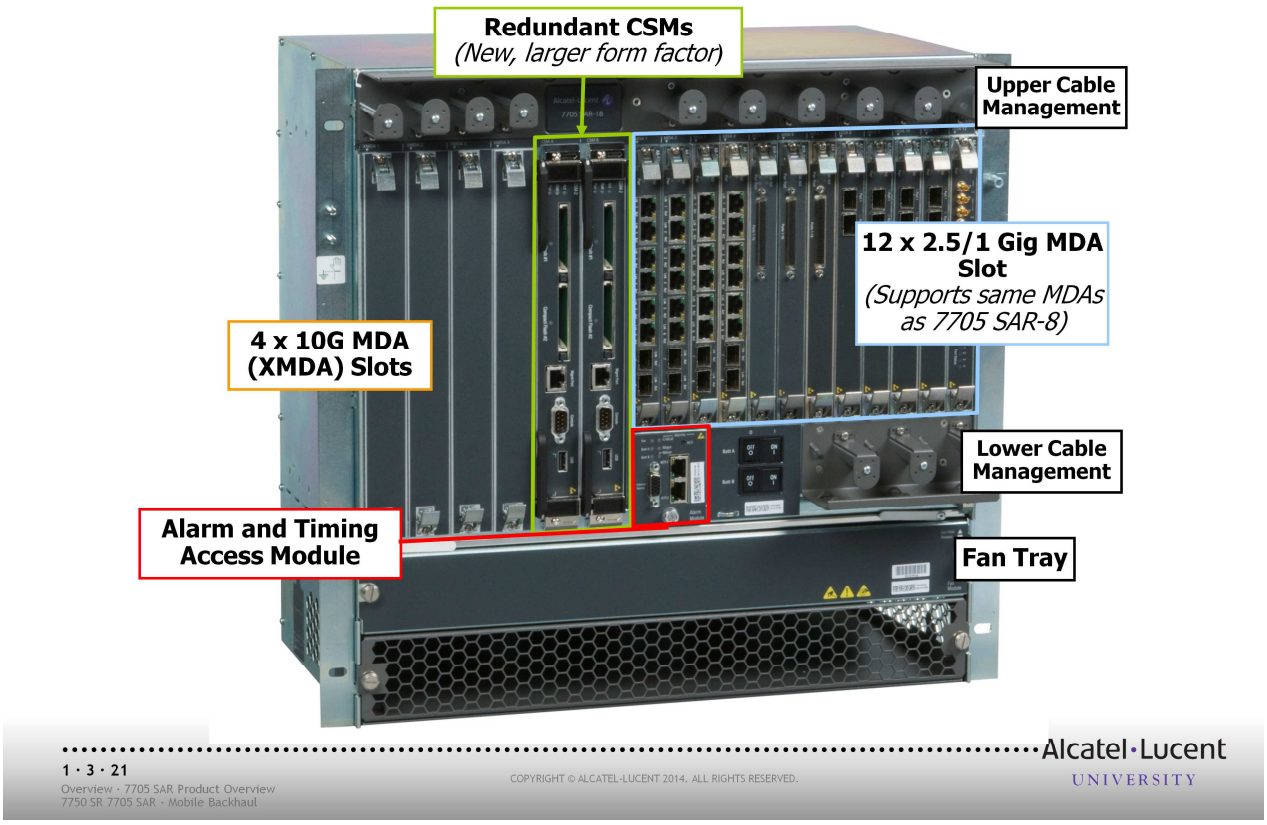
The 7705 SAR-Hc is a temperature- and Electromagnetic Compatibility (or EMC)-hardened platform.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 7705 SAR-18 System Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-18 Chassis Overview



The SAR-18 chassis fits into a standard 19” rack, and is 10RU high and 10” deep.

Components are field replaceable and hot-swappable.

Two Control and Switching Module slots are provided with integrated Ethernet switch-based fabric for Control and Fabric Redundancy.

The SAR-18 provides 70 gigabits per second full duplex Switch capacity to the media dependent adapter slots used to house the interface adapter cards.

The 12 MDA slots are individually configurable for 1 or 2.5 gigabits per second.

The 4 XMDA slots are configurable at 10 gigabits per second.

- The chassis also houses an alarm module and a fan tray with 8 fans.

The power system supports -48/-60 volts DC input power, with 3rd party AC solutions available.

The redundant input feeds A and B terminals are installed directly on the backplane with access from the front.

The SAR-18 supports combined SyncE and IEEE 1588 for frequency and time alignment.

It supports up to 12 ordinary slave clocks, master clocks, or boundary clocks.

A nodal clock is equipped in each CSM. Up to two PTP ordinary or boundary clocks can be configured per node as references to the nodal clock.

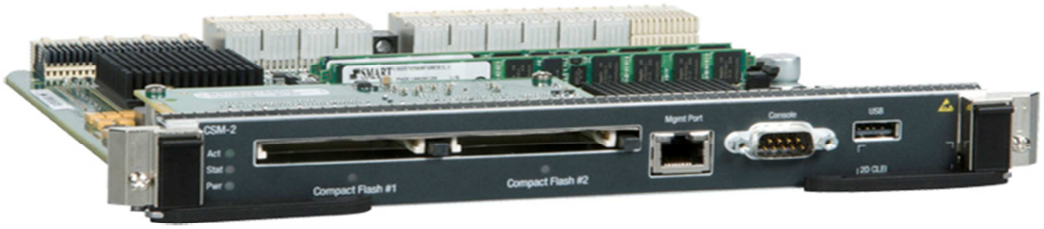
For all 7705 SAR platforms and clock types, when the node loopback address is used as the source interface for 1588 packets, the packets can ingress and egress over IES interfaces.

SAR-18 interface adapter cards on the access side support VLL/PW, VPLS, RVPLS, IES, and VPRN services.

Adapter cards on the network side support: Ethernet Null and Dot1q encapsulation; ASAP/SONET/SDH PPP/MLPPP, SONET SDH OC3/ST1; and layer 3 protocols (including IPv4 and IPv6 dual stack, static routes, PIM-SSM, OSPFv2 and v3, IS-IS, BGP, DHCP, ACL filters, and policy based routing).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-18 CSM OVERVIEW



7705 SAR-18 CSM is the Control and Switch Module for the shelf:

- Ethernet switching fabric
- Control processor
- System synchronization
- Face plate accessible Compact Flash cards (CF1 and CF2)
- Face plate accessible USB port
- Higher power processor with 4x memory
- Higher power fabric
- System Sync input/output connector moved to Alarm card

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-18 provides two Control and Switching Module slots for redundancy support.

Each CSM [C-S-M] is integrated with an Ethernet switch-based fabric for control and redundancy.

The CSM provides console, Sync-in, TOD-out, Management, and Alarm interfaces.

The system requires one CSM card; it can be installed in the slot for CSM-A or CSM-B.

A second CSM is required if redundancy protection is desired.

The CSM provides 70 gigabits per second Switch Capacity, as well as Console, Sync-in, TOD-out, Management, and Alarm interfaces.

Three compact flash cards are available per CSM. One flash card houses the system startup and operation software; this card is not accessible via the faceplate.

The other two cards are accessible from the faceplate and can be used for statistics collection, configuration storage, and upgrades. 2-, 4- or 8-Gigabit Compact Flash cards are available.

A USB port is also available for downloading information.

The two synchronization (BITS) ports are connected redundantly.

An RJ-45 connector is supported for management access in full and half duplex modes, with 10 and 100 megabytes per second auto-negotiation.

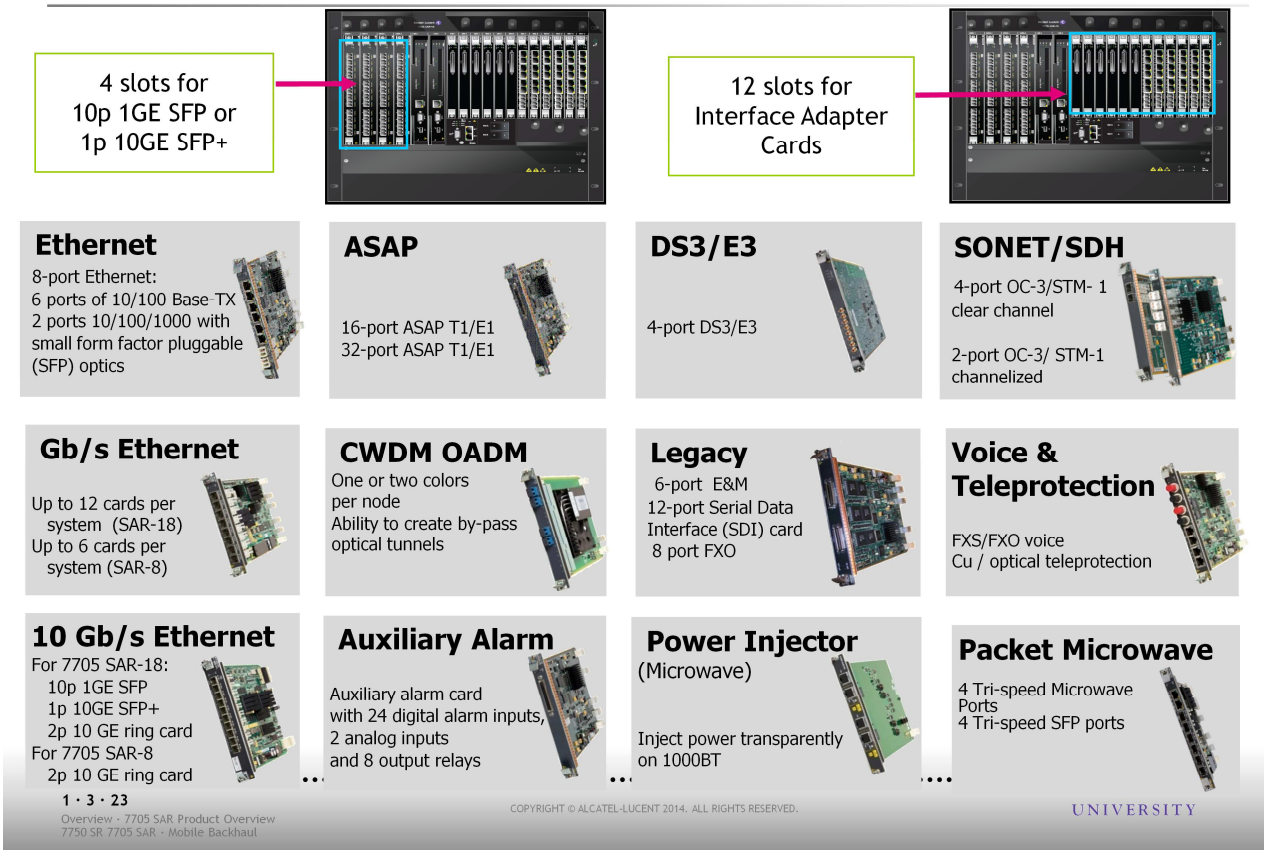
A 9-pin D-Sub console connector provides the ability to connect a console directly to the system.

Supported baud rates are 9,600, 19,200, 38,400, 57,600 or 115,200.

The CSM also provides Power, Status, and Activity LEDs.

The 7705 SAR supports a centralized synchronization system with an SSU in each CSM.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



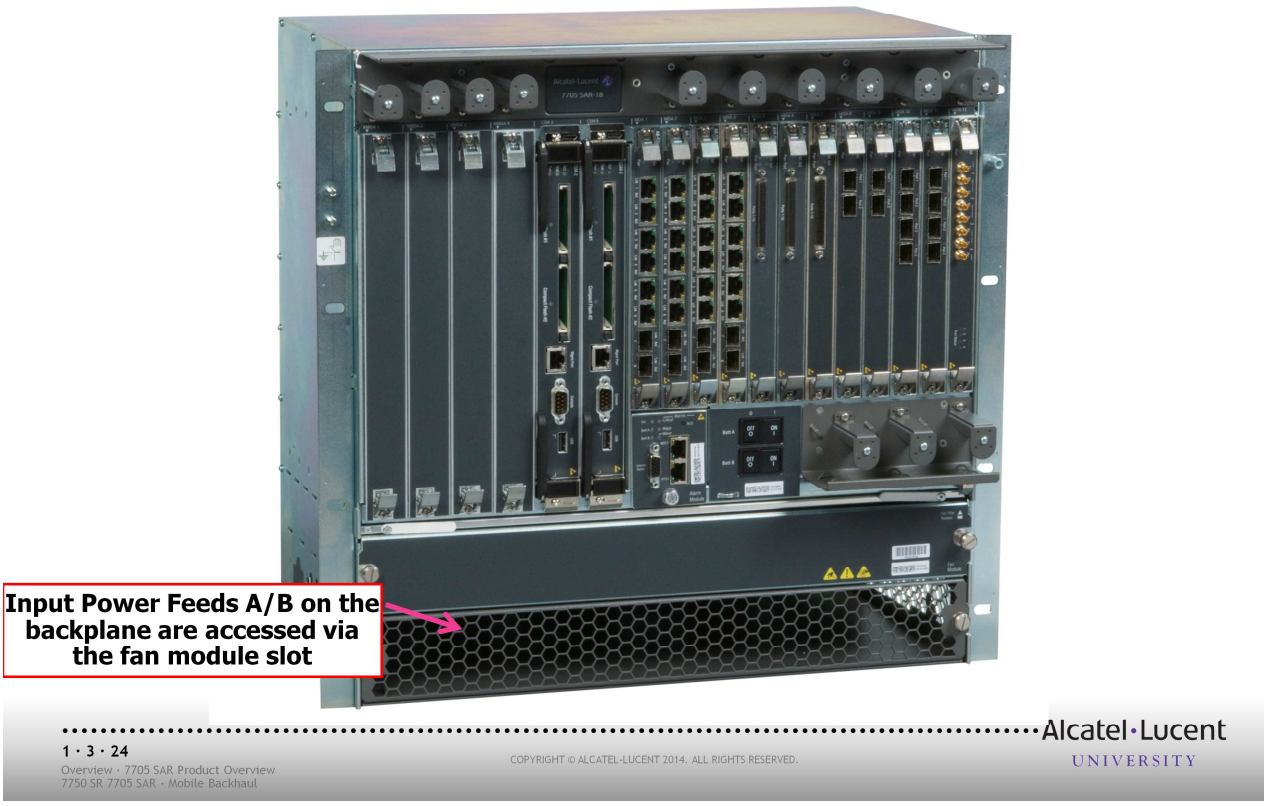
The SAR-18 provides twelve MDA slots for the available interface adapter cards, and four XMDA slots for the 10-port 1GigE SFP or 1-port 10GigE SFP+ cards.

The SAR-18 supports the adapter cards shown here.

More information about the interface adapter cards and their supported functionality in the 7705 SAR-8 chassis is described in a later module.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-18 Power Operations



The SAR-18 supports -48/-60 volts DC input power, with third-party AC power solutions available.

Redundant input feed A and B terminals are installed on the backplane with access from the front after removal of the fan module.

Two circuit breakers on the front of the chassis allow the A and B feeds to be disconnected.

Two openings on the left side of the chassis are for routing the DC power cables from the power terminals on the backplane to the front or back of the rack.

The SAR-18 uses a distributed power design, where each CSM and adapter card provides independent power for its own functionality.

No power input modules are required and the power system has no field-replaceable parts.

The DC power LEDs are located on the Alarm module (labeled "Batt A" and "Batt B").

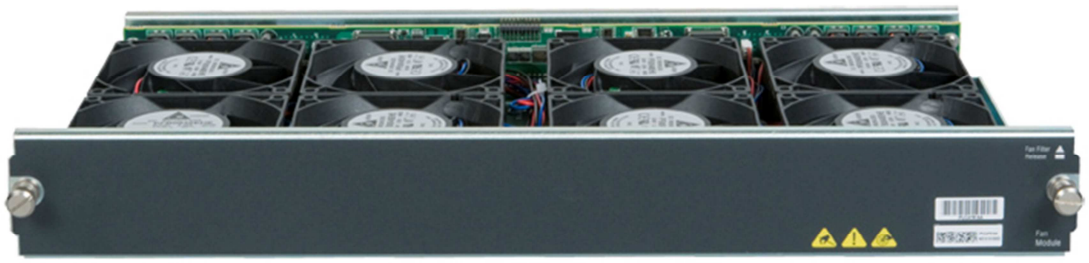
A green LED indicates that power for that feed is on; an unlit LED indicates no or faulty power.

Typical power consumption with all slots utilized would be about 1000 Watts; the maximum system power dissipation is 1430 Watts.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-18 FAN Operations

- 8 fans with self-regulated speed based on temperature sensor on the controller board
- Voltage regulation provided by fan controller board to avoid speed fluctuation due to low battery voltage
  - CSM alerted on power regulation failure
- Fans monitored for failures:
  - CSM alerted on fan failure
  - Fans will be forced to max speed on any one fan failure
- Fan status LED is located on the alarm module



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-18 provides housing for one field-replaceable Fan Tray with 8 fans.

The Fan module provides the cooling for the SAR-18 system. The fan speed is self-regulated by sensors built into each fan.

These sensors continually monitor the air intake temperature of the SAR-18 chassis. Fans start to ramp up at 77 degrees Fahrenheit (25 degrees Celsius), and become fully activated when the temperature reaches 104 degrees Fahrenheit (40 degrees Celsius).

The normal operating temperatures range is -5 degrees Celsius to +45 degrees Celsius. The fan may continue to operate at +55 degrees Celsius for a maximum of 96 hours.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-18 Alarm Operations



- LED status for alarm, batteries and fan
- ACO/LT (Audible Alarm Cut Off / Lamp Test):
  - Turns off all external alarm relay control bits until the next new alarm condition
  - Verifies the operability of LEDs
- BITS Access (Building Integrated Timing Systems):
  - SAR-18 provides two RJ45 BITS ports on the alarm module for system synchronization
  - Extracted input clock provided to both CSMs
  - Transmitted output clock derived from the active CSM
- Same external alarm inputs and outputs as SAR-8

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-18 Alarm module has two RJ-45 BITS ports that provide redundant clocking sources.

Each BITS port provides access to input and output timing signals.

The BITS port can be configured for T1 and E1 (both at 50 ohms and 75 ohms) or as a G.703 Clause 13 synchronization interface.

DS1 synchronization status messages are carried over the ESF data link; E1 messages are carried over SA bits.

Both BITS ports outputs are always active and driven by the active CSM to the frequency of its SSU.

Both BITS inputs are available as two separate sync reference options for the node (SSU), and are available to both CSMs.

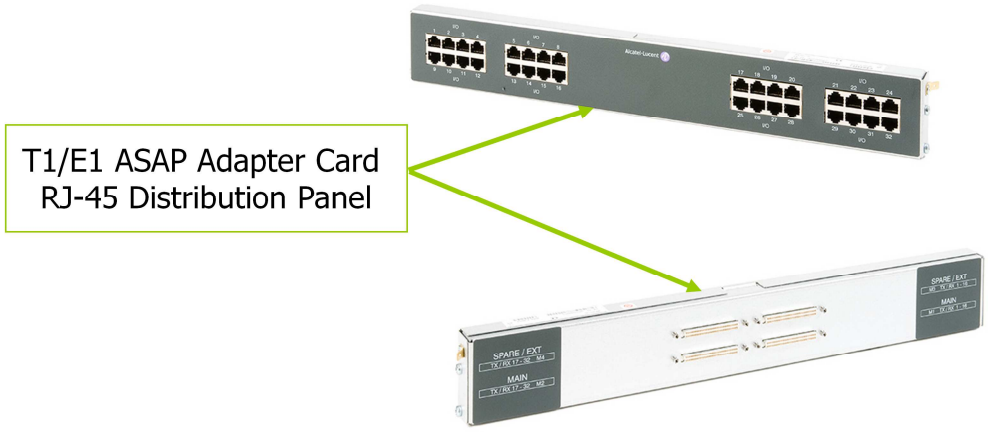
The Alarm module LEDs show the fan status, power status, and critical, major, and minor alarm indications.

The Alarm module also has an Audible Alarm Cutoff button (labeled A-C-O).

For applications where additional alarm outputs and alarm inputs are required, an Auxiliary Alarm card can be used in one of the MDA slots.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-18 Distribution Panels



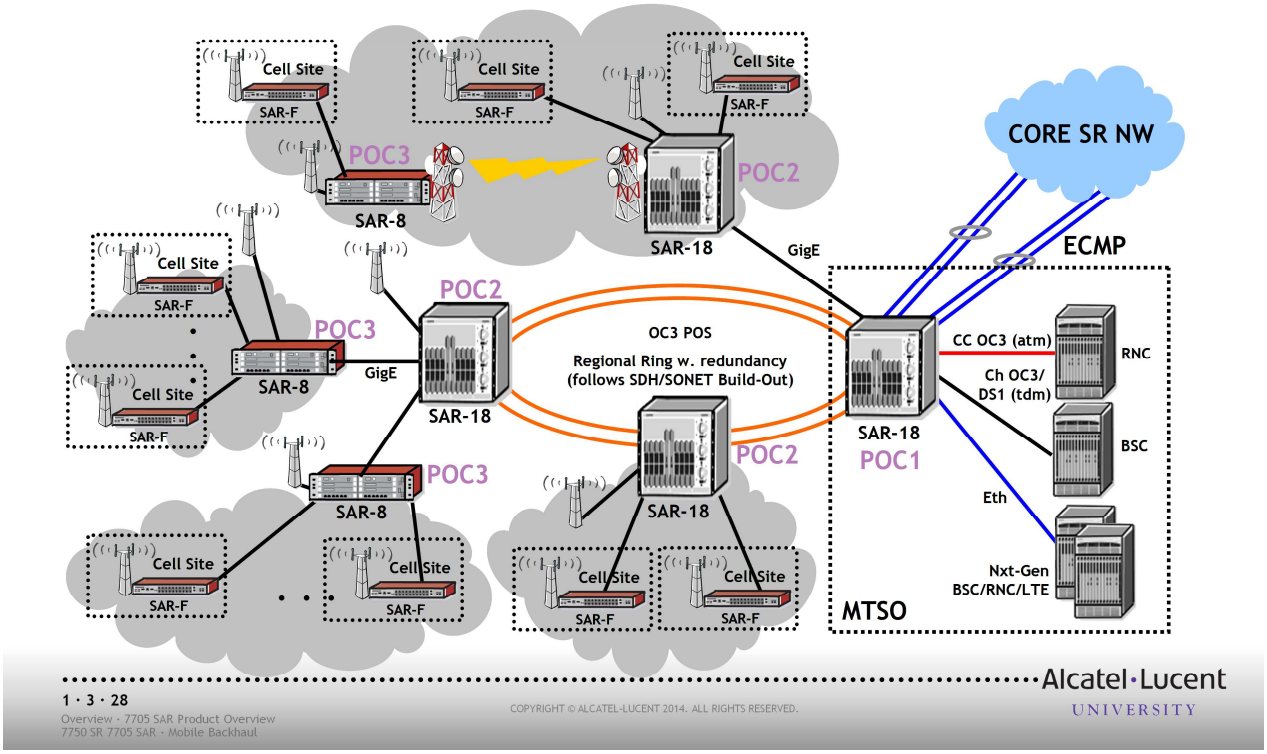
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Distribution panels are used to connect the 12-port SDI [S-D-I] cards installed in the SAR-18 MDA slots to customer equipment.

Distribution panels may also be used to connect the 16-port and 32-port T1/E1 ASAP Adapter Cards to the customer equipment in cases where high-density connectors cannot be used.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-18 Mobile Backhaul Aggregation Example



This slide provides an example of how the SAR-18 may be deployed for mobile backhaul aggregation.

Many mobile operators use a radio access network model with several stages of concentration.

Each of these stages are considered to be a "point of concentration" or "POC" .

In this illustration, POC1 is located in the Mobile Transport Switching Office or "MTSO", with the mobile radio control equipment (RNC/BSC).

At POC1, the 7705 SAR-18 is responsible for instantiating the services that carry the traffic from the RNC/BSC toward the Node B/BTS equipment.

POC2 is located within a region and is responsible for transporting the traffic that is to be distributed toward the NodeB/BTS equipment.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

5 7705 SAR-8 System Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8 Chassis Overview



- 2 Control and Switch Module (CSM or CSMv2) card slots: Slot A and Slot B
- V1: 6 interface card slots @ 1 Gb/s FD
- V2: 4 interface card slots @ 2.5Gb/s FD plus 2 slots @ 10Gb/s FD
- Fan module provides cooling for the system
- Alarm indicators (LEDs) and external alarm connector
- Two bipolar power entry connectors: redundant power supply feeds
- All parts are field replaceable and support hot insertion/removal
- Fits into a standard 2U rack (12'' deep, 19'' wide)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-8 chassis supports eight horizontal slots for one or two CSMv1 or CSMv2 cards and 6 interface adapter cards, as well as one vertical slot for the fan module.

The SAR-8 v1 chassis supports the 6 interface adapter card slots at 1 gigabit per second full duplex.

SAR-8 v2 supports 4 adapter card slots at 2.5 Gigabits per second full-duplex, and 2 slots at 10 gigabits per second full-duplex.

The connectors for the DC power feeds are located to the right of the Fan module and are factory-installed.

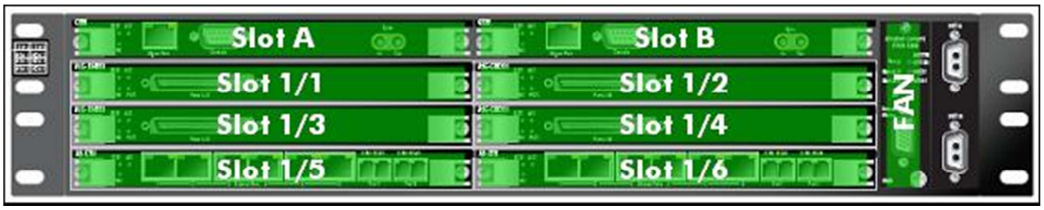
The CSM, adapter cards, and Fan module are all customer-installed.

All physical connections are made at the front of the chassis, including the chassis ground point.

There are no back panel connections.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8 Chassis V2



- SAR-8 v2 Chassis has a new backplane that is hardware-capable of supporting up to 10 Gb/s
- Slots 1 and 2 support 10 Gb/s FD with CSMv2 or 1 Gb/s with CSMv1
- Slots 3 to 6 support 2.5 Gb/s FD with CSMv2 or 1 Gb/s with CSMv1
- 7705 SAR-8 v2 accepts redundant DC-power feeds, up to 2 CSMv1 cards or 2 CSMv2 cards and up to 6 interface cards
- Chassis is referred to as “7705 SAR-8 v2” in CLI

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR-8 v2 Chassis accepts redundant DC-power feeds, up to 2 CSMv1 cards or 2 CSMv2 cards, and up to 6 interface adapter cards.

The SAR-8 chassis v2 is capable of supporting an increased bandwidth per interface adapter card slot.

Slots 1 and 2 support 10 Gb/s FD with CSMv2 or 1 Gb/s with CSMv1. Slots 3 through 6 support 2.5 Gb/s FD with CSMv2 or 1 Gb/s with CSMv1.

The SAR-8 CSMv2 supports both –48 volts DC and +24 volts DC.

The SAR-8 supports combined SyncE and IEEE 1588 for frequency and time alignment.

IEEE 1588 support is for up to 6 ordinary slave clocks, ordinary master clocks, or boundary clocks.

The 8-port Ethernet Adapter card, version 2, 8-port Gigabit Ethernet Adapter card, Packet Microwave Adapter card, 2-port 10GigE (Ethernet) Adapter card, and the 10-port 1GigE/1-port 10GigE X-Adapter card each support one PTP clock.

A conformal coating variant is available for the SAR-8 v2 shelf.

Conformal coating provides extra protection to sensitive electronic components when the 7705 SAR is deployed in harsh environments.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Conformal Coated Card Variants

Applied to many existing and new hardware systems, cards, and modules

Software releases are the same as for non-conformal variants

Conformal coating provides extra protection to sensitive electronic components

Conformal coat variants available for the:

- SAR8 CSMv2 (-48/+24VDC)
- SAR-8 Shelf V2
- Fan Module for SAR-8 Shelf V2 Ext. Temp (-48VDC)
- Fan Module for SAR-8 Shelf V2 Ext. Temp (+24VDC)
- 8 Port GE/FE Ethernet Card V2
- 12 Port Serial Data Card
- 16-port T1/E1 ASAP Card V2 (-48/+24 VDC)
- 8-Port GE SFP Card V2 (-48/+24 VDC)
- 8-Port GE SFP Card V3 – IPSec-Capable
- 2-Port 10GigE (Ethernet) XFP Card (-48/+24 VDC)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

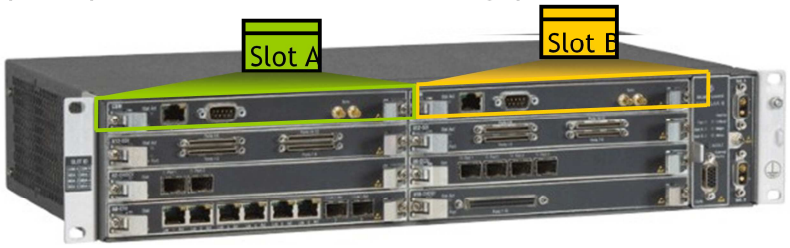
Many existing and new hardware systems, cards, and modules are now available in conformal coated variants. Software releases that support conformal coated variants are the same as the software releases for non-conformal variants of the same hardware.

Conformal coating provides extra protection to sensitive electronic components when the 7705 SAR is deployed in harsh environments.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8 control and switching Module (CSM)

- CSM slots:
  - 1 CSMv1 or CSMv2 (Slot A or Slot B) or optional 2 CSMv1 or 2 CSMv2 for redundancy
  - Each CSM ships with one compact flash memory device that stores system boot images, software images, and configuration files and logs
- CSM functions:
  - Management and console interfaces
    - 10/100 Ethernet
    - Serial Interface
    - Alarm interfaces input/output ports
  - CSMv2: ToD in and out ports plus increased chassis throughput
  - Routing and switching
    - Core control block
    - GigE switch



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-8 provides 2 Control and Switching Module slots. The CSM [C-S-M] is a field-replaceable module integrated with an Ethernet switch-based fabric. It provides hot redundant protection for the IP/MPLS control planes and database, switch fabric protection, external synchronization input and output ports, Serial and Ethernet management ports and Alarm interface input and output ports.

The CSM connects directly to the backplane and carries traffic between adapter cards.

The switch fabric receives and directs traffic to the appropriate destinations according to the routing information.

The CSMv2 provides 2 additional ToD in and out ports and increased chassis throughput.

The CSMv1 supports a maximum bandwidth of 1 Gigabits per second per adapter card slot.

The CSMv2 supports 10/2.5/1 Gigabits per second in the first two adapter card slots and 2.5/1 Gigabits per second in the remaining four adapter card slots.

Support for 2.5 Gigabits per second and 10 Gb/s adapter cards on the 7705 SAR-8 v2 chassis requires use of the CSMv2.

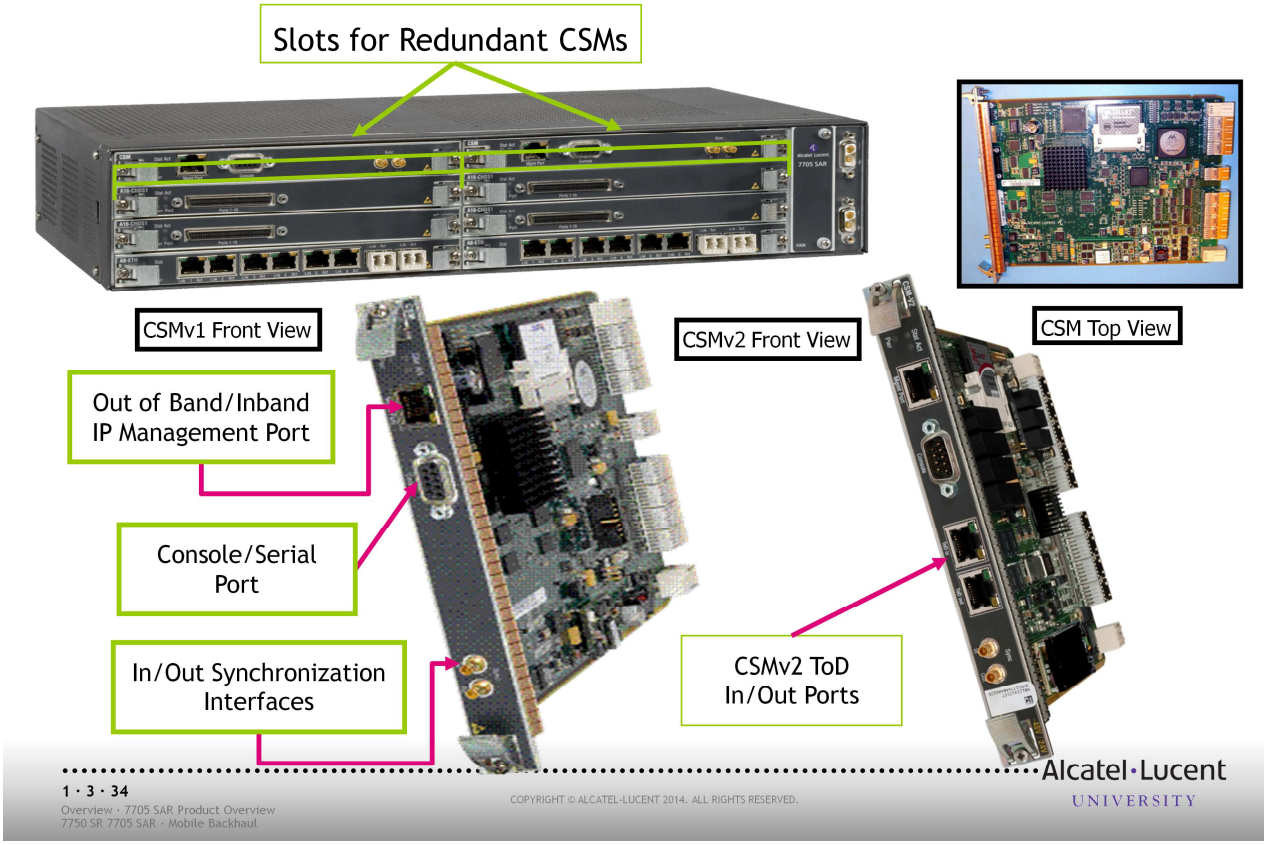
The SAR-8 supports two variants of the CSMv1; a –48 volts DC variant and a +24 volts DC variant.

There is one CSMv2; it supports both –48 volts DC and +24 volts DC.

Each CSM ships with one compact flash memory device that stores system boot images, software images, and configuration files and logs. The compact flash device cannot be accessed or removed by an operator or installer.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8 CSMv1 and CSMV2



The CSMv1 and CSMv2 both support the Management Ethernet port with full and half duplex mode, 10M/100M speed, and Auto negotiation.

The DB-9 Console port supports baud rates of 9600, 19.2k, 38.4k, 57.6k or 115.2K. A standard RS-232 serial cable with a male DB9 connector is supported.

The management port supports telnet connections to the router from a PC or a workstation connected to the network. The router must be initialized and have an IP address assigned to the management Ethernet port in the BOF, and the telnet server must be enabled.

The CSMv1 supports 2 MHz, 5 MHz, and 10 MHz synchronization.

The CSMv2supports 2 MHz and 10 MHz synchronization.

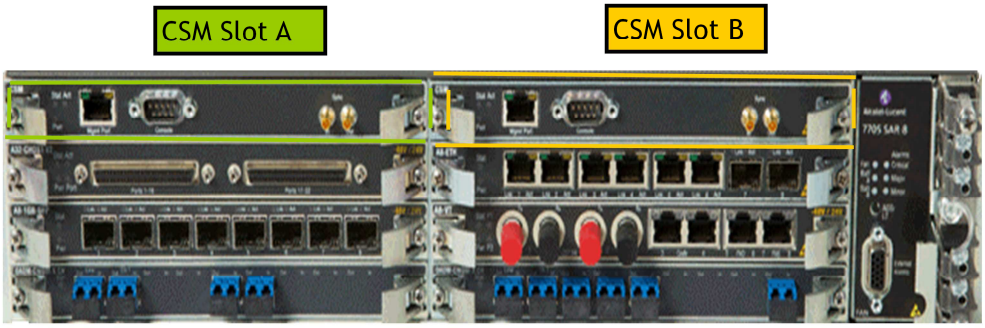
1.0/2.3 coaxial connectors are used for external synchronization input and output.

The CSMv2 provides RJ-45 input/output ToD/PPS (Time of Day Pulse Per Second) ports that are used to receive and send a signal to and from base stations or GPS receivers to communicate Time-of-Day and Phase at up to 115 200 baud.

A conformal coated variant of the CSMv2 (-48/+24VDC) is available.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8 CSM Redundancy



- CSM provides 1.0/2.3 coaxial connectors for an external synchronization input and output
- Y cable are used to connect the Synch in connectors on two CSMs to the same external synchronization source



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR-8 supports CSM redundancy when two CSMs are installed in the CSM slots.

The first CSM card installed in slot A or B becomes the active card; the second CSM installed becomes the hot-standby.

Preference is given to the CSM in slot A if two are installed and initialized at the same time.

Configuration and learned state on the active CSM are buffered and propagated over the GigE matelink to the standby CSM.

If the active CSM fails, the features are brought up on the standby CSM that takes over the mastership Operational protocols and services stay up and the standby CSM transparently takes over from the formerly active CSM.

When the failed CSM comes back online, it assumes the role of the standby.

You can configure automatic synchronization for the CSMs using the CLI (C-L-I) or 5620 SAM network manager.

It is possible to apply automatic synchronization to the configuration file or to the BOF, Boot.ldr, config and image files.

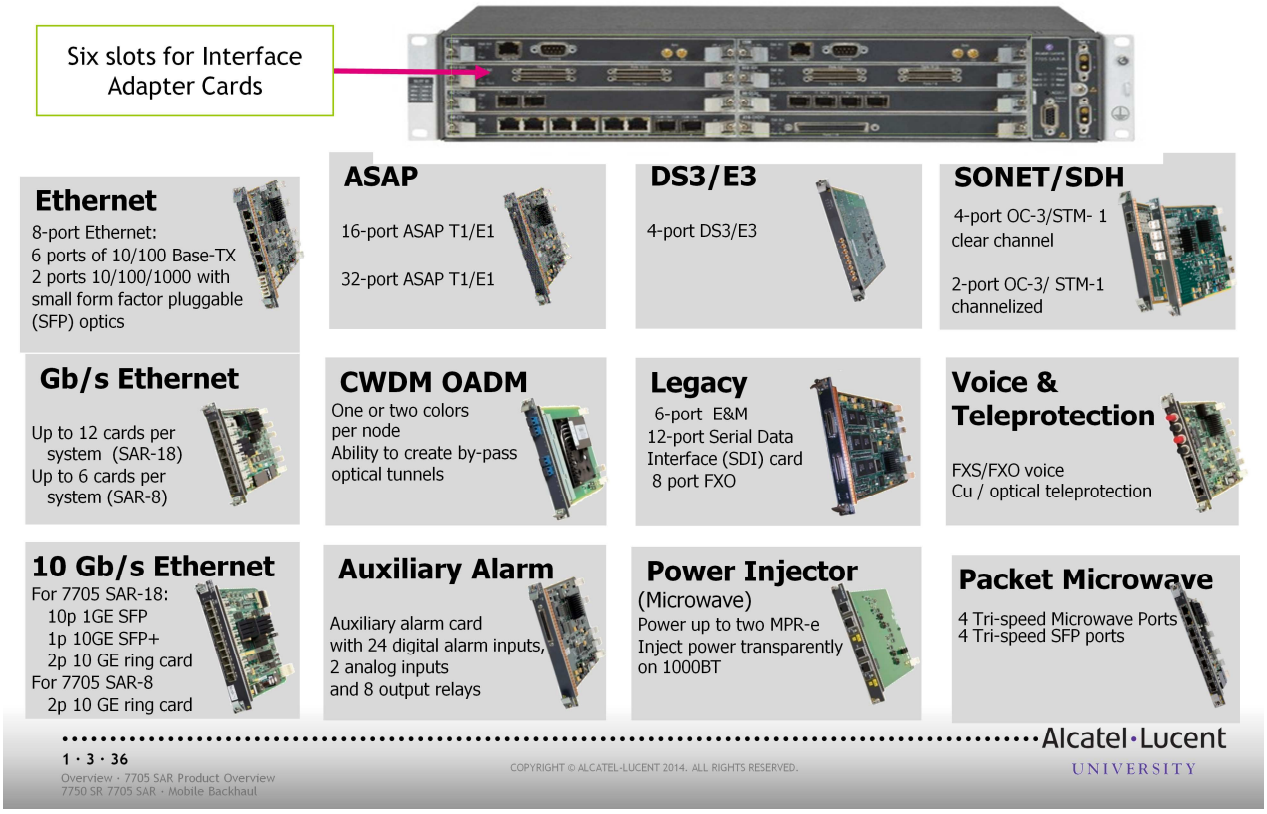
Note that CSMv1 is shown in the CLI as csm-1g and the CSMv2 is shown as csmv2-10g.

(3The CSM provides 1.0/2.3 coaxial connectors for an external synchronization input and output.

For redundant CSM configurations, a Y-cable can be ordered from Alcatel-Lucent to connect the Sync In connectors on the two CSMs to the same external synchronization source.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8 Adapter Cards



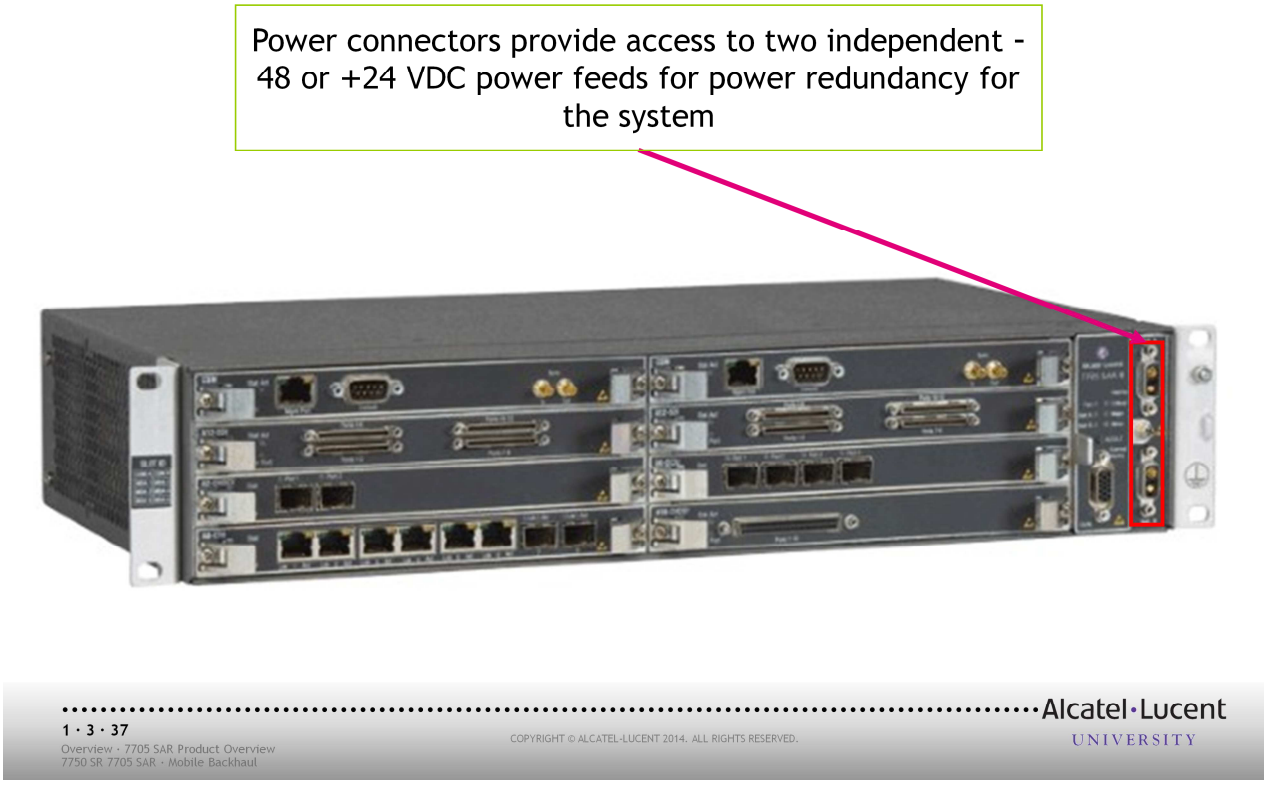
The 7705 SAR-8 provides six slots for the available interface adapter cards.

This slide shows the interface adapter cards that are supported for the 7705 SAR-8. More details about the cards and their supported functionality in the 7705 SAR-8 chassis will be described later.

Conformal coated variants are available for some of the adapter cards.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8: Power System



The SAR-8 and SAR-8 v2 chassis are each available in a –48/–60 volts DC version and a +24 volts DC version.

When a chassis is used for –48/–60 volts DC operation, the –48/–60 volts DC version of the components must be installed.

When a chassis is used for +24 volts DC operation, the +24 volts DC version of the components must be installed.

Each SAR-8 chassis has two power connectors mounted on the front of the chassis.

These connectors provide access for two independent power feeds.

Power redundancy for the system is provided when both are used.

The SAR-8 uses a distributed power design, where each CSM and adapter card provides independent power for its own functionality.

The power system has no field replaceable parts.

DC power cables are available from Alcatel-Lucent.

The DC power LEDs are located on the Fan module.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8: Fan Operation

- The Fan module provides cooling for the system
- Alarm indicators (LEDs)
- The Fan LED on the Fan module indicates:
  - Green: normal operation
  - Amber: one or more fans out of operation
  - Unlit: fan power failure
- Audible Alarm Cutoff/Lamp Test (ACO/LT) pushbutton
- External alarm I/O connector
  - Normal Operating Temperature of -40 to 149ºF (-40 to 65ºC)
  - Cooling system uses eight 40mm fans



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-8 fan module houses 8 fans.

Air enters from the intake vent on the right side of the chassis and exits through the exhaust vent on the left side.

Fans operate at full-speed and are always operational, regardless of ambient temperature.

Individual fans provide sufficient cooling if another fan fails.

The fans are not field-replaceable.

The Fan LED indicates the operational status of the fans: green indicates normal, amber indicates 1 or more fans out of order, and red indicates a fan failure.

The fan module must be replaced if 2 or more fans fail.

A critical alarm is generated if a fan has a fault.

Alarms are raised if the temperature exceeds 75 degrees Celsius or 167 Fahrenheit.

If temperature exceeds 117 degrees Celsius or 243 degrees Fahrenheit the system shuts down until the temperature returns within operational thresholds.

The SAR-8 v1 chassis supports three variants of the fan module: the –48 volts DC version introduced in Release 1.0 does not support an extended temperature range; the –48 volts DC and the +24 volts DC versions introduced in release 2.0 both support an extended temperature range.

The SAR-8 v2 supports two variants of the fan module: the –48 volts DC and the +24 volts DC versions both support an extended temperature range.

The SAR-8 v1 and SAR-8 v2 fan modules are not interchangeable and cannot be used in the other chassis variant.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8: v2 Fan Operation



- The SAR-8v2fan module size is wider, allowing for increased cooling capacity
- Power requirement is -48V
- This fan module is referred to as "SAR-8v2Fan"

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-8 v2 Fan module is wider in size than the SAR-8 v1 Fan module; this enables increased cooling capacity.

The SAR-8 v2 supports both a –48 volts DC fan and a +24 volts DC fan.

Both support an extended temperature range.

The SAR-8 v1 fan and the SAR-8 v2 fan are only compatible with the corresponding chassis. The fan modules cannot be used in the other chassis.

Conformal coated variants are available for both SAR-8v2 fan modules (-48VDC and +24VDC).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8 Distribution Panels



- A Distribution Panel is used for 16-port ASAP adapter cards to connect to T1/E1 circuits via 68-pin AMP connector
- There are two distribution panels:
  - RJ45 - 100-ohm T1 or 120-ohm E1 access for up to 32 ports
  - BNC - 75-ohm E1 access for up to 32 ports

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A Distribution Panel is used to connect to T1/E1 circuits via a 680pin AMP connector for 16-port ASAP adapter cards.

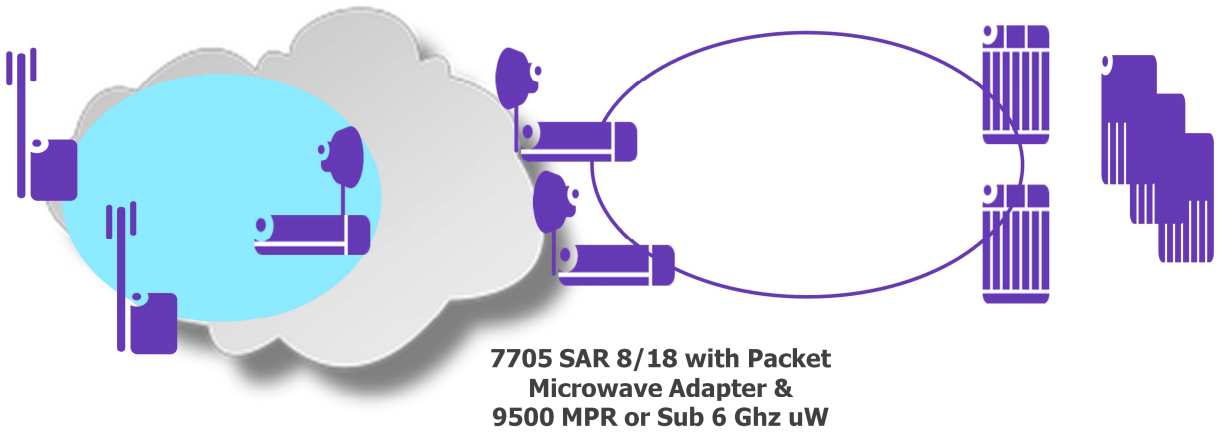
The RJ45 100-ohm T1 or 120-ohm E1 provides access for up to 32 ports, and the BNC 75-ohm E1 access for up to 32 ports.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6 SAR-8/SAR-18 Microwave Radio Connectivity

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8/18: Packet Microwave Radio Integration



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Microwave Packet Radio product family has been integrated into the 7705 SAR family to give operators a seamless IP over microwave experience and evolution to fiber.

The MPR-e is a zero-footprint, outdoor microwave solution that allows customers to migrate from TDM microwave to pure packet microwave.

Supported MPR-e radios include the:

•MPT-MC medium capacity,

•MPT-HC V2/9558HC High Capacity Version 2, and the

•MPT-XP High Capacity High Power

Microwave link connectivity to the MPR-e is provided by the SAR-8 and SAR-18 platforms using the packet microwave and power injector adapter cards.

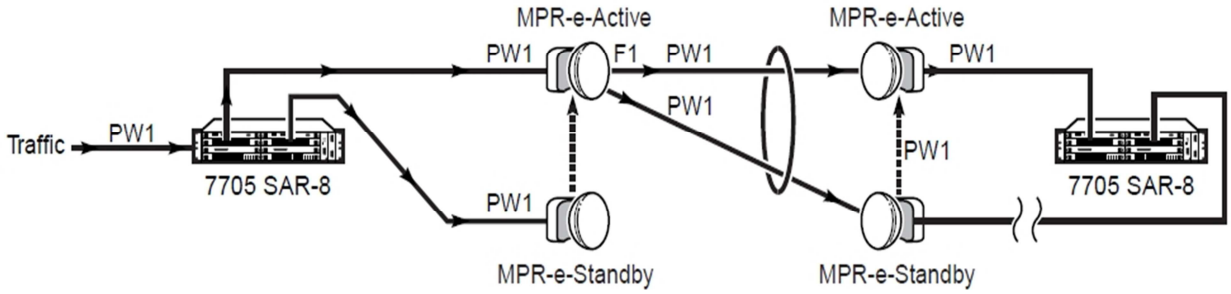
A microwave link connection can be made to the MPR-e from ports 1 to 4 on a 7705 SAR Packet Microwave Adapter card installed in the SAR-8 or SAR-18 chassis, using either an electrical or optical connection as supported by the radio variant.

This is described in more detail with the Packet Microwave Adapter Card.

A microwave link is configured on a 7705 SAR-8 or 7705 SAR-18 as a virtual port object, not a physical port, using the CLI command mw-link-*id* .

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8/18: Packet Microwave Radio hot Standby



In this 1+1 HSB with SD deployment, only one microwave frequency channel is active, and only the main MPR-e radio is transmitting data to the remote ends while the spare MPR-e radio is acting as the standby.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The supported microwave link types are 1+ 0 and 1+ 1 Hot Standby.

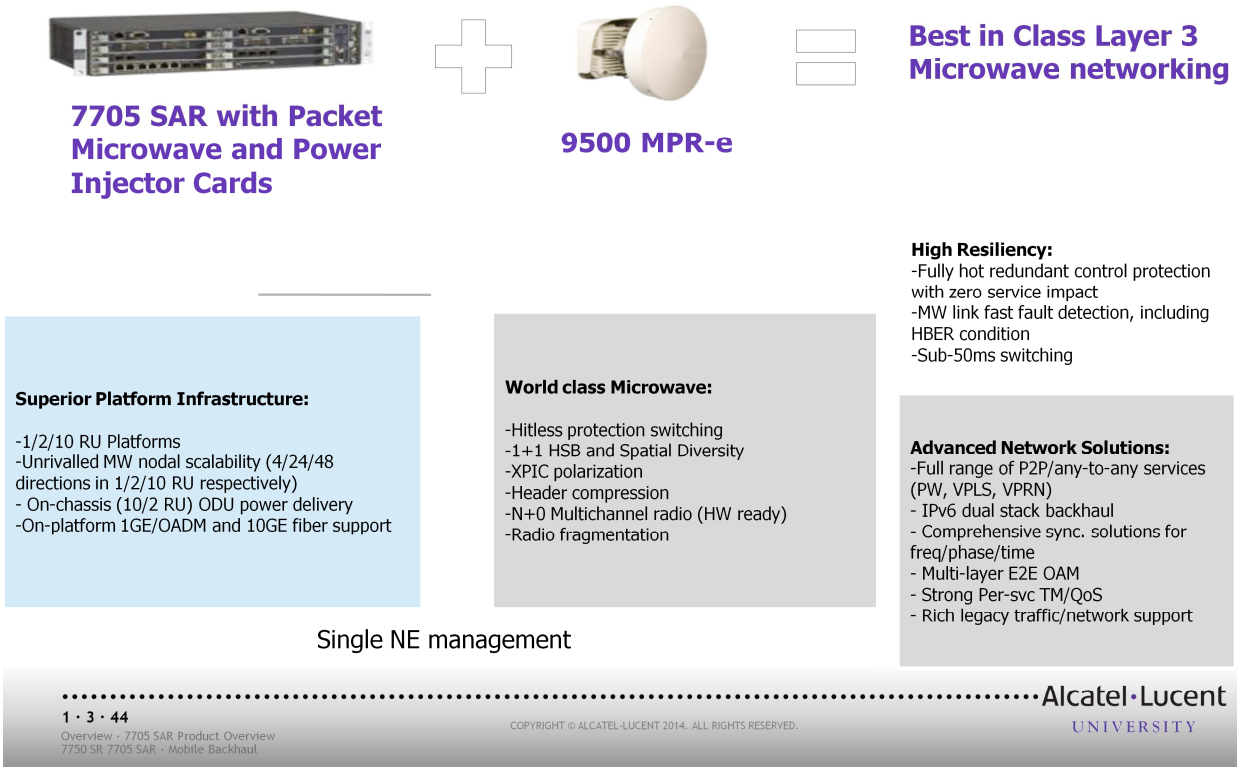
Multiple links of 1+0 can be configured separately. 1 + 1 HSB provides one to one equipment, transmission, and radio protection switching.

The requirements for HSB configuration include one frequency channel, two Packet Microwave cards installed in adjacent slots so each port on one card can protect the equivalent port on the adjacent card, two microwave-aware Gigabit Ethernet ports configured in network mode on the packet microwave cards, and two MPR-e radios each connected to one of the MWA Gigabit Ethernet ports to act as main and spare cards.

The configuration requirements for hot-standby for microwave links on the SAR-8 or SAR-18 include: one frequency channel, two Packet Microwave cards installed in adjacent slots, each with microwave-aware GigE ports configured in network mode, and an MPR-e radio connected to each of the MWA GigE ports.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8/18 and MPR-e configuration modes



The MPR can be configured in standalone mode to provide basic microwave connectivity. Alternatively, it can be configured in Single Network Element mode to provide networking capabilities to the radio over the microwave link; these functions include single NE Management, Microwave Link Fast Fault Detection, and one-to-one hot-standby.

In standalone mode, each MPR-e that is connected to a 7705 SAR-8 or 7705 SAR-18 is managed as a separate standalone NE by the 9500 MPT Craft terminal element manager.

In the default single-NE mode, the SAR-8 or SAR-18 and the MPR-e radios to which it is connected are integrated for management as a single NE.

For example, when using a network element manager such as the 5620 SAM, only the IP address of the SAR-8 or SAR-18 is required.

The 7705 SAR Release 6.1 OS supports MPR-e radios operating in Single NE mode when attached to the 7705 SAR. Applicable MPR-e OS licenses may be required. Packet radios that are supported in Single NE mode include the: MPT-XP, MPT-HCv2, MPT-MC, and 9558HC. Specific software, included in the R6.1 software bundle and named "**7705-TiMOS.6.1.R1.MWA.zip"** is required to support the MPR-e radios operating in Single NE mode.

Single NE management on the SAR side includes MPR-e fast fault detection, alarm management, software and upgrade, configuration database file management, inventory and microwave link performance statistics, and radio reset and mute control.

Some MPR-e radio configuration is also included on the SAR side, such as 1-to-1 hot-standby and epipe VLAN SAP parameters.

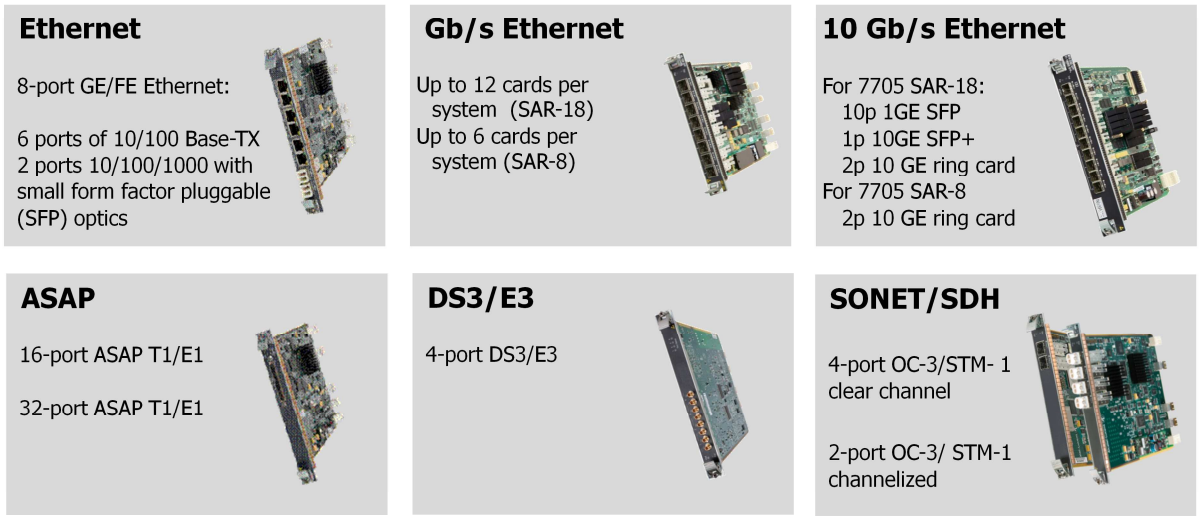
Radio link and QoS classification parameters are configured on the MPR-e side.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7 SAR-8/SAR-18 Interface Adapter Cards

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8/18 Interface Adapter Cards



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Each of the six adapter card slots in the 7705 SAR-8 and the twelve 2.5 Gb/s adapter card slots in the 7705 SAR-18 can be used to house the available adapter cards.

•The 8-port Ethernet adapter card supports six ports of auto-sensing 10/100 Base-TX ports, plus two further ports supporting 10/100/1000 Ethernet with small form factor pluggable (SFP) optics.

•The 8-port Gigabit Ethernet Adapter Card version 1 and version 2 provide GE connectivity.

•The 2-port 10 gigabit Ethernet card connect to and from access rings carrying a high concentration of traffic.

•The 10-port 1 gigabit and 1-port 10 gigabit Ethernet X-Adapter card is supported in the four XMDA slots on the SAR-18.

•The 16-port ASAP T1/E1 adapter card supports ATM, inverse multiplexing over ATM (IMA), TDM and multiclass ML-PPP.

•The 32-port ASAP T1/E1 adapter card supports ATM, inverse multiplexing over ATM (IMA), TDM and multiclass ML-PPP.

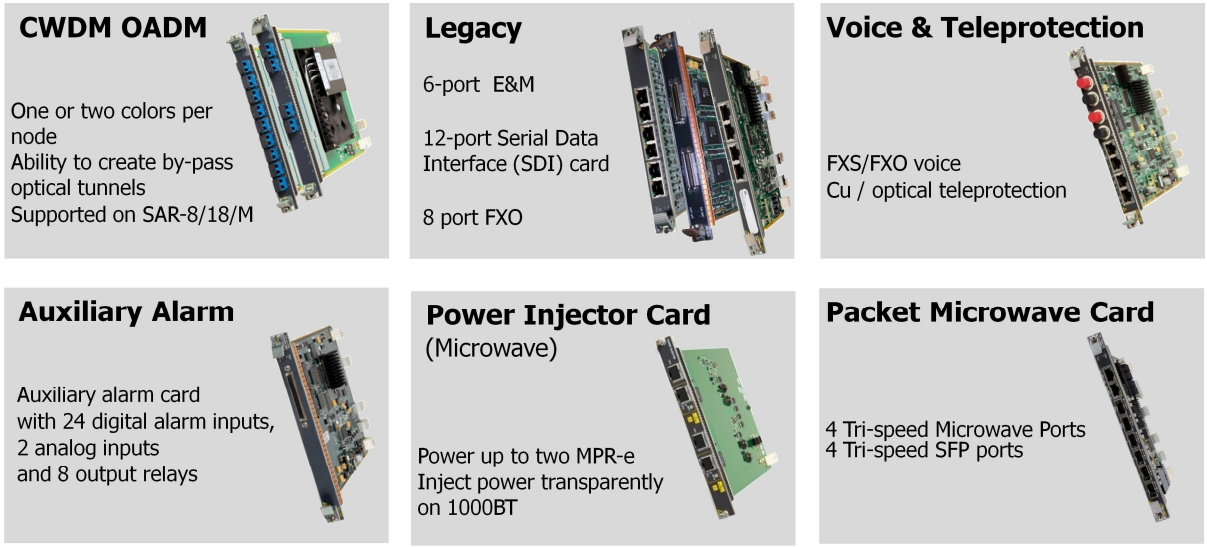
•The 4-port DS3/E3 adapter card supports clear channel PPP and ATM service (ATM on DS3 only).

•The 4-port OC-3/STM- 1 clear channel adapter card supports ATM and Packet over SONET/SDH (POS) with ports configurable for SONET or SDH operation.

•The 2-port OC-3/ STM-1 channelized adapter card supports ATM, inverse multiplexing over ATM (IMA), TDM and ML-PPP with ports configurable for SONET or SDH operation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-8/18 Interface Adapter Cards, continued



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The CWDM adapter cards provide better utilization of optical infrastructure. One or two colors per node are supported with both 1GigE and 10GigE per lambda

•The 6-port Ear and Mouth (E&M) adapter card supports selectable µ-Law or A-Law encoding.

•The 12-port Serial Data Interface (SDI) card can be configured for RS232, V.35 or X.21 operation.

•The 8-port Voice and Teleprotection adapter card provides legacy voice, data, teleprotection, and networking applications, as well as a migration path to MPLS with the optical interfaces.

•The FXS/FXO voice card compliments existing E&M and SDI cards and provides G.703 co-directional and C37.94 optical teleprotection.

•The power injector card can power up to two 9500 MPR-e, provides lightning /voltage surge protection , injects power transparently onto 1000BT, avoids Ethernet frame regeneration and retains synchronization.

•The packet microwave card provides 4 Tri-speed Microwave ports and 4 Tri-speed SFP ports, provides feature parity with the 8-port GigE Ethernet card and the full set of IP/MPLS/Ethernet networking.

•An auxiliary alarm card is also available and supports 26 digital alarm inputs, 2 analog inputs and 8 output relays.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

8-port GE/FE Ethernet adapter card v1/v2



8-port Ethernet Interface Adapter Card:

- 6 ports of 10/100Mbps
- 2 ports of 10/100/1000Mbps
- Supports Ethernet/VLAN Services
- Ports can be configured for access or network modes

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-8 supports the 8-port Ethernet Adapter card, version 1 and version 2.

They are identified in the CLI as "a8-eth" and "a8-ethv2."

Features include six 10/100 RJ-45 ports with Auto sensing, and two 10/100/1000 Megabits per second, SFP ports, 802.1q VLAN tag support, 802.1p priority bits support, classification/marking of packets .1p bits and 802.1ad VLAN stacking and QinQ, and Ethernet OAM.

Version 2 adds support for synchronous Ethernet as a timing source, more memory for storage of MPLS labels, and a +24 volts DC variant.

The electrical SFP does not support synchronous Ethernet.

Version 2 also supports larger tables, such as FIB and ACLs tables, and higher limits when all adapter cards in a node are equipped with the hardware for larger table support.

Any port on an 8-port Ethernet Adapter card can be used either as 'Access-' facing or 'Network-' facing, depending on the requirements.

By using network-facing Ethernet ports, all of the Access traffic can be switched out from the Cell Site in the form of VLLs across an MPLS network.

The card supports access service support, including Null and Dot1q Epipe, Ethernet to IP PW Ipipe, VPLS, IES and VPRN services, Physical protection, network encapsulation (Null and Dot1q Ethernet and IPV4/IPv6 dual stack), and static route.

The Ethernet ports also support combined SyncE and IEEE 1588 for frequency and time alignment.

IEEE 1588v2 PTP support is for one master, one slave, one boundary and one transparent clock.

A conformal coated variant of the 8-port GE/FE Ethernet v2 card is available.

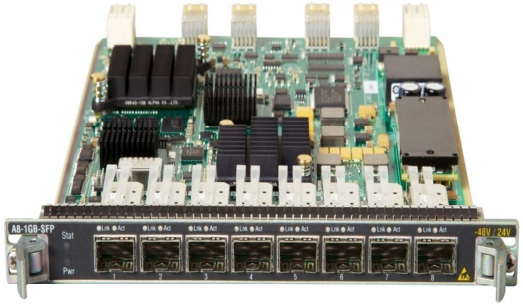
For a complete list of supported services and features in the current release, see the "7705 SAR Services per Card Quick Reference."

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

8-port Gigabit Ethernet SFP Adapter Card

The 8-port GE SFP Adapter Card supports:

- Universal power block with -48V to +24V DC range
- 10/100/1000 Mb/s Auto sensing (Speed Auto-Negotiation)
- IEEE 802.3 Frames on access
- Ethernet v2 Frames
- 6 cards for SAR-8 and 12 for SAR-18
- 1 Gb/s or 2.5Gb/s selectable fabric interface per CSM type
- 2.5 Gb/s fabric interface when plugged in to a SAR-18
- Full-Duplex with auto negotiation
- Half-Duplex on 10/100 ports only
- Access or Network Modes
- SyncE and IEEE 1588v2
- LAG at access across cards (eg. 1 port from a8-ethv2 and 1 port from a8-1gb-sfp or 2 a8-1gb-sfp)
- Null and Dot1q encapsulation
- Mini Jumbo frames
- EFM- OAM on access side
- Y.1731
- Configurable Port MAC address
- MAC Filters
- IPv6 full subnet range for IPv6 routes and interface IP



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 8-port Gigabit Ethernet Adapter Cards versions 1, 2, and 3 provide GE connectivity for the SAR-8 and SAR-18 systems. Version 3 is IPSec capable.

The cards are identical except that version 2 provides more memory to support larger tables, such as FIBs and ACLs.

They are identified in the CLI as "a8-1gb-sfp" and "a8-1gb-v2-sfp."

The cards provides 8 small, form-factor pluggable (SFP) ports on its faceplate for 10/100/Gigabit Ethernet optical or electrical SFPs.

The cards have a Universal power block to support -48V to +24V DC range.

On the 7705 SAR-8 version 1 or version 2 with CSM version 1, the card supports 1 gigabits per second fabric interface.

On the 7705 SAR-8 v2 with a CSMv2 and on the SAR-18, the card supports a 2.5 Gigabits per second fabric interface.

Supported features include 10/100/1000 megabits per second Auto sensing, IEEE 802.3 Frames on access, Ethernet v2 Frames, full-duplex with auto negotiation and half duplex on 10/100 ports, Access or Network Mode, SyncE and IEEE 1588 version 2, LAG at access across cards, Null and Dot1q encapsulation, Mini Jumbo frames, EFM- OAM on access side, Y.1731, Configurable Port MAC address, MAC Filters, and full IPv6 subnet range for IPv6 routes and interface IP.

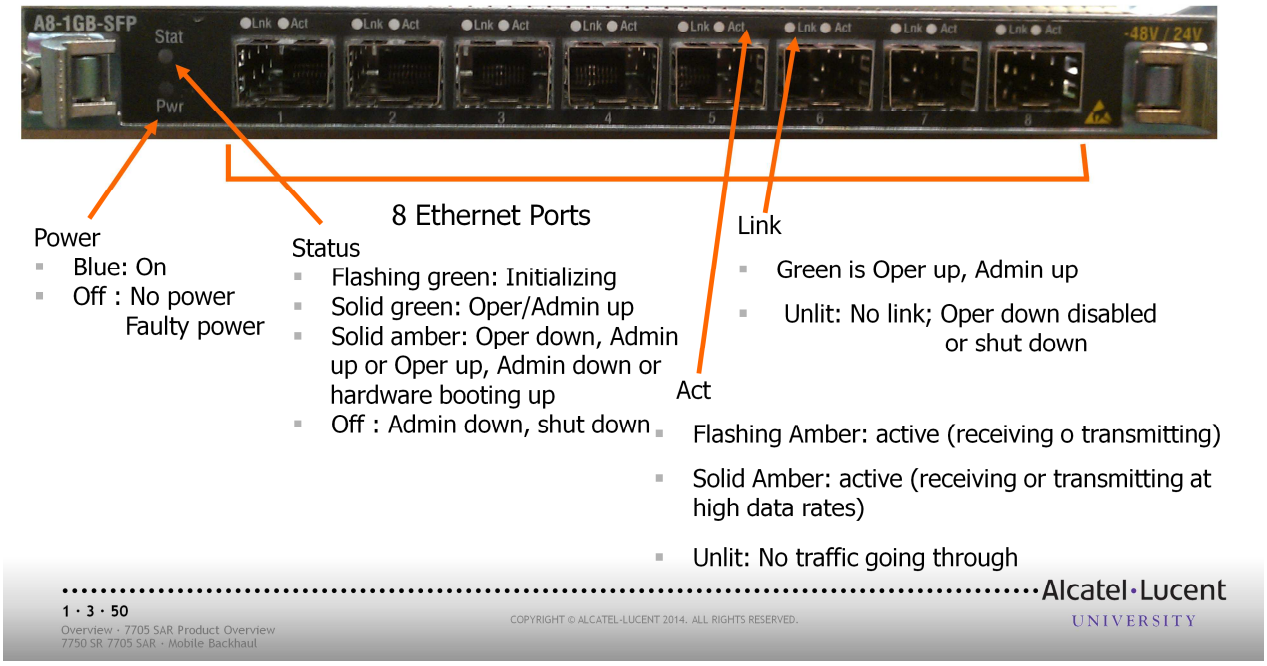
Conformal coated variants of the 8-port GE SFP v2 and v3 cards are available.

For a complete list of supported services and features in the current release, see the "7705 SAR Services per Card Quick Reference."

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

8-port Gigabit Ethernet SFP Adapter Card [cont.]

Ports and LEDs



The 8-port Gigabit Ethernet card provides 8 small form-factor pluggable (SFP) ports on its faceplate for 10/100/Gigabit Ethernet optical or electrical SFPs.

LEDs on the faceplate indicate the status of the power, module and ports.

The Ethernet ports support combined SyncE and IEEE 1588 for frequency and time alignment.

IEEE 1588v2 PTP support is for one master, one slave, one boundary and one transparent clock.

One nodal clock is also supported, and up to two PTP ordinary or boundary clocks can be configured per node as references to the nodal clock.

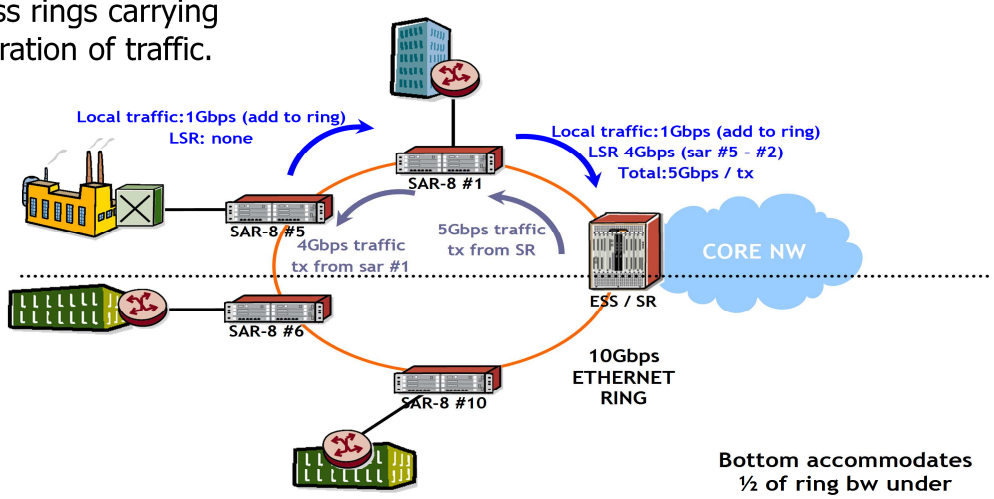
For all 7705 SAR platforms and clock types, when the node loopback address is used as the source interface for 1588 packets, the packets can ingress and egress over IES interfaces.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2-port 10 GigE Ethernet XFP Adapter Card

The 2-port 10 GigE card can be used in the 7705 SAR-8 or SAR-18 chassis to connect to and from access rings carrying a high concentration of traffic.





COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 2-port 10 gigabit Ethernet card can be used in a SAR-8 or SAR-18 chassis to connect to and from access rings carrying a high concentration of traffic.

A maximum of two cards are supported in the 7705 SAR-8 with CSMv1, four cards in the SAR-8 with CSMv2, and six cards in the SAR-18.

A minimum of two cards is required for redundancy.

A number of SAR nodes in a ring typically aggregate traffic from customer sites, map the traffic to a service, and connect to an SR node, which acts as a gateway point out of the ring.

Using a 10 GigE ring permits higher bandwidth services and aggregation on a per-7705 SAR basis, and increases the capacity of backhaul networks by providing increased port capacity through the 10GigE support on the aggregation nodes.

The card has two small form-factor pluggable (XFP) ports that use 10-Gigabit hot-swappable, Ethernet XFPs.

It supports 1 gigabits per second fabric interface on a SAR-8 version 1.

It supports 2.5 Gigabits per second fabric interface on a SAR-18 and on a SAR-8 version 2 with a CSM version 2.

The card provides –48/–60 VDC and +24 VDC power and has additional memory to support larger tables, such as FIBs, ACLs, and so on.

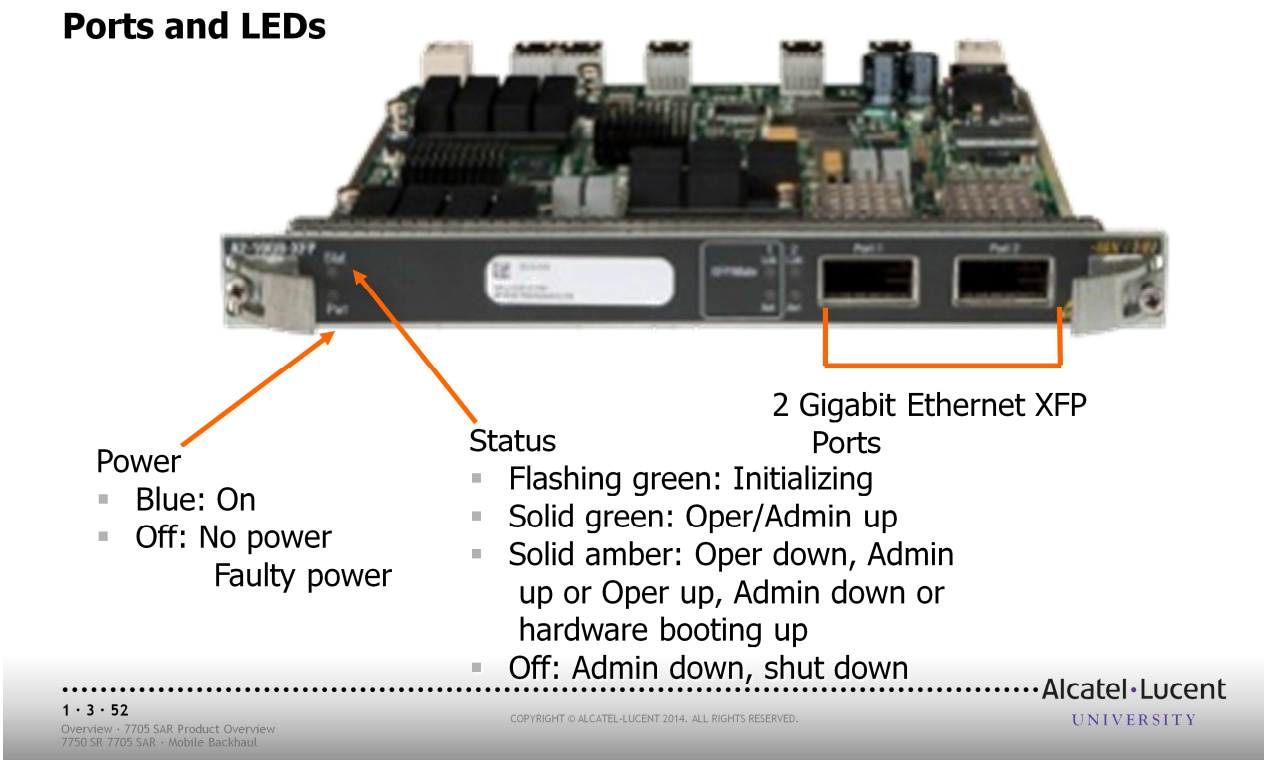
Card features include line timing, synchronous Ethernet, IEEE 1588v2 PTP**,** Digital Diagnostics, Ethernet version 2 Frames, LAN or WAN mode, full duplex mode, Ethernet Bridging, and services uplink over network interfaces, access service support including Null and dot1q Epipe, Ethernet to IP PW Ipipe, IES, VPRN, and VPLS, network encapsulation including Null and Dot1q Ethernet and full IPv6 subnet range for IPv6 routes and interface IP.

A conformal coated variant of the 2-port 10Gige Ethernet XFP card is available.

For a complete list of supported services and features in the current release, see the "7705 SAR Services per Card Quick Reference."

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2-port 10 GigE Ethernet XFP Adapter Card [cont.]



The 2-port 10 gigabit Ethernet Adapter card has two small form-factor pluggable (XFP) ports that use 10-Gigabit hot-swappable, Ethernet XFPs.

The XFPs use the LC connector type. Supported modules include SR, LR, ER, ZR EZX, CWDM, and DWDM XFPs with a variety of wavelengths and reach capacities from 300 meters to 120 kilometers.

The Ethernet ports support combined SyncE and IEEE 1588 for frequency and time alignment.

IEEE 1588v2 PTP support is for one master, one slave, one boundary and one transparent clock.

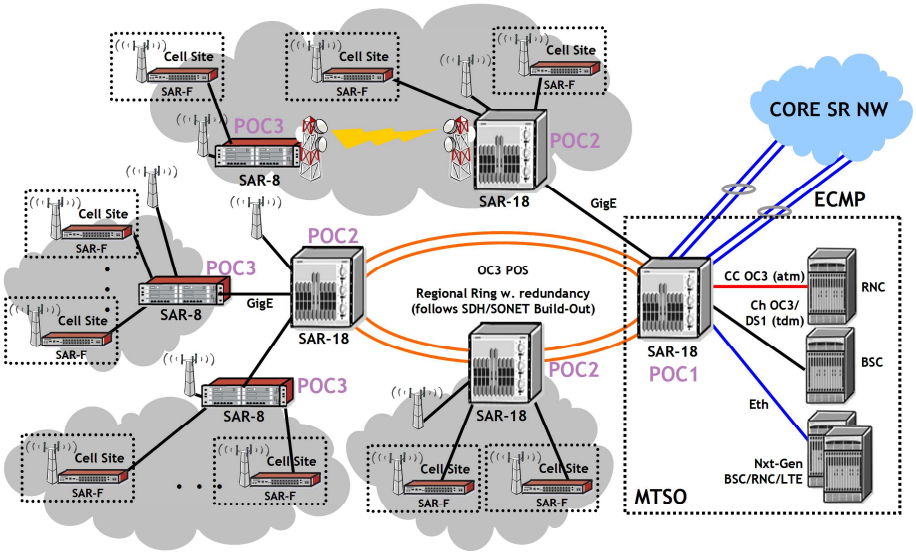
One nodal clock is also supported, and up to two PTP ordinary or boundary clocks can be configured per node as references to the nodal clock.

For all 7705 SAR platforms and clock types, when the node loopback address is used as the source interface for 1588 packets, the packets can ingress and egress over IES interfaces.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

10-port 1 GigE/1-port 10 GigE X-Adapter Card

The 1-10GigE / 10-1GigE XMDA introduces the first 10GigE interface on the SAR-18 platform, providing increased bandwidth handling capabilities to aggregate an ever increasing amount of data.



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

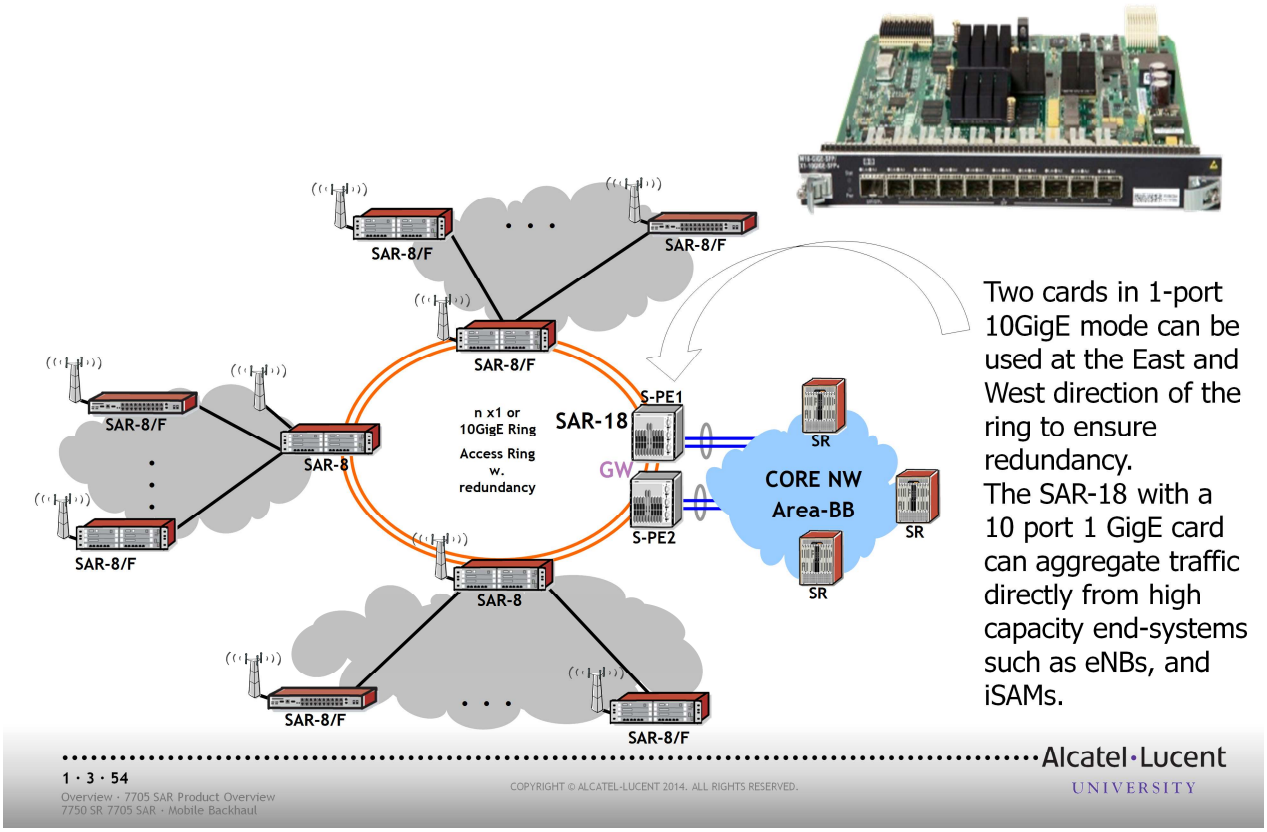
The SAR-18 supports the 10-port 1 gigabit and 1-port 10 gigabit Ethernet X-Adapter card.

With the explosion of data usage for video, multimedia and other applications, the 10GigE interface allows increased data-handling capabilities over existing links.

When operating in 10-1 GigE mode, the XMDA provides 10x 1 GigE interfaces, providing a higher-density port option on the SAR-18 platform.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

10-port 1 GigE/1-port 10 GigE X-Adapter Card [cont.]



Typically the X-Adapter card can be used in a SAR-18 chassis to provide links from access rings to higher capacity platforms for aggregation across the access rings, to add and drop local and regional traffic to CO servers, and for switching transit traffic.

The card is user-configurable in either mode.

In 1-port 10GigE mode, only port 1 is available for use at 10 gigabits per second.

This mode is designed for situations where greater processing power and higher throughput capacity are required.

The SAR-18 with a 1 port 10 GigE card can be used to face an access ring.

In this example, two cards are used at the East and West direction of the ring to ensure redundancy.

Protection against fiber cuts and nodal failures is provided by utilizing protection mechanisms such as FRR, PW-redundancy, and fail over to the surviving direction.

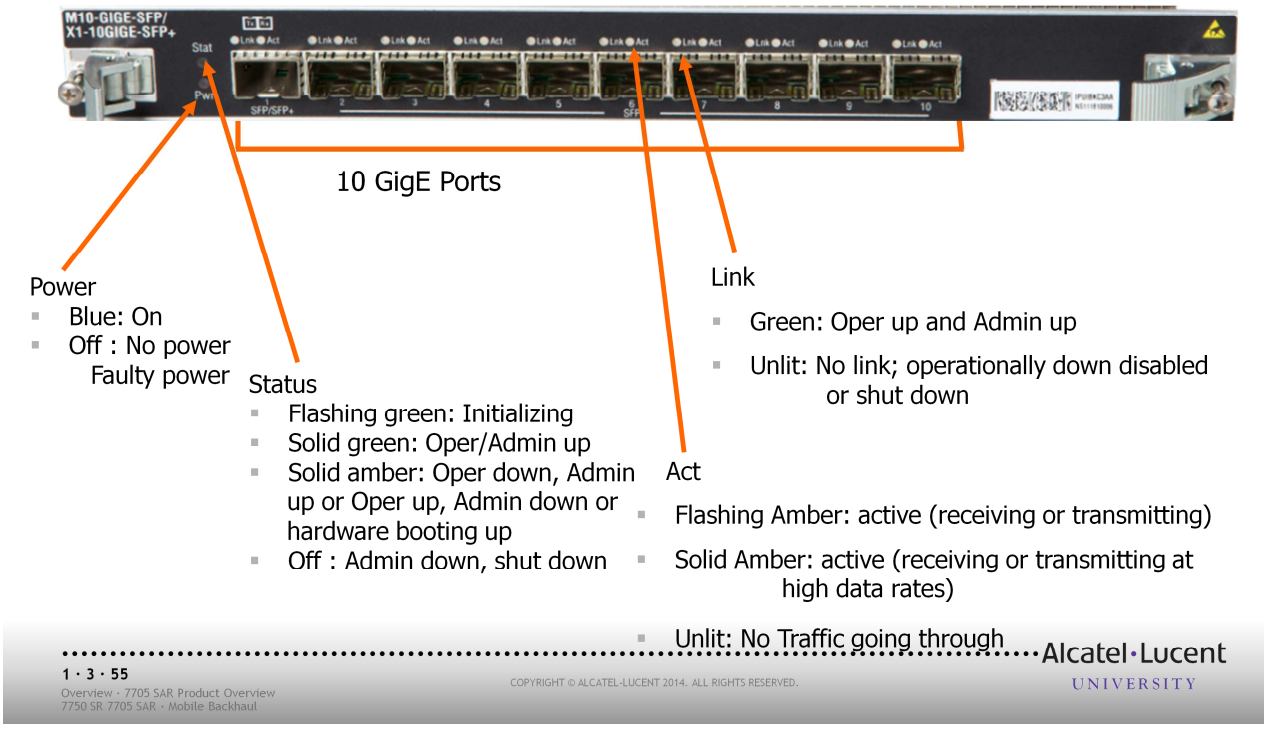
The SAR-18 with the 10 port 1 GigE card can aggregate traffic directly from high-capacity end-systems such as eNBs, and iSAMs, when Fast Ethernet capacity is insufficient and the end-system is an aggregation platform by itself.

It can also be used in NorthWest mode to aggregate traffic.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

10-port 1 GigE/1-port 10 GigE X-Adapter Card [cont.]

Ports and LEDs



The 10-port 1GigE/1-port 10GigE X-Adapter card has 10 small form-factor pluggable (SFP) ports that use optical or electrical SFPs.

In 10-port 1GigE mode, the card can operate at 10/100/1000 megabytes per second.

The single SFP+ port supports 10-Gigabit Ethernet optical or electrical SFPs including SR,LR,ER,ZR, XLR variants.

The SFP supports all SFPs similar to existing interface cards, such as the 8-port Ethernet v1 and v2, except for the FX SFP.

The card has a power block that supports –48/ –60 VDC power.

The supported temperature range is 0C to +55C operating.

LEDs on the faceplate provide visual indication of the status of the power, module, and individual ports.

The Ethernet ports support combined SyncE and IEEE 1588 for frequency and time alignment.

IEEE 1588v2 PTP support is for one master, one slave, one boundary and one transparent clock.

One nodal clock is also supported, and up to two PTP ordinary or boundary clocks can be configured per node as references to the nodal clock.

For all 7705 SAR platforms and clock types, when the node loopback address is used as the source interface for 1588 packets, the packets can ingress and egress over IES interfaces.

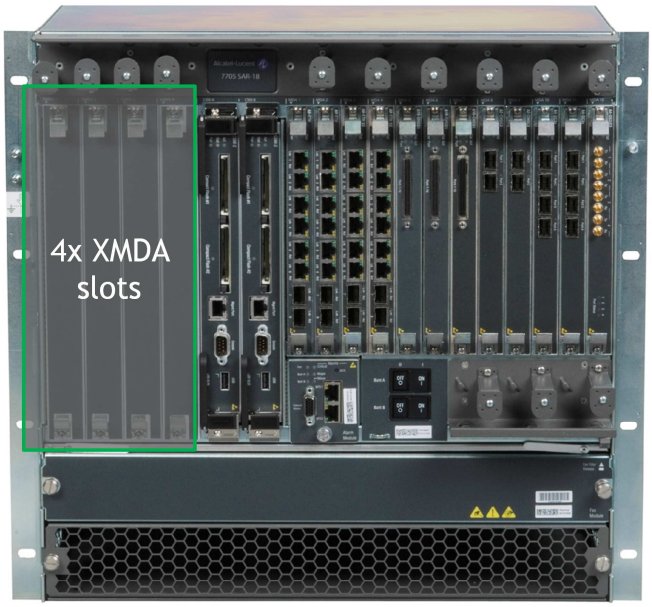
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

10-port 1 GigE/1-port 10 GigE X-Adapter Card [cont.]

Card slots

The 4 slots (indicated by the green box) on the 7705 SAR-18 platform support the 1 GIGE/1-port 10 GIGE XMDA.

SAR-18 Chassis: XMDA



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

As with other adapter cards, the SAR-18 XMDA slots can be populated in any order, and support hot-swap / insertion.

The XMDAs are referenced in the CLI by the slot ID, which is always 1, followed by a forward slash and the MDA reference. From left to right, the MDA reference is capital X1 to capital X4. For example, the card in XMDA slot 1 is referenced using the format 1/X1 [one forward slash capital X1]. The entries are case-sensitive.

Card features include:

•Automatic discovery protocol, Multi-Chassis LAG Redundancy, line timing, synchronous Ethernet,

•IEEE 1588v2 PTP, access service support (Null and dot1q Epipe, Ethernet to IP PW Ipipe),

•Services (IES, VPRN, and VPLS) and network encapsulation (Null and Dot1q Ethernet), and

•Full IPv6 subnet range for IPv6 routes and interface IP.

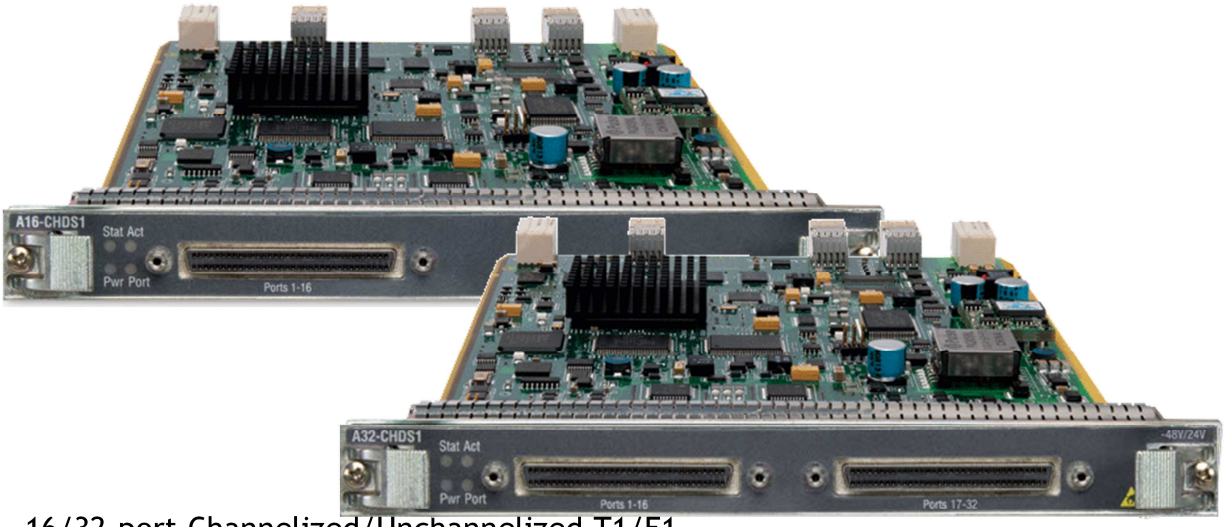
The QoS features include:

- Ingress classification based on EXP (MPLS), DSCP(IP), Dot1p (Ethernet),
- 8 queues per Network interface / SAP,
- WRED [w-r-e-d] and Tail Drop congestion management,
- Egress-rate shaping, dot1p/DSCP/TC marking and re-marking per forwarding class,
- 16 priority scheduling at Network Ingress and egress,
- Per-Destination (Network) and Aggregate fabric shapers, and
- Default 200MB aggregate.

For a complete list of supported services and features in the current release, see the "7705 SAR Services per Card Quick Reference."

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

16/32 Port T1/E1 ASAP Adapter Card



16/32-port Channelized/Unchannelized T1/E1

- Any service any port (ASAP) card
- Supports Unchannelized T1(DS1)/E1 and channelization down to DS0
- Supports ATM/PPP/TDM encapsulations
- Each port can be independently configured for the different services
- Each port can be used for access or network port

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-8 supports the 16-port T1/E1 ASAP Adapter card version 1 and version 2, and the 32-port card version 2.

The SAR-18 supports only the 16-port and 32-port version 2 cards.

In the CLI, the cards are referenced as "16-chds1," "16-chds1v2" and "a32-chds1v2."

The 16-port card has one SCSI-2 connector and the 32-port card has two connectors.

The connectors use a single cable connection to a 32-port BNC, 32-port RJ-45, or 32-port Mini-Coaxial distribution panel.

A T1/E1 port must be configured in access or network mode to transport traffic.

Channel groups on a port must be all access or all network.

You must delete and reconfigure all the groups in order to switch modes.

In access mode, each port supports TDM (for 2G BTS), ATM/IMA (for 3G UMTS Node Bs), IP over PPP/MLPPP (for CDMA BTS). IPCP, CEM, frame relay, HDLC and Cisco-HDLC.

In network mode, either MLPPP can be configured on a number of T1/E1 ports within a bundle on the same card, or a PPP channel group with a number of DS0/ 64k channels may be configured.

The clocking source on each T1/E1 port can be configured to be loop-timed, node-timed, or adaptive-timed.

The 16 port card Version 1 supports a single recovered clock; Version 2 supports two reference clocks from different framers on the card.

The 32-port card supports 2 loop-timed ports or adaptive-timed ports from different framers.

Each T1/E1 CES circuit can be independently configured for adaptive timing or differential timing.

ACR is not supported on DS1 or E1 channels that have CAS signaling enabled.

A conformal coated variant of the 16-port T1/E1 ASAP v2 card is available.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

16/32 Port T1/E1 ASAP Adapter Card [cont.]

T1/E1 Framing Options

Port Type
DS1 Mode
DS1 Framing: SF (D4) and ESF
DS1 Framing: No framing
DS1: B8ZS zero suppression
DS1: 100 Ohm termination impedance
DS1: Line build out = short or long (225 or 450 feet)
DS1: ESF FDL as per Bellcore 54016 and ANSI T1.403, including Remote loopback
E1 Mode
E1: G703, G703 with no CRC
E1: No framing
E1: HDB3 zero suppression
E1: 120 and 75 Ohm termination impedance

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

You can configure the framing mode for the DS1 and E1 ports on the 16-port and 32-port T1/E1 cards, as well as the DS1 ports on the 2-port OC3/STM1 Channelized Adapter card, or DS3 ports on the 4-port DS3/E3 Adapter card.

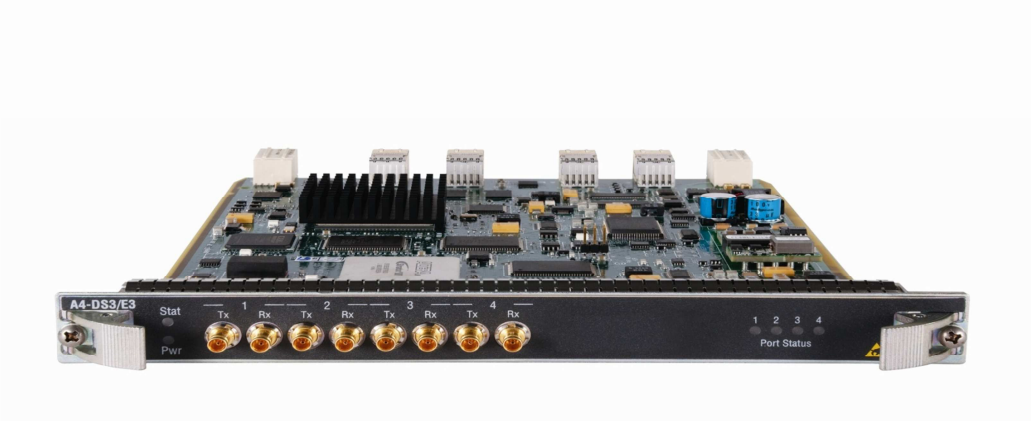
For E1 ports, this includes g704 framing, g704 framing with no CRC4, and unframed G.703 mode. E1 unframed mode is only applicable if the encapsulation type is CEM.

For DS1 ports, this includes extended superframe framing, superframe framing, and unframed G.703 mode.

DS1 unframed mode is only applicable if the encapsulation type is CEM or ppp-auto.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4-port DS3/E3



- DS3/E3 Card allows a connection to be formed to an existing Layer 1 network
  - ATM access
  - PPP network ports
- Transporting ATM traffic from an ATM switch or a Node B with a DS3 ATM port via Apipe services

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 4-port DS3/E3 Adapter card has four sets of DIN 1.0/2.3 connectors; each with one transmit (TX) and one receive (RX) connector.

Ports must be configured for either all DS3 or all E3.

Each DS3 port can be clear-channel or channelized down to DS0 (64 kb/s).

E3 ports can be clear-channel only.

The port mode must be configured to be either access or network.

In access mode, the DS3/E3 clear channel ports can be configured for ATM, TDM, or frame relay.

The DS3 channelized ports can be configured for TDM or frame relay.

ATM service categories include CBR, VBR-rt, VBR-nit, UPR and UBR plus MCR.

In network mode, the DS3/E3 ports must be clear-channel and must be configured for PPP.

PPP/MLPPP support is PPP (RFC 1661); LCP options are RFC1661, RFC1570IPv4 Control Protocol – RFC1332.

For network synchronization, each DS3/E3 port can be independently configured to be loop-timed or node-timed.

The card is available in a -48/-60 volts DC variant and +24 volts DC variant.

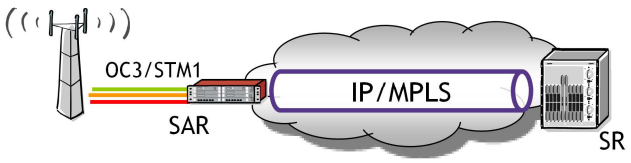
The 7705 SAR-8 and 7705 SAR-8 v2 chassis support both variants of the card.

The 7705 SAR-18 chassis only supports the -48/-60 volts DC variant of the card.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OC-3/STM-1 Cards

- OC-3/STM-1 cards can provide connection to an existing Layer 1 network
  - Aggregate traffic from an ATM switch or a Node B with an OC3/STM1 ATM port
  - Provide two OC3/STM1 options:
    - 2-port channelized for ATM/IMA or TDM in access mode, or MLPPP in access or network mode, with ports configured to be either SONET(OC3) or SDH (STM1)
    - 4-port unchannelized for ATM in access mode or Packet over SONET/SDH (POS) in network mode



- SONET/SDH based optical network or microwave network connections
- Packet over SONET/SDH (POS) communications protocol transmits PPP packets over optical fiber links
- The 4 port OC3/STM1 Clear Channel Adapter card can be configured as POS in network mode



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR OC-3/STM-1 cards allow a connection to be formed to an existing Layer 1 network.
The connection aggregates ATM traffic from an ATM switch or a Node B with an OC3/STM1 ATM port.

The 7705 SAR supports two OC-3/STM-1 cards.

The 2-port channelized card has two hot-pluggable optical or electrical SFP-based ports that can be configured for ATM/IMA or TDM in access mode or MLPPP in access or network mode.

The 4 port unchannelized card provides four hot-pluggable SFP-based ports that can be independently configured for ATM in access mode or for Packet over SONET/SDH in network mode.

Each port can be independently configured to be SONET (OC3) or SDH (STM1).

SONET/SDH utilizes point to point circuits, so PPP over SONET/SDH or PPP is well suited for use over these links.

In a SONET/SDH based optical network or microwave network an OC3 or STM1 POS link supports up to 150.336Mbps of payload data, and 155.520 megabits per second at line rate.

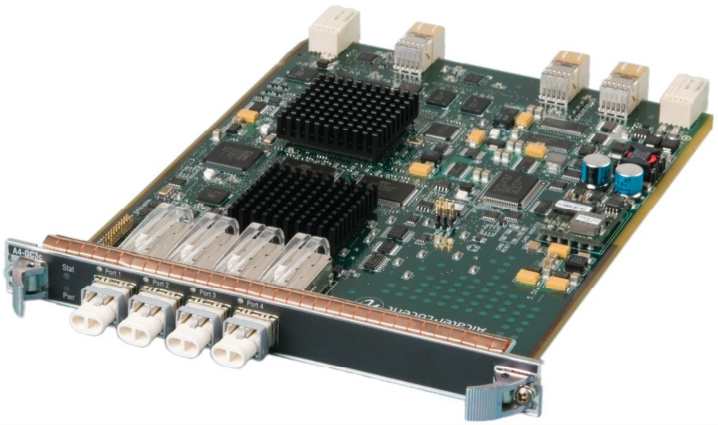
All services can be transported when using POS ports as the network link.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4-port OC-3/STM-1 Clear Channel Card

Feature summary:

- ATM/IMA supported in Access Mode
- Packet Over Sonet/SDH supported in Network Mode allows transmission of PPP over optic links
- High Availability during CSM switch
- Up to two ports can be configured as a timing source for the SSU (node clock)
  - CSμ +24v supports two clocks per MDA
  - CS μ -48v supports one clock per MDA



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 4-port OC-3/STM-1 [s-t-m-1] unchannelized card provides four hot-pluggable SFP ports that can be independently configured for ATM in access mode, or Packet over SONET/SDH in network mode. Each network port can be independently configured to be SONET (OC3) or SDH (STM1).

The module supports clear-channel only.

On ingress in access mode, the ports support ATM PW, UNI only, IMA, and Channelized to DS1/E1.

In network mode, the ports can be configured for POS to connect to the packet network, and PPP can be enabled on a port by setting the encapsulation type to ppp-auto.

- The card supports configurable MTU, and configurable SONET/SDH framing including both framing modes, CRC 16 and 32, Layer 1 (SONET/SDH) statistics, SONET/SDH Line and Section Alarms, and SONET/SDH Path Alarms.
- Each port's transmit clock may be configured as loop-timed or node-timed, and any port's receive clock rate may be used as a system synchronization source.

POS attributes can be configured for the port; these include: section Trace (J0) byte to ensure proper physical cabling, local line and internal loopbacks, link hold timers to control link up and link down indications, line Signal Degradation Bit Error Rate (BER-SD) threshold, and line Signal Failure Bit Error Rate (BER-SF) threshold.

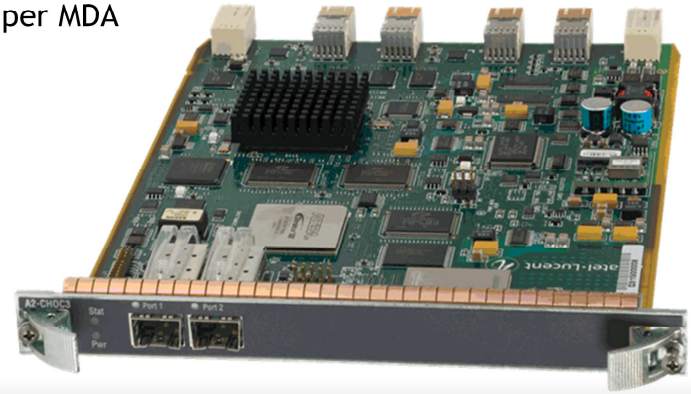
All SONET/SDH line and path alarms can be enabled or disabled.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2-port OC-3/STM-1 Channelized Card

Feature summary:

- ATM/IMA supported in Access Mode
- PPP/MLPPP supported in Network Mode
- High Availability during CSM switch
- Up to two ports can be configured as a timing source for the SSU (node clock)
  - CSµ +24v supports two clocks per MDA
  - CS µ -48v supports one clock per MDA



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 2-port OC-3/STM-1 channelized card has two hot-pluggable optical or electrical SFP ports that can be configured to ATM in access mode or SONET (OC3) or SDH (STM1) in network mode.

The card supports channelization down to channel group DS0, with all channels on a port configured as access or network, not both.

The SAR-8 CSMv1 supports up to six 2-port OC-3/STM-1 channelized cards if DS1/E1 and DS3 channelization is being used or two cards if DS0/64 kb/s channelization is being used.

The SAR-8 CSMv2 supports six 2-port Channelized cards if DS1/E1 and DS3 channelization is used, and four if DS0/64 kilobits per second channelization is used.

The total number of channel groups per card and node is release-specific.

In access mode, each port can be configured for ATM/IMA [i-m-a], TDM, or IP over PPP/MLPPP (for CDMA BTS).

All member links of an IMA or MLPPP group must reside on the same card.

In network mode, each port must be configured for PPP/MLPPP.

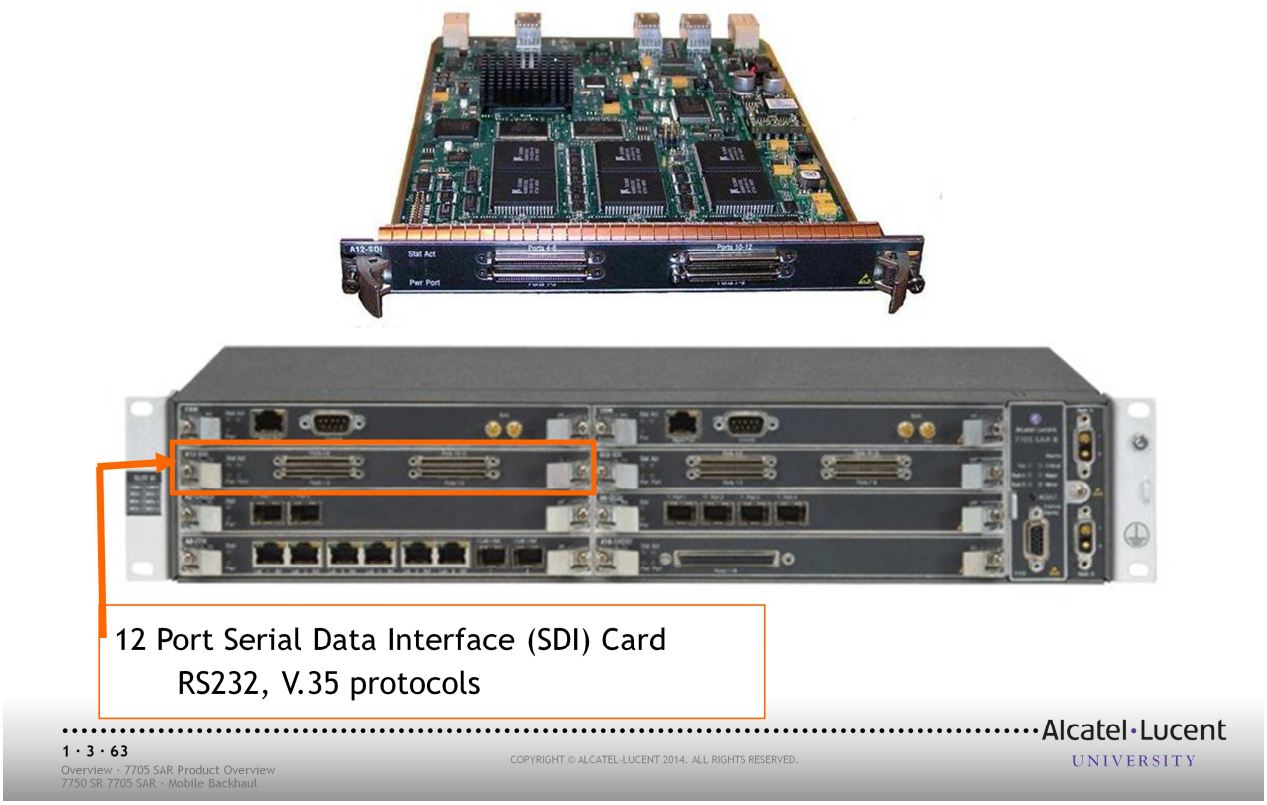
Each SONET/SDH port can be configured to be loop-timed or node-timed.

A loop-timed SONET/SDH port can be configured to be a timing source for the node.

The card supports configurable MTU, and configurable SONET/SDH framing including both framing modes, CRC 16 and 32, Layer 1 (SONET/SDH) statistics, SONET/SDH Line and Section Alarms, and SONET/SDH Path Alarms.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

12-port Serial Data Adapter Card



The 12-port serial data card interfaces to legacy supervisory control and data acquisition and teleprotection equipment to permit the evolution of services into a next-generation IP/Ethernet/MPLS network.

The SDI [s-d-i] card has four 68-pin connectors on its faceplate, each of which supports three data ports labeled 1 to 3, 4 to 6, 7 to 9, and 10 to 12.

The data ports operate in access mode only.

The card supports V.35, RS-232, and X.21 operation via connection to a V.35, RS-232, or X.21 distribution panel using a 2 meter cable, or to a customer-supplied distribution panel using a 10 meter open-ended cable.

Data is mapped to TDM pseudowire (c-pipe) or IP pseudowire for existing routers with V.35 interfaces to get statistical gain benefits at access PPP termination.

The RS-232 interface can be configured for CEM and the V.35 and X.21 interfaces can be configured for CEM, frame relay, IPCP HDLC, or Cisco-HDLC.

Speeds higher than 64 kilobits per second should be carried as a super-rate group of n by 64 kilobits per second channels.

The Maximum super-rate size is 1920 kilobits per second.

Signaling will not be transported with the payload because it utilizes transparent mode.

The card uses a proprietary Alcatel-Lucent subrate framing protocol, High Capacity Multiplexing or HCM [h-c-m], to provide rate adaptation in multiples of 8 kilobits per second.

A single sub 64 kilobits per second channel will utilize a full 64 kilobits per second timeslot.

The card is interoperable with existing 36XX equipment.

Since the sub-rate data is transported using HCM, the other end must terminate on either a 7705 SAR or a 36XX MUX.

Sub-rate support is only required on RS-232 ports.

The data start position in the HCM frame for the RS-232 or X.21 interface can be configured using the CLI or 5620 SAM.

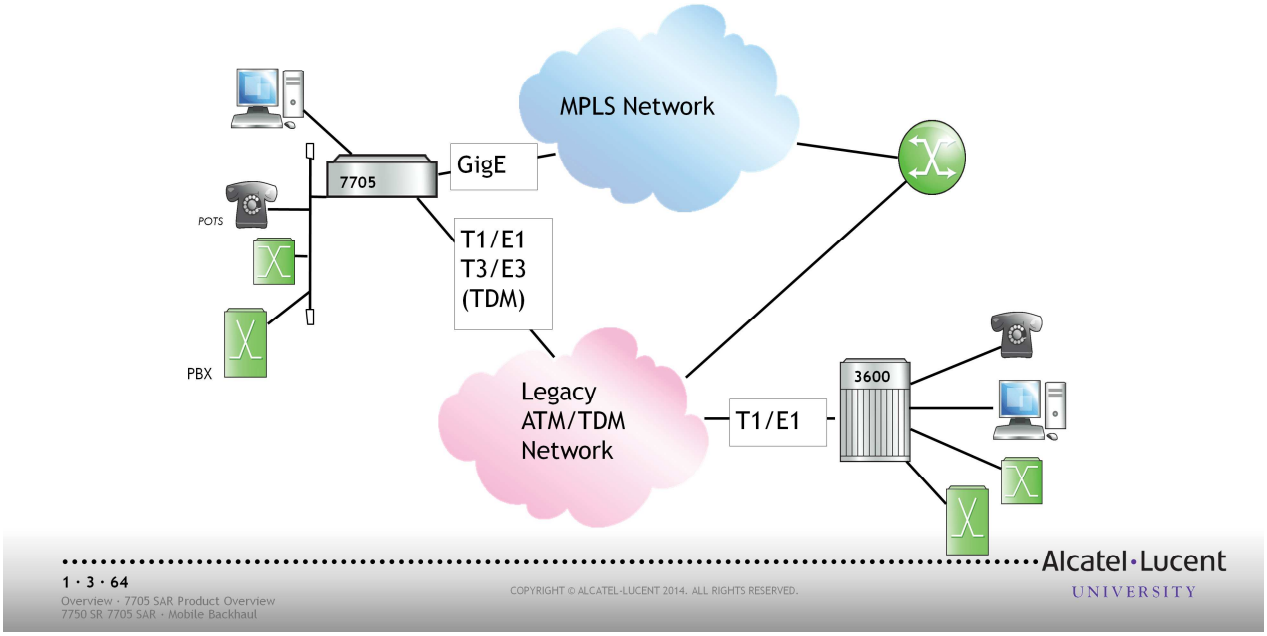
A conformal coated variant is available for the 12-port serial data card.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

12-port Serial Data Adapter Card [CONT.]

Telco Digital Data Network (DDN) applications

- The 7705 SAR acts as an access and aggregation node, consolidating legacy TDM services as well as new packet services.
- They may be transported over the existing legacy TDM/ATM network in TDM format or using the MPLS network as pseudowires.



The 7705 SAR acts as an access and aggregation node to consolidate legacy TDM services, as well as new packet services.

The primary application of digital data networks (DDNs) is to provide transport of traditional data using TDM leased lines.

The most typical application is to interconnect routers between customer locations via serial data interfaces.

These are mainly static connections with primarily *n* by 64 kilobits per second super rate channels, with some sub 64 kilobits per second services.

V.35 is the primary protocol, and V.35 and RS-232 are also utilized.

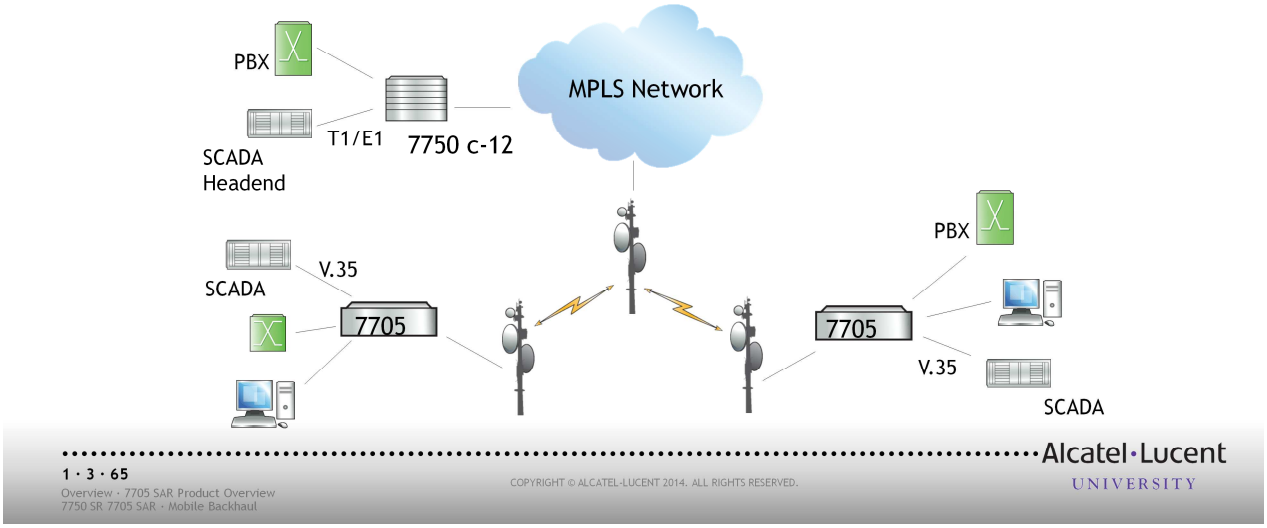
The 3600 MainStreet Bandwidth Manager is an example of a product line that has a large installed base of DDNs around the world; it must continue to be capable of offering both these legacy and packet-based services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

12-port Serial Data Adapter Card [cont.]

Vertical applications

- The current application uses a separate access MUX (36XX) for voice and low-speed data, and a 7270 Multiservice Concentrator (MSC) to provide the L2 networking capability.
- The 7705 SAR will combine the functions of a TDM (3600 Mainstreet Bandwidth Manager) and ATM (7270 MSC) into a single box that provides CAPEX and OPEX savings, as well as resiliency functionality provided by the MPLS networking.



State and local governments and utilities (such as hydro, oil and gas, rail and transportation), are vertical segments which can utilize the 7705 SAR as part of their WAN infrastructure.

A characteristic of these markets (particularly utilities/transportation) is that there is a lot of legacy Supervisory Control And Data Acquisition (SCADA) equipment which utilizes traditional interfaces (RS-232) to connect the remote terminal units (RTU) to the central control center. The primary purpose of SCADA is to monitor, control and alarm plant or regional operating systems from a central location.

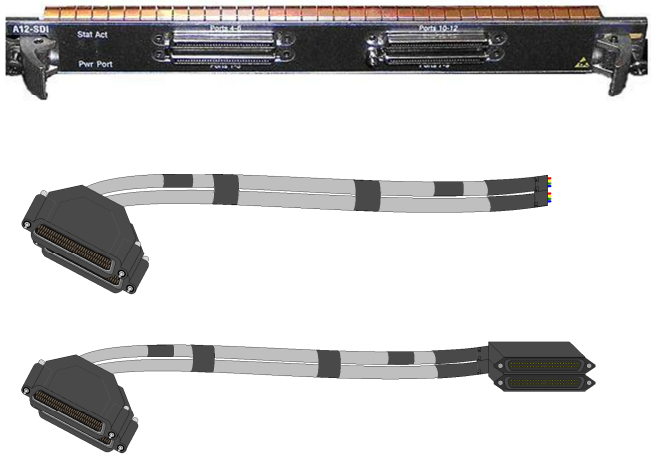
New services, such as expansion of Corporate LAN/IP services, video surveillance and smart electrical power meters, have increased the bandwidth requirements and added the requirement for an upgraded, more flexible WAN.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

12-port Serial Data Adapter Card [cont.]

Connectors and cables

- Access to the data ports is via 4 x 68-pin mini-champ connectors
- Each connector supports 3 data ports (1-3, 4-6, 7-9, and 10-12)
- Two cable types are offered for the SDI MDA:
  - Single-ended cable with the un-terminated end, connecting SDI MDA to customer supplied panel; same cable assembly can be use for both RS232 and V.35 interface
  - Double-ended cable connecting SDI MDA to V.35 / RS232 panels (modified versions of the existing 3600 panels); different cable assembly for RS232 and V.35
  - Cable assemblies consist of 2 cables bundled into single assembly



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A V.35 cable connects the Serial Data Interface card to the V.35 distribution panel.

The RS-232 cable connects the Serial Data Interface card to the RS-232 distribution panel.

The Open-ended SDI cable connects the Serial Data Interface card to customer-supplied external connector panel.

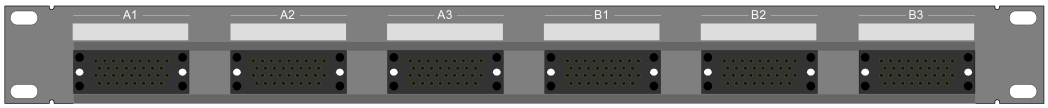
The mini-SCSI connector attaches to the Serial Data Interface card. The open end can be directly attached to other telecom equipment.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

12-port Serial Data Adapter Card [cont.]

Cables and Connector panels

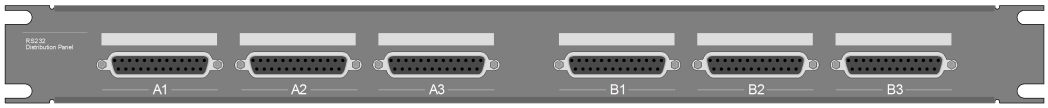
- Each panel supports 6 ports
- Different cable assemblies are required for each connector panel type (V.35/RS232 variants)



V.35 (M34 F connector)



V.35/RS232 (Rear View) (AMP-CHAMP M connector)



RS232 (DB25 F connector)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This is the 6-port V.35 distribution panel Breakout panel with six M34 connectors for V.35 access; it requires a V.35 cable to connect to the Serial Data Interface card.

The RS-232 distribution panel Breakout panel with six DB25 connectors for RS-232 access requires an RS-232 cable to connect to the Serial Data Interface card.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

12-port Serial Data Adapter Card [cont.]

Configuration options for RS-232 and V.35 Ports

Parameter	Options
Device Mode	Synchronous*, Asynchronous (RS232 only)
Device Gender	DTE, DCE*
Duplex Method	Full Duplex*
Clocking Type Source	Slave*
Clocking Source Dependence	Locked*
CRC	16*, 32
Character Length (bits)	6, 7, 8*
Parity	None*, Odd, Even, Mark, Space
Stop bits	1*, 2

* Default Settings

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 12-port SDI adapter card RS-232 and V.35 ports support several configuration options.

Synchronous mode transmits data continuously, bit in, bit out.

Asynchronous mode transmits data one character at a time.

Device Gender must not be configured as the same gender type on two ends of a physical link

Clock Type Source can be configured in “Slave” mode.

For Asynchronous configuration, the character Length can be configured for the number of data bits used to transmit a character.

The Stop Bits can be configured to the number of stop bits used to signify the end of a character, and the Parity configures the parity bit in a character.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Control Lead Signaling

- The SDI supports the following relevant signaling bits.
- The input or output bits can be enabled on a local basis or on an end-to-end basis on sub-rate HCM circuits.

RS232	V.35	Signal (DCE / DTE)	Options
Y	Y	DTR / DSR	High*, Low
Y	Y	RTS / DCD	High*, Low, End-to-End
Y	Y	ALB / CTS	High*, Low, End-to-End
Y		RDL / RI	High*, Low



The SDI supports signaling bits.

The input or output bits can be enabled on a local basis or on an end-to-end basis on sub-rate HCM circuits.

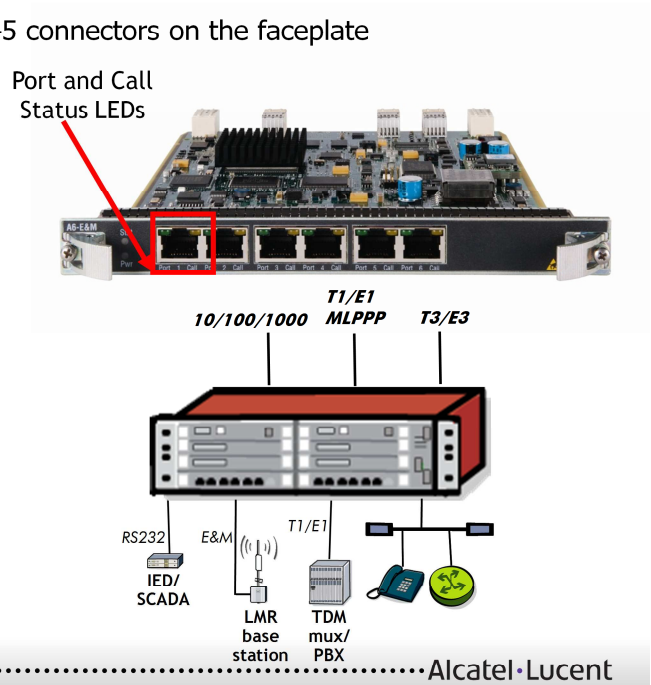
Supported signaling bits include: DTR Data Terminal Ready, RTS = Request To Send, ALB = Analog Loopback, RDL = Remote Digital Loopback, DSR = Data Set Ready, DCD = Data Carrier Detect, CTS = Clear To Send, and RI = Ring Indicator.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6-port E&M analog Voice Card

- A 7705 SAR equipped with the SDI and E&M voice cards provides the majority of the functionality needed to replace 36XX access devices and 7X70 ATM networking devices in a single chassis
- Access to the E&M ports via standard RJ-45 connectors on the faceplate
- Pinout of the RJ-45 as shown:

RJ45 Pin	Description	Twisted pair #
1	SB	1
2	M	1
3	RR	2
4	R	3
5	T	3
6	TR	2
7	E	4
8	SG	4



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 6-port E&M Adapter card has six RJ-45 ports that support the transport of an analog voiceband signal between two analog devices over a digital network.

It is used in on-premise applications only and specifications and performance are based on the 3600 voice cards, updated with relevant standards.

The card can utilize traditional T1/E1 network interfaces or Ethernet/MLPPP interfaces.

The 7705 SAR terminates the voice circuit and then transmits the data over a TDM SAP-to-SAP or SAP-to-SDP packet-based network interface.

For standard TDM, it utilizes a T1 or E1 interface.

For MPLS, any network interface such as Ethernet, T1/E1 MLPPP, or OC3/STM1 is used for transmission across the network.

The card maps the traffic into an MPLS TDM pseudowire, also called “c-pipe.” One pseudowire per port is supported.

The card terminates the E and M analog signaling leads and translates them to corresponding signaling bits. It then maps the bits into a network signaling scheme for transport through the network to termination on the end device.

Network signaling transport schemes include:

- Circuit Emulation Service over Packet Switched Network TDM pseudowires for MPLS,
- E1 Channel Associated Signaling (“C-A-S”), and
- T1 Robbed Bit Signaling (“R-B-S”).

E1 CAS to T1 RBS signaling conversion is not supported.

Each port on the card faceplate supports a Port and Call status LED.

A 7705 SAR equipped with the E&M voice and SDI cards provides most of the functionality needed to replace the 36xx access devices and the 7x70 ATM networking devices in a single chassis.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6-port E&M analog Voice Card [cont.]

Signaling and configuration options

- E&M Signaling:
- Type I (North America)
  - Type I is the default signaling for µ-Law operation
- Type V (World-Wide)
  - Type V is the default for A-Law
- The E&M card monitors the incoming M signaling lead and drives the outgoing E lead for any transitions

Card Level	Options
Companding	µ-Law * A-Law
Signaling type	Type I (µ-Law) * Type II (µ-Law) Type V (A-Law)
Port Level	**Options**
Signaling mode	E&M * Transmission only
Fault signaling	Seized Idle *
Audio wires	2 wire 4 wire *
TLP range	-16 to +7 dB for 4W, TX/RX -10 to +6 dB for 2W, TX/RX adjustable in 0.1dB steps

* Default Settings

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This slide shows the signaling configuration options for the E&M voice card.

Analog signals are converted into a 64 kilobits per second digital Pulse Code Modulation or "PCM" format, using either the Mu-Law companding that is used in North America, or the A-Law companding that is used elsewhere in the world.

The card supports E&M signaling Type I, Type II, and Type V.

Type I is the default for Mu-Law. Type V is the default for A-Law.

Type III and IV are not required on the 7705 SAR.

Companding conversion of Mu-Law to A-Law or vice versa is not supported.

The companding and signaling types are selectable on a per-card basis.

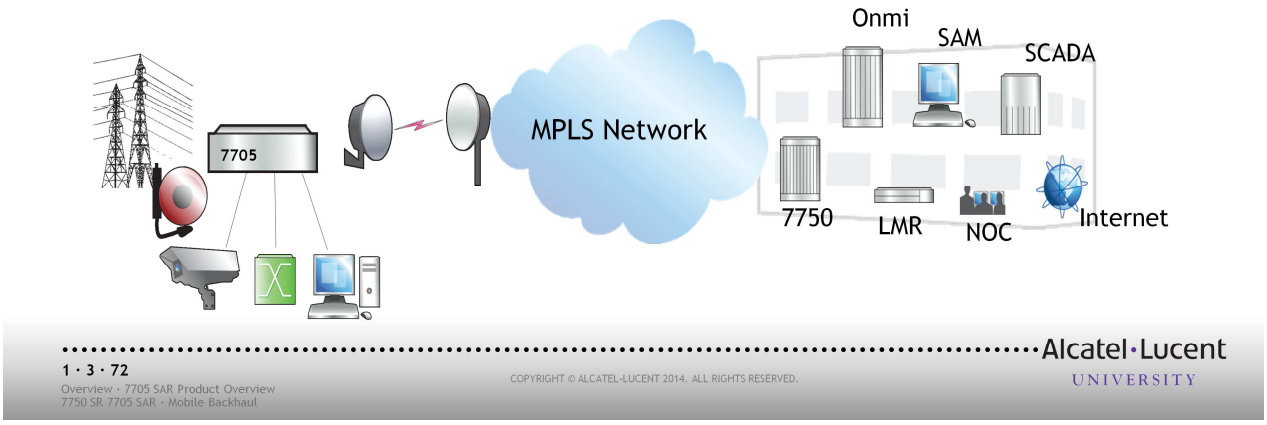
It is possible to monitor the status of the control leads as well as program the leads to whatever state is desired using the CLI or 5620 SAM.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6-port E&M Analog Voice Card [cont'd]

Access and network node applications

- Currently a 3600 Bandwidth Manager is used as an access MUX for voice and low-speed data; either a 7270 MSC/7470 MSP (Multiservice Platform) or 7250 SAS (Service Access Switch) provide the L2 networking capability
- The 7705 SAR serves as a combination access/networking node at remote sites
  - The 7705 SAR operates as an LSR to provide fast re-route (FRR) as well as pseudowire redundancy
  - Most of the traffic is homed on a central control center, which would house a 7710 SR or 7750 SR to provide the service routing functionality



Utilities - such as hydro, oil, gas, and rail - are segments in the Industry and Public Sector (IPS) market which can utilize the 7705 SAR in their WAN infrastructure.

These markets typically have a significant amount of legacy communications, teleprotection, and SCADA equipment that will utilize traditional interfaces for the foreseeable future.

Electrical utilities use teleprotection equipment to remotely switch high voltage transmission lines in and out of the network.

This can be manually initiated by the operator, or automatically triggered if a fault condition occurs.

In the event of a fault, the line should be switched in less than one 60-hertz cycle or 16 mili seconds.

When a fault occurs, the tone frequency is changed, causing the other protection device to activate.

Legacy equipment typically utilizes analog protocols - such as E&M and 4W TO, RS-232, X.21 or G.703 links - for communication links between teleprotection devices.

Newer equipment is based on both standard and C37.94 utility specific Ethernet technology.

When analog signaling is used, specific voice band tones are continuously transmitted between the protection devices.

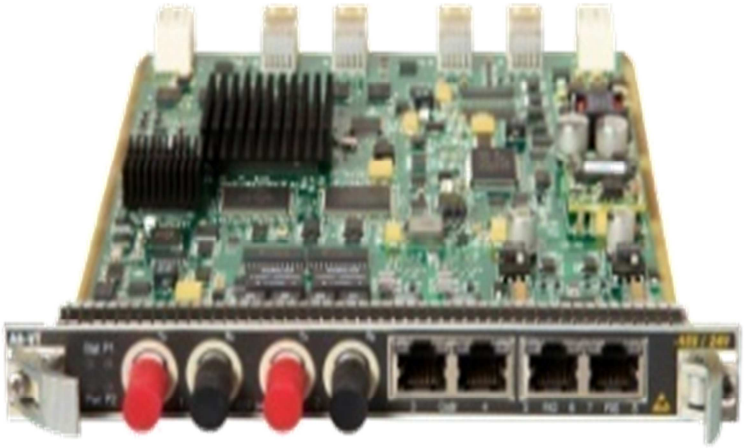
In addition to teleprotection, some applications still use E&M interfaces to connect to mobile radio base stations to the central hub.

For example, in railway applications, analog E&M interfaces are used to connect remote radio base stations for train-control, with train-to-train voice communications, similar to LMR radio.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

8-Port VOICE & TELEPROTECTION (FXS/FXO) Adapter Card

- FXS/FXO voice
- G.703 co-directional
- C37.94 optical teleprotection
- Complements existing E&M and SDI cards
- MPLS provides low latency and guaranteed bandwidth demanded by teleprotection



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The FXS/FXO Voice and Teleprotection Adapter Card provides legacy voice, data, teleprotection, and networking applications, as well as a migration path to MPLS with the optical interfaces.

The card has two FXS ports, two FXO ports, two G.703 64-kilobits per second codirectional ports, and two IEEE C37.94 teleprotection interfaces (TPIF).

FXS/FXO interfaces can be used to connect analog FXS phones (FXS) with a PBX (FXO).

The FXS and FXO ports are accessed through two RJ-45 connectors on the faceplate, each of which supports two voice ports.

One RJ-45 connector supports two FXO ports labeled ports 5 and 6, and the other connector supports two FXS ports labeled ports 7 and 8.

The A G.703 codirectional interface provides a 64 kilobits per second channel over a G.703 framed link.

The AG.703 bipolar signal transmits data and timing over twisted pairs (one is transmit and one is receive).

The two G.703 64-kilobits per second co-directional ports are accessed through two RJ-45 connectors on the faceplate labeled ports 3 and 4.

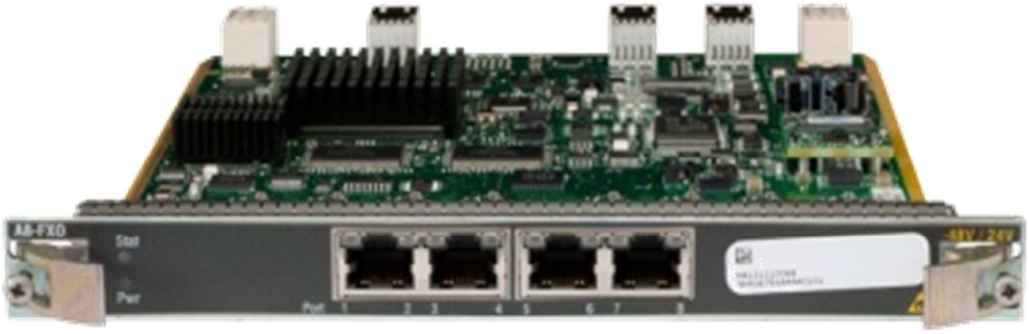
The card also has two IEEE C37.94 teleprotection interfaces for N x 64-kilobits per second transmission between teleprotection and multiplex equipment.

The optical ST [s-t] connectors are labeled ports 1 and 2.

The G.703 64-kilobits per second codirectional data ports and IEEE C37.94 teleprotection interfaces can be configured for T1/E1 or MPLS network access services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

8-port FXO adapter Card



- A/D, u-A Law selectable
- RJ-45 connector access for the four 2-channel FXS ports
- Loopbacks
- 600Ω impedance
- CAS/RBS/CESoPSN signaling translation
- 3600/1511MAX interoperability

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 8-port FXO Adapter card provides 8 FXO analog interfaces for high-density connections to a PBX.

These can be connected over the MPLS network via a TDM pseudowire C-pipe to an FXS interface on an 8-port Voice & Teleprotection card, or to an FXS interface in a TDM multiplexer connected to the 7705 SAR via a T1/E1 interface.

The FXO ports use four RJ-45 connectors on the faceplate.

Each FXO interface separates the analog signal into two streams, one for voice and one for control signaling.

The connectors support two FXO ports, labeled ports 1 and 2, 3 and 4, 5 and 6, and 7 and 8.

Common applications for FXS/FXO include off-premises PBX extensions for corporate voice networks to remote locations, maintenance hotlines for site-to-site or remote site-to-control center communications, remote access to metering data for utilities, backup substation access over PSTN, and secure access between corporate networks.

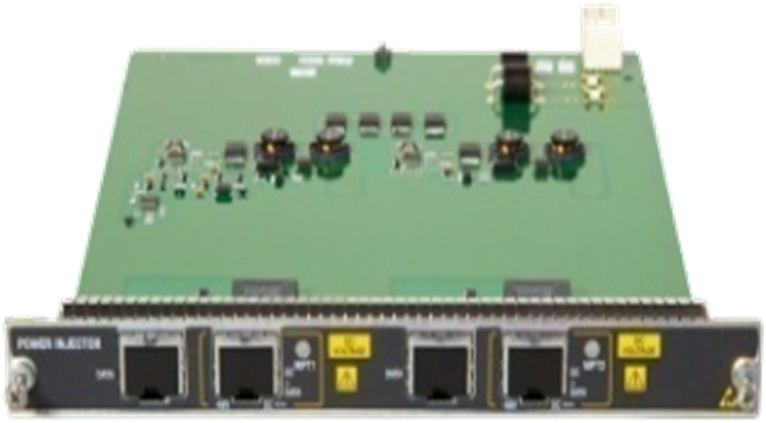
The card supports features such as Loopbacks, CAS, RBS, CESoPSN signaling translation, 3600 and 1511 MAX interoperability, CEM encapsulation type, channelized ports, and line balance.

Since the 8-port FXO Adapter card only supports access mode, for network applications a maximum of 5 cards can be installed in a SAR-8 chassis and a maximum of 11 cards can be installed in a SAR-18 chassis.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Power Injector Adapter Card

- Occupies one slot in SAR-8/18 chassis
- Powers up to two 9500 MPR-e
- Provides lightning /voltage surge protection
- Injects power transparently onto 1000BT
- No Ethernet frame regeneration
- Retains synchronization



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

When installed in a SAR-8 or SAR-18 chassis, the Power Injector card can deliver power, or power and data, to an MPR-e radio.

Up to four Power Injector cards can be installed in a 7705 SAR-8 chassis; up to eight cards can be installed in a 7705 SAR-18 chassis.

The card draws its power from the chassis backplane. It operates in at -48 volts DC, plus or minus 20 percent.

IF the input voltage to a SAR-8 or SAR-18 chassis drops below -37 volts DC or goes over -59 volts DC, the card stops providing power to the MPR-e radio.

The Power Injector card can withstand DC voltage up to -80 volts DC. Since the power feed to the card comes from the SAR-8 or SAR-18 chassis, as long as there are dual power feeds to the chassis, the powered MPR-e radio also has power feed redundancy protection.

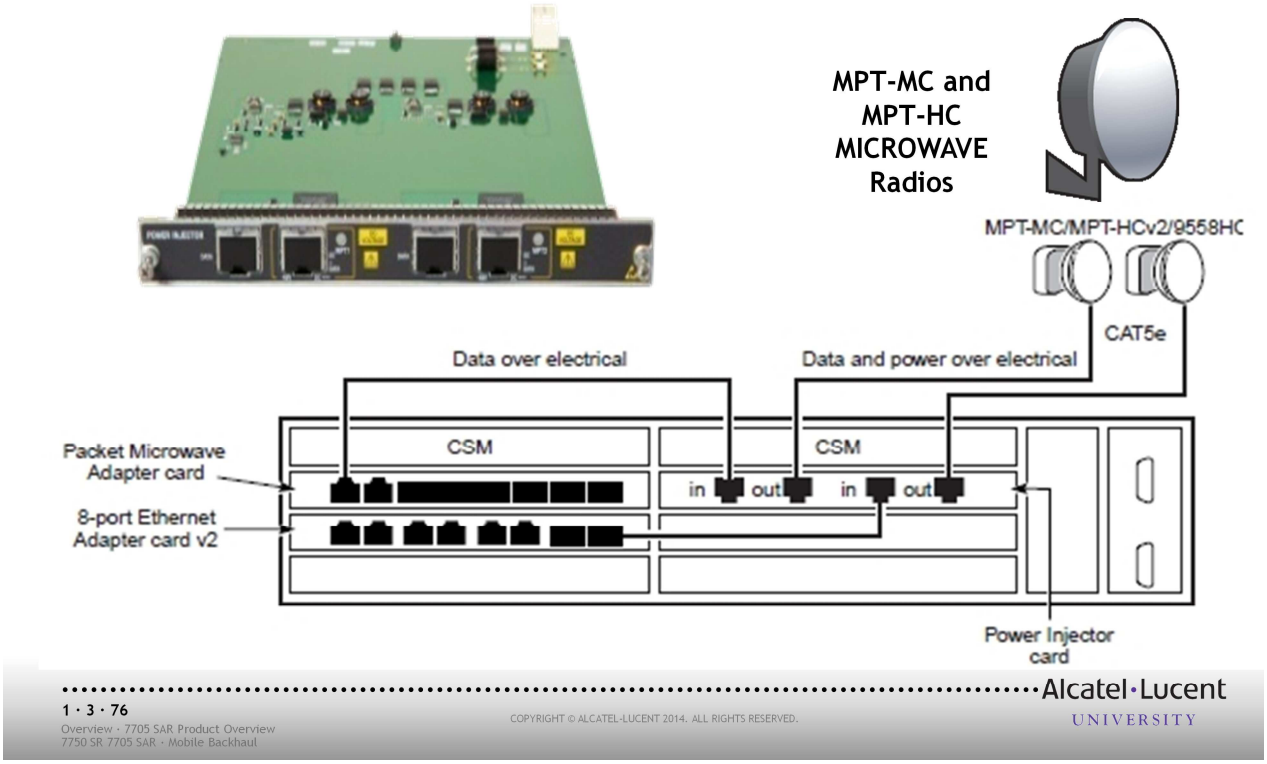
If power feed redundancy is not required, a single power feed is sufficient.

The card supports 2 LEDs on the faceplate that show the state of power being delivered by the Power Injector card to each MPR-e radio (MPT1 and MPT2).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Power Injector Adapter Card [cont.]

Card connections



The Power Injector card faceplate has two sets of RJ-45 electrical connectors, labeled Data and DC+Data.

The Data connector can receive data from a copper SFP or RJ-45 port on a Packet Microwave Adapter card, a copper SFP port on an 8-port Ethernet Adapter card version 2, or a copper SFP port on an 8-port Gigabit Ethernet Adapter card (version 1 and version 2).

The DC+Data connector takes that data and transmits it along with DC power to an MPR-e radio.

When the SAR-8 or SAR-18 chassis is within a distance of 328 ft (100 m) from the MPT-M or MPT-HC radio, an electrical Gigabit Ethernet (1000BASE-T) CAT5e cable can be used to deliver power from the DC+Data port to the supported radios using power over Ethernet technology.

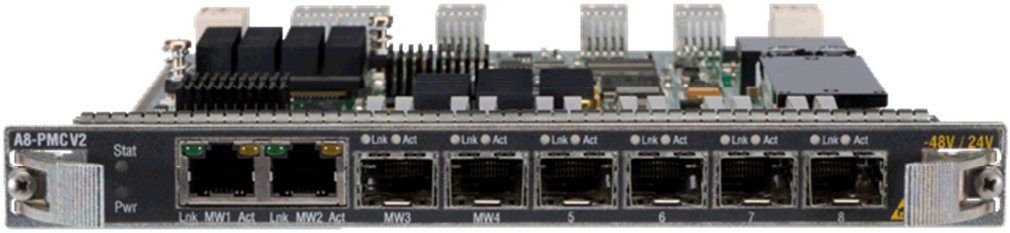
Power can also be delivered to the MPT-HC radio over a coaxial cable.

The power connector types on the Power Injector card and the radio are RJ-45, so two pigtail converters are required at each end of the coaxial cable.

Two types of coaxial cables with different diameter and length are supported.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Packet Microwave Adapter Card



- 4 Tri-speed Microwave ports
  - 2 x on-board RJ45 Copper sync Eth capable
  - 2 x SFP support optical and copper SFP
- 4 Tri-speed SFP ports with feature parity with the 8-port GigE card
- Full feature set for IP/MPLS/Eth networking

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The packet microwave card supports a 1-gigabit per second fabric interface in a SAR-8 v1 chassis, and a 2.5-gigabits per second fabric interface in a SAR-8 v2 with CSMv2 or SAR-18 chassis.

The card provides microwave link capability, configured as a virtual port object, for connectivity to supported MPR-e radios including the MPT-MC medium capacity, MPT-HC V2/9558HC High Capacity Version 2, and MPT-XP High Capacity and high power radios. The link can be configured in standalone mode where each MPR-e is managed as a separate NE, or it can be configured in Single NE mode for single NE management, microwave link FFD and 1+1 HSB.

Up to 6 packet microwave cards can be installed in a SAR-8 chassis and up to 12 in a SAR-18 chassis.

The card has a universal power block that supports an ultra-wide power range of –48/ –60 volts DC to +24 volts DC.

Ports 1 and 2 are RJ-45 ports, and ports 3 to 8 are SFP ports.

All Ports support Ethernet/IP/MPLS networking and ports 1 to 4 support Microwave Awareness.

All ports provide 10/100/1000 megabits per second connections.

Ports 1 to 4 always operate at 1 gigabit per second mode if connected to an MPR-e radio.

All Gigabit Ethernet ports provide the same networking feature capability as the 8-port Gigabit Ethernet Adapter card. The exception is when ports 1 to 4 have a microwave link configured; in this case, they do not provide 802.1x authentication, active/standby operation on Ethernet access ports configured as LAGs, or hard-policing of Ethernet ports.

The packet microwave card faceplate provides port status LEDs and power and operational status LEDs.

The Packet Microwave Adapter Card supports features including MC-LAG, synchronous Ethernet, line timing, proprietary clock recovery, and IEEE 1588v2 PTP, encapsulation type null or dot1q for network uplink ports, access port peering with user equipment such as a node B or MPR-e radio, and full IPv6 subnet range for IPv6 routes and interface IP.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

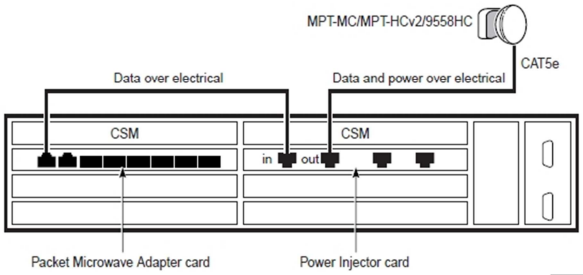
Packet Microwave Card [cont.]



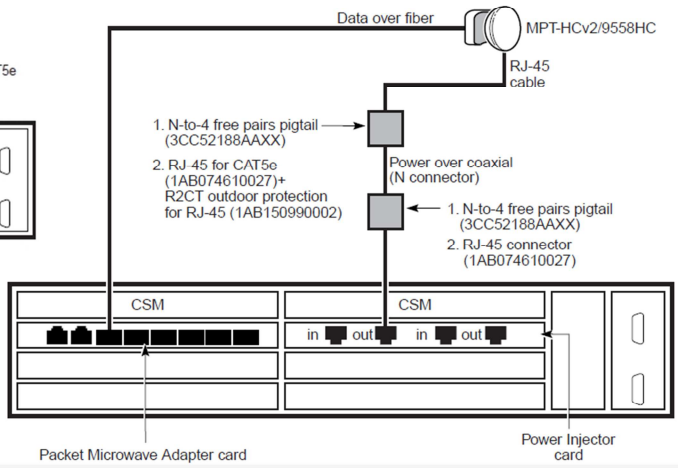
MPT-MC and MPT-HC MICROWAVE Radios



Scenario A: Data and Power Over Electrical Connection



Scenario B: Data Over Optical and Power over Coaxial Cable



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Depending on the MPR-e radio type, the Packet Microwave Adapter card can deliver data to the MPR-e over fiber, or it can be connected to the Power Injector card to deliver data and power over an electrical Gigabit Ethernet (1000Base-T) connection.

Electrical connections are used when the distance between the SAR-8 or SAR-18 chassis and the radio is 328 feet or 100 meters or less.

A fiber connection is used when the distance is greater than 328 feet or 100 meters.

Both the MPT-MC and the MPT-HC microwave radios can receive data via a copper SFP or RJ-45 port on the Packet Microwave Adapter card that is connected to the Data port on the Power Injector card.

The data and power are delivered to the radio from the DC and Data port on the Power Injector, over an electrical Gigabit Ethernet (1000Base-T) CAT5e cable connection, using Power Feed over Ethernet delivery.

If an external power injector solution is preferred, an Alcatel-Lucent Power Injector Box can be used in place of the Power Injector Card.

For the MPT-HC only, a fiber-optic connection from SFP port 3 or 4 con the Packet Microwave Adapter card an be used to deliver data to the radio, while power is delivered over a coaxial cable.

2 pigtail converters are required at each end of the coaxial cable for the RJ-45 power connector on the Power Injector card and the radio. Two types of coaxial cables of different diameter and length are available.

Appropriate grounding and lightning protection is required for the coaxial cable along the radio tower.

For frequency synchronization, synchronous Ethernet and SSM are applied when using optical 1000Base-SX to connect to an MPR-e radio.

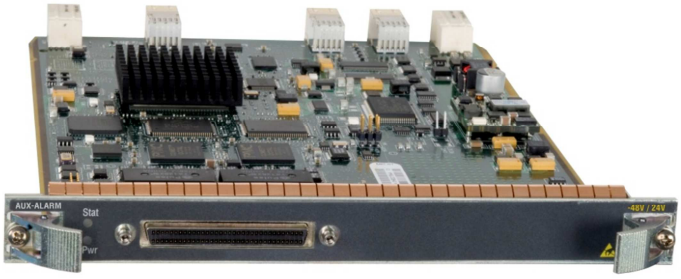
When using electrical 1000Base-T to connect the Packet Microwave Adapter card to MPR-e radio, Proprietary Clock Recovery (PCR) is used and a copper SFP is required on ports 3 and 4.

To configure a microwave link the latest 7705 SAR OS software package that includes the MPR-e radio software must be downloaded from OLCS to the SAR-8 or SAR-18.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Auxiliary Alarm Adapter Card

- Digital Alarm Inputs (26)
  - Connects to dry contacts of security sensors (door/window), HVAC systems and telecom systems
  - Senses and reports the state (open or closed) to 5620/CLI/SNMP
- Analog Inputs
  - Input voltage range between 0 and 75 Volts with multiple configurable thresholds for alarms/event per port (up to 4)
  - Input isolation prevent any possibility of damage to external equipment
  - Ideal for DC battery monitoring
- Output Relays
  - Dry-contact outputs to interface to external audible / visual / telecom equipment
  - Normally-Opened (NO) and Normally-Closed (NC) pins available



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Auxiliary Alarm Card supports 24 Digital Inputs, two Analog Inputs, and eight Digital Outputs.

The Digital Inputs Connect to dry contacts of security sensors such as doors and windows, HVAC systems and telecom systems.

The input senses and reports the state to the 5620 SAM, CLI, and SNMP interfaces.

They are connected to common to become active.

Analog Inputs support input voltage range between 0 to 75 Volts DC, with up to 4 configurable alarm and event thresholds per port. Alarms can be configured for less than or greater than values.

Input isolation prevents possible damage to external equipment and is ideal for DC battery monitoring.

Output Relays are Dry-contact outputs to interface to external audible, visual and telecom equipment.

Digital Outputs have Normally Open or “NO” and Normally Closed or “NC” contacts.

The NO contacts are closed and the NC contacts are open when an output is active.

The DB15 Alarm connector on the 7705 SAR Faceplate supports 4 inputs corresponding to 1 Minor, 2 Major, and 1 Critical) and 3 outputs including one each for Minor, Major and Critical.

●Each port can be individually configured for alarm description, enabled or disabled, and debounce durations.

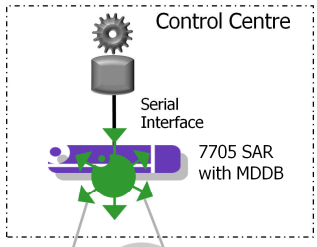
●Multiple user-defined alarms can be configured with description, severity, enabled and disabled status, voltage thresholds for analog input, actions such as local logging SNMP trap, and log text.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

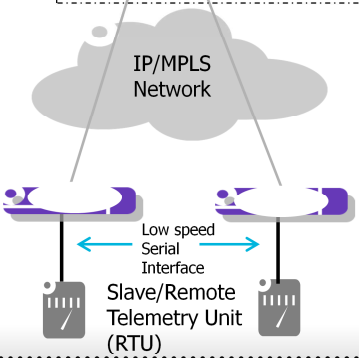
MDDB Enabling HW - Integrated

Resource card for 7705 SAR-8 and SAR-18 for advanced networking functions
Requires adaptor card for data rx/tx
First networking function is Multi-Drop Data Bridge (MDDB)

MDDB Empowers Serial-Based SCADA
Applications over IP/MPLS







COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This Multi-Drop Data Bridge Resource card is available for both the 7705 SAR-8 and SAR-18 for advanced networking functions.

It requires an adaptor card for data rx/tx [receive and transmit] functions.

The first networking function is Multi-Drop Data Bridge (MDDB) for Serial-based Supervisory Control and Data Acquisition ,or SCADA [scada], applications over an IP/MPLS network.

This provides the capability of supervising and monitoring remote industrial processes, for example power utilities and rail operations.

- The Integrated Service Card support s up to 480 slaves per card and up to 16 bridges per card.
- It can be configured for multiple bridges on the same card, that is 16 bridges with 30 slaves

- The card supports up to 30 slaves per bridge and support a bridge cascade configuration to scale.

- The Integrated Services card is an application resource card and requires the purchase of an application-specific RTU. This card is supported in both -48 VDC and +24 VDC systems.

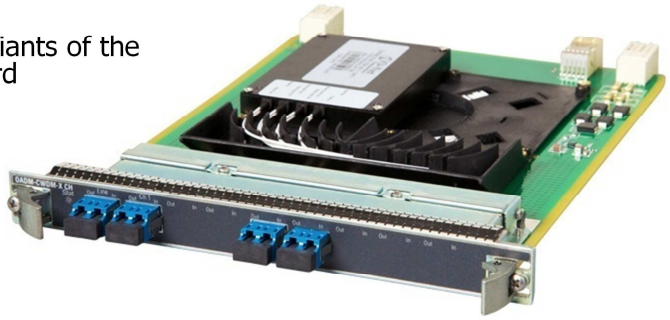
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

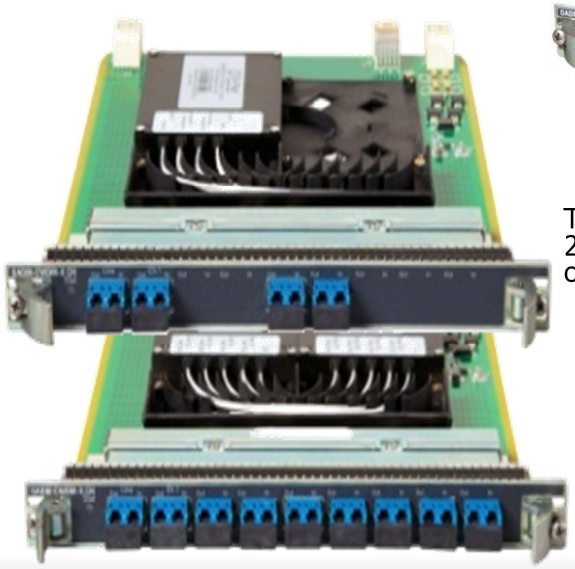
8 7705 SAR-8/SAR-18/SAR-M: CWDM/OADM Adapter Cards

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Sar-8/18/M CWDM OADM Adapter Cards

The SAR-M supports eight variants of the 1- channel CWDM adapter card





The SAR-8 and SAR-18 support 1-channel, 2-channel, 4-channel and 8-channel variants of the CWDM adapter card

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR CWDM OADM Adapter cards for the SAR-8, SAR-18 and SAR-M add Wavelength Division Multiplexing or "WDM"

capabilities to increase bandwidth within existing fiber networks by adding multiple wavelengths to the fiber.

The SAR-8 and SAR-18 use 1-channel, 2-channel, 4-channel, and 8-channel cards.

The SAR-M uses eight variants of the 1-channel card.

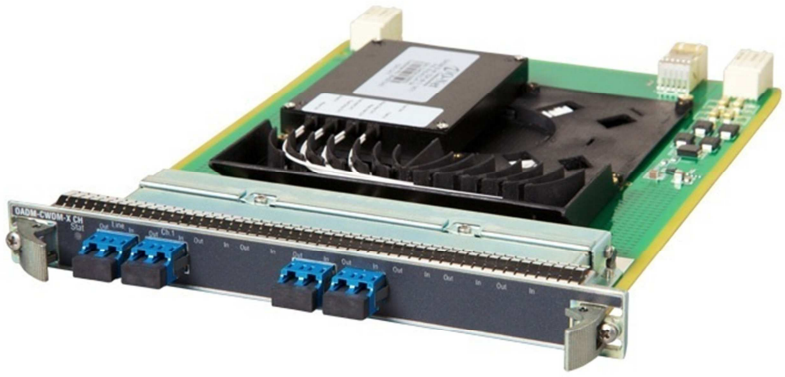
The cards can be used in ring or linear topologies to increase the available bandwidth in the network through Wavelength Division Multiplexing.

The cards have LC ports on their faceplates that accept duplex LC fiber-optic connectors to add and drop specific wavelengths.

The CWDM OADM Adapter cards/modules are equipped with a universal -48 volts DC to +24 volts DC power supply.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1-channel CWDM OADM card



- 8 variants of the single-channel CWDM Optical Add/Drop adapter card are available for the SAR-M and 8variants are available for the SAR-8 and SAR-18 chassis.
- Each variant is fixed to one specific CWDM (Course Wavelength Division Multiplexing) wavelength: 1471,1491, 1511,1531, 1551, 1571, 1591 and 1611 nm.
- One Tx wavelength and one Rx wavelength are filtered for the East and West directions.
- Cards are temperature hardened to-40 to +65ºC (-40 to 149ºF)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The single-channel CWDM OADM Adapter Card provides a scalable, resilient integrated solution for building higher bandwidth backhaul rings, thus eliminating the need for separate devices to perform this function.

The card uses wavelength-division multiplexing (WDM) to allow a higher number of 7705 SARs to be deployed around a ring by removing the need for a large amount of tandem traffic processing.

Two optical blocks make up the passive optical components in these cards, where both an East and West direction are incorporated in the same module card.

The SAR-M supports 8 variants and the SAR-8 and SAR-18 chassis support 8 variants.

The variants correspond to wavelengths 1471, 1491, 1511, 1531, 1551, 1571, 1591, and 1611.

The supported wavelength is added and dropped from the East direction as well as added and dropped from the West direction.

All remaining wavelengths are passed through on the “express lane” between the East and West line ports.

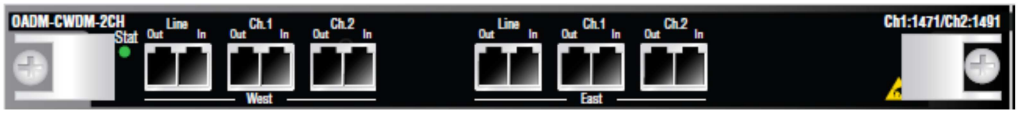
Unsupported wavelengths represent data that was not designed to be destined for this router and therefore optically transverses through.

Both ring and linear topologies are supported.

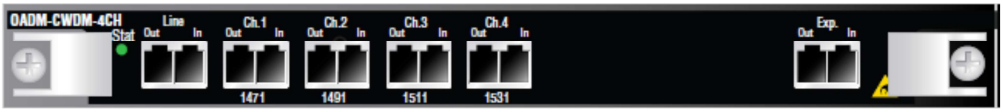
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2- and 4-Channel CWDM OADM Cards

SAR-8/18: Two-Channel OADM Faceplate



SAR-8/18: Four-Channel OADM Faceplate



- A total of 2 variants of this adapter card are available for the SAR-8 and the SAR-18, with each variant fixed to a set of CWDM wavelengths:
- 1471/1491/1511/1531 or 1551/1571/1591/1611 nm
- Both adapter cards temperature hardened :-40 to +65ºC (-40 to 149ºF)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Two optical blocks make up the passive optical components in the 2-channel cards, where both the East and West directions are incorporated in the same adapter card.

The supported wavelengths are added and dropped from both the East and West directions.

All other wavelengths are passed through on the “express lane” between the East and West line ports.

These other wavelengths represent data that was not designed to be destined for this router and therefore optically transverses through.

Both ring and linear topologies are supported.

In the 4-channel cards, one optical block makes up the passive optical components.

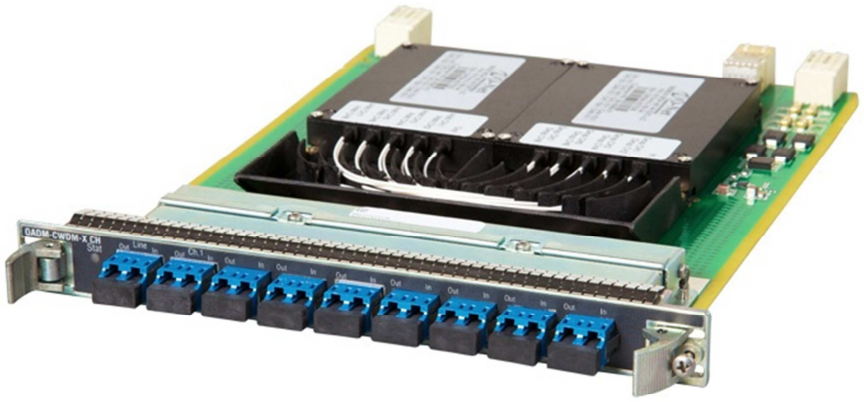
The supported wavelengths are added and dropped from the line port used for either the East or West directions.

All other wavelengths are passed through on the Expansion port.

Since each card is intended to support a single direction only, 2 cards are required per node if both an East and West direction are required.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

8-channel CWDM OADM MUX/DEMUX



- A single variant of this adapter card for the SAR-8 or SAR-18 supports wavelengths 1471, 1491, 1511, 1531, 1551, 1571, 1591 and 1611 nm.
- Temperature hardened :-40 to +65ºC (-40 to 149ºF)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Two optical blocks make up the passive optical components of the 8-channel CWDM OADM MUX/DEMUX.

Each card is intended to support a single direction only; therefore, if both an East and West direction are required, two of these adapter cards must be used per node.

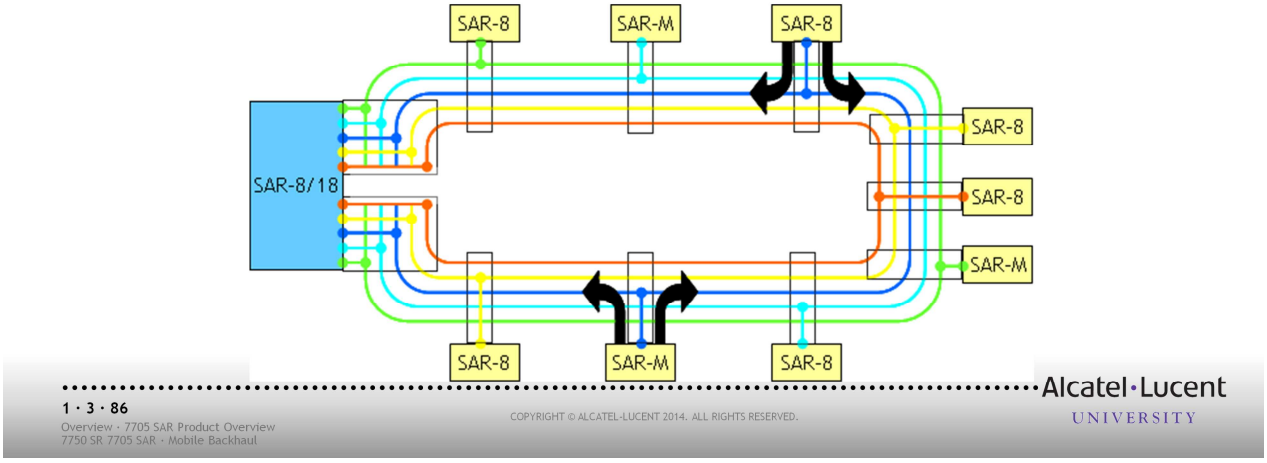
All eight wavelengths in the ITU CWDM grid are added and dropped from the line port with this adapter card.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Single-Channel CWDM OADM Optical Ring Application

Optical Ring Application

- If the capacity exceeds the line rate of the links, then WDM over the same fibers around the ring can add optical layers to multiply the bandwidth available.
- This can be achieved with optical integration in the 7705 SAR routers.
- The single physical ring can be lit up with 5 different wavelengths (colors).
- The 7705 SAR-8 at the top right and the SAR-M (1 color only) at the bottom middle are in the same wavelength around the ring with the central site (left).



If the capacity exceeds the line rate of the links, WDM over the same fibers around the optical ring can add optical layers to multiply the bandwidth available.

This can be achieved with optical integration in the 7705 SAR routers.

The single physical ring can be lit up with 5 different wavelengths, or “colors”.

In the illustration in this slide, the SAR-8 at the top right and the SAR-M (1 color only) at the bottom middle are in the same wavelength around the ring with the central site (left).

Given that the physical ring can be lit up with 5 different wavelengths, the bandwidth is increased 5 fold.

By using CWDM SFPs on the Ethernet SFP ports and OADM cards for a specific color, each router around the ring will selectively operate within that wavelength.

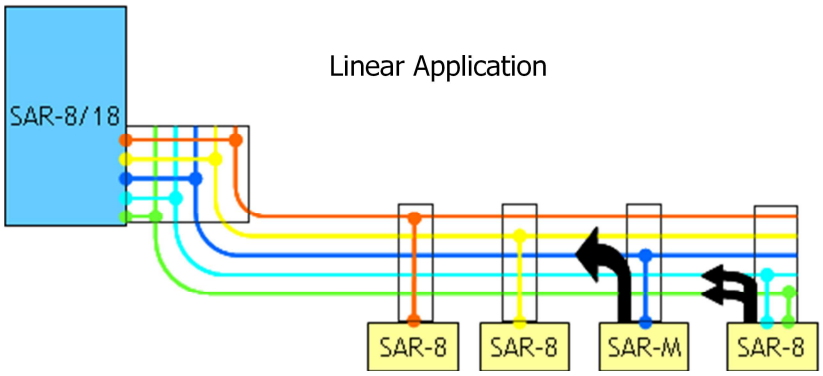
This optical solution creates parallel lanes in each physical optical link and can optically bypass routers that do not need to process the traffic.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Single-Channel CWDM OADM Linear Application

Linear Application Example

- Using the same OADM cards as described for optical rings in the last slide, each router in the chain can select different wavelengths to avoid exceeding the bandwidth limit of any link or router capacity.



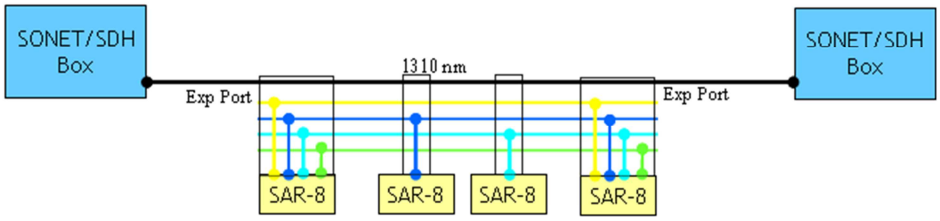
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Using the same OADM cards as described for optical rings in the last slide, each router in the chain can select different wavelengths to avoid exceeding the bandwidth limit of any link or router capacity.

Normally, all the traffic is aggregated hop by hop where the last link between the central site and penultimate site is most stressed in terms of bandwidth needs. This linear application avoids that situation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Other CWDM OADM Optical Ring and Linear Applications



- The 4 channel OADM cards have a special optical characteristic compared to the other CWDM cards in which they have an expansion port that allows 1310 nm signals to pass through.
- The 7705 SAR can be deployed with the 4 channel OADM cards and WDM operation between the existing boxes, provided the 1310 optics have sufficient optical budget.
- The other OADM cards will attenuate the 1310 nm signal and may not be used in this application.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The range of 1-, 2- and 4-channel CWDM OADM adapter cards available for 7705 SAR-8 and SAR-18 devices are used to attach to a ring or daisy chain optical infrastructure.

The 4 channel OADM cards support an expansion port that allows 1310 nm signals to pass through.

The SAR-8 or SAR-18 can be deployed with the 4-channel OADM cards and WDM operation between the existing boxes, provided the 1310 optics have sufficient optical budget.

The other OADM card types will attenuate the 1310 nm signal and may not be used in this application.

The 8-channel MUX/DEMUX variant is used typically for deployment at the head end of an optical ring or daisy chain topology.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

9 7705 SAR-M System Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M System Overview



7705 SAR-M Variants:
- 7 Ethernet ports, 16 T1/E1 ports, 1 module slot, actively cooled
- 7 Ethernet ports, 0 T1/E1 ports, 1 module slot, actively cooled
- 7 Ethernet ports, 16 T1/E1 ports, 0 module slots, passively cooled
- 7 Ethernet ports, 0 T1/E1 ports, 0 module slots, passively cooled

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-M is a high-performance 1 rack unit high form factor platform that is optimized for smaller standalone sites and has feature parity with other 7705 SAR platforms.

It transports all types of data from a mobile cell site to a higher aggregation point of presence or to the Mobile Telephone Switching Office over a packet switched network. Other key targets are Fixed and Vertical networks.

The SAR-M comes in two fan cooled variants and 2 fanless variants.

All variants support the same operating system software and all have 7 Ethernet ports.

The fan-cooled variants include a slot for an xDSL, GPON, DCM, or CWDM OADM module.

16 T1/E1 ports are also supported on 1 of the fan cooled and 1 of the fanless variants.

In release 5.0 the SAR-M supported 2.5 Gigabits per second of full-duplex switch capacity and in release 6.0 it supports 5.0 gigabits switch capacity.

For specific up-to-date capacity information contact your Alcatel-Lucent customer service representative.

The SAR-M supports redundant wide-mouth power supplies with -48 volts DC or +24 volts DC with an AC solution, and is temperature-hardened from -40 to 65 degrees celsius.

Automatic shutdown is available when the voltage drops below a threshold for both nominal levels.

An alarm is generated when for gradual voltage drop for the +24 volts DC case (not -48 volts DC).

A 256 Mbytes Compact Flash card is shipped preloaded in the SAR-M, including the application load which is assigned in the BoM.

The SAR-M supports combined SyncE and IEEE 1588 for frequency and time alignment.

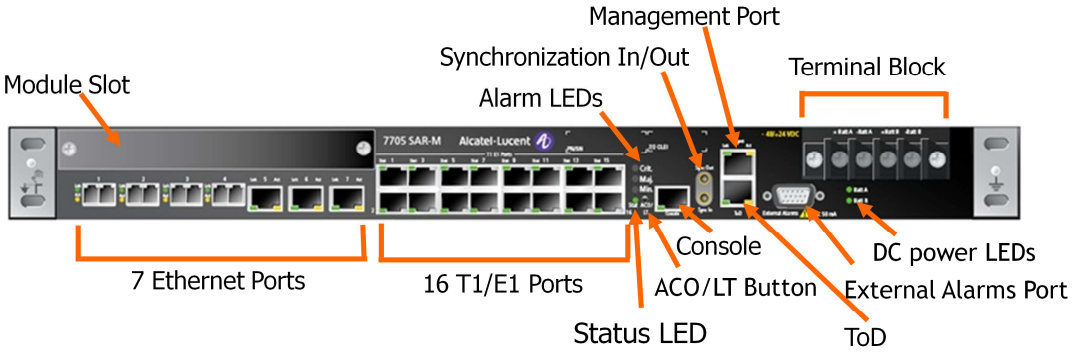
IEEE 1588v2 PTP support is for one master, one slave, one boundary and one transparent clock.

One nodal clock is also supported and up to two PTP ordinary or boundary clocks can be configured per node as references to the nodal clock.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M Connectors

7705 SAR-M Fan-cooled and Fanless with 16 T1/E1 ports and 7 GigE ports



- All user interface ports and controls are front facing.
- The system compact flash is accessible from the rear of the SAR-M.
- Available modules are: GPON, xDSL, DSL Combination Module (DCM) and OADM 1 Color Add/Drop CWDM (The OADM is available on the 7705-SAR 8 and 7705 SAR-18 also.)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

All 4 variants of the SAR-M chassis have 7 Ethernet ports. Three ports support 1000 Base-T auto-sensing Ethernet interfaces via Ethernet connectors, and four ports support 10/100/1000 Base-TX optical or electrical SFPs.

The SFP modules are hot-swappable and field-replaceable by qualified personnel.

Two of the SAR-M variants also support 16 T1/E1 ports with RJ-45 connectors.

All16 ports must be configured as either T1 or E1; a mix of T1 and E1 ports is not supported.

The T1/E1 ports are on-premises, intra-building SELV ports that must only be connected to other SELV ports.

Odd-numbered ports are located on the top row, and even-numbered ports are located on the bottom row.

The SAR-M “in” and “out” synchronization ports are provisioned with a mini 1.0/2.3 coaxial connection that can be used to receive/provide an external synchronization input/output signal.

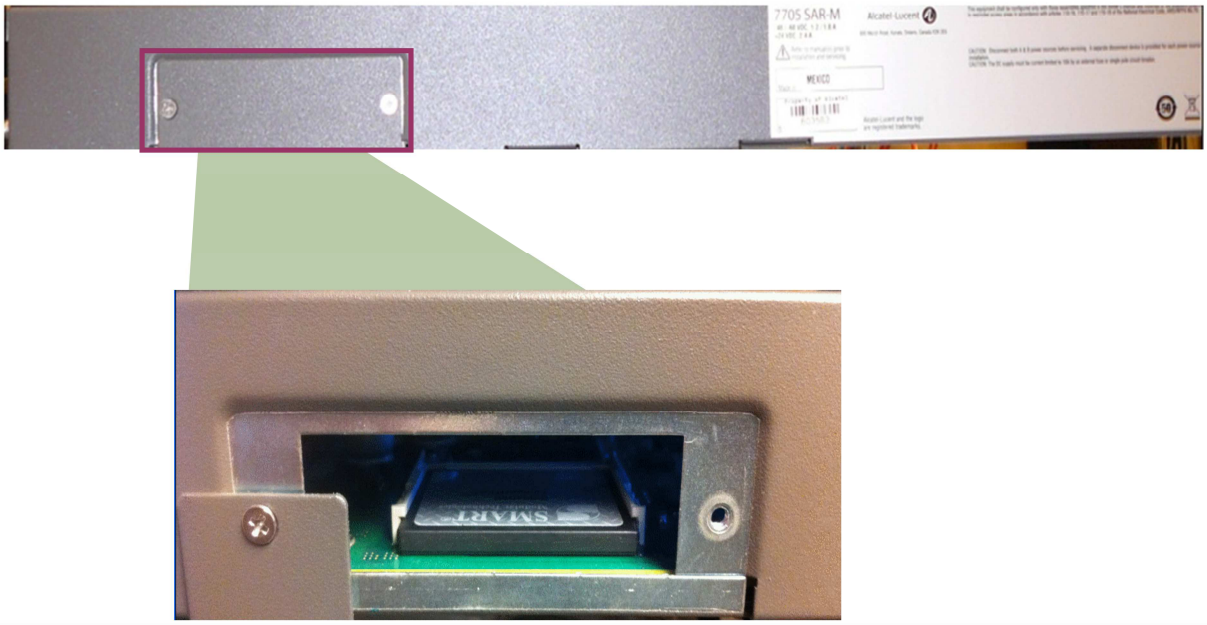
When pressed, the Audible Alarm Cutoff button enables the Lamp Test. When this occurs, the status LED on the chassis glows green, all ASAP ports glow green, critical and major Alarm LEDs glow red, and the minor Alarm LED glows amber. When the A-C-O is released, the status and ASAP port LEDs return to their pre-Lamp test state.

The Alarm LEDs become unlit until the next alarm condition.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M Compact Flash

7705 SAR-M Rear View



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-M provides compact flash that you can access from the rear of the SAR-M chassis. The compact flash cannot be removed while the system is powered.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M GPON Module



- Contains a single GPON (Gigabit Passive Optical Network) port SPF uplink with B+ optics
- Gigabit Ethernet throughput
- Compatibility with any Alcatel-Lucent OLT (7342,7302,7330, 7360)
- Fully supports GPON Physical layer synchronization (clock recovery)
- Temperature hardened :-40 to +65ºC (-40 to 149ºF)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The integrated GPON on the 7705 SAR-M allows for:

- Ethernet aggregation via an integrated Network Interface Device (NID) and ONT within a single 1RU box,
  therefore reducing footprint and improving deployment options
- A single cost-optimized solution for high-density T1/E1 delivery via GPON with up to 16 T1/E1 ports with
  advanced OAM
- An effective means of delivering native ATM, Frame Relay, HDLC, TDM or Ethernet business services, thereby
  expanding legacy offerings over an IP/MPLS infrastructure
- Flexible architecture deployments using IP, MPLS and/or Ethernet for backhaul

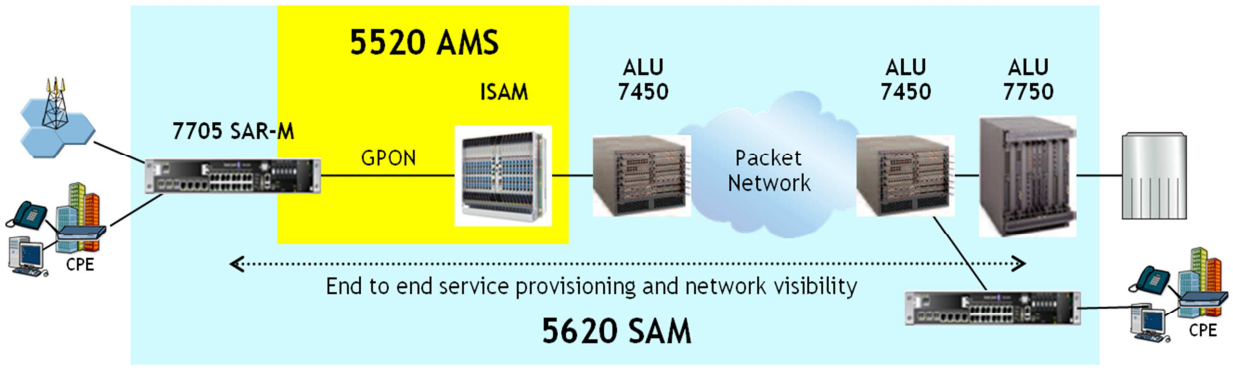
Specifications:

- 2.488 Gb/s line rate downstream, and 1.244 Gb/s line rate upstream
- Available in 28 dB optical budget with up to 20 km reach: B+ optics
- 1490 nm wavelength downstream, and 1310 nm wavelength upstream
- Single mode fiber (SC/APC connector)
- GEM mode support for IP/Ethernet service traffic transport
- Received Signal Strength Indicator (RSSI)
- One Gigabit Ethernet interface to SAR-M host
- 802.1q support
- 802.1p support

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M GPON Target Applications

GPON Infrastructure: Mobile Backhaul Network Architecture



- A Passive Optical Network (PON) is a P2MP FTTP network architecture in which unpowered optical splitters are used to enable a single optical fiber to service multiple premises.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

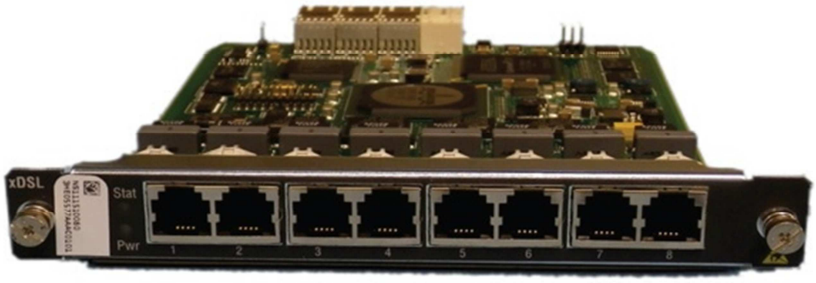
A passive optical network or PON takes advantage of wide division multiplexing, using one wavelength for downstream traffic and another for upstream traffic on a single non-zero dispersion shifted fiber. A GPON makes use of the 1490nm wavelength for downstream traffic and 1310nm wavelength for upstream traffic. The 7705 SAR is a platform designed to transport all types of traffic coming from the Mobile Cell Site to a higher hierarchical aggregation point of presence or to the MTSO (Mobile Trunking Switching Office) over a PSN (Packet Switched Network).

For mobile backhaul, the diagram in this slide shows that a typical W-CDMA/GSM operator has 2G Radio(s), the BTS (Base Transmitter Station), 3G Radio(s), the eNode-B.

Additional applications generating low-bandwidth traffic at the cell site such as video surveillance, VoIP phones or e911 locators may also be present at the cell-site.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M xDSL Module



- Supports up to 8-pair PTM bonding over ADSL2 (Asymmetric Digital Subscriber Line), ADSL2+ or VDSL2 (Very High Speed Digital Subscriber Line) and up to 2-pair ATM bonding over ADSL2 or ADSL2+
- NTR (Network Timing Reference) is supported over xDSL
- Has 8 RJ-11 faceplate connectors
- Supports in-service installation
- Temperature hardened :-40 to +65ºC (-40 to 149ºF)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-M XDSL module supports up to 8-pair PTM bonding over ADSL2, ADSL2+ or VDSL2 and up to 2-pair ATM bonding over ADSL2 or ADSL2+.

It also supports Network Timing Reference, or “NTR” over xDSL

NTR can be used as a timing reference for T1/E1 ports, SyncE, sync out, 1588 Master Clock or in conjunction with Differential Clock Recovery (DCR).

Multi-pair bonding support is essential when comparing backhaul alternatives.

With up to 8-pair bonding over VDSL2, operators have the alternative to provide new services to existing subscribers, allowing copper to remain competitive with cable or fiber, as well as extending coverage in order to reach more subscribers.

Integrated DSL on the SAR-M provides:

• a reduced footprint and improved deployment options using High-capacity Ethernet aggregation over copper within an integrated 1RU box

• An effective means of delivering native ATM, Frame Relay, HDLC (High Level Data Link Control), TDM or Ethernet business services expanding legacy offerings over an IP/MPLS infrastructure

• Flexible architecture deployments using IP, MPLS and/or Ethernet for backhaul

An 8 pair xDSL module supports

8-pair VDSL2 PTM bonding or 2-pair ADSL2/2+ ATM bonding,

ITU-T G.998.2 PTM bonding,

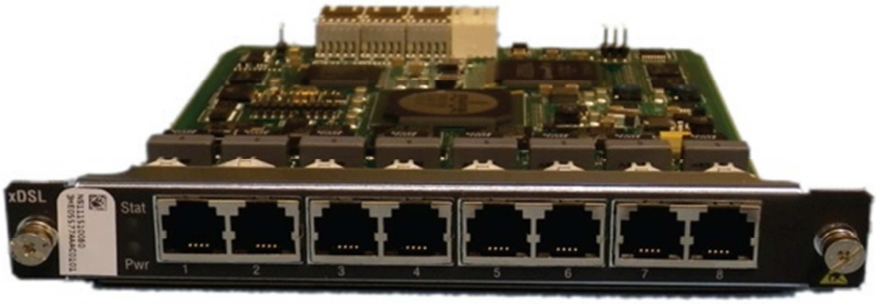
ITU-T G.998.1 ATM bonding,

8 RJ-11 connectors,

2mA pulsed wetting current,

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M DCM (DSL Combination Module)



- Supports 6 copper pairs: 4 G.SHDSL.bis interfaces with 4-pair EFM/PTM and 2 xDSL interfaces (ADSL2/ADSL2+/VDSL2) with 2-pair with ATM or PTM (Plesiochronous Transmission Mode) bonding.
- NTR is supported over SHDSL(Single Pair High Speed Digital Subscriber Line) and xDSL
- Has 6 RJ-11 faceplate connectors
- Supports in-service installation
- Temperature hardened :-40 to +65ºC (-40 to 149ºF)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-M DSL combination module provides support for both SHDSL and xDSL in the same module.

It includes six RJ-11 connectors, SHDSL interface for voice/signaling and xDSL for High Speed Downlink Packet Access or “HSDPA “ offload,

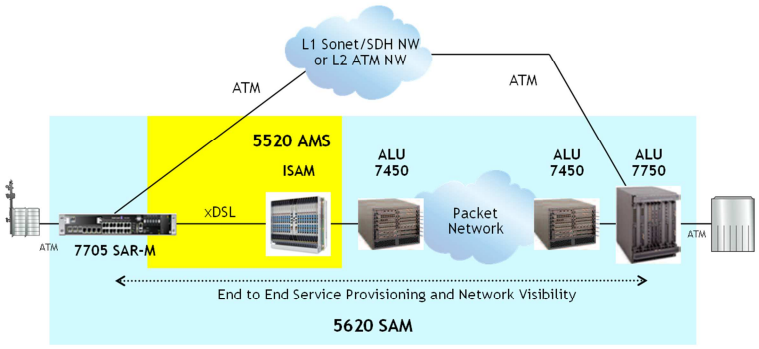
4-pair G.SHDSL.bis, ITU-T G.991.2 Annexes A, B, F and ITU-T G.991.2 Amd. 2 Annex G, IEEE EFM 802.3-2004 EFM and ITU-T G.998.2 PTM via a single bonded group.

The module also supports 4-, 6- and 8-wire bonding, 2mA pulsed wetting current, STU-R, NTR via SHDSL, 2-pair xDSL supporting 2-pair PTM/ATM bonding, G.992.3 ADSL2 and G.992.5 ADSL2+, G.993.2 (VDSL2), up to profile 17a, Band-plans 998, 997, 997E, 998ADE, and 998E, 2-pair ATM and PTM bonding, and NTR via VDSL2.

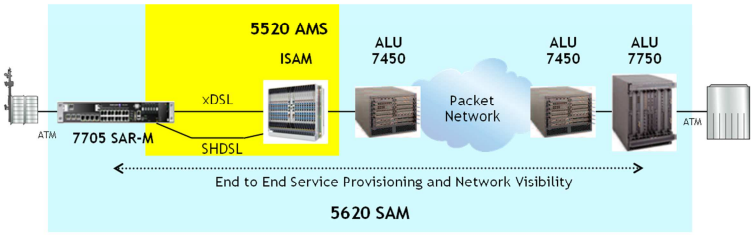
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M xDSL and DCM Target Applications

Typical DSL Offload Scenario with xDSL



Typical DSL Offload Scenario with DCM



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

HSDPA Offload is a Hybrid solution that provides non-real time UMTS traffic backhauled over the xDSL connection, while all voice traffic remains on the existing attached TDM network.

- It also provides DCM, where non-real-time UMTS traffic is backhauled over the xDSL connection and all voice traffic is backhauled over the SHDSL interface.

In a Pure DSL Backhaul, all traffic types (GSM and UMTS rt/nrt) are backhauled over the xDSL connection.

- In the case of DCM, the xDSL interface on the DCM would be unused while all traffic is backhauled over the SHDSL interface.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-M 2-Port 10GigE Ring Module

2-Port 10G Ring Module for the 7705 SAR-M

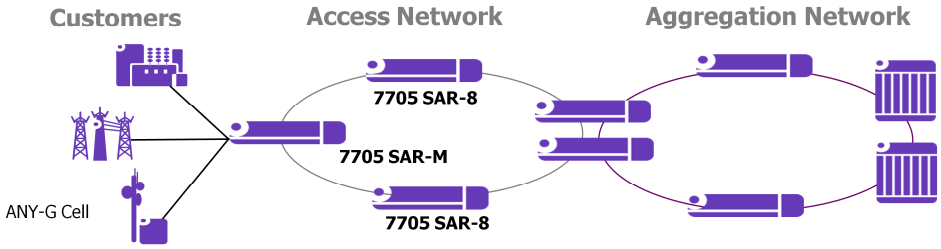
Based on latest generation chipset technology

Enable node evolution to 10G ring network topologies

All services supported: IES v4/v6, VPRN, VPLS, VLL

2-Port 10GigE Ring Module





COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A number of SAR nodes in a ring typically aggregate traffic from customer sites, map the traffic to a service, and connect to an SR node. The SR node acts as a gateway point out of the ring.

A 10GigE ring allows higher bandwidth services and aggregation on a per-7705 SAR basis.

The 2-port 10GigE (Ethernet) Adapter card/module increases the capacity of backhaul networks by providing 10GigE support on the aggregation nodes, thus increasing the port capacity.

In a deployment of a 2-port 10GigE (Ethernet) Adapter card/module, each 7705 SAR node in the ring is connected to the east and west side of the rings over two different 10GigE ports.

If10GigE is the main uplink, two cards per two 7705 SAR-M nodes each equipped with a 2-port 10GigE (Ethernet) module are required for redundancy. With card or module redundancy, east and west links of the ring can be terminated on two different adapter cards or modules, reducing the impact of potential hardware failure.

The physical ports on the 2-port 10GigE (Ethernet) Adapter card/module boot up in network mode and cannot be disabled or altered. At boot-up, the MAC address of the virtual port is programmed automatically for efficiency and security reasons.

The 2-port 10GigE (Ethernet) module is a 7705 SAR-M expansion module with 2-port 10GigE (Ethernet) XFPs for network (ring) connectivity. The module supports 10Gig Full Duplex, or FD, to both the East and West paths. It supports a 2.5 Gb/s drop to the fabric. This module supports network mode port operation only and is supported in both -48 VDC and +24 VDC systems.

The following services are supported by this module: IES v4/v6 [I-E-S versions 4 and 6], VPRN, VPLS and VLLs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

10 7705 SAR-F System Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-F Hardware and features Overview



- SAR-F has a single circuit board with:
  - 1 Control and Switch Module (CSM)
  - 16 port ASAP card
  - 8 port Ethernet card
- 256M Compact Flash memory device
- No replaceable modules, except for SFPs
- 1 Rack-Unit x 19" rack mountable x 10" (height x width x depth)
- Operating Temperature range: -40°C to +65°C. Max power consumption: 55W
- Includes standard terminal block for dual power feeds:
  - -48 VDC/+24 VDC

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-F is a compact platform for multi-service access.

It is a fixed configuration version of the Service Aggregation Router packaged in a 19 inch one-rack unit high form factor.

It supports up to 16 T1/E1 any-service-any-port (ASAP) ports which can be configured to support ATM, ATM IMA, TDM and MLPPP.

There are six 10/100 Base-T auto-sensing Ethernet ports, plus two extra ports supporting 10/100/1000 Base-TX with small form factor pluggable optics (SFPs).

There is one control and switch module and a 256 megabytes compact flash memory device that stores system boot images, software images, configuration files and logs.

It supports 1 Gigabits per second switch capacity.

There are no replaceable modules, except for SFPs.

The Operating Temperature range is -40°C to +65°C.

There is a standard terminal block for dual power feeds and Maximum power consumption is 55 watts.

The power feed red.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-F T1/E1 ASAP Ports



- 16 T1/E1 ASAP ports with physical RJ-45 connectors on faceplate
- Ports can be either all T1s or all E1s, not a mixture of both
- Each port has an associated 'Status' LED to report its status

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-F has 16 T1/E1 ASAP ports with physical RJ-45 connectors on faceplate
Ports can be either all T1s or all E1s, not a mixture of both
Each port has an associated 'Status' LED to report its status
In access mode the ports support ATM/IMA, PPP/MLPPP and TDM.
In Network Mode the ports support PPP/MLPPP.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-F Ethernet Ports



- 6 ports 10/100 Mbps Ethernet with RJ45 connectors on the faceplate
- 2 ports 10/100/1000 Mbps Ethernet with SFP

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-F has 6 Ethernet ports with RJ-45 10/100 Auto sensing, and two ports that support 10/100/1000 Megabits per second SFPs for10 and 40 kilometers reach and CWDM SFPs for 120 kilometers reach.
The SAR-F Ethernet ports can be used either as 'Access' facing or 'Network' facing depending on the requirements.

With the use of Network facing Ethernet ports, all the Access traffic can be switched out from the Cell Site in the form of VLLs across an MPLS network.
Ethernet ports support features including 802.1q (VLAN tag), 802.1p (Priority bits), Classification/Marking of packets as per .1p bits,
802.1ad (VLAN Stacking, QinQ), Ethernet OAM, and Synchronization.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-F Synchronization

- A maximum of three synch sources can be configured:
  - 2 internal
  - 1 external – synch input port
- IEEE SyncE is supported on SFP based Ethernet ports that are populated with optical SFPs (not supported on copper ports/SFPs)
- Adaptive Clock Recovery (ACR) is supported
- SAR-F supports up to 2 synchronization sources (line timing) per ASAP Adapter card:
  - First source within ports 1 to 8
  - Second source within ports 9 to 16
- SAR-F supports up to 2 SyncE clock source references
  - Ports 1/2/7 and 1/2/8
- The SAR-F supports IEEE 1588v2 frequency synchronization including one ordinary slave clock, ordinary master clock, or boundary clock.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-F supports up to 3 synch sources, 2 internal and 1 external via the synch input port.

Adaptive Clock Recovery is supported on T1/E1 CES circuits

2 synchronization sources for line timing are supported, one for ASAP ports 1 to 8 and one for ports 9 to 16.

The SAR-F supports combined SyncE and IEEE 1588 for frequency and time alignment.

IEEE 1588v2 frequency synchronization includes one ordinary slave clock, ordinary master clock, or boundary

clock. 1588v2 or Precision Time Protocol is a packet-based time transfer protocol t hat is capable of carrying microsecond level time synchronization over large networks.

One important advantage of PTPv2 is that it provides time-of-day synchronization.

However it is a packet-based protocol that is susceptible to packet delay variation (PDV), as is the case with ACR.

The SAR-F also supports a nodal clock and up to two PTP ordinary or boundary clocks can be configured per node as references to the nodal clock. Each PTP slave clock can be configured to receive timing from up to two PTP master clocks

in the network.

For all 7705 SAR platforms and clock types, when the node loopback address is used as the source interface for 1588 packets, the packets can ingress and egress over IES interfaces.

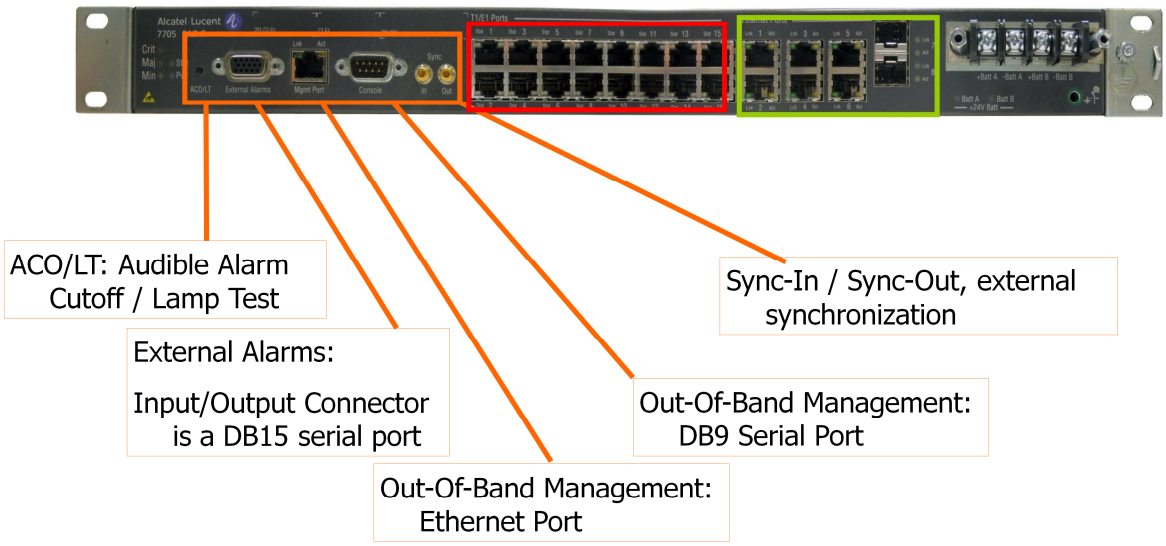
Redundancy is offered on SAR-F in the physical layer.

IP messaging between the PTP master clock and PTP slave clock over the PTP-enabled IP interface is done using IPv4 unicast mode.

Each PTP instance supports up to 128 synchronization messages per second. The default is 64 synchronization messages per second.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-F Ports and Connectors



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

In addition to the 16 T1/E1 ASAP ports, 6 Ethernet ports and 2 SFP ports, the SAR-F provides the “in” and “out” synchronization ports, DB9 serial port for out-of-band management, eternal alarm input and output connector and the ACO and lamp test button.

The synchronization ports are provisioned with a mini 1.0/2.3 coaxial connection that can be used to receive/provide an external synchronization input/output signal.

Audible Alarm Cutoff/ Lamp Test button has two functions:

when pressed, the Lamp Test is enabled and the Status LED on the chassis glows green, all ASAP ports glow green, critical and major Alarm LEDs glow red and the minor Alarm LED glows amber.

When released, Status and ASAP ports LEDs return to their pre-Lamp test state. The Alarm LEDs become unlit until the next alarm condition.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-F Power Supply



SAR-F Dual Terminal Power block

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- The 7705 SAR-F has a standard, dual terminal block (four terminals) attached to the front of the chassis.
- The terminals provide access for two independent power feeds, allowing power redundancy for the system.
- When only one power feed is used, the system does not have power supply redundancy.
- The power system has no field-replaceable parts
- -48 volts DC and +24 volts DC are supported.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-F Fan Operation

- 7705 SAR-F is equipped with 5 built-in fans that are not field replaceable
- All 5 fans are either ON or OFF
- Fans are controlled by software and based on outside/inside temperature monitoring
- 7705 SAR-F is designed to operate within its normal operating temperature range with only 4 of the 5 equipped fans operational
- A minor alarm is raised if one fan fails
- A critical alarm is raised if two or more fan failures are detected, and SAR-F must be serviced



The fans are controlled by software and based on the following temperature monitoring:

The outside temperature is continually monitored starting early in boot-up.

Fans are turned ON whenever the temperature exceeds +40 degrees Celsius (104F) and OFF when the temperature drops below +15 degrees.

After boot-up is completed, the internal temperature of the components is also monitored.

The fans will be forced ON if internal temperature reaches +55 celsius (131 Fahrenheit) regardless of outside temperature.

Fans will remain ON until the chassis temperature is below +50C celsius (122 Fahrenheit) degrees.

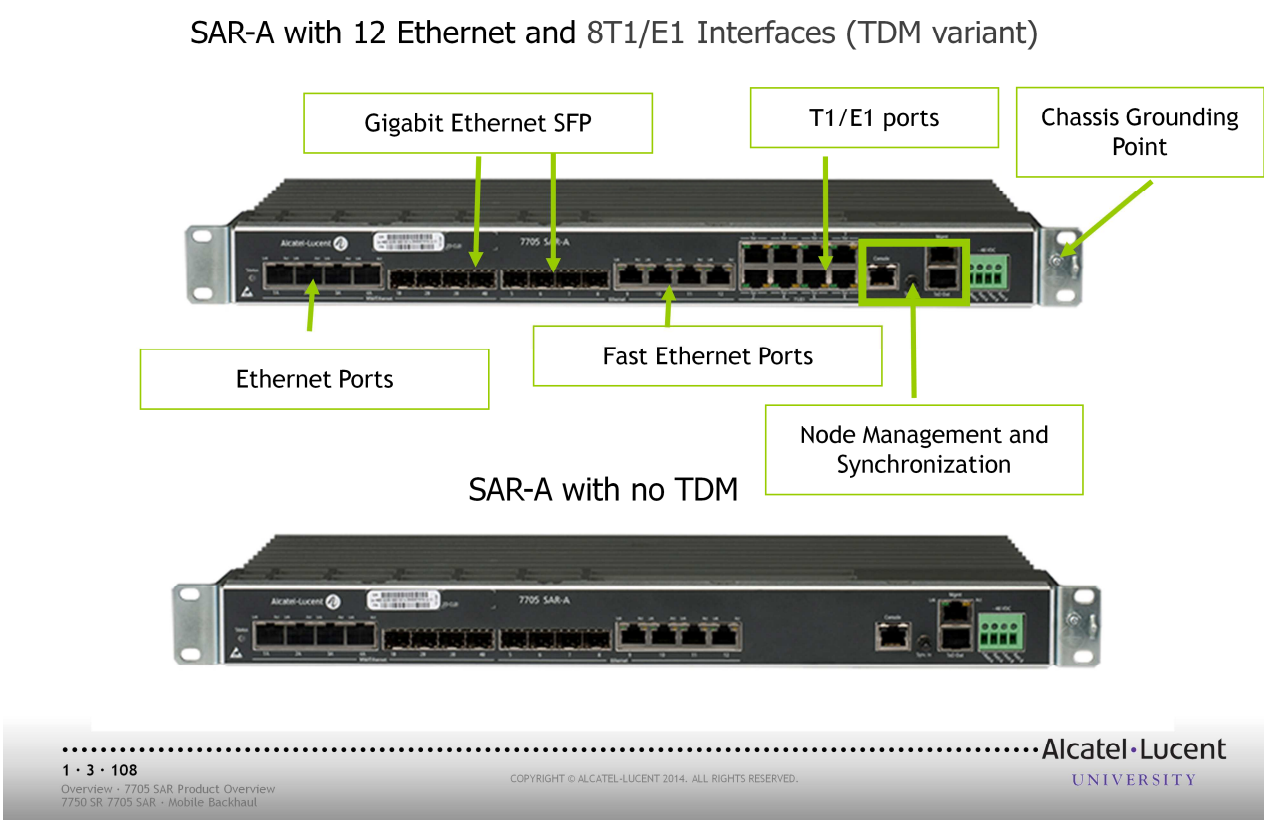
An overheat alarm is raised if any component temperature exceeds +84 celsius (183 celsius).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

11 7705 SAR-A System Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-A Hardware and features Overview



The 7705 SAR-A transports all types of traffic from a mobile cell site to a higher point of presence or to a mobile telephone switching office, over the packet-switched network.

It delivers Ethernet scalability in a 1 RU form factor with full 7705 SAR IP/MPLS features, optimized for smaller standalone sites.

The SAR-A comes in 2 variants both of which run the same operating system software and support 12 Ethernet ports.

One variant also provides eight T1/E1 ports for TDM support.

The SAR-A circuit board supports all functions of the router, including control and switching, Ethernet interfaces, T1/E1 interfaces if applicable, power and alarm status LED, and connectors for node management and external synchronization.

The SAR-A supports 5.0 gigabits per second of full–duplex switch capacity and an extended operating temperature of -40 to 65 degrees Celsius.

All physical connections are made at the front of the chassis, including the ground connection.

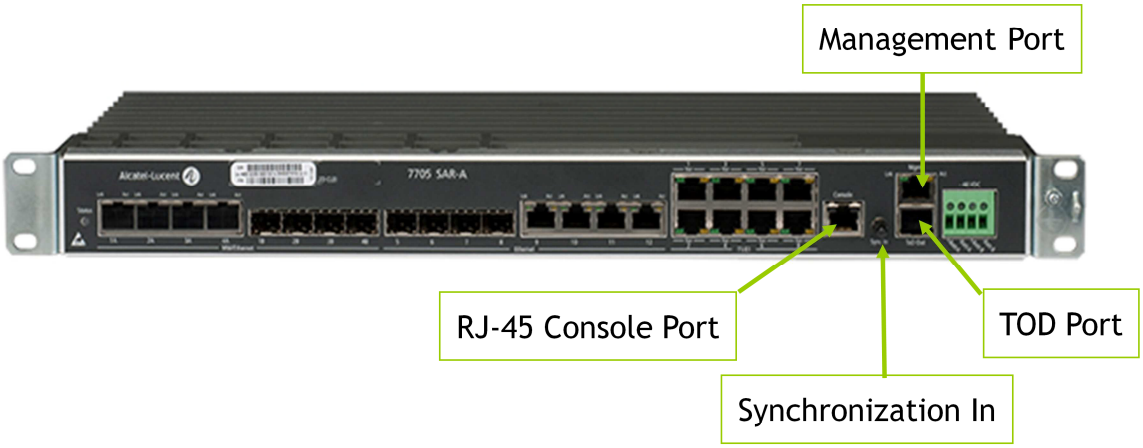
The mounting brackets are factory-installed for mounting in a standard 19-inch rack.

The SAR-A chassis ships with an integrated , non-accessible 256 Megabyte flash memory device that stores the system boot and OS software, configuration files, and logs.

The SAR-A router uses port level provisioning, with I/O ports grouped into virtualized IOM and MDA slots for convenience of assignment.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-A with 12 Ethernet and 8 T1/E1 Interfaces (TDM variant)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

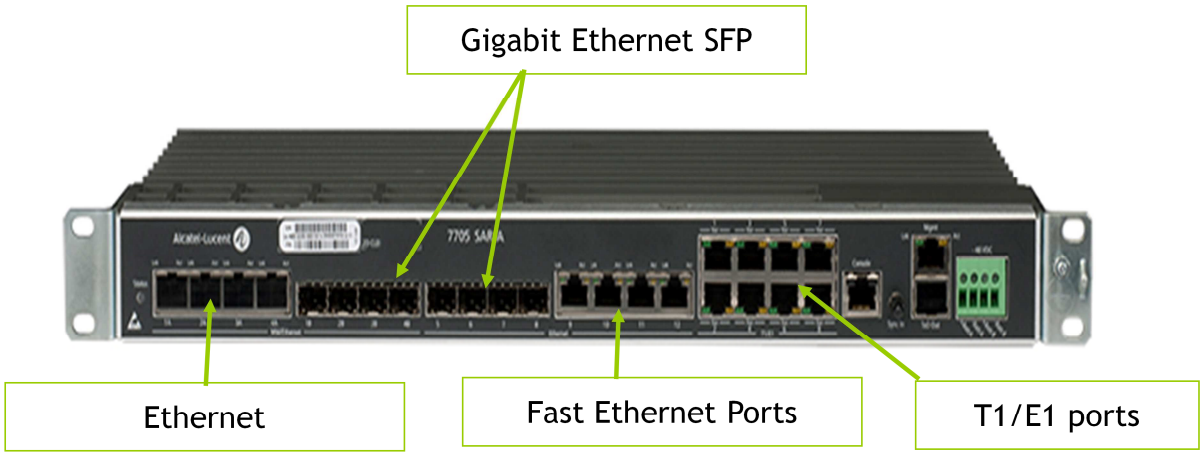
The 7705 SAR-A CSM is integrated into the chassis and does not require provisioning. In the CLI it appears as CSM A.

The control and switching functions include the console and management interfaces, the synchronization interface, system LEDs, and the routing, switching, and services functions for the entire system.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-A Ethernet and T1/E1 Ports

SAR-A with 12 Ethernet and 8 T1/E1 Interfaces (TDM variant)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 2 SAR-A variants are both equipped with 12 Ethernet ports.

Ethernet ports 1 to 4 are exclusive-OR (X-O-R) ports.

Ports 1A to 4A can be configured as 10/100/1000 Base-T electrical RJ-45 ports or ports 1B to 4B can be configured as 100/1000 SFP ports.

The interface type can be configured on each port independently and the default is RJ-45.

Ethernet Ports 5 to 8 are Gigabit Ethernet ports that use hot-swappable field replaceable 100/1000 SFPs.

Ethernet Ports 9 to 12 are Fast Ethernet ports that use RJ-45 connectors.

The SAR-A supports a variety of copper and optical SFPs with various wavelength and reach capacity.

1 of the SAR-A variants also provides 8 T1/E1 ports for TDM support.

The T1/E1 ports support many interface speeds and types, including T1/E1 with TDM-based services such as SAToP, CESoPSN, and CESoETH. Ethernet1000Base-T, 100Base-T, 10Base-T, and optical.

All 8 T1/E1 ports must be configured as either T1 or E1 and all use RJ-45 connectors.

The T1/E1 ports support on-premises, intra-building SELV connections and require a CSU for off-premises connections.

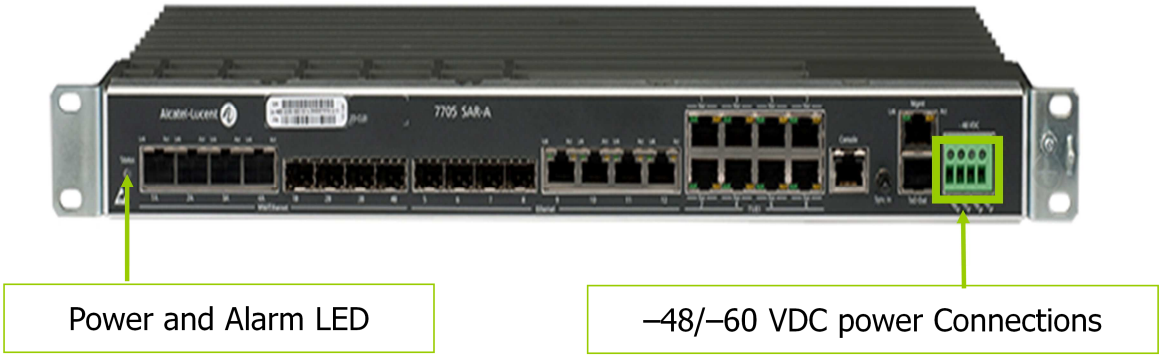
An adapter cable is available to convert RJ-45 connectors to BNC connectors for E1 ports.

CAT5e shielded cable is required for Gigabit Ethernet and T1/E1 connections and CAT5 shielded cable is required for Fast Ethernet connections.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-A Power System

SAR-A with 12 Ethernet and 8 T1/E1 Interfaces (TDM variant)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-A supports a –48/–60 volts DC power supply through a wire-to-board pluggable terminal block with four terminals attached to the front of the chassis.

The terminals provide access for two independent DC power feeds.

DC power can be supplied by a DC circuit or from an AC source using an external AC-to-DC power converter.

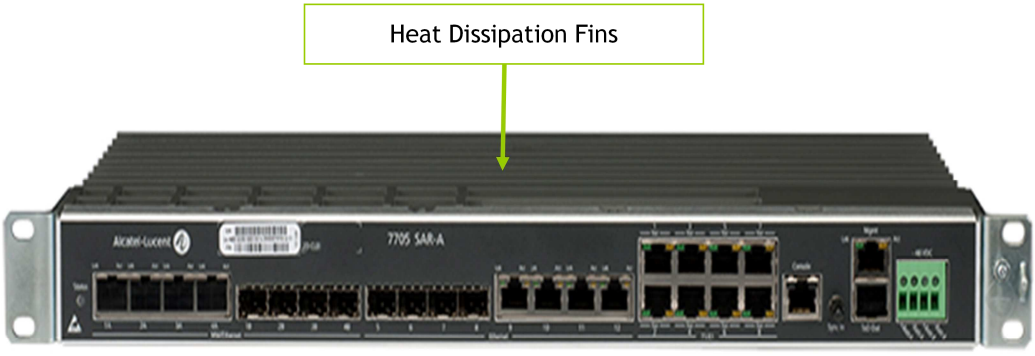
A 250W 120/240V AC power converter and a 7705 AC power converter with 16 AWG pigtail O-ring are available from Alcatel-Lucent to facilitate AC source-to-router connection for –48 volts DC installations.

The SAR-A power system has no field-replaceable parts. One LED is located on the front of the chassis to indicate the DC power supply and alarm status.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-A Chassis Cooling

SAR-A with 12 Ethernet and 8 T1/E1 Interfaces (TDM variant)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-A uses a built-in heat sink to provide passive cooling.

It is equipped with fins for heat dissipation and does not use internal fans for forced air.

At least 2.5 inches or 6.4 centimeters clearance must be maintained at the front of the chassis for cable management and at least 2 inches or 5.1 centimeters on each side and 1.75 inches or 4.4 centimeters above and below the chassis for proper airflow.

The SAR-A operates at an external ambient temperature of up to 149° F or 65° C with a minimum air movement of 0.5 millimeters per second.

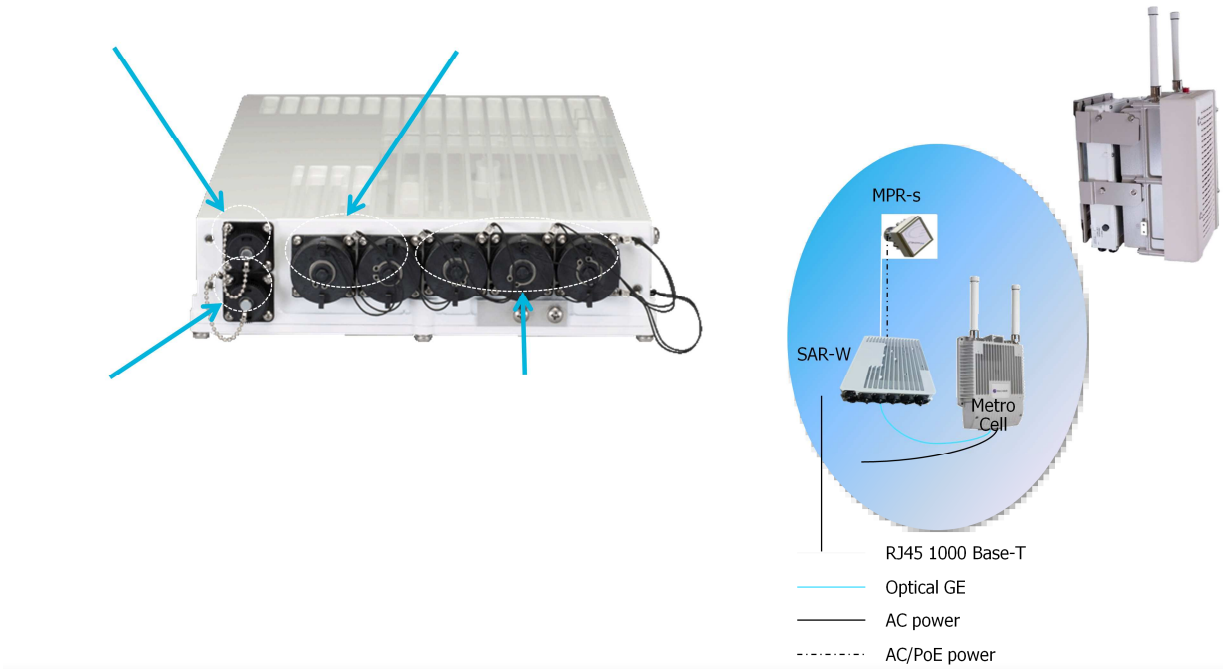
An Overheat alarm is raised if these conditions are exceeded.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

12 7705 SAR-W System Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-W Hardware and features Overview



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR-W is small metro cell router that transports all types of traffic from a mobile cell site to a higher point of presence or to a mobile telephone switching office, over the packet-switched network.

It is optimized for IP/MPLS over any access.

The SAR-W chassis is environmentally sealed and can be deployed indoors or outdoors.

It is equipped with five Gigabit Ethernet data ports. Three of the ports are SFP ports and two are RJ-45 Power over Ethernet ports.

The SAR-W has an RJ-45 RS-232 Serial Console port and RJ-45 Ethernet Management port, and system LEDs.

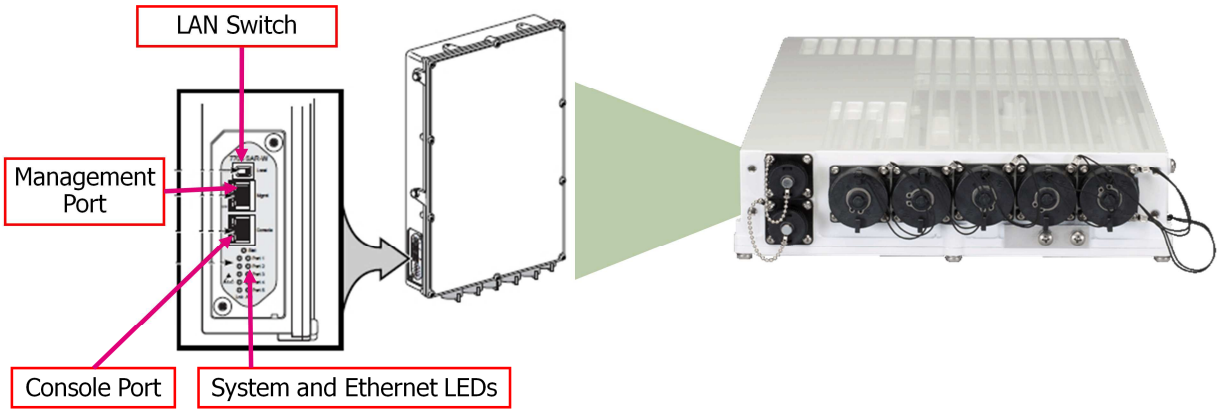
It supports AC power input from an AC source and DC power input is from a DC power supply or battery.

A SAR-W can be installed on a utility or light pole or on a wall.

It can be installed jointly with a metrocell basestation for metrocell services and small cell backhauling for service providers, or individually with connections to point-to-point radios or surveillance cameras.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-W Control and Switching



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR-W has an integrated control and switching block that provides routing, switching, and services functions, system synchronization, and node management interfaces.

The console and management ports, the LAN switch, and the system and Ethernet LEDs are located on the side of the chassis, behind a removable screw-secured access panel.

It supports 5.0 gigabits switch capacity.

The Console port uses an RJ-45 serial connector to provide connectivity to the CLI.

The Management port uses an RJ-45 Ethernet connector to provide Out-of-Band system management.

The LAN management switch disables the Out-of-Band management and switches to in-band management over one of the data ports.

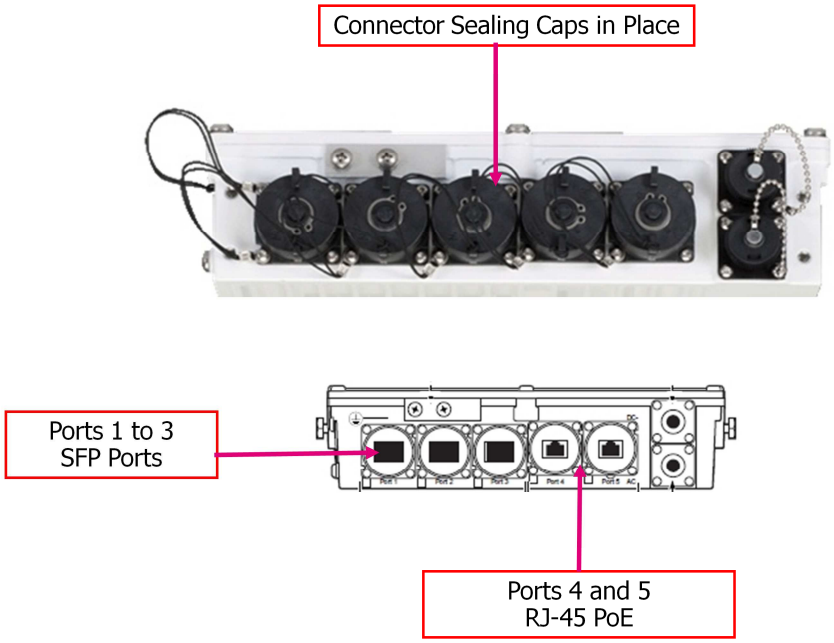
When the switch is set to in-band, an internal link is created between a data port and the system management interface which uses V-LAN 0.

The SAR-W chassis ships with an integrated, non-accessible 256 Mega byte flash memory device that stores the system boot and OS software, configuration files, and logs.

The SAR-W supports port level provisioning with pre-assigned virtualized IOM and MDA slot identifiers for convenience of assignment.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-W Ethernet Ports



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-W provides five Gigabit Ethernet data ports.

Ports 1-3 are S-F-P ports and ports 4-5 are RJ-45 Power over Ethernet (PoE) ports.

There are 5 sets of LINK and Activity LEDs that indicate the link and activity status of the 5 Ethernet ports.

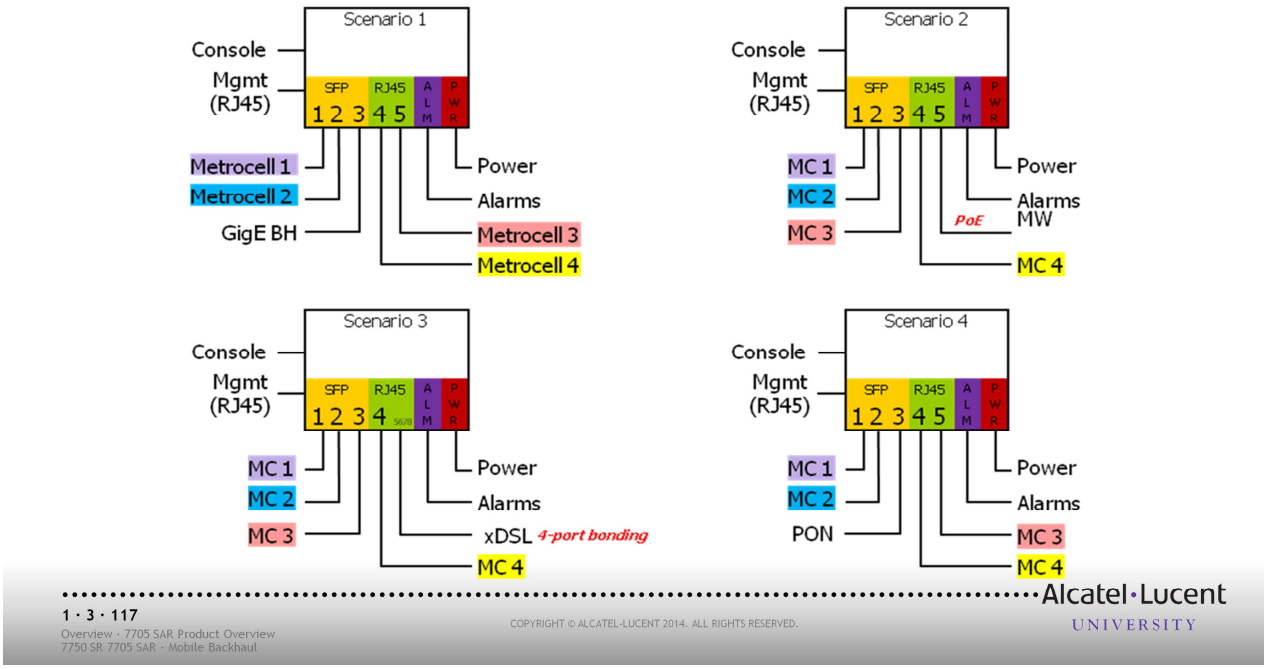
The LEDs are on the side of the chassis, behind the removable screw-secured access panel.

The SAR-W ships with sealing caps in each connector that should be locked when not in use.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-W Ethernet Ports Continued

SAR-W Ethernet Ports Support Combinations of
Metrocell, Microwave, GPON and EPON Connections



All 5 SAR-W Ethernet ports support metrocell connections.

The three SFP ports support network connections using Gigabit Ethernet fiber and a maximum of two GPON fibers.

GPON connections act as optical network termination points.

An EPON ONT SFP is also supported, to enable the SAR-W to act as a full–data–only optical network terminator, when connected to an Alcatel-Lucent 73xx OLT.

The 2 PoE ports support power back up using uninterruptible power source Ethernet links for SNMP alarm management and non-line-of-sight or line-of-sight microwave connections which are typically for point-to-point microwave radios or surveillance cameras.

The SAR-W Ethernet data ports support the described connectivity in any combination that does not exceed the limits for the RJ-45 PoE and GPON connections.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-W Grounding



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-W supplies one two-hole lug grounding point on the bottom of the chassis when installed vertically.

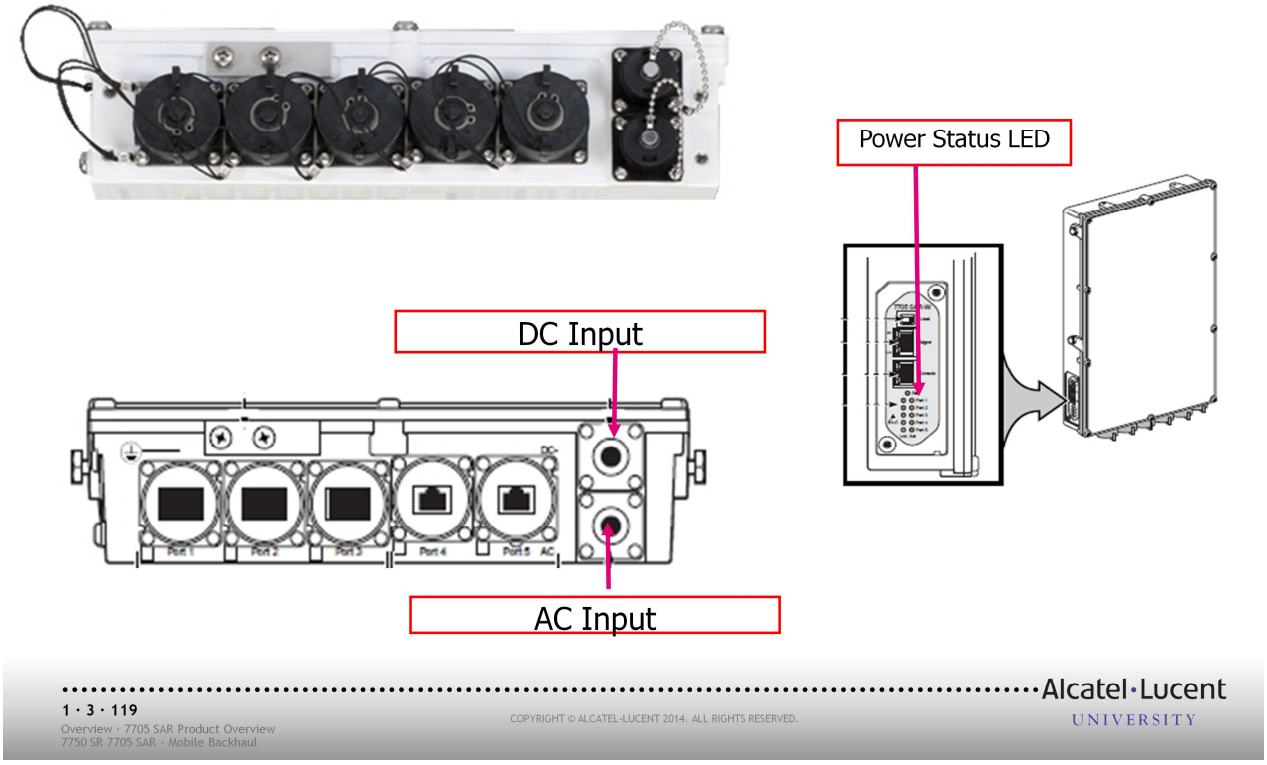
The SAR-W supports both Common Bonding Networks and Isolated Bonding Networks in that the positive battery inputs are floating relative to the digital or chassis ground.

The earth grounding point can be a grounding bar or a pole grounding rod, in accordance with regional NEC and NESC guidelines.

If other equipment is installed jointly with the SAR-W chassis, such as a metrocell basestation or microwave radio, it must also be grounded to the same grounding point as the chassis.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-W Power System



The SAR-W can operate in AC, AC with DC backup, or DC power only modes.

The AC and DC power supply inputs are at the bottom of the chassis when it is installed vertically.

The power rating is 120 to 240 VAC at 50/60 hertz.

If the SAR-W is mounted individually, the AC power supply can come from an AC disconnect Junction box, or DC power can come from a battery cabinet with a built-in AC and DC surge protector.

If the SAR-W and a metrocell basestation are mounted together, the primary AC power comes from an AC distribution box, also called a Power Distribution Unit or P-D-U.

The PDU provides AC power to the SAR-W and the metrocell basestation, and to the microwave radio, if installed.

If DC power is required, it can come from a battery cabinet with built-in AC and DC surge protection connected to an AC disconnect box.

The AC and DC power cables have a wire gauge of 14 AWG.

The maximum supported distance to the AC or DC source varies depending on the normal operating voltage being deployed.

The power status LED is on the side of the chassis behind the removable screw-secured access panel.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

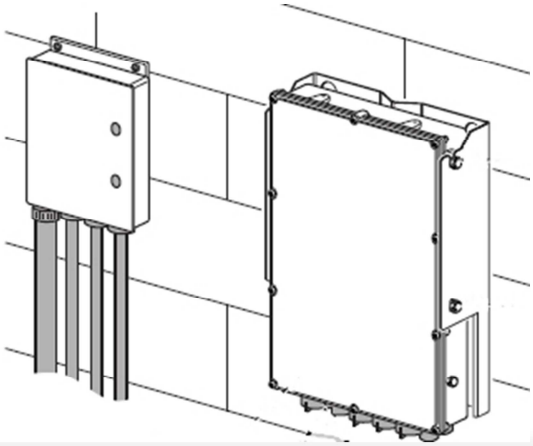
7705 SAR-W Cooling System



•Cooling fins face the pole or wall and orient vertically.

•Unit cannot be mounted sideways or on its back

•Air channels created by the mounting bracket(s) must be unobstructed



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-W chassis operates using passive (fanless) cooling within its element-proof enclosure.

Normal operating temperatures are minus 40 to plus 65 degrees celsius or minus 40 to plus 149 degrees Fahrenheit.

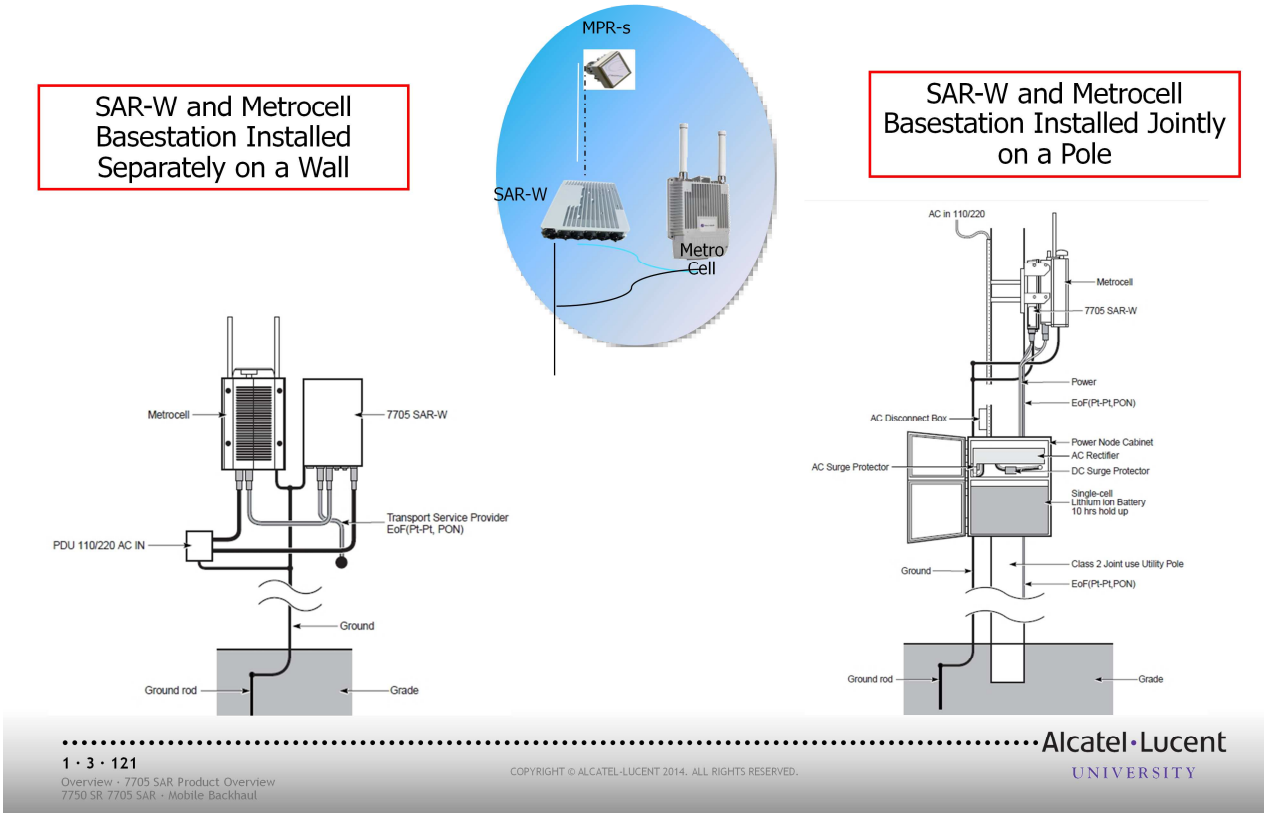
An overheat alarm is raised if the chassis internal temperature exceeds 203 degrees Fahrenheit or 95 degrees celsius and is cleared when the internal temperature drops below the limit.

In all installations, the SAR-W cooling fins must be facing the pole or the wall and oriented vertically.

You must not mount the unit sideways or on its back and you must ensure that the air channels created by the mounting brackets are unobstructed.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-W Mounting Options



The SAR-W chassis can be installed on a utility or light pole or on a wall.

When installed on a pole, the SAR-W can be installed jointly (in "piggy-back" fashion) with a metrocell basestation, or individually with connection to equipment such as a microwave radio or surveillance camera.

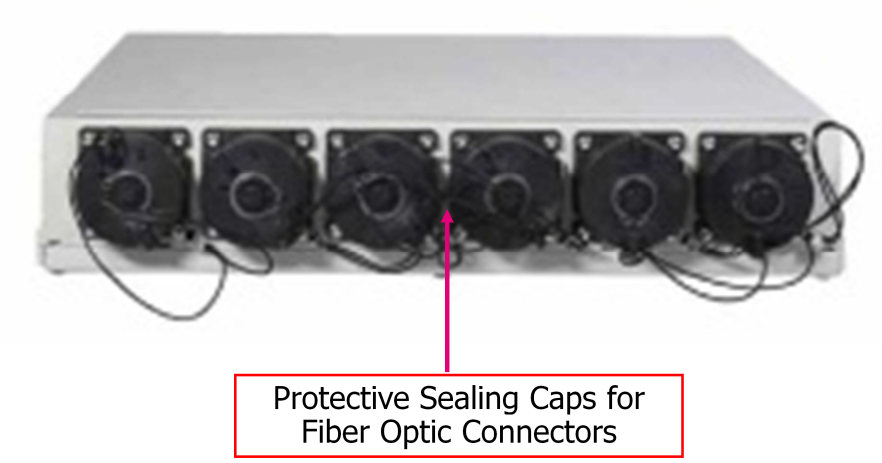
When installed on a wall, the SAR-W can be installed jointly or separately from a metrocell basestation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

13 7705 SAR-O Optical Service Router

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 Service Aggregation Router-Optical (SAR-O)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-O is a passive optical unit that is used to multiplex and demultiplex up to 8 CWDM wavelengths from an optical network.

It can be used to front-haul and back-haul metrocell basestations or switches and routers such as the 7705 SAR-W.

The SAR-O comes in two 4-Wavelength C-W-D-M Dual-Fiber variants and two 8-wavelength CWDM single-fiber variants.

The SAR-O is a light-weight, compact module designed for outdoor installation on a wall, pole, or roof.

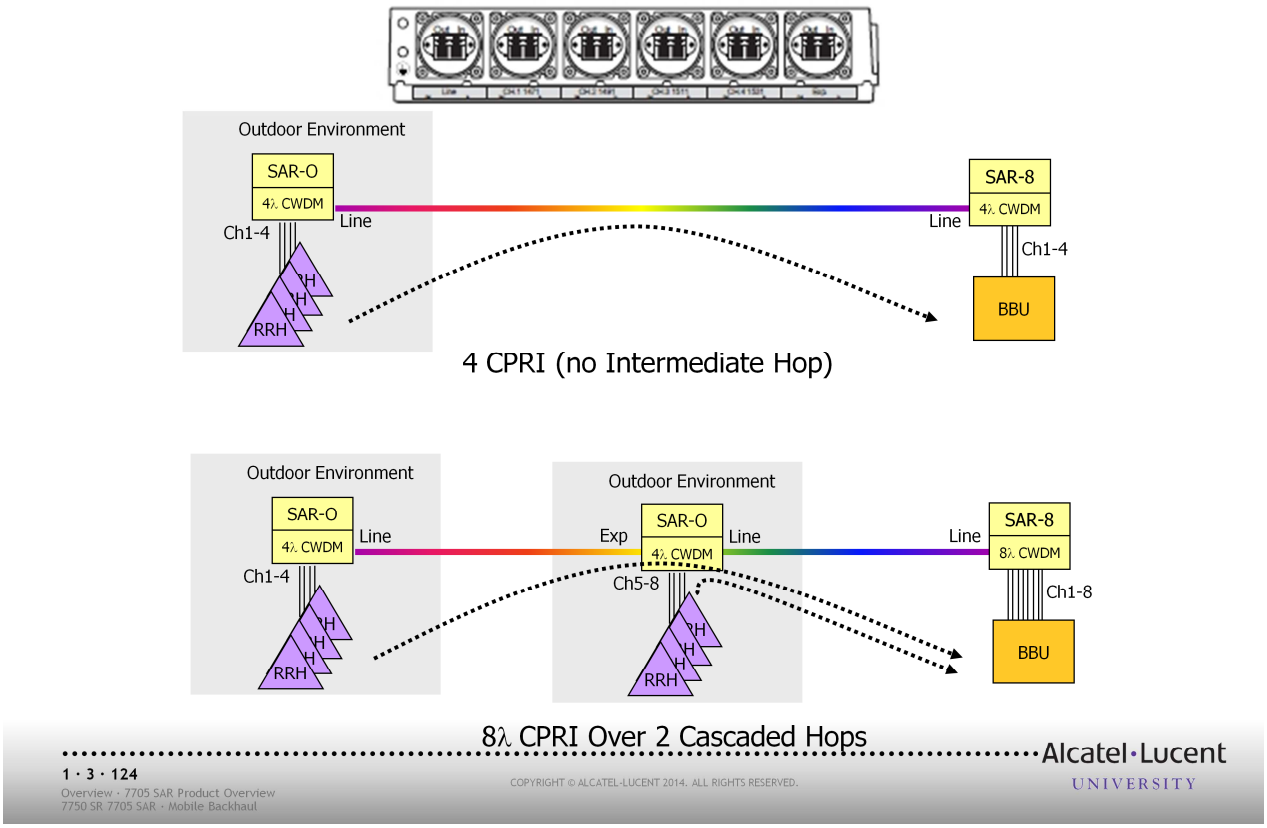
It has a sealed chassis for maximum resilience and handling, and individual protective caps for the interfaces.

The SAR-O is an optical module that does not require any power to operate.

It also supports connection of previously unused ports to new basestations, without disrupting existing traffic.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-O 4-Wavelength CWDM Dual-Fiber Variant



The SAR-O comes in two 4-color OADM variants that add and drop 4 specific wavelengths from the network.

The modules work exactly like other SAR 4-channel OADM modules, with the addition of a robust design for outdoor installations.

1 variant supports wavelengths of 1471, 1491, 1511, and 1531 n-m.

The other variant supports wavelengths of 1551, 1571, 1591, and 1611 n-m.

Both variants have 6 LC ports that accept pluggable duplex LC fiber-optic bulkhead connectors and cables of variable lengths.

The ports include a Line port, 4 add/drop ports, and an expansion port.

Each port has a pair of out and in connectors that use separate cables connected to the SAR-O.

Fiber pair is used for Transmit and Receive.

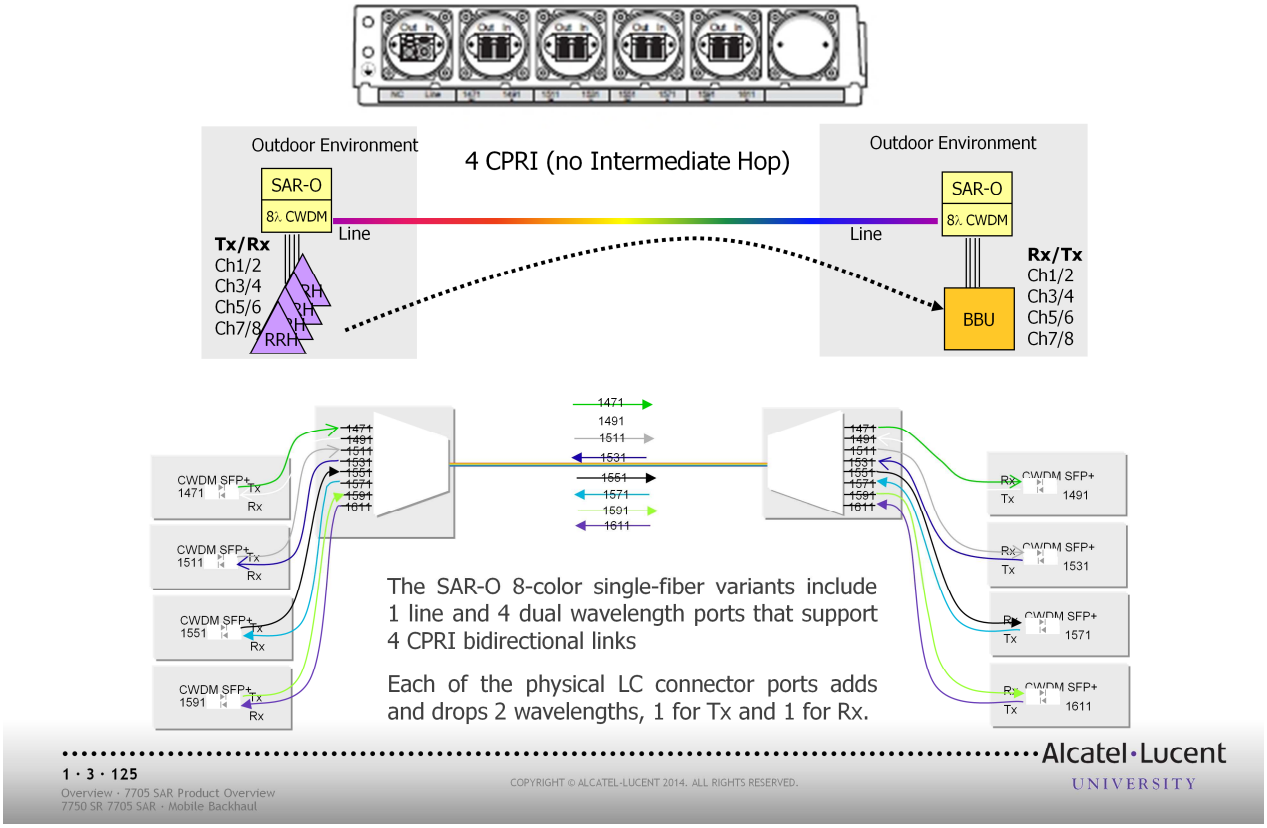
If all 4 channels are not required at commissioning the unused channels may be connected later when addition RRH equipment is installed.

All SAR-O variants ship with sealing caps installed in the LC ports to protect against dust and moisture.

All SAR-O variants also have a two-hole lug grounding point on the chassis.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-O 8-Wavelength CWDM Single-Fiber Variant



The SAR-O comes in two 8-color OADM variants that add and drop eight wavelengths from the network over a single fiber.

The 8-color variants have 5 LC ports that accept pluggable duplex LC fiber-optic bulkhead connectors.

There is 1 line port that uses a single fiber to add and drop 8 wavelengths.

There are 4 add/drop ports with a pair of out and in connectors that support fiber pairs of 2 different wavelengths.

Each port includes 1 color for transmit and another color for receive via the pluggable cable.

The T-X signal from the S-F-P to the SAR-O optical input is multiplexed onto the line signal.

The R-X signal from the S-F-P to the SAR-O optical output is demultiplexed from the line signal.

One of t he 8-color variant adds and drops 4 wavelengths on TX [transmit] including 1471, 1511, 1551, and 1591 nm and 4 wavelengths on RX [receive] including 1491, 1531, 1571, and 1611 nm.

The other variant adds and drops 4 wavelengths on TX including 1491, 1531, 1571, and 1611 nm and 4 wavelengths on RX including 1471, 1511, 1551, and 1591 nm.

Both 8-color variants ship with sealing caps installed in the LC ports to protect against dust and moisture, a plug in the Line port Out connector, and a metal cap covering the unused connector on the right of the unit.

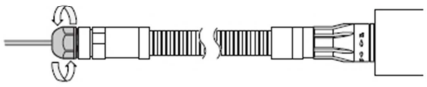
Each module has one two-hole lug grounding point.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-O Fiber Optic Connections



Customer-supplied Fiber Optic Cable with Adapter Kit



Factory Built Tyco Electronics Fiber Optic Cables



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-O supports factory-built and customer-supplied fiber-optic cables for connections to the SAR-O ports.

An Alcatel-Lucent Ethernet cable kit with five cable adapters is required for customer-supplied fiber cables.

Factory built cables are Tyco Electronics Ethernet cables with FullAXS single-mode LC/DPX connectors, or equivalent.

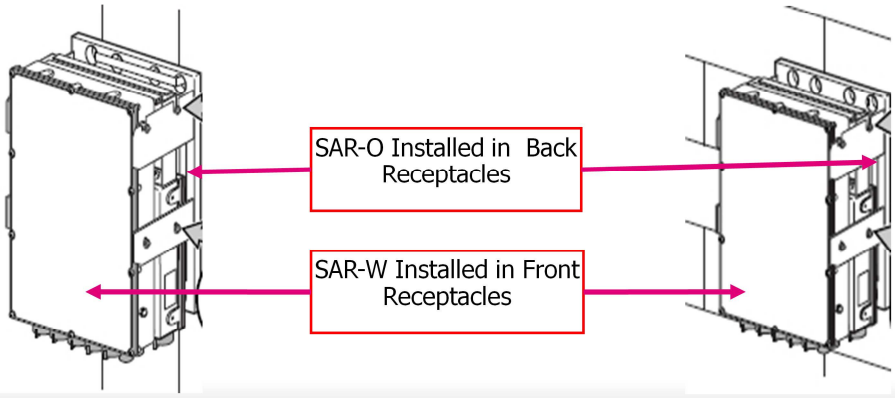
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-O Mounting Options



SAR-O with SAR-W Pole Mount

SAR-O with SAR-W Wall Mount



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-O chassis can be installed on a Pole or Wall, either individually or jointly with a SAR-W chassis.

For joint installations with the SAR-W, the SAR-O chassis uses the back receptacles in the mounting arm, and the 7705 SAR-W chassis uses the front receptacles.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

14 7705 SAR-H System Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-H Key Features

7705 SAR-H	FEATURE HIGHLIGHTS
CHASSIS	5Gb/s, 1.7 RU, fan-less
INTERFACES	2x100/1000 SFP 2 combo 100/1000 SFP/RJ45 4x 10/100/1000 (PoE capable), ToD-out (IRIG-B), Alarm, Console, Management
MODULES	Combination module: 2p T1/E1 plus 2p RS232 serial
SECURITY	Integrated stateful firewall / NAT
EMI & ENVIRONMENT	IEEE 1613 and IEC 61850-3
POWER	Low-voltage DC variant: two feeds: +24/-48 V DC High-voltage AC/DC Variant: AC: 85 to 264 V AC, 50/60Hz DC: two feeds: +88 to +300 V DC



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-H was introduced to the 7705 SAR portfolio to extend the IP/MPLS benefits further into the utility distribution network.

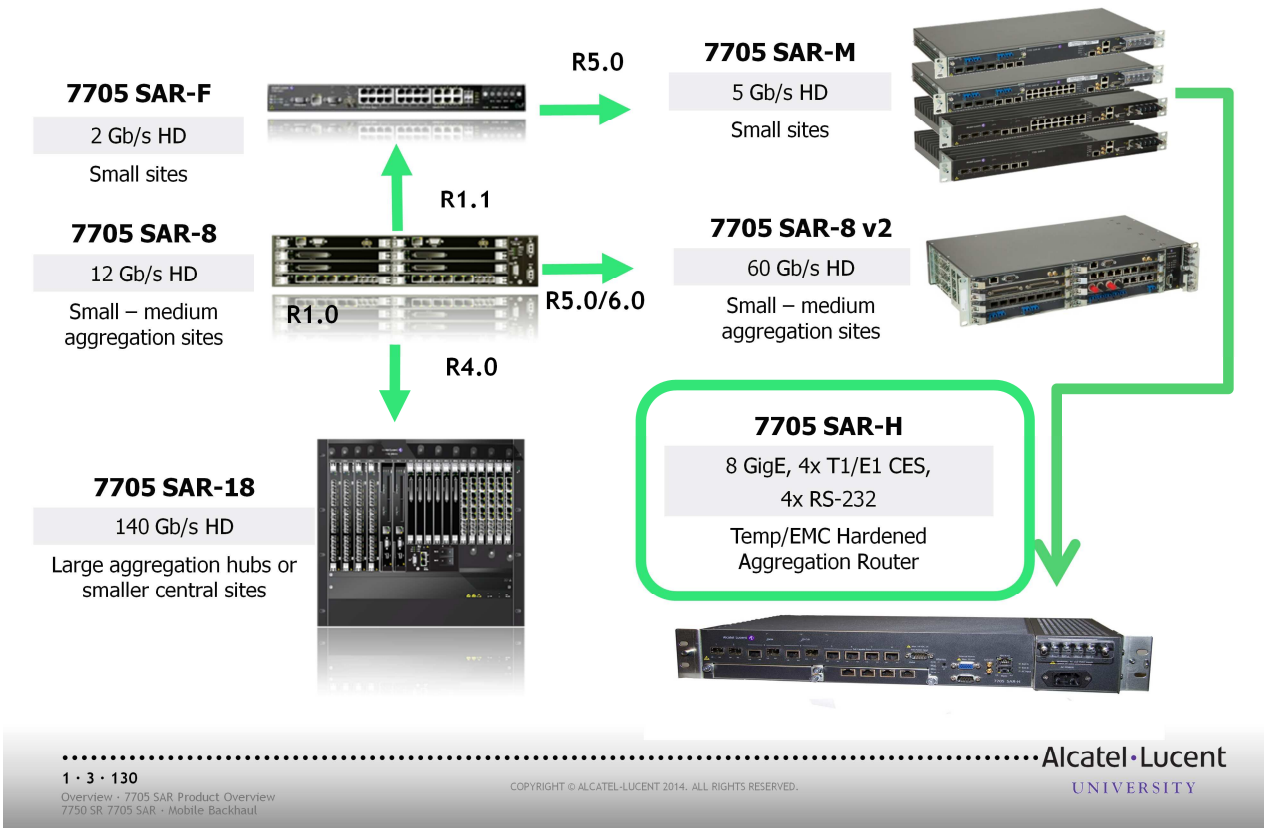
It supports the same features as other 7705 SAR products, and also incorporates new technologies to meet utility substation specifications for critical electrical relaying components.

Some of the key features that SAR-H provides include:

- One low-power and one high-power variant,
- TDM and packet interfaces,
- 2 module slots that currently support 4-port T1/E1 ASAP and RS-232 combination modules,
- PoE [p-o-ee] (Power over Ethernet) support,
- Fanless operation that meets the utility substation IEEE 1613 Class 1 and IEC 61850-3 specifications that define the demanding EMI and environmental requirements for critical electrical relaying components,
- Layer 2 and 3 switching and routing functionality,
- Extensive timing and synchronization capabilities (such as IEEE 1588v2, SyncE, and IRIG-B),
- Feature commonality with existing 7705 SAR platforms at R5.0r3 stream,
- Security capabilities that promote data security and meet North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) compliance, and
- Management by the CLI or 5620 SAM management suite

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Evolution of the SAR-H Platform



The 7705 SAR-H evolved from the SAR-8 and SAR-M platforms. The SAR-H extends the benefits of IP/MPLS to the utility distribution substation, transportation, government, and metrocell mobile backhaul markets. It addresses the needs of these markets for robust, hardened, secure solutions that can manage both legacy and IP/MPLS applications and services for mission-critical networks.

The SAR-H provides 7705 SAR features supported by other SAR platforms, including layer 2 and 3 switching and routing functionality, and advanced timing and synchronization features (including external timing reference, synchronous Ethernet, line timing on Ethernet and T1/E1 module ports, SyncE and IEEE 1588v2 Precision Time Protocol (PTP) with Time of Day and Frequency Synchronization via Master, slave and boundary clocks).

The SAR-H provides eight built-in Ethernet interfaces with 4 power over Ethernet (PoE)-capable ports, module adapter slots that support the T1/E1 and RS-232 combination module, and an IRIG-B ToD interface for ToD/phase recovery. The IRIG-B supports a synchronization standard that is widely used in the utility industry.

The SAR-H also supports fanless operation that meets utility substation IEEE 1613 Class 1 and IEC 61850-3 specifications; these specifications define the demanding EMI and environmental requirements for critical electrical relaying components.

The security capabilities promote data security and meet North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) compliance.

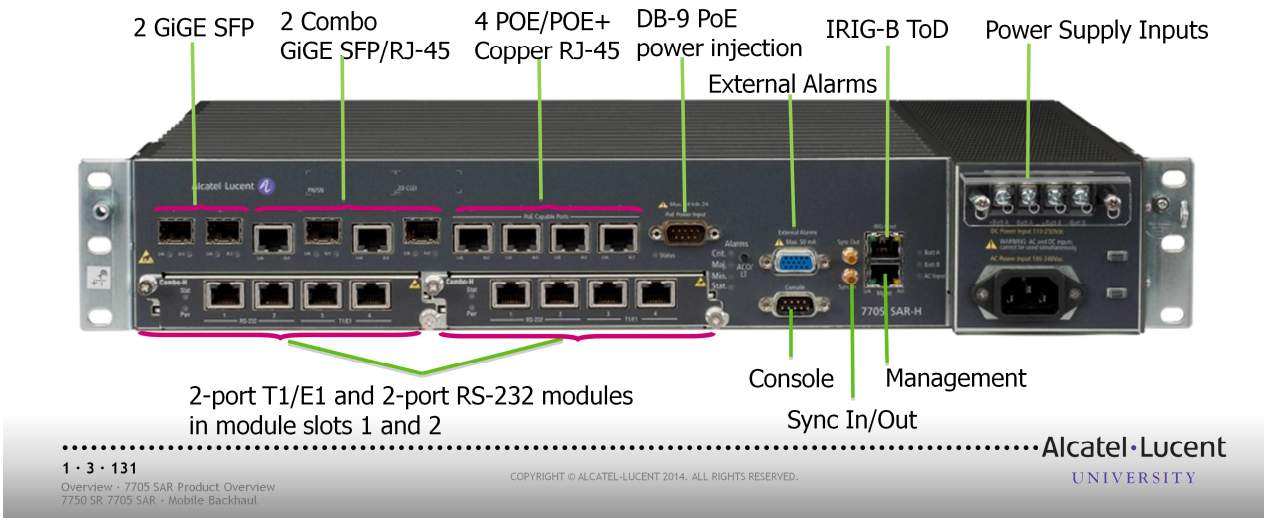
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Chassis Overview

The 7705 SAR-H is a 1.7 RU fan-less member of the SAR family, introduced with the SAR R5.0 software stream.

There are two SAR-H variants:

- SAR-H High voltage: 88-264 V AC/DC
- SAR-H Low voltage: -48/-60 and _24 V DC



The SAR-H is a 1.7 RU fan-less platform introduced to the SAR product family with the 5.0 software stream.
It can be rack-mounted or wall-mounted (with the additional wall mounting kit).

The SAR-H Chassis Interfaces include 8 Ethernet ports:

•1 DB-9 console port

•2 External timing input/output reference

•1 10/100 Management Ethernet RJ-45

•1 IRIG-B time of day (ToD) interface

•AC or DC Terminal block power feed

•1 DB-9 PoE input power connector, and

•1 HD-15 External Alarm connector

The SAR-H comes in 2 power variants:

- SAR-H High voltage, which supports 88-264 volts AC/DC; and
- SAR-H Low voltage, which supports -48/-60 and +24 volts DC

The SAR-H is passively cooled using a heat sink / fins for heat dissipation.

The SAR-H supports temperature and EMC hardening defined by IEEE 1613 and IEC 61850-3, which are applicable for use in electrical utilities where temperature and EMC hardening are required.

To ensure that proper air flow is maintained, you must leave at least 2 in. (5.1 cm) on each side, and 1.75 in. (4.4 cm) clearance above and below the chassis.

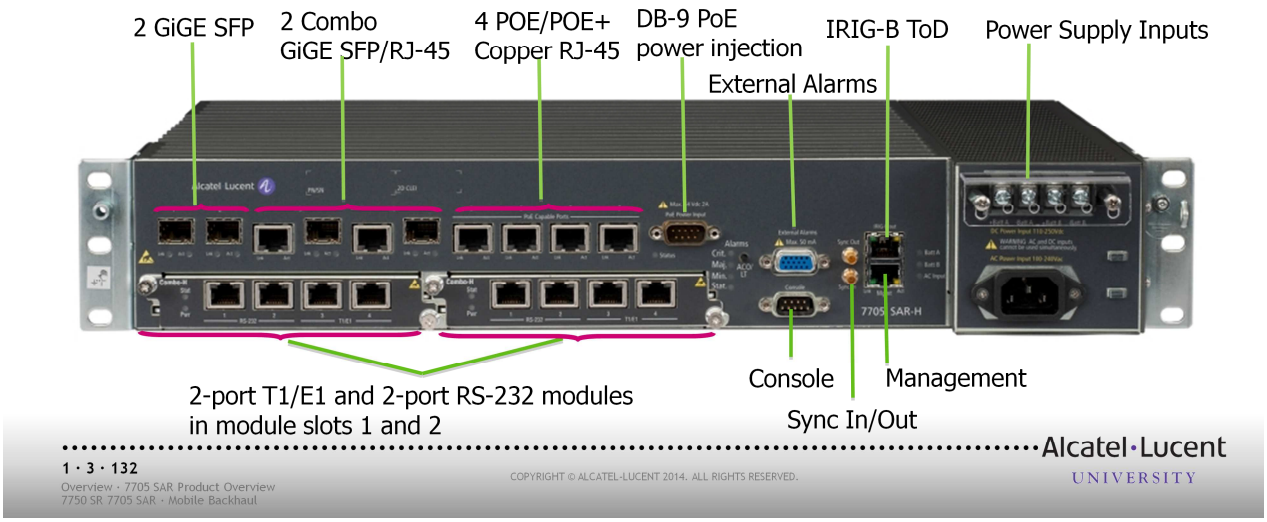
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Chassis Overview [cont'd]

The 7705 SAR-H is a 1.7 RU fan-less member of the SAR family, introduced with the SAR R5.0 software stream.

There are two SAR-H variants:

- SAR-H High voltage: 88-264 V AC/DC
- SAR-H Low voltage: -48/-60 and -24 V DC



The SAR-H is equipped with a single 1 Gigabit Compact Flash card that is accessible at the back of the SAR-H chassis with a screw cover. The slot can be secured with tamper-proof tape. The card provides storage for the boot loader, boot options file, software image and configuration files. It can also be used to provide local storage for logs and accounting information.

The SAR-H Grounding options are Common Bonding Network (CBN) and Isolated Bonding Network (IBN).

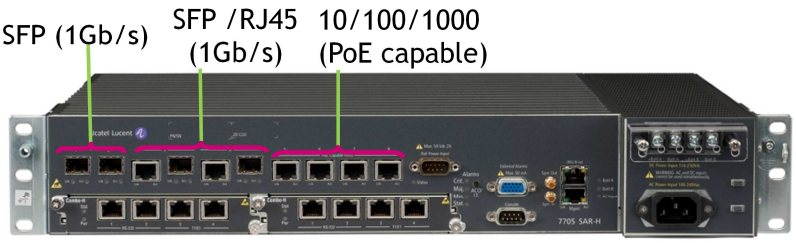
The SAR-H supports the Automatic Discovery Protocol (ADP) for provisioning.

Ongoing Configuration and management can be done using CLI or the 5620 SAM, via the console port or a remote telnet connection to the management port. The port must be preconfigured.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Ethernet Interfaces

- All Ethernet ports are classified for indoor connection
- CAT5e shielded cable is required for 1000BaseT ports
- SFP support matches existing SAR platform options



1	GigE SFP	TRD0+
2	GigE SFP	TRD0-
3	10/100/1000 SFP/RJ-45	TRD1+
4	10/100/1000 SFP/RJ-45	TRD2+
5	10/100/1000 Copper, PoE onboard power	TRD2-
6	10/100/1000 Copper, PoE onboard power	TRD1-
7	10/100/1000 Copper, PoE+ external power supply	TRD3+
8	10/100/1000 Copper, PoE+ external power supply	TRD3-

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-H chassis is equipped with eight Ethernet ports.

- Ports 1 and 2 are GigE SFP ports.
- Ports 3 and 4 are 10/100/1000 SFP/RJ-45 ports.
- Ports 5 to 8 are Power over Ethernet (PoE) [P-O-E] capable, via 10/100/1000 RJ-45 copper.
  - Ports 5 and 6 support 10/100/1000 Copper Internal PoE capable using the onboard power supply. In this mode, 15.4 W standard PoE is available.
  - Ports 7 and 8 are 10/100/1000 Copper PoE+ capable external ports.
  - Only 1 port of each pair (5/6 and 7/8) can support PoE+ at a time.
  - PoE power mode A is supported, including IEEE 802.3at, and 802.3af.

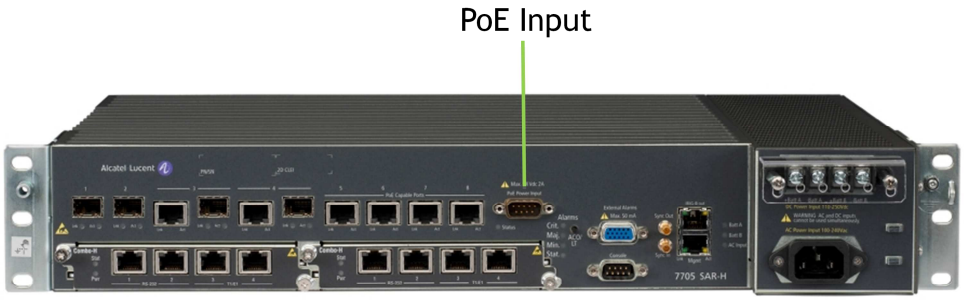
All of the Ethernet ports are classified for indoor connections.

CAT5e shielded cable is required for 1000BaseT ports.

The SFP support matches other existing SAR platforms.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Power over Ethernet Interfaces



- Using an external power supply connected through the PoE power injecting port provides the following enhanced capabilities
  - Up to 4 PoE (15.4W)
  - Up to 3 PoE and 1 PoE+ (34W)
  - 1 PoE and 2 PoE+
- Two external power supply options are available (matching the SAR-H high and low-power variants; using a DB-9 connector to the SAR-H, the power supply provides increased PoE power at 54V DC (nominal) power output

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-H supports the ability to connect an external power supply through the PoE power injecting port, to provide enhanced capabilities including:

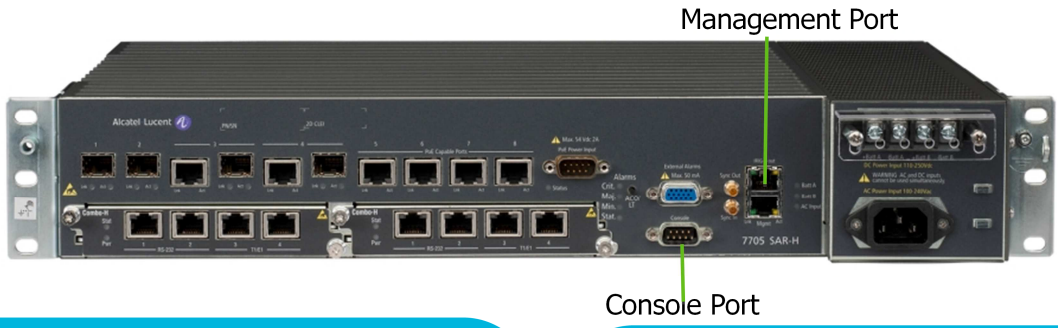
- 15.4W [watts] for up to four PoE,
- 34W for up to three PoE and one PoE + [plus], and
- 1 PoE and 2 PoE+ [plus]

Two external power supply options are available, one for the SAR-H high-power variant and one for the low-power variant.

The external power supply uses a DB-9 connecter to the SAR-H to provide the increased PoE power at 54 volts DC (nominal) power output.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Console and Management Interfaces



- The SAR-H console port uses a shielded DB-9 connector (for EMC compliance)
- The port provides serial access to the SAR-H
- Provides an RS-232 CLI Craft Terminal Interface
- Supports the following speeds:
  - 9600, 19200, 38400, 57600 and 115200 baud
  - Default is 115200, 8N1

- The SAR-H out-of-band management Ethernet port provides a mechanism to access the node via Telnet or SSH
- It is a copper RJ-45 port
- It supports:
  - Full/Half duplex operation
  - 10/100M speed
  - auto-negotiation
  - Telnet access from a PC connected to the network

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Console port on the front of the 7705 SAR-H provides serial access to the SAR-H.

The interface supports connection to RS-232 CLI Craft Terminals at speeds of 9600, 19200, 38400, 57600 or 115200 baud. The Default speed is 115200, 8N1.

To establish a console connection, you need an ASCII terminal or a PC running terminal emulation software and a shielded DB-9 cable.

The shielded cable is required to maintain EMC-compliance.

For management using Telnet access, you can use a connection to the Ethernet Management port, which provides the same options for user and administrator access as those available through the Console port.

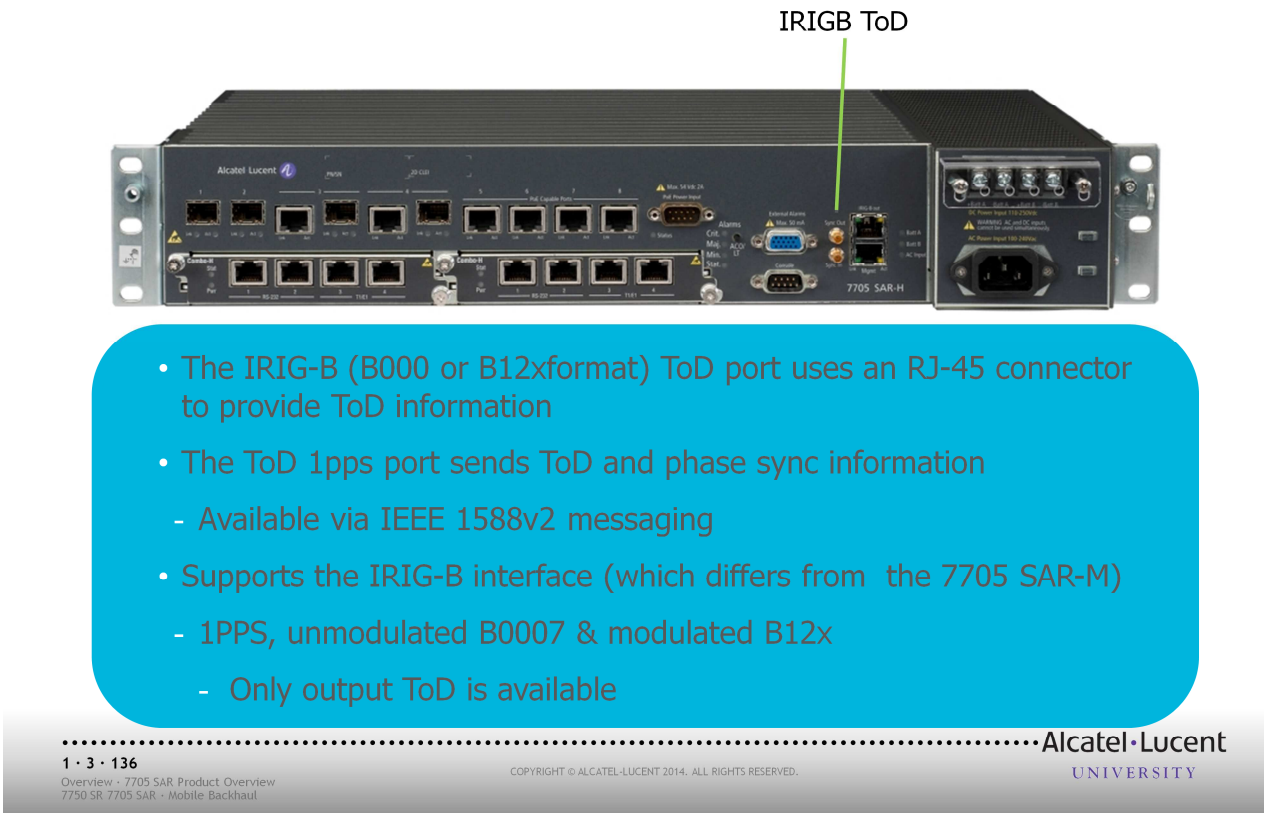
To establish a Telnet connection to the SAR-H from a PC or workstation connected to the network, the SAR-H must be initialized and the management port must be configured for access.

You can configure the management port using the 5620 SAM or using the CLI [c-l-i] bof *address* command.

For the CLI command, the IP-prefix in the format *a.b.c.d* [a dot b dot c dot d] and IP-Prefix length information (which is between 0 to 32) are required.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H IRIGB Time of Day Interface



The IRIG-B Time of Day (ToD) interface is shown.

IRIG-B is a commonly used synchronization source in the utility industry.

The SAR-H sends time of day (ToD) information through the IRIG-B output, using the unmodulated B007 format and modulated B12x format. It does not utilize the IRIG-B control fields.

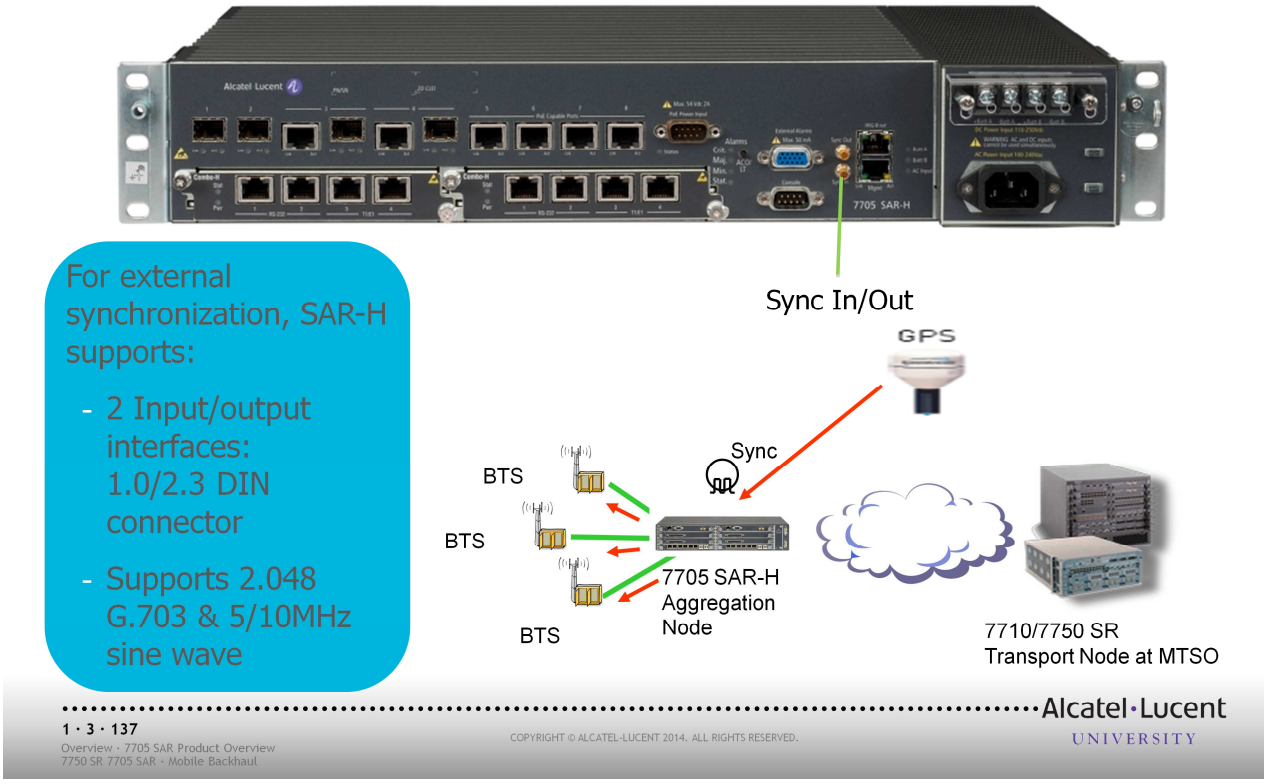
The IRIG-B Time of Day (ToD) / 1 Pulse Per Second (1PPS) interface supports 1 pulse per second unmodulated B0007 and modulated B12x format ToD and phase sync information.

The 1PPS signal is an electrical 1Hz pulse sent out the ToD port at the top of the second. ToD information is made available via IEEE 1588v2 messaging. Only output ToD is available. The interfaces uses an RJ-45 connector to provide ToD information. The Time of Day (ToD) is sent to the base station in a ToD message output datagram, which is generated by the node. The ToD is obtained from a 1588v2 clock. The ToD message datagram contains the number of seconds elapsed since 00:00:00 UTC on January 1st 1970 (Unix epoch).

Base stations may use the ToD for phase alignment and special services (such as the Multimedia Broadcast Multicast Service (MBMS)). MBMS allows mobile providers to broadcast or multicast multimedia to its subscribers and requires time synchronization amongst base stations.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H External Synchronization Interfaces



The SAR-H can receive or provide an external reference frequency through a mini 1.0/2.3 coaxial connection located on the front of the chassis.

The connections support:

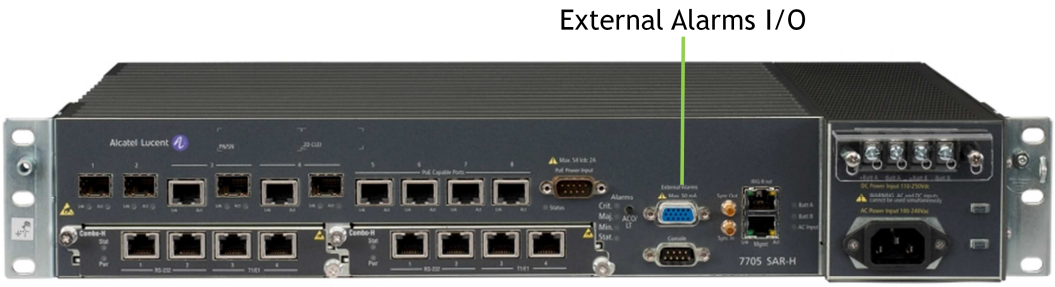
- 2 external Input/output: 1.0/2.3 DIN connector, and
- 2.048 G.703 & 5/10MHz sine wave

The interfaces must be configured to accept either a 2.048 MHz G.703 compliant signal OR a 5 or 10 MHz sine wave.

Note that if all sync references are shutdown, the node sync goes free run; however, if the references are administratively “up” but operationally “down,” then the node sync runs as holdover.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H External Alarm Interface



- The SAR-H Alarm interface uses an HD-15 connector classified for indoor and permanent connection
- Alarm interfaces are 5V-tolerant and outputs can source a max of 100mA
- Connector supports three sets of alarm output contacts and four alarm input contacts
- Each of the 4 inputs can be configured with:
  - User configurable name
  - User configurable description
  - User configurable administrative state
  - User configurable detect and clear de-bounce timers
  - Association of up to 4 user-defined alarms with customizable description, severity and action

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-H external Alarm interface uses an HD-15 connector classified for indoor and permanent connection.

Alarm interfaces are 5-volt tolerant, and outputs can source a maximum of 100 milli amps.

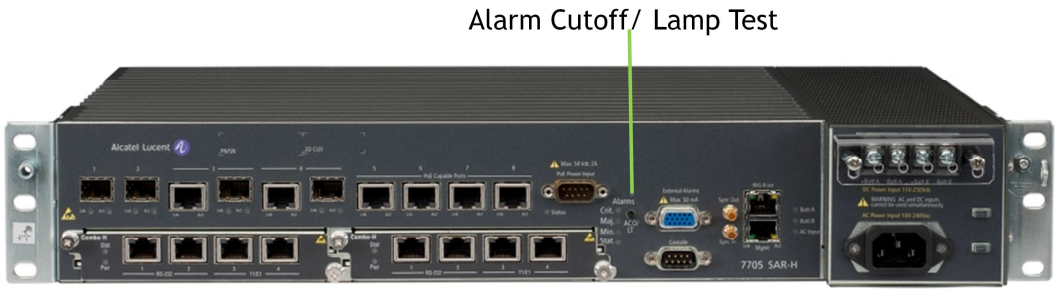
The connector supports three sets of alarm output contacts and four alarm input contacts.

Each of the 4 inputs can be configured by the user with:

- A User name,
- A description,
- An administrative state,
- Detect and clear de-bounce timers, and
- Association of up to 4 user-defined alarms with customizable description, severity and action.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Audible Alarm Cut-Off / Lamp Test Button



- The Audible Cutoff/Lamp Test (ACO/LT) button performs two functions:
  - All LEDs under software control will illuminate while the button is pressed
  - Pressing the button will turn off all external alarm relay control bits; external alarms will trigger again on new alarm conditions.
- The ACO is also available on the rear of the shelf, along with the system alarm LEDs, to provide flexible mounting options

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SAR-H chassis supports an Audible Cutoff/Lamp Test (ACO/LT) button. When pressed, the ACO performs two functions: all LEDs under software control illuminate, and all external alarm relay control bits are turned off. External alarms will trigger again upon new alarm conditions.

The ACO is also available on the rear of the chassis, along with the system alarm LEDs, to provide flexible mounting options.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Chassis Leds

LED	Tested by ACO/LT	Label	LED Color	LED State	Status Condition
Logo	No	<TBD>	White	Solid	On
			Unlit		No power or faulty power
System Status *	Green	Stat	Green	Solid	Operationally up
			Green	Blinking	Initializing
			Unlit		Operationally down
Ethernet Link	No	Lnk	Green	Solid	Valid communication link
			Amber	Solid	Valid communication link, PoE enabled
			Unlit		No link, or operationally down/disabled/shutdown
Ethernet Activity	No	Act	Amber	Blinking	Receive or transmit activity
			Unlit		Down, or disabled
Critical Alarm *	Red	Cri	Red	Solid	Critical alarm
			Unlit		No alarm
Major Alarm *	Red	Maj	Red	Solid	Critical alarm

* Also available on rear of chassis

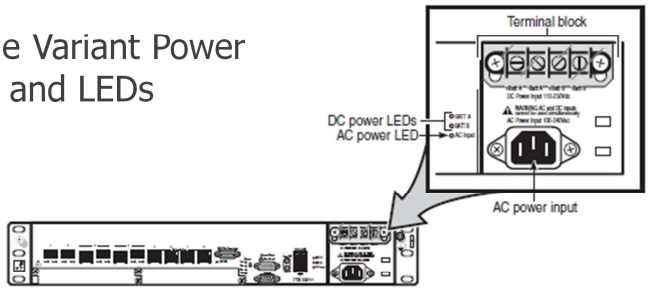
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This slide lists the LEDs that appear on the SAR-H chassis. LED color, state and status condition are indicated.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

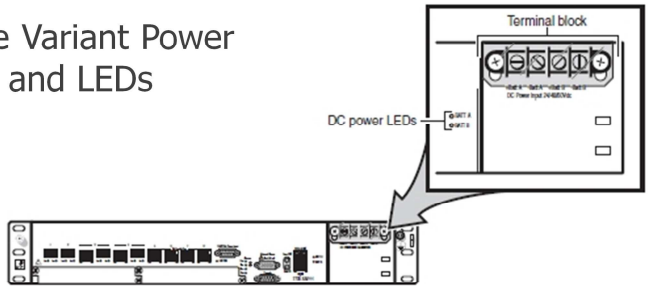
SAR-H Power Connectors

- High Voltage Variant Power Connectors and LEDs



Caution: High-voltage DC and AC power inputs cannot be used simultaneously.

- Low voltage Variant Power Connectors and LEDs



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Both the low and high voltage variants of the SAR-H have a standard, single terminal block (four terminals) attached to the front of the chassis.

The terminals provide access for two independent power feeds to provide power redundancy for the system.

DC power is supplied by a DC circuit for the low-voltage +24 Volts DC and -48/-60 Volts DC systems, and high-voltage 110 to 250 volts DC systems.

The high-voltage variant of the SAR-H also has a standard single AC input feed below the DC terminal block.

When the AC power feed is used, or when only one DC power feed is used, the system does not have power supply redundancy.

The High-voltage DC and AC power inputs cannot be used simultaneously. The power system has no field-replaceable parts.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Power Leds

LED	LED	Tested by ACO/LT	Label	LED Color	LED State	Status Condition
Low Voltage DC	Battery Feed A	No	Bat-A	Green	Solid	input power
				Unlit		power not installed or not connected
	Battery Feed B	No	Bat-B	Green	Solid	
				Unlit		
High Voltage AC/DC	Battery Feed A	No	Bat-A	Green	Solid	input power
				Unlit		power not installed or not connected
	Battery Feed B	No	Bat-B	Green	Solid	input power
				Unlit		power not installed or not connected
	AC Input	No	AC	Green	Solid	input power
				Unlit		
Power over Ethernet	PoE power input	No	PoE	Green	Solid	PoE power
				Unlit		no PoE power, no power supply, or faulty power

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This slide lists the status of the power LEDs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Module Slots

Two module positions are available on the 7705 SAR-H chassis:

- Capable of TDM and packet services
- Hot swap/insertion of plug-in modules
- Blanking plates are provided for EMC and thermal reason if no module is installed

MDA Number	Description
1	Main Assembly Ethernet Ports (8)
2	SAR-H module position 1
3	SAH-H module position 2



The SAR-H supports two module slots. The 4-port T1/E1 ASAP and RS-232 module, also called the ASAP/Serial Combo module, is the plug-in module currently supported for the module slots.

When deployed in the SAR-H chassis, you can configure the module and ports using the console or Telnet interfaces on the SAR-H chassis.

The IOM is an integral part of the module that must be activated first, in order to configure the module parameters.

To activate the IOM you can use the CLI commands card and card-type. The card slot number is always 1. The card type is “iom-sar.”

The CLI commands “MDA” and “MDA-type” are used to configure the module. The MDA numbers for the SAR-H chassis ports and module ports are:

→ 1, for the Ethernet ports on the main chassis (8),

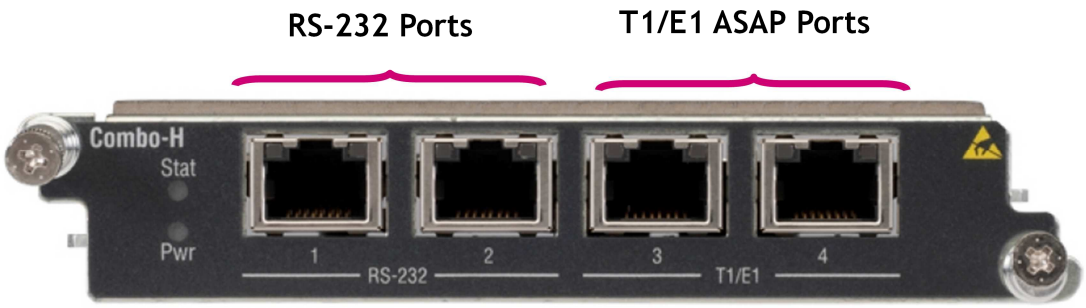
→ 2, for 7705 SAR-H module position 1, and

→ 3, for 7705 SAR-H module position 2

You can configure the Ports using the CLI *port* command, or using the 5620 SAM.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4-port T1/E1 ASAP and RS-232 Combination Module



The 4-port T1/E1 ASAP and RS-232 combination module supports RS-232 and T1/E1 services when installed in a SAR-H module slot position 1 or 2.

- Ports 1 and 2 are RS-232 ports
- Ports 3 and 4 are T1/E1 ASAP ports

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 4-port T1/E1 ASAP and RS232 module supports RS-232 and T1/E1 services when installed in a SAR-H module position 1 or 2. Ports 1 and 2 are RS-232 capable ports, and Ports 3 and 4 are T1/E1 ASAP ports.

The RS-232 ports support RS-232 / V.24 for connecting remote SCADA equipment.

Supported RS-231/V.24 characteristics include:

- Asynchronous operation,
- Full duplex mode, and
- Operation at 600, 1200, 2400, 4800, 9600, 19200, 38400, 56000 baud

The RS-232 ports also operate in Cpipe mode and can initiate or terminate Cpipes from the 12 port SDI MDA, if required.

- The ports also support interoperation with legacy 36XX Mainstreet products.

The RS-232 ports use the same configuration and HCM sub-rate multiplexing technology as the SAR-8/SAR-18 12-port SDI Card. For more information, refer to the slides on the SAR-8 and SAR-18 SDI card in Module 7: 7705 SAR-8/SAR-18: 12-port Serial Data Adapter Card.

Ports 3 and 4 are 2 T1/E1 capable ports. They provide the same functionality as the ASAP ports on the 7705 SAR-8/F/M, with the exception of ATM support. This includes, for example, TDM (for 2G BTS), IP over PPP/MLPPP (for CDMA BTS). IPCP, CEM, frame relay, and HDLC. For more information, you can refer to the slides on the SAR-8/SAR-18 interface adapter cards, such as the SAR-8/SAR-18: 16/32 Port T1/E1 ASAP (v1/v2), or the SAR-M or SAR-F System Overview modules.

The ports support TDM/CESoPSN, SATOP and ML-PPP (bonding the two ports), as well as both network and access mode connectivity.

An adaptor cable is also available to convert the RJ-45 ports to BNC for E1 ports. The port should be configured for 75 ohm impedance in this case.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

RS-232/V.24 ports are 8-pin RJ-45 connectors.

RS-232/V.24 Port Pinout:

Pin	Function	Description
1	RI	Ring Indicator
2	DCD	Carrier Detect
3	DTR	Data Terminal Ready
4	GND	Signal/Common Ground
5	RxD	Receive Data
6	TxD	Transmit Data
7	CTS	Clear To Send
8	RTS	Request To Send

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The RS232/V.24 ports are 8-pin RJ-45 connectors. This slide shows the port pinouts.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

T1/E1 ASAP Port Pinout

T1/E1 ASAP ports use 8-pin RJ-45 connectors.

T1/E1 ASAP Port Pinout:

Pin	Function
1	Receive +
2	Receive -
3	
4	Transmit +
5	Transmit -
6	
7	
8	

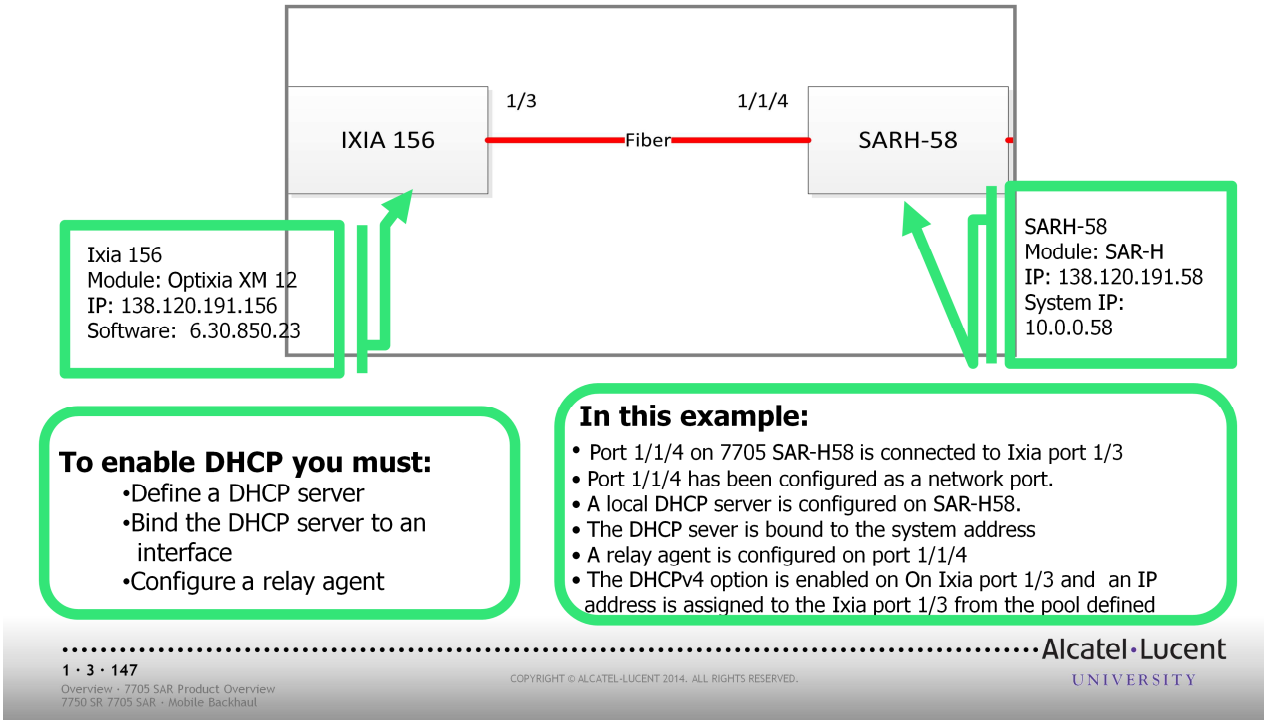
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

T1/E1 ASAP ports use 8-pin RJ-45 connectors. This slide describes the T1/E1 ASAP port pinout.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAR-H Local DHCP ServeR

This example illustrates a SAR-H configured with a local DHCP server and relay agent on a network interface. The application applies to the base router context.



The SAR-H is based on the 7705 SAR software steam. It has feature parity with the 7705 portfolio of platforms at this release level (except where noted in the Release Notice and customer documentation).
As described in earlier slides, the SAR-H also meets utility substation IEEE 1613 Class 1 and IEC 61850-3 specifications for demanding EMI and environmental requirements and supports security capabilities that meet NERC Critical Infrastructure Protection (CIP) compliance.

In addition, the SAR-H also supports DHCP (Dynamic Host Configuration Protocol) server functionality to handle assignment of IP addresses, subnet masks and default gateway information to clients that do not have an IP address.

The local DHCP server feature provides a standards-based DHCP Server implementation for IPv4 address allocations and management.

The local DHCP Server can be defined for the base router or VPRN interfaces.

Locally attached hosts can obtain addresses directly from the SAR-H DHCP server.

Routed hosts receive addresses through a relay point in a typical network.

The example shown in this slide illustrates a SAR-H configured with a local DHCP server and a relay agent on a network interface. The application applies to the base router context.

In this example:

• Port 1/1/4 on 7705 SAR-H58 is connected to Ixia port 1/3,

• Port 1/1/4 has been configured as a network port, and

• A local DHCP server is configured on SAR-H58.

• The DHCP sever is bound to the system address and a relay agent is configured on port 1/1/4.

• The DHCPv4 option is enabled on Ixia port 1/3 and an IP address is assigned to the Ixia port 1/3 from the pool that is defined.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

15 7705 SAR-Hc System Overview

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc: DIN Mount Hardened IP/MPLS



7705 SAR-Hc	FEATURE HIGHLIGHTS
CHASSIS	2.5Gb/s HD, full featured IP/MPLS router 9.1cm x 15.2cm x 17.8cm (3.6” x 6” x 7”) DIN rail mount, Rated IP40 design Temperature and EMC hardened -40 to +65°C Fanless operation IEEE 1613, IEC 61850-3 compliant
INTERFACES	2 x 10/100/1000 SFP 2 x 10/100/1000 copper Ethernet 2 x 10/100/1000 (PoE capable) 2 x RS232 Serial
SECURITY FEATURES	NAT, Encryption
POWER	Low voltage (20-75 VDC) High voltage (88-300V AC/DC) provide by external DIN Mount power supply Redundant DC feeds

Temperature and electromagnetic hardening for harsh environments

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR-Hc is a compact, secure DIN rail-mounted IP/MPLS router that supports 2.5 Gb/s of full-duplex switch capacity. It is designed for flexible installation and supports a number of mounting options - DIN rail-mounted or panel/wall-mounted – so that it can be used in a variety of cabinets and enclosures.

The 7705 SAR-Hc is a temperature- and Electromagnetic Compatibility (or EMC)-hardened platform. It is passively cooled, with vents on the top and bottom of the unit. The router supports an operating temperature range from -40 to 65°C.

The 7705 SAR-Hc has six 10/100/1000 Mb/s Ethernet ports and two RS-232 ports.

NAT and encryption security features are supported.

The 7705 SAR-Hc supports redundant DC input feeds with a nominal +/-24 VDC, +/-48 VDC, or +/-60 VDC rating. When used with the separately orderable 100W High Voltage Power Supply, the chassis can be used for AC or high-voltage DC applications.

Some features supported on this platform require a Right-to-Use (RTU) license. The OS [O-S] licenses for the 7705 SAR-Hc are sold separately.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc Chassis

One circuit board to support all functions of the router and connectors for node management and alarms

All interfaces and power inputs located on the front of the chassis

Status and alarm LEDs visible on the front of the chassis



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

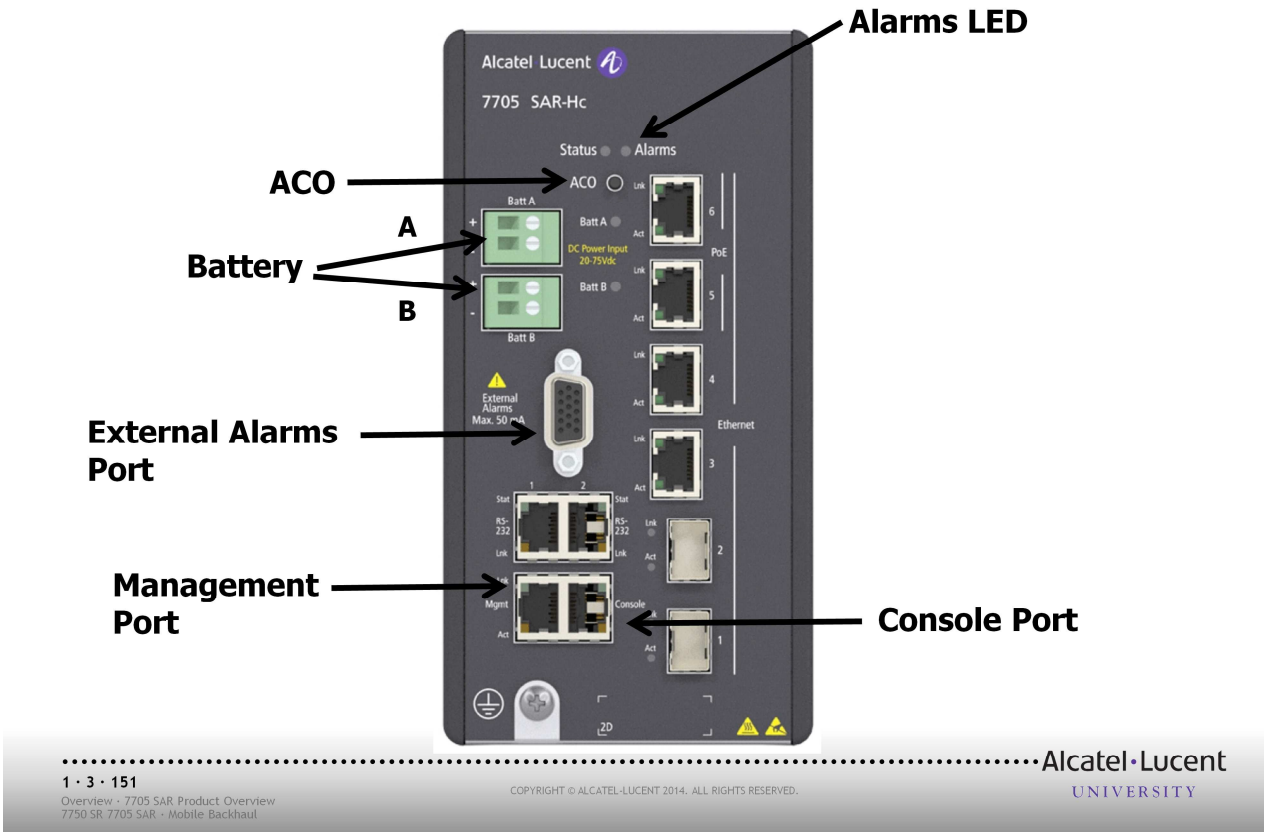
The 7705 SAR-Hc chassis has one circuit board that supports all functions of the router (including control and switching, Ethernet and RS-232 interfaces, and indicator LEDs) and connectors for node management and alarms.

All physical connections are made at the front of the chassis, including the chassis ground connection and two DC power inputs for battery redundancy. There are no back panel connections. Status and alarm LEDs are also visible on the front of the chassis.

A conformal coated variant of the SAR-Hc chassis is available.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc: Control and Switching



The control and switching functions include the console and management interfaces, the alarm functions, and system LEDs.

Control and switching on the 7705 SAR-Hc provide:

- Node management interfaces to the 7705 SAR-Hc (Management (Ethernet) and Console),
- An interface for external alarm inputs and outputs, and
- Routing, switching, and services functions for the entire system

The Management port supports half-duplex and full-duplex communication via 10/100 or auto-negotiated Ethernet. The Management port provides a channel to download software and configuration files and to manage the system.

The Console port uses an RJ-45 connector to provide serial console access for the 7705 SAR-Hc. The Console port is used to configure router and system parameters. It can also be used for monitoring purposes. It supports baud rates of 9600, 19,200, 38 ,400, 57,600, and 115,200. The port also supports 8 data bits, no parity, and 1 stop bit. The Console port provides connectivity for the RS-232 CLI.

The External Alarms port provides access to two sets of alarm output contacts and four alarm inputs. All alarm interfaces are rated for 5 VDC and 100 mA [milliamp](source or sink).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

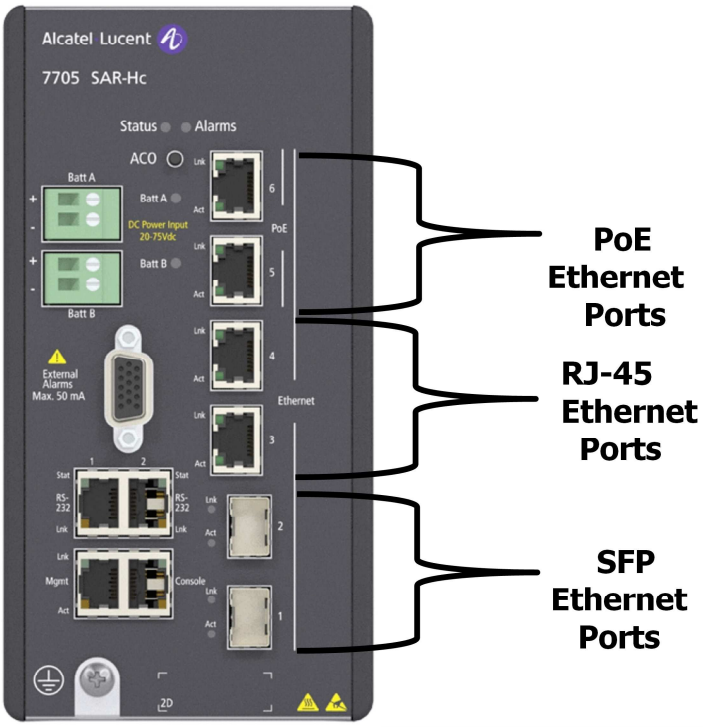
7705 SAR-Hc: Ethernet Ports

Six Ethernet ports:

Two SFP Gigabit Ethernet ports (ports 1 and 2)

Two RJ-45 10/100/1000 Ethernet ports (ports 3 and 4)

Two PoE-capable RJ-45 10/100/1000 copper Ethernet ports (ports 5 and 6)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR-Hc chassis is equipped with six Ethernet ports, using port numbers 1 through 6:

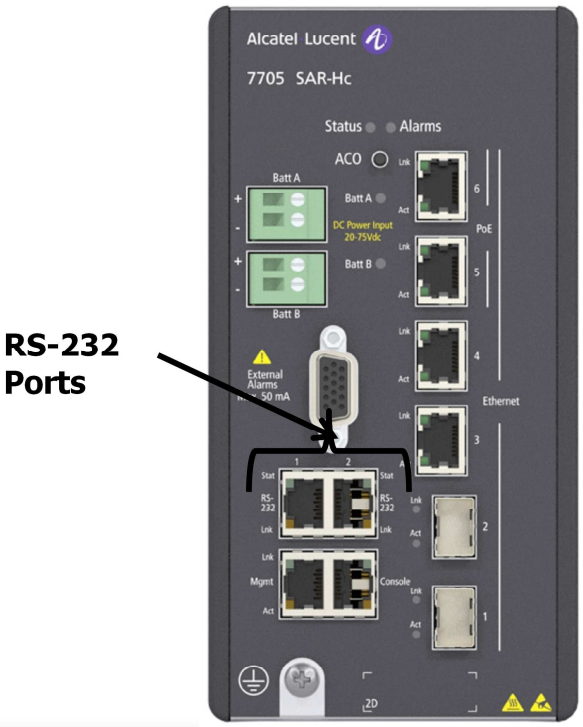
- Two SFP Gigabit Ethernet ports (ports 1 and 2),
- Two RJ-45 10/100/1000 Ethernet ports (ports 3 and 4), and
- Two PoE-capable RJ-45 10/100/1000 copper Ethernet ports (ports 5 and 6)

These ports provide access for a wide variety of Ethernet interface speeds and types, including 1000Base-T and optical. The SFP modules are hot-swappable and field-replaceable by qualified personnel. When making connections to the Ethernet ports, shielded cable must be used to maintain EMC-compliance.

PoE is available on ports 5 and 6. Both ports can be used for PoE simultaneously. Both ports are also capable of supporting PoE+; however, if one port is operating at PoE+, the other port can only operate at PoE. Ports 5 and 6 can also operate in non-PoE mode. The 7705 SAR-Hc PoE ports use PSE pinout Alternative A (MDI-X).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc: RS-232 ports



Two RS-232 ports:

Typically used for SCADA equipment

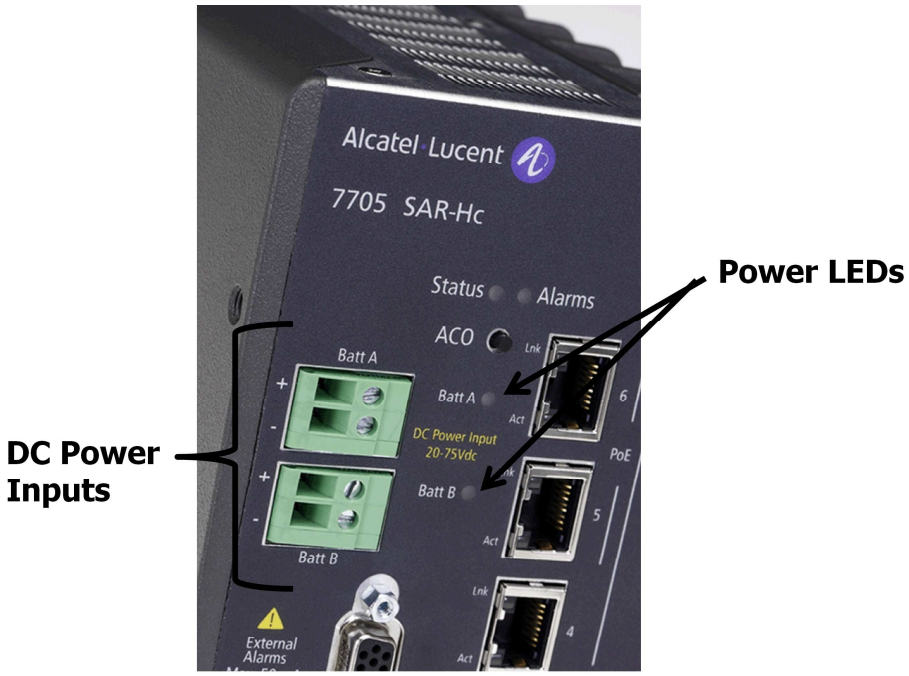
Use RJ-45 connectors

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR-Hc is equipped with two RS-232 ports. These ports are typically used for connecting SCADA equipment. The RS-232 ports use RJ-45 connectors. The port number for RS-232 ports can be 1 or 2.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc: Power Supply Inputs



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR-Hc has dual-feed DC power inputs on the front of the chassis. The inputs provide access for two independent power feeds, allowing power redundancy for the system. The system is equipped with a single internal power supply that operates at +/–20 VDC to 75 VDC.

When the system is being used in high-voltage applications, a 100W High Voltage Power Supply is available. The 100W High Voltage Power Supply input operates from 85 VAC to 264 VAC or from 88 VDC to 300 VDC. The input uses a standard IEC320-C14 male connector and 1 ft (0.3 m) of cable. The output is 54 VDC, with 6 ft (1.8 m) of cable that can be connected directly to one input feed (Batt A or Batt B) on the chassis. If required, the chassis can operate one battery pair with a low-voltage DC power supply and the other pair with the 100W High Voltage Power Supply (using AC input).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc: Cooling

7705 SAR-Hc chassis is passively cooled using fans for heat dissipation

Overheat alarm is raised if the chassis internal temperature exceeds 203°F (95°C)

Overheat alarm is cleared when the chassis internal temperature drops below 203°F (95°C)



The 7705 SAR-Hc chassis is passively cooled using fans for heat dissipation.

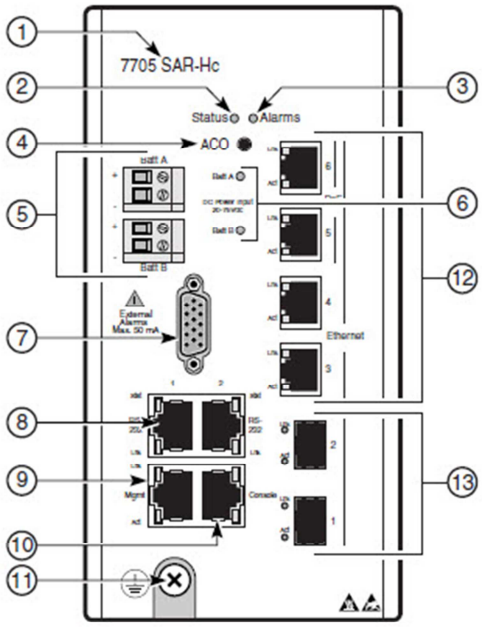
An Overheat alarm is raised if the chassis internal temperature exceeds 203°F (95°C).

The overheat alarm is cleared when the chassis internal temperature drops below 203°F (95°C).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc LEDs and connectors

1	Product Logo	White: power to the router is on and the system is receiving power feed from source A and/or source B, and the power rails are at their proper levels Unlit: no (or faulty) power to the router
2	Status	Combined status of the router's 3 main functional blocks Green (solid): system is operationally up Green (blinking): one or more functional blocks is initializing Unlit: system is operationally down



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Following are the LEDs and connectors and their descriptions on the 7705 SAR-Hc.

The numbers correspond to those indicated in the diagram of the 7705 SAR-Hc.

1 The Product Logo

If White: power to the router is on and the system is receiving a power feed from source A and/or source B, and the power rails are at their proper levels

If Unlit: there is no (or faulty) power to the router

2 Status

Combined status of the router's 3 main functional blocks

If Green (solid): system is operationally up

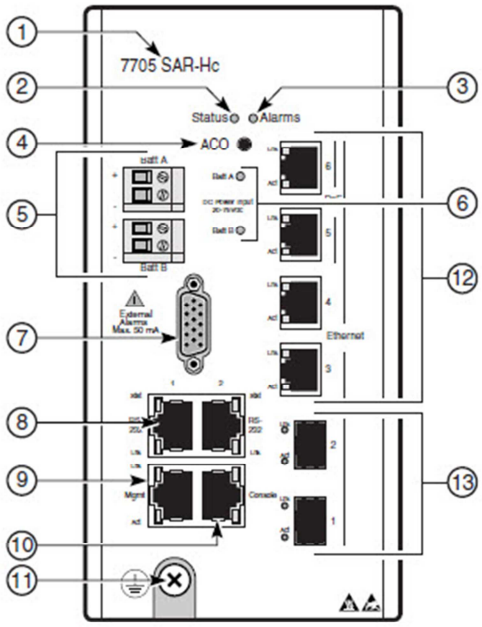
If Green (blinking): one or more functional blocks is initializing

If Unlit: the system is operationally down

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc LEDs and connectors

3	Alarms	Red (solid): critical alarm has been raised Red (blinking): major alarm has been raised Yellow: minor alarm has been raised
4	ACO (Audible Alarm Cutoff) Push Button	Verifies LED operation, turns off the external alarm control bits, and controls the ADP interface during startup
5	+Batt A/-Batt A +Batt B/-Batt B Connector	DC power connector is a dual power feed input for redundant DC supplies; can also be used for redundant AC power with the 100W High Voltage Power Supply



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

3 Alarms LEDs

If Red (solid): a critical alarm has been raised

If Red (blinking): a major alarm has been raised

If Yellow: aminor alarm has been raised

4 ACO (Audible Alarm Cutoff) Push Button

This Verifies LED operation, turns off the external alarm control bits, and controls the ADP interface during startup

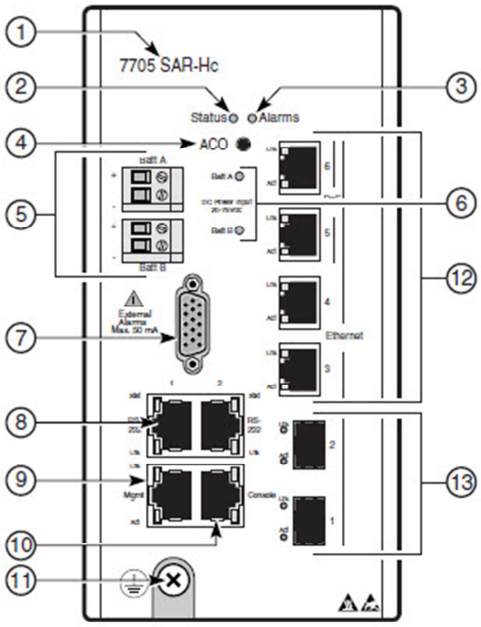
5 +Batt A/-Batt A +Batt B/-Batt B Connector

The DC power connector is a dual power feed input for redundant DC supplies; and can also be used for redundant AC power with the 100W High Voltage Power Supply

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc LEDs and connectors

6	Batt A Batt B	Green: input power is present and operational Unlit: power supply is not installed or the power feed is not connected
7	External Alarms	Serial port that uses an HD-15 female connector; and receives input signals from four external alarm devices and provides output signals through two sets of contacts



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

6 Batt A Batt B LEDs

If Green: the input power is present and operational

If Unlit: the power supply is not installed or the power feed is not connected

7 External Alarms

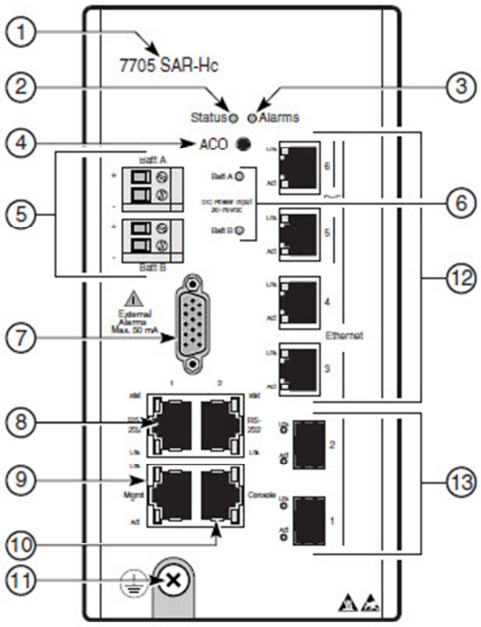
This serial port uses an HD-15 female connector; and receives

input signals from four external alarm devices and provides output signals through two sets of contacts

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc LEDs and connectors

8	RS-232 Ports Connector	Typically used for connecting remote SCADA equipment
	RS-232 Ports Stat LED	Green: port is active Unlit: port is down, disabled, in a loopback state, or experiencing HCM synchronization loss
	RS-232 Ports Lnk LED	Amber (solid): communications link experiencing HCM synchronization loss Amber (blinking): port is in a loopback state Unlit: port is not experiencing HCM synchronization loss and is not in a loopback state



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

8 RS-232 Ports Connector

This typically is used for connecting remote SCADA equipment

RS-232 Ports Stat LED

If Green: the port is active

If Unlit: the port is down, disabled, in a loopback state, or is experiencing HCM synchronization loss

RS-232 Ports Lnk LED

If Amber (solid): the communications link is experiencing HCM synchronization loss

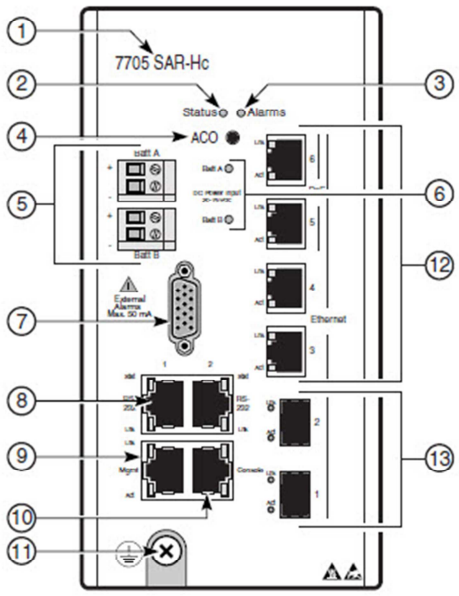
If Amber (blinking): the port is in a loopback state

If Unlit: the port is not experiencing HCM synchronization loss and is not in a loopback state

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc LEDs and connectors

9	Mgmt Port Connector	RJ-45 connector used for the initial system startup, system configuration and monitoring
	Mgmt Port Lnk LED	Amber (blinking): Ethernet link has Rx/Tx activity Unlit: Ethernet link has no activity, is down or disabled
	Mgmt Port Act LED	Green: there is a valid communications link Unlit: no communications link, or that link is operationally down, disabled, or shut down
10	Console port	Uses an RJ-45 connector and is used for the initial system startup, system configuration and monitoring



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

9 Mgmt Port Connector

This RJ-45 connector is used for the initial system startup, system configuration and monitoring

Mgmt Port Lnk LED

If Amber (blinking): The Ethernet link has Rx/Tx [Receive/Transmit] activity

If Unlit: The Ethernet link has no activity, is down or disabled

Mgmt Port Act LED

If Green: there is a valid communications link

If Unlit: there is no communications link, or that link is operationally down, disabled, or shut down

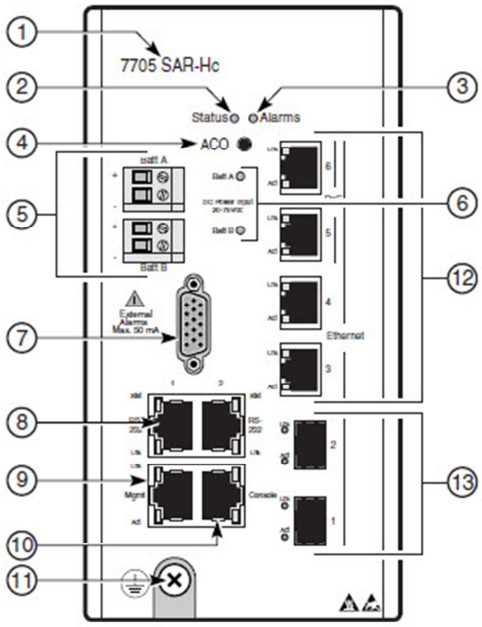
10 Console port

This port Uses an RJ-45 connector and is used for the initial system startup, system configuration and monitoring

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc LEDs and connectors

11	Chassis Ground	Uses an M4 screw and ring lug to allow a direct connection to the building ground from the chassis ground point
12	Ethernet Ports: RJ-45 ports	Four Ethernet ports have an RJ-45 connector for attaching user devices
	RJ-45 ports: Lnk LED	Green: the link is up Amber: a valid communications link has been established and the PoE has been enabled on the port (only applies to ports 5 and 6) Unlit: no link or the link is operationally down, disabled, or shut down
	RJ-45 ports: Act LED	Amber (blinking): port is active Unlit: port is down or disabled



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

11 Chassis Ground

This Ground uses an M4 screw and ring lug to allow a direct connection to the building ground from the chassis ground point

12 Ethernet Ports: RJ-45 ports

These Four Ethernet ports have an RJ-45 connector for attaching user devices

RJ-45 ports: Lnk LED

If Green: the link is up

If Amber: there is a valid communications link has been established and the PoE has been enabled on the port (only applies to ports 5 and 6)

If Unlit: there is no link or the link is operationally down, disabled, or shut down

RJ-45 ports: Act LED

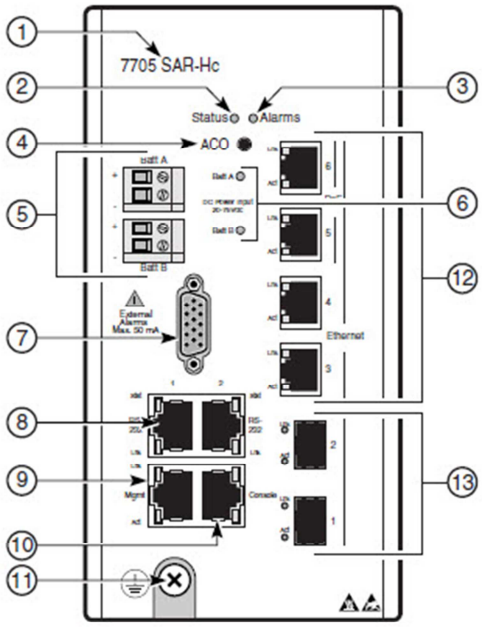
If Amber (blinking): the port is active

If Unlit: the port is down or disabled

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR-Hc LEDs and connectors

13	Ethernet Ports: SFP ports	Receptacles for SFP modules
	SFP ports: Lnk LED	Green: link is up Amber: communications link is valid Unlit: link is disabled or shut down, or SFP optics are installed but no link is present, or no SFP installed
	SFP ports: Act LED	Amber (blinking): port is active Unlit: no port activity



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

13 Ethernet Ports: SFP ports
These are Receptacles for SFP modules

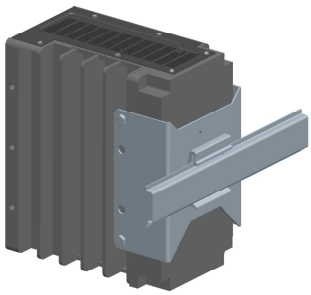
SFP ports: Lnk LED
If Green: the ink is up
If Amber: the communications link is valid
If Unlit: the link is disabled or shut down, or SFP optics are installed but no link is present, or no SFP installed

SFP ports: Act LED
If Amber (blinking): the port is active
If Unlit: there no port activity

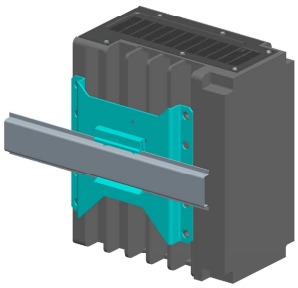
Please note that for Pinout assignments, please consult the Alcatel-Lucent 7705 Service Aggregation Router Release 6.1R1 SARHc Installation Guide.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

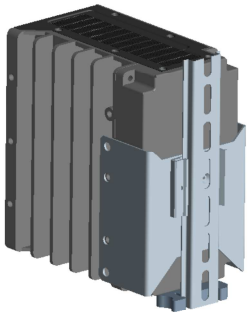
SAR-Hc DIN MOUNTING OPTIONS



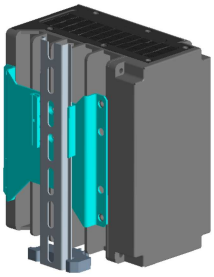
Rear Mount Horizontal DIN



Side Mount Horizontal DIN



Rear Mount Vertical DIN



Side Mount Vertical DIN

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

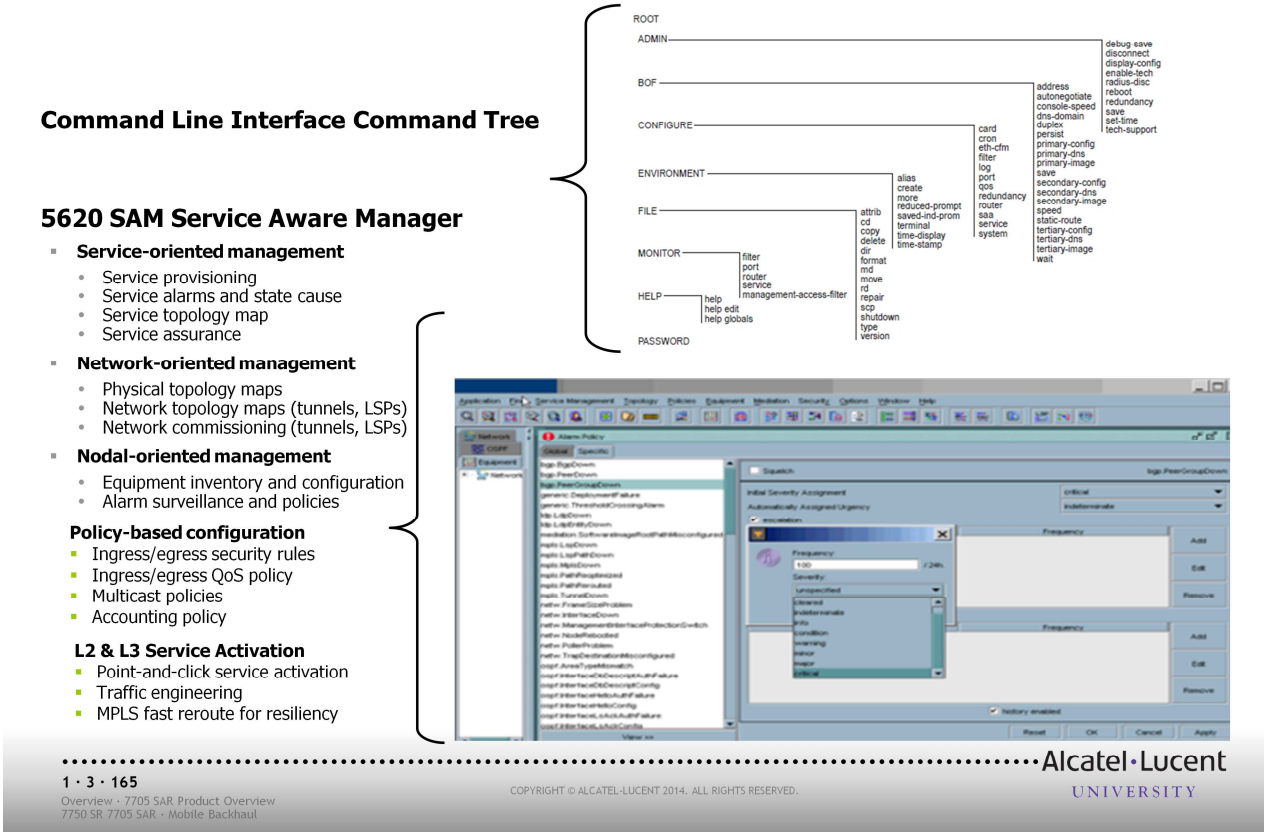
Pictured here are the Horizontal and Vertical DIN rail mounting options.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

16 7705 SAR System Provisioning and Management

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR System Provisioning and Maintenance



The 7705 SAR provides system management and maintenance access via the management ports on the various SAR systems.

Management tools include SNMP, CLI, and the 5620 Service Aware Manger.

CLI is the command-driven interface accessible through the console, Telnet, and secure shell (SSH) that can be used for configuration and management of 7705 SAR routers.

The 7705 SAR CLI command tree is a hierarchical inverted tree. At the highest level is the ROOT level.

Below this level are other tree levels with the major command groups; for example, configuration commands and show commands are levels below ROOT.

As shown in this example, the CLI is organized so that related commands with the same scope are at the same level or in the same context. Sublevels or sub-contexts have related commands with a more refined focus.

The Alcatel-Lucent 5620 Service Aware Manager is a GUI based tool that simplifies and unifies the system configuration and management process.

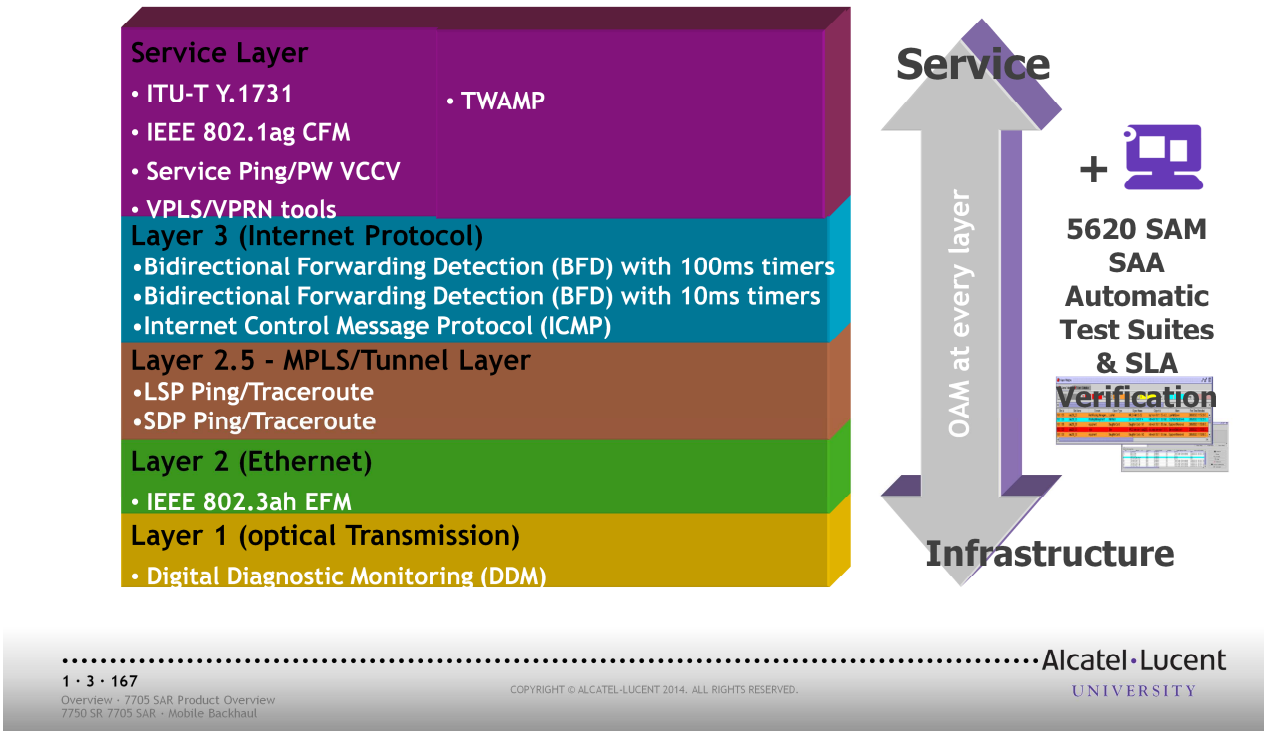
5620 SAM provides unified, end-to-end, service aware management across the 7705 SAR , 7750 SR and MPR-e family of products including automated service provisioning, alarm management, assurance and topology mapping, network oriented management tools including network topology maps and commissioning, and node oriented management including equipment inventory and configuration and alarm surveillance and management.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

17 7705 SAR OAM and Diagnostics

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR OAM toolSEt overview



Delivery of services requires that a number of operations occur properly and at different levels in the service delivery model.

In order to verify that a service is operational, a set of in-band, packet-based OAM tools is provided, with the ability to test each of the individual packet operations.

The 7705 SAR suite of OAM diagnostics supplements the basic IP ping and traceroute operations with diagnostics specialized for the different levels in the service delivery model.

In addition, there are diagnostics for MPLS LSPs, SDPs, and Services within a service.

Diagnostic tools include ICMP and ICMPv6, TWAMP, which is 2-way active measurement protocol, LSP, SDP, Service, VLL, and VPLS MAC.

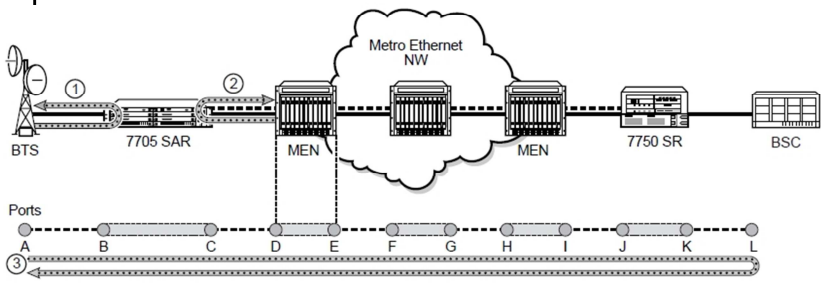
Ethernet OAM capabilities, Ethernet loopbacks, OAM propagation to attachment circuits, LDP status signaling, IP multicast debugging, and Service Assurance Agent.

OAM tools are available via the CLI and the 5620 SAM.

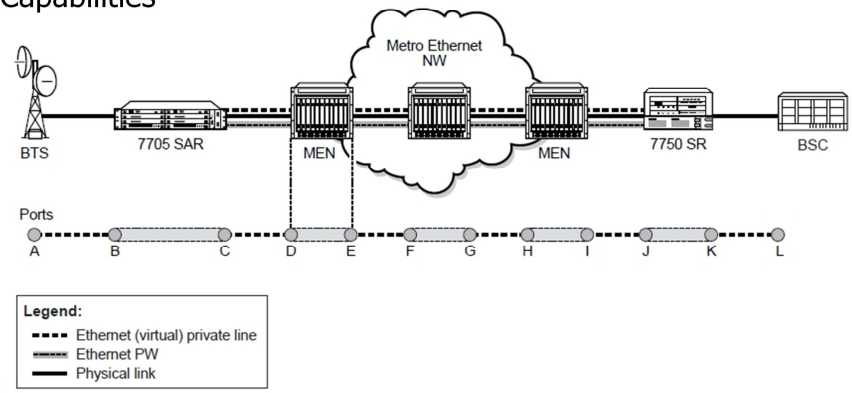
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR Ethernet OAM

EFM OAM (Dot3ah) Capabiities



ETH-CFM (Dot1ag) Capabilities



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR supports various Ethernet OAM capabilities.

• Ethernet Connectivity Fault Management, also called ETH-CFM is supported for network layer OAM according to IEEE 802.1ag (dot1ag) and ITU Y.1731.

Standards include: Loopbacks, Linktrace, continuity checks, and remote defect indicators (RDI).

The "Network layer" refers to an end-to-end context across a network.

ITU-T Y.1731 provides functional enhancements to 802.1ag ETH-CFM, including alarm indication signals and Ethernet signal tests.

CFM Loopback Message for unlabeled packets on Ethernet ports allows for OAM tests to be run before services are setup.

• Performance Monitoring is supported according to the ITU-T Y.1731 standard, including delay measurements, delay variation measurements, and loss measurements .

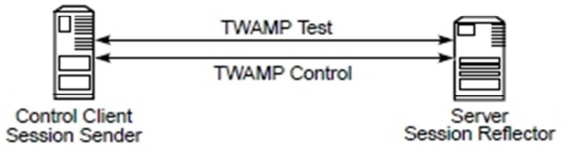
• Ethernet First Mile (EFM) OAM is supported for the transport layer OAM according to IEEE 802.3ah (dot3ah) standards.

"Transport layer" refers to a point-to-point link context or transport hop.

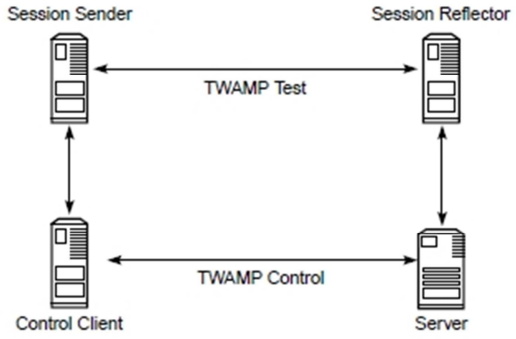
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

TWAMP IP Performance Measuring

TWAMP Typical Implementation



TWAMP Logical Entities



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A 7705 SAR can be configured as a TWAMP server.

TWAMP is the "Two-Way Active Measurement Protocol " (rfc-5357) and is based on OWAMP.

It provides a standards-based method for measuring round-trip IP performance between two devices, including packet loss, delay and jitter.

TWAMP provides a few key capabilities that ICMP does not, including:

- time stamping for delay and jitter measurements,
- time stamps applied at the echo destination (reflector) to enable greater accuracy (processing delays can be accounted for),
- and
- intelligent control plane including Port information negotiation and Number of concurrent tests

TWAMP uses 4 logical entities including:

a control client to initiate TWAMP control session and negotiate security protocols and tests,

a server to negotiate with the control client request to establish the control session,

a session sender to transmit test packets to the session reflector,

and a session reflector to transmit the response packets to the session sender

The 7705 SAR responds when the TWAMP control-client initiates a 'control' session to negotiate the test or tests to be executed, or the security protocol or port to be used.

Once the negotiation takes place the 7705 SAR will

- Timestamp TWAMP packets upon reception,
- Process the TWAMP packets and generate a response, and
- Time stamp once again before transmitting these packets over the wire.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SUMMARY

- Define the roles of the 7705 SAR in the aggregation and backhaul zone of the service provider network
- Describe how the 7705 SAR is used in the service provider network
- Identify the components and functionality of the 7705 SAR
- For release specific hardware and software features, see the corresponding 7705 SAR OS Software Release Notice

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 2
System Operation

Module 1
System Initialization and CLI

TER36075_V3.1-SG-English-Ed1 Module 2.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives



Upon completion of this module, you should be able to explain:

- Access options
- System Initialization
  - Initialization process
  - Boot Option File (BOF)
  - Configuration File
- Command Line Interface (CLI)
  - Basic CLI commands
  - Command contexts and navigation
  - File structure, file management system

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — Access options	**7**
2 — System Initialization	**9**
3 — Command Line Interface (CLI)	**15**
4 — vi Editor+Rollback	**26**
5 — Transactional Configuration	**44**

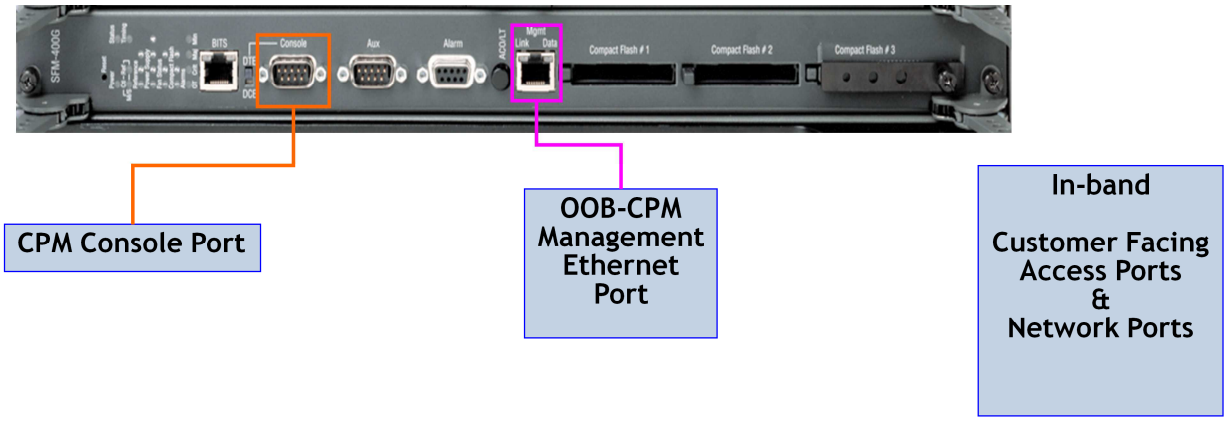
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Access options

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Physical Access

SF/CPM card in SR-7 or SR-12



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

There are three ways to access a node:

1. The console port, a DB-9 serial port, which is enabled by default. Initially, the node must be configured through this serial port.

   The default settings are:

   Baud Rate: 115,200

   Data Bits: 8

   Parity: None

   Stop Bits: 1

   Flow Control: None

2. The CPM management Ethernet port, a 10/100 Ethernet management port located on the front of the CPM, which must be initialized first (in the BOF or through the console). This is considered Out Of Band (OOB) traffic.
3. Through the access and network ports. These are the in-band ports that carry the network and customer traffic.

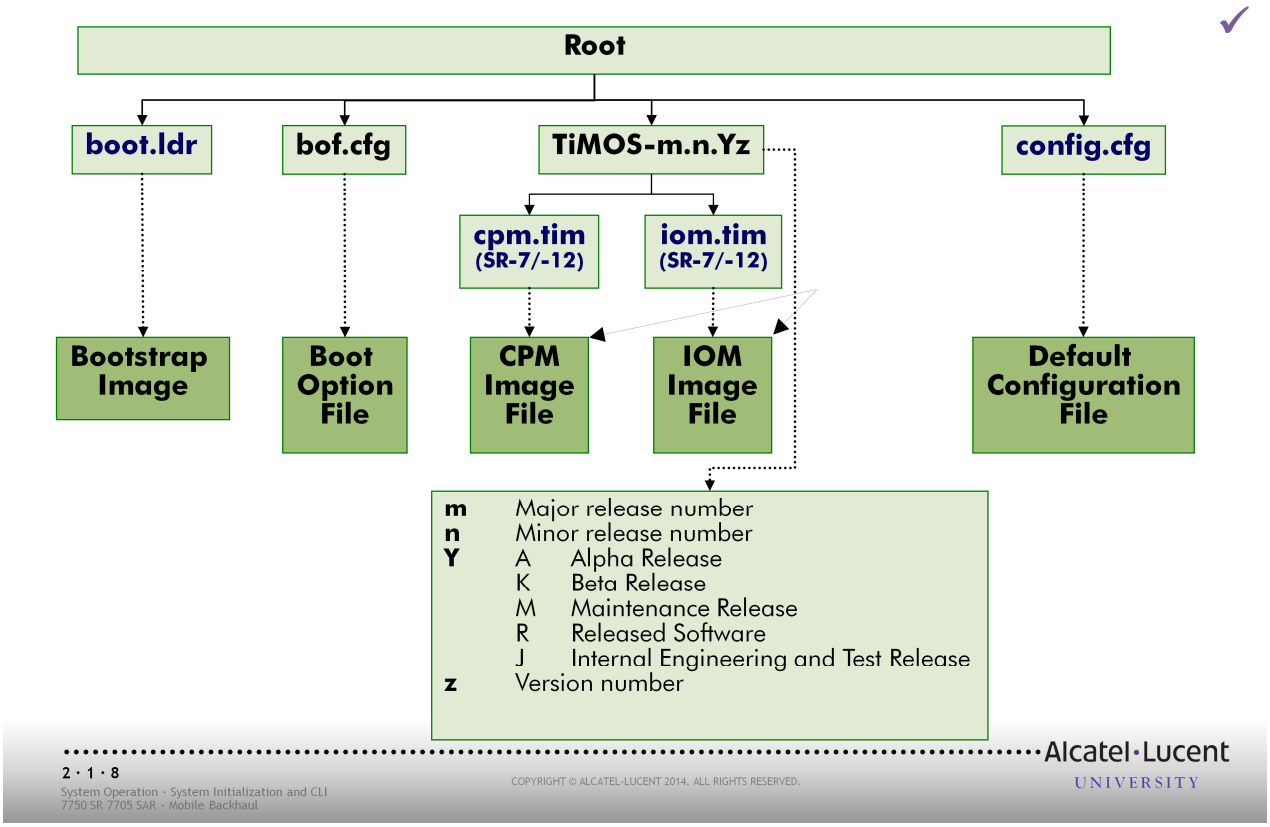
Note: By default, a node can only be accessed through the console port. Once a management IP address and port have been configured, the Ethernet or in-band management ports can be used, through the use of Telnet or SSH.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 System Initialization

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

System Initialization Components



The following files are required:

1. **boot.ldr:** Contains the system bootstrap image file, which is used to initialize the basic system hardware and allow the system to process the boot option file.
2. **bof.cfg:** This user-configurable file contains a set of pointers that indicate locations (e.g. the image files, the configuration files, …) and initial parameters (e.g. the management port IP address, the serial interface characteristics, …).
3. **TiMOS-m.n.Y.z:** This is a directory named according to the major and minor software release, type of release and version. For example, if the software release is Version 1.2 of a released software version the name would be "TiMOS-6.0.R.0". On an SR-7 and SR-12, this directory contains two files, "cpm.tim" and "iom.tim", for the SF/CPM and IOM cards respectively. An SR-1 has an integrated SF/CPM and IOM, there is only one file, named "both.tim".
4. **config.cfg:** This file contains the default configuration file. The default configuration file is very basic and provides just enough information to make the system operational. Other configuration files can be created by the user.

The initialization process requires the Boot.ldr and the Bof.cfg to be present on the Compact Flash Card 3 (CF3).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

System Initialization

When a system is powered up or rebooted the system initialization process follows the sequence below:

The system checks CF3 for the bootstrap loader (boot.ldr) file used to initialize the basic system hardware and allow the system to process the boot option file.

Boot Option File (bof.cfg)

The boot option file is stored on CF3 and contains information used to configure access to the system (serial port speed, management IP address) and the location of Runtime Image and Configuration files.

After the BOF has been loaded, the system may enter a wait time. Wait times, configured in the BOF, allow the system initialization process to pause for a configured time. Wait times provide the user with an opportunity to interrupt the system initialization process.

Runtime Image

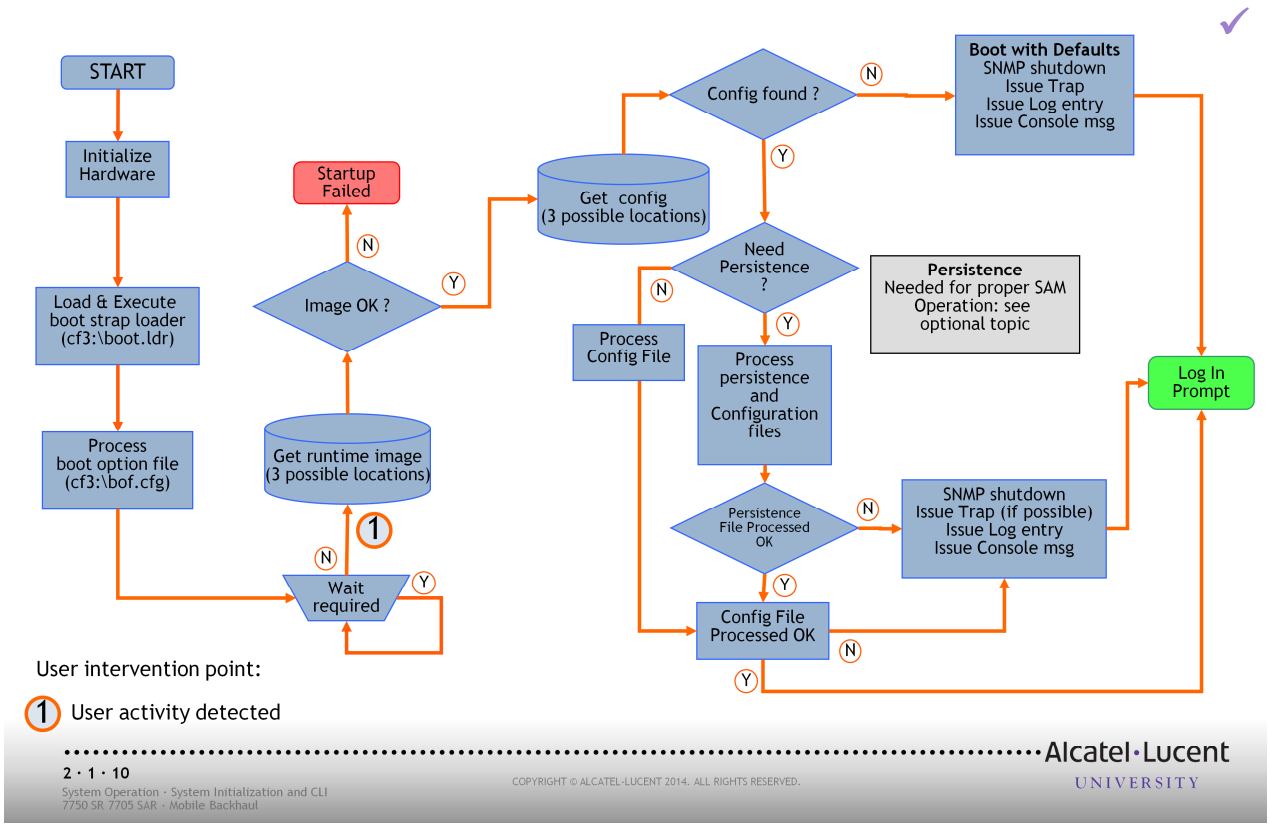
The runtime image files (cpm.tim, iom.tim or both.tim) contain the system application software. The runtime image file can be stored locally or remotely in any of three locations (primary, secondary, and tertiary) specified in the BOF. The system checks each location in sequence for an image. The first image found is the one that will be used. Once the runtime image is loaded, control is passed from the bootstrap loader to the image. If a runtime image cannot be loaded the system will fail to start and user intervention will be required to correct the problem.

Configuration File

After loading the runtime image, a user-configurable configuration file, containing chassis, IOM, MDA, port, routing, system and service configuration information, is loaded. If a configuration file cannot be found the system is initialized with default configuration settings and SNMP is shutdown (Get and Set functionality is disabled), however traps will continue to be issued. The system issues traps, log messages, and console messages to advise the user. It requires a ***configure system snmp no shutdown*** to reactivate full SNMP functionality.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

System Initialization Process



Persistence specifies whether the system will preserve system indexes when a save command is executed. During a subsequent boot, the index file is read along with the configuration file. Indexes uniquely identify objects in the router (ie Interfaces, LSPs) and are used by SNMP tools (ie MIB Browsers, the SAM database) to identify these objects. When configuration changes on a device are saved, a corresponding index file (.ndx extension) is created.

During a reboot of the network element, the configuration file is compared to the index file to ensure that indexes remain the same, thus establishing a persistent index. This reduces the number of resynchronizations between the 5620 SAM and the affected network element.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Managing the BOF (Boot Option File)

The BOF file stores the following information, used during the boot process and that can be modified during system operation:

1) Configure Primary, Secondary, Tertiary software image source
2) Configure Primary, Secondary, Tertiary configuration source
3) Create an IP address for the CPM Ethernet port
4) Create a Static route for the CPM Ethernet port
5) Configure the DNS Domain name
6) Set up the CPM Ethernet port (speed, duplex, auto)
7) Configure persistence requirements
8) Enable/disable Lawful Intercept configuration to be saved locally
9) Enable/disable separate access to Lawful Intercept (LI) information
10) Set the console port speed

Always be sure to save the BOF!

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Parameters that are configured in the BOF are shown in the chart above.

Some commands:

Node# bof	Enter the CLI BOF context to change or create a bof file.
Node>bof# address 10.10.10.2/24 primary	Change or create the CPM Ethernet Port IP address.
Node>bof# speed 100	Set the CPM Ethernet Port speed to 100 Mbps.
Node>bof# primary-image cf3:/TIMOS.5.0.R0	Set the primary image directory.
Node>bof# primary-config cf3:/test.cfg	Set the primary configuration file (eg. test.cfg).
Node>bof# save	Save the bof.
Node# show bof	Display the in-memory bof file (last used).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Managing the Configuration File



The configuration file stores the following information, used during the boot process and that can be modified during system operation:

1) System parameters (e.g. name, security, login control, time, chassis mode)
2) Card types (IOM and MDA)
3) Port parameters
4) Interfaces, routing protocols, MPLS tunnels configured
5) Service configuration information
6) Quality of Service policies

The configuration file is not automatically saved!

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 Command Line Interface (CLI)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Command Line Interface (CLI)

The Command Line Interface (CLI) is a uniform command driven interface, used for node configuration and management, accessible through the console, Telnet and Secure Shell (SSH1 and SSH2). The CLI command tree is a hierarchical inverted tree with the root at the top. Navigating down the tree can be accomplished simply by typing the name of the successively lower contexts (extra parameters may be required).

At the prompt, which represents the ROOT context, enter show (or configure):

```
Node# show
Node# configure
```

Now you are in the show (or configuration) context.

```
Node>show#
Node>config#
```

Sometimes the desired lower context can be specified from within another context by typing a single keyword, such as shown below:

```
Node# configure
Node>config# router
Node>config>router#
```

Other times, to move to another context, a keyword and a user-supplied identifier (parameter) are required:

```
Node>config>router# interface system
Node>config>router>if#
```

The identifier ‘system’ specifies the system loopback interface used by routing protocols such as OSPF and BGP.

The show command is special, this command can be entered at any given prompt. All other contexts can only be entered by following the hierarchical tree.

```
Node>config>router# show
Node>show#
```

Note: As of Release 5.0 the “absolute path” command option can be used to allow commands, which can be entered anywhere.

```
Node>config>router>if# /configure system
Node>configure>system#
```



Refer to the *OS Basic System Configuration Guide* for detailed information on CLI commands and navigation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The CLI Command Prompt

By default, the CLI command prompt indicates the device being accessed and the current CLI context.

For example, the prompt: A:ALA-1>config>router>if# indicates the active context, the user is on the device with hostname ALA-1 in the configure>router>interface context.
In the prompt, the separator used between contexts is the ">" symbol.

At the end of the prompt, there is either a pound sign ("#") or a dollar sign ("$"). A "#" at the end of the prompt indicates the context is an existing context.

A "$" at the end of the prompt indicates the context has been newly created.

New contexts are newly created for logical entities when the user first navigates into the context.



Since there can be a large number of sublevels in the CLI, the environment command reduced- prompt no of nodes in prompt allows the user to control the number of levels displayed in the prompt.

All special characters (#, $, etc.) must be enclosed within double quotes, otherwise it is seen as a comment character and all characters on the command line following the # are ignored. For example:

*A:ALA-1>config>router# interface "primary#1"

When changes are made to the configuration file a "*" appears in the prompt string (*A:ALA-1) indicating that the changes have not been saved. When an admin save command is executed the "*" disappears. This behavior is controlled in the saved-ind-prompt command in the environment context.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The CLI Navigation

back	- Brings you back one context
exit all	- Brings you back to the root-level context
<Ctrl-z>	- Acts like typing **exit all** and then hitting <ENTER>
<Ctrl-c>	- Clears the command prompt
up/down arrow	- Lists previous command(s) to be repeated/edited
tree	- Shows available commands from context

Note: preceding a command by a slash (/) is equivalent to issuing the command from the root context

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Moving down the hierarchy can be accomplished by:

1. Entering the next context at the prompt to move down one step in the tree. For example the command: **router** at the **root>config#** prompt
2. Entering a string of contexts at the prompt to move down several levels at once. For example the command: **config router ospf** at the **root#** prompt.

Moving up the hierarchy can be accomplished by:

1. Entering the **back** command to go up one context in the tree.
2. Entering the **exit** command to return to the previous higher context.
3. Entering the **exit all** command to return directly to the root context.
4. Entering <Ctrl-z> which represents a special keyboard sequence that acts like pressing the **<Enter>** key and entering **exit all** to return the user to the ROOT context.
5. Entering <Ctrl-c> which clears a typed-in string at the prompt in stead of backspacing.



Refer to the *OS Basic System Configuration Guide* for detailed information on CLI commands and navigation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Viewing the CLI Tree Structure

- The tree command provides a list of commands available at current context and sub-contexts
- If the ***detail*** option is used, a list of parameters is also displayed for each command

```
Node>config>router>ospf# tree
ospf
|
+---area
|   |
|   +---area-range
|   |
|   +---blackhole-aggregate
|   |
|   +---interface
|   |   |
|   |   +---advertise-subnet
|   |   |
```

```
Node>config>router>ospf# tree detail
ospf [<ospf-instance>] [<router-id>]
|
+---area <area-id>
|   no area <area-id>
|   |
|   +---no area-range <ip-prefix/mask>
|   |   area-range <ip-prefix/mask> [not-advertise]
|   |
|   +---blackhole-aggregate
|   |   no blackhole-aggregate
|   |
|   +---interface <ip-int-name>
|   |   no interface <ip-int-name>
|   |   |
|   |   +---advertise-subnet
|   |   |   no advertise-subnet
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The hierarchical CLI command structure can be viewed below the current position with the **tree** and **tree detail** commands:

```
Node>config>router# tree
Node>config>router# tree detail
```

These commands provide a long list of lower contexts (and attributes if the tree detail command is issued). When

```
Press any key to continue (Q to quit)
```

is displayed, you can choose to stop displaying the list by typing "Q".

The Tree command shows all lower contexts and attributes in the form of a large tree. The Help command only shows a list of the contexts and attributes of the current context.



Refer to the *OS Basic System Configuration Guide* for detailed information on CLI commands and navigation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Viewing the CLI Tree Structure - continued

- The tree command can also be issued with the ***flat*** option, which provides the same set of commands without the tree structure
- Useful when searching for a command and we do not know the context or sub-context where it can be issued

```
Node>config>router>ospf# tree flat | match originate-default-route
area nssa originate-default-route
```

Sub-context — Command was found

```
Node>config>router>ospf# tree flat detail | match originate-default-route
area nssa no originate-default-route
area nssa originate-default-route [type-7]
```

Sub-context — Command was found — Required parameter

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.



Refer to the *OS Basic System Configuration Guide* for detailed information on CLI commands and navigation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Help Command

Help	Displays a brief description of the help system
?	Lists all commands in the current context
string **?**	Lists all commands available in the current context that start with *string*
command **?**	Displays *command*'s syntax and associated keywords
command keyword **?**	Lists the associated arguments for *keyword* in *command*
Help Edit	Displays help on editing (editing keystrokes) Lists available editing key strokes
Help Globals	Displays help on global commands Lists available global commands

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Help command is one of the most useful commands. While configuring or managing an SR, the help command can provide the syntax and attributes available in the current context.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Global Commands

logout	Terminates the CLI session
oam	OAM test suite. See the Service OAM section of the SR OS Services Guide.
ping	Verify the reachability of a remote host
pwc	Displays the present or previous working context of the CLI session.
sleep	Causes the console session to pause operation (sleep) for one second or for the specified number of seconds. Primary use is to introduce a pause within the execution of an exec file.
ssh	Open a secure shell connection to a host
telnet	Telnet to a host
traceroute	Determine the route to a destination address
tree	Displays a list of all commands at the current level and all sublevels.
write	Sends a console message to a specific user or to all users with active console sessions.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The Global Commands are commands that can be entered at any context. The entire list can be viewed with the “help globals” command and, since help is one of the global commands, this can be done at also any context.

Back	**- Go back a level in the command tree**
Echo	**- Echo the text that is typed in**
enable-admin	**- Enable the user to become a system administrator**
Exec	**- Execute a file - use -echo to show the commands and prompts on the screen**
Exit	**- Exit to intermediate mode - use option all to exit to root prompt**
Help	**- Display help**
History	**- Show command history**
Info	**- Display configuration for the present node**
Logout	**- Log off this system**
Mrinfo	**- Request multicast router information**
Mstat	**- Trace multicast path from a source to a receiver and display multicast packet rate and loss information**
Mtrace	**- Trace multicast path from a source to a receiver**
Oam	**- OAM Test Suite**
Ping	**- Verify the reachability of a remote host**
Pwc	**- Show the present working context**
Sleep	**- Sleep for specified number of seconds**
Ssh	**- SSH to a host**
telnet	**- Telnet to a host**
Traceroute	**- Determine the route to a destination address**
Tree	**- Display command tree structure from the context of execution**
write	**- Write text to another user**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Auto-completion Commands

Command completion can be achieved by:

Abbreviation, if keystrokes entered are unique enough.

```
Node>config# ro [ENTER]
Node>config>router#
```

Tab Key or **Space** Key to auto-complete the command.

```
Node>config# ro [TAB]
Node>config# router

Node>config# ro [SPACE]
Node>config# router
```

If match is not unique CLI will display possible matches:

```
Node>config# r [TAB]
redundancy router
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The CLI is able to auto-complete partially entered commands. This auto-complete function is invoked by hitting “ENTER”, “TAB” or “SPACE”.

1. As long as the partial command can uniquely identify a command or context that is allowed in the current context “TAB” and “SPACE” will auto-complete the command.

```
Node>config# ro [TAB] (or [SPACE])
Node>config# router
```

2. “ENTER” will auto-complete the command AND execute it.

```
Node>config# ro [ENTER]
Node>config>router#
```

3. If the partial command is ambiguous and indicates more than one option, “TAB” and “SPACE” will list all the remaining possible matches.

```
Node>config# r [TAB] (or [SPACE])
redundancy  router
```

4. “ENTER” will result in an error message:

```
Node>config# r [ENTER]
Error: Ambiguous command
```

The system maintains a history of 30 previously entered commands that can be displayed with the “history” command from any context (global command).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Info Command

The **info** command displays the non-default values that have been configured for the parameters corresponding to a certain context

```
Node>config>router# interface Toronto
Node>config>router>if# info
----------------------------------------------
          address 131.131.131.1/30
          port 1/1/1
----------------------------------------------
```

More detail, including default values, can be viewed by using the **info detail** command.

To view the entire configuration file:

```
Node# admin display-config
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

There are two options to see what has already been configured:

1. The “admin display-config” command, a global command, displays the entire present configuration.
2. The “info” command can be used in any sub-context of the **config** context.

   This command will show the present configuration within the current context.

   This command only shows the configuration that is different from the default configuration. To view the entire configuration of the current context (including the default settings), the “info detail” command can be used.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

File System Management

A DOS-like file system is used to store files used and generated by the system. Files can be stored on a compact flash (CF) cards in cf1:, cf2:, or cf3:.

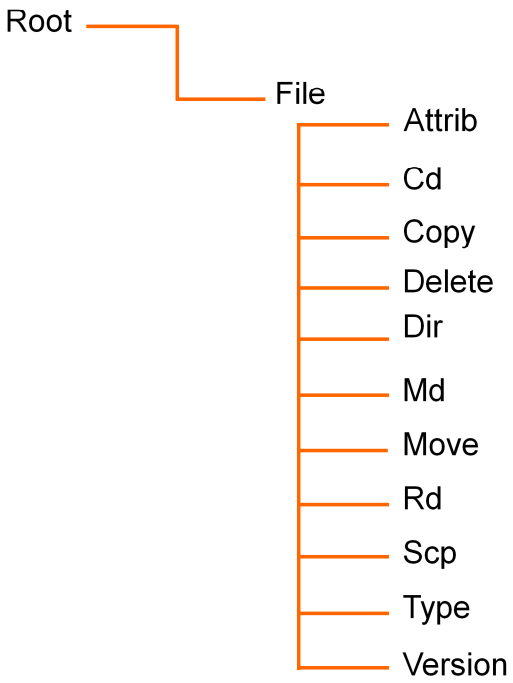
All file system commands operate on the local file system and some, such as copy, delete, and dir, can operate on remote file systems. Arguments for the file commands are based on a URL structure. Local and remote file operations are divided into three types: local, ftp, and tftp.

Some commands for file and directory management:

Node# file	Enter the CLI File context.
Node>file cf3:\ # attrib	Display or change the current working directory in the local file system.
Node>file cf3:\ # cd [..]	Display or change the current working directory in the local file system.
Node>file cf3:\ # dir	Display a list of files and subdirectories in a directory.
Node>file cf3:\ # md	Create a new directory in the local file system.
Node>file cf3:\ # rd	Remove (delete) a directory in the local file system.
Node>file cf3:\ # copy **Node# file copy cf3:\config.cfg ftp://10.1.1.1/config.cfg**	Copy a file or all files in a directory from a source URL to a destination URL. At least one of the specified URLs should be a local URL. The optional wildcard (*) can be used to copy multiple files that share a common (partial) prefix and/or (partial) suffix. Copy methods include ftp and tftp as specified in the URL. The example copies the file “config.cfg” from cf3: to an FTP server.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

File System CLI Context



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Some commands:

Node>file cf3:\ # delete	Delete the specified file. The optional wildcard (*) can be used to delete multiple files that share a common (partial) prefix and/or (partial) suffix.
Node>file cf3:\ # move	Move a local file, system file, or a directory. If the target already exists, the command fails and an error message displays.
Node>file cf3:\ # scp	Copy a file from the local files system to a remote host on the network. scp uses ssh for the data transfer, and uses the same authentication and security as ssh.
Node>file cf3:\ # type	Display the content of a text file.
Node>file cf3:\ # version	Display the version of an OS “cpm.tim” or “iom.tim” file.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 vi Editor+Rollback

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SROS vi editor

SROS has a full screen text editor used to:

- Create and modify any ASCII files on the CF cards of your 7x50

The integrated text editor is a simplified version of the comprehensive vi editor (well-known in most UNIX systems)

Example application:

Edit your config.cfg file without any need to transfer the file via ftp/scp to a desktop PC or server



The SROS has a full screen editor to create and modify any ASCII files on the compact flash of the 7x50 service routers.

The integrated text editor is a simplified version of the comprehensive vi editor.

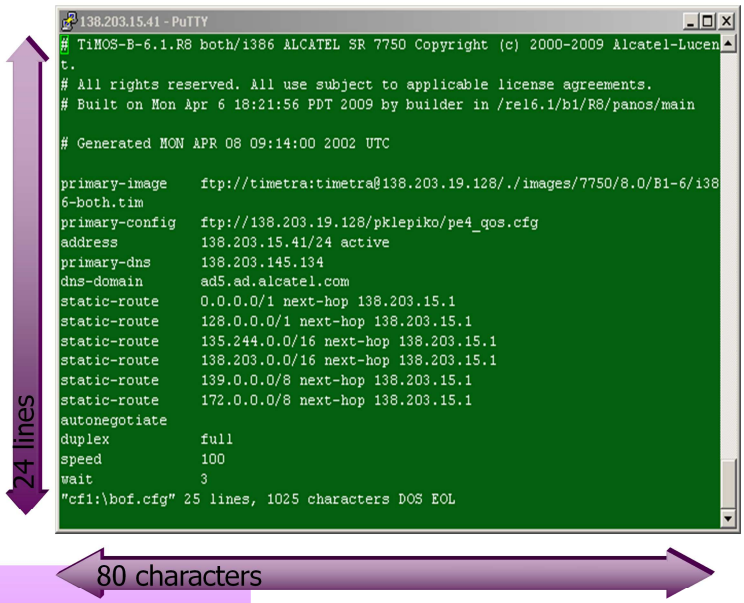
The configuration file can now be edited on the service router without sending it to a desktop PC or server.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SROS run vi editor from CLI

Run vi editor:

- VT100 terminal mode needs to be supported
- Editor's resolution is fixed to 24 lines with 80 characters
- Only files on the local CF card are applicable for editing (no remote URLs)




```
# file vi ?
  - vi <local-url>

 <local-url>   : [<cflash-id>/]<file-path>
                 cflash-id       - cf1:|cf2:|cf3:
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

To run the vi editor vt100 terminal mode needs to be supported.

The editor's resolution is fixed to 24 lines with 80 characters.

Only files on the local CF card are applicable for editing.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Why rollback?

Purpose of rollback functionality is to undo changes without:

- reverting everything manually (shutdown xxx, no xxx, back, ...)
- rebooting the whole node (maybe after editing the config)

"Checkpoints" can be set whenever you feel that one might be needed later on to:

- Return to these checkpoints with a single command
- Useful in case of accidental misconfigurations or for lab environments

Not within scope of rollback: CLI transactions

- CLI commands become active immediately
- When <Enter> key is depressed, it happens...



One of the latest CLI features is the rollback functionality.

This rollback allows you to undo changes to the configuration without reverting everything manually or rebooting the whole node.

The point where you return to is called the checkpoint. Checkpoints can be set whenever you feel you might possibly need one later on.

A single command returns to a particular checkpoint.

This is extremely useful in case of accidental misconfigurations or for lab environments.

Note that CLI commands that are typed also take effect immediately.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

How does it work?

You need to enable rollback first by configuring it

- configure a location for the rollback files

At suitable times, you create a rollback checkpoint

- the system creates sort of a running config file in the background
- this includes all settings made via CLI and SNMP
- does **not** include BOF, LI and SNMP index settings

When necessary, you can return to any of your existing checkpoints



Before rollback is configured, a location to store the rollback files has to be set.

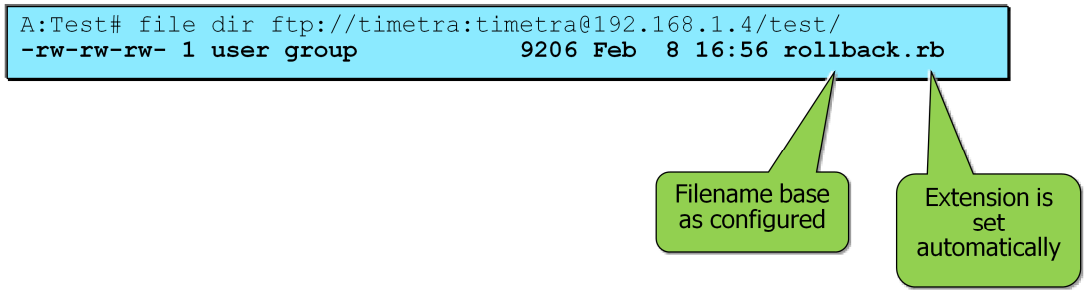
Whenever a configuration is found stable, a checkpoint can be set. The system creates a sort of a running configuration file in the background. This file includes all settings made via CLI and SNMP. But it doesn't include BOF, LI and SNMP index settings.

When necessary, you can return to any of the set checkpoints.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: What happened inside?

A new rollback file is created:



The system rotates the existing rollback files automatically to make space

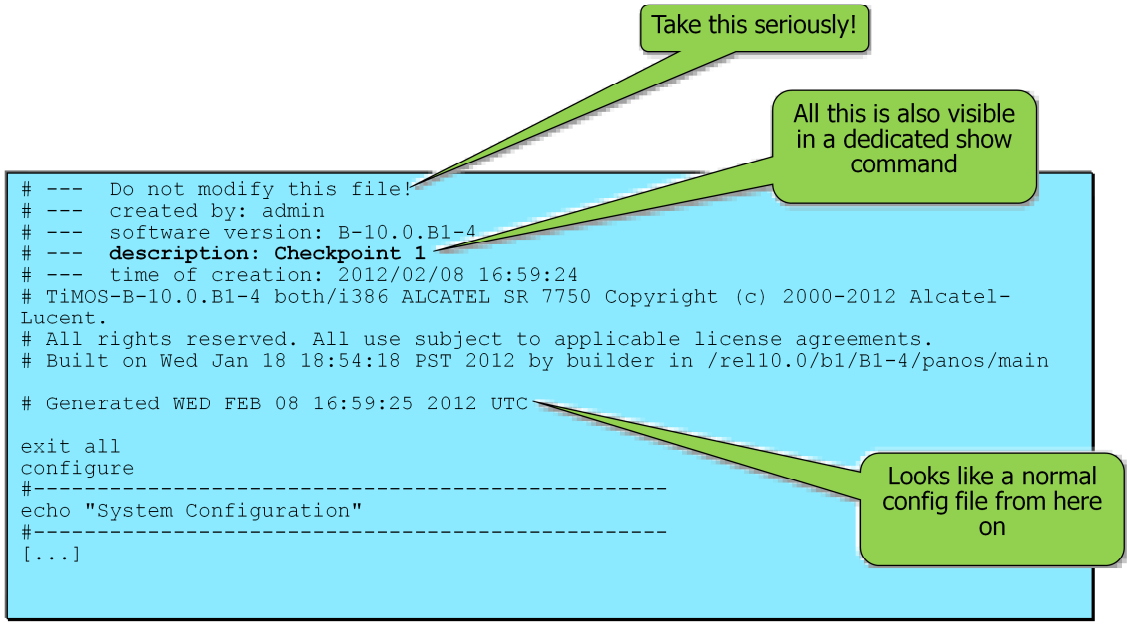
- Amount of checkpoints to be maintained is configurable (*shown later in course*)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A new rollback file is created on the configured location. The system rotates the existing rollback files automatically. Whenever there is a new checkpoint created, it will be labeled “rollback.rb” in this case and the older one gets “rollback.rb.1” as name. The file without a number as an extension will be the latest checkpoint.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: Rollback of contents



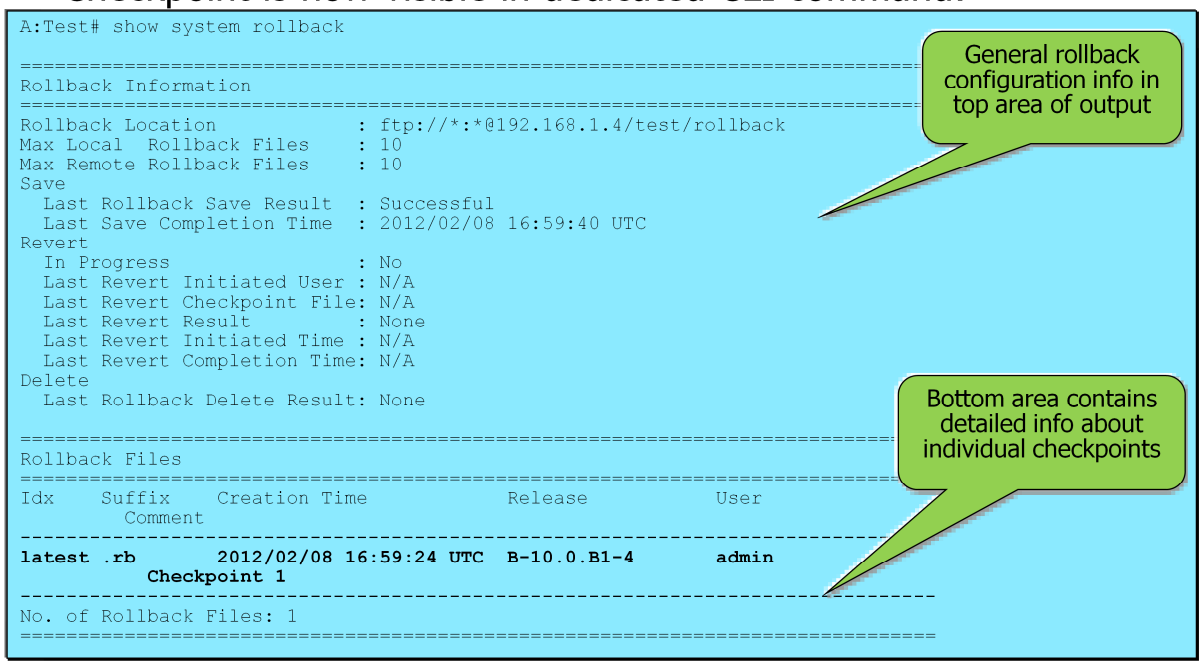
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A rollback file is created by the service router and should never be changed manually. The file can be viewed by entering a dedicated show command and except for the header, looks like a normal configuration file.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: CLI view

Checkpoint is now visible in dedicated CLI command:



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The check point is visible with the CLI command “show system rollback. After the general information, all info can be found about the individual checkpoints.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: Change and create another checkpoint

Now configure something, and create another checkpoint:

```
A:Test# configure service ies 42 customer 1 create
[...]
*A:Test>config>service>ies# info
----------------------------------------------
            shutdown
            interface "T42" create
                address 42.42.42.42/30
                sap 1/1/2 create
                exit
            exit
----------------------------------------------
[...]
*A:Test# admin rollback save comment "IES42 created"
Saving rollback configuration to ftp://*:*@192.168.1.4/test/rollback.rb ...
OK

*A:Test# file dir ftp://timetra:timetra@192.168.1.4/test/
-rw-rw-rw- 1 user group           9550 Feb  8 17:03 rollback.rb
-rw-rw-rw- 1 user group           9206 Feb  8 16:56 rollback.rb.1
```

Rollback files are rotated automatically

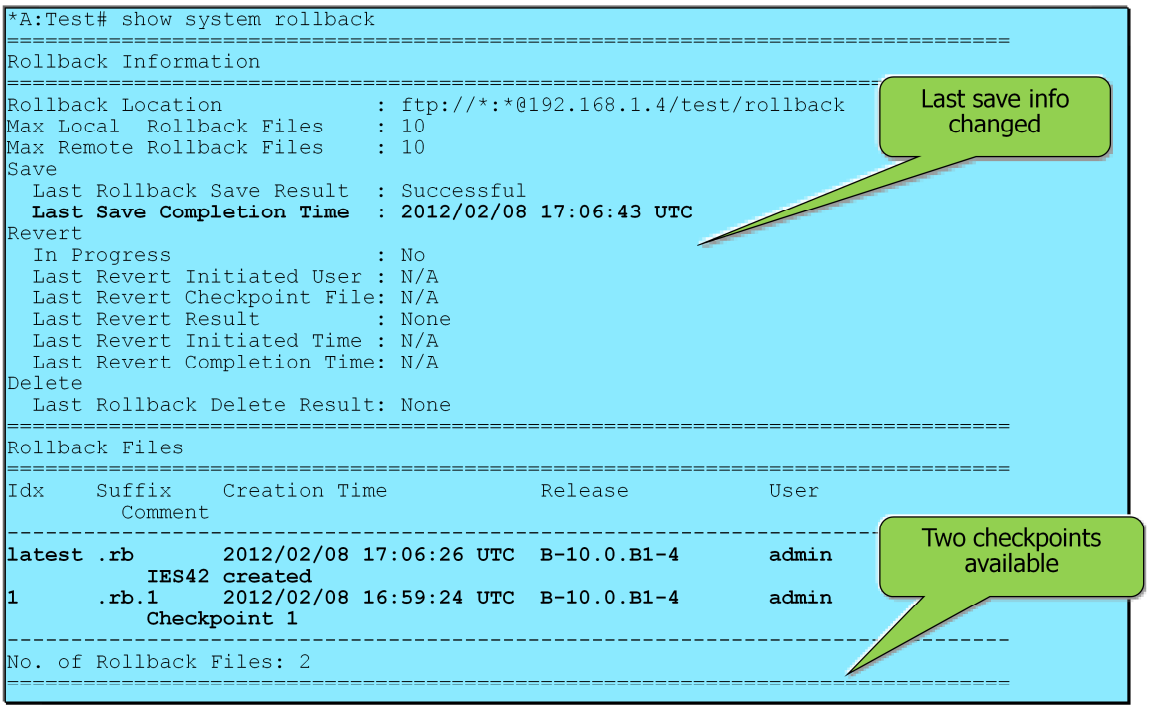
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

If changes are made to the configuration , a checkpoint with new content can be made

This example shows a creation of an IES service 42.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: CLI view with new Checkpoint



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Two checkpoints are now available. The latest one created has been added to the list.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: Create third checkpoint

Again configure something, and create the third checkpoint:

```
*A:Test# configure service ies 66 customer 1 create
[...]
*A:Test>config>service>ies# info
----------------------------------------------
            shutdown
            interface "T66" create
                address 66.66.66.66/30
                sap 1/1/3 create
                exit
            exit
----------------------------------------------
[..]
*A:Test# admin rollback save comment "IES66 created additionally"
Saving rollback configuration to ftp://*:*@192.168.1.4/test/rollback.rb ... OK
*A:Test# file dir ftp://timetra:timetra@192.168.1.4/test/
-rw-rw-rw- 1 user group           9885 Feb  8 17:07 rollback.rb
-rw-rw-rw- 1 user group           9550 Feb  8 17:03 rollback.rb.1
-rw-rw-rw- 1 user group           9206 Feb  8 16:56 rollback.rb.2
*A:Test# show service service-using

===============================================================================
Services
===============================================================================
ServiceId    Type       Adm  Opr  CustomerId Service Name
-------------------------------------------------------------------------------
42           IES        Down Down 1
66           IES        Down Down 1
2147483648   IES        Up   Up   1          _tmnx_InternalIesService
2147483649   intVpls    Up   Down 1          _tmnx_InternalVplsService
-------------------------------------------------------------------------------
Matching Services : 4
-------------------------------------------------------------------------------
===============================================================================
```

Note how files are rotated

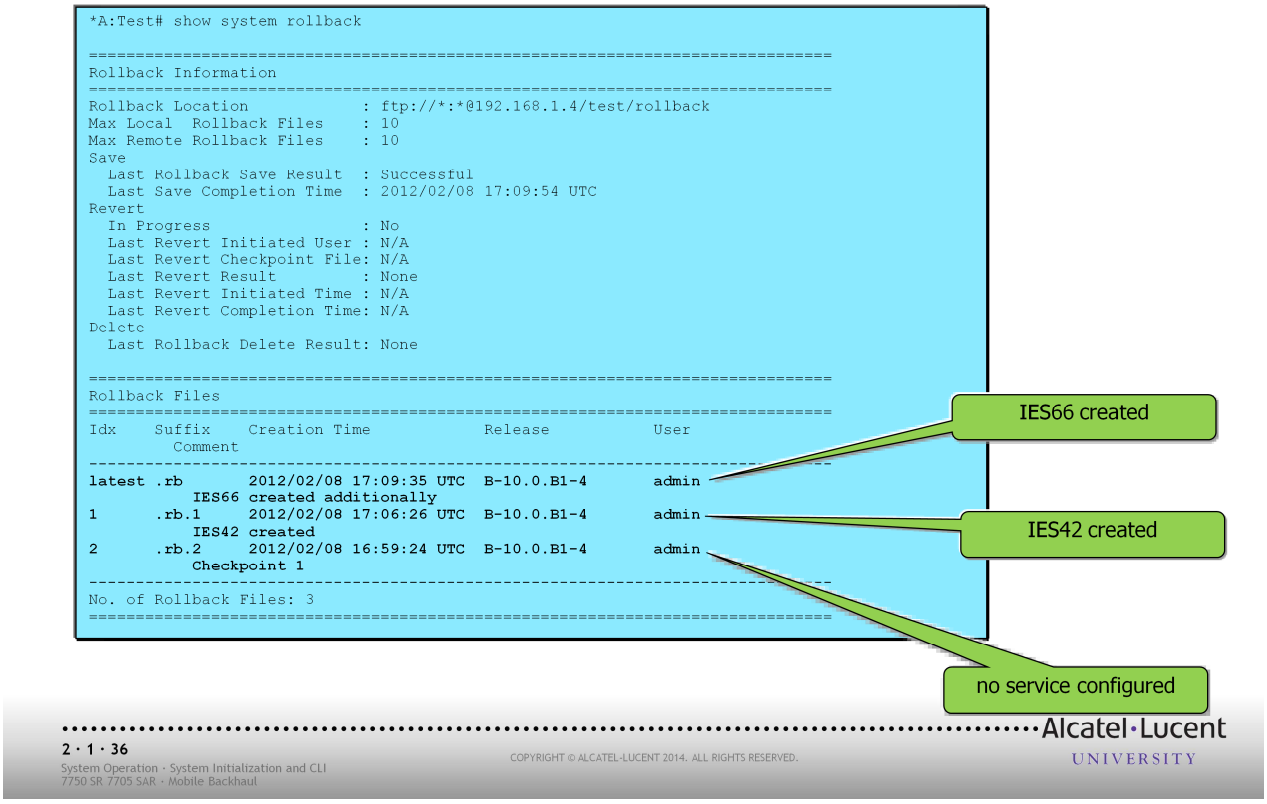
Two IES created now (both with SAPs to make manual rollback more complicated)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

After a third change a new checkpoint is created. A new IES has been added to the configuration.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: CLI view of our Playground



So in total three (3) checkpoints have been created.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: Comparing checkpoints

The CLI has a special command to check which changes happened between two checkpoints.

```
*A:Test# admin rollback compare
  - compare [to <checkpoint2>]
  - compare <checkpoint1> to <checkpoint2>

 <checkpoint1>         : active-cfg|rescue|latest-rb|<checkpoint-id>
                           active-cfg      - Current running config (Default)
                           rescue          - Rescue config file
                           latest-rb       - Most recent checkpoint file
                           checkpoint-id   - [1-10] - Checkpoint files
 <checkpoint2>         : active-cfg|rescue|latest-rb|<checkpoint-id>
                           active-cfg      - Current running config
                           rescue          - Rescue config file
                           latest-rb       - Most recent checkpoint file
(Default)
                           checkpoint-id   - [1-10] - Checkpoint files
```

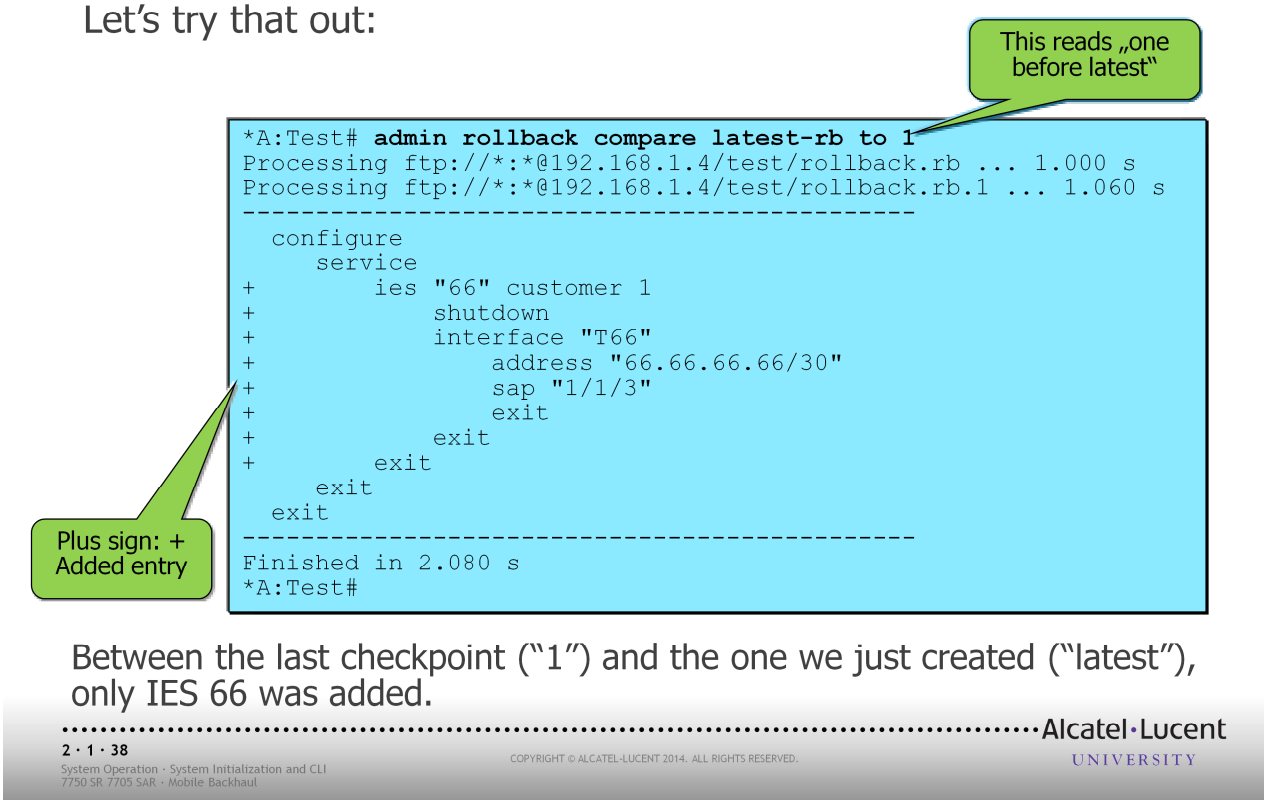
Note: You cannot use the comment fields to refer to a specific checkpoint – you must always give its numeric index. Do a "*show system rollback*" beforehand when you belong to those individuals to whom names mean more than a number.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

But what is the difference between two checkpoints? A comparison between checkpoints can be seen by typing "admin rollback compare". Note that the ID of the checkpoint is used and not the description. The relation between the checkpoint ID and the description can be seen by "show system rollback".

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: Comparing checkpoints

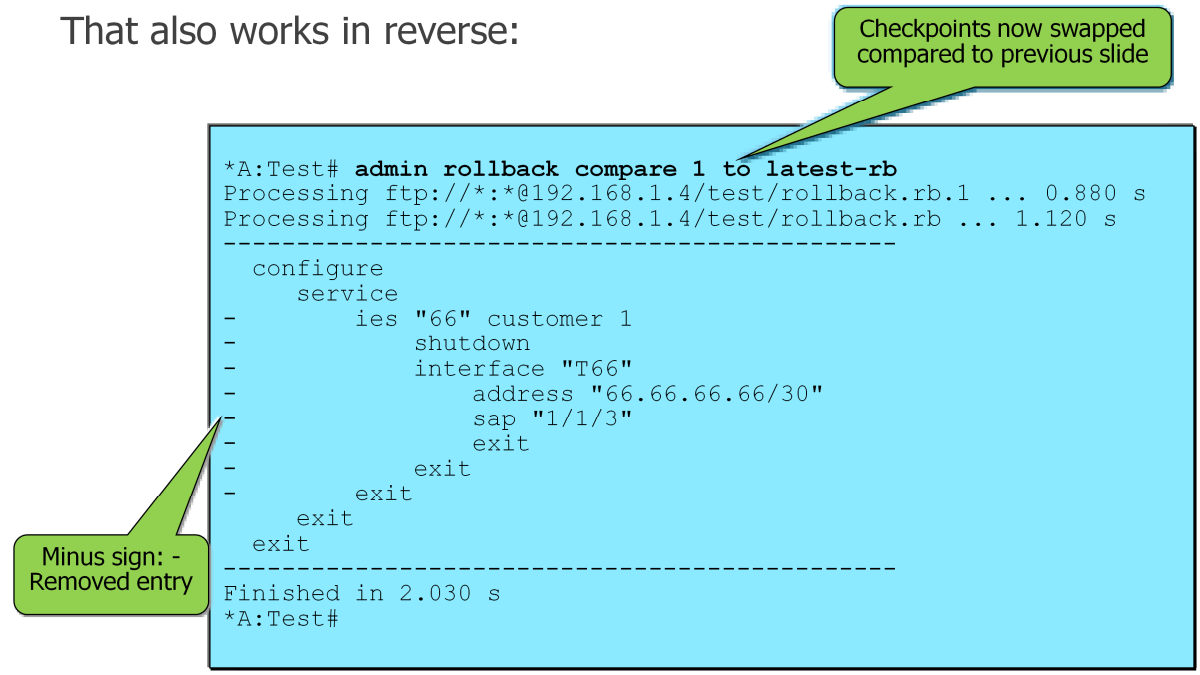


Let us compare the two checkpoints. A keyword latest-rb can be given. This addresses the latest created checkpoint. "1" is the one before the latest.

The difference is the ies 66 service as expected. An added plus sign identifies an added line of configuration.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step by Step: Comparing checkpoints



We could also make a comparison between an older and the latest one. This results in minus signs, removed entries.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: Doing an actual rollback

So this was it before we try a rollback:

```
A:Test# show system rollback

===============================================================================
Rollback Information
===============================================================================
[...]
===============================================================================
Rollback Files
===============================================================================
Idx    Suffix    Creation Time            Release          User
       Comment
-------------------------------------------------------------------------------
latest .rb       2012/02/08 17:09:35 UTC  B-10.0.B1-4      admin
           IES66 created additionally
1      .rb.1     2012/02/08 17:06:26 UTC  B-10.0.B1-4      admin
           IES42 created
2      .rb.2     2012/02/08 16:59:24 UTC  B-10.0.B1-4      admin
           Checkpoint 1
-------------------------------------------------------------------------------
No. of Rollback Files: 3
-------------------------------------------------------------------------------
A:Test# show service service-using

===============================================================================
Services
===============================================================================
ServiceId    Type       Adm  Opr  CustomerId Service Name
-------------------------------------------------------------------------------
42           IES        Down Down 1
66           IES        Down Down 1
2147483648   IES        Up   Up   1          _tmnx_InternalIesService
2147483649   intVpls    Up   Down 1          _tmnx_InternalVplsService
-------------------------------------------------------------------------------
Matching Services : 4
-------------------------------------------------------------------------------
===============================================================================
A:Test#
```

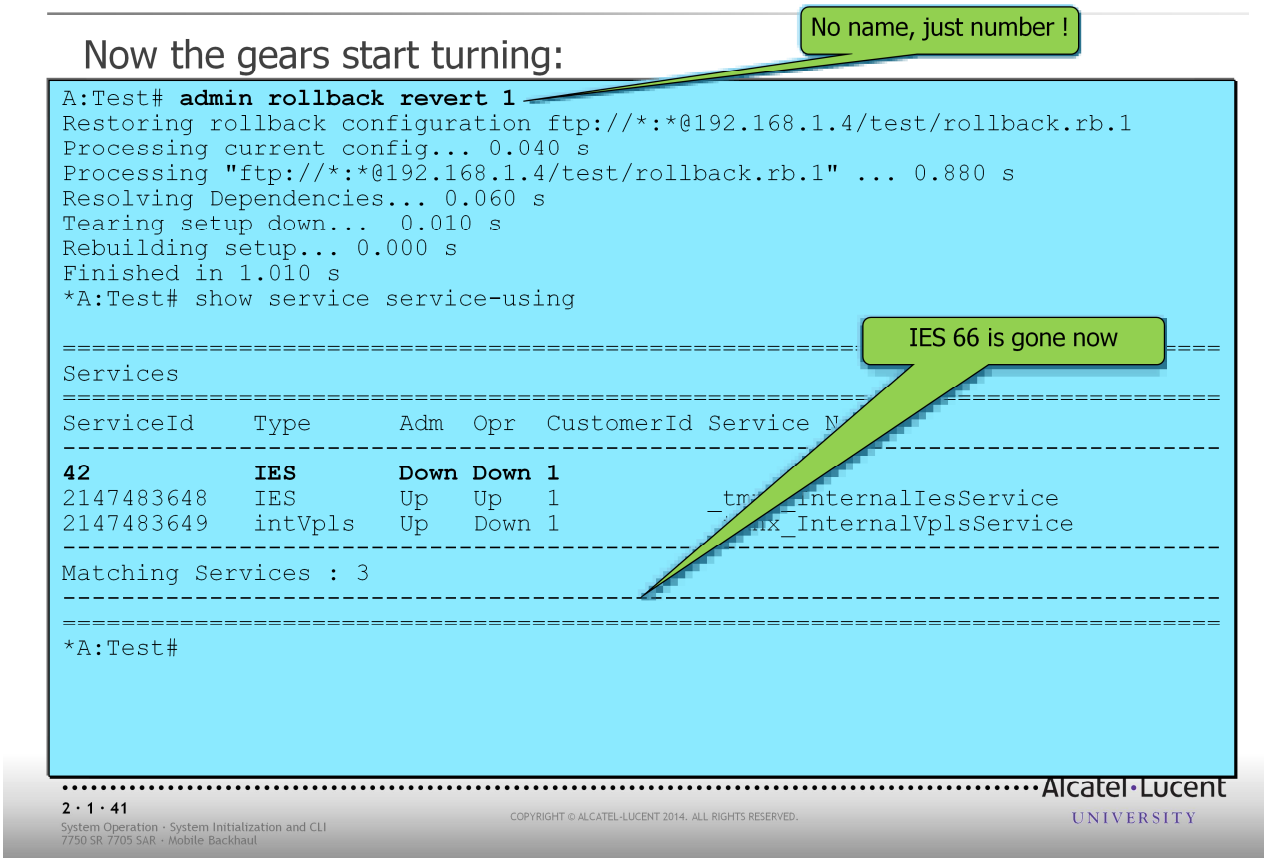

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Before any rollback, the latest configuration contains now two IES services, IES 42 and IES 66.

“Show service service-using” is the command to check the services running on a node.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Step-by-step: Doing an actual rollback



Let's revert to the one older checkpoint. Perform an "admin rollback revert 1".

After the processing, it shows the lack of IES 66 as expected. This was a successful rollback.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Rolling back a rollback

Rollback is just called "**rollback**", should not be taken literally.
- Use the term "revert" in any discussions, as this has less of a reference to the actual timing of checkpoints

It actually rolls forward as well between checkpoints when required.

Rollback checkpoints are not deleted when reverting.
- Not the one you are reverting to, nor
- Any checkpoints that have been taken/occurred in between

"Revert from a revert" is also possible:
- To create a checkpoint just before reverting
- Leaves option to come back to where you already were, in case revert is worse in its actual outcome



The command rollback might create the perception that there can only be reverted back in time. However, also a roll forward can be possible in time.

Rollback checkpoints don't get deleted when reverting, neither the one you are reverting to, nor any checkpoints that have been taken in between.

So a "revert from a revert" is also possible. You might want to create a checkpoint just before reverting.

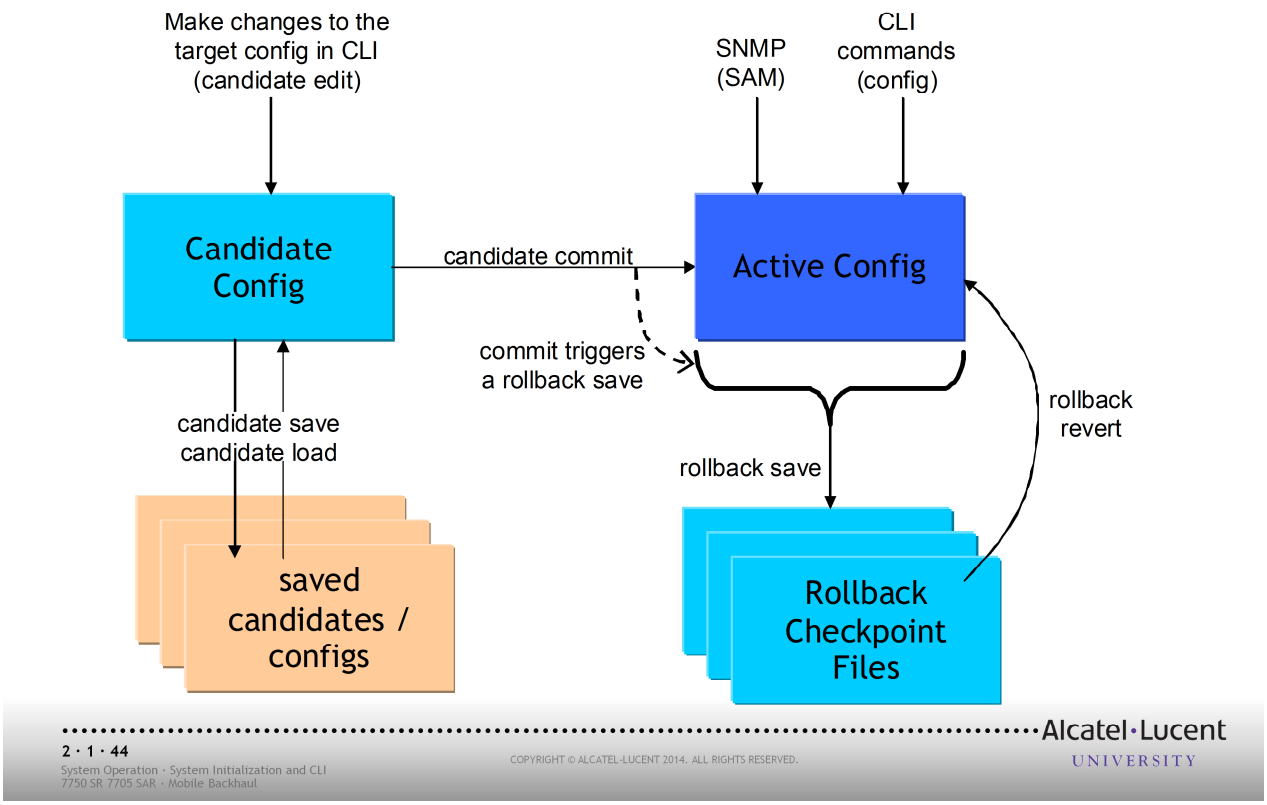
That leaves you the option to backup to where you already were, in case the revert that was performed turns out to be worse in its actual outcome.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

5 Transactional Configuration

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Transactional Configuration Model



Transactional Configuration and Configuration Rollback, together, provide the operational model as shown here.

Transactional configuration allows a user to generate a candidate configuration.

The user enters commands as normal in CLI. This candidate configuration could then be saved to be executed at another time or committed to execute the candidate configuration immediately.

During the creation of a candidate configuration, syntax will be verified and confirmed; however, resource allocation will not. If a candidate configuration will cause the exhaustion of a system resource, memory for example, this will not become apparent until the candidate configuration is executed.

A new set of commands is provided for this functionality under the global “candidate” command. Many candidate commands are only visible once the operator is in edit-cfg [edit-c-f-g] mode by typing “candidate edit”.

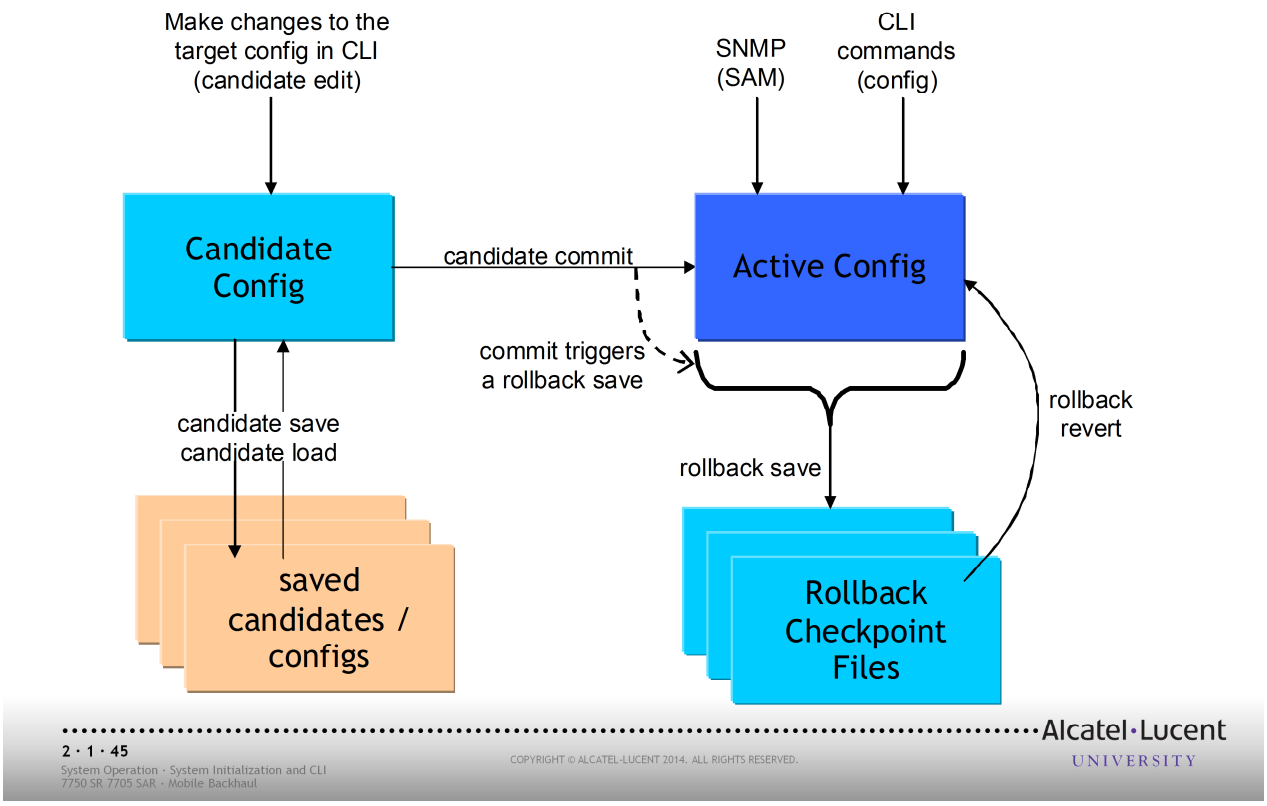
The operator can enter and quit the configuration mode as many times as desired, before finally committing the candidate.

Caution should be exercised if multiple users are concurrently modifying a candidate configuration. If a second user were to commit before the first user completed configuration changes, all configuration from both users, up to that point, would be loaded into the router. This situation can be avoided by including exclusive in the candidate command string, i.e., “candidate edit exclusive”.

Once the candidate configuration is complete, the operator can explicitly commit the changes and cause the entire new configuration to become active.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Transactional Configuration Model [cont'd]



In edit-cfg mode, the operator builds a set of candidate configuration changes using the same CLI tree as standard (line-by-line non-transactional) configuration. Tab completion and keyword syntax checking is available.

If a commit operation is successful, then all of the candidate changes will take operational effect and the candidate is cleared. If there is an error in the processing of the commit, or a 'commit confirmed' is not confirmed and an auto-revert occurs, then the router will return to a configuration state with none of the candidate changes applied. The operator can then continue editing the candidate and try a commit later.

All commands in the candidate configuration must be in the correct order for a commit to be successful. A set of candidate editing commands (for example, copy, insert) are available to correct and reorder the candidate configuration.

There is no SNMP [S-N-M-P] access to the candidate configuration and no SNMP management of candidates, although any configuration changes done via a transaction are reported via the standard SR-OS [S-R-O-S] SNMP change traps, and basic candidate status information is available via SNMP.

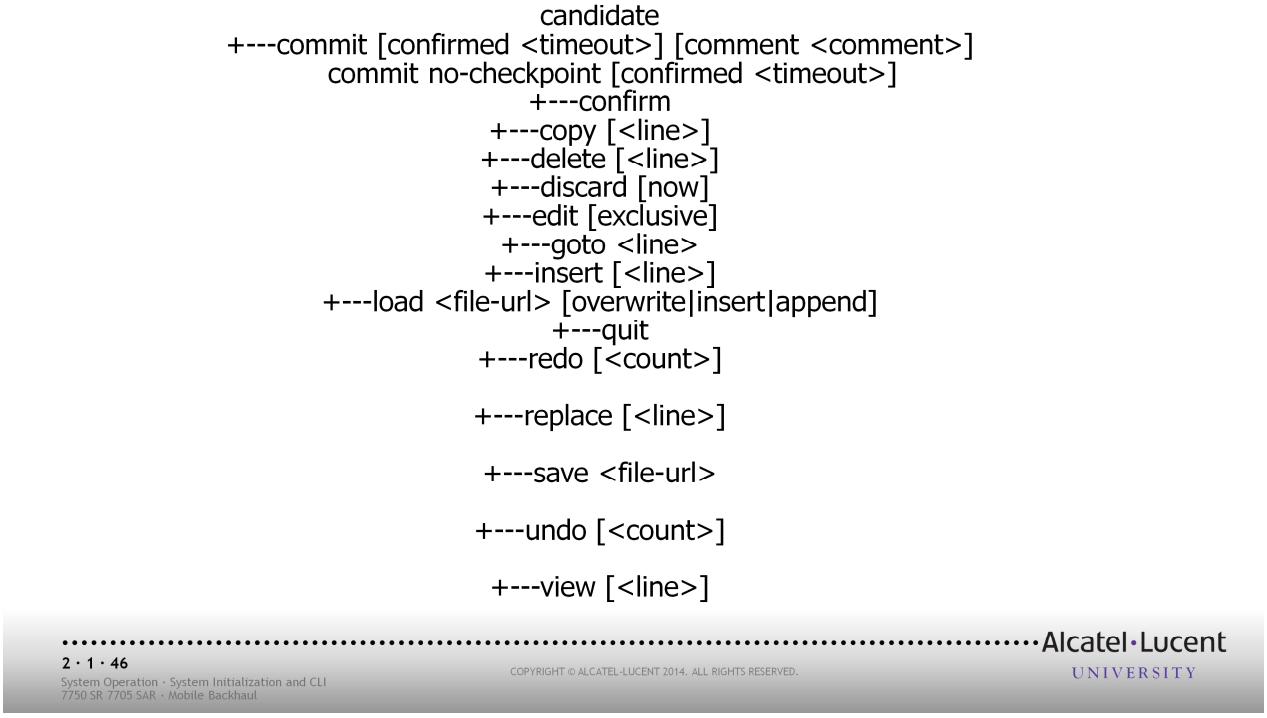
Standard line-by-line (immediate operational effect upon pushing the enter/return key) non-transactional CLI and SNMP commands are not blocked during the creation/editing of a candidate or the processing of a commit. These commands take immediate effect as normal.

If a command causes an error or resource exhaustion, the router will be returned (using rollback) to the state it was before the execution of the candidate configuration.

By default, SR-OS will automatically create a new rollback checkpoint after a commit operation. The rollback checkpoint will include the new configuration changes made by the commit. An optional "no-checkpoint" keyword can be used to avoid the auto-creation of a rollback checkpoint after a commit. If the commit fails, then no new rollback checkpoint is created.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Transactional Configuration CLI Tree



The CLI tree for Transactional Configuration is shown here.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Transactional Configuration Example

```
A:196# candidate edit exclusive

INFO: CLI Entering exclusive mode. Leaving the candidate config without committing will
discard the content of your candidate config.

A:196>edit-cfg#
A:196>edit-cfg# configure system name PE1
A:196>edit-cfg# configure card 1 card-type "iom3-xp"
A:196>edit-cfg# configure card 1 mda 1 mda-type m20-1gb-xp-tx
A:196>edit-cfg# configure router interface "system" address 10.10.10.1/32
A:196>edit-cfg# configure router interface toPE2
A:196>edit-cfg>config>router>if# address  10.1.2.1/30
A:196>edit-cfg>config>router>if# port 1/1/1
A:196>edit-cfg>config>router>if# no shutdown
A:196>edit-cfg>config>router>if# exit all
A:196>edit-cfg# configure port 1/1/1 no shutdown
A:196>edit-cfg# configure port 1/1/2 shutdown
A:196>edit-cfg# configure port 1/1/2 ethernet mode access
A:196>edit-cfg# configure port 1/1/2 ethernet encap-type dot1q
A:196>edit-cfg# configure port 1/1/2 no shutdown
A:196>edit-cfg# candidate save cf1:\ExampleCandidate
Writing candidate-cfg to cf1:\ExampleCandidate.. OK
A:196>edit-cfg# candidate commit no-checkpoint
Processing current config... 0.010 s
INFO: CLI Successfully executed 32 lines in 0.090 s.
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A candidate configuration example is shown here.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 2
System Operation

Module 2
Basic System and Hardware Configuration

TER36075_V3.1-SG-English-Ed1 Module 2.2 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to:

- Explain physical access options
- Perform basic system configuration: system name, CPM Ethernet port address, change admin password
- Perform basic hardware configuration: IOMs, MDAs, and ports

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — Basic system configuration	**5**
2 — Basic hardware configuration	**11**

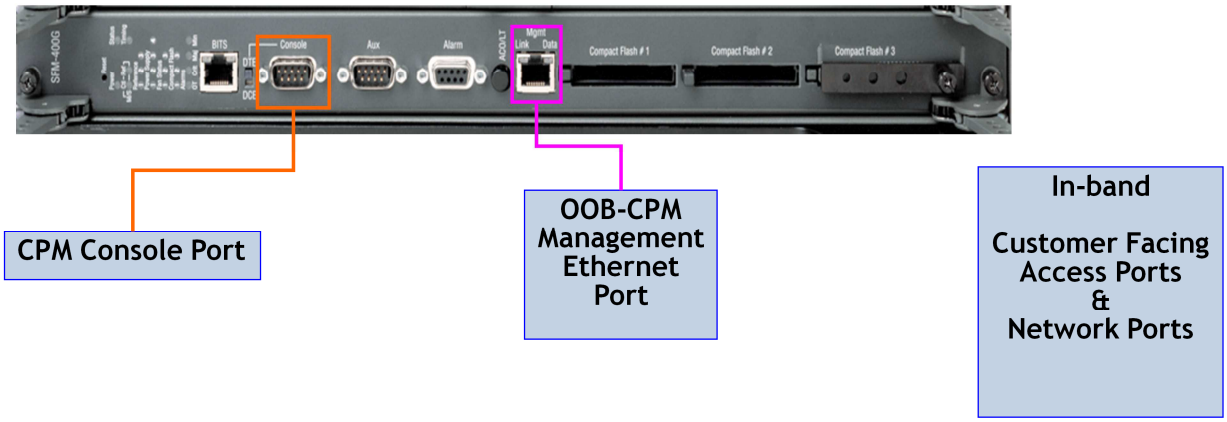
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Basic system configuration

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Physical Access

SF/CPM Card Common to the SR-7, and SR-12



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

There are three ways to access a node:

1. The console port, a DB-9 serial port, which is enabled by default. Initially, the node must be configured through this serial port.

   The default settings are:

   Baud Rate: 115,200

   Data Bits: 8

   Parity: None

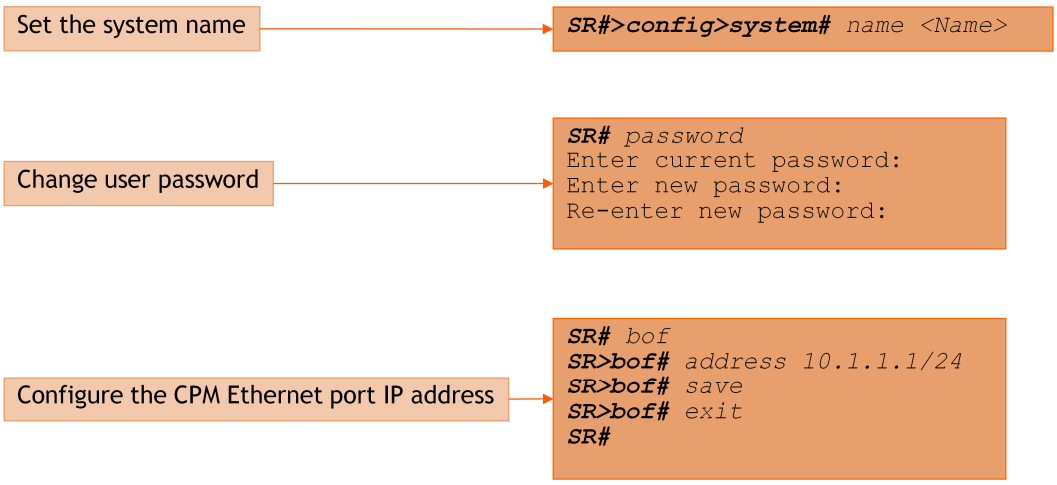
   Stop Bits: 1

   Flow Control: None

2. The CPM management Ethernet port, a 10/100 Ethernet management port located on the front of the CPM, which must be initialized first (in the BOF or through the console). This is considered Out Of Band (OOB) traffic.
3. Through the access and network ports. These are the in-band ports that carry the network and customer traffic.

Note: By default, a node can only be accessed through the console port. Once a management IP address and port have been configured, the Ethernet or in-band management ports can be used, through the use of Telnet or SSH.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Basic System Management Configuration

Some basic configuration on the 7750 is required before putting it into service:

- System name
- Change admin password
- CPM Ethernet management port IP address
- Configure IOMs, MDAs, and ports

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

System Name

The system name can be any American Standard Code for Information Interchange (ASCII) printable string of up to 32 characters. The system name is configured in the **config** CLI context. If the name contains spaces it must be enclosed in double quotes to delimit the start and end of the name. The system name will become part of the CLI prompt.

```
Node>config>system#name
```

Passwords

The default login and password is '**admin**'. You should change this password before putting your SR into service.

The system automatically creates at least one admin user (the default) and must retain at least one admin user unless you use an external authentication protocol such as Remote Authentication Dial In User Service (RADIUS) or Terminal Access Controller Access Control System + (TACACS+).

You can configure the following password parameters:

- Aging – the maximum number of days (1 – 500) that a password remains valid before the user must change it. Default is no aging enforced.
- Attempts – the number of unsuccessful login attempts allowed in a specified time period. If the configured threshold is exceeded, the system locks the user out for the specified lockout time period (default is attempts:3 – time: 5 – lockout:10).

  ***Count:** 4* (maximum 4 attempts allowed)

  ***Time (minutes):** 10* (4 failed attempts in 10 minutes locks out the user)

  ***Lockout (minutes):** 10* (the user is locked out for 10 minutes)
- In the example above, the system will lock out a user if, in 10 minutes time, she attempts to log in and fails 4 consecutive times. She remains locked out for 10 minutes. Also aging is set to 30 days.

```
Node# configure system security password [Enter]
Node>config > system > security>password# aging 30
Node>config > system > security>password# attempts 4 time 10 lockout 10
```

- Authentication Order – you can configure the order in which password authentication is attempted among RADIUS, TACACS +, and Local methods.

- Complexity – you can use this parameter to specify if passwords must contain upper and lower case characters, numerics, and special characters.

- Minimum Length – you can specify the minimum number of characters (1 – 8) required for a password (default is 6).

```
Node>config > system > security>password# attempts 4 time 10 lockout 10
Node>config > system > security>password# complexity
Node>config > system > security>password# minimum-length 8
Node>config > system > security>password# exit all
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Configuring the admin user password

- The default login ID and password are both ‘admin’ (it should be changed before putting SR into service)
- At least one admin user must exist, unless an external authentication protocol (RADIUS or TACACS+) is used
- You can configure the following password parameters:
  - Aging – number of days that a password remains valid
  - Attempts:
    - Count: number of unsuccessful attempts allowed
    - Time (minutes): period during which attempts are made
    - Lockout (minutes): period during which login is blocked after the number of unsuccessful attempts is reached
  - Complexity – specifies if passwords must contain upper and lower case letters, numbers, and special characters
  - Minimum Length – minimum number of characters required for a password



To access the CPM management Ethernet port, use the following commands to assign it an IP address. This address is assigned to the active CPM in the running configuration and the BOF or the standby CPM for systems using redundant CPMs. Always save the BOF!

```
Node# bof ↵
Node>bof# address <xxx.xxx.xxx.xxx/xx> or
Node>bof# address <xxx.xxx.xxx.xxx/xx> <active|standby>
Node>bof# save
Node>bof# ctrl+z
Node#
```

Note: Login to a standby CPM card is not allowed neither through the management ethernet nor the console port. Assigning a separate management IP address to the standby CPM allows for remote connectivity testing to both CPM cards available on the system. Unlike management access requests, the standby CPM replies to ping requests directed onto its own IP address.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Configuring the CPM Ethernet Port Address

SR# bof
SR>bof# address <xxx.xxx.xxx.xxx/xx> or
SR>bof# address <xxx.xxx.xxx.xxx/xx> <active|standby>
SR>bof# save



To access the CPM management Ethernet port, use the following commands to assign it an IP address. This address is assigned to the active CPM in the running configuration and the BOF or the standby CPM for systems using redundant CPMs. Always save the BOF!

```
Node# bof ↵
Node>bof# address <xxx.xxx.xxx.xxx/xx> or
Node>bof# address <xxx.xxx.xxx.xxx/xx> <active|standby>
Node>bof# save
Node>bof# ctrl+z
Node#
```

Note: Login to a standby CPM card is not allowed neither through the management ethernet nor the console port. Assigning a separate management IP address to the standby CPM allows for remote connectivity testing to both CPM cards available on the system. Unlike management access requests, the standby CPM replies to ping requests directed onto its own IP address.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Basic hardware configuration

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Provisioning Cards & MDAs

IOM Configuration

- Example:
  - **SR#**configure card 1
  - **SR>config>card#** card-type iom3-xp

MDA Configuration

- Example:
  - **SR#**configure card 1
  - **config>card#** mda 1
  - **config>card>mda#** mda-type m60-10/100eth-tx

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Hardware provisioning:

The SR allows you to provision slots, IOMs, MDAs, and ports before or after they are physically installed.

You can also optionally specify what line cards are permitted to be installed in a particular slot and what MDAs are permitted to be installed in a particular IOM. A line card or MDA will not initialize unless the installed type matches the permitted type.

Provision hardware in the following order:

1. Select a chassis slot and provision the IOM type for the slot.
2. Select an MDA slot and specify the MDA type for the slot.
3. Select a port and configure it.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Provisioning Ports

Enable a Port

- Example:
  - SR# configure port <1/1/1> no shutdown
  - SR# show port

Ports can be enabled individually, or use a range command to enable a series of ports

- SR# configure port 1/1/[1..9] no shutdown

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Note: The brackets denoting the range of ports

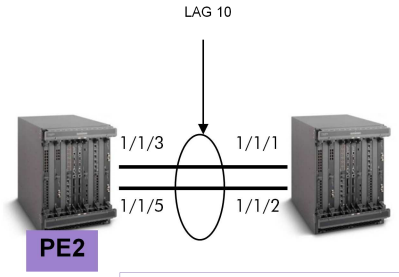
Auto-completion does not work after closing the bracket

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Provisioning – Link Aggregation Groups

Link Aggregation Groups (LAG) combine multiple ports together to form a single logical link

- Increased bandwidth incrementally
- Redundancy if one or more links in the LAG should fail



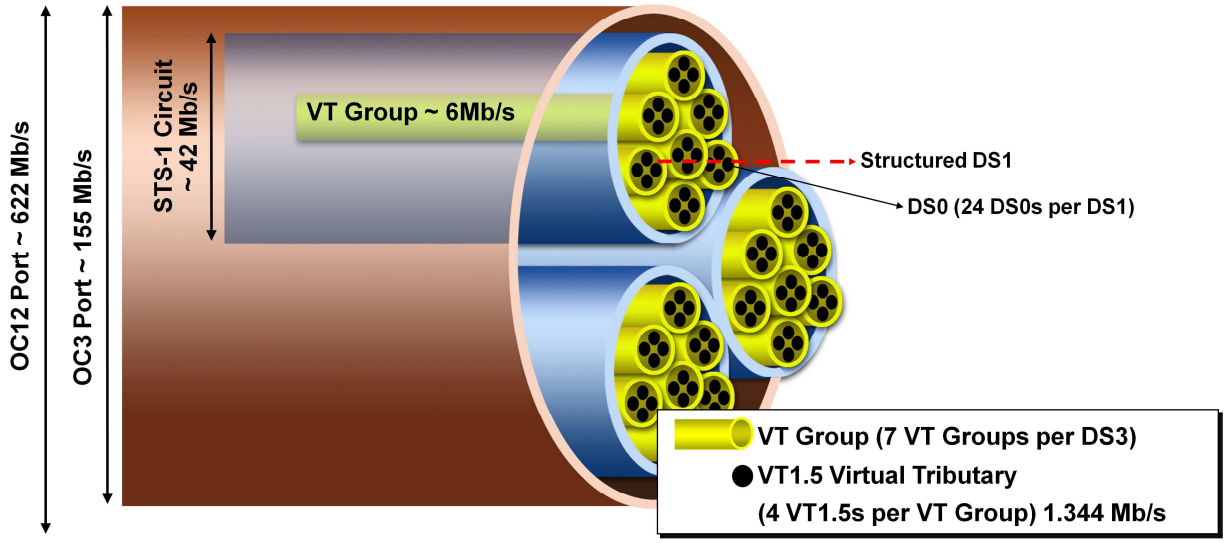

```
PE2# configure port 1/1/3
PE2>config>port# ethernet autonegotiate limited
PE2>config>port# /configure port 1/1/5
PE2>config>port# ethernet autonegotiate limited
PE2>config>port# /configure lag 10
PE2>config>lag# port 1/1/3
PE2>config>lag# port 1/1/5
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A LAG increases the bandwidth available between two nodes by grouping up to eight ports into one logical link. The aggregation of multiple physical links allows for load sharing and offers seamless redundancy. If one of the links fails, traffic is redistributed over the remaining links. Up to eight links can be supported in a single LAG

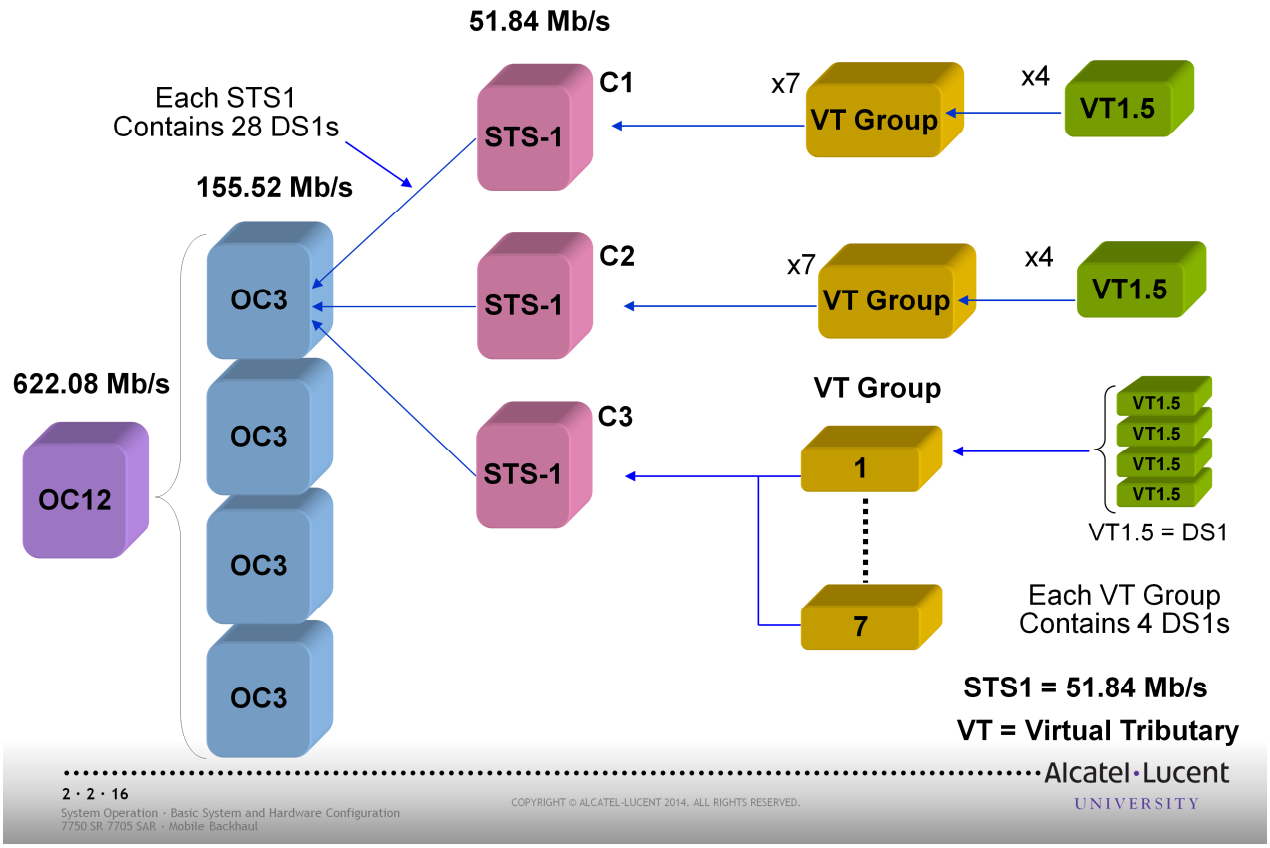
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OC12 VT Group Circuits



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



SONET OC3 Modes

VT Group Mode

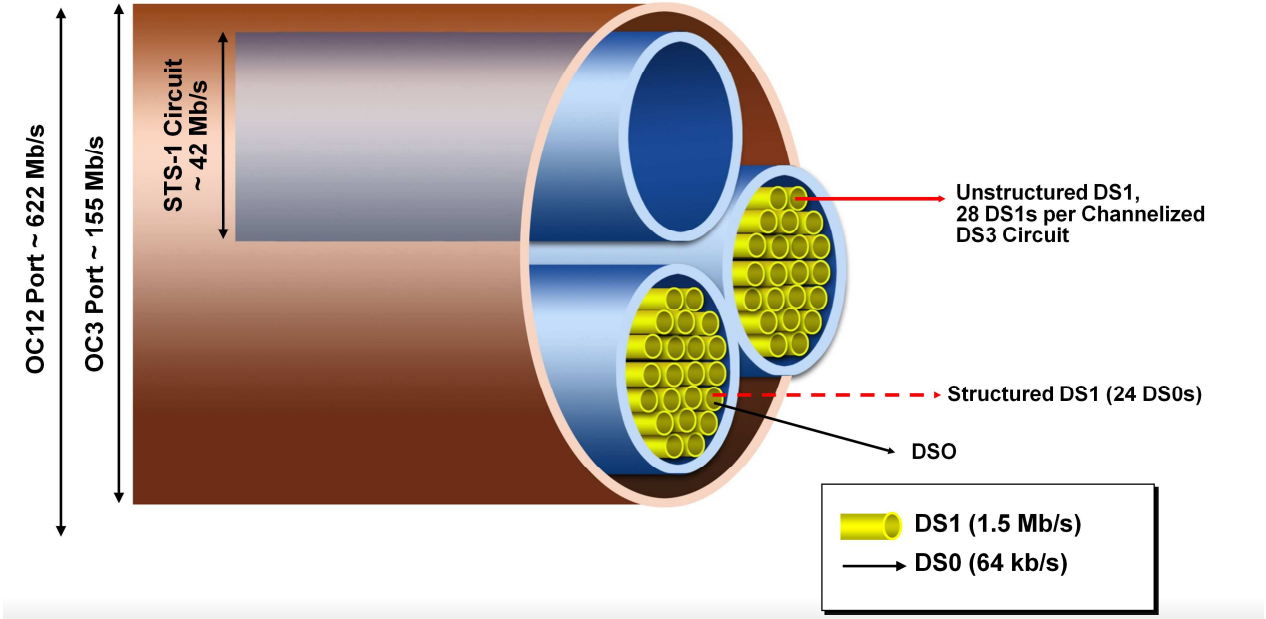
A SONET OC-3 interface operates at a rate 155.52 Mb/s and is comprised of three STS1 (51.84 Mb/s) SONET frames. A SONET OC-3 interface operates at a rate 155.52 Mb/s and can be subdivided into three STS1 (51.84 Mb/s) SONET frames. The payload area of each STS-1 SONET frame, the synchronous payload envelope (SPE), can carry one DS-3 (44.736 Mb/s) channel. Overall, an OC-3 interface can carry up to three DS-3 channels.

In order to carry traffic at rates below DS-3, the SPE is divided into seven Virtual Tributary Groups (VTG), each of which can contain four VT1.5 virtual tributaries. Each VT1.5 virtual tributary carries one DS1.

Each VT Group can be unstructured or structured. Unstructured mode allows access down to the DS1 circuit level. Structured mode allows access down to the N x 64 Kb/s circuit level.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

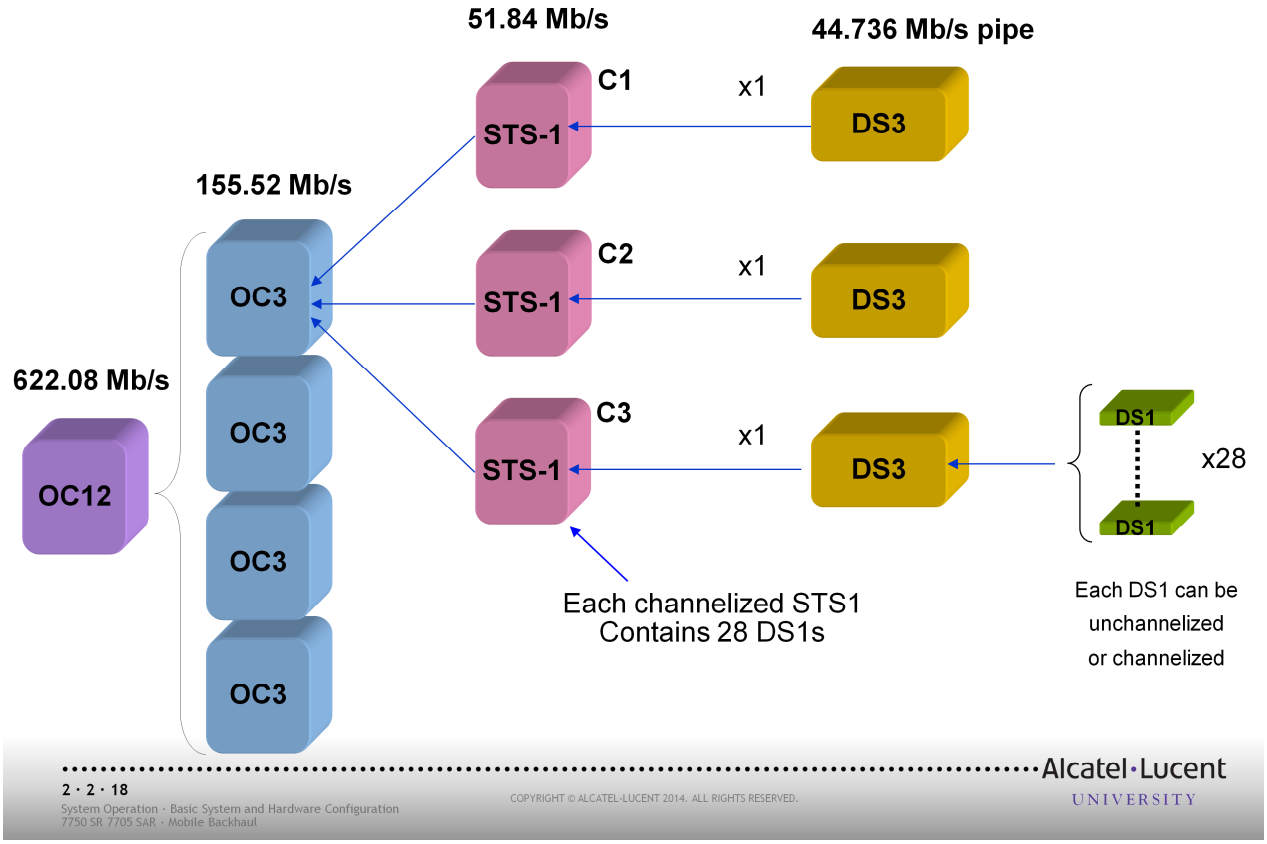
OC12 Bulk Payload Circuits



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

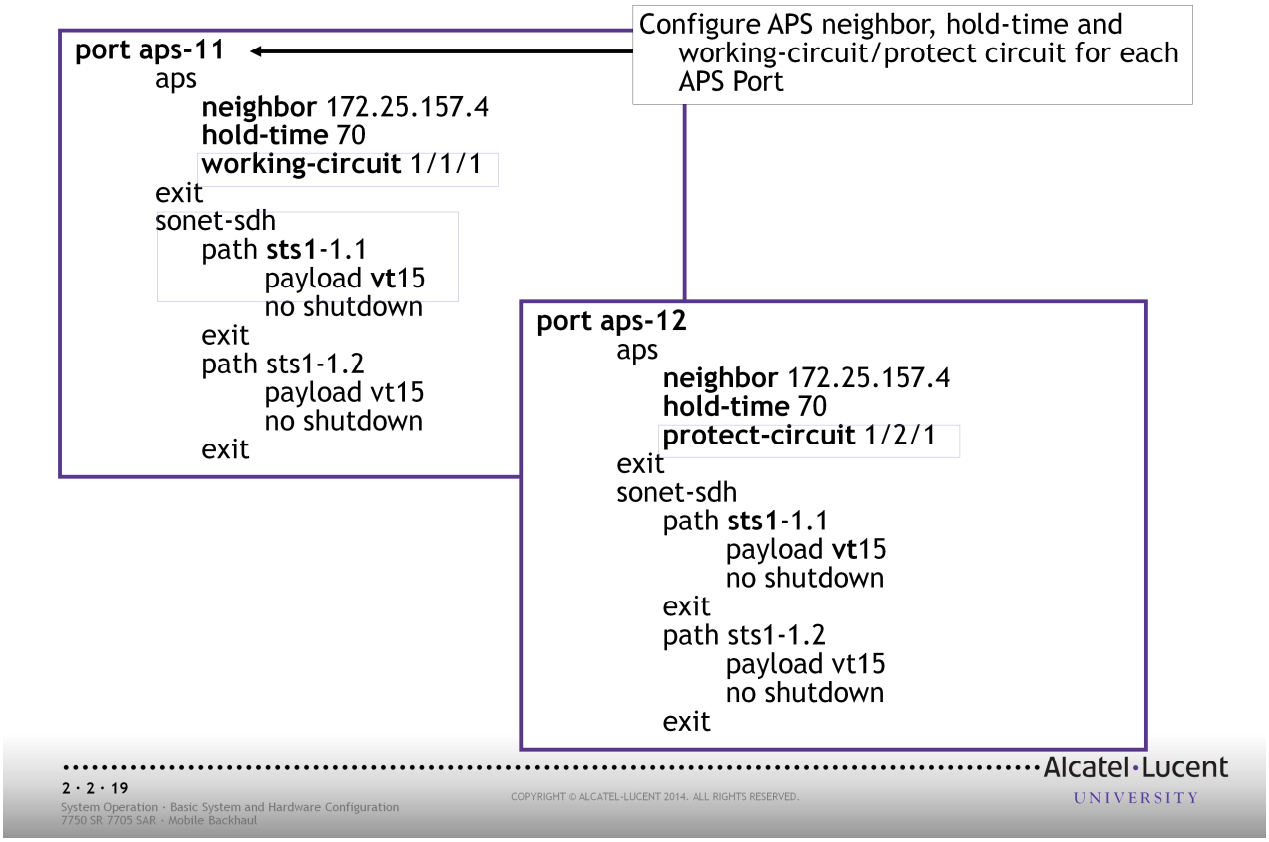
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OC12



Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

APS Configuration Example



The Any Service Any Port (ASAP) cards support a number of encapsulation and framing types. In the IP Backhaul environment, typical installations call for either STS or STM channels.

Depending on the network, you may either create SONET virtual tributaries (vt's) or channelized DS3's through which the routers transport individual clear-channel DS-1s. The syntax you use depends on the configuration you choose.

The range command allows you to build and configure multiple SONET paths simultaneously. The example below builds all twelve STS-1s on a single OC-12 port, and configures the STS payload as vt15s. You need not build all STS-1s at once. For OC-3 ports, you would only build out the three STS-1s. For DS3's, you would leave the payload set to the default payload of DS3.

Once you have built out the STS1's, you need to build the virtual tributary groups (VTGs) and VT's. Each STS-1 supports 7 VTGs with 4 VTs each. Again, build what you need. We are still working within the APS group context.

OC-12 ports:

MLSx>config>port>sonet-sdh# path sts1-[1..4].[1..3] payload vt15

MLSx>config>port>sonet-sdh# path sts1-[1..4].[1..3] no shutdown

MLSx>config>port>sonet-sdh# path vt15-[1..4].[1..3].[1..7].[1..4] no shutdown

Note: For more extensive information on APS, see Section 6, Module 1.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

DS1 Configuration Example

Once you have built the vts, configure the DS1s

Within the APS group context, build the individual, clear-channel DS1s

- Whether you use VT or DS3 payloads, the requirements here are the same

```
tdm
        ds1 1.1.1.1
            clock-source node-timed
            channel-group 1
                description "BTS120-DO-MLG1-URC05-T1-1"
                encap-type ipcp
                timeslots 1-24
                ppp
                    keepalive 4 dropcount 3
                exit
                no shutdown
            exit
        no shutdown
exit
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.


```
MLSx>config>port# tdm
MLSx>config>port>tdm# ds1 [1..4].[1..3].[1..7].[1..4] clock-source {loop-timed|node-timed}
MLSx>config>port>tdm# ds1 [1..4].[1..3].[1..7].[1..4] channel-group 1 encap-type ipcp
MLSx>config>port>tdm# ds1 [1..4].[1..3].[1..7].[1..4] channel-group 1 timeslots 1-24
MLSx>config>port>tdm# ds1 [1..4].[1..3].[1..7].[1..4] channel-group 1 ppp keepalive 4 dropcount 3
MLSx>config>port>tdm# ds1 [1..4].[1..3].[1..7].[1..4] channel-group 1 no shutdown
MLSx>config>port>tdm# ds1 [1..4].[1..3].[1..7].[1..4] no shutdown
MLSx>config>port>tdm# exit all
MLSx# show port <X/X/X.Y.Y.Y.Y> detail
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

BPGRP (Bundle Protection Group)

BPGRP provides APS 1+1 (bi-directional) protection for a channelized SONET/SDH port and for IMA bundles which member links all reside on the protected SONET/SDH port

BPGRP supports APS functionality for the IMA bundle on the channelized ASAP MDA (m4-choc3-as-sfp)

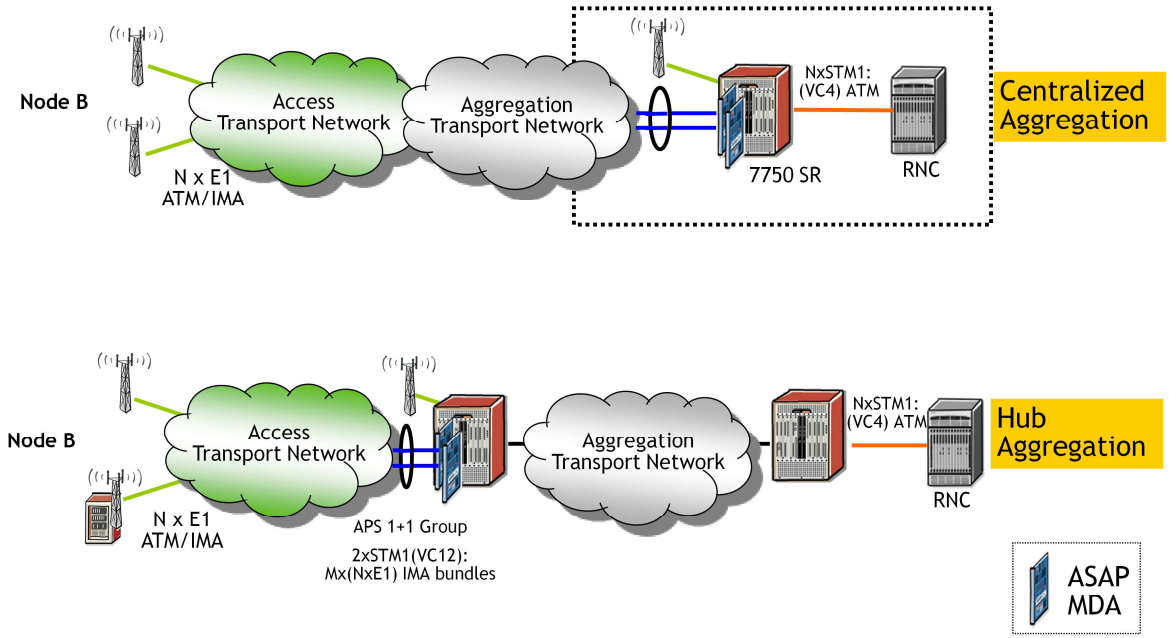
The protection port of the same speed could be on a different ASAP MDA in the same chassis or on a different port of the same MDA

77x0 supports APS 1+1 protection in compliance with GR-253-CORE and ITU.T G.841. All TDM channels within a SONET/SDH port are protected

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

A Typical Application in 3G Mobile



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

BPGRP Features

An APS circuit port can only be protected by another APS circuit port of the same physical speed.

Bundle members used by an MLPPP bundle cannot be APS protected.

An APS circuit port cannot be used by an MLPPP bundle.

MC-APS is not supported with IMA bundles.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

BPGRP Features

The initial APS implementation is to support APS 1+1 (bi-directional) only.

The 7750 SR only transmits traffic on an active circuit.

The APS working and protect ports could be connected in one of the following scenarios:

- Two ports on the same MDA
- Two ports, one in MDA 1 and one in a different MDA but on the same I/O module
- Two ports on different I/O modules (installed in different slots)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

BPGRP Features

The APS 1+1 system provides the revertive and non-revertive modes (default)

Relative priorities of events affecting 1+1 protection

Automatically Initiated, External, or State Request
Lockout of Protection
Signal Failure of Protection Line
Forced Switch
Signal Failure of Working Line
Signal Degrade
Request Switch
Revert-time (only applies to revertive switching)
Do Not Revert (only applies to non-revertive switching)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

BPGRP Limitations

IMA protocols support: both v1.1 (default) and v1.0

Min. number T1/E1 paths in an IMA group: 1

Max. number T1/E1 paths in an IMA group: 8

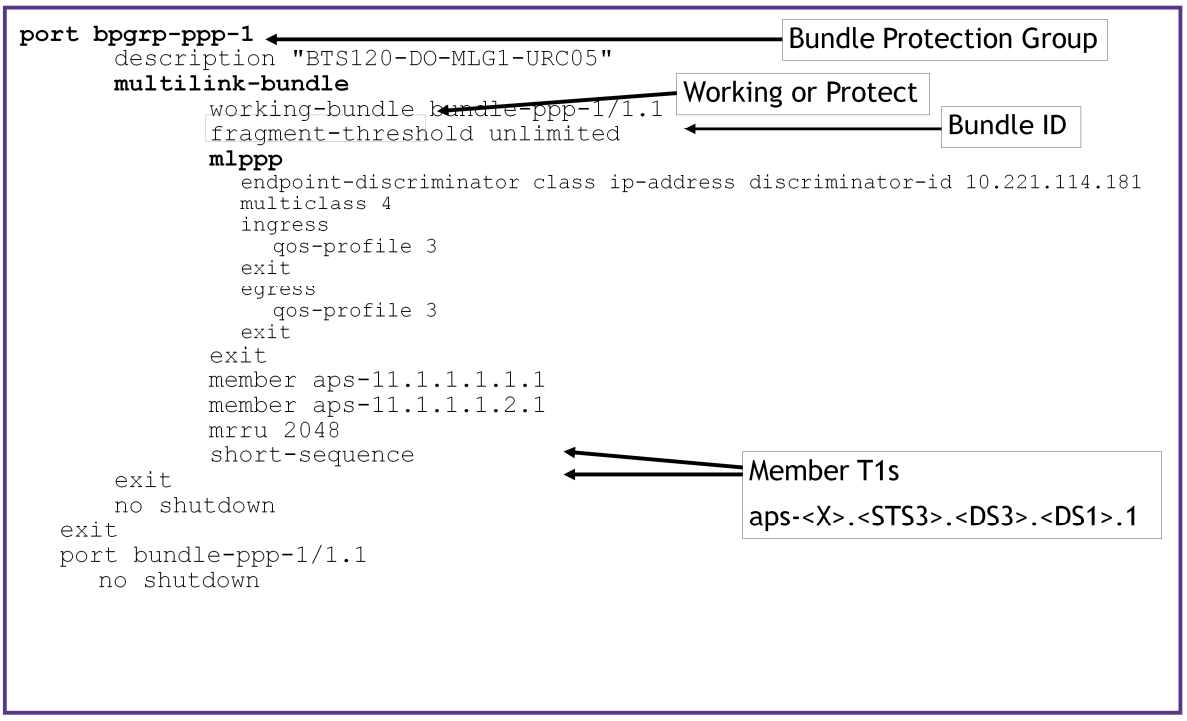
Service support: on the access side

No mixing of DS1 and E1 within the same STS-1 or TUG-3

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MLG Configuration Example



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
Basic System and Hardware Configuration

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 3
Synchronization

Module 1
Synchronization Techniques for TDM Networks

TER36075_V3.1-SG-English-Ed1 Module 3.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to describe:

Network synchronization options for cPipes

- TDM-based
  - External BITS clock
  - Line reference
- Packet-based
  - Adaptive Clock Recovery
  - Synchronous Ethernet
  - IEEE 1588v2

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

1 — Network synchronization options for cPipes **6**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Network synchronization options for cPipes

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Timing/Synchronization

The 7705 SAR has sophisticated synchronization functionality to operate in traditional TDM as well as packet networks:

- TDM
  - External BITS clock
  - Line reference
  - Local Stratum 3 holdover/free run
- Packet
  - Adaptive Clock Recovery (ACR)
  - Synchronous Ethernet (ITU G.826)
  - IEEE 1588v2 slave

- 7750 SR synchronization timing:
  - BITS port

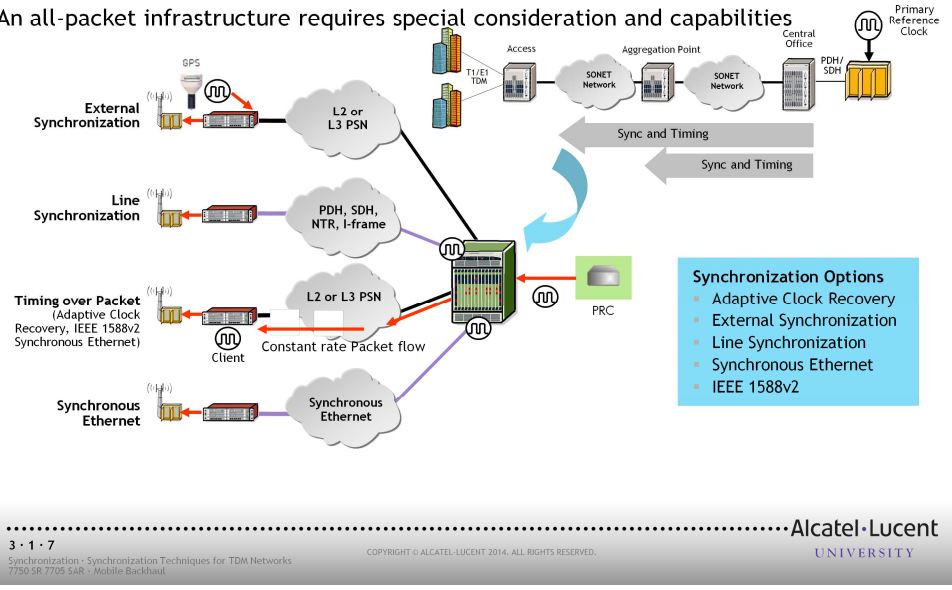
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Network timing and synchronization

Synchronization is as basic to network operation as power and grounding

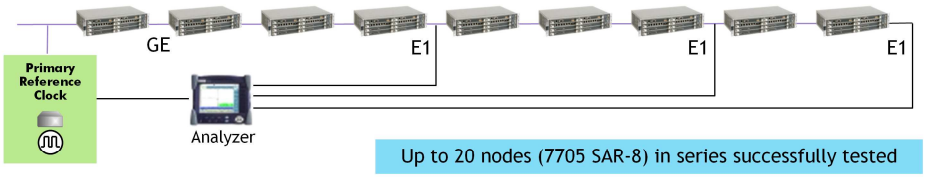
An all-packet infrastructure requires special consideration and capabilities



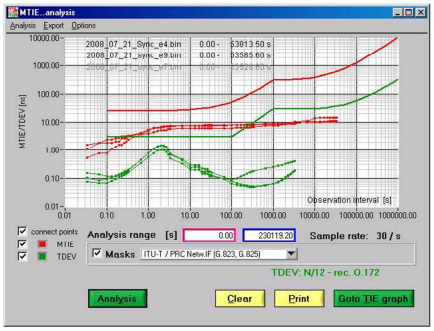
The 7705 SAR supports external reference timing, line timing and adaptive timing in R1.0. The adaptive timing is fully capable of offering end-to-end synchronisation. The IEEE1588v2 standard defines a method to minimize the effects of delay and delay variation (jitter). This is accomplished by a combination of built-in platform architectural features and also powerful QoS mechanisms to minimize the delay experienced by synchronization traffic. The SyncE feature is a hardware level synchronization which happens at level 1 similar to SONET/SDH timing mechanisms implemented today. These are a cornerstone of the design of the 7705 SAR. A built-in Stratum-3 clock is available in the control module to assist in sync maintenance.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

End-to-end synchronous Ethernet performance



Up to 20 nodes (7705 SAR-8) in series successfully tested



All MTIE/TDEV plots lie well under the G.823 PRC Synchronization Interface network limit (although they only need to target performance under the G.823 SEC Synchronization Interface network limit)

Measurement	Exceeds Requirements
Time Interleave Error (TIE)	✓
Maximum Time Interval Error (MTIE)	✓
Time Deviation (TDEV)	✓

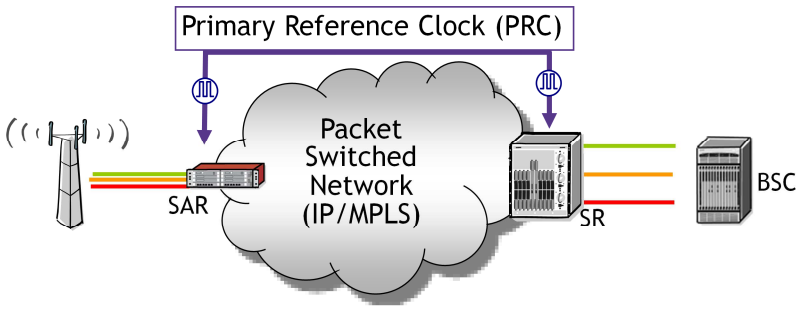
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Synchronous Networks

Proper synchronization is essential for wireless carriers to ensure smooth call hand-off between base stations

- When a packet switched network is used to deliver traffic in a synchronized network, the synchronization chain is broken so the timing has to be recovered



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

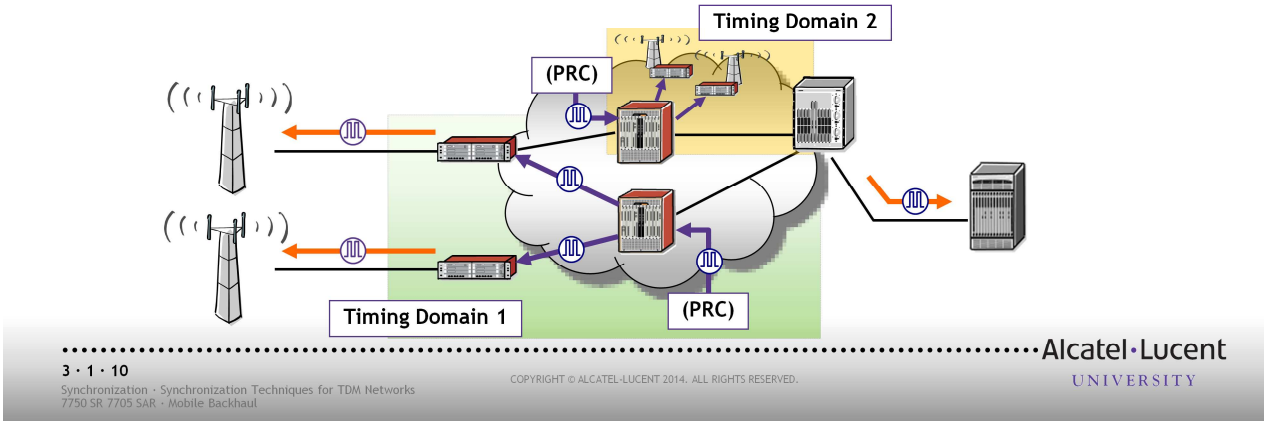
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Timing Domains

One misconception for maintaining network synch in large networks is that the same clocking source used at the BSC/RNC must be the timing source at the BTS/Node B

Multiple clocking sources may be required to maintain clocking quality and to maintain end-to-end synchronization

- In this case, each 7705 at a cell site within a local domain derives a clock from a strategically placed central PW source
- The timing domains are chosen such that they are manageable in size, each deriving a clock from a different source



Distributed Clocking Sources

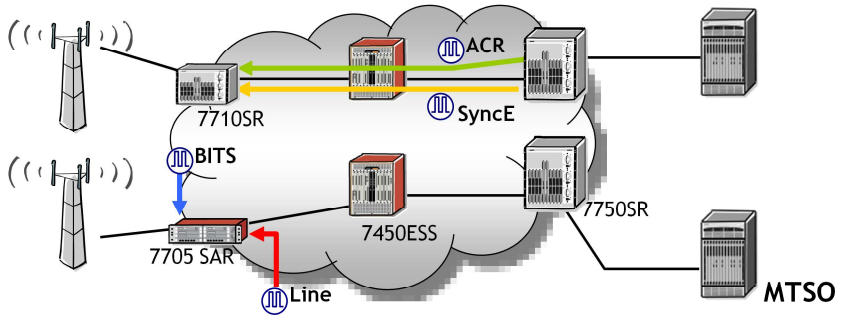
In general, the amount of noise introduced by the network increases with the number of network elements between a PRC master and the client device. Therefore it is always good to minimize the number of network hops between the master and the client. This may be achieved by distributing the PRC around the network, or by the use of strategically placed boundary clocks to terminate the timing fow, and re-generate for the next network segment. For example, in it is better to place a boundary clock after 5 hops than to attempt to span the entire 10 hop network.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Network Synchronization Options

Synchronization architecture depends on the option selected for the deployment:

- BITS: Using a GPS clocking module co-located at the cell site
- Line: Using a T1/E1 channel available at the cell site either via a GPS based CDMA basestation or a collocated PDH/SDH/SONET backhaul network
- Synchronous Ethernet (SyncE)
- Adaptive Clock Recovery (ACR): Using clock propagation from Core network through RNC-7750-7705 to Node B



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Distribution of clocking within traditional SDH/SONET networks has been defined for two applications. Synchronization reference distribution and traffic transport. Each application has its own performance target which is expressed in defined limits to accumulated jitter and wander. The jitter is fairly easy to remove but the wander tends to accumulate and becomes the more important limit to monitor. In addition, mobile operators are more concerned with the 50 ppb accuracy of the intended frequency reference.

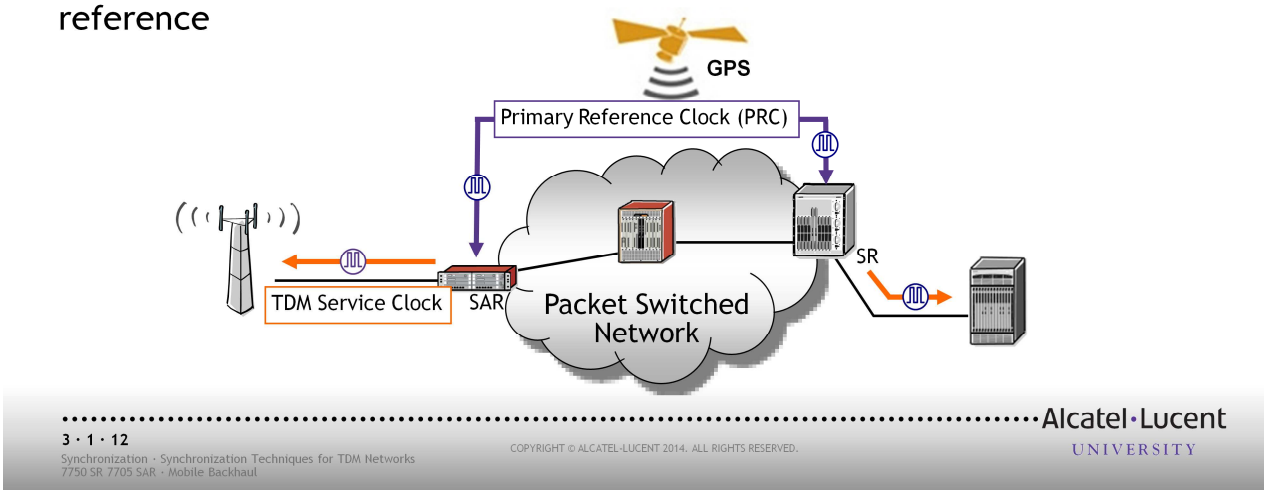
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

BITS: External Synchronization

One deployment example is to use equipment based on GPS clocking facilities to generate the clocking necessary for the platforms

Signals from GPS satellites are used to correct a local oven controlled crystal oscillator which results in a low cost frequency reference that is comparable to that of a Cesium clock

The outputs of these GPS synch units can be fed to the external clocking interface or a T1/E1 port on an ASAP MDA on the 7705 and used as a reference



The external clocking interface of the 7705 allows for three different clocking frequencies to be used as external references for the system clock:

- 2.048 MHz, 5 MHz, and 10 MHz

The SR and ESS platforms have a standard BITS interface that can also provide a synchronization source to the clocks on the system

Differential methods

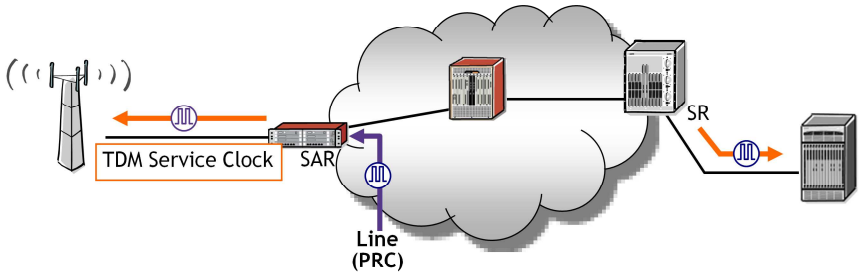
According to the differential methods, the difference between the service clock and the reference clock is encoded and transmitted across the packet network. The service clock is recovered on the far end of the packet network making use of a common reference clock

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Line Synchronization

In PDH/SDH/SONET networks, available interfaces can be used to transmit a PRC traceable signal between the RNC and Node B

If a PRC traceable signal is not possible through the aggregation network, then the accessibility to one T1/E1 line signal that is PRC traceable is sufficient to get a clock reference to the Node Bs



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

If a PRC traceable signal is not possible through the aggregation network, then the accessibility to one T1/E1 line signal that is PRC traceable is sufficient to get a clock reference to the Node Bs

- On the 7705 SAR, an ASAP MDA port is configured as the Synchronization Supply Unit (SSU) reference source
- Each adapter card can only supply a single monitored timing reference to the SSU, except on the 7705 SAR-F which supports multiple (two) line references from the same MDA

Adaptive methods

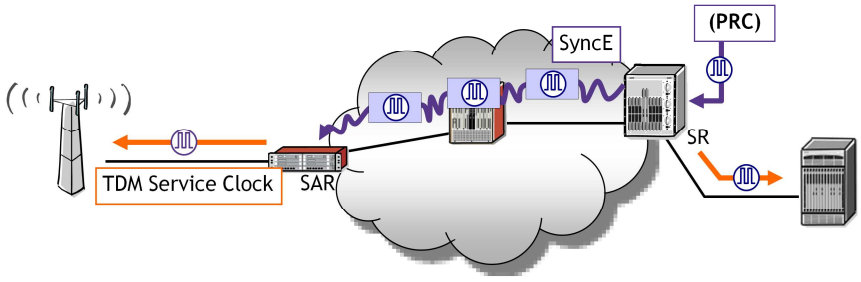
In the adaptive methods, the timing can be recovered based on the inter-arrival time of the packets or on the fill level of the jitter buffer. It should be highlighted that the method preserves the service timing

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Synchronous Ethernet

Synchronous Ethernet enables the SSU to derive its clock from an Ethernet based port as it had traditionally done with SONET/SDH ports

- The physical layer Tx clock is locked to a high-quality frequency reference clock (eventually PRC traceable clock)
- The receiver at the far end locks to the physical layer clock of the Rx signal, gaining access to a highly accurate reference



Note: In order for Synchronous Ethernet to work, each node along the path must have a Sync-E SFP

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Using SyncE the usually free running Ethernet physical layer clocks are synchronized to a network clock. At the inter-working function, the primary reference clock (PRC) is used to drive the Ethernet PHY. The clock is extracted from the PHY layer at each packet-switching node, filtered and used for system and downstream clocking to extend the idea of synchronous networks to the Ethernet. ITU-T G.8262, describes the timing characteristics of the Synchronous Ethernet Equipment Slave Clock (EEC). The EEC clocks are specified to perform in a manner consistent with existing synchronous equipment slave clock in the SDH domain.

G.8262 outlines minimum requirements for timing devices used in synchronizing network equipment supporting the Synchronous Ethernet architecture. The specification outlines requirements for clock accuracy, noise (Jitter and Wander - transfer, tolerance and generation) transient and holdover performances.

Similar to G.813 which describes SDH Equipment Clock, the Ethernet Equipment Clock also contains two options: EEC option 1 applies to Synchronous Ethernet equipments that are designed to inter-work with networks optimized for the 2,048kbps hierarchy and EEC-Option 2 applies to Synchronous Ethernet equipments that are designed to inter-work with networks optimized for the 1,544kbps hierarchy.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Synchronous-Ethernet: Requirements

What do I need for Synchronous-Ethernet?

Every node and every interface between the synch source and destination needs to be Sync-E capable

Synch-E requirements on the 7705 SAR

- SAR-8: Ethernet V2 adapter card
- SAR-F: Sync-E is supported
- Only SFP ports support Sync-E

Not all SFPs support Sync-E (see notes)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Part #	Short Description
3HE00027AA	PBA GIGE SX SFP OPTICS MODULE - LC
3HE00028AA	PBA GIGE LX SFP OPTICS MODULE - LC
3HE00867AA	KIT GIGE EX SFP OPTICS MODULE - LC
3HE00029AA	PBA GIGE ZX SFP OPTICS MODULE - LC
3HE00024AA	PBA 100FX SFP OPTICS MODULE - LC
3HE00266AA	KIT 100FX SFP OPTICS MODULE - SM 24km – L

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SFP Sync-E Support

SFP Sync-E capability status information indicates whether the installed SFP is Sync-E capable

```
sar-F# show port 1/2/7 detail
Ethernet Interface
==================
Description        : 10/100/Gig Ethernet SFP
Interface          : 1/2/7                       Oper Speed       : 1 Gbps
Link-level         : Ethernet                    Config Speed     : 1 Gbps
.....
    (Output omitted)
.....
Transceiver Data
Transceiver Type   : SFP
Model Number       : 3HE00027AAAA01  ALA  IPUIAELDAA
TX Laser Wavelength: 850 nm                      Diag Capable     : no
Connector Code     : LC                            Vendor OUI       : 00:0a:1d
Manufacture date   : N/A                         Media            : Ethernet
Serial Number      : 00005283802
Part Number        : TRP-G1BCTM
Optical Compliance : GIGE-SX
Link Length support: 550m for 50u MMF; 280m for 62.5u MMF;
SFP Sync-E Capable : yes
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

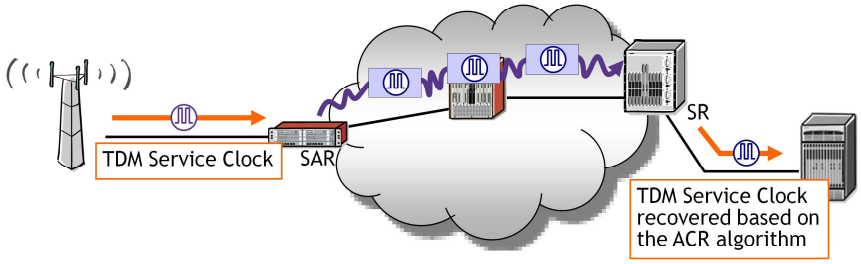
Adaptive Clock Recovery

Adaptive Clock Recovery (ACR) uses an averaging process that negates the effect of the packet delay variation by averaging the rate of incoming packets of encapsulated TDM traffic

ACR is possible since the source TDM device is producing bits at a constant rate determined by its clock

When ACR is used, the more packets sent on the cpipe, the more accurate the ACR algorithm will be

- The configurable limit for the 7705 SAR is currently 4000 packets-per-second



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The most economical option for ACR is to use a 7705 to source it. If redundant sources are desired, then two 7705 chassis can be used.

When ACR is used, the more packets sent on the cPipe, the more accurate the ACR algorithm will be. The configurable limit for the current release of the 7705 is 4000 packets-per-second. That being the case, for a single timeslot, the SAP should configure payload size to be 8 bytes. This value comes from the fact that a single timeslot can transmit 8 KB per second, so stuffing 8 bytes per packet gives a total of 1000 pps.

CES PW starts at either a 77x0 SR or 7705. The PRC quality reference signal can come from RNC, BITS, or reference line signal.

No more than 3 heavily loaded intermodal links between the ACR source node and the cell site's 7705 SAR. The CES PW is to be sized to allow 1000 packets/sec and priority NC.

No more than 80% traffic loading on any of the inter-nodal links.

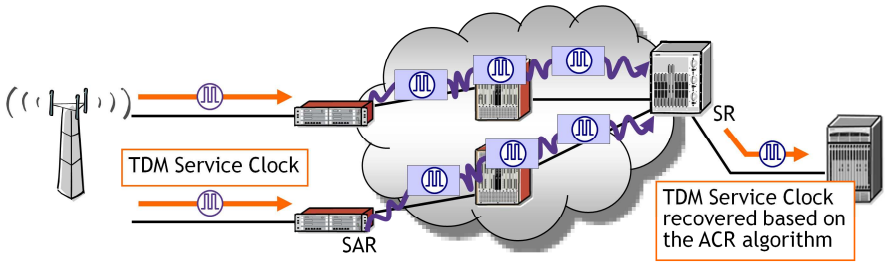
APS Protection of CES origination at 7750 SR

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ACR synchronization source clock protection

In order to protect ACR synchronization source clocks, one solution is to source ACR from two 7705s with two different CESoPSN PW

This configuration provides ACR source protection at the head-end, including multi-chassis redundancy



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Note: On the receive end, the redundant sources must terminate on two different ASAP MDAs on a 7705 SAR-8 . Alternatively, on the 7705 SAR-F available in R1.1, support for multi-sync on the same ASAP adapter is available.

Requirements for ACR:

- CES PW starts at either a 77x0 SR or 7705 SAR. The PRC quality reference signal can come from RNC, BITS, or reference line signal.
- No more than 3 heavily loaded intermodal links between the ACR source node and the cell site's 7705 SAR. The CES PW is to be sized to allow 1000 packets/sec and priority NC.
- No more than 80% traffic loading on any of the inter-nodal links.
- APS Protection of CES origination at 7750 SR

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IEEE 1588v2 Overview

1588 is a form of delivering network clock over a packetized network, using Precision Time Protocol (PTP)

- Pure IP; no service (PW) is needed for delivering the PRC
- Uses UDP/IP messaging (multicast and unicast) over Ethernet
- Server/Client model (Master/Slave clock)

Advantage of 1588

- Lower BW requirement for delivering the Network clock
  - With 7705 SAR default setting ≈ 46.5 Kbps
- Network core does not need to be PTP-aware
- Synchronized with nanosecond accuracy
- Not susceptible to the "beating effect" that may impairs ACR performance

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

7705 SAR approximates BW requirement for 1588v2:
-Announce message is (110 octets) at 1msg/2s = 440 bps
-Sync message (90 octets) at 64pk/s = 45.08 Kbps

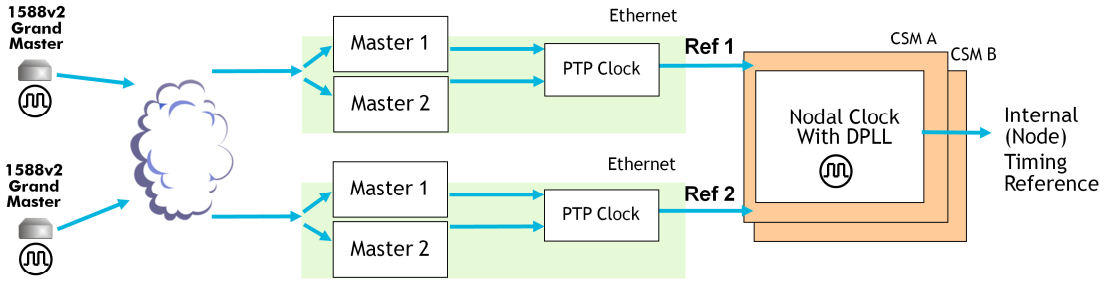
UDP port 319 and 320

What is supported by 7705 SAR:

- 7705 operates in **slave-only** mode.
- 7705 supports **Unicast** Sync Negotiation mode with the GM.
- 7705 supports **frequency transports**.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IEEE1588v2 PTP Timing and Resiliency Model



Each 7705 has a nodal clock implemented in redundant CSMs (Control and Switching Module)

Each PTP clock can be configured to receive timing from 2 PTP Master clocks in the network

- Each of the 2 Master clocks has its own configuration for IP Address/packet rate/etc and statistics/alarms/events
- The Best Master Clock Algorithm (BMCA) is used by each PTP clock to select the best Master clock available. This dynamic selection is based on data connectivity to each master as well as clock master
- Master 1 and 2 in the 2 PTP clocks can point to the same 2 masters or to a maximum of 4 different masters

The 2 PTP clocks can be simultaneously synced to a master (same or different) and be available as hot standby references to the nodal clock

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

2 x PTP per SAR Node:

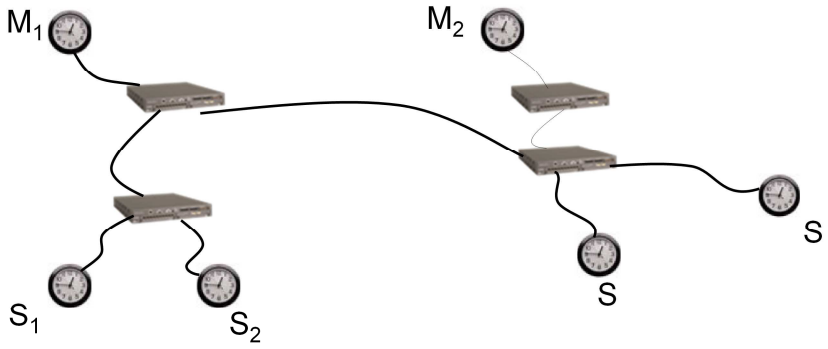
- 2 PTP instances can be the source of reference to the SSU:
  - SAR-8
    - 2 instances must exist on two separate Ethernet-V2 MDA.
  - SAR-F
    - Can only support one PTP instance.
- Automatically switches between ref1/ref2 on port, fiber or MDA failure detection.
- The two PTP instances are hot redundant.

2 x Designated master per PTP Instances:

- Automatically tries to sync with the alternate master if the current master is not available.
- User configured timeout must expire before declaring the master unavailable.
- PTP reference is disqualified if both masters are timed out/not available.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Best Master Clock (Unicast Mode)



Each slave device sends unicast sync request to both masters

Based on information received from both masters, the slave runs the BMC algorithm and decides which master to sync to

If the communication with the master is lost, the slave will attempt to communicate and sync to the alternate master

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

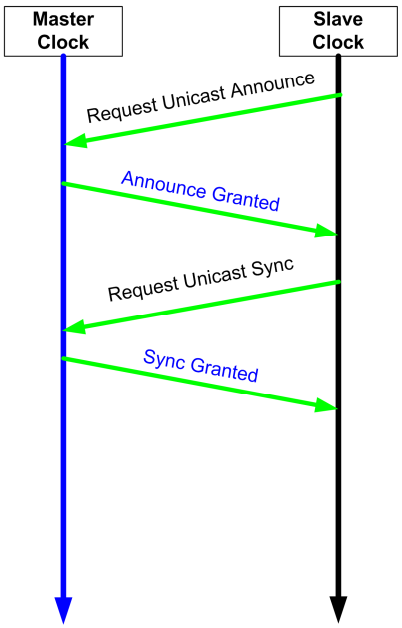
The Best Master Clock Algorithm (BMCA) is defined to dynamically determine which Master to sync to. The BMCA determines the best clock based on the content obtained from each received GM,s announce message.

Clock attributes (considered in the order given)

1. **Priority1** (User configurable level 0 to 255)
2. **Clock Class** (6 is stratum 1 synchronized, 255 is Ssave clock)
3. **Clock Accuracy** (defines the accuracy of the GM clock),
4. **PTP variance**
5. **Priority2** (User configurable level 0 to 255)
6. **Grand Master's Clock Identity**
7. **Distance** (number of boundary clock)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IEEE 1588 PTP Unicast Negotiation Sequence



How it works:

Slave sends Request Unicast Announce message to the configured master

- Requests and negotiates Announce transmission rates

Master responds to the slave with Announce Granted message

Slave sends Request Unicast Sync message to the master

Requests and negotiates Sync transmission rates

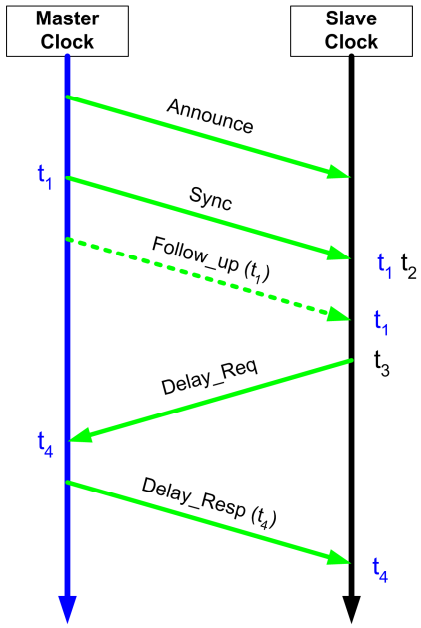
Master responds to the slave with Sync Granted message

Slave re-sends Request Announce message before the negotiated announce time is expired

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IEEE 1588v2 PTP Sync Sequence



How it works

Master starts sending Announce message to the slave after Announce Granted message is sent

- Announce message sending rate is base on the slave requested rate
- The default rate is 1 message / 2 seconds

Master starts sending SYNC messages after Sync Granted message

- The default rate is 64 packets/second

Each SYNC packet is time stamped (t1) by the master when it egresses the master

Slave takes another time stamp (t2) on arrival

t1 could also be sent in a FOLLOW-UP packet if the master does not support sending it with the SYNC packet

Slave sends Request Unicast delay_request message to the configured master

Master responds to the slave with delay_response message (t4)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Clock Recovery Process by Slave (7705 SAR):

- Each SYNC packet is time stamped (t1) by the master when it egresses the master.
- t1 is sent with the SYNC packet to the slave and the slave takes another time stamp (t2) on arrival.
- The best packet (t2-t1) is considered every x seconds window by the slave, for disciplining the oscillator. (window size is defined by the vendor equipment)
- Slave clock is compensated for the Master/Slave deviation by accelerating or slowing down the local oscillator.
- A given window might be ignored if there were too many missing SYNC packets or if the best packet was much worse than expected; based on previous windows.
- After 5 minutes of sequential ignored windows, the sync algorithm will go into holdover state.
- ALU products 7705 SAR, 7x50 SR and TSS05 use the same 1588 Algorithm.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1588 Configuration Example on 7705 SAR

Configuration

Configure system sync-if-timing **source-interface** (must be on Ethernet card)

Give master IP to begin unicast negotiation

```
SAR>config>system>sync-if-timing>ref1# info detail
----------------------------------------------
      no source-port
      source-interface ptp_1588
      ptp-ordinary-clock
          domain 0
      exit
      ptp-port
          master-1 192.168.2.10
          no master-2
          anno-rx-timeout 3
          log-anno-interval 1
          log-sync-interval -6
          unicast-negotiate
```

Expired time (2 to 10 missed intervals)

Request Announce Interval x, for 1 message/2x sec

Where x = 0 to 3 => 1msg/s to 1msg/8s

Request Sync Interval x, for 2-x packets/sec

Where x = -6 or -7 => 64Pk/s or 128Pk/s

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

CLI Show 1588 Sync Verification Commands

```
*A:SAR122# show system sync-if-timing summary
===============================================================
System Interface Timing Operational Info
===============================================================
System Status CSM A                 : Master Locked
    Reference Input Mode            : Non-revertive
Reference Order                     : external ref1 ref2
Reference Input 1
    Admin Status                    : up
    Qualified For Use               : Yes
    Selected For Use                : Yes
    Source Port                     : None
    Source Interface                : to_1588-GM
        ptp-ordinary-clock          :
            Domain                  : 0
        ptp-port                    :
            Unicast                 : TRUE
            Master-1                : 192.168.2.10
            Master-2                : 0.0.0.0
            Anno-rx-timeouts        : 3
            Log-anno-interval       : 1
            Log-sync-interval       : -6
```

PTP may take more than 15 minutes to obtain Master Locked status

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
Synchronization Techniques for TDM Networks

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 4
IGP Routing

Module 1
IGP Routing

TER36075_V3.1-SG-English-Ed1 Module 4.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to describe:

- The Internet Protocol (IPv4 and IPv6), its addressing and packet structure
- Layer-3 interface types
- Basic routing principles
  - Static vs dynamic routing
  - Distance Vector vs Link State routing protocols
- Routing protocols
  - OSPF (Open Shortest Path First)
  - IS-IS (Intermediate System to Intermediate System)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — The Internet Protocol addressing	**5**
2 — Basic routing principles	**8**
3 — Layer-3 interface types	**20**
4 — Evolution towards IPv6	**25**
5 — Basic Provisioning of IPv6 on 7750 SR-OS	**31**
6 — OSPF (Open Shortest Path First)	**42**
7— IS-IS (Intermediate System to Intermediate System)	**49**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 The Internet Protocol addressing

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Internet Protocol

IP Addressing

One of the main functions of the network layer is addressing.

An IPv4 address is a sequence of 32 bits or 4 bytes. For example:

01000000.11101001.10100001.01101000

This binary notation can be presented in a more human-friendly way (dotted-decimal notation):

64.233.161.104

This address represents a single entity in the global Internet. There are roughly 2^32 possibilities since the address contains 32 bits.

In order to allocate the available addresses efficiently, the addresses can be grouped into collections of addresses, called networks and sub-networks (subnets). This grouping is performed in two ways:

Classful addressing is based on the address itself:

- Class A: uses 8 bits for the network identification and the remaining 24 bits for the hosts and ranges from 0.H.H.H to 127.H.H.H.
- Class B: uses 16 bits for the network identification and the remaining 16 bits for the hosts and ranges from 128.N.H.H to 191.N.H.H.
- Class C: uses 24 bits for the network identification and the remaining 8 bits for the hosts and ranges from 192.N.N.H to 223.N.N.H
- Class D and E are used for multicast and experiments.

Classless addressing is calculated based on subnet masks. A subnet mask is a set of 1's followed by a set of 0's and indicated by a "/X" notation where X represents the number of 1's. For example:

64.233.161.104/8

A logical AND calculation with the address and the subnet mask results in the network address, the broadcast address, and the available host addresses in between. This classless addressing allows Classless Inter Domain Routing (CIDR) and Variable Length Subnet Masking (VLSM) for more efficient use of the limited IP address space.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Internet Protocol – IP Addressing

An IPv4 address is a sequence of 32 bits or 4 bytes ✓

Public address range*	Class A: 1.H.H.H → 126.H.H.H Class B: 128.N.H.H → 191.N.H.H Class C: 192.N.N.H → 223.N.N.H
Private address range	Class A: 10.H.H.H Class B: 169.254.H.H Class B: 172.16.H.H → 172.31.H.H Class C: 192.168.N.H
Multicast address range	Class D: 224.H.H.H → 239.H.H.H
Scientific address range	Class E: 240.H.H.H → 255. H.H.H
Loopback address range	127.H.H.H
Default address range	0.H.H.H

*Minus the Private address ranges.
Note: **H** indicates bits corresponding to the Host address, and **N** indicates bits corresponding to the Network address.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Each node in the Internet has to obtain a unique public IP address. These public addresses are obtained from the Internet Assigned Numbers Authority (IANA: www.iana.org) and its Community Members, The Regional Internet Registries (RIR).

In addition to the public address ranges, some addresses are reserved for other purposes, such as:

1. The private address range
2. The multicast address range
3. The experimental and engineering address range
4. The loopback address
5. The default Gateway

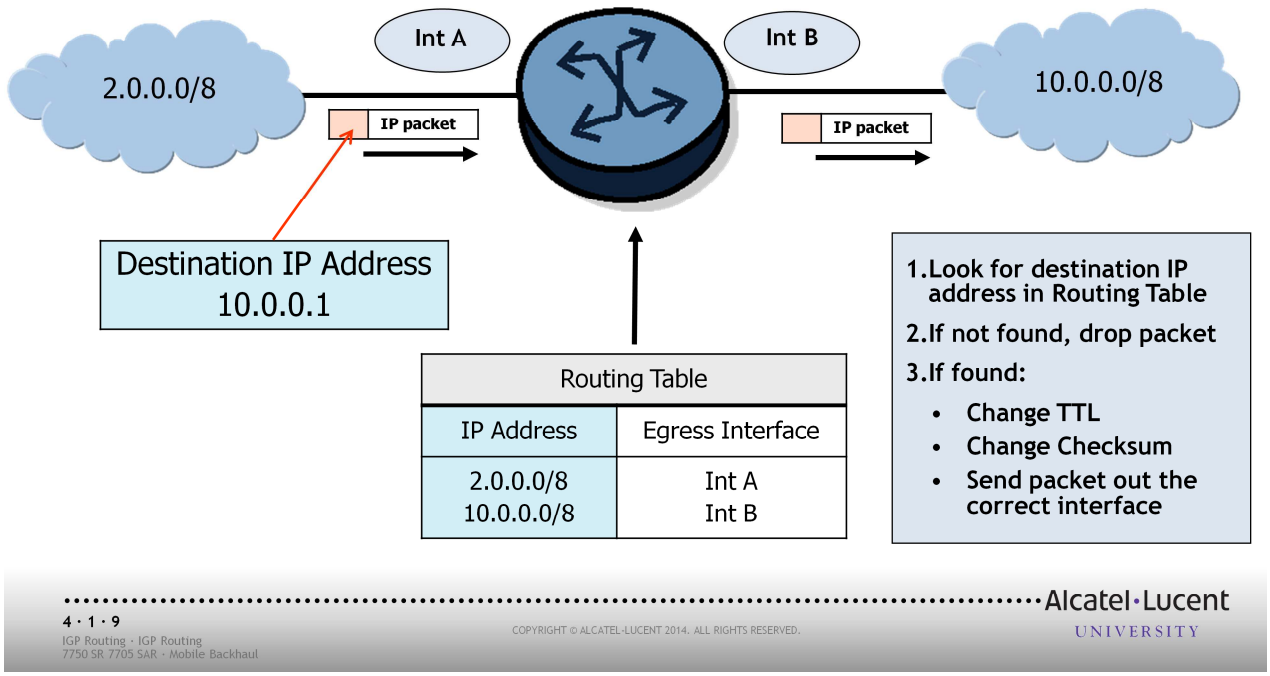
These addresses cannot be used in the public domain. Public addresses can be used in a private domain, although this is not a good idea. For example, if the public address 64.233.161.104, one of the www.google.com servers, is used to identify a node in a private domain, any attempt to access this server will fail, since the private domain will send the packets to this particular node, instead of the public server. So, although technically possible, it is not advisable for administrators to configure public addresses in a private domain.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Basic routing principles

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Routing Principles



Routing an IP packet from a sender to a receiver is the process of transporting the packet from node to node, be it an end point (sender or receiver itself) or an intermediate point (router). Every node receives packets (called ingress) through one of its interfaces and must decide where to send the packet next by choosing an outgoing interface (egress). All the routers perform the same process.

Deciding what interface to send a packet to depends on the destination IP address contained in the IP header of each IP packet. The router checks a list, the routing table, which stores destination addresses mapped to egress interfaces. If a packet arrives on the ingress with a destination address not stored in the routing table, the packet is thrown away (dropped). Listing every individual destination addresses can use up a lot of router resources so usually the router groups addresses according to networks or sub-networks.

In summary:

1. A packet arrives on an ingress interface of a router.
2. The IP destination address is read and compared to the routing table entries.
3. If no match is found, the packet is dropped.
4. If a match is found, the **TTL** is decremented, the header checksum is recalculated and the packet is sent out the egress interface listed in the routing table.
5. Each router in the path from source to destination performs the same operation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Ethernet Fundamentals

Until now, Layer 3 has been discussed since this is the layer where IP routing is performed.

The Data Link Layer is responsible for transportation and addressing of data over a single connection or link (Local Area Network – LAN). The Network Layer handles transportation and addressing over multiple links (Wide Area Network – WAN).

Ethernet (IEEE 802.3) uses a mechanism called Carrier Sense Multiple Access with Collision Detection (CSMA/CD) to transport data over twisted pair cables. When a device connected to the LAN wants to send data it first listens to see if the link is free. If it is, the network card can transmit data to a specific destination or broadcast it to all destinations on the LAN. When two devices simultaneously start sending data, a collision occurs and the two senders attempt to send again after a random waiting period.

Ethernet devices can send data to:

1. A single (unicast) unique Ethernet Media Access Control (MAC) address that identifies a single destination. For example:

   00-12-79-3E-c7-1E

2. A multicast Ethernet Media Access Control (MAC) address that identifies a group of nodes. For example:

   01-00-5E-00-00-05

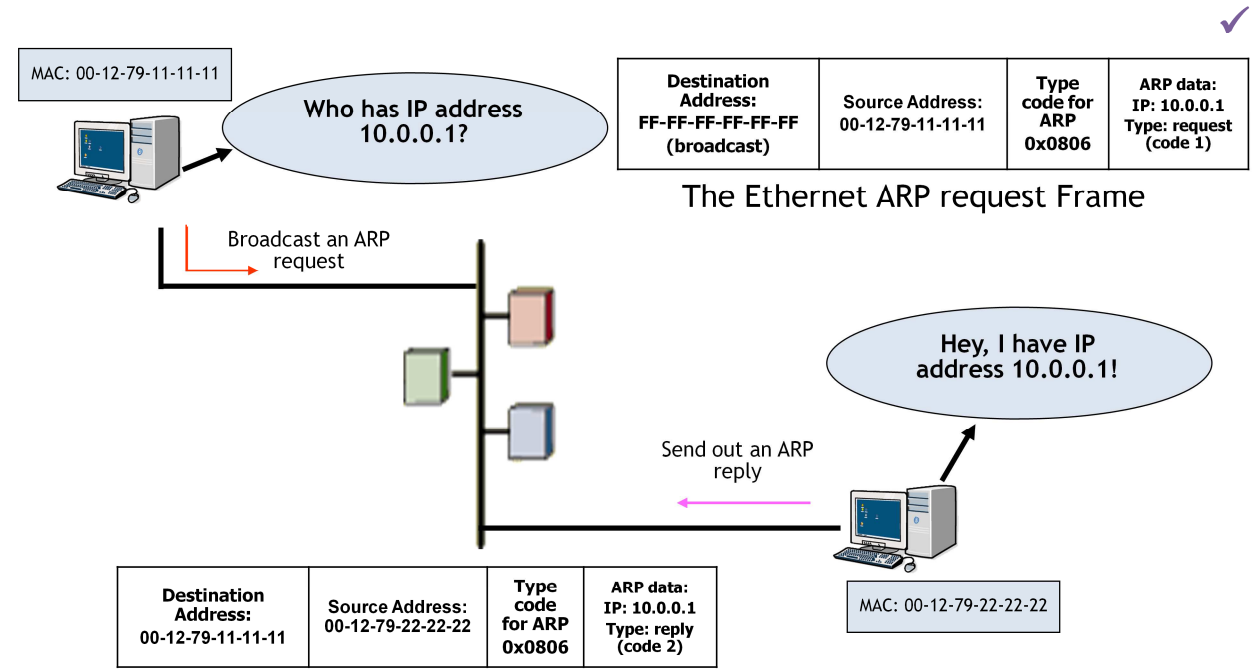
   In this case, the most significant 25 bits are fixed (01-00-5E plus an additional bit set to zero) and the least significant 23 bits are copied from the multicast IP address associated to the packet.

1. All the nodes that are connected to the Ethernet LAN (broadcast). The special Broadcast Ethernet MAC-address is (all 1's):

   FF-FF-FF-FF-FF-FF

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Other Protocols – ARP



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The TCP/IP protocol suite is made up of many protocols, one of these is the Address Resolution Protocol (ARP).

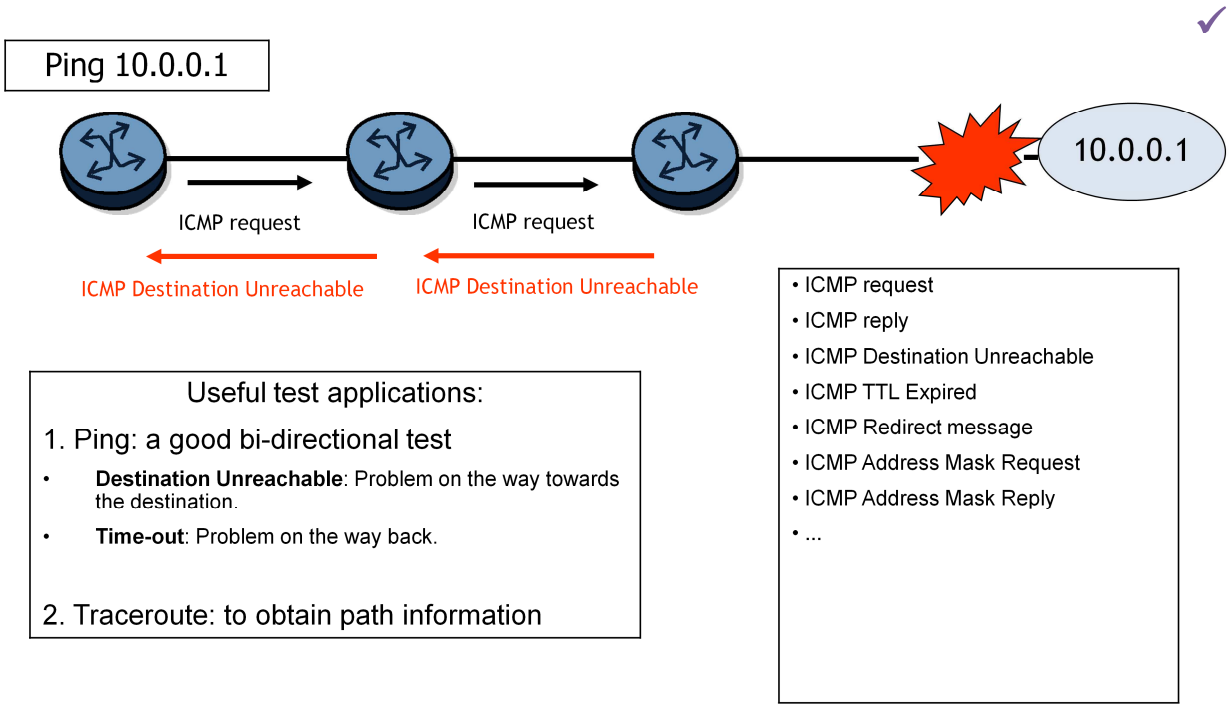
When an Ethernet Card needs to send out an Ethernet Frame onto the link it needs to know the destination MAC address of the device it is trying to reach. It uses the ARP to determine the MAC address associated with an IP address.

When an ARP request is broadcast on the LAN all devices connected to the LAN receive the broadcast. The broadcast attempts to find a device with a particular IP address and determine its MAC address. The device that receives the broadcast and recognizes its own IP-address will send out an ARP reply towards the original sender containing its own MAC address. Now, the sender will be able to construct the Ethernet Frame with the destination Address being the Source MAC address of the ARP reply.

It is time consuming to send out an ARP request for the same address over and over, so the sending device stores a table of IP addresses with their corresponding MAC addresses in an ARP cache. Individual ARP entries will be flushed out of the cache after a certain period of inactivity.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Other Protocols – ICMP



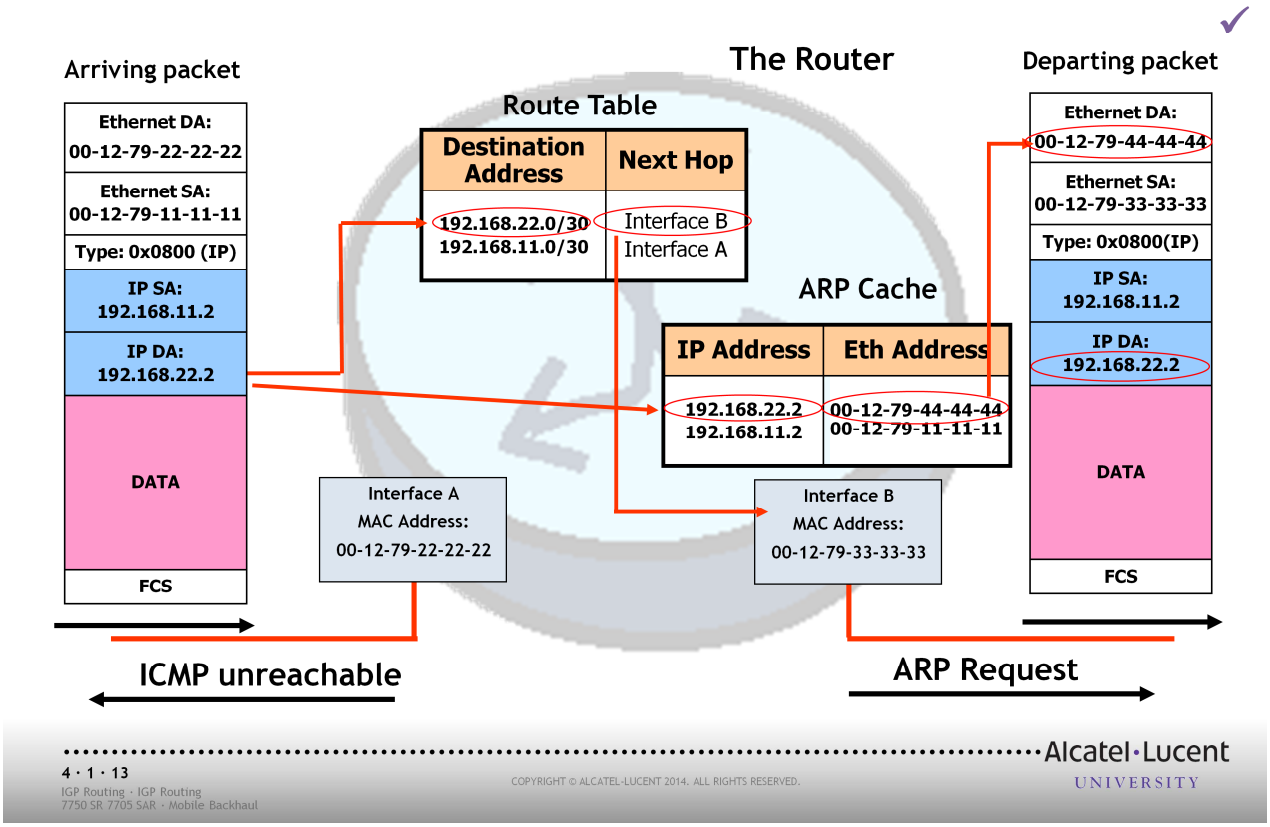
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Another protocol in the TCP/IP suite is the Internet Control Message Protocol (ICMP). The ICMP provides several functions:

1. ICMP request and reply, commonly used in the PING application. This function allows a network node or operator to determine if a certain address is reachable. It works by sending an ICMP request to a certain destination (IP-address) and waiting for a reply. A device is reachable if it replies to the ICMP request.
2. ICMP Destination Unreachable. When a packet arrives at a node that has no further connection to the destination (for example the link is down or the router has no entry for this destination in its routing table) the packet is dropped and an ICMP Destination Unreachable message is sent back to the sender.
3. ICMP TTL expired. When a router is forced to drop a packet, because it's TTL has reached zero, it will send an ICMP TTL Expired message back to the sender. This functionality is used in the common application TRACEROUTE where ICMP requests are sent with incrementing TTL's. The TRACEROUTE application uses the saved ICMP TTL Expired messages to obtain information on the path to a certain destination.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Full Routing Cycle



Combining the L3 and L2 functions, the Routing Cycle is complete:

1. An Ethernet Frame arrives at an ingress interface with the Destination Address (DA) set to the MAC-address of the Network Card (NIC) of that interface.
2. Since the NIC recognizes the Ethernet-DA as its own MAC address, it strips the Ethernet Frame from the link and since the Ethernet Type Field indicates that the content is an IP packet the router analyses the IP-DA in the IP header.
3. The IP-DA is compared with all the entries in the routing table to find the longest match. If no match is found, the router discards the packet and sends an ICMP Destination Unreachable message to the IP-SA.
4. The Routing Table entry tells the router where this packet should be sent next. The routing table lists an egress interface and the IP-address of the interface of the next router.
5. This IP-address is compared to the ARP cache of the router. If there is no entry, an ARP request is sent out on the same link. When the entry is known, the MAC address can be used.
6. A new Ethernet Frame is created, the SA is now the MAC address of the egress interface, the DA is the MAC address that was found in the table or determined by the ARP request, the Type Field is 0x0800 for IP and the FCS is calculated on the new Frame. The Data Payload of the Frame is only altered a little at the IP header where the TTL is decremented and the Checksum recalculated.

These 6 steps are the basic steps for the routing process. It is important to note that the routing table is a crucial item in this process.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Routing Table

Dest Address	Next Hop	Type	Metric
192.168.11.0/30	Interface A	Local	0
10.12.1.0/29	Interface B	Local	0
192.168.22.0/30	10.12.1.2	Remote	10

```
==============================================================================
Route Table (Router: Base)
==============================================================================
Destination Prefix    Next Hop                Type        Protocol   Age      Preference Metric
                      [Interface Name]
------------------------------------------------------------------------------------------------------

1.1.1.1/32            system                  Local       Local          02d18h18m   0     0
2.2.2.2/32            10.12.1.2               Remote      OSPF           02d04h10m   10    1000
4.4.4.4/32            10.12.1.2               Remote      Static         02d18h18m   5     1
10.12.1.0/29          B                       Local       Local          02d18h18m   0     0
192.168.22.0/30       10.12.1.2               Remote      OSPF           02d04h10m   10    1000
------------------------------------------------------------------------------------------------------
No. of Routes: 5
==============================================================================
```

4 · 1 · 14
IGP Routing · IGP Routing
7750 SR 7705 SAR · Mobile Backhaul

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Alcatel·Lucent UNIVERSITY

There are two techniques used to build the Routing Table:

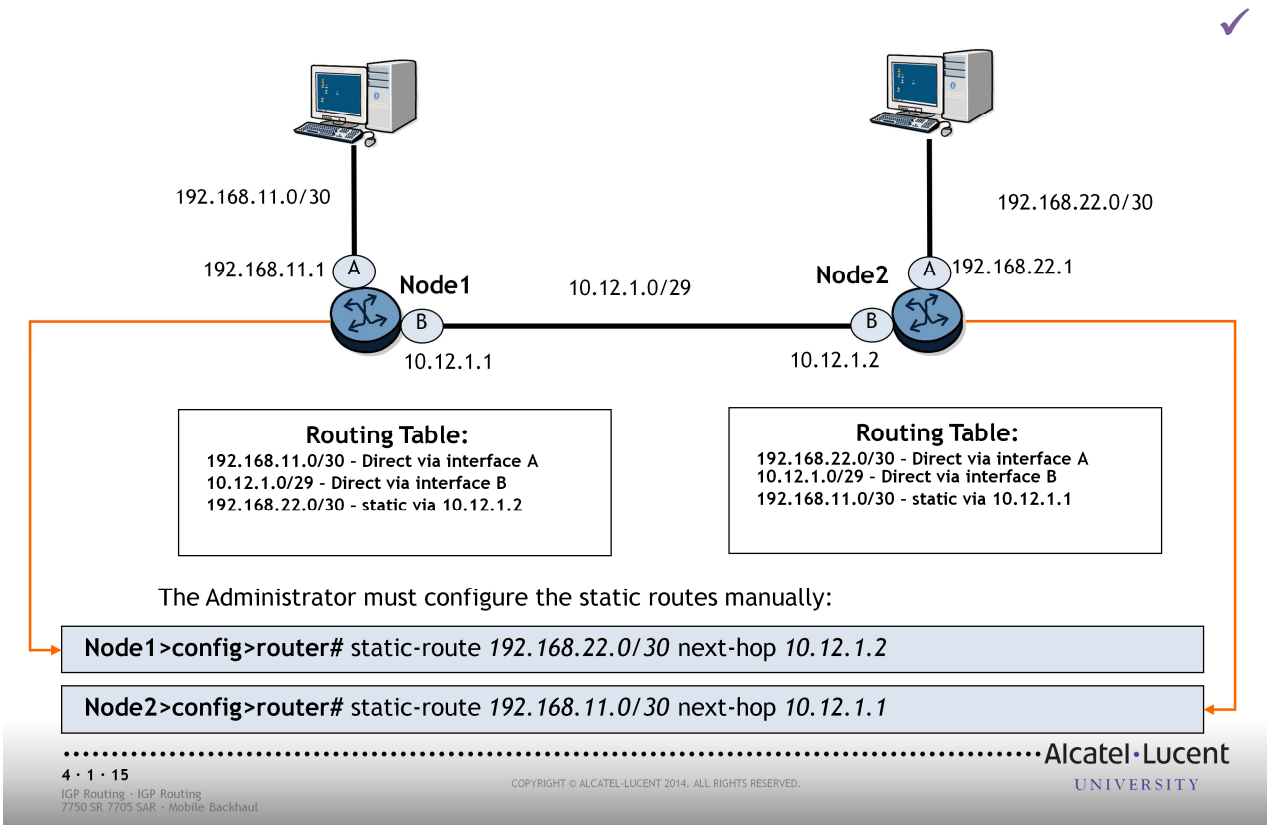
1. Someone can create the table manually, by logging in and typing all the entries into the Routing Table. This process is referred to as: **Static.**
2. A program can create the Routing Table automatically. Such a program is called a Routing Protocol and this process is referred to as: **Dynamic.**

Static routing is very time consuming and when a failure occurs, the administrator has to be aware of it and reconfigure all the nodes to avoid the failed link or router. Dynamic routing using routing protocols simplifies the process. The routing protocols build all the routing tables in the routers and when there is a topology change (a Router or network has been added, or a failure occurs) these routing protocols update all the Routing Tables dynamically without requiring any human intervention.

Although dynamic routing protocols make thing easier, static routing is still used for some purposes, for example when an administrator wants to keep certain routes under strict control.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Static Routing



Static routes are entries in the routing table that were manually entered by someone, typically the network administrator. The administrator must have a good understanding of the existing network topology and be confident that any changes in the network topology will not affect these static routes. Static routes are often used to connect two autonomous systems (AS's) or to provide a default route for Stub Networks.

There are three types of static routes:

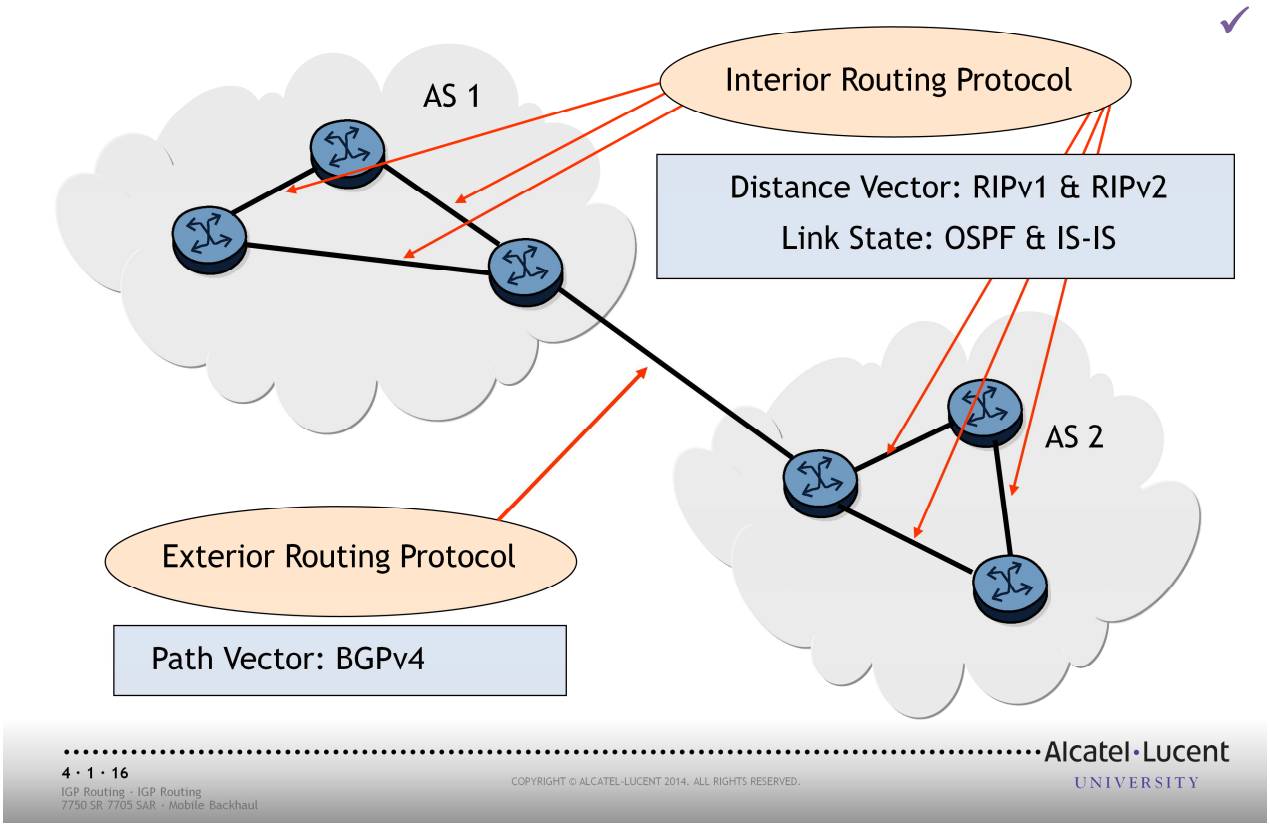
1. Next-hop: specifies the IP-address of the interface of the next hop router on a directly connected link.
2. Indirect: specifies the IP address of the interface of the next hop router, not directly connected, but at least 1 hop away.
3. Black Hole: used to silently discard an IP packet with the specified IP-DA.

Static routes can be viewed using the following command:

```
show router static-route
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The Routing Protocols



The Routing protocols fall into two categories, Interior Gateway Protocols (IGP) and Exterior Gateway Protocols (EGP) – a gateway is the legacy name of a router. The distinction is clear, while the one is inside "something" the other is outside "something". To answer the question on what this "something" is, an Autonomous System (AS) needs to be introduced. An Autonomous System (AS) is a collection of networks and routers under a single administration. This basically means that all the routers under the administration of a single company represent an AS.
The IGPs are used within (intra) an AS and are of two types: Distance Vector and Link State.

Distance Vector IGPs:

1. Routing Information Protocol version 1: RIPv1
2. Routing Information Protocol version 2: RIPv2

Link State IGPs:

1. Open Shortest Path First: OSPF
2. Intermediate System – Intermediate System: IS-IS

The EGPs are normally used between (inter) AS's. The Border Gateway Protocol (BGPv4) is the best known EGP.

As far as routing protocols, we will go into more details of Link State IGPs only.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Link State Protocols Overview

1. Link State Update (LSU), sent to all the other routers (flooding) in the AS, contain information on the local “Links” (metric) and their “State” (Active or not-Active and metric)
2. A metric, cost- or bandwidth based, is associated to each link
3. Very infrequent periodical updating, mostly triggered updates => Fast Convergence, better efficiency
4. A dual level hierarchy to improve scalability
5. Allows up to thousands of nodes in an AS
6. Two protocols simultaneously developed:
    1. TCP/IP model: OSPF
    2. OSI model: IS-IS

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

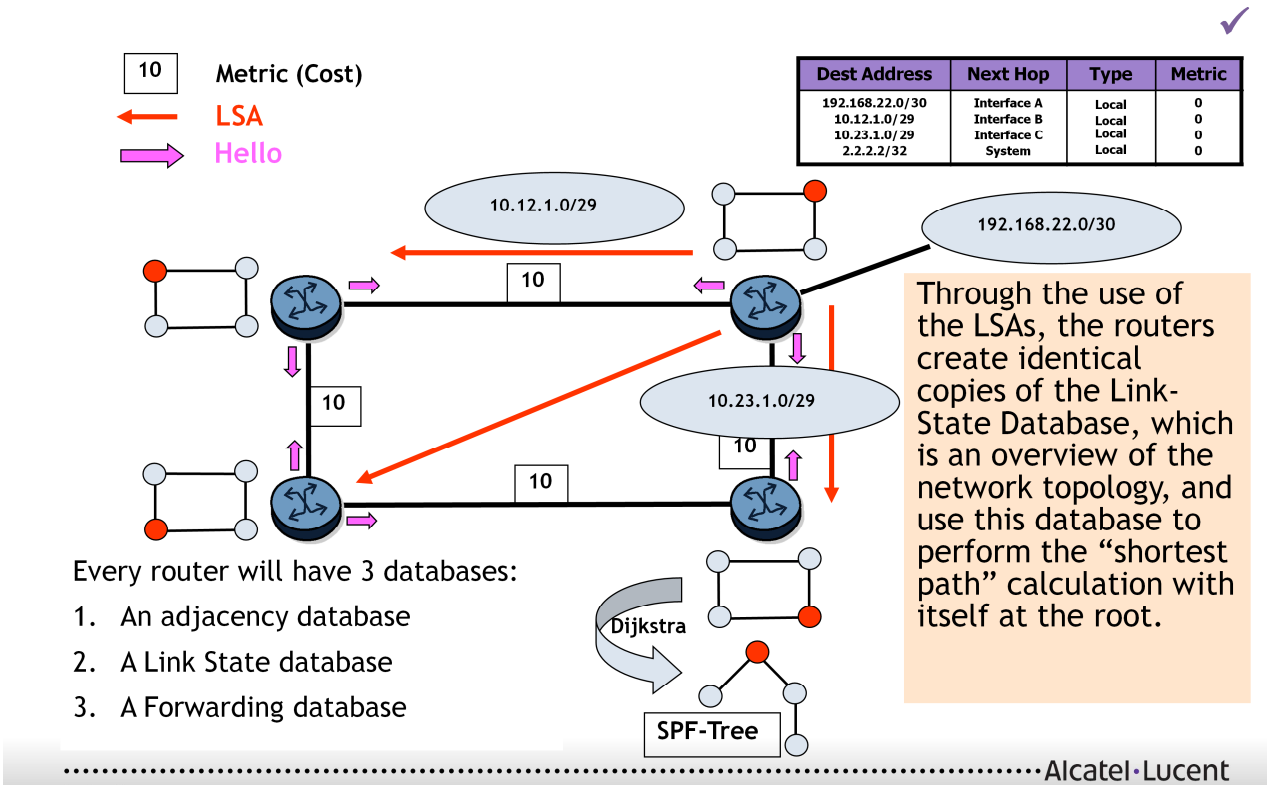
Routing information distributed by Distance Vector protocols is not very reliable since it was not received directly from the source, but from a third party, a direct neighbor. It would be better if every router could pass local information directly to all other routers.

This idea resulted in a new generation of IGPs, the Link State Protocols. Routers running these protocols distribute local information to every other router in the network using Link State Advertisements (LSAs). This “flooding” of LSAs assures that every router has information on routes coming from the most reliable source, the updating router itself. This new approach radically changed Intra-AS Routing and resulted in two IGPs, Open Shortest Path First and Intermediate System to Intermediate System. In addition to changing the way that routing information is updated, these Link State Protocols offer other advantages:

1. A new metric system, cost or bandwidth based, that is no longer limited to 15 hops.
2. Instead of sending complete updates frequently, topology changes are advertised at the time they occur. This reduces the overhead of route updates compared to the Distance Vector Routing Protocols.
3. A dual-level hierarchy, together with the unlimited metric allows the network to contain many more nodes so the new IGPs are scalable for large Autonomous Systems.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Link State Protocols – Link State Advertisements



LSAs are sent using reserved multicast addresses. The LSAs tell all the other routers what active Links (destination address + metric) are directly connected to the advertising router. This way all the routers, using the LSAs from the other nodes, can create a network topology, represented by the Link State or Topological Database. This is a crucial difference from the Distance Vector Routing Protocols because now every node has the exact same Link State Database. Each node can now perform a calculation, known as the Dijkstra Algorithm, to create an SPF-tree with itself at the root. Using this SPF-tree the shortest paths to all destination are known resulting in a single entry in the Forwarding Database: The Route Table.

LSAs:

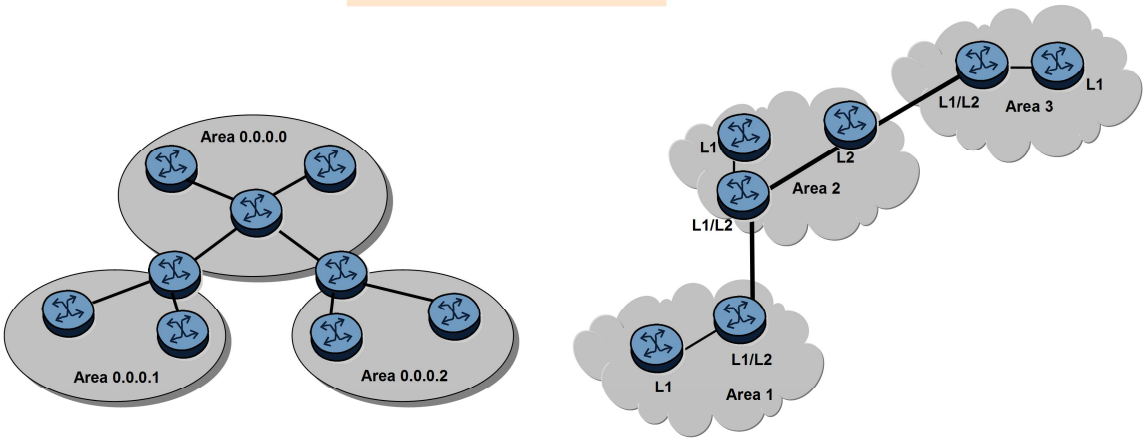
- Have a sequence number
- Are sent out to and acknowledged by neighboring routers
- Recursively propagated (flooded)
- Are sent out when:
  - a Router or its IGP instance comes up
  - a new Link (interface) is added (Active) to the IGP instance
  - a Link fails or is removed from the IGP instance (Inactive)
  - the Hello Protocol has found or lost a neighbor
  - a keep-alive timer has expired.

A third database, called the Adjacency or Neighbor Database, contains all the directly attached neighbors or adjacencies, that were discovered by the Hello-protocol.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Link State Protocols – Hierarchical Structure

Multi – Level Hierarchy



OSPF Hierarchy:

- Area 0: backbone
- Other areas: lower-level areas

IS-IS Hierarchy:

- L2-capable: backbone routers
- L1-capable: lower-level routers

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Link State Protocols introduced the idea of hierarchies. A router will only learn topology information at its own level, information between levels is handled by specially designated routers. This concept was introduced to reduce the size of link state databases and the number of LSAs propagated in the network.

It improves scalability by reducing the number of link-state updates that have to be exchanged, the database size, and the complexity of the SPF algorithm needed to find the shortest path to every other router in the same area only.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 Layer-3 interface types

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Layer-3 interface types

There are three types of layer-3 interfaces:

System: logical interface, associated with the router as a whole and not with a specific physical port; mainly useful to provide a stable IP address for the protocols that the device is running

Loopback: also logical interfaces, mainly used to simulate the existence of directly-attached networks during configuration and testing

Physical: interface associated to a physical port, TDM channel or SAP



Note: the IP address of a loopback interface can also be used to play a similar role as that played by the system IP address (i.e. to identify the router). This is commonly used for instance in multicast environments where two or more routers are configured to be Rendezvous Points (RP) for the same multicast group; both routers are configured with the same IP address for their corresponding loopback interfaces and will be accessed in an anycast fashion by the multicast members.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

System Interface

It is very important to configure a system interface

Many protocols use the system IP address; e.g. when signaling an MPLS LSP (via LDP or RSVP) and when establishing a t-LDP session to signal service labels

It must be a /32 address

System IP address is referred to as the main loopback IP address

```
PE# configure router interface system
PE>config>router>if# address <ip-address/32>

PE# show router interface system
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.


```
PE# configure router interface system
PE>config>router>if# address 10.10.10.237/32

PE# show router interface system detail
===============================================================
Interface Table (Router: Base)
===============================================================
-------------------------------------------------------------------------------
Interface
-------------------------------------------------------------------------------
If Name         : system
Admin State     : Up                    Oper State      : Up
Protocols       : MPLS LDP
IP Addr/mask : 10.10.10.237/32      Address Type    : Primary
IGP Inhibit     : Disabled              Broadcast Address: Host-ones
-------------------------------------------------------------------------------
Details
-------------------------------------------------------------------------------
If Index        : 1                     Virt. If Index    : 1
Last Oper Chg: 10/30/2007 15:47:56    Global If Index  : 33
Port Id         : system
TOS Marking  : Trusted                 If Type           : Network
Egress Filter  : none                  Ingress Filter    : none
SNTP B.Cast  : False                   QoS Policy        : 1
MAC Address : 7c:ed:ff:00:00:00        Arp Timeout       : 14400
IP MTU          : 1500                 ICMP Mask Reply : True
Arp Populate : Disabled
.
.
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Loopback Interfaces

More than one loopback interface can be configured if needed

Loopback interface IP address must be configured

```
PE# configure router interface <interface-name>
PE>config>router>if# address <ip-address/mask>
PE>config>router>if# loopback

PE# show router interface <interface-name>
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Physical Interfaces

Only one IP address can be configured per interface

```
PE# configure router interface <interface-name>
PE>config>router>if# address <ip-address/mask>
PE>config>router>if# port <port-id>

PE# show router interface <interface-name>
```

Using LAGs in an Interface. Example:

```
PE# configure router interface to-PE31
PE>config>router>if# address 192.168.7.1/24
PE>config>router>if# port lag-10
```



When the uplink port is Ethernet and it is configured with null encapsulation, then only 1 network interface exists for the network port.

While the command address refers to the 'primary address' and there can only be one, an interface can have up to 16 secondary addresses (we use secondary in VRRP).

When the Ethernet port is however configured with dot1q encapsulation, there is a max of 4094 vlan interfaces that can be configured each having its own ip address.

PE# **configure router interface to-PE13**
PE>config>router>if# **address 192.168.3.1/24**
PE>config>router>if# **port 1/1/1**

PE# **configure router interface to-PE33**
PE>config>router>if# **address 192.168.5.1/24**
PE>config>router>if# **port 1/1/5:2**

PE# **show router interface**

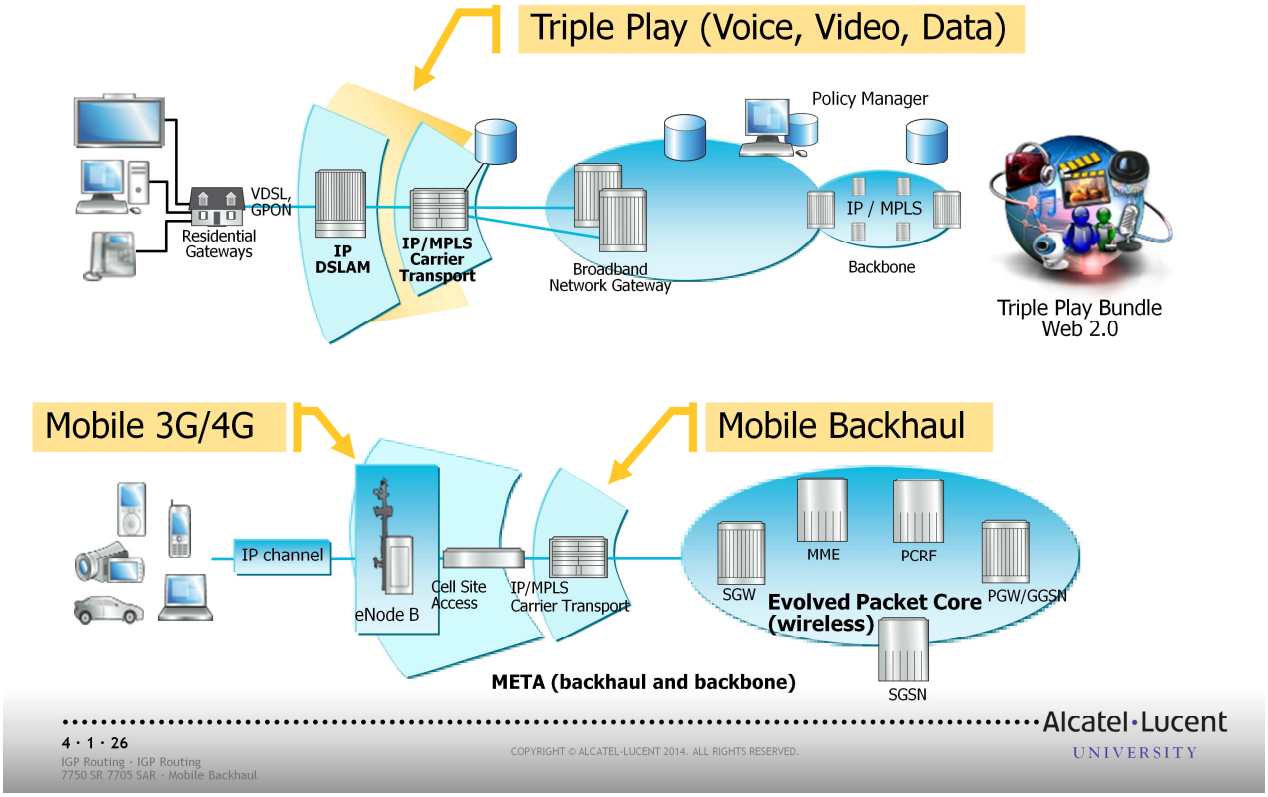
```
===============================================================
Interface Table (Router: Base)
===============================================================
Interface-Name              Adm       Opr       Mode     Port/SapId
  IP-Address                                             PfxState
-------------------------------------------------------------------------------
system                      Up        Up        Network  system
  10.10.10.237/32                                        n/a
to-PE13                     Up        Up        Network  1/1/1
  192.168.3.1/24                                         n/a
to-PE33                     Up        Up        Network  1/1/5:2
  192.168.5.1/24                                         n/a
-------------------------------------------------------------------------------
Interfaces : 3
===============================================================
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 Evolution towards IPv6

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IPv4 Success Stories



The demand for bandwidth is still growing, driven by Internet Video, Triple Play and smart phones.

IP made everything feasible. The success of the wireline and wireless network evolution originates from IPv4, but IPv4 address pool has been exhausted. The continuity of this evolution requires for service providers to quickly adapt to IPv6.

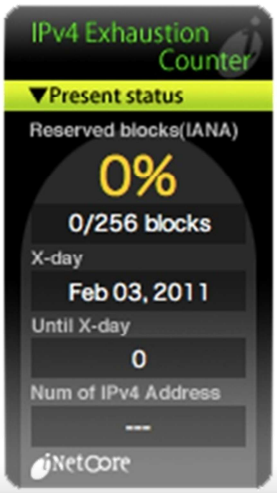
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Why IPv6?

The main reason to migrate from IPv4 to IPv6 is the exhaustion of IPv4 addresses

The Internet Assigned Number Authority (IANA) coordinates the global IP address space, and allocates blocks of IP addresses to Regional Internet Registries (RIRs)

Since 2011, IANA does not have any more IPv4 addresses to allocate to RIRs



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

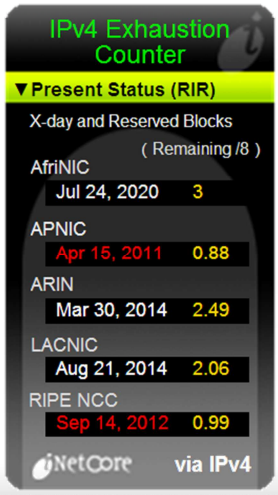
As of March 2013, as reported by INTEC Systems Institute, Inc.
http://www.inetcore.com/project/ipv4ec/index_en.html

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Why IPv6? (continued)

Even Regional Internet Registries (RIRs) have either run out of unallocated IP addresses or are very close to it

- **AfriNIC** - Africa Region
- **APNIC** - Asia/Pacific Region
- **ARIN** - North America Region
- **LACNIC** - Latin America and some Caribbean Islands
- **RIPE NCC** - Europe, the Middle East, and Central Asia



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

As of March 2013, as reported by INTEC Systems Institute, Inc.
http://www.inetcore.com/project/ipv4ec/index_en.html
Dates in red are actual exhaustion dates (APNIC and RIPE NCC). The ones shown in white are estimated exhaustion dates.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The need to migrate

The key issue is the fact that IPv6 is not backwards compatible

Network equipment vendors and operators must plan and prepare for IPv6

There is no time for a smooth transition

An approach is required to provide co-existence of IPv4 and IPv6 during the transition phase

The solutions introduce additional complexities but they cannot be avoided

- The alternative — creating an IPv6-only environment — is extremely expensive to achieve in the short term



The key issue around IPv6 migration is rooted in the fact that, while IPv6 was meant to be an evolution of IPv4 and carries almost all of its functionalities forward, it is not backwards compatible. IPv6 impacts the data path as well as routing, control and management planes as it introduces a different packet header format with a simplified structure and in which IP addressing is extended from 32 to 128 bit fields.

Today, we find ourselves in a situation where IPv4 address exhaustion is imminent, but there is no time for a smooth transition and there are no easy fixes in sight. This is no cause for panic but it is a fact that network equipment vendors and operators must plan and prepare for.

The introduction of a dual-stack approach is required to provide co-existence of IPv4 and IPv6 during the transition phase. The available solutions introduce additional complexities in the network but, unfortunately, they can not be avoided since the alternative – creating an IPv6-only environment – is extremely expensive to achieve in the short term.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

What does IPv6 offer?

Its main advantage over IPv4 is that it provides a huge address space

- 2^{128} (more than 3.4e38) addresses

It includes many more improvements:

- Hierarchical address allocation: smaller routing tables
- Efficient IP header with fewer mandatory fields
- Flow Label field for per-flow classification
- Flexible packet format by using optional extension headers
- Stateful (DHCPv6) and stateless (no DHCPv6) dynamic address configuration
- Built-in IPSec Security: Authentication Header (AH) and Encapsulation Security Payload (ESP)
- Built-in Multicast Listener Discovery protocol, which makes IGMP unnecessary

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

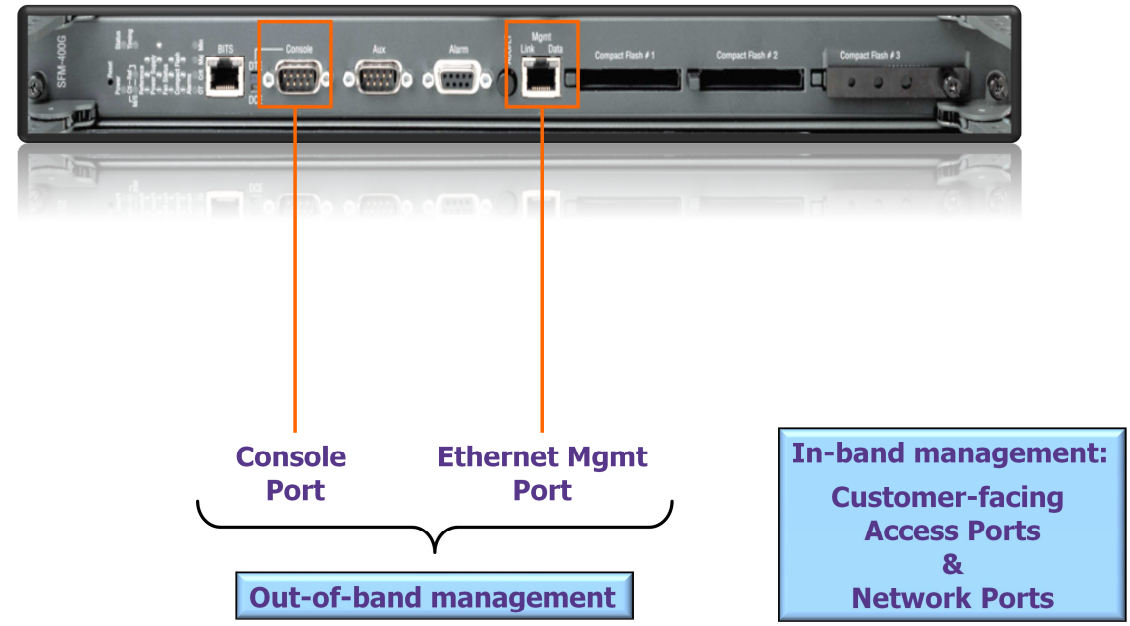
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

5 Basic Provisioning of IPv6 on 7750 SR-OS

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Physical Access for Management

SF/CPM Card Common to the 7750 SR-7 and SR-12



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The CLI commands are sent either in-band or out-of-band. Out-of-band management traffic is sent either to the Ethernet management port or via the console port. When sent in-band, the CLI management traffic is sent together with user traffic via either customer facing access ports or network ports.

Each 7750 Service Router has two connectors available for out-of-band management located on the SF/CPM card.

Initially, a node can only be accessed through the console port. Once a management IP address has been configured on the BOF (Boot Options File), as will be discussed shortly, the Ethernet management port can also be used via Telnet or SSH. Finally, when data ports have been configured and are operational and the system interface of the node has been properly created, in-band management can be used as well.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Boot Options File (BOF)

The BOF includes the following parameters, which determine the initial operation of the node after booting:

- Primary, Secondary, Tertiary **software image** location
- Primary, Secondary, Tertiary **configuration file** location
- IP address for the **Ethernet management port**
- Additional parameters for the **Ethernet management port** (speed, duplex, auto-configuration)
- Static route for the **Ethernet management port**
- **Console port** speed
- **DNS** server address
- Enable/disable **persistence** of system indexes (e.g. interface index, LSP IDs, path IDs, etc., needed for 5620 SAM - Service-Aware Manager)
- Enable/disable **Lawful Intercept** configuration to be saved locally
- Enable/disable separate access to **Lawful Intercept** (LI) information

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IPv6 and the BOF

BOF configuration supports IPv6 addresses
Management access filters also allow the use of IPv6 addresses as criteria

Example of BOF:

```
primary-image     ftp://ftp:ftp@3FFE::300:100:1/./7750/act/both.tim
primary-config    ftp://ftp:ftp@3FFE::300:100:1/./test/mgtIpv6.cfg
secondary-image   ftp://ftp:ftp@3FFE::300:100:1/./7750/act/both-2.tim
secondary-config  ftp://ftp:ftp@3FFE::300:100:1/./test/mgtIpv6-2.cfg
tertiary-image    ftp://ftp:ftp@3FFE::300:100:1/./7750/act/both-3.tim
tertiary-config   ftp://ftp:ftp@3FFE::300:100:1/./test/mgtIpv6-3.cfg
address           3FFE::100:100:1/112 active
address           3FFE::100:100:3/112 standby
static-route      3FFE::200:100:0/112 next-hop 3FFE::100:100:2
primary-dns       3FFE::100:100:189
secondary-dns     3FFE::200:100:189
tertiary-dns      3FFE::300:100:189
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Management access filters are used to decide which packets are allowed to be processed by the control plane of the node and which ones should be dropped on arrival.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IPv6 Support in 7750 SR-OS

In order to use IPv6 on the Alcatel-Lucent 7750 SR-OS, chassis mode “c” or higher must be enabled

IPv6 is only supported on IOM2s or newer

Oldest IOM version in chassis	Chassis mode	IPv6 support
IOM1	A	None
IOM1-B	B	None
IOM2	C	Supported (some features not supported; limited scalability)
IOM3 or IMM	D	Supported (all features; good scalability)

IPv6 supported with chassis-modes A and B if **mixed mode** is enabled → only on installed IOM2s, IOM3s and IMMs

For future IPv6 growth, IOM3s/IMMs in all slots and chassis-mode D are recommended

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Review of IPv6 Addressing

Link-local unicast address is always assigned to an interface upon activation, using prefix **fe80::/64** and interface-ID derived using EUI-64

Global unicast address configuration options:

- **Stateful using DHCPv6**
  Clients use scoped multicast to reach servers and relays, servers allocate IP addresses to hosts and routers
- **Stateless (applicable to hosts) using ICMPv6**
  Hosts use prefix information in ICMPv6 Router Advertisements and derive interface ID using EUI-64 to create valid addresses
- **Combination of both stateless and stateful**
  Router Advertisement messages include stateless address prefixes and require that hosts use DHCPv6 for additional configuration
- **Manual Configuration**
  Prefix is assigned manually and Interface-ID calculated using EUI-64, or both prefix and interface-ID are manually assigned

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IPv6 Addressing in SR-OS

As soon as IPv6 is enabled on a physical interface, a **link-local address** is automatically assigned to it based on the EUI-64 method

Most of the time, routers do not need for global unicast addresses to be assigned to physical interfaces interconnecting them

- Their link-local addresses are enough

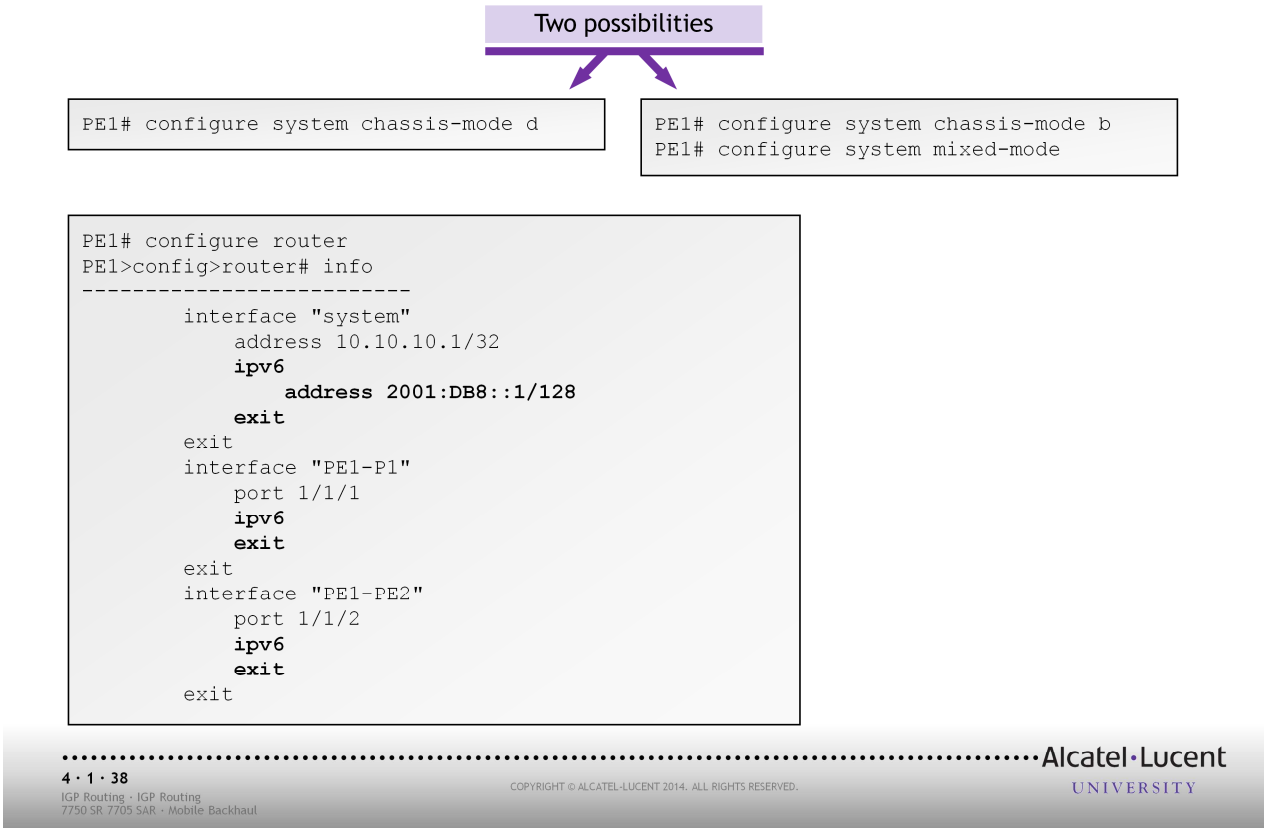
System interfaces, on the other hand, need to be assigned global unicast addresses because of the frequent need for non-adjacent routers to talk to each other using such addresses as identifiers

Irrespective of the way hosts or routers get their IP addresses, the ICMPv6 Duplicate Address Detection procedure is triggered

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Basic Provisioning of IPv6 on 7750 SR-OS

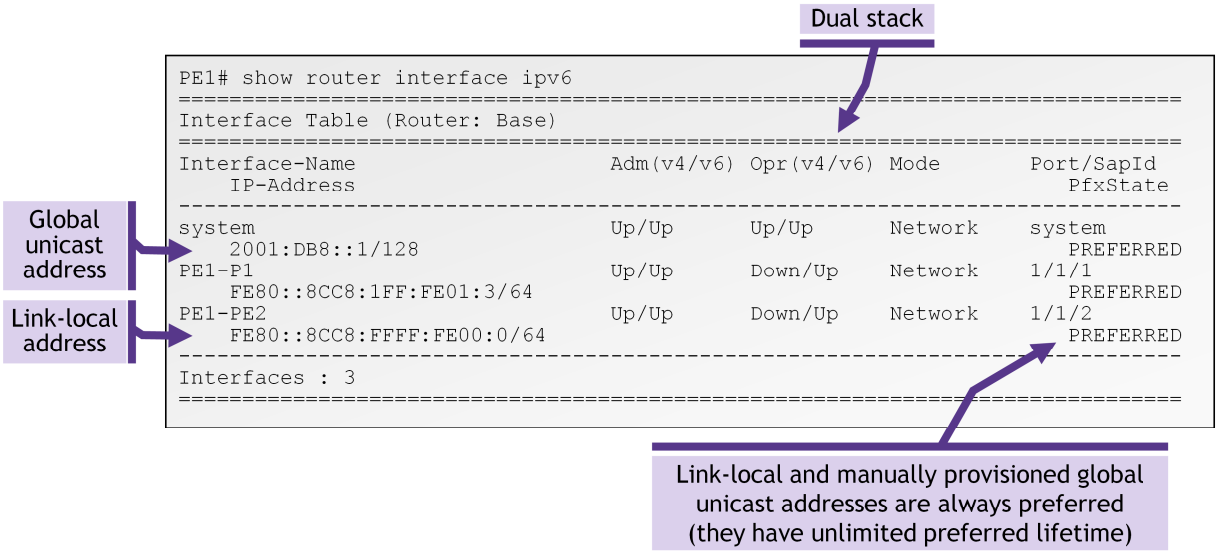


When the chassis mode is configured as C or D, IPv6 will be supported.

If the chassis mode is configured as A or B, IPv6 will **not** be supported, unless **mixed-mode** is enabled; even in mixed-mode, IPv6 is only supported on those interfaces configured over ports that correspond to installed IOM2s, IOM3s or IMMs. If the port corresponds to an IOM2, some features may not be supported.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

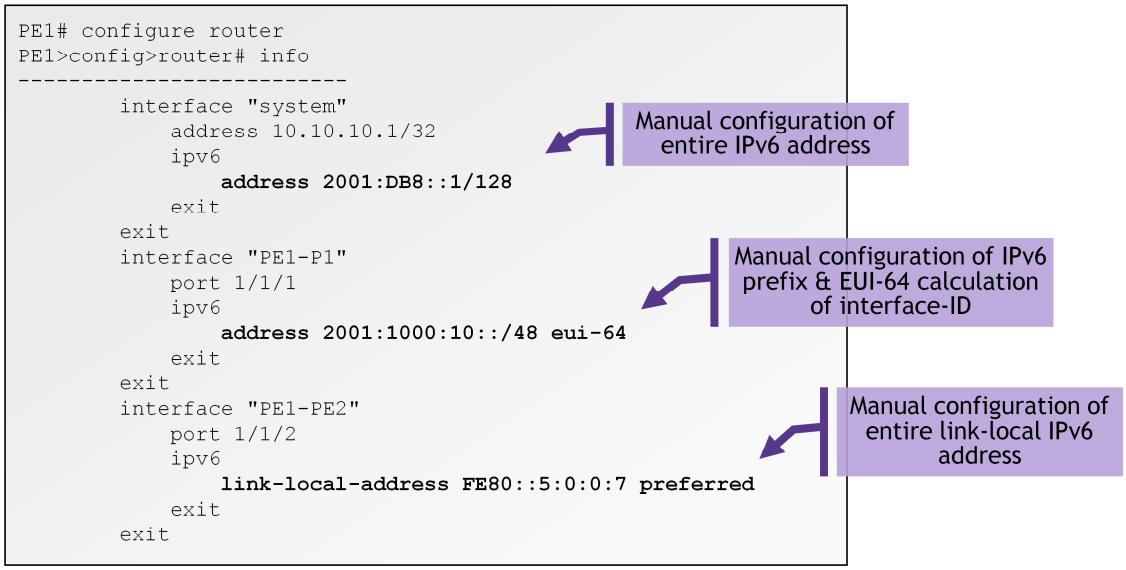
Verification of IPv6 interface configuration



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Provisioning of IPv6 interfaces - Manual Configuration



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

When only the prefix is configured manually, the algorithm called “EUI-64” is used to calculate the interface-ID and form a complete IPv6 address. The 64-bit interface identifier is derived from the MAC address on Ethernet interfaces.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Verification of IPv6 manual interface configuration

```
PE1# show router interface ipv6
===============================================================================
Interface Table (Router: Base)
===============================================================================
Interface-Name                   Adm(v4/v6) Opr(v4/v6) Mode        Port/SapId
    IP-Address                                                        PfxState
-------------------------------------------------------------------------------
system                           Up/Up      Up/Up      Network     system
    2001:DB8::1/128                                                   PREFERRED
PE1-P1                           Up/Up      Down/Up    Network     1/1/1
    FE80::8CC8:1FF:FE01:3/64                                          PREFERRED
    2001:1000:10::8CC8:1FF:FE01:3/48                                  PREFERRED
PE1-PE2                          Up/Up      Down/Up    Network     1/1/2
    FE80::8CC8:FFFF:FE00:0/64                                         PREFERRED
-------------------------------------------------------------------------------
Interfaces : 3
===============================================================================
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

We can see in the screen capture above that the manual configuration of the system IPv6 address has been successful.

We can also see that the prefix configuration on interface PE1-P1 took effect and that the interface-ID has also been calculated and assigned as part of the IPv6 address.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6 OSPF (Open Shortest Path First)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OSPF overview

- **OSPF workgroup started in 1987, lead by John Moy**
- **Present standard: RFC 2328: OSPFv2**
- **Link cost = reference bandwidth (100Gbps) / link bandwidth**
  - Reference bandwidth can be changed, or a fixed value can be manually assigned for the link cost
- **IP and MAC multicast addressing**
  - 224.0.0.5 equals MAC 01-00-5E-00-00-05 listened to by any OSPF router
  - 224.0.0.6 equals MAC 01-00-5E-00-00-06 listened to by any DR/BDR router
- **No Transport Layer Protocols (TCP/UDP): OSPF works on top of IP (Protocol field: 89)**
- **Router ID address is necessary, and may be:**
  - The router-id in the ***config>router>ospf#*** context
  - The router-id in the ***config>router#*** context
  - The same numerical value as the system IP address
  - The last 32 bits of chassis MAC address
- **Authentication:**
  - No Authentication
  - Simple Authentication
  - MD5 Authentication



The most specific configuration command takes effect

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Open Shortest Path First (OSPF) is a link state protocol. The present standard is the OSPFv2 based on RFC 2328.

- OSPF Link Cost = a reference bandwidth (100Gbps) divided by the link bandwidth. For example a 10 Gbps link will have a cost of 10, but the costs are configurable if the administrator prefers other values.
- OSPF uses IP and MAC multicast addresses, instead of broadcast, to distribute LSAs. This reduces the overhead on other devices on the same segment that are not running OSPF.
  - IP 224.0.0.5 translates into MAC 01-00-5E-00-00-05 for any OSPF speaker
  - IP 224.0.0.6 translates into MAC 01-00-5E-00-00-06 for any DR/BDR speaker
- OSPF works on top of Layer 3 in the OSI model. It uses no transport layer protocol such as TCP or UDP but duplicates their functions through the use of acknowledgements and sequence numbers.
- OSPF requires each OSPF speaker to have a Router ID (RID) to identify the node in the Link State Databases. This RID can be:
  - The last 32 bits of the chassis MAC address (default),
  - The system IP address (overrides the default),
  - The Router ID defined in the **config>router#**router-id context (overrides the system IP address).
  - The Router ID defined in the **config>router>ospf#**router-id context (overrides the router ID value configured at the router level).
- OSPF supports three types of authentication
  - None (default)
  - Simple authentication
  - MD5 authentication

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OSPF Packet Types

- OSPF Hello
- OSPF Database Descriptor
- OSPF Link State Request
- OSPF Link State Update
- OSPF Link State Acknowledgement

- Routers use Hello messages to discover each other and to verify compatibility
- Once discovered, they use Database Descriptor messages to describe what is in their databases
- After that, routers use Link State Request, Update and Acknowledgement messages to exchange topology information until their Link-State databases are identical
- At that point, routers become adjacent to each other

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

OSPF uses 5 different types of packets to establish and maintain router connectivity and network convergence:

1. **Hello Packets:** generated by all OSPF speaking routers. They are used to discover neighbors, and to form and maintain adjacencies. They are propagated periodically (10 seconds).
2. **Database Descriptors:** used to distribute a summary of all the networks in the router's database. Typically this will be the classless network, routers cost to access, and the sequence number associated with that network entry.
3. **Link State Requests:** used to request additional information on a particular network entry on which the present information is non-existant or outdated after comparing the Database Descriptors.
4. **Link State Updates:** respond to Link State Requests by using the requested LSAs. There are many forms of LSAs available.
5. **Link State Acknowledgments:** acknowledge every newly received LSA. Many acknowledgments may be grouped together into a single Link State Acknowledgment packet.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OSPF Configuration

Although OSPF is a far more complex design than RIP for example, a basic OSPF network is very easy to install and configure. Here are the fundamental steps:

• Configure a Router ID (optional):

```
config>router# router-id x.x.x.x
```

• Configure the Backbone Area (the only one needed in a single-level hierarchical network):

```
config>router>ospf$ area 0
```

• Configure the interfaces, created in advance, that need to be part of the OSPF network:

```
config>router>ospf>area# interface "system"
config>router>ospf>area>if$ exit
config>router>ospf>area# interface "loopback_1"
config>router>ospf>area>if$ exit
config>router>ospf>area# interface "to_neighbor_1"
config>router>ospf>area>if$ exit
```

The router will send and receive OSPF messages on the configured physical interfaces and try to establish neighbor adjacencies

LSAs will describe networks associated to both physical and logical interfaces (system and loopbacks) included in the configuration

It is good practice to configure interfaces as point-to-point interfaces to cut down on the overhead in electing DR and BDR:

```
config>router>ospf>area>if$ interface-type point-to-point
```

Some commands that can be useful to troubleshoot or verify the network:

• To show all the neighbors and the state the adjacency is in:

```
Node>show>router>ospf# neighbor
```

• To show the status of the local OSPF instance :

```
Node>show>router>ospf# status
```

• To show the area information:

```
Node>show>router>ospf# area 0.0.0.0
```

• To show the link state database:

```
Node>show>router>ospf# database
```

• To clear the link state database:

```
Node# clear router ospf database
```

• To clear the OSPF statistics:

```
Node# clear router ospf statistics
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OSPF overview

- **OSPF workgroup started in 1987, lead by John Moy**
- **Present standard: RFC 2328: OSPFv2**
- **Link cost = reference bandwidth (100Gbps) / link bandwidth**
  - Reference bandwidth can be changed, or a fixed value can be manually assigned for the link cost
- **IP and MAC multicast addressing**
  - 224.0.0.5 equals MAC 01-00-5E-00-00-05 listened to by any OSPF router
  - 224.0.0.6 equals MAC 01-00-5E-00-00-06 listened to by any DR/BDR router
- **No Transport Layer Protocols (TCP/UDP): OSPF works on top of IP (Protocol field: 89)**
- **Router ID address is necessary, and may be:**
  - The router-id in the ***config>router>ospf#*** context
  - The router-id in the ***config>router#*** context
  - The same numerical value as the system IP address
  - The last 32 bits of chassis MAC address
- **Authentication:**
  - No Authentication
  - Simple Authentication
  - MD5 Authentication



The most specific configuration command takes effect

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Open Shortest Path First (OSPF) is a link state protocol. The present standard is the OSPFv2 based on RFC 2328.

- OSPF Link Cost = a reference bandwidth (100Gbps) divided by the link bandwidth. For example a 10 Gbps link will have a cost of 10, but the costs are configurable if the administrator prefers other values.
- OSPF uses IP and MAC multicast addresses, instead of broadcast, to distribute LSAs. This reduces the overhead on other devices on the same segment that are not running OSPF.
  - IP 224.0.0.5 translates into MAC 01-00-5E-00-00-05 for any OSPF speaker
  - IP 224.0.0.6 translates into MAC 01-00-5E-00-00-06 for any DR/BDR speaker
- OSPF works on top of Layer 3 in the OSI model. It uses no transport layer protocol such as TCP or UDP but duplicates their functions through the use of acknowledgements and sequence numbers.
- OSPF requires each OSPF speaker to have a Router ID (RID) to identify the node in the Link State Databases. This RID can be:
  - The last 32 bits of the chassis MAC address (default),
  - The system IP address (overrides the default),
  - The Router ID defined in the **config>router#**router-id context (overrides the system IP address).
  - The Router ID defined in the **config>router>ospf#**router-id context (overrides the router ID value configured at the router level).
- OSPF supports three types of authentication
  - None (default)
  - Simple authentication
  - MD5 authentication

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OSPF Packet Types

- OSPF Hello
- OSPF Database Descriptor
- OSPF Link State Request
- OSPF Link State Update
- OSPF Link State Acknowledgement

- Routers use Hello messages to discover each other and to verify compatibility
- Once discovered, they use Database Descriptor messages to describe what is in their databases
- After that, routers use Link State Request, Update and Acknowledgement messages to exchange topology information until their Link-State databases are identical
- At that point, routers become adjacent to each other

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

OSPF uses 5 different types of packets to establish and maintain router connectivity and network convergence:

1. **Hello Packets:** generated by all OSPF speaking routers. They are used to discover neighbors, and to form and maintain adjacencies. They are propagated periodically (10 seconds).
2. **Database Descriptors:** used to distribute a summary of all the networks in the router's database. Typically this will be the classless network, routers cost to access, and the sequence number associated with that network entry.
3. **Link State Requests:** used to request additional information on a particular network entry on which the present information is non-existant or outdated after comparing the Database Descriptors.
4. **Link State Updates:** respond to Link State Requests by using the requested LSAs. There are many forms of LSAs available.
5. **Link State Acknowledgments:** acknowledge every newly received LSA. Many acknowledgments may be grouped together into a single Link State Acknowledgment packet.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OSPF Configuration

Although OSPF is a far more complex design than RIP for example, a basic OSPF network is very easy to install and configure. Here are the fundamental steps:

• Configure a Router ID (optional):

```
config>router# router-id x.x.x.x
```

• Configure the Backbone Area (the only one needed in a single-level hierarchical network):

```
config>router>ospf$ area 0
```

• Configure the interfaces, created in advance, that need to be part of the OSPF network:

```
config>router>ospf>area# interface "system"
config>router>ospf>area>if$ exit
config>router>ospf>area# interface "loopback_1"
config>router>ospf>area>if$ exit
config>router>ospf>area# interface "to_neighbor_1"
config>router>ospf>area>if$ exit
```

The router will send and receive OSPF messages on the configured physical interfaces and try to establish neighbor adjacencies

LSAs will describe networks associated to both physical and logical interfaces (system and loopbacks) included in the configuration

It is good practice to configure interfaces as point-to-point interfaces to cut down on the overhead in electing DR and BDR:

```
config>router>ospf>area>if$ interface-type point-to-point
```

Some commands that can be useful to troubleshoot or verify the network:

• To show all the neighbors and the state the adjacency is in:

```
Node>show>router>ospf# neighbor
```

• To show the status of the local OSPF instance :

```
Node>show>router>ospf# status
```

• To show the area information:

```
Node>show>router>ospf# area 0.0.0.0
```

• To show the link state database:

```
Node>show>router>ospf# database
```

• To clear the link state database:

```
Node# clear router ospf database
```

• To clear the OSPF statistics:

```
Node# clear router ospf statistics
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7 IS-IS (Intermediate System to Intermediate System)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IS-IS Overview

- **Developed by DEC, later handed over to International Standards Organization (ISO)**
- **Link cost = 10 by default**
  - Configurable (reference bandwidth setting can be applied or a different specific value)
- **MAC multicast addressing**
  - Level 1 updates use 01-80-C2-00-00-14
  - Level 2 updates use 01-80-C2-00-00-15
- **No Network or Transport Layer Protocols: IS-IS works on top of Ethernet 802.3 LLC Encapsulation (DSAP/SSAP: 0xFEFE)**
- **System ID address is necessary (6 bytes), and may be**
  - The chassis MAC address
  - Derived from the system IP address
  - Derived from the router-id in the config>router# context
- **IS-IS uses an NSAP (Network Service Access Point) addressing, including area and system IDs**
- **Authentication:**
  - No Authentication
  - Simple Authentication
  - MD5 Authentication

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Another Link State Protocol is Intermediate System to Intermediate System (IS-IS). An Intermediate system, in comparison to an end-system, is a router. This protocol was developed by Digital Equipment Corporation (DEC) and later handed over to the International Standards Organization (ISO) who implemented it into the OSI protocol stack. Later this OSI protocol was extended to support IP and called Integrated IS-IS. OSPF and IS-IS are extremely similar Link State Protocols and are evenly used amongst networks worldwide.

Characteristics of IS-IS.
•The cost of the links is by default 10 but is configurable (reference bandwidth can also be configured as in OSPF).
•IS-IS uses L2 multicasting (instead of L3 multicast in OSPF):

- Level 1 updates use 01-80-C2-00-00-14
- Level 2 updates use 01-80-C2-00-00-15

•IS-IS works on top of layer 2 in the OSI model, it uses no IP or Transport Layer Protocol but takes care of their responsibilities itself through the use of acknowledgements and sequence numbers.
•IS-IS uses an ISO standardized network addressing method, called NSAP (Network Service Access Point) addressing.
•IS-IS requires a System ID of 6 bytes which can be derived from the chassis MAC address, the system address, or the router-id, configured in the **config>router#** context.
•IS-IS supports three types of authentication

- None (default).
- Simple authentication.
- MD5 authentication.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IS-IS Protocol Data units (PDU)

- IS-IS Hello PDU
- IS-IS LSP (Link State PDU)
- IS-IS PSNP (Partial Sequence Number PDU)
- IS-IS CSNP (Complete Sequence Number PDU)

- Routers use Hello messages to discover each other and to verify compatibility
- Once connectivity and compatibility have been verified, routers become adjacent to each other
- After that, routers use CSNP and PSNP messages to describe what is in their databases
- If databases differ, LSP messages are used to exchange topology information until their Link-State databases are identical

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

OSPF uses 5 different types of packets to establish and maintain router connectivity and network convergence:

1. **Hello Packets:** generated by all OSPF speaking routers. They are used to discover neighbors, and to form and maintain adjacencies. They are propagated periodically (10 seconds).
2. **Database Descriptors:** used to distribute a summary of all the networks in the router's database. Typically this will be the classless network, routers cost to access, and the sequence number associated with that network entry.
3. **Link State Requests:** used to request additional information on a particular network entry on which the present information is non-existant or outdated after comparing the Database Descriptors.
4. **Link State Updates:** respond to Link State Requests by using the requested LSAs. There are many forms of LSAs available.
5. **Link State Acknowledgments:** acknowledge every newly received LSA. Many acknowledgments may be grouped together into a single Link State Acknowledgment packet.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IS-IS Configuration

Although IS-IS is a far more complex design then RIP for example, a basic IS-IS network is very easy to install and configure. Here are the fundamental steps:

• Configure a Router ID (optional):

```
config>router# router-id x.x.x.x
```

• By default routers will be level 1/level 2 capable, meaning that the two levels of hierarchy are present even if there is only one area. To optimize, level 1-only can be configured:

```
config>router>isis$ area-id 49.0001
config>router>isis$ level-capability level-1
```

• Configure the interfaces, created in advance, that need to be part of the IS-IS network:

```
config>router>isis# interface "system"
config>router>isis>if$ exit
config>router>isis# interface "loopback_1"
config>router>isis>if$ exit
config>router>isis# interface "to_neighbor_1"
config>router>isis>if$ exit
```

• The router will send and receive IS-IS messages on the configured physical interfaces and try to establish neighbor adjacencies

• LSPs will describe networks associated to both physical and logical interfaces (system and loopbacks) included in the configuration

It is good practice to configure interfaces as point-to-point interfaces to cut down on the overhead in electing DR and BDR:

```
config>router>isis>if# interface-type point-to-point
```

Some commands that can be useful to troubleshoot or verify the network:

• To show all the adjacencies and their state:

```
SR>show>router>isis# adjacency
```

• To show the status of the local IS-IS instance :

```
SR>show>router>isis# status
```

• To show the LSP database:

```
SR>show>router>isis# database
```

• To show the IS-IS learned routes:

```
SR>show>router>isis# routes
```

• To show the IS-IS enabled interfaces:

```
SR>show>router>isis# interface
```

• To clear the link state database:

```
SR# clear router isis database
```

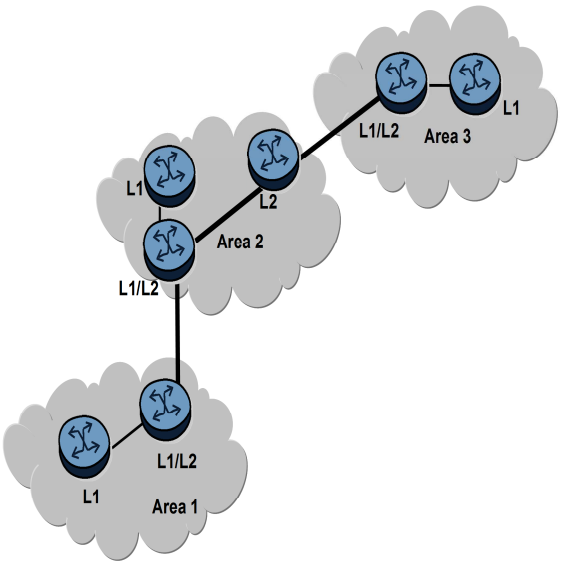
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IS-IS hierarchy

A **level-2-capable** router knows explicitly about every reachable network, IS-IS internal or external

A **level-1-only** router only knows about networks within its own IS-IS area; relies on level-2-capable routers to reach everything else by means of a default route

A **level-1/level-2** router sets the ATT (attached) bit in its level-1 LSPs to inform other level-1 routers that it can reach beyond the area in which they are located



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

IS-IS hierarchy

A **level-2-capable** router will have explicit entries in its routing table for every reachable network, either within the IS-IS domain or external

A **level-1-only** router will only have explicit entries in its routing table for networks directly attached to routers within the same IS-IS area; it will rely on level-2-capable routers to reach both IS-IS networks in other areas or IS-IS-external networks by means of a default route

A router that is **both level-1 and level-2** capable will inform other level-1 routers that it can reach networks beyond the mere area in which they are located by setting the ATT (attached) bit in its level-1 link-state PDUs (LSPs)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
IGP Routing

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 5
MPLS and GRE

Module 1
MPLS and GRE

TER36075_V3.1-SG-English-Ed1 Module 5.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to describe:

- Limitations of traditional IP routing and benefits of MPLS
- MPLS terminology and concepts
- MPLS data and control plane
- Label signaling protocols: static, LDP, RSVP-TE, and GRE
- MPLS OAM tools

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1. Limitations of Traditional IP Routing and benefits of MPLS	5
2. MPLS terminology and concepts	8
3. MPLS control plane	14
4. Dynamic label signaling protocols	17
5. Label Distribution Protocol – LDP	19
6. Resource Reservation Protocol – RSVP-TE	22
7. Generic Routing Encapsulation (GRE)	35
8. MPLS OAM tools	41

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

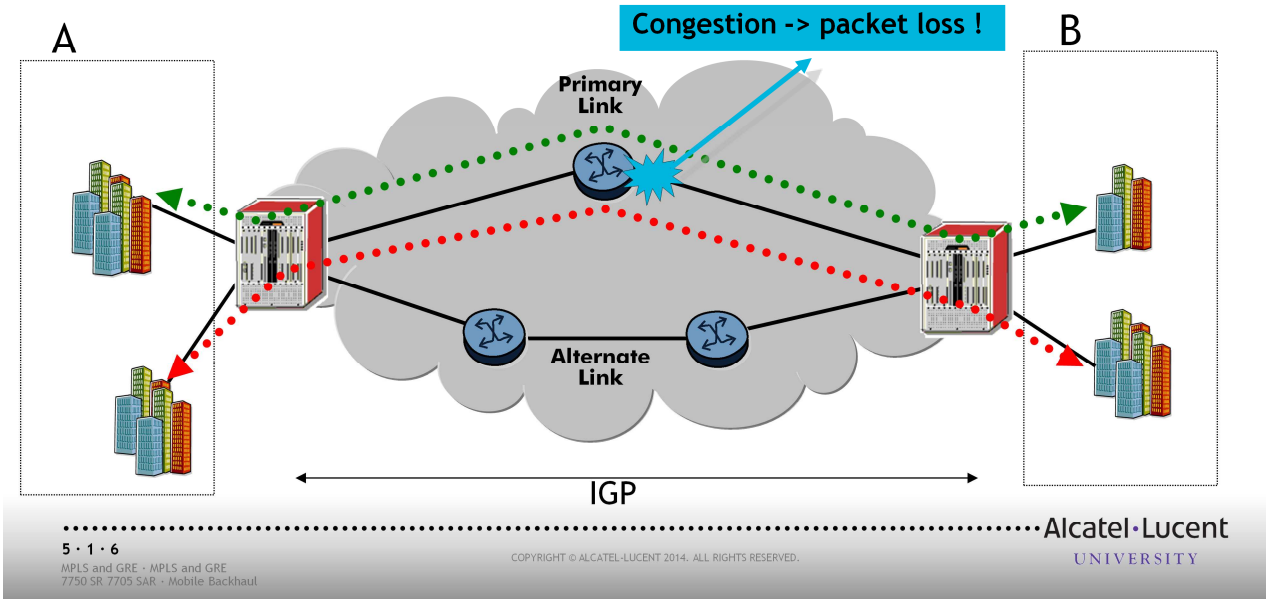
1 Limitations of Traditional IP Routing and benefits of MPLS

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Limitations of Traditional IP Routing: Hyper-Aggregation

IP has a limited ability to alleviate hyper aggregation which leads to network and link congestion

- All network traffic will flow via the primary path
- No traffic will use the Alternate Link → Inefficient use of resources



One of the major limitations in a classical IP routing network is that packets entering the network will follow the IGP shortest path based on the metric calculations.

This implies that packets from different routers at side A that need to send traffic to side B over the IP network, will follow the same path defined by the IGP topology. This can lead to congestion and under-usage of other available resources. MPLS provides a whole array of tools to allow a network architect to direct traffic over other paths depending on criteria such as bandwidth, link colors, hop limit and manual configuration of the path preference.

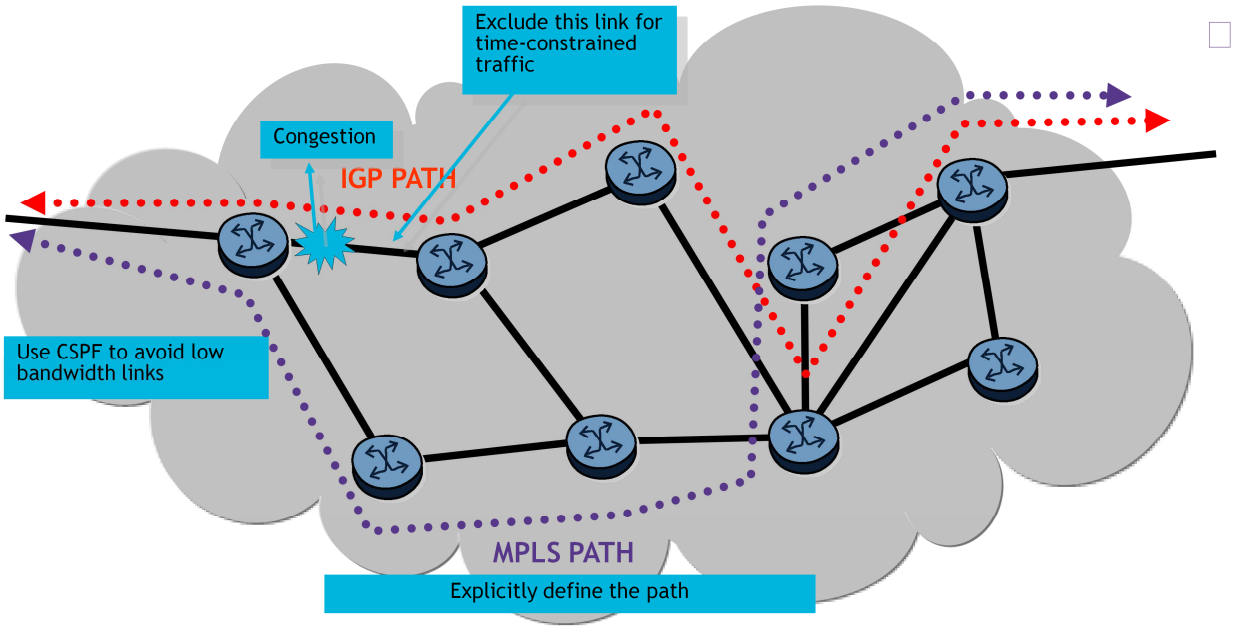
The IP protocol alone is also unable to provide guaranteed service levels across a network end to end. Certain applications may require a guaranteed amount of bandwidth and Service Providers want to be able to offer service level agreements to their customers guaranteeing bandwidth and resource availability.

Traditional IP routing protocols do not consider the available bandwidth in the network across the primary or alternate links. This means that routers in the network are not aware if what bandwidth resources are available over primary or alternate paths.

As shown in the example above, if all packets take the primary path the link may soon become congested, resulting in packet loss.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Benefits of MPLS



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Greater flexibility:

- Label tagging allows forwarding along an explicitly defined path, which may be different from the IGP path
- MPLS can find paths based on different criteria, e.g. bandwidth constraints, coloring constraints

Increased performance:

- MPLS offers improved network resiliency and recovery options compared to traditional IP networks
- Using traffic engineering and techniques such as fast reroute, congestion and interruptions can be reduced
- Paths can be set up manually or automatically in accordance to the set constraints

MPLS is independent of any IP routing protocol:

- The underlying routed infrastructure may be provided by any IGP

After path setup, data forwarding is done independently of the destination address.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

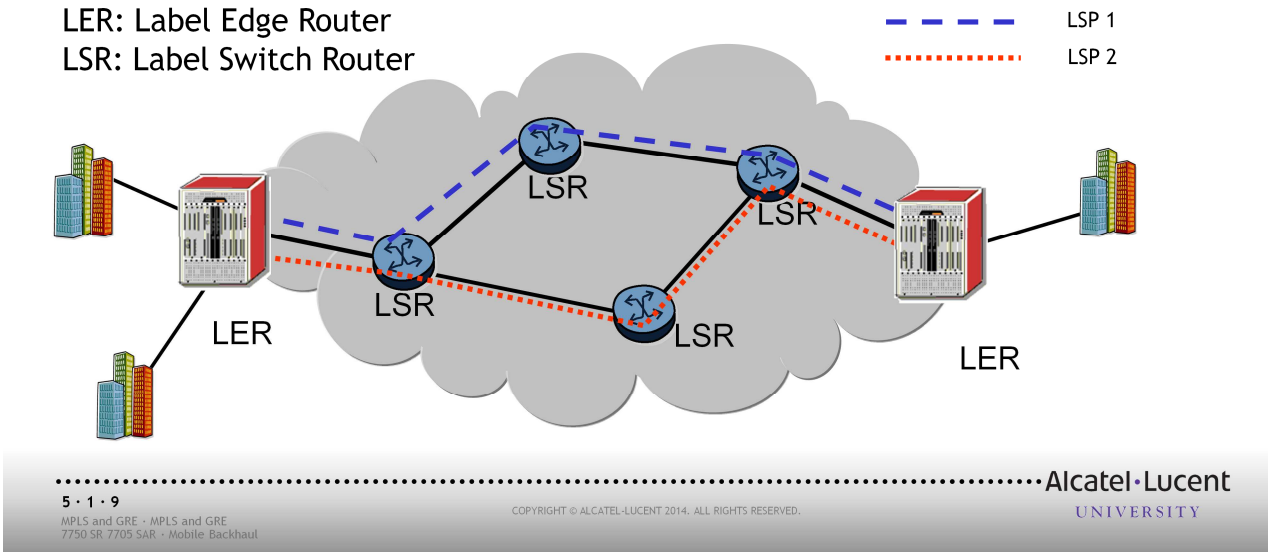
2 MPLS terminology and concepts

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MPLS: Terminology

Multi Protocol Label Switching, MPLS:

- Allows the network operator to create end-to-end label-switched paths (LSPs) for data forwarding, instead of using hop-by-hop IP routing
- Alleviates the limitations of traditional IP routing



MPLS provides the network administrator to create “tunnels” from the ingress to the egress of the MPLS domain, usually a Provider’s network. These end-to-end tunnels alleviate the limitations of traditional IP hop-by-hop routing, since the tunnel does not have to follow the path chosen by the IGP and it can be created with certain characteristics such as bandwidth requirements, allowing SLAs to be defined.

Label Edge Router (LER)

An LER sits at the edge of an MPLS domain, either at the beginning (ingress) or end (egress) of a Label Switched Path.

Label Switch Router (LSR)

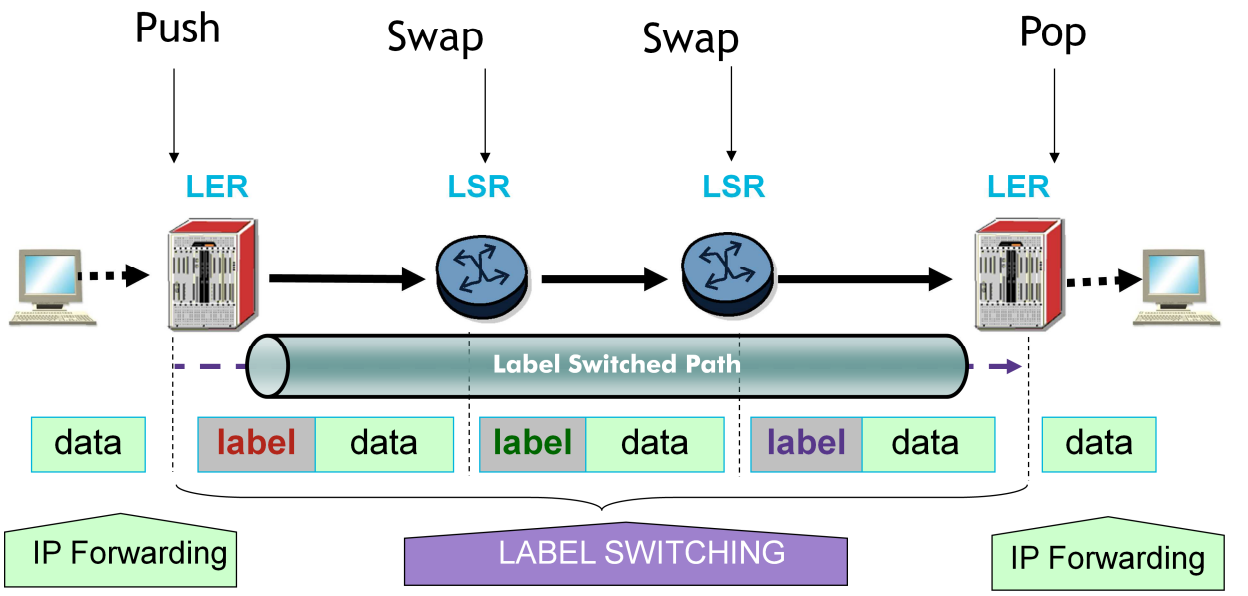
A device that typically resides somewhere in the middle of an MPLS network and is capable of forwarding datagrams based upon a label. An LSR will develop a Label Information Base (LIB) and a Label Forwarding Information Base (LFIB) to switch packets according to the label value assigned to the packet.

Label Switch Path (LSP)

A specific, unidirectional tunnel set up across the MPLS network between two LERs. Label Switch Paths are established by network operators for a variety of purposes, such as to guarantee a certain level of performance, to route around network congestion, or to create IP tunnels for network-based virtual private networks.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MPLS: Basic operation



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The MPLS LSPs are virtual “tunnels” created through the use of labels signalled between MPLS speaking routers. Once a label is chosen at the ingress, the label header is put at the front of the packet header so that the label value can be carried across the network with the packet. At each subsequent hop, the Label Switch Router (LSR) simply looks up the label value in a table to make the forwarding decision, there is no need to parse the IP header. Since the label is a fixed length, label look-up is fast and simple

MPLS performs three basic operations:

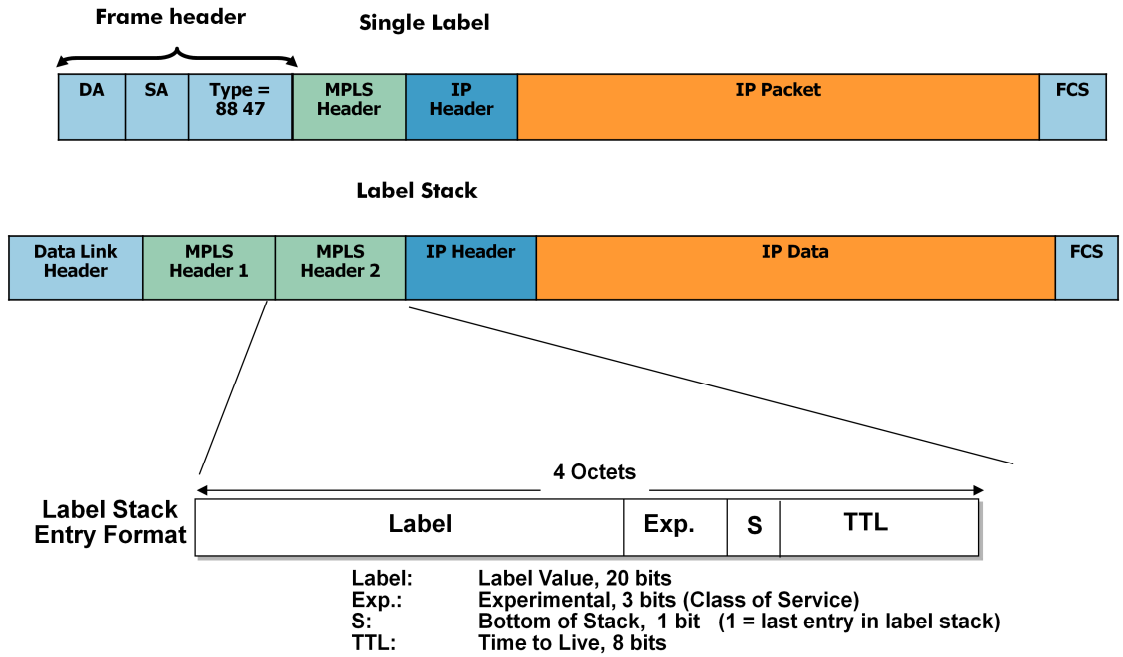
- **Push** - Puts a label onto the packet.
- **Swap** - Swaps or changes a label received at an ingress interface with a label at an egress interface of the node. The label swapping is done in accordance to the Label Forwarding Information Base (LFIB).
- **Pop** - Removes the label from the packet.

An LSR router can perform pop, push and swap operations. An LER can perform pop and push operations.

Penultimate Hop Popping (PHP) pops a label one hop before the last node. This was initially done to take some of the processing load off of the last router. This is not an issue anymore since most routers can handle label popping at wire speed and the operation does not cause additional delays. Alcatel-Lucent supports PHP but not if a node is the last hop. This means that the node does not initiate PHP but will pop labels if requested to do so by the last router. This ensures interoperability of Alcatel-Lucent systems with other vendor’s products.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MPLS Label



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

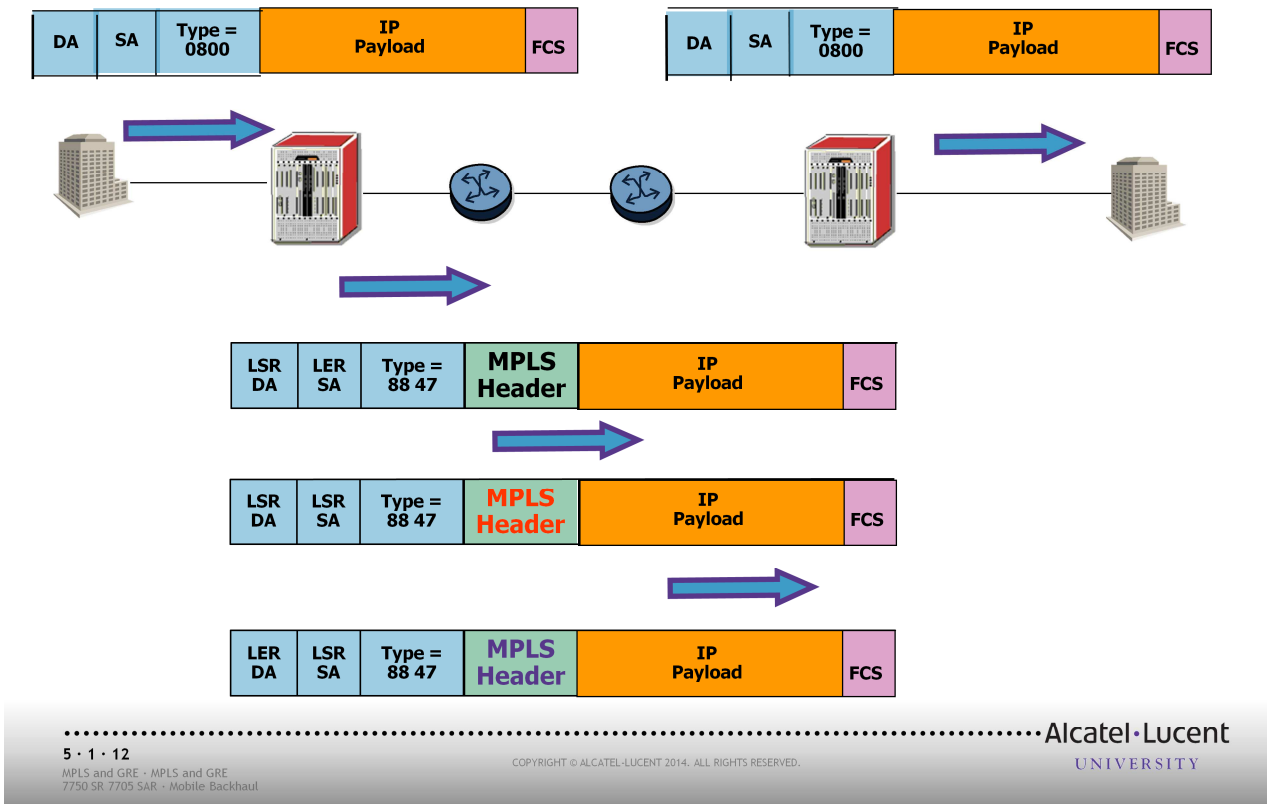
Field Descriptions:

- Label: 20-bit field that carries the actual value of the label.
- Exp: This 3-bit field is reserved for experimental use. It is currently used for Class of Service(CoS).
- S: This bit is set to 1 for the last entry (bottom) in the label stack, and 0 for all other label stack entries.
- TTL: This 8-bit field is used to encode a TTL value.

In MPLS, packets can carry not just one label, but a set of labels in a stack. An LSR can swap the label at the top of the stack, pop the stack, or swap the label and push one or more labels into the stack. The processing is always based on the top label, without regard for the possibility that some number of other labels may have been above it in the past, or that some number of other labels may be below it at present.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MPLS Encapsulation: The Shim Header



The MPLS label values are carried in an MPLS Shim header.

As defined by the Internet Assigned Numbers Authority (IANA) the Ethertype field of an Ethernet frame must carry the following type codes to identify the payload of the frame.

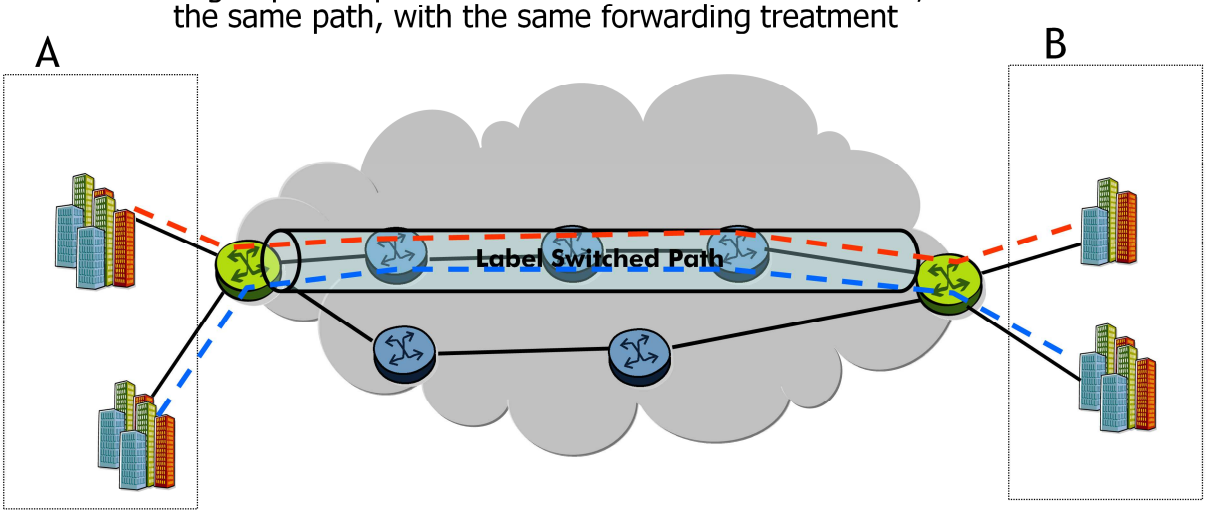
Ethernet	Description	References
0x0800	Internet IP (IPv4)	[IANA]
0x8847	MPLS Unicast	[Rosen]
0x8848	MPLS Multicast	[Rosen]

The MPLS encoding technique implementing the MPLS shim header.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Forwarding Equivalence Classes

- Forwarding Equivalence Class (FEC)
- A group of IP packets forwarded in the same manner, over the same path, with the same forwarding treatment



MPLS packets are assigned to a FEC at the network ingress

- FEC packets are transported by the LSP which has a label to identify it
- Label switching is used to forward the labelled packet

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The FEC is an important concept in MPLS. A FEC is any subset of packets that are forwarded in the same way by a router. When a packet enters the MPLS network at the ingress node, the packet is mapped to a particular FEC and forwarded in the same way across the network. Packets belonging to the same FEC will get the same label.

When a packet enters the MPLS network at an iLER, the packet is mapped into a FEC. FEC assignment is performed only once at the ingress, and the packet follows the LSP assigned to the FEC until network egress.

Using MPLS, the aggregation of packet flows into FECs provides scalability that meets the demands of the public Internet as well as enterprise applications.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 MPLS control plane

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Static Label distribution

Static LSPs are manually configured on each LER/LSR

Labels are assigned on each router individually

Allows the creator to have full control on the path

Disadvantages:

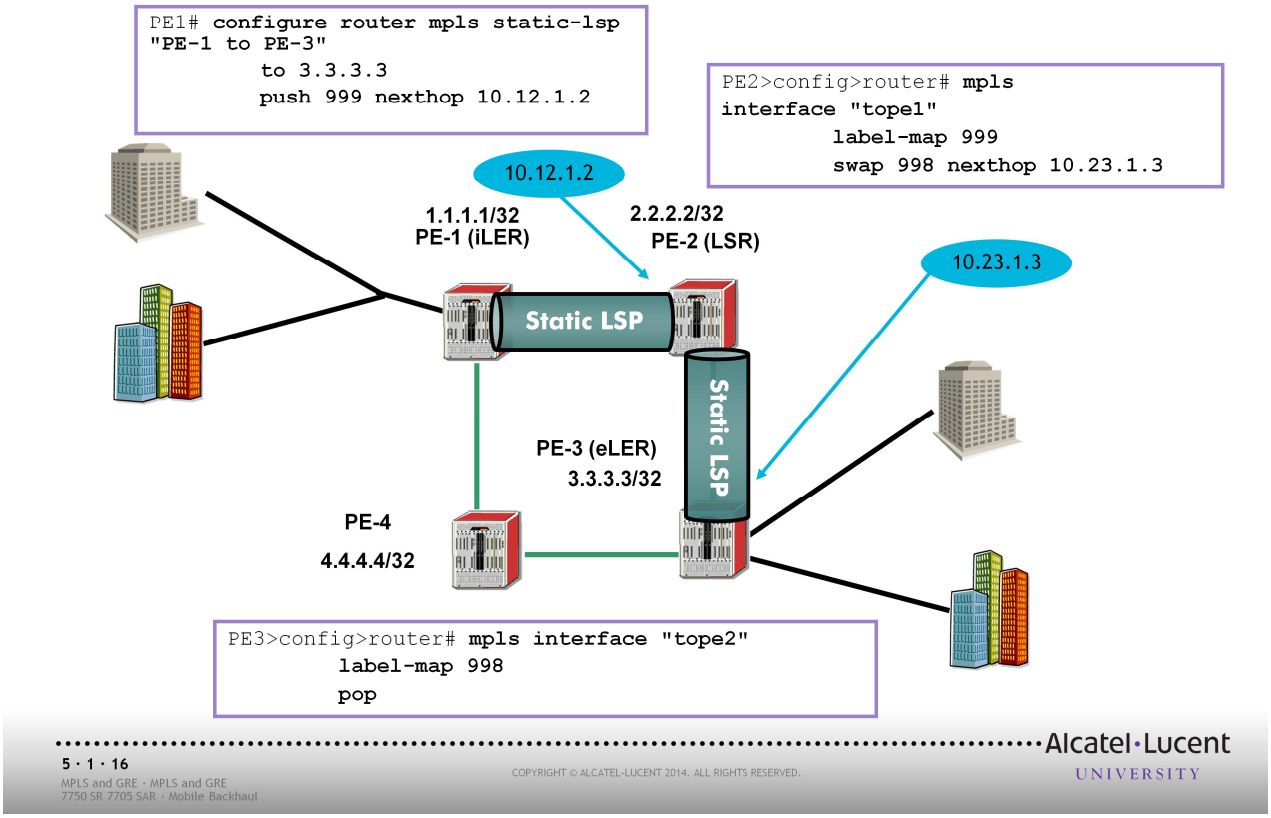
- Labour intensive operation
- Changes need a reconfiguration on every node
- No back-up or fast re-route
- No support of label stacking

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A static LSP specifies a static path and all routers that the LSP traverse must be configured manually with labels. No signalling such as RSVP or LDP is required.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Static Label distribution



The configuration above shows the static LSP configuration of PE-1. The static LSP transport tunnel is configured to forward traffic across the provider core from PE1 to PE3.

The Static LSP is configured between these devices, from system address 1.1.1.1 to the device with system address 3.3.3.3.

PE1 performs a PUSH operation and forwards the incoming packets to the next-hop address of 10.12.1.2, LSR2, with a label of 999.

The transit LSRs perform SWAP operations and forward the packet to the manually defined next-hop.

PE3 performs a POP operation and forwards unlabeled packets external to the MPLS domain.

Note: An LSP is always unidirectional, therefore after the configurations shown above, only traffic from PE1 has an LSP available to reach PE3, not the other way around.

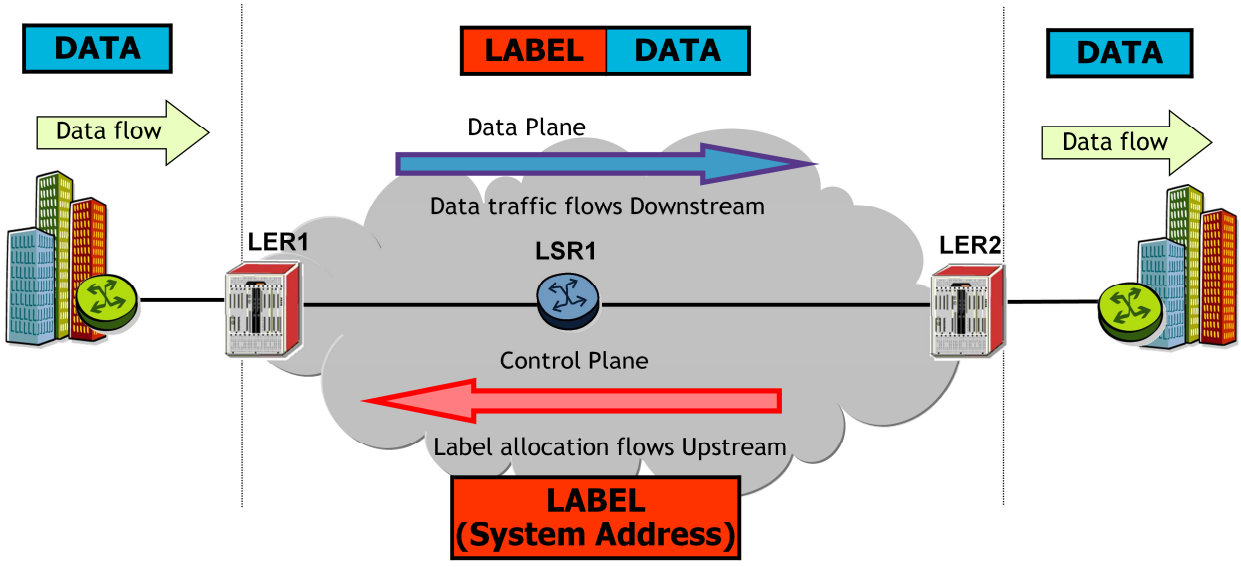
These configuration steps demand the operator to log in and manually enter all the necessary commands in every node, an extremely heavy task that can be accomplished by dynamic signalling protocols instead.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 Dynamic label signaling protocols

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Label distribution: Traffic/Control flow



Data packets flow in the downstream direction
Label bindings are distributed from the downstream to the upstream direction

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Terminology

Data packets flow in the downstream direction (data plane).

Control packets follow the upstream direction (control plane).

Label distribution

In the initial phase, LER2 is initiating the label distribution by sending a label advertisement message to LER1 of its system address (FEC = system address). Label distribution is initiated at LER2 and follows the upstream direction.

Data flow

After label distribution, data flows in the opposite direction of the label distribution path.

Packets flow from the ingress Label Edge Router (iLER) LER1 to the egress Label Edge Router (eLER), in this case LER2.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

5 Label Distribution Protocol - LDP

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LDP: Signaling

Each LSR will originate a label for its system address by default (this is enough to create transport tunnels for services)

Each LSR may originate a label for other directly-attached prefixes: an export policy is needed !



LSR 1 LFIB	Prefix	Ing. Label	Egr. Label	Egr. Intf	Next-hop
	10.2.1.0/24	-	131068	1/1/2	LSR2
	4.4.4.4/32	-	131071	1/1/2	LSR2

LSR 4 LFIB	Prefix	Ing. Label	Egr. Label	Egr. Intf	Next-hop
	10.1.1.0/24	-	131065	1/1/3	LSR3
	1.1.1.1/32	-	131070	1/1/3	LSR3

Control Plane

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Label binding to a FEC

There are two ways defined in the industry to bind a label to a FEC:

1. Advertise a label for each prefix in the routing table of the advertising router. This implies a large number of labels in the MPLS network and may cause scalability issues.
2. Advertise a label per system address.

Alcatel-Lucent products advertise a label per system address as the default, resulting in fewer labels being used.

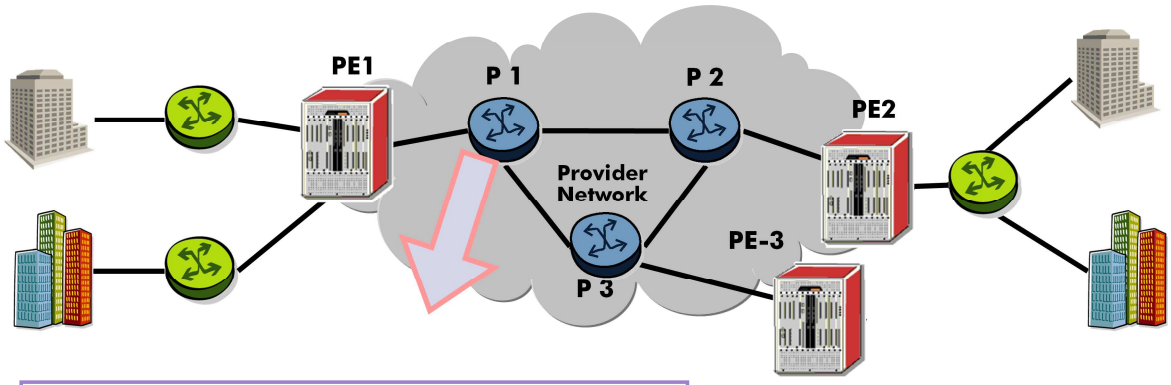
Once LDP neighbors have been established, each LSR will originate a label for its system address. This is enough to be able to create services that use the transport tunnels created. LDP may also originate a label for other prefixes corresponding to directly-attached networks, but to do this, an export policy is required. This is not needed in a service-only environment; it is needed when MPLS shortcuts for IGP need to be enabled in the network.

In the example shown above, LSR 4 is directly attached to network 10.2.1.0/24 and has created a local label binding for this FEC and will propagate it into the MPLS domain to its LDP peer LSR 3.

Similarly, LSR 1 will originate a label for FEC 10.1.1.0/24.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LDP: Minimum Configuration




```
P1# configure router
P1>config>router# ldp
P1>config>router>ldp# interface-parameters
P1>config>router>ldp>if-params$ interface "P1-PE1"
P1>config>router>ldp>if-params>if$ exit
P1>config>router>ldp>if-params$ interface "P1-P2"
P1>config>router>ldp>if-params>if$ exit
P1>config>router>ldp>if-params$ interface "P1-P3"
P1>config>router>ldp>if-params>if$ exit all
```

- Enable LDP context
- Add physical interfaces on which the router will "speak" LDP with other routers
- It is not necessary to add the system or loopback interfaces

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

All provider core facing interfaces must have LDP enabled. LDP must be enabled on each router's physical interface, to allow direct LDP sessions to be established between adjacent routers. Note that LDP is not enabled on the router's system or loopback interfaces.

Context: **config>router>ldp**

Syntax: `interface-parameters`

Description: This command enables the context to configure LDP interfaces and parameters applied to LDP interfaces.

Context: **config>router>ldp>if-params**

Syntax: `[no] interface ip-int-name`

Description: This command enables LDP on the specified IP interface.

The no form of the command deletes the LDP interface and all configuration information associated with the LDP interface. The LDP interface must be disabled using the `shutdown` command before it can be deleted.

Parameters: `ip-int-name` - The name of an existing interface.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6 Resource Reservation Protocol – RSVP-TE

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Dynamic Label Distribution: RSVP-TE

Each LSP has to be manually configured at the ingress node, and only then the label signaling process starts

A request to bind labels to a specific LSP tunnel is initiated by the ingress node through an RSVP **Path message**

Labels are requested downstream and distributed (propagated) upstream by means of an RSVP **Resv message** originated by the egress node

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

RSVP-TE is an MPLS signaling protocol based on the resource reservation protocol originally used for signaling IP quality of service connections.

RSVP-TE defines a set of traffic engineering extensions to the Resource Reservation Protocol (RSVP) standard. RSVP-TE extensions provide a method by which RSVP may be used for traffic engineering in MPLS environments. These extensions add support for assigning MPLS labels and specifying explicit paths as a sequence of loose and strict hops. These extensions are supported by providing a Label Request field and an Explicit Route Object field in the path message. The destination LSR responds to a label request by providing a label object in its RESV message. Labels are then assigned at each intermediate node which processes the RESV message. RSVP-TE operates in downstream-on-demand (DoD) label advertisement mode with ordered LSP control. It can be said that RSVP-TE uses conservative retention since only labels that will be used are requested, so there is no superfluous information being stored.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

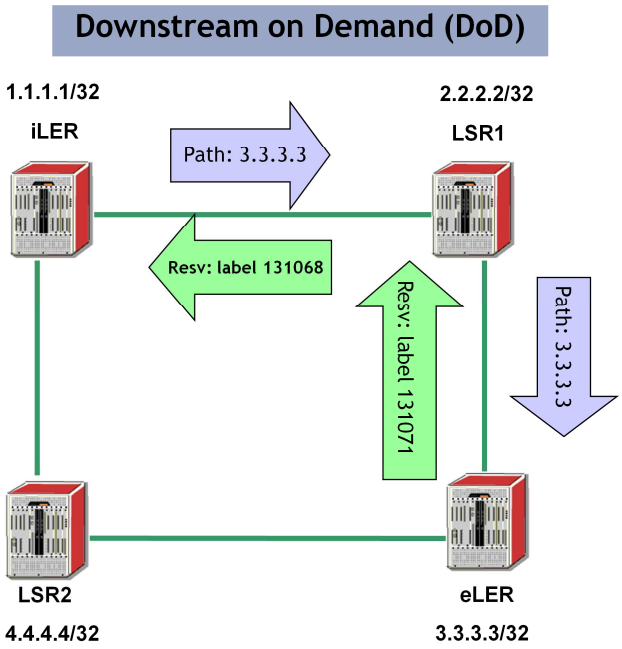
RSVP-TE: Message Types

PATH message sent by iLER towards tunnel destination (eLER)

Receiver (eLER) sends RESV message back towards sender

eLER sends label binding info in RESV message

Path Refresh and RESV Refresh messages are sent periodically afterwards



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

RSVP is a network control protocol used by a host to request specific qualities of service from the network for particular application data streams or flows. RSVP is also used by routers to deliver quality of service (QoS) requests to all nodes along the path(s) of the flows and to establish and maintain state to provide the requested service. RSVP requests generally result in resources reserved in each node along the data path. MPLS leverages this RSVP mechanism to set up traffic-engineered LSPs. RSVP requests resources for simplex flows. It requests resources in only one direction (unidirectional).

RSVP treats a sender as logically distinct from a receiver, although the same application process may act as both a sender and a receiver at the same time. Duplex flows require two LSPs, one to carry traffic in each direction. RSVP is not a routing protocol, it operates with unicast and multicast routing protocols. Routing protocols determine where packets are forwarded and RSVP consults local routing tables to relay RSVP messages.

The sender (the ingress LER), sends PATH messages toward the receiver (the egress LER) to indicate the FEC for which label bindings are desired. PATH messages are used to signal and request label bindings required to establish the LSP from ingress to egress. Each router along the path observes the traffic type. PATH messages facilitate the routers along the path to make the necessary bandwidth reservations and distribute the label binding to the router upstream. The egress LER sends label binding information in the RESV messages in response to PATH messages received. The LSP is considered operational when the ingress LER receives the label binding information.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

RSVP-TE advantages

Advantages of using RSVP-TE to establish LSP tunnels are:

Traffic engineering

- It enables the verification of bandwidth availability along the path and its reservation
- It provides for better control of the path that packets will follow (explicit path, link admin groups, link risk groups, hop count)

Better data protection mechanisms

- Secondary paths
- Fast reroute

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Since the flow along an LSP is identified by the label applied at the ingress node of the path, these paths may be treated as tunnels. A key application of LSP tunnels is traffic engineering with MPLS. The resulting label switched tunnels can be automatically routed away from network failures, congestion, and bottlenecks.

There are different ways of doing traffic engineering with RSVP-TE:

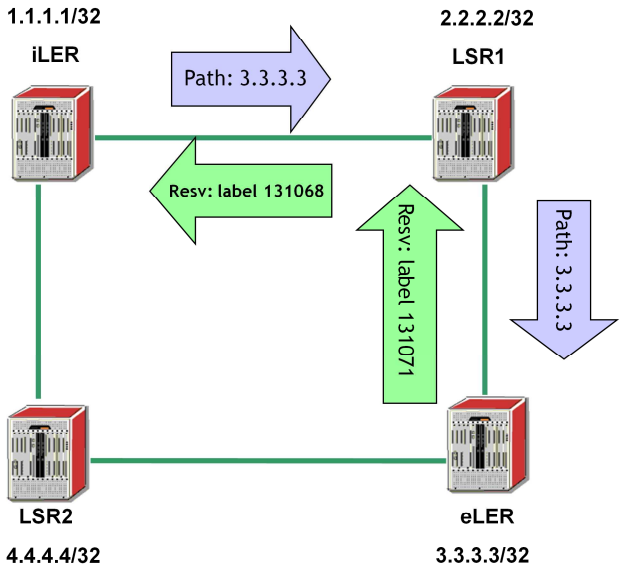
- by explicitly specifying the routers that will be part of the path (all of them or a partial list)
- by classifying the links existing in the network into groups (admin groups or link colors) and by specifying which groups should be included and which ones excluded
- by classifying links as belonging to a certain risk group and by making sure that primary and secondary paths do not share the same risks
- by limiting the maximum allowed number of hops that the path can have
- by choosing only from among links that have at least the bandwidth needed for proper performance

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

RSVP-TE: Label allocation

If traffic engineering is not needed, the iLER and intermediate routers will forward the Path message to the IGP next hop

If traffic engineering is needed, the iLER will pre-calculate the path and include it in the Path message's ERO (Explicit Route Object)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

If traffic engineering is not needed, the iLER and all intermediate routers will forward the PATH message to the next hop according to the shortest IGP path from tunnel head to tunnel destination.

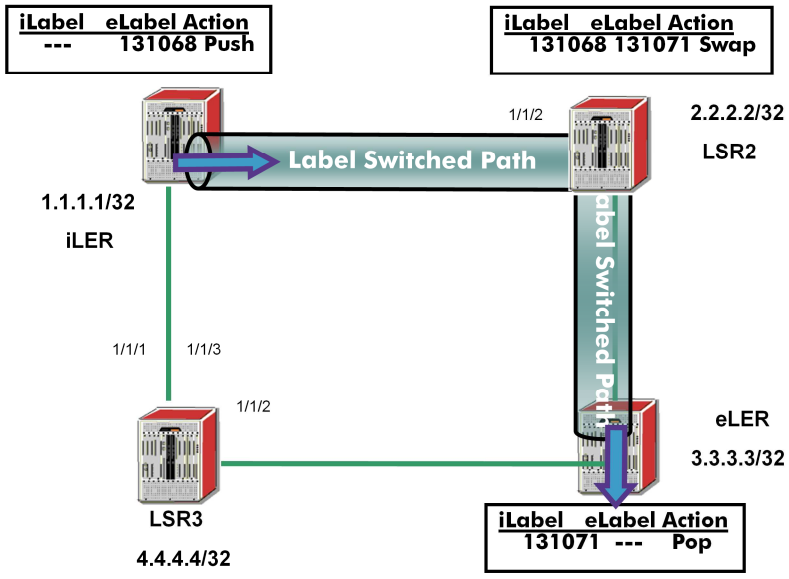
If traffic engineering is needed, the iLER will pre-calculate the path and include it in the PATH message's ERO (Explicit Route Object). In this case, each router will forward the PATH message to the next router in the ERO.

The RESV message will follow the exact same path but in reverse. To do that, each router will store the interface IP address of the router from which the PATH message was received.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

RSVP-TE: Label allocation

Only when the LSP has been successfully signaled can the data start flowing inside the tunnel



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

RSVP Path messages use a label request attribute and await a label reply in the RSVP Resv message. Once the Resv message is received, a label mapping is created in the LIB which provides a POP, SWAP, or Push action. The terminology of ingress or egress label is used with respect to the data plane of the packet flow.

Once an LSP is established, the traffic through the path is defined by the label applied at the ingress node of the LSP. The set of packets that are assigned the same label value by a specific node are considered to belong to the same FEC which defines the RSVP flow.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

RSVP-TE: Strict versus Loose hops

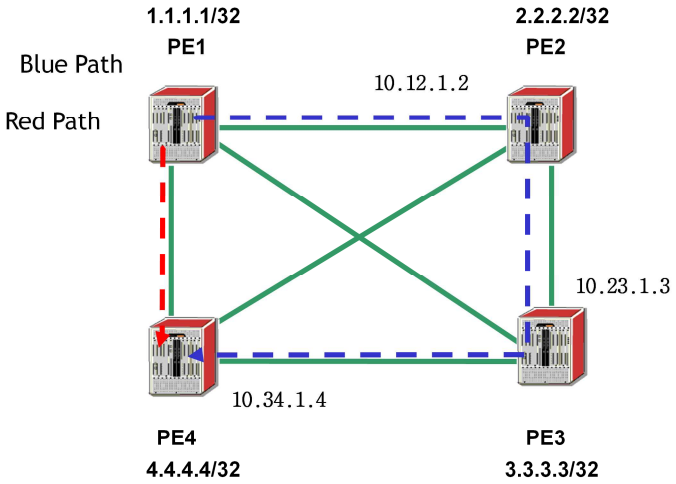
Example of strict and loose path

Blue path => ERO (Explicit Route Object) includes strict hops from end to end

- ERO: PE1 strict => PE2 strict => PE3 strict => PE4 strict

Red Path => ERO is empty or includes only PE4 as a loose hop

- ERO: PE4 loose



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A path can be defined to include some or all hops that must be part of an LSP. A **hop** that is included as **strict** has to be directly connected to the previous hop in the path, or to the iLER if it is the first one. A **hop** that is included as **loose** may or may not be directly connected to the previous hop in the path. Hops can be included in a path definition using the interface IP address or the system IP address. Interface addresses are preferred to avoid ambiguities.

A **totally loose path** is one that does not include any specific hops that have to be included in the path.

A **totally strict path** is one that includes every single hop from iLER to eLER

The following example displays path command usage:

PE1>**config>router#** mpls

```
config>router>mpls# path “toPE4_blue_strict”
config>router>mpls>path$ hop 1 10.12.1.2 strict
config>router>mpls>path# hop 2 10.23.1.3 strict
config>router>mpls>path# hop 3 10.34.1.4 strict
config>router>mpls>path# no shutdown
config>router>mpls>path# exit

config>router>mpls# path “toPE4_red_loose"
config>router>mpls>path# hop 1 4.4.4.4 loose
config>router>mpls>path# no shutdown
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Traffic Engineering implementation

When an LSP that requires to satisfy traffic engineering (TE) requirements is needed, the path is pre-calculated at the iLER before signaling it

To do that, a link-state routing protocol needs to be enabled to collect detailed topology information

For each link, a TE-enabled routing protocol (OSPF or IS-IS) will collect, in addition to the traditional metric, enough information to know:

- the amount of bandwidth still available for reservation on it
- a separate traffic-engineering metric value (can be different from the traditional one)
- the admin group (color) that the link belongs to
- the risk group that the link belongs to

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- When an LSP that requires to satisfy traffic engineering (TE) requirements is needed, the path is pre-calculated at the iLER before signaling it
- To do that, a link-state routing protocol needs to be enabled to collect detailed topology information
- For each link, a TE-enabled routing protocol (OSPF or IS-IS) will collect, in addition to the traditional metric, enough information to know:
  - the amount of bandwidth still available for reservation on it
  - a separate traffic-engineering metric value (can be different from the traditional one)
  - the admin group (color) that the link belongs to
  - the risk group that the link belongs to

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Traffic Engineering implementation (cont'd)

To pre-calculate a path that satisfies TE requirements, RSVP uses a method called CSPF:

Constrained-based Shortest Path First

CSPF has two phases:

- Creating a modified view of the network topology by removing from it those links that do not satisfy the TE requirements (e.g. not enough bandwidth, wrong color)
- Using SPF (Shortest-path First) to find the shortest path to destination using only the links left

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Traffic Engineering implementation (cont'd)

The link-state routing protocols with traffic-engineering extensions are respectively called **OSPF-TE** and **IS-IS-TE**

This functionality provides the capability to traffic-engineer LSPs based on the following constraints:

- Bandwidth requirements
- Link admin groups (include/exclude)
- Link risk groups (add/do not add redundancy)
- Hop-count limitations

To enable the traffic-engineering capabilities of OSPF and IS-IS:

```
config>router>ospf# traffic-engineering
config>router>isis# traffic-engineering
```



Link State Routing Protocols have traffic-engineering extensions, OSPF-TE and ISIS-TE.

These extensions enable the protocol to collect additional information about each link in the entire topology.

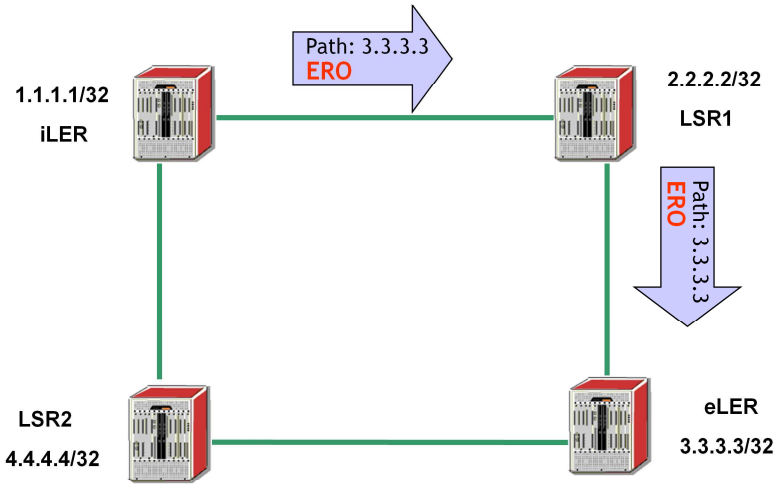
To enable the traffic-engineering capabilities of OSPF and IS-IS:

```
config>router>ospf# traffic-engineering
config>router>isis# traffic-engineering
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Traffic Engineering implementation (cont'd)

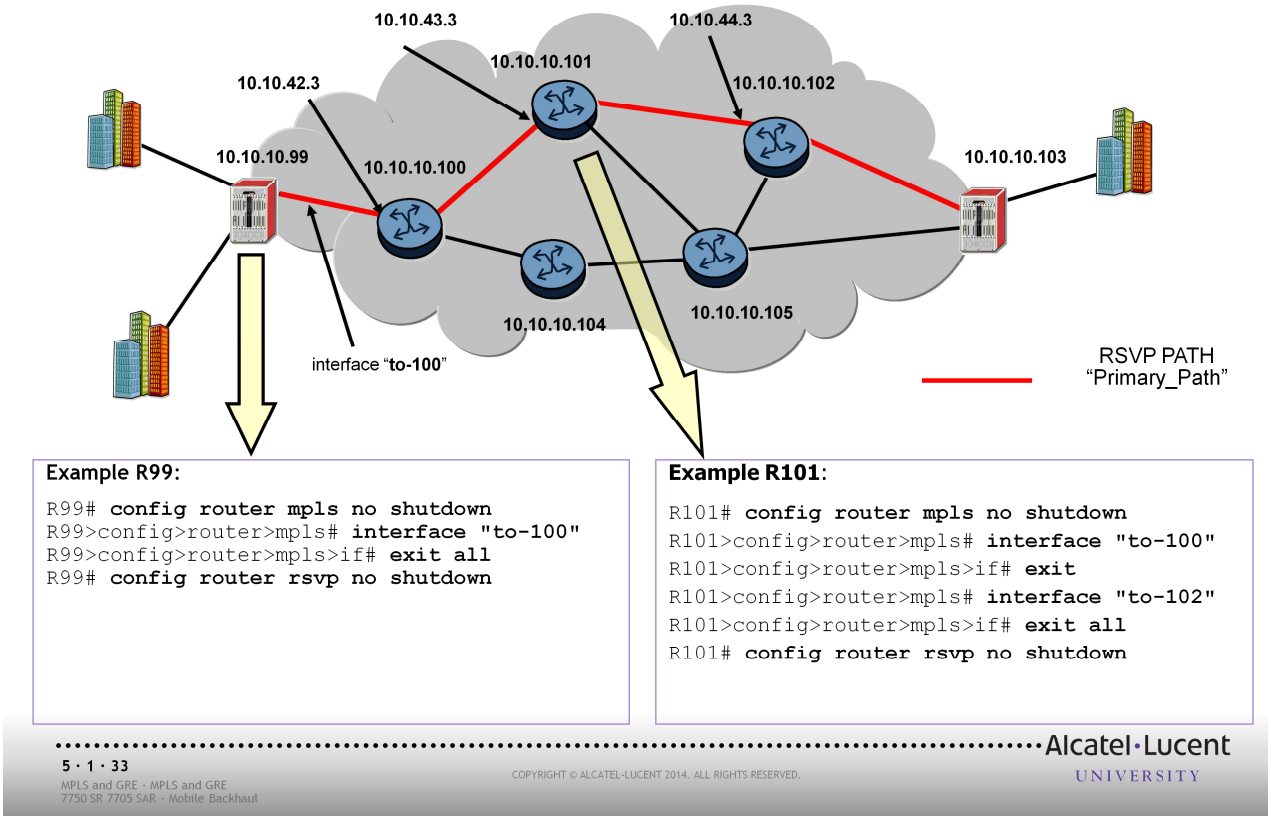
Once the path has been pre-calculated at the iLER, the LSP is signaled sending a Path message that includes the ERO (Explicit Route Object) describing all the hops that need to be included in the path



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

RSVP-TE: Preliminary Configuration



Example R99:

```
R99# config router mpls no shutdown
R99>config>router>mpls# interface "to-100"
R99>config>router>mpls>if# exit all
R99# config router rsvp no shutdown
```

Example R101:

```
R101# config router mpls no shutdown
R101>config>router>mpls# interface "to-100"
R101>config>router>mpls>if# exit
R101>config>router>mpls# interface "to-102"
R101>config>router>mpls>if# exit all
R101# config router rsvp no shutdown
```

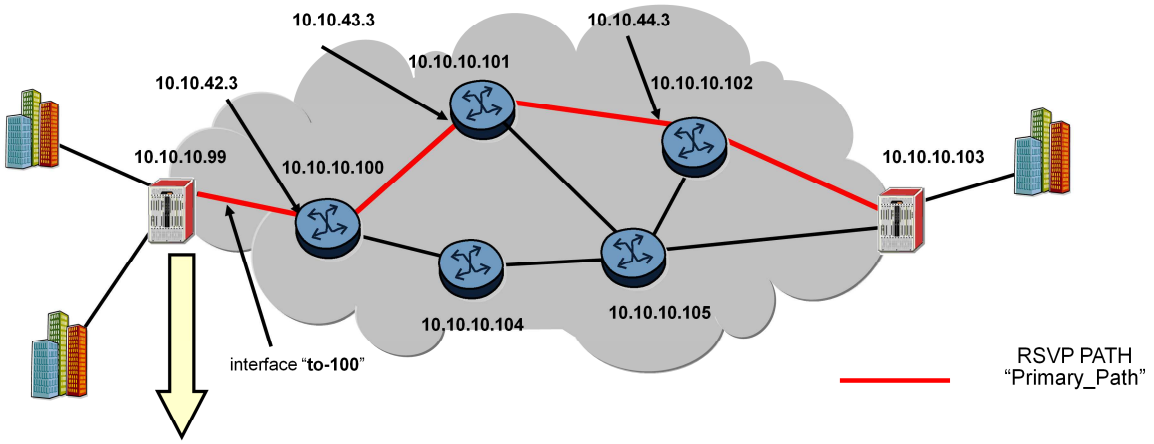

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The minimum set of steps needed to properly configure RSVP-TE to be ready to signal labels are:

- Enable the MPLS and RSVP-TE contexts (no shutdown)
- Add to the MPLS context those physical interfaces on which the router will "speak" RSVP-TE with other routers; interfaces will automatically be also added to the RSVP context
- The system interface will be added automatically to both the MPLS and RSVP contexts

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

RSVP-TE: LSP Configuration



Example R99:

```
R99>config>router# mpls
R99>config>router>mpls# path "Primary_Path"
R99>config>router>mpls>path$ hop 1 10.10.42.3 strict
R99>config>router>mpls>path$ hop 2 10.10.43.3 strict
R99>config>router>mpls>path# hop 3 10.10.44.3 strict
R99>config>router>mpls>path# hop 4 10.10.10.103 strict
R99>config>router>mpls>path# no shutdown
R99>config>router>mpls>path# exit
```

```
R99>config>router# mpls
R99>config>router>mpls# lsp "LSP_99_103"
R99>config>router>mpls>lsp# to 10.10.10.103
R99>config>router>mpls>lsp# cspf
R99>config>router>mpls>lsp# primary "Primary_Path"
R99>config>router>mpls>lsp>primary# hop-limit 5
R99>config>router>mpls>lsp>primary# bandwidth 256
R99>config>router>mpls>lsp>primary# include red
R99>config>router>mpls>lsp>primary# no shutdown
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

As shown above, the ERO is built up hop by hop in the "path" instance of the "mpls" context. After the creation of a certain path, the LSP can be created using this path as a primary or secondary path (see following slides). Other constraints can be configured such as a hop limit, or a bandwidth reservation. For these extra constraints to work properly, CSPF must be enabled on the LSP which enables RSVP to perform a constrained SPF calculation using the extended topology information collected by the TE-enabled IGP.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7 Generic Routing Encapsulation (GRE)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

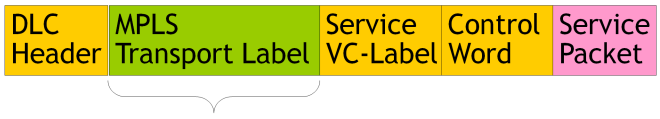
Generic Routing Encapsulation (GRE) Overview

GRE is one of the most common tunneling techniques implemented in the industry

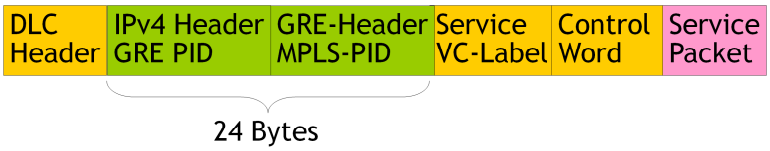
Like MPLS, it is a tunneling technology used to transport PW traffic directly over IP on SAR

- Used when there is a Layer-3 only network between the two endpoints of PWs i.e. no MPLS network available
- ATM, Ethernet and TDM PWs over GRE are supported

MPLS Packet Format



GRE Packet Format



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

GRE tunnels are designed to be completely stateless. This means that each tunnel end-point does not keep any information about the state or availability of the remote tunnel end-point. A consequence of this is that the local tunnel end-point router does not have the ability to bring the line protocol of the GRE tunnel interface down if the remote end-point is unreachable.

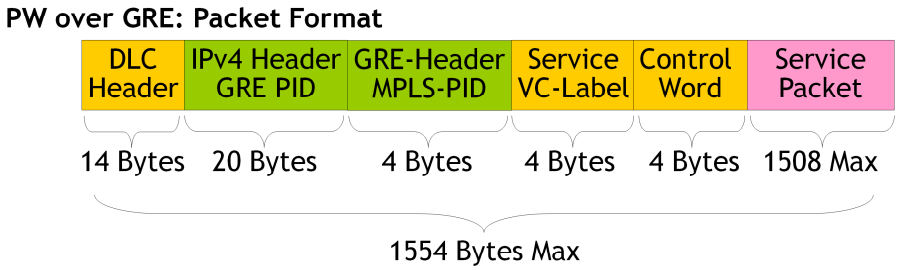
Normally, a GRE tunnel interface comes up as soon as it is configured and it stays up as long as there is a valid tunnel source address or interface which is up. The tunnel destination IP address must also be routable. This is true even if the other side of the tunnel has not been configured. This means that forwarding of packets via the GRE tunnel interface remains in effect even though the GRE tunnel packets do not reach the other end of the tunnel.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PseudoWires over GRE

At the 7705 SAR network egress, the source and destination addresses of the IP header are always set to the system IP address of the SAR and to the address of the far-end router

This setting ensures that any IP link between the SAR and SR can be used for transporting GRE/IP packets



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

GRE SDPs are supported on any Ethernet port on the Ethernet module

- The port is in Network mode

Ether-type is always set to IP (0x800)

- In case of mismatch, unexpected/illegal ether-type counter is incremented
- The only exception is ARP packets.

ARP over Ethernet is implemented on the 7705 SAR. Only one MAC address can be learned per interface and connection to a shared infrastructure (i.e. LAN) is not supported.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OAM, Failure Detection and Re-Route

VCCV type-1 is supported over GRE tunnels for OAM capabilities

BFD for static routes can be used to detect failures in the transport network

When a fault is detected:

- The GRE tunnel is brought down and an snmp message is sent to the 5620 SAM
- The 5620 SAM administrator can reconfigure the desired sap (i.e. HSDPA) to start using the ATM port facing the network

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Inband VCCV (Type 1) - PWE3 Control Word

PW Associated Channel Header:

```
    0               1               2               3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |0 0 0 1|Version|   Reserved    |       Channel Type            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The first nibble is set to 0001b to indicate a channel associated with a Pseudowire. The Version and the Reserved fields are set to 0, and the Channel Type is set to 0x0021 for IPv4 and 0x0057 for IPv6 payloads.

The example below shows how the Ethernet PW-ACH would be received containing an LSP Ping payload corresponding to a choice of CC Type of 0x01 and a CV Type of 0x02:

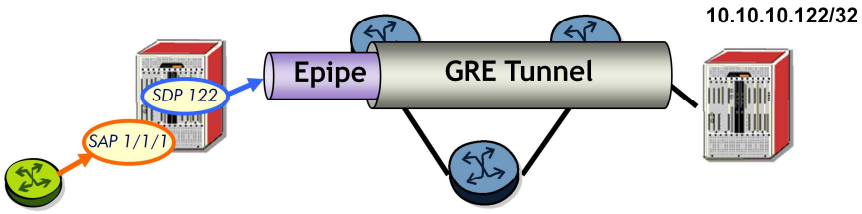
```
    0               1               2               3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |0 0 0 1|0 0 0 0|0 0 0 0 0 0 0 0|   0x21 (IPv4) or 0x57 (IPv6)  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

It should be noted that although some PW types are not required to carry the control word, this type of VCCV can only be used for those PW types that do employ the control word when it is in use. Further, this CC Type can only be used if the PW CW follows the "Generic PW MPLS Control Word" format. This is the mode of VCCV operation MUST be supported when the control word is present.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

GRE Configuration

```
Configure a GRE sdp to the far end
B:SAR-121# configure service sdp 122 gre create
B:SAR-121>config>service>sdp$ far-end 10.10.10.122
B:SAR-121>config>service>sdp$ no shutdown

Create an Epipe to be transported over the GRE tunnel
B:SAR-121# configure service epipe 10 customer 1 create
B:SAR-121>config>service>epipe# sap 1/1/1 create
B:SAR-121>config>service>epipe>sap# back
B:SAR-121>config>service>epipe# spoke-sdp 122:10 create
B:SAR-121>config>service>epipe>spoke-sdp# back
B:SAR-121>config>service>epipe# no shutdown
```



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

GRE Configuration

Display the configured SDP

```
B:SAR-121# show service sdp
===============================================================================
Services: Service Destination Points
===============================================================================
SdpId    Adm MTU   Opr MTU   IP address       Adm     Opr     Deliver   Signal
-------------------------------------------------------------------------------
122        0         1530    10.10.10.122     Up      Up      GRE       TLDP
```

Display the configured service

```
B:SAR-121# show service id 10 all
===============================================================================
Service Detailed Information
===============================================================================
Service Id        : 10
Service Type      : Epipe
Customer Id       : 1
 Admin State      : Up
      <... omitted ...>
Sdp Id 122:10  -(10.10.10.122)
SDP Id: 122:10                                    Type            : Spoke
VC Type: Ether                                    VC Tag          : n/a
Admin Path MTU: 0                                 Oper Path MTU   : 1530
Far End: 10.10.10.122                             Delivery        : GRE
     <... omitted ...>
```

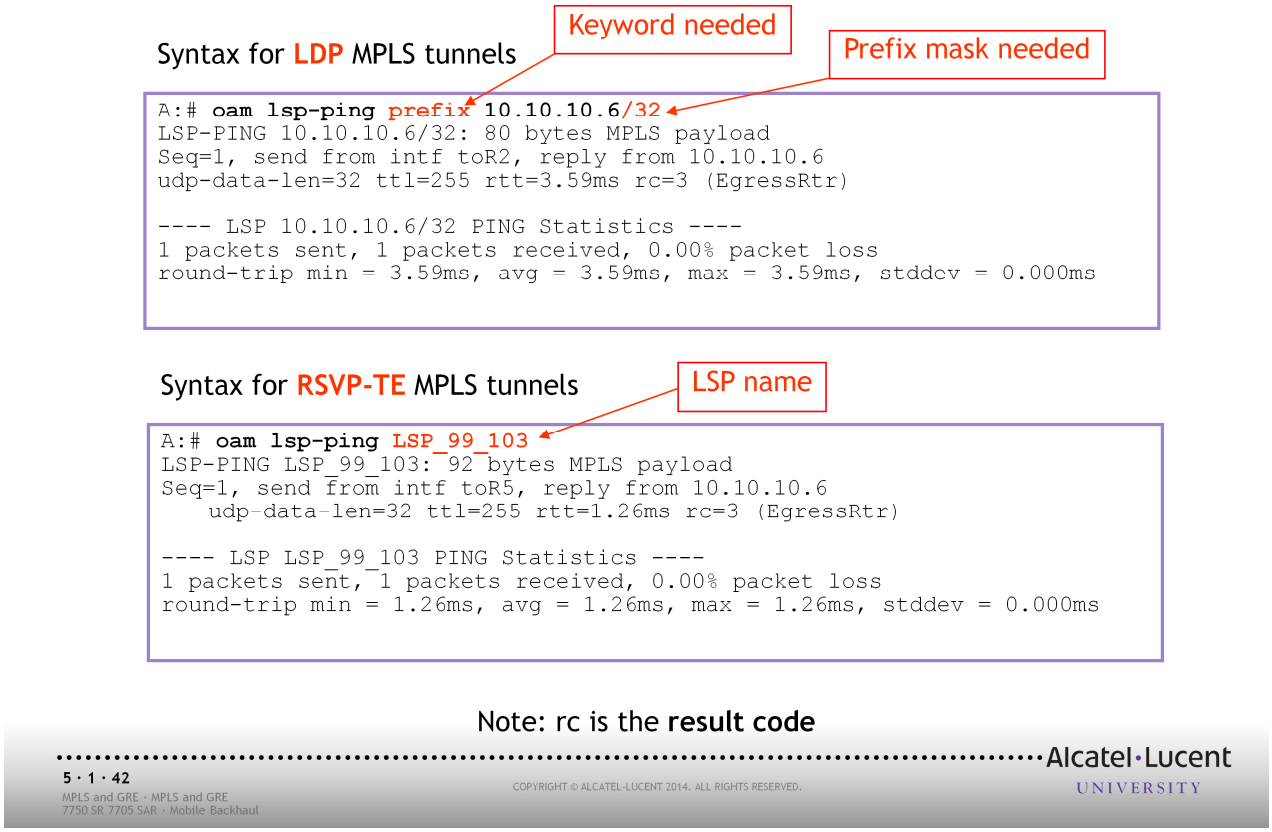

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

8 MPLS OAM tools

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OAM Tools: OAM LSP-ping



Alcatel-Lucent LSP diagnostics are implementations of LSP ping and LSP traceroute based on Internet Draft draft-ietf-mpls-lsp-ping-xx.txt.

LSP Ping

The lsp-ping command provides a mechanism to detect data plane failures in MPLS LSPs. For a given FEC, LSP ping verifies whether the packet reaches the egress LER.

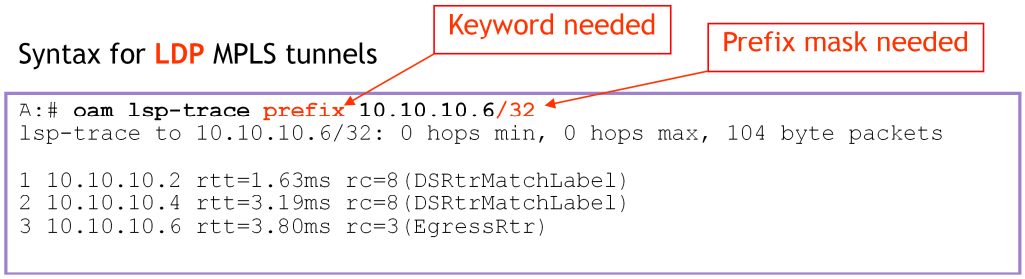
LSP Traceroute

The lsp-trace command performs an LSP traceroute using the protocol and data structures defined in the IETF draft (draft-ietf-mpls-lsp-ping-02.txt). The LSP traceroute operation is modeled after the IP traceroute utility which uses ICMP echo request and reply packets with increasing TTL values to determine the hop-by-hop route to a destination IP. In an LSP traceroute, the originating device creates an MPLS echo request packet for the LSP to be tested with increasing values of the TTL in the outermost label. The MPLS echo request packet is sent through the data plane and awaits a TTL exceeded response or the MPLS echo reply packet from the device terminating the LSP. The devices that reply to the MPLS echo request packets with the TTL exceeded and the MPLS echo reply are displayed.

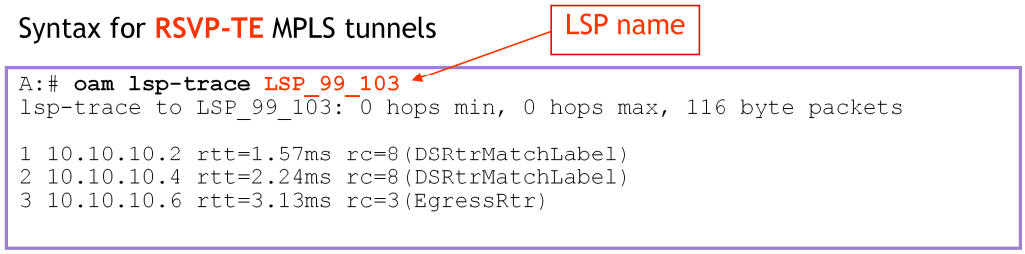
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

OAM Tools: OAM LSP-trace

Syntax for **LDP** MPLS tunnels



Syntax for **RSVP-TE** MPLS tunnels



Note: rc is the **result code**

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Alcatel-Lucent LSP diagnostics are implementations of LSP ping and LSP traceroute based on Internet Draft draft-ietf-mpls-lsp-ping-xx.txt.

LSP Ping

The lsp-ping command provides a mechanism to detect data plane failures in MPLS LSPs. For a given FEC, LSP ping verifies whether the packet reaches the egress LER.

LSP Traceroute

The lsp-trace command performs an LSP traceroute using the protocol and data structures defined in the IETF draft (draft-ietf-mpls-lsp-ping-02.txt). The LSP traceroute operation is modeled after the IP traceroute utility which uses ICMP echo request and reply packets with increasing TTL values to determine the hop-by-hop route to a destination IP. In an LSP traceroute, the originating device creates an MPLS echo request packet for the LSP to be tested with increasing values of the TTL in the outermost label. The MPLS echo request packet is sent through the data plane and awaits a TTL exceeded response or the MPLS echo reply packet from the device terminating the LSP. The devices that reply to the MPLS echo request packets with the TTL exceeded and the MPLS echo reply are displayed.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
MPLS and GRE

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 6
High Availability

Module 1
High Availability

TER36075_V3.1-SG-English-Ed1 Module 6.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives



Upon completion of this module, you should be able to understand resiliency and redundancy features available, including:

- Bi-directional Forwarding Detection (BFD)
- LAG and Multi-Chassis LAG (MC-LAG)
- Multi Link Point to Point Protocol (ML-PPP)
- Automatic Protection Switching (APS) to protect SONET/SDH lines
- 7705 SAR Fast Reroute
- Pseudowire redundancy
- Virtual Router Redundancy Protocol (VRRP)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — Bidirectional Forwarding Detection (BFD)	**6**
2 — Link Aggregation Group (LAG)	**12**
3 — Multi-Chassis LAG (MC-LAG)	**23**
4 — Multi Link Point to Point Protocol (ML-PPP)	**29**
5 — Automatic Protection Switching (APS)	**35**
6 — 7705 SAR Fast Re-Route (FRR)	**48**
7 — Pseudo-Wire Redundancy	**57**
8 — Virtual Router Redundancy Protocol (VRRP)	**83**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

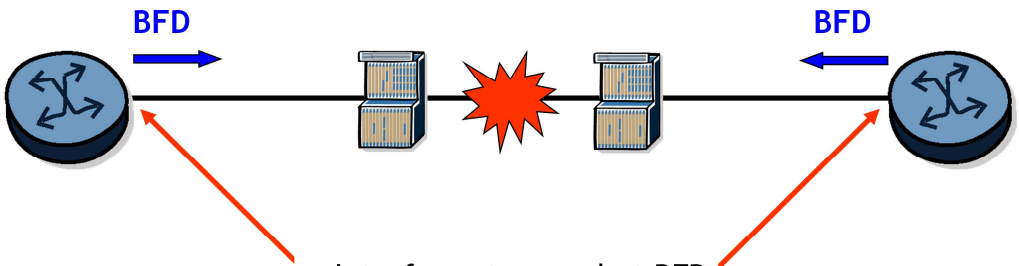
1 Bidirectional Forwarding Detection (BFD)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Bidirectional Forwarding Detection (BFD)

BFD sends control messages periodically to the far end

- Supplements discovery and keep-alive mechanisms of other protocols
- Lightweight messages, can be sent more frequently
- Failure to receive messages in the configured time interval causes the far-end node to be declared down
- Increases convergence rate: sub-second detection of path failures



Interface stays up but BFD detects a failure much faster than the routing protocol

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Bidirectional Forwarding Detection (BFD) is a HA feature that speeds up convergence time when a link, a node, or a protocol fails by rapidly detecting the failure. If, for example, a fiber link fails between two Add Drop Multiplexers (ADM) and the interface isn't aware of the failure, it is up to the routing protocol to discover the failure. This can be longer than is desirable.

BFD is an IETF feature designed to improve this detection time. It is a lightweight, low-overhead protocol that creates sessions between the routing protocol instances of two adjacent routers and sends very small packets back and forth to evaluate the condition of the link. If something should go wrong, BFD will detect this in a sub-second time interval and update the routing protocol it works for. BFD is implemented in the control plane of routers and other systems. A network failure detected by BFD can be corrected by the forwarding plane (for instance, in MPLS fast reroute), or by the control plane (for example, when BFD is used to speed up the operation of routing protocols).

BFD can detect failures at many different layers, and can therefore be employed to monitor the validity of Ethernet networks, MPLS Label Switched Paths (LSPs), Generic Routing Encapsulation (GRE), or virtually any other type of transport.

The time between BFD messages is 100 - 100000 ms (timer granularity: 100ms). A separate BFD session is created for each routing protocol. BFD on the 7750 currently supports OSPF, IS-IS, PIM and static routes.

In Release 9.0, BFD support has been extended to support IPv6-based BFD sessions for certain protocols including static IPv6 routes, OSPFv3, IS-IS, BGP and IPv6 VRRP interfaces.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Commands to configure BFD on an interface

Configure BFD on the interface (has to be done first, on both ends)

```
configure router interface <interface-id>
  bfd <tx-interval> [receive <rx-interval>] [multiplier <multiplier>]
```

- The minimum interval between messages (tx-interval/rx-interval) is 100 ms
- The multiplier can have values from 3 to 20

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Commands to enable BFD for different protocols

Enable BFD for a static route

```
configure router static-route <ip-prefix> next-hop <interface-ip> bfd-enable
```

Enable BFD for OSPF

```
configure router ospf area <area-id> interface <interface-name> bfd-enable
```

Enable BFD for IS-IS

```
configure router isis interface <interface-name> bfd-enable {ipv4 | ipv6}
```

Enable BFD for MPLS

```
configure router ldp interface-parameters interface <interface-name> bfd-enable
configure router rsvp interface <interface-name> bfd-enable
```

Enable BFD for VRRP

```
configure router interface <interface-name> vrrp bfd-enable interface
    <interface-name> dst-ip <ip-address>
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Commands to display BFD sessions

Display BFD configuration for a given interface

show router bfd interface [<interface-id>]

Display BFD sessions

show router bfd session [src <ip-addr> [dest <ip-addr>] | [detail]]

```
PE1# show router bfd interface "TO_R2"

===============================================================================
BFD Interface
===============================================================================
Interface name                    Tx Interval    Rx Interval    Multiplier
-------------------------------------------------------------------------------
TO_R2                             100            100            3
-------------------------------------------------------------------------------
No. of BFD Interfaces: 1
===============================================================================

PE1# show router bfd session

-------------------------------------------------------------------------------
BFD Session
===============================================================================
Interface                     State                Tx Intvl  Rx Intvl  Multipl
  Remote Address              Protocols            Tx Pkts   Rx Pkts   Type
-------------------------------------------------------------------------------
TO_R2                         Up (3)               100       100       3
   140.10.0.114               isis, ldp            377       44        iom
-------------------------------------------------------------------------------
No. of BFD sessions: 1
===============================================================================
```

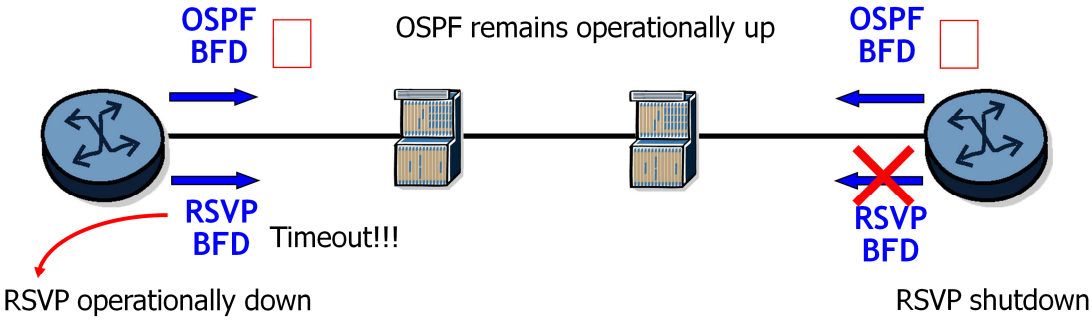

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Bidirectional Forwarding Detection (BFD)

A separate BFD session is created for each protocol in use between two systems

Even if interface remains operational, if something fails for a specific protocol (e.g. protocol is shut down on far end), BFD messages stop being received and local protocol instance is notified



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Link Aggregation Group (LAG)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LAG Overview

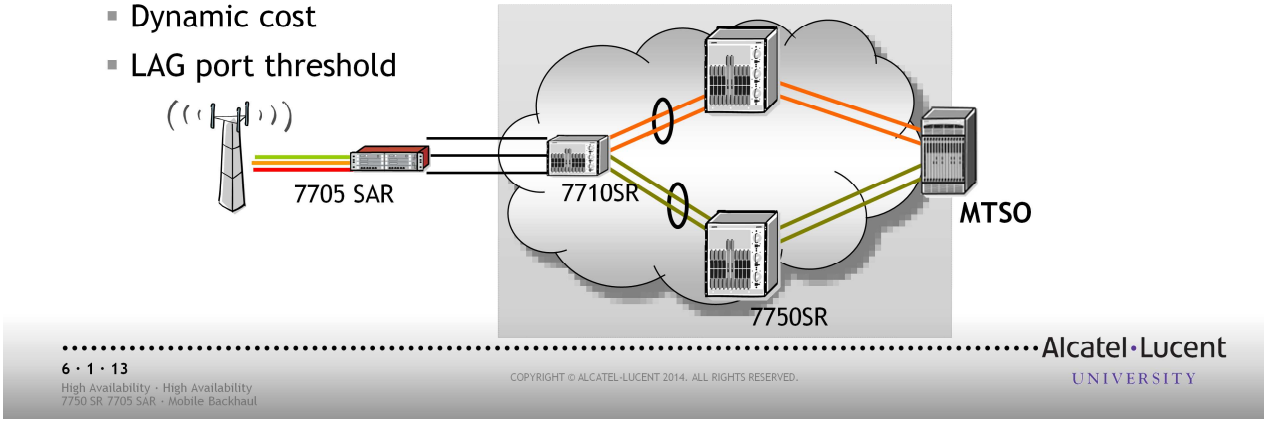
Link Aggregation Groups (LAG) combine multiple ports together to form a single logical link

LAGs allow for:

- Redundancy if one or more links in the LAG should fail
- Increased perceived bandwidth as demand grows without upgrading hardware (load is shared by different flows across ports in the LAG, based on hashing)

Alcatel-Lucent enhanced LAG features:

- Dynamic cost
- LAG port threshold



Link Aggregation Group:

- Aggregates up to 8 Ethernet ports in one LAG
- LAG forms one logical link

Lags are used for:

- Bandwidth increase
- Redundancy

LAGs are Static or signaled via LACP

Auto-negotiation must be disabled or set to limited mode for ports that are part of a LAG to guarantee that all ports share the same speed

All packets that belong to the same flow (e.g. same source and destination IP addresses) use the same physical port to maintain packet sequencing. That is accomplished by the hashing algorithm used to select the port to be used.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LAG Basic Configuration

When configuring a LAG:

- disable auto-negotiation or set it to *limited* for ports to be included in a LAG include at least two and at most sixteen ports per LAG
- all ports must share the same characteristics (speed, duplex, hold-timer, etc)

```
configure port 1/1/[1..2]
config>port# shutdown
config>port# ethernet no autonegotiate
config>port# no shutdown
config>port# exit all

configure port 2/1/[1..2]
config>port# shutdown
config>port# ethernet autonegotiate limited
config>port# no shutdown
...
```

Both options are equally acceptable

```
configure lag 1
config>lag# description "LAG1"
config>lag# port 1/1/1 1/1/2 2/1/1 2/1/2
config>lag# no shutdown
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

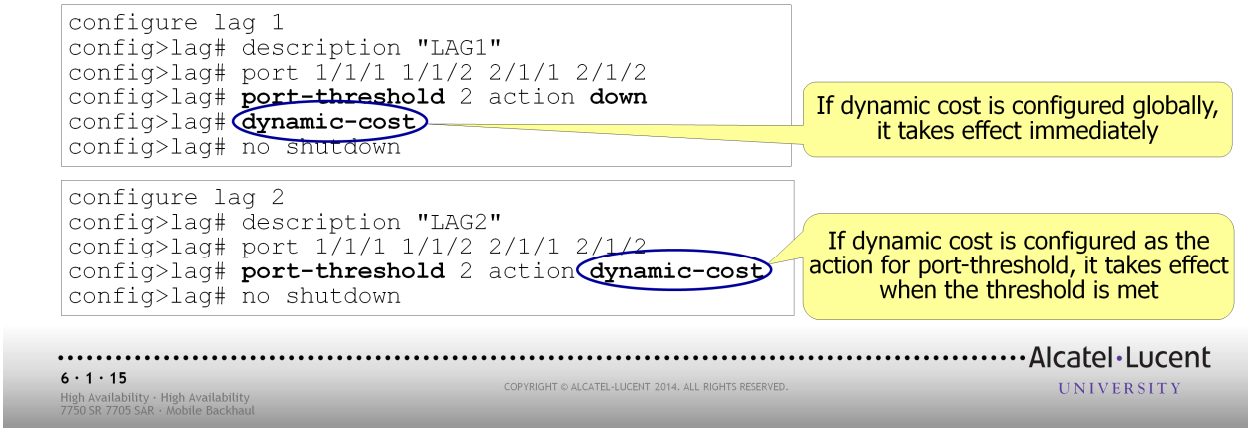
LAG Additional configuration parameters

Dynamic cost

- Link metric is calculated based on the aggregate bandwidth of **operational ports**
- If not enabled, link metric is calculated based on the aggregate bandwidth of **all configured ports**, regardless of operational status

Port threshold

- If the number of operational ports goes down to the configured threshold or below, an action is executed
- The action can be to turn down the lag or to start advertising a dynamic cost



- **Dynamic cost**
  - The link metric used by OSPF (and IS-IS if reference bandwidth is configured) is calculated based on the aggregate link bandwidth of **operational ports**
  - If not enabled, the link metric is calculated based on the aggregate link bandwidth of **all configured ports**, regardless of operational status
- **Port threshold**
  - If the number of operational ports goes down to the configured threshold, the action is executed
  - The action can be to turn down the lag or to start advertising a dynamic cost

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LAG Verification

```
*A:PE1# show lag 1 detail

===============================================================================
LAG Details
===============================================================================
Description:

-------------------------------------------------------------------------------
Details
-------------------------------------------------------------------------------
Lag-id              : 1                     Mode                : access
Adm                 : up                    Opr                 : up
Thres. Exceeded Cnt : 2                     Port Threshold      : 2
Thres. Last Cleared : 01/26/2007 23:35:18   Threshold Action    : down
Dynamic Cost        : true                  Encap Type          : null
Configured Address  : 1e:2f:ff:00:01:42     Lag-IfIndex         : 1342177282
Hardware Address    : 1e:2f:ff:00:01:42     Adapt Qos           : distribute
Hold-time Down      : 0.0 sec
LACP                : disabled

-------------------------------------------------------------------------------
Port-id         Adm    Act/Stdby Opr    Primary   Sub-group     Forced   Prio
-------------------------------------------------------------------------------
1/1/1           up     active    up     yes       1             -        32768
1/1/2           up     active    up               1             -        32768
2/1/1           up     active    up               1             -        32768
2/1/2           up     active    up               1             -        32768
===============================================================================
*A:PE1#
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The command “show lag x detail” displays some useful info:

- Adm/Opr status
- Port Threshold: minimum number of ports that should be up/up
- Threshold action: the action taken when port threshold is met (default = down)
- Dynamic cost: whether a metric depending on the number of operational ports is advertised (default disabled)
- Configured/Hardware Address: Mac Address that is used by the LAG interface. By default first 3 bytes of the MAC address are taken from the system MAC.
- Hold-time down, used for dampening (default 0): This command specifies the timer, in tenths of seconds, which controls the delay between detecting that a LAG is down and reporting it to the higher levels.
- Adapt QoS: by default ‘distribute’
  - link — Specifies that the LAG will create the SAP queues and virtual schedulers with the actual parameters on each MDA.
  - distribute — Specifies that each MDA will receive a fraction of the SAP and scheduler parameters.
- LACP: by default disabled. Enabling LACP will cause the ‘show lag x detail’ to display more info
- Primary: all ports in the LAG will follow the port settings of this link
- Priority: (default 32768) the Priority is used in the election of the preferred link and the active/standby

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Link Aggregation Control Protocol (LACP)

By default, for a given LAG :

- the set of member ports is configured statically
- traffic is load-balanced across all non-failing member ports

This is not flexible enough if we need to choose which ports should be **active** and which should be in **stand-by**

- For example, it may be desirable to allow ports on a given IOM to be active and to keep ports on other IOMs in stand-by (e.g. to enforce QoS policies)

LACP allows active lag-member selection based on particular criteria

Based on the IEEE 802.3ax standard

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

LAGs membership can be statically configured. The 7750 SR also supports LACP so that link membership in a group can be negotiated dynamically. Using LACP links can be dynamically added and deleted from a link group. The endpoints of the links are monitored to ensure that both ends are connected to the appropriate group. The optional marker protocol described in IEEE 802.3ad is not implemented.

Under normal LAG operation, all non-failing links in a given LAG will become active and traffic is load-balanced across all active links.

In some circumstances, however, this is not the desired behavior. For example, enforcing QoS policies across links attached to different IOMs is not possible and therefore it is desirable that traffic always flows through a single IOM. This can be achieved by selecting only links of a single IOM as active LAG members and keeping all other LAG members in stand-by condition.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Link Aggregation Control Protocol (Continued)

LACP allows routers to talk and agree on which member ports will be active

LAG members can be assigned to **sub-groups**

Only members of a single sub-group are selected as active links

Active links can be selected based on the following criteria:

- Choose the sub-group with the **highest number** of eligible links, or
- Choose the sub-group with the **highest aggregate weight** of all eligible members

Note: "weight" is related to the priority of the ports, selected when each port is added to the LAG

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

"Weight" is related to the priority of the ports in the LAG, selected when a port is added to the LAG:

```
configure lag 5
config>lag# port 1/1/1 priority 100 sub-group 1
```

The lower the priority, the more preferred the port is.

Choosing the “highest aggregate weight" actually refers to adding the priorities of ports within a sub-group and selecting the smallest value.

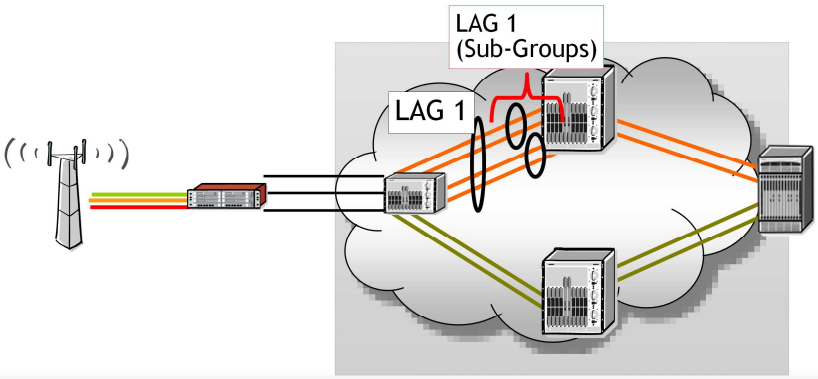
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LACP: Sub-Groups

Maximum 8 sub-groups in each LAG

For each port, its sub-group can be selected:

- **explicitly**, by configuring a value from 1 through 8
- **automatically**, by configuring auto-mda/auto-iom: all ports of the same MDA/IOM are assigned to the same subgroup



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

By default LAG ports belong to sub-group 1. Sub-groups should only be configured on one side of a LAG for consistent selection.

Note that sub-groups, even if configured, have no effect on static LAGs (when LACP is not enabled): all subgroups are active.

If the selection criteria chosen is highest-count and the sub-groups are configured with the same number of links, the sub-group with the highest aggregate weight will become active. If there is still a tie, the subgroup that contains the link with the lowest priority value will become active. At that point, the tie is broken by the lowest port ID.

If multiple groups satisfy the selection criteria, the sub-group being currently active remains active.

Each time the configuration changes or the status of any link in a lag changes, the selection algorithm is re-run.

Selection-criteria:

'highest-count' (default): highest number of eligible members. If same # members -> highest weight

'highest-weight': highest weight (65535 – priority)

Optional parameter: 'slave-to-partner': considers configured selection-criteria + members should be operationally up for use by the remote side, i.e. partner sync bit

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LACP – Modes of operation

LACP supports two modes of operation:

- **Active**: The system issues LACP packets on the member ports to initiate LACP exchange with another connected system
- **Passive**: The system does not initiate the LACP exchange, but replies to received LACP packets

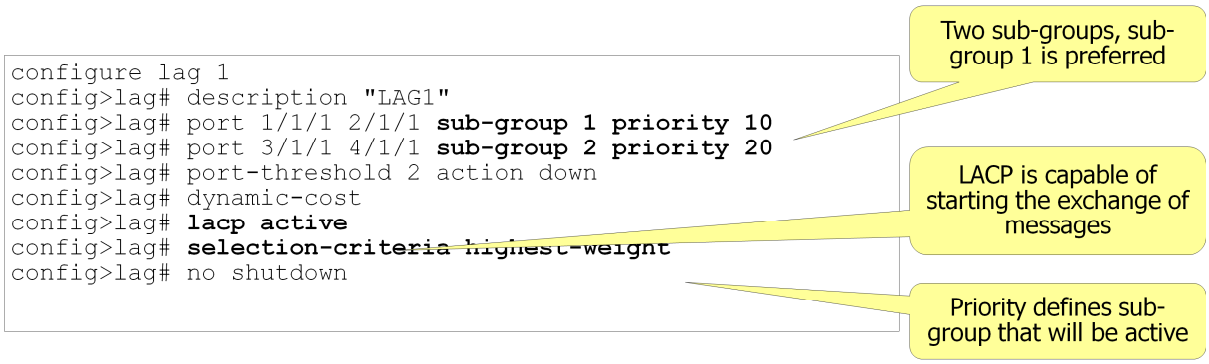
An active LACP interface may participate in exchanges with either a passive or active interface on the far end

A passive LACP interface may only participate in exchanges with an active interface on the far end

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LACP – Example



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

LACP verification

```
*A:PE2# show lag 1 detail

Details
-------------------------------------------------------------------------------
Lag-id              : 1                     Mode                : access
Adm                 : up                    Opr                 : up
Thres. Exceeded Cnt : 6                     Port Threshold      : 2
Thres. Last Cleared : 02/01/2007 21:45:16   Threshold Action    : down
Dynamic Cost        : true                  Encap Type          : null
Configured Address  : 1e:2f:ff:00:01:42     Lag-IfIndex         : 1342177282
Hardware Address    : 1e:2f:ff:00:01:42     Adapt Qos           : distribute
Hold-time Down      : 0.0 sec
LACP                : enabled               Mode                : active
LACP Transmit Intvl : fast                  LACP xmit stdby     : enabled
Selection Criteria  : highest-weight        Slave-to-partner    : disabled
Number of sub-groups: 2                     Forced              : -
System Id           : 1e:2f:ff:00:00:00     System Priority     : 32768
Admin Key           : 32768                 Oper Key            : 32768
Prtr System Id      : 1e:2d:ff:00:00:00     Prtr System Priority : 32768
Prtr Oper Key       : 32768
-------------------------------------------------------------------------------
Port-id         Adm    Act/Stdby Opr    Primary   Sub-group     Forced   Prio
-------------------------------------------------------------------------------
1/1/1           up     active    up     yes       1             -        32768
1/1/2           up     active    up               1             -        32768
2/1/1           up     active    up               2             -        32768
2/1/2           up     active    up               2             -        32768
-------------------------------------------------------------------------------
Port-id         Role       Exp   Def   Dist  Col   Syn   Aggr  Timeout  Activity
-------------------------------------------------------------------------------
1/1/1           actor      No    No    Yes   Yes   Yes   Yes   Yes      No
1/1/1           partner    No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/2           actor      No    No    Yes   Yes   Yes   Yes   Yes      No
1/1/2           partner    No    No    Yes   Yes   Yes   Yes   Yes      Yes
...
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

configure [no] lag lag-id

[no] lacp [mode] [administrative-key admin-key]

[no] lacp-xmit-interval {slow | fast}

[no] lacp-xmit-stdby

[no] selection-criteria [highest-count | highest-weight] [slave-to-partner]

exit

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 Multi-Chassis LAG (MC-LAG)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Multi-Chassis LAG

MC-LAG extends the concept of LAG sub-groups

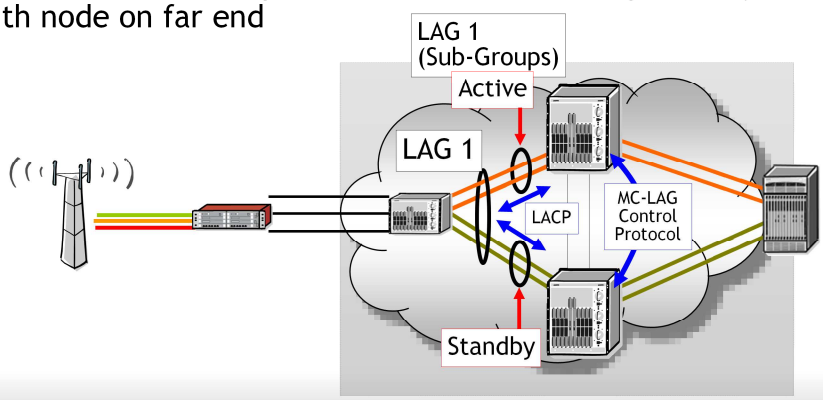
- One end of the LAG is split between two systems

Adds **node redundancy** since connectivity is maintained even on complete failure of a single system

LACP is used to manage the LAG links in **active** and **standby** states such that only links from one node are active at a time

Additional **MC-LAG control protocol** runs between the redundant nodes

- Protocol that allows peer nodes to act as a single entity when communicating with node on far end



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- The LAG between the 7710 and the redundant 7750s in the example is controlled using the Link Aggregation Control Protocol (LACP). LACP is used to manage the available LAG links into active and standby states such that only links from one PE node are active at a time to and from the Ethernet edge device.
- MC-LAG control protocol runs between the redundant pair of PEs. This is an IP-based protocol that synchronizes the LAG state between the MC-LAG peer nodes and allows them to act as a single entity when communicating with the node on the far end.

- MC-LAG Provides access link and PE node level redundancy to the access node:
- Redundancy to max 2 PE routers
- Redundant PE routers appear as 1 and same LACP partner -> can interop with any access node that supports LACP
- Configuration and states signaled between redundant PE routers via proprietary protocol. Protocol is routed and uses UDP port 1025
- PE router can have max 4 MC peers, corresponding to different MC-LAGs
- Max 200 LAGs on SR/ESS 7/12, Max 64 LAGs on SR/ESS1 and SR
- LAG on access + Ethernet MDA only

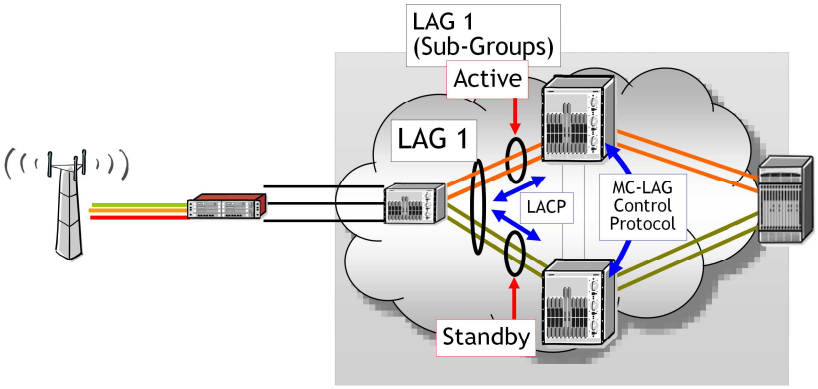
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Inter-Chassis LAG Control Protocol

The Inter-Chassis LAG Control Protocol verifies configuration on both chassis

- **lacp-key**, **system-id**, **system-priority**, and **sub-group selection criteria** must be the same
- Signals active/standby selection - all active links must be on the same chassis
- Signals link failure and detects node failures

A heartbeat mechanism is used to detect node failures



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

In steady state, one LAG subgroup connected to one PE is set to active, and one is set to standby. This choice is by configuration or based on administrative parameters such as weight or the subgroup containing the most links that are currently up. MC-LAG uses a LAG mode where all Ethernet traffic uses the active subgroup, while no traffic is forwarded on a standby subgroup. A failure of the active subgroup is detected using, for example, keepalive messages in LACP, and causes the MC-LAG protocol to switch to the standby PE and the standby subgroup. This state change is reflected in LACP, which forces the Ethernet device to switch the active subgroup.

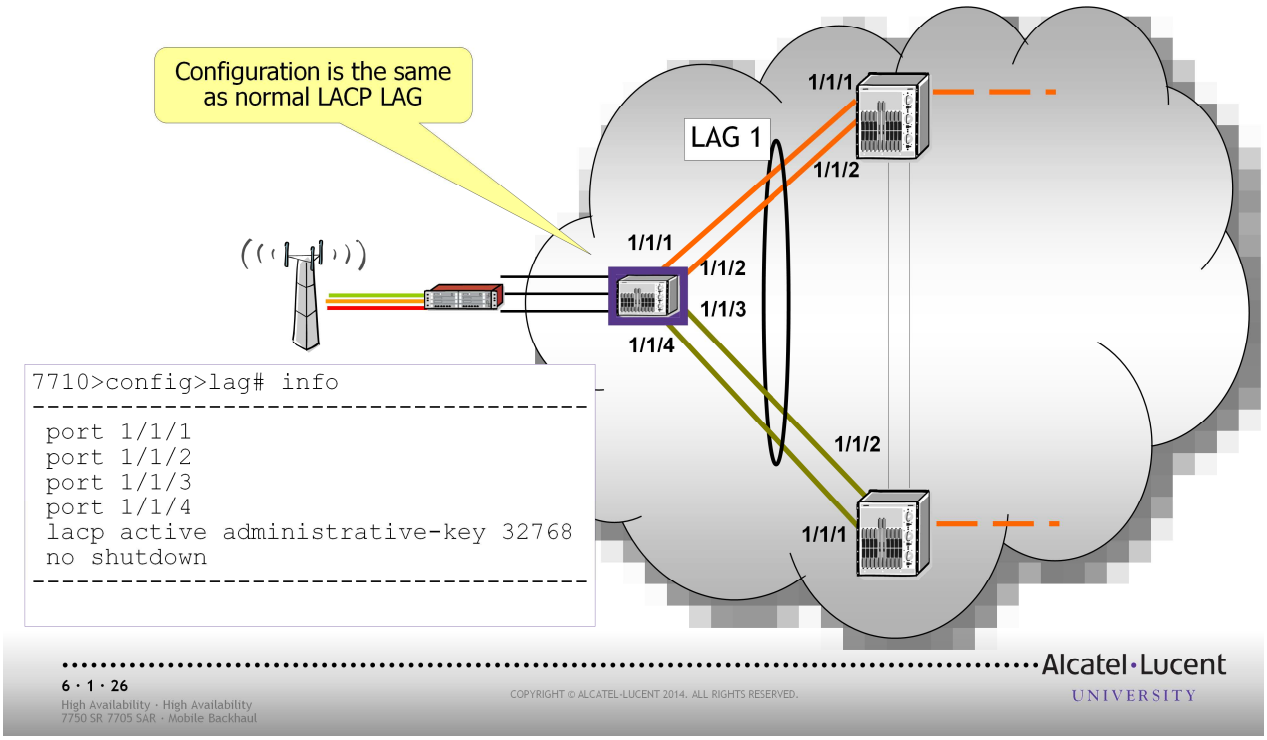
Keep-alive-interval (5-500 deci-seconds) and hold-on-neighbor (2-25)

```
7750>config>redundancy>mc>peer>mc-lag# info detail
   ----------------------------------------------
           hold-on-neighbor-failure 3
           keep-alive-interval 10
           lag 1 lacp-key 1 system-id 00:00:00:00:00:01 remote-lag 1 system-priority 100
           no shutdown
   ----------------------------------------------

7750# show redundancy multi-chassis mc-lag peer 10.0.0.2
   ===============================================================================
   Multi-Chassis MC-Lag Peer 10.0.0.2
   ===============================================================================
   Last Changed    : 11/18/2008 23:04:25
   Admin State     : Up                  Oper State           : Up
   KeepAlive       : 10 deci-seconds     Hold On Ngbr Failure : 3
   -------------------------------------------------------------------------------
   Lag Id Lacp Key Remote Lag Id System Id          Sys Prio Last Changed
   -------------------------------------------------------------------------------
   1      1        1             00:00:00:00:00:01  100      03/18/2007 23:04:25
   -------------------------------------------------------------------------------
   Number of LAGs : 1
   ===============================================================================
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MC-LAG Configuration: Access node

Access node is unaware about MC-LAG

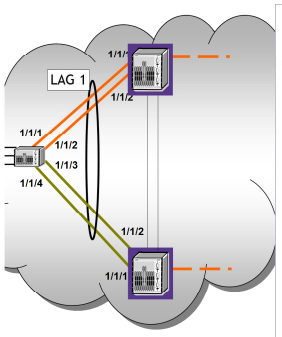


Example of what the 7710 LAG will look like once the two 7750 PE's are configured:

```
7710# show lag 1 detail
...
LACP                : enabled              Mode                : active
LACP Transmit Intvl : fast                 LACP xmit stdby     : enabled
Selection Criteria  : highest-count        Slave-to-partner    : disabled
Number of sub-groups: 1                    Forced              : -
System Id           : 1e:2e:ff:00:00:00    System Priority     : 32768
Admin Key           : 32768                Oper Key            : 32768
Prtr System Id      : 00:00:00:00:00:01    Prtr System Priority : 100
Prtr Oper Key       : 1
--------------------------------------------------------------------------------
Port-id        Adm    Act/Stdby Opr    Primary   Sub-group     Forced   Prio
--------------------------------------------------------------------------------
1/1/1          up     active    up     yes       1             -        32768
1/1/2          up     active    up               1             -        32768
1/1/3          up     active    down             1             -        32768
1/1/4          up     active    down             1             -        32768
--------------------------------------------------------------------------------
Port-id        Role      Exp   Def   Dist  Col   Syn   Aggr  Timeout  Activity
--------------------------------------------------------------------------------
1/1/1          actor     No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/1          partner   No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/2          actor     No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/2          partner   No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/3          actor     No    No    No    No    Yes   Yes   Yes      Yes
1/1/3          partner   No    No    No    No    No    Yes   Yes      Yes
1/1/4          actor     No    No    No    No    Yes   Yes   Yes      Yes
1/1/4          partner   No    No    No    No    No    Yes   Yes      Yes
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MC-LAG configuration: Redundant PE nodes




```
PE1>configure lag 1
PE1>config>lag# info
----------------------------------------------
   port 1/1/1
   port 1/1/2
   lacp active administrative-key 32768
   no shutdown
----------------------------------------------
PE1>config>redundancy>multi-chassis# info
----------------------------------------------
   peer 10.0.0.2 create
      mc-lag
          lag 1 lacp-key 1 system-id 00:00:00:00:00:01 system-priority 100
          no shutdown
      exit
   exit
----------------------------------------------
```

LAG configuration is also the same as normal LACP LAG

Additional configuration needed to identify multi-chassis peer for LAG 1

```
PE2>configure lag 1
PE2>config>lag# info
----------------------------------------------
   port 1/1/1
   port 1/1/2
   lacp active administrative-key 32768
   no shutdown
----------------------------------------------
PE2>config>redundancy>multi-chassis# info
----------------------------------------------
   peer 10.0.0.1 create
       mc-lag
          lag 1 lacp-key 1 system-id 00:00:00:00:00:01 system-priority 100
          no shutdown
       exit
   exit
----------------------------------------------
```

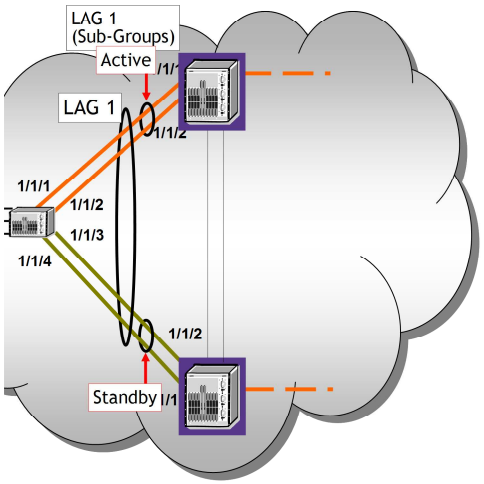
These values must match!

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.


```
PE1>config>redundancy>multi-chassis# show lag 1 detail
...
MC Peer Address     : 10.0.0.2              MC Peer Lag-id       : 1
MC System Id        : 00:00:00:00:00:01     MC System Priority   : 100
MC Admin Key        : 1                     MC Active/Standby    : active
MC Lacp ID in use   : true                  MC extended timeout  : false
MC Selection Logic  : peer decided
-------------------------------------------------------------------------------
Port-id        Adm    Act/Stdby Opr    Primary   Sub-group     Forced   Prio
-------------------------------------------------------------------------------
1/1/1          up     active    up     yes       1             -        32768
1/1/2          up     active    up               1             -        32768
-------------------------------------------------------------------------------
Port-id        Role      Exp   Def   Dist  Col   Syn   Aggr  Timeout  Activity
-------------------------------------------------------------------------------
1/1/1          actor     No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/1          partner   No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/2          actor     No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/2          partner   No    No    Yes   Yes   Yes   Yes   Yes      Yes
===============================================================================
PE2# show lag 1 detail
...
MC Peer Address     : 10.0.0.1              MC Peer Lag-id       : 1
MC System Id        : 00:00:00:00:00:01     MC System Priority   : 100
MC Admin Key        : 1                     MC Active/Standby    : standby
MC Lacp ID in use   : true                  MC extended timeout  : false
MC Selection Logic  : local master decided
-------------------------------------------------------------------------------
Port-id        Adm    Act/Stdby Opr    Primary   Sub-group     Forced   Prio
-------------------------------------------------------------------------------
1/1/1          up     standby   down   yes       1             -        32768
1/1/2          up     standby   down             1             -        32768
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MC-LAG configuration: MC configuration verification




```
PE1# show lag 1 detail
...
MC Peer Address     : 10.0.0.2              MC Peer
    Lag-id        : 1
MC System Id        : 00:00:00:00:00:01     MC System
    Priority    : 100
MC Admin Key        : 1                     MC
    Active/Standby    : active
MC Lacp ID in use   : true                  MC extended
    timeout   : false
MC Selection Logic  : peer decided
-------------------------------------------------------
    -------------------
Port-id         Adm    Act/Stdby Opr    Primary  Sub-
    group  Forced   Prio
-------------------------------------------------------
    -------------------
1/1/1           up     active    up     yes       1
    -         32768
1/1/2           up     active    up               1
    -         32768
```

```
PE2# show lag 1 detail
...
MC Peer Address     : 10.0.0.1              MC Peer Lag-id
    : 1
MC System Id        : 00:00:00:00:00:01     MC System Priority
    : 100
MC Admin Key        : 1                     MC Active/Standby
    : standby
MC Lacp ID in use   : true                  MC extended timeout
    : false
MC Selection Logic  : local master decided
-------------------------------------------------------------
    -----------
Port-id         Adm    Act/Stdby Opr    Primary  Sub-group
    Forced   Prio
-------------------------------------------------------------
    -----------
1/1/1           up     standby   down   yes       1          -
    32768
1/1/2           up     standby   down             1          -
    32768
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.


```
PE1>config>redundancy>multi-chassis# show lag 1 detail
...
MC Peer Address     : 10.0.0.2              MC Peer Lag-id       : 1
MC System Id        : 00:00:00:00:00:01     MC System Priority   : 100
MC Admin Key        : 1                     MC Active/Standby    : active
MC Lacp ID in use   : true                  MC extended timeout  : false
MC Selection Logic  : peer decided
-------------------------------------------------------------------------------
Port-id         Adm    Act/Stdby Opr    Primary   Sub-group     Forced   Prio
-------------------------------------------------------------------------------
1/1/1           up     active    up     yes       1             -        32768
1/1/2           up     active    up               1             -        32768
-------------------------------------------------------------------------------
Port-id         Role      Exp   Def   Dist  Col   Syn   Aggr  Timeout  Activity
-------------------------------------------------------------------------------
1/1/1           actor     No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/1           partner   No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/2           actor     No    No    Yes   Yes   Yes   Yes   Yes      Yes
1/1/2           partner   No    No    Yes   Yes   Yes   Yes   Yes      Yes
===============================================================================
PE2# show lag 1 detail
...
MC Peer Address     : 10.0.0.1              MC Peer Lag-id       : 1
MC System Id        : 00:00:00:00:00:01     MC System Priority   : 100
MC Admin Key        : 1                     MC Active/Standby    : standby
MC Lacp ID in use   : true                  MC extended timeout  : false
MC Selection Logic  : local master decided
-------------------------------------------------------------------------------
Port-id         Adm    Act/Stdby Opr    Primary   Sub-group     Forced   Prio
-------------------------------------------------------------------------------
1/1/1           up     standby   down   yes       1             -        32768
1/1/2           up     standby   down             1             -        32768
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 Multi Link Point to Point Protocol (ML-PPP)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Point to Point Protocol (PPP) / MultiLink-PPP

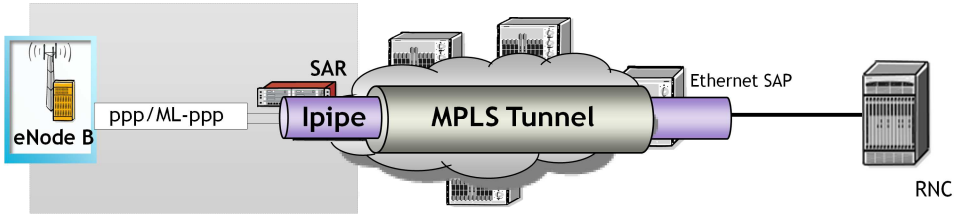
PPP is a data link protocol commonly used to establish a direct connection between two networking devices

PPP can be used over many types of physical links, including serial cable, trunk line or optical links

PPP connection can be carried over synchronous and asynchronous circuit

MLPPP is a virtual link created by bundling multiple PPP links together

PPP and MLPPP supports Ipipe's SAP termination only



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

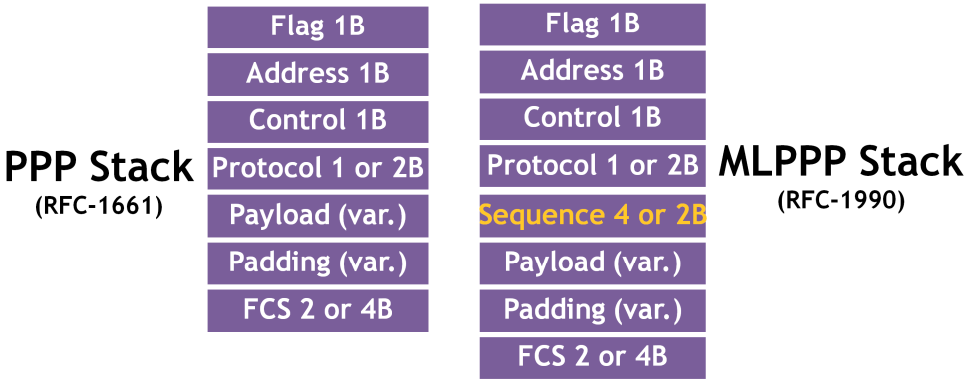
All datagrams transiting through MLPPP are subject to fragmentation.

MLPPP transmits a single data stream by splitting and sequencing the datagram into multiple MLPPP frames, and evenly distributing them across multiple physical links (that are logically grouped) for transmission. The far-end equipment recombines the received multi MLPPP frames back to a single datagram.

Fragmenting the datagram and transmitting it across multiple physical links, allows the service provider to incrementally increase the bandwidth and lower the latency of the transmitting data.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PPP & MLPPP Encapsulation (Stack)

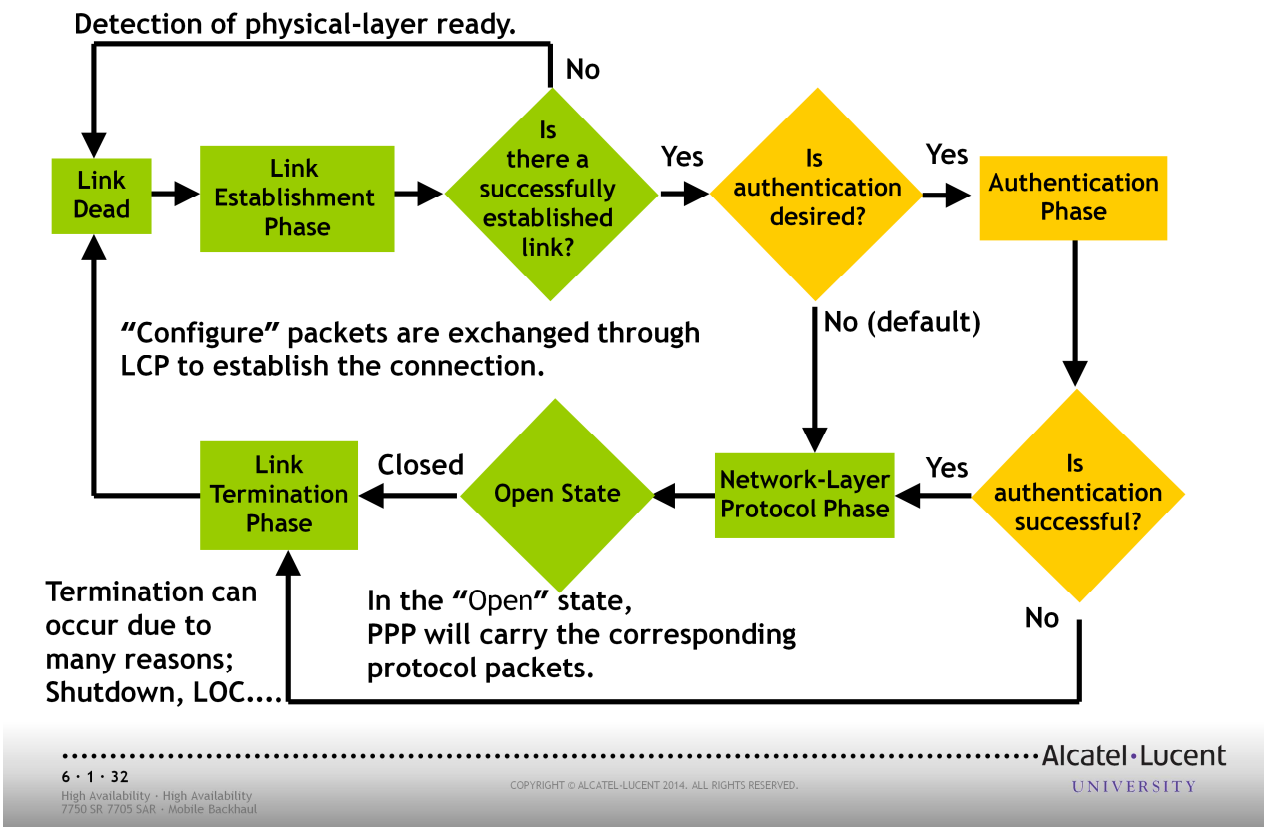


- Flag → Indicates frame's begin or end (always = 0x7E)
- Address → Broadcast address. (0xFF)
- Control → Control byte. ((PPP = 0x03) (MLPPP = 0x3d)
- Protocol → Identifies the data type encapsulated in the Payload. (0x0021)
- Sequence → Fragment ID of each fragmented PPP pocket
- Payload → Datagram
- Padding → Optional padding
- FCS → Error check sum

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PPP State Machine



Establish communication phase (over a P2P link)

- Each end sends LCP packets to configure and test the data link.
- Once established, the peer may **optionally** be authenticated (currently the 7705 SAR does not supports any authentication)

Configure network-layer protocols phase

- Send NCP packet to choose and configure Network-layer protocol
- Datagram from each network-layer protocol can be sent over the link

Remain in operational state until link down

- An explicit LCP or NCP packets close the link down
- An inactivity timer expires
- Network administrator intervention

LCP → Link Control Protocol.

NCP → Network control Protocol.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PPP/MLPPP Termination at Access

T1/E1 access ports with PPP encapsulation
- Non-contiguous n x DS0 time slot is supported
- Number of DS0s (n x 64 Kbps) and TS# (i.e. TS1, TS24) must matched on both ends of the link
- Maximum number of PPP per T1/E1 link is restricted to the maximum number of SAP supported per chassis

T1/E1 access ports with MLPPP encapsulation
- Up to 8 links per MLPPP bundle
- "ipcp" is the only supported encapsulation type

PPP/MLPPP on access port supports only Ipipe termination
- PPP & MLPPP will not be in the operation "UP" state until Ipipes and CE addresses are assigned on both ends of the PPP
- Multi-Class MLPPP is supported on ASAP access
  - Discussed further within the traffic management section of this course

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

MLPPP Available BW:
- Bundle BW = Sum of all links BW
- Can be see in CLI {show multilink-bundle <bundle_ID> detail}

MLPPP Operational State:
- Remains in operational state as long as # of Up link ≥ Minimum link
- Traffic will drop in case of congestion

Adding / Removing T1/E1 links to the bundle while it is in operational State:
- Adding / removing is possible, with minimal traffic impacts

IPCP → Internet Protocol Control Protocol; Network control protocol for establishing and configuring internet protocol over a P2P protocol link.

Note:
- T1/E1 Unframed and E1 CAS signaling is not supported
- The channel-group must consist of the entire T1/E1 (i.e. 24xDS0 or 31xDS0)
- Fractional T1/E1 is not supported

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Basic PPP / MLPPP Configuration

PPP configuration Steps:

- Configure the T1/E1 with framing
- Configure the encapsulation type to ipcp
- Configure the Channel-group to include the desired timeslot(s)
- Assign the channel-group to the service SAP

MLPPP Configuration Steps:

- Configure the T1/E1 with framing type
- Configure encapsulation type to ipcp
- Configure the Channel-group to include **all timeslots**
- Create the MLPPP bundle
- Add the links as bundle members
- Set the minimum-links field (default is 1)

Note: only use ipcp encapsulation on PPP/MLPPP access ports, and use ppp-auto encapsulation for PPP/MLPPP network ports

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.


```
sar1# configure port <1/x/y>
sar1>config>port# tdm ds1/e1
sar1>config>port>tdm>ds1# channel-group 1
sar1>config>port>tdm>ds1>channel-group# encap-type ipcp
sar1>config>port>tdm>ds1>channel-group# timeslots 1-24
sar1>config>port>tdm>ds1>channel-group# no shutdown
sar1>config>port>tdm>ds1>channel-group# exit
sar1>config>port>tdm>ds1# exit
sar1>config>port# no shutdown
```

```
sar1# configure port bundle-ppp-1/4.1
sar1>config>port# multilink-bundle member 1/4/1.1
sar1>config>port# multilink-bundle member 1/4/2.1
sar1>config>port# multilink-bundle member 1/4/3.1
sar1>config>port# no shutdown
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

5 Automatic Protection Switching (APS)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Automatic Protection Switching (APS)

Automatic Protection Switching (APS) is used to protect **SONET/SDH** lines from failure by providing a backup path

It increases overall system availability

Failover may be initiated as a result of:

- Signal **failure** (hard failures such as Loss of Frame)
- Signal **degradation** (soft failures such as an error rate exceeding a configured threshold)

Switching can be:

- **Revertive** – Service is automatically restored to the working facility as soon as the failure condition clears
- **Non-Revertive** – The protection facility is treated as the working facility pending manual intervention



APS

APS is designed to protect SONET/SDH lines from linear uni or bi-directional failures. APS is not designed to perform ring recovery, this is typically done using either Bi-directional Line Switched Ring (BLSR) or Unidirectional Path Switched Ring (UPSR).

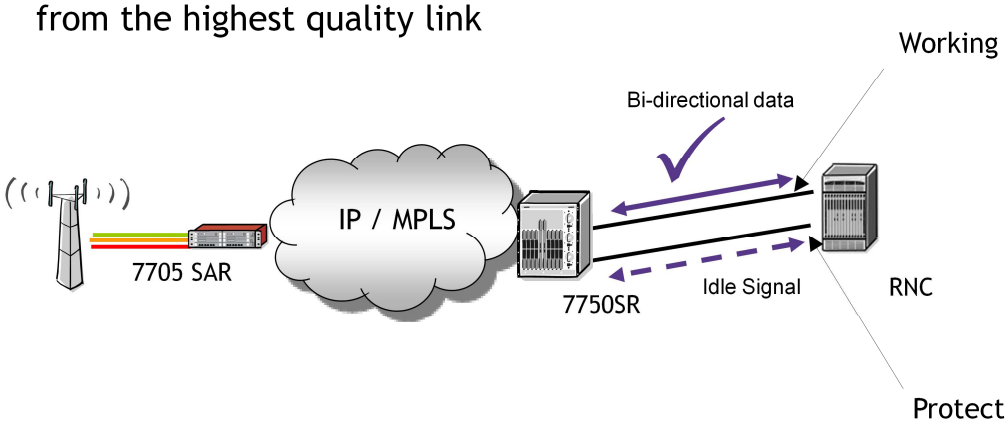
The Network Elements (NEs) in a SONET/SDH network constantly monitor the network. When a failure is detected, the network proceeds through a coordinated, predefined sequence of steps to transfer (or switchover) live traffic to the backup facility (called “protection” facility.) This is done very quickly to minimize lost traffic. Traffic remains on the protection facility until the primary facility (called “working” facility) fault is cleared, at which time the traffic may optionally be reverted to the working facility.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Bi-Directional 1+1 APS

1+1 APS

- One protection link for each working link
- Traffic is replicated onto both links producing a working signal and a protection signal that are identical
- The PE independently monitors the links to ensure traffic is received from the highest quality link



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The standard mandates that using the 1+1 architecture, the active OC-N/STM signal is permanently transmitted to both the working and protection ports so that in the egress direction the same payloads are transmitted identically to the working and protection ports.

Note: For efficiency (replication) purposes the 7750 does not transmit the same payload on the standby port that we transmit on the active port. If an ADM (Add-Drop-Multiplexer) measures for quality and switch-over purposes, then this measurement will perform equally well on the idle stream.

In bi-directional mode:

- A failure of the signal in either direction causes both near-end and far-end equipment to switch to the protecting lines
- The highest priority local request is compared to the remote request (received from the far-end node using an APS command), and whichever has the greater priority is selected

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

APS 1+1

The APS channel (bytes K1 and K2 in the SONET/SDH header) are used to exchange requests and acknowledgments for protection switch actions

Switch priority of a request is assigned as indicated by bits 1 through 4 of K1 byte

The channel requesting switch action is assigned by bits 5 through 8

- When channel number 0 is selected, the condition bits show the received protection channel status
- When channel number 1 is selected, the condition bits show the received working channel status

K1 and K2 bytes are only transmitted on the protect circuit

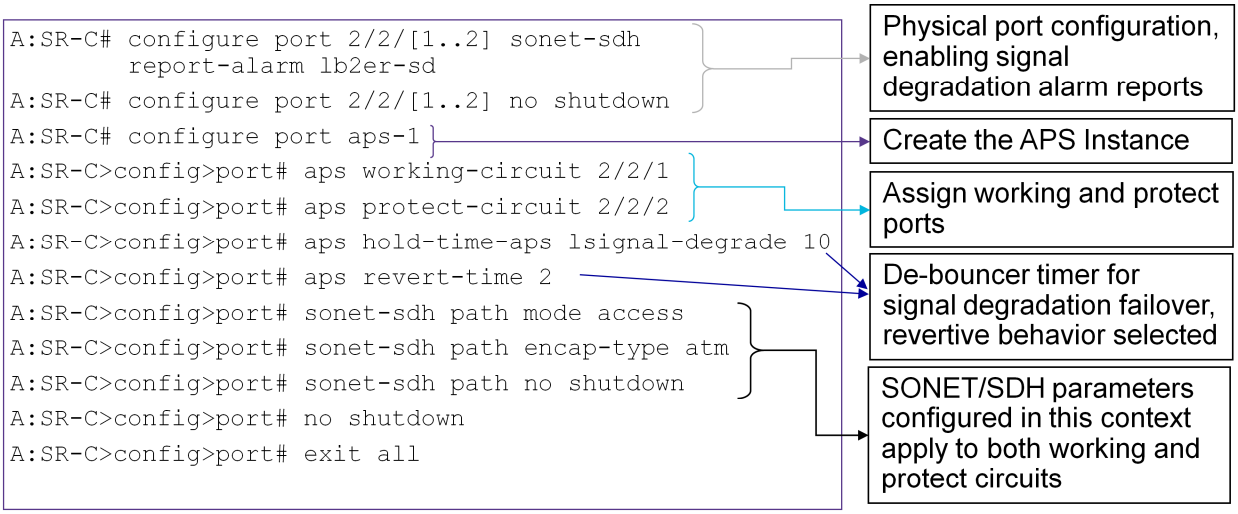
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Relative priorities of events affecting 1+1 protection:

- Automatically Initiated, External, or State Request
- Lockout of Protection
- Signal Failure of Protection Line
- Forced Switch
- Signal Failure of Working Line
- Signal Degrade
- Request Switch Exercise
- Reverse Time
- Do Not Revert (only applies to non-revertive switching)
- No Request

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Example – APS CLI Sample with an ATM interface





In the above sample the following is the MDA configuration

```
PE# show mda
===============================================================================
MDA Summary
===============================================================================
Slot Mda        Provisioned           Equipped              Admin    Operational
                Mda-type              Mda-type              State    State
-------------------------------------------------------------------------------
1    1          m60-10/100eth-tx      m60-10/100eth-tx       up       up
     2          m4-oc48-sfp           m4-oc48-sfp            up       up
2    1          m60-10/100eth-tx      m60-10/100eth-tx       up       up
     2          m16-oc12/3-sfp        m16-oc12/3-sfp         up       up
===============================================================================
```

The alarms enabled in the "**configure port sonet-sdh report-alarm**" context will be the ones triggering the switchover. It can be **lb2er-sd** or **lb2er-sf** for signal degradation and/or signal failure respectively.

The parameter **lsignal-degrade** indicates the time in milliseconds after which failover will be initiated during a signal degradation period. Similarly, the parameter **lsignal-failure** can be used instead of or in addition to lsignal-degrade to indicate that a switch-over will be initiated during a signal failure. This is to avoid unnecessary switchovers due to short-lived problems (de-bouncer).

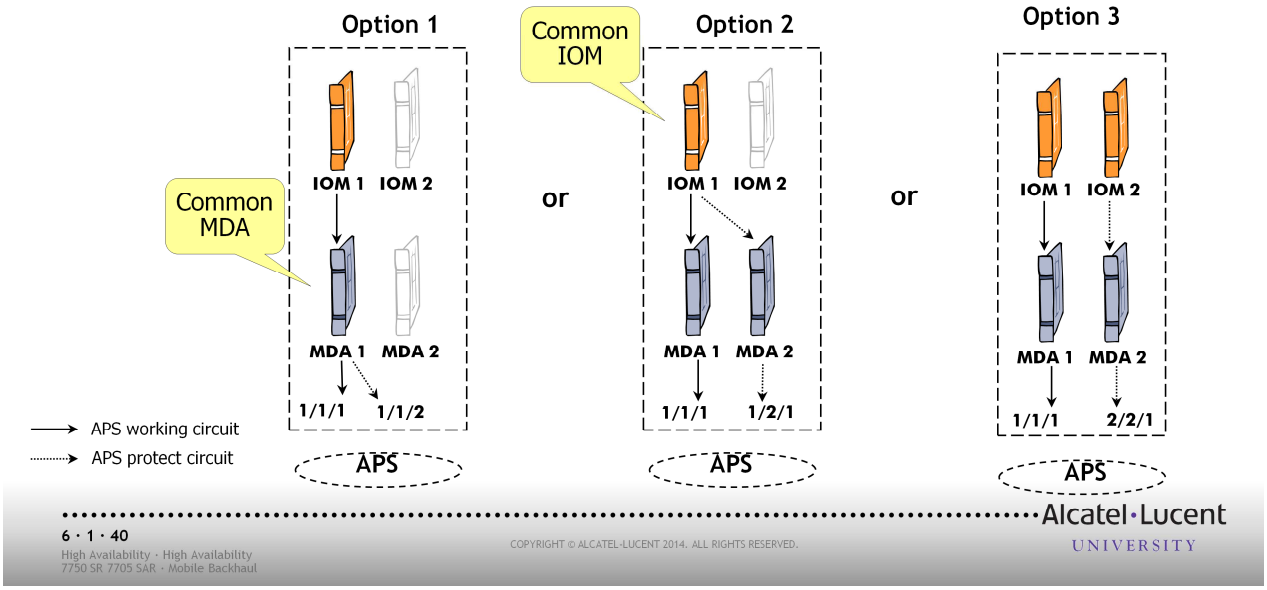
The parameter **revert-time** determines how long to wait, in minutes, before switching back to the working circuit after that circuit has been restored into service. The default is not to revert back to the working circuit and to stay on the protect circuit after the switchover.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

APS Resiliency Options – Single Chassis

Redundancy Available across both MDAs and IOMs

- Option 1 = Port redundancy only: if **common MDA** fails, APS is down
- Option 2 = Port and MDA redundancy only: if **common IOM** fails, APS is down
- Option 3 = Port, MDA and IOM redundancy



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

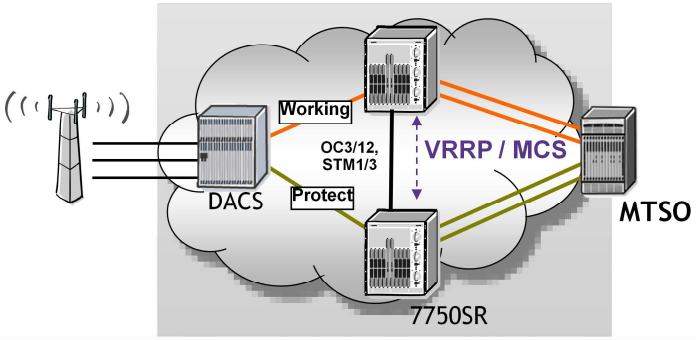
Note: Option 3 is available after release 6.0

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Multi-Chassis APS

MC-APS extends the protection offered by APS to include protection against nodal failure

- One end of the APS is split between two systems



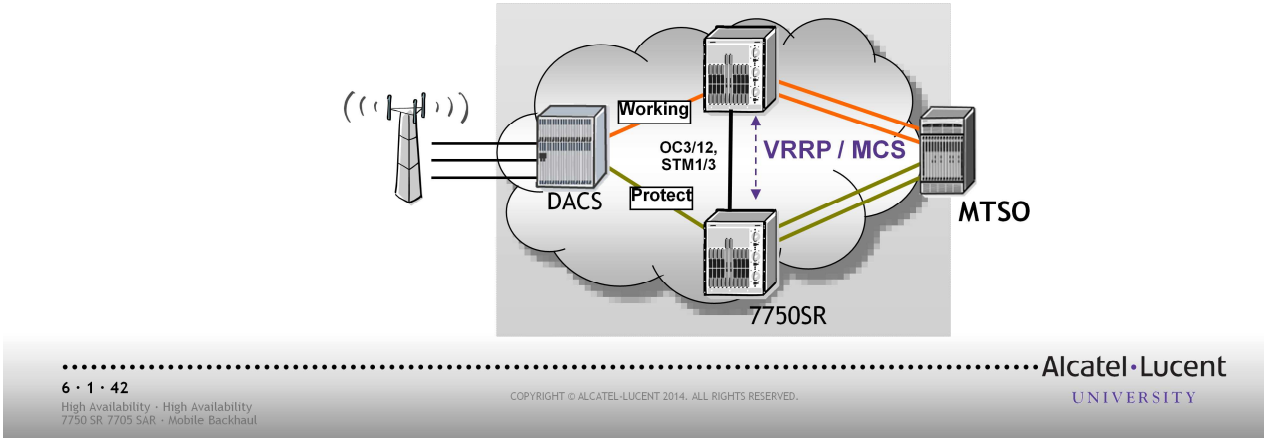
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Multi-Chassis APS

In addition to offering layer-2 protection, bundles (such as IMA and ML-PPP) can be protected with APS through the use of Bundle Protection Groups (BPGRP)

Synchronization across two SRs maintained using Multi-Chassis Synchronization (MCS) protocol



In addition to offering layer-2 protection, bundles such as IMA (Inverse Multiplexing over ATM) and MLPPP (Multi-Link Point-to-Point) can be protected with APS through the use of Bundle Protection Groups (bpgrp).

For APS-protected bundles, all members of a working bundle must reside on the working port of an APS group. Similarly all members of a protecting bundle must reside on the protecting circuit of that APS group.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

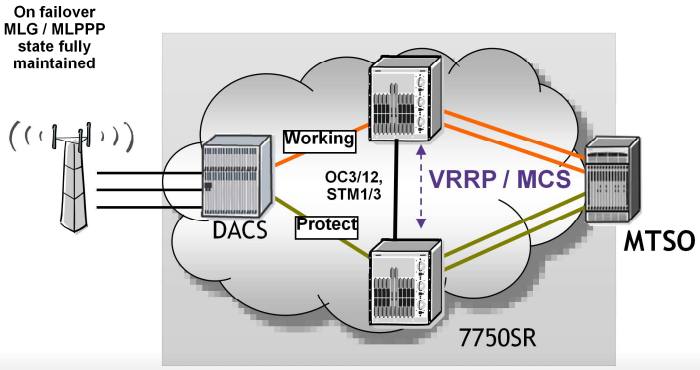
Multi-Chassis APS

If **ML-PPP link groups** are being used and if **only layer-2 APS protection** is configured, ML-PPP groups must be re-established in the case of failure

⇒ calls are dropped

MC-APS provides stateful ML-PPP protection across two different routers, eliminating the need to re-establish the ML-PPP sessions

The alternative would be to use VRRP, but it requires longer failover times



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- MC-APS reduces the recovery time and enables faster switchover
- ML-PPP State is actively maintained across two chassis
- ML-PPP State synchronization uses Multi-Chassis Synchronization (MCS) protocol
- MC-APS eliminates the requirement to re-establish the ML-PPP Groups
- Handles any APS switch-over in less than 5 seconds so NO Calls are dropped
- Significantly reduces recovery time by seconds for a large number of groups (ML-PPP)
- Enables high-scale for a large number of base stations coming into the MLS

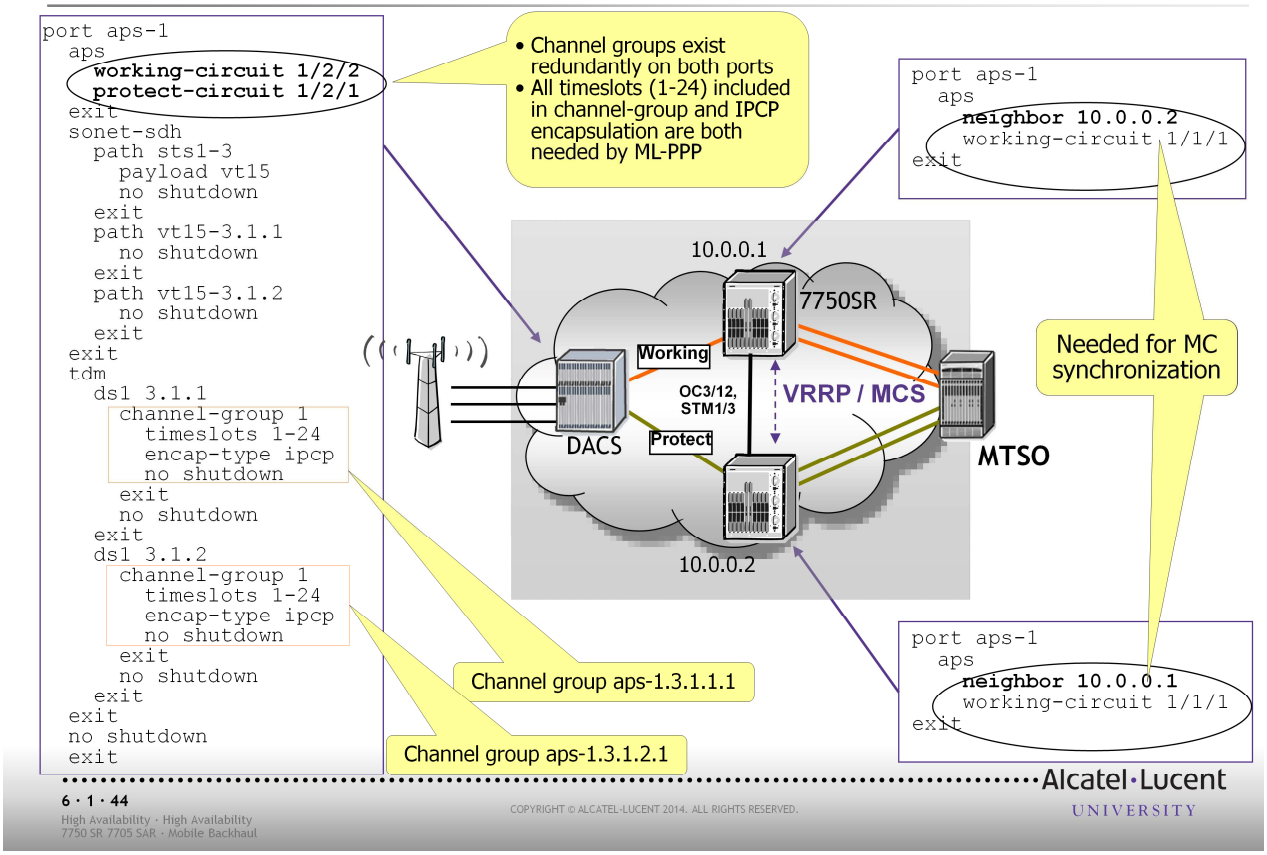
The Alternative using VRRP

1. Physical failure on active APS link triggers physical protection failover
2. ML-PPP group are re-established (ML-PPP state synchronization eliminates this step)
3. Local route failure to cell sites on VRRP master is identified and advertised via OSPF
4. VRRP backup router identifies new route to cell site and advertises via OSPF
5. VRRP master updates route to cell site through the VRRP backup router

(UMTS): The MC-APS with ATM VLL redundancy (R6.0) is an extension of the R5.0 MC-LAG with PW redundancy feature. This feature allows MC-APS to operate with PW redundancy in a similar manner that MC-LAG operates with PW redundancy in R5.0.The combination of both features provides a solution for access node redundancy and network redundancy

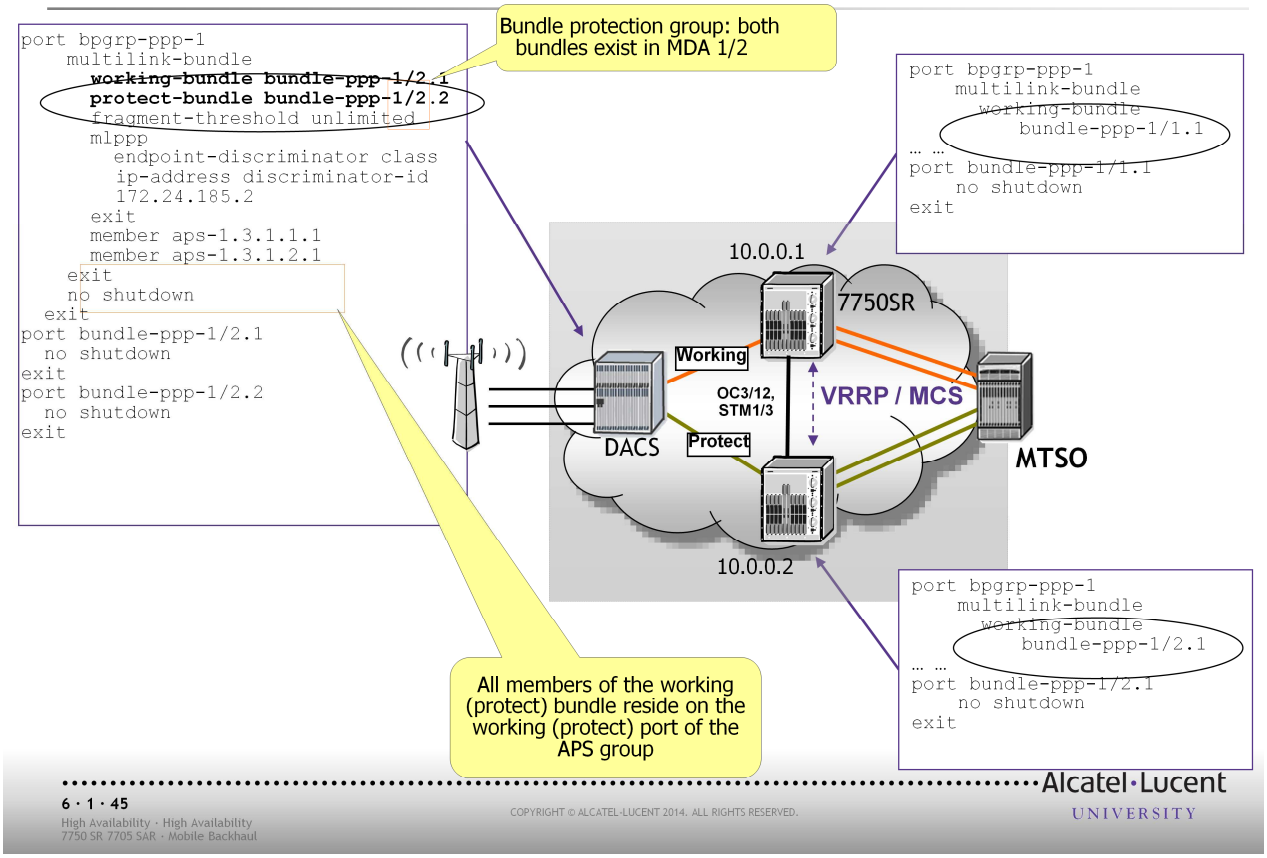
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MC-APS Configuration



Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MC-APS Configuration - BPGRP Configuration

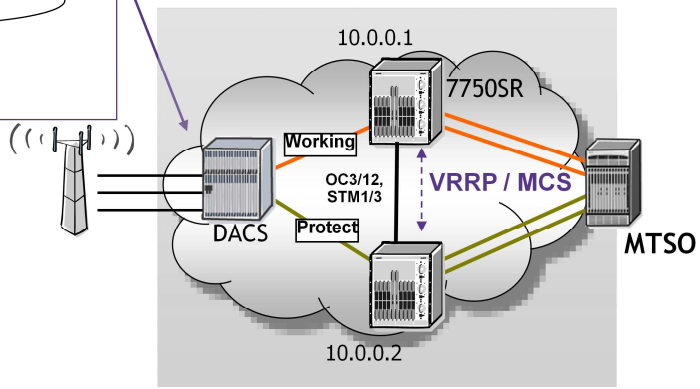


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MC-APS Configuration – Using BPGRP in IES

```
ies 101 customer 1 create
      interface "to-PE" create
        address 172.24.185.2/24
        ipcp
          peer-ip-address
            172.24.185.1
        exit
        sap bpgrp-ppp-1 create
        exit
      exit
      no shutdown
    exit
```

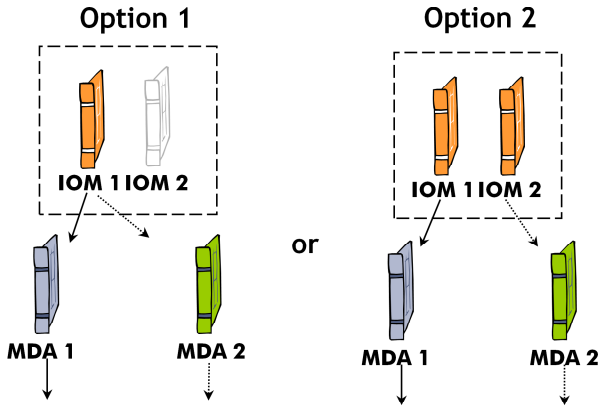


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Multi-Chassis APS

Multi-chassis protection can be combined with port, MDA and IOM protection by selecting ports that belong to different cards in each system



Scaling	7750 SR7/SR12	7710 SR c4 / c12
Max single chassis APS groups / system	64	16
Max multi-chassis APS groups / system	32	8
Max LAG groups / system	200	200

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

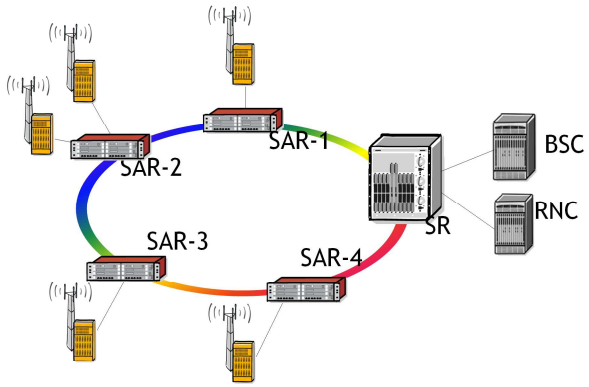
APS Switching times in both single chassis and multi-chassis scenarios will be dependent on number of services running over the APS protected port.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6 7705 SAR Fast Re-Route (FRR)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Fast Reroute Application



Fast Reroute (FRR) is another protection mechanism tied to RSVP-TE signaling

FRR recovers node or link failure in an RSVP-TE signaled LSP in a timely fashion

In the ring topology network above, in case the link between SAR-1 and SR at the MTSO fails, all the LSPs would be rerouted over SAR-2 to SAR-3

With Secondary Path, the PathErr message generation and processing is usually per LSP base and it is time consuming

With Facility Backup, SAR-1 would assume the sole responsibility to recover all the LSPs

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Fast Reroute Overview

Disadvantages of Secondary Path only Protection

- Failure downstream might take a while to reach the head of LSP
- Double booking of resources
- No selective protection of node or link

Fast Reroute (FRR) is used to establish backup label-switched path (LSP) tunnels for local repair of LSP tunnels

FRR defines ways of pre-configuring and signaling backup paths before a failure

The mechanisms enable the redirection of traffic onto backup LSP tunnels within 50 msec upon failure

When Fast Reroute is enabled, each node along the path of the LSP tries to establish a backup LSP

FRR is only available for the Primary path

CSPF must be enabled for FRR to work

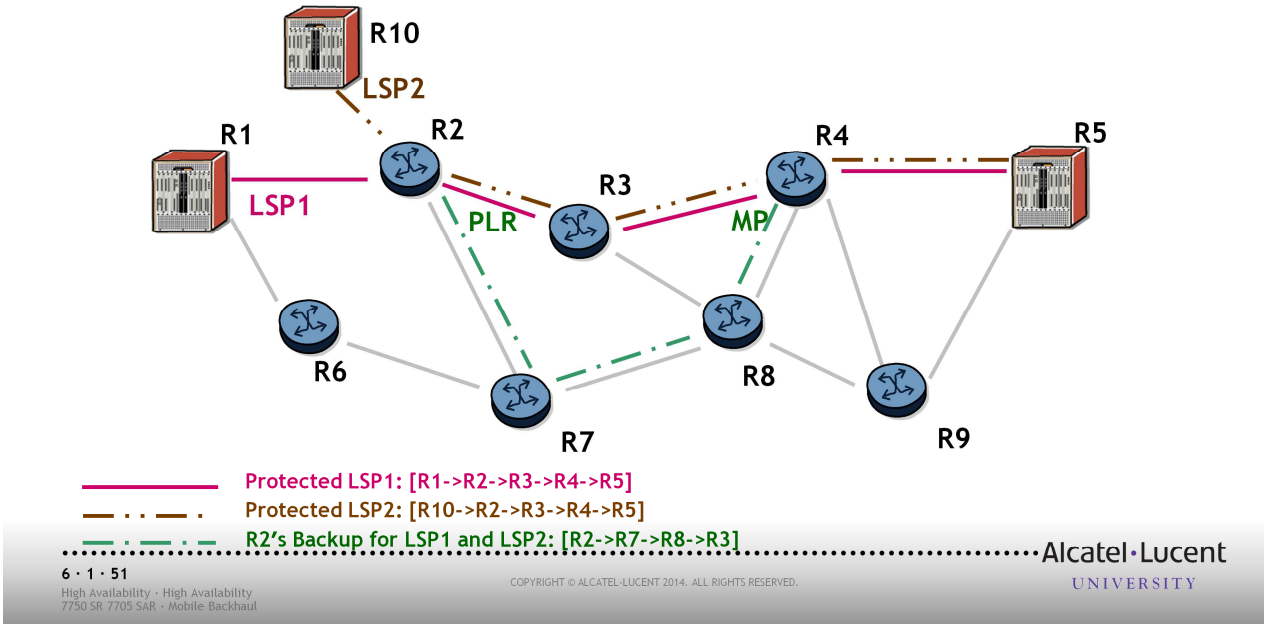
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- When Fast Reroute is enabled, each node along the path of the LSP tries to establish a backup LSP
  - Each upstream node sets up a backup LSP that avoids only the immediate downstream node (by default node protection is enabled)
  - The Point of Local Repair (PLR) looks for the backup path which merges back to the protected LSP sooner
    - i.e., the Merge Point (MP) is closer to the PLR
  - The backup LSP may take one or more hops merging back to the main LSP or it may only merge at the eLER
  - If it is not possible to set up a backup LSP that avoids the immediate downstream node, a backup can be set up to the downstream node on a different interface
- In case of failure, traffic is immediately rerouted by the PLR onto the pre-computed backup LSP, minimizing packet-loss
- When the upstream node (ILER) is informed by the PLR that a downstream router is using its backup LSP, the iLER switches traffic to a standby path if one was set up for the LSP
- A locally repaired LSP (i.e., using the backup path) will try to globally revert back when the retry timer expires
- FRR is only available for **primary** path
- No configuration is required on the transit hops of the LSP (except Manual Bypass Tunnel)
- **CSPF** must be enabled for Fast Reroute to work

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Facility Backup

- Instead of creating a separate LSP for every protected LSP, a single LSP is created to back up a set of LSPs
- The facility backup method takes advantage of the MPLS label stack
- The backup LSP is also called a bypass tunnel



Two LSPs, LSP1 originating from R1 and LSP2 originating from R10, are to be protected. Node protection is provided in the example

The bypass tunnel must intersect the path of the original LSP(s) somewhere downstream of the PLR. Naturally, this constrains the set of LSPs being backed up via that bypass tunnel to those that pass through some common downstream node. All LSPs that pass through the point of local repair and through this common node that do not also use the facilities involved in the bypass tunnel are candidates for this set of LSPs.

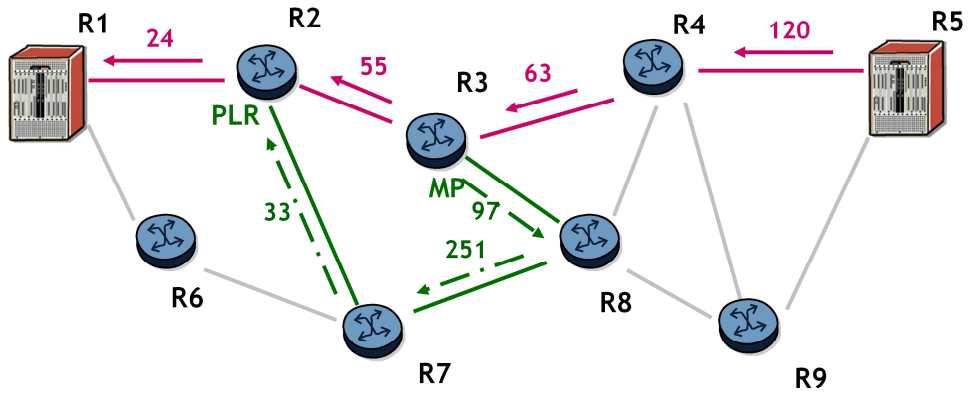
In the above example, R2 has built a bypass tunnel that protects against the failure of link [R2->R3] and node [R3]. This technique provides a scalability improvement, in that the same bypass tunnel can also be used to protect LSPs from any of R1, R2, R8 to any of R4, R5, or R9. The example describes two different protected LSPs that are using the same bypass tunnel fo protection.

Similarly to the one-to-one method, there could be as many as (N-1) bypass tunnels to fully protect an LSP that traverses N nodes. However, each of those bypass tunnels could protect a set of LSPs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Facility Backup – Link Protection Label Exchange

- The labels exchanged for the bypass tunnel include the push, swap and pop operations, compared to swap only in the one-to-one backup method
- Two labels will be used by the PLR to redirect traffic to the bypass tunnel
  - One label advertised from the next-hop of the protected LSP
  - The other label from the next-hop of the bypass tunnel which is shared with other protected LSPs
- The facility backup method allows the "tunneling" of multiple LSPs through the bypass and improves scalability of the protected paths

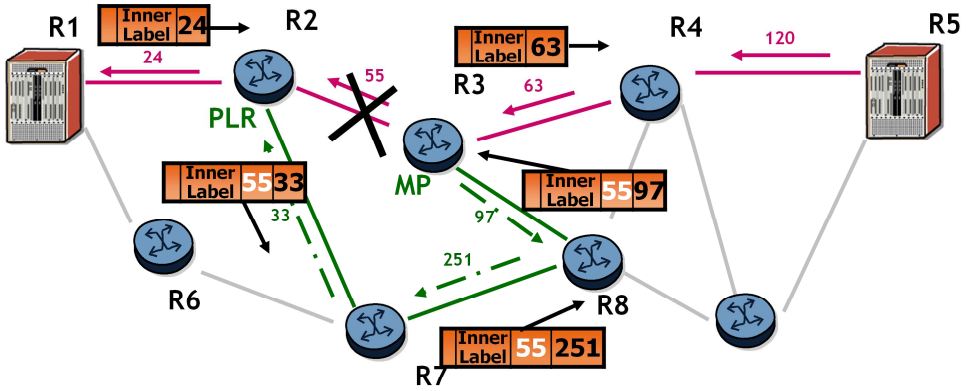


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Facility Backup – Label Switch upon Link Failure

- When R2 (PLR) detects that the link **R2->R3** fails on the protected LSP,
  - R2 swaps the label 24 with **55** previously received from **R3**, the neighbour of the failed link
  - R2 also pushes the label **33** obtained from **R7**, the downstream backup neighbour on the data path
  - **The depth of the label stack is two**
- Along the bypass tunnel, R7 and R8 will swap the top label
- When R3 (MP) receives the packet from the upstream backup neighbour
  - R3 removes the top label **97** and examines the next label (the current top label)
  - The current top label **55** is the same label as it would have received directly from **R2** had the link not failed
  - R3 would switch label 55 to 63 to merge back to the protected LSP

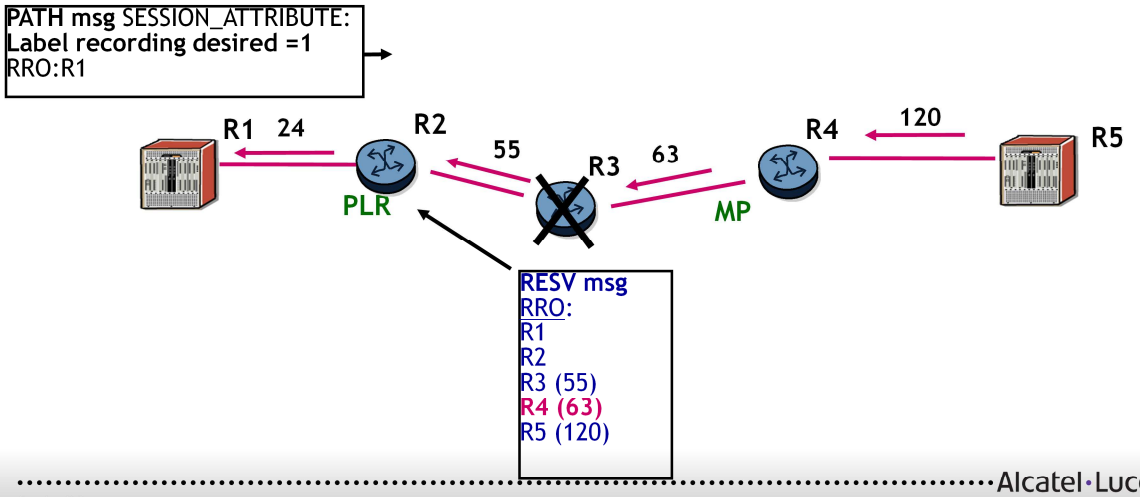


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Facility Backup – Node Protection

- The PLR must be able to discover the downstream labels to provide facility backup in case of node failure
  - Address of the Merge Point (MP) is obtained from the RRO
  - The label propagated to the protected LSP by the MP upstream is recorded in the RRO of the RESV message when the "label recording desired" flag in the SESSION_ATTRIBUTE object is set in the PATH message

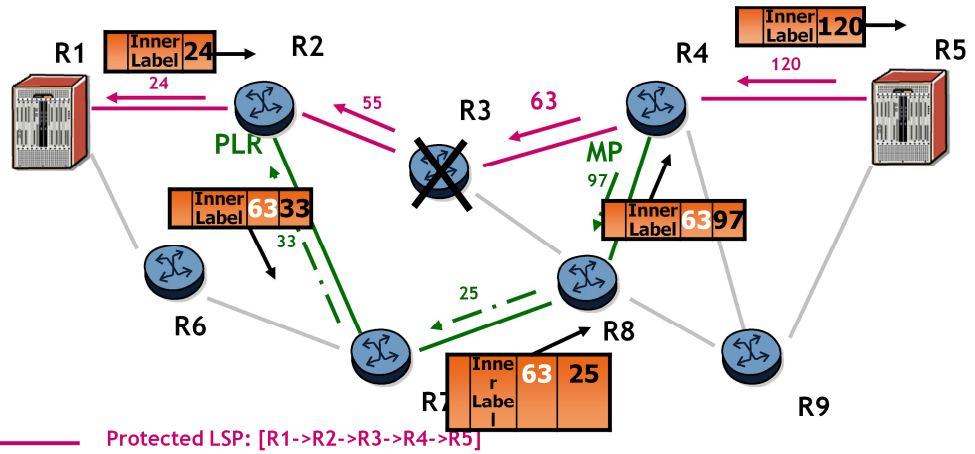


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Facility Backup – Label Switch upon Node Failure

- When R2 (PLR) detects that R3 fails on the protected LSP
  - R2 swaps the label 24 with **63,** which is known from the RRO in the RESV message
  - R2 pushes the label **33** onto the header retaining 63 as an inner label
- Along the bypass tunnel, R7 and R8 will swap the outer label as the packet progresses along the path
- When R4 (MP) receives the packet from the upstream backup neighbour
  - R4 removes the outer label (**97**) and examines the inner label
  - The label (**63**) is the same label as it would have received directly from **R3** had the node not failed
    - R4 then switches the label 63 to 120 completing the merge back from the protected LSP

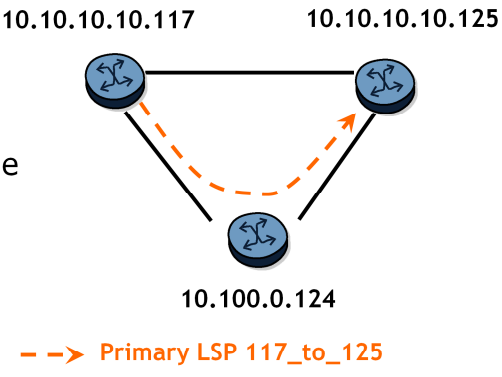


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

FRR Configuration

- CSPF has to be enabled for Fast-Reroute
- Node-protect is enabled by default
- Record-label is enabled by default under the primary path
- Bandwidth reservation NOT supported




```
*A:SAR-117>config>router>mpls>lsp# fast-reroute
 - fast-reroute
 - no fast-reroute

[no] bandwidth       - Configure bandwidth
                       for fast reroute
[no] hop-limit       - Configure hop limit
                       for fast reroute
[no] node-protect    - Configure node
                       protect
```

```
A:SAR-117>config>router>mpls# info
                ……
            lsp "117_to_125"
             to 10.10.10.125
             cspf
             fast-reroute
             exit
             primary "long_path"
             exit
             no shutdown
          exit
```

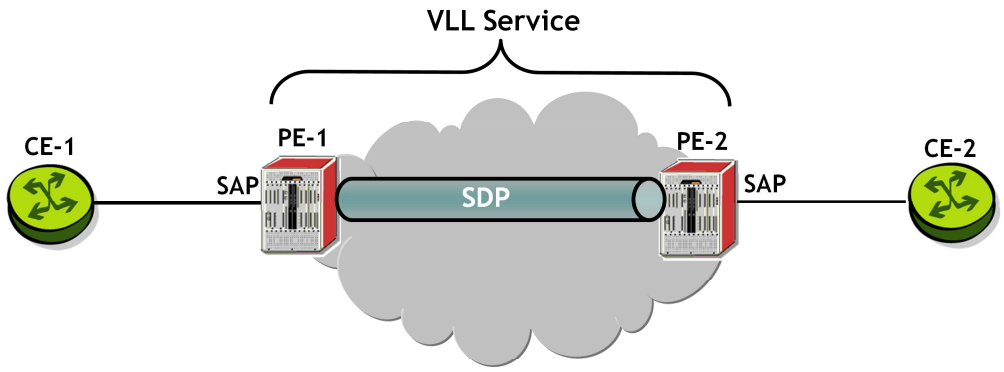

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7 Pseudo-Wire Redundancy

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Pseudowire Redundancy - Prelude



- A "traditional" VLL (e.g. Epipe) service has two components on each PE router which serve as traffic entry and exit points for customer data:
  - A SAP: towards the CE (Customer End)
  - An SDP binding (Pseudowire): towards the provider core
- The SDP is inherently redundant thanks to the MPLS protection mechanisms.
  - Dynamic failover in LDP
  - Secondary standby/Fast Reroute paths in case of RSVP-TE
- What if we introduce redundancy on the access side (as in MC-LAG)?

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

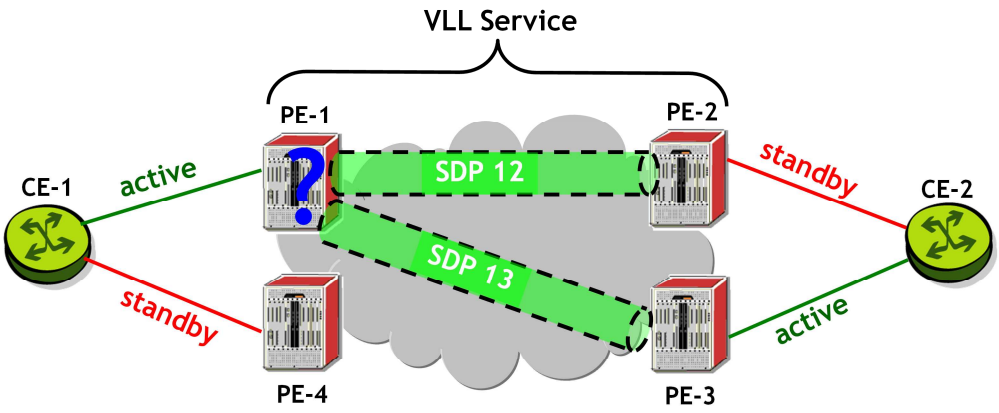
Definition of PW (Pseudowire) from Wikipedia:

"In computer networking and telecommunications, a pseudowire (PW) is an emulation of a native service over a Packet Switched Network (PSN). The native service may be ATM, Frame Relay, Ethernet, low-rate TDM, or SONET/SDH, while the PSN may be MPLS, IP (either IPv4 or IPv6), or L2TPv3."

The term Pseudowire is interchangeably used with SDP (Service Distribution Path) in the Alcatel-Lucent parlance.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Introduction



With the added redundancy on the access side and a VLL service between the two sites, there exists two design challenges:

1: How to overcome the limitation of the "traditional" VLL service which allows for provisioning only one SAP and one SDP due to its point-to-point nature?

2: Considering a traffic flow from CE-1 to CE-2:

Upon receiving the traffic from its SAP, how is PE-1 supposed to decide which SDP to deliver the data to (SDP 12 or SDP 13)?

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Here, considering traffic flow from CE-1 to CE-2 only:

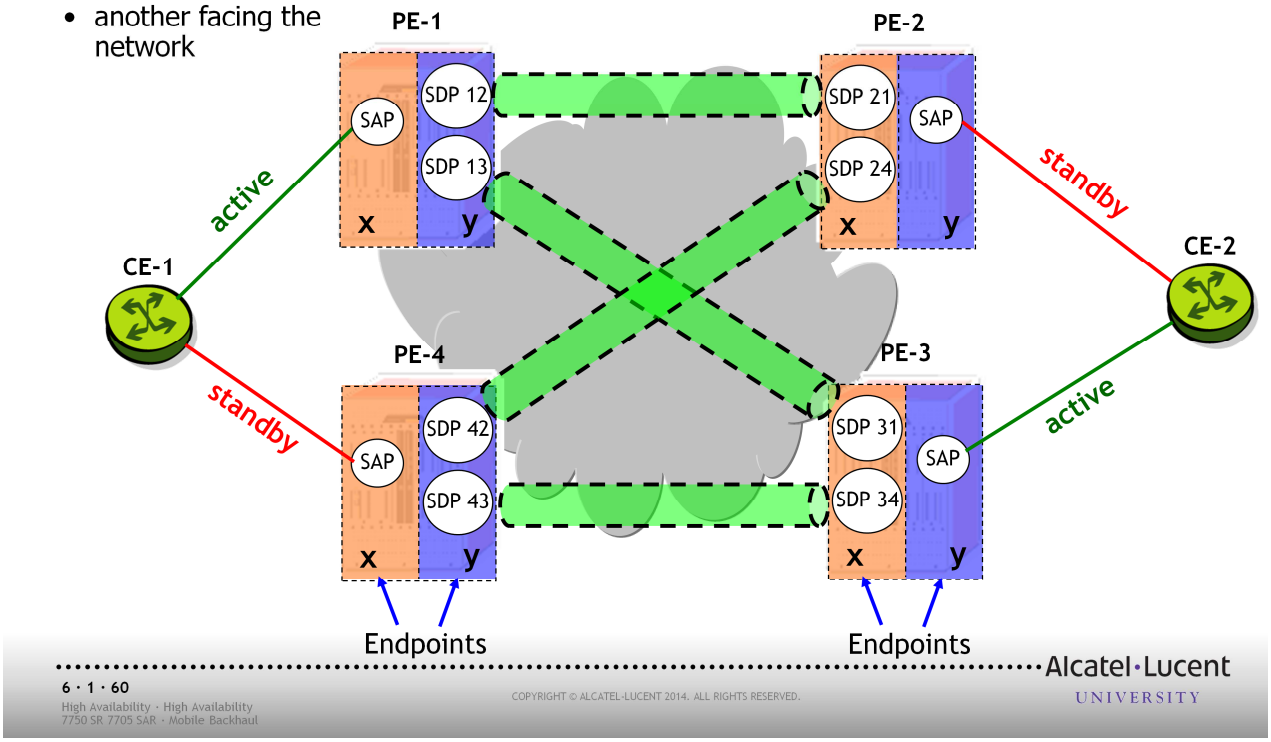
PE-3 is the router with the active SAP on itself and PE-2 is in standby, but the question boils down to how PE-1 is going to be made aware of this situation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Endpoints

We still have two components inside a VLL service:

- one facing the customer
- another facing the network



By introducing the endpoint concept, we still have two components inside a given VLL service: an “x” and a “y” endpoint

(Note: could be named anything: “left” - ”right”, “west” – “east”, etc..)

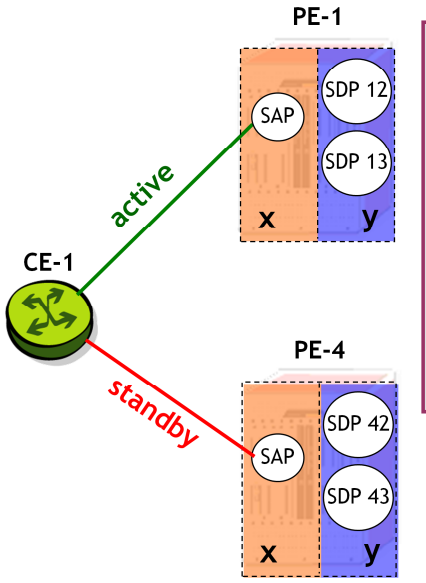
Types of endpoint objects:

- SAP: max 1 per endpoint
- Primary spoke-SDP (precedence value set to zero or to “primary”): max 1 per endpoint
- Secondary spoke-SDP (precedence value different from zero, default 4): max 4 per endpoint
- Inter-Chassis Backup (ICB) spoke-SDP

- Endpoint can have max 1 SAP + 1 ICB (SAP must be part of LAG if ICB is already present)
- Maximum 4 spoke-SDPs, any combination of:
  - Primary spoke-SDP (max 1, revertive)
  - Secondary spoke-SDP (max 4, not revertive, precedence)
  - ICB spoke-SDP (max 1)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Endpoints - Configuration




```
*A:PE1# configure service epipe 10
*A:PE1>config>service>epipe# info
----------------------------------------------
            endpoint "x" create
            exit
            endpoint "y" create
            exit
            sap lag-1 endpoint "x" create
            exit
            spoke-sdp 12:10 endpoint "y" create
            exit
            spoke-sdp 13:10 endpoint "y" create
            exit
            no shutdown
----------------------------------------------
```

Question still remaining for PE routers:

- Which SDP to choose?

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

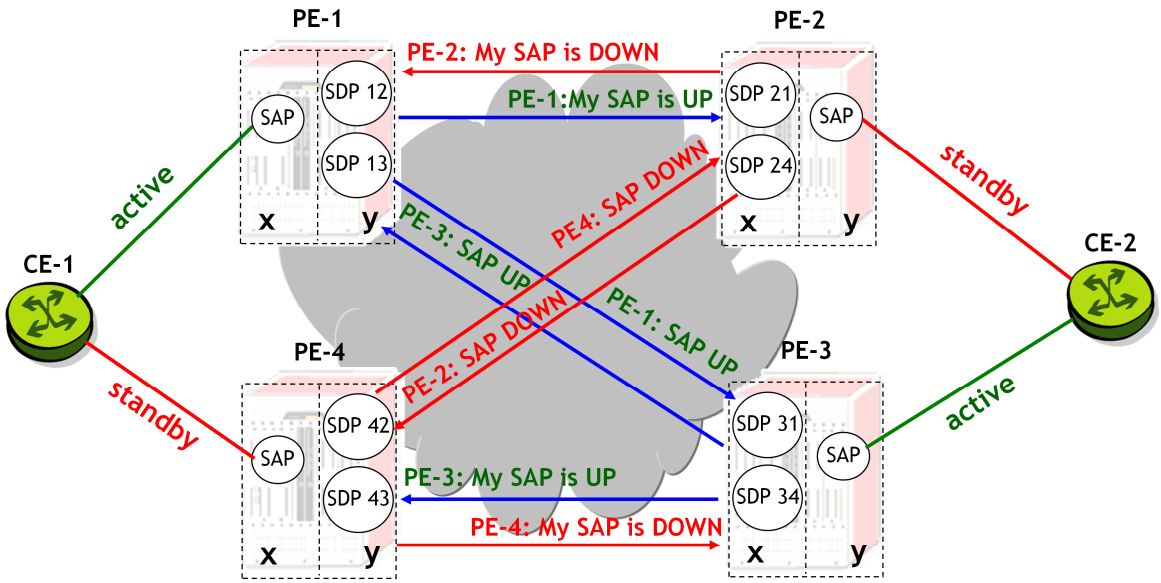
Similar configuration should be done on all the other PE's.

The question that still remains is: How are the PE routers supposed to decide on the actual data paths to be taken (which SDP to choose)?

The answer is in the next slide.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – T-LDP Status Bits

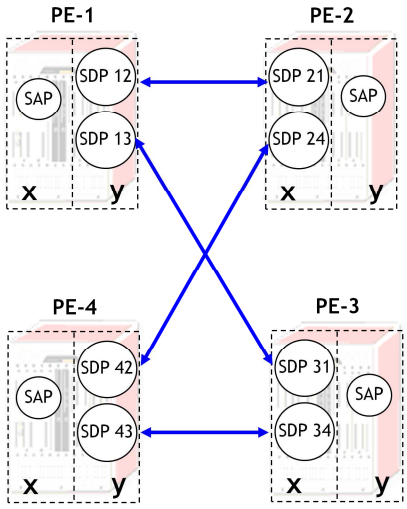


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The PE nodes notify each other of their corresponding SAP states using the T-LDP status bits included in LDP Notification messages.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – T-LDP Status Bits - CLI



Note: **LAC** stands for "Local Attachment Circuit" which is another term denoting the SAP; **PW** stands for Pseudo-Wire

```
*A:PE1# show service id 10 sdp 12 detail
```
(What is PE-2 reporting?)

```
-------------------------------------------------------------------------------
 Sdp Id 12:10  -(2.2.2.2)
-------------------------------------------------------------------------------
SDP Id              : 12:10                     Type              : Spoke
VC Type             : Ether                     VC Tag            : n/a
Admin Path MTU      : 0                         Oper Path MTU     : 9190
Far End             : 2.2.2.2                   Delivery          : LDP

Admin State         : Up                        Oper State        : Up
.....................................................................
.....................................................................
Flags               : None
Peer Pw Bits        : lacIngressFault lacEgressFault pwFwdingStandby
```

```
*A:PE1# show service id 10 sdp 13 detail
```
(What is PE-3 reporting?)

```
-------------------------------------------------------------------------------
  Sdp Id 13:10  -(3.3.3.3)
-------------------------------------------------------------------------------
SDP Id              : 13:10                     Type              : Spoke
VC Type             : Ether                     VC Tag            : n/a
Admin Path MTU      : 0                         Oper Path MTU     : 9190
Far End             : 3.3.3.3                   Delivery          : LDP

Admin State         : Up                        Oper State        : Up
.....................................................................
.....................................................................
Flags               : None
Peer Pw Bits        : None
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

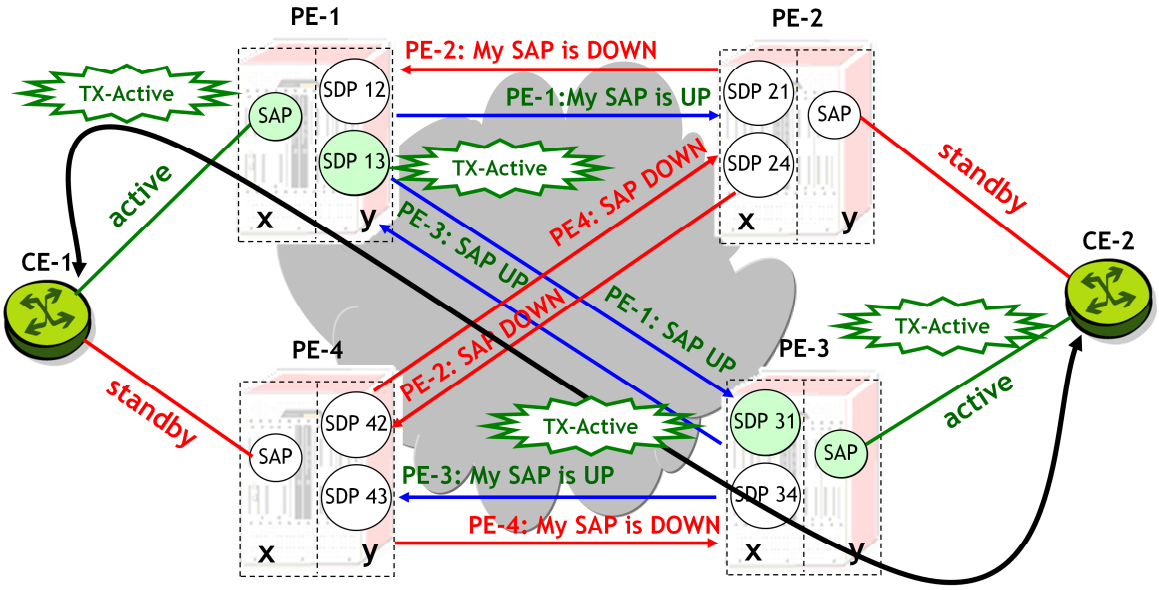
The Peer PW bits indicate the status of the other end peer.

Here, PE-1 is receiving "**lacIngressFault lacEgressFault pwFwdingStandby**" from PE-2 since the LAG is set operationally down as it is in standby mode.

LAC here stands for "Local Attachment Circuit" which is another term denoting the SAP.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: Initial Condition



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

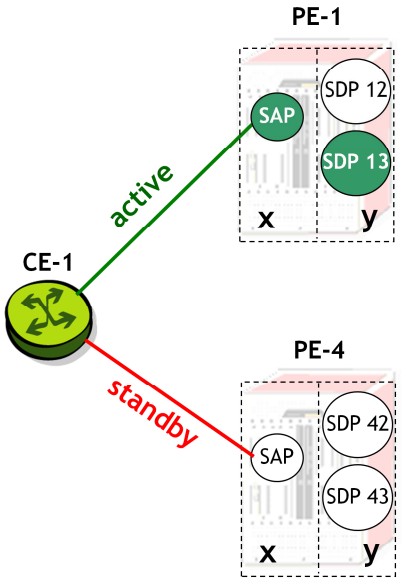
The PE nodes notify each other of their corresponding SAP states using the T-LDP status bits included in LDP Notification messages.

A path is formed following the endpoints that are set in TX-Active state.

The LAG's that are in active state are set TX-Active. Accordingly, the spoke-SDP bindings that are pointing to each other having the active LAG's are both set "TX-Active", completing the forwarding path.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: CLI




```
*A:PE1# show service id 10 endpoint

===============================================
Service 10 endpoints
===============================================
Endpoint name       : x
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : lag-1
-----------------------------------------------
Members
-----------------------------------------------
SAP                 : lag-1
===============================================
Endpoint name       : y
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 13:10
-----------------------------------------------
Members
-----------------------------------------------
Spoke-sdp           : 12:10 Precedence:4
Spoke-sdp           : 13:10 Precedence:4
===============================================
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Similarly for PE3:

```
*A:PE3# show service id 10 endpoint

===============================================================================
Service 10 endpoints
===============================================================================
Endpoint name       : x
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 31:10
-------------------------------------------------------------------------------
Members
-------------------------------------------------------------------------------
Spoke-sdp           : 31:10 Precedence:4
Spoke-sdp           : 34:10 Precedence:4
===============================================================================
Endpoint name       : y
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : lag-1
-------------------------------------------------------------------------------
Members
-------------------------------------------------------------------------------
SAP                 : lag-1
===============================================================================
===============================================================================
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: Service States

```
*A:PE1# show service service-using

===================================
Services
===================================
ServiceId    Type       Adm    Opr
-----------------------------------
10           Epipe      Up     Up
-----------------------------------
Matching Services : 1
-----------------------------------
```

```
*A:PE2# show service service-using

===================================
Services
===================================
ServiceId    Type       Adm    Opr
-----------------------------------
10           Epipe      Up     Down
-----------------------------------
Matching Services : 1
-----------------------------------
```

```
*A:PE4# show service service-using

===================================
Services
===================================
ServiceId    Type       Adm    Opr
-----------------------------------
10           Epipe      Up     Down
-----------------------------------
Matching Services : 1
-----------------------------------
```

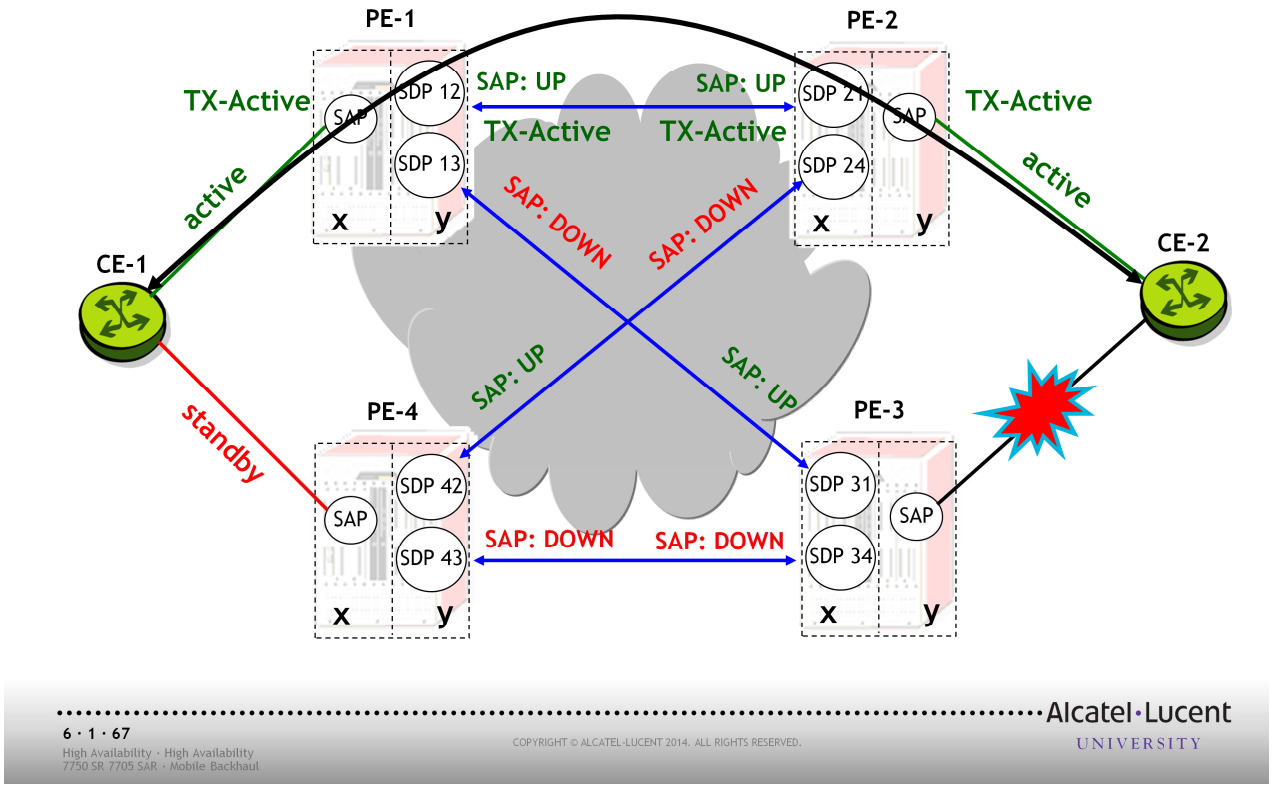
```
*A:PE3# show service service-using

===================================
Services
===================================
ServiceId    Type       Adm    Opr
-----------------------------------
10           Epipe      Up     Up
-----------------------------------
Matching Services : 1
-----------------------------------
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The service states on the PE nodes where the LAG states are “standby”, appear as “down”. This behaviour is going to change when ICB (Inter-Chassis Backup) spoke SDP’s are introduced.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: Access Link Failure



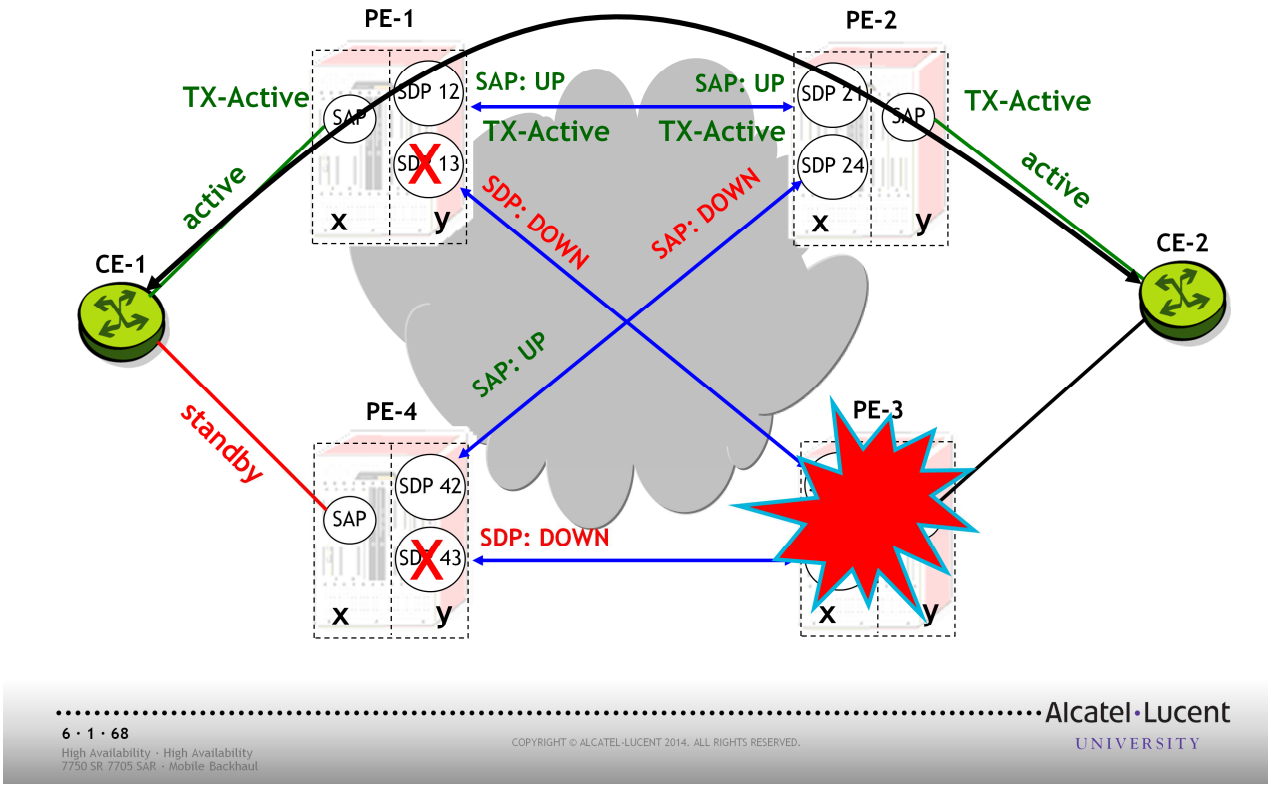
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Upon access link failure on PE-3, MC-LAG switches activity to PE-2 and the spoke-SDP bindings are adjusted accordingly.

A new forwarding path is found depending on the new situation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: Access Node Failure



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

In case of a complete nodal failure at the access side, convergence relies on two different triggers:

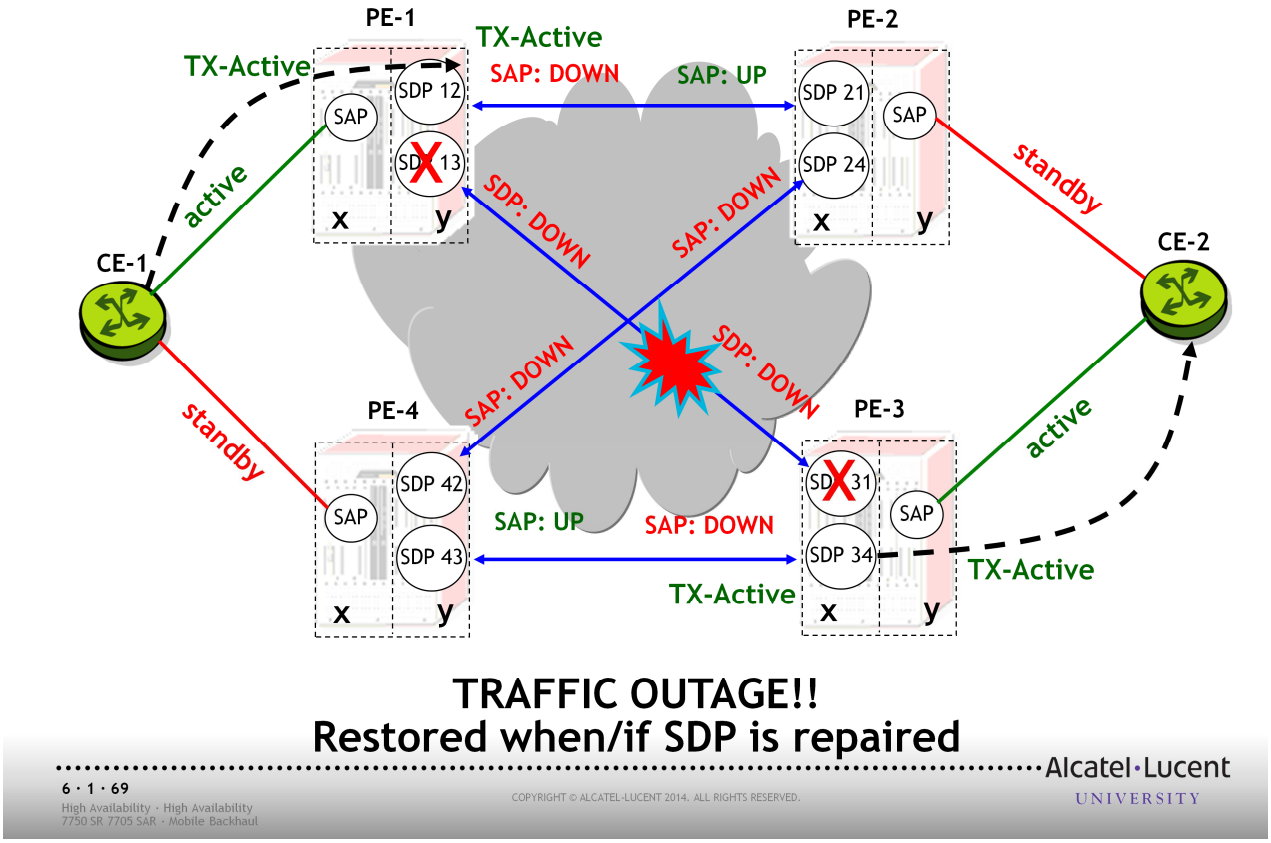
a. Timeout on keep-alive message (**keep-alive-interval & hold-on-neighbor failure** settings)

b. Removal of the route pointing to the peer from the FIB (Forwarding Information Base). This is also known as Next-Hop Tracking in Alcatel-Lucent parlance.

Detection time is the **better** of these two mechanisms.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: SDP Failure



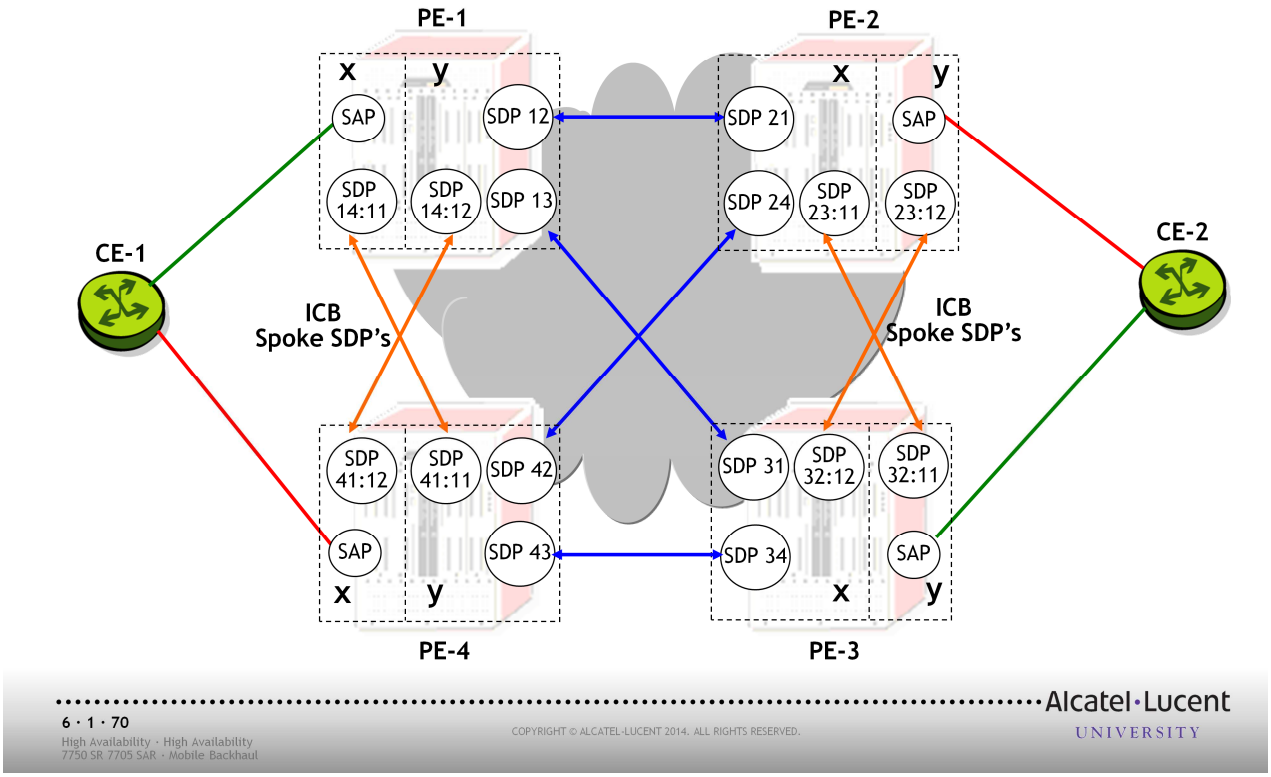
It is the preassumption that the SDP's themselves are on a protected path (core link redundancy LDP or secondary/fast reroute protection mechanisms in RSVP-TE). Hence, a failure of the spoke SDP binding between the two active access sides cannot be dealt with as depicted in this scenario.

This could be demonstrated by administratively shutting down SDP 13 on PE-1 or SDP 31 on PE-3.

ICB (Inter-Chassis Backup) Spoke SDP's can also be handy in this case, as explained in the following slides.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Inter-Chassis Backup Spokes



PE routers at the same access sites are "cross-connected" to each other as shown in the figure, using the "ICB Spoke SDP" connections.

The rules governing the use of ICB Spoke SDP's are given in the following slides.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

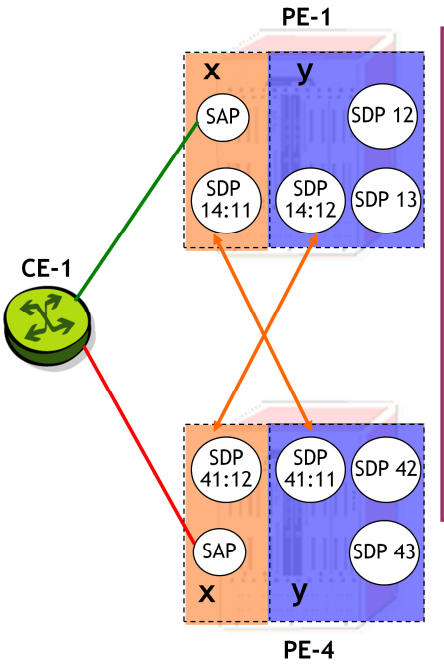
PW Redundancy – ICB Spokes Characteristics

- ICB spoke SDP's can be used to protect in-flight packets during LAG link transition
- Only one ICB spoke SDP can exist in an endpoint
- The ICB spoke SDP's must cross each other, i.e. one end should be associated with endpoint 'x' and the other end should be associated with endpoint 'y' on the other router
- If both an ICB and a SAP coexist in an endpoint, the ICB will forward traffic only if the SAP goes down
- If an ICB exists together with other spoke-SDP's in an endpoint, the ICB will forward traffic only if the other spokes are not active
- ICB's cannot forward traffic between each other on the same node

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – ICB Spokes: Configuration




```
*A:PE1# configure service epipe 10
*A:PE1>config>service>epipe# info
----------------------------------------------
            endpoint "x" create
            exit
            endpoint "y" create
            exit
            sap lag-1 endpoint "x" create
            exit
            spoke-sdp 12:10 endpoint "y" create
            exit
            spoke-sdp 13:10 endpoint "y" create
            exit
            spoke-sdp 14:11 endpoint x icb create
            exit
            spoke-sdp 14:12 endpoint y icb create
            exit
            no shutdown
----------------------------------------------
```

NOTE: Remember to use the "icb" keyword while provisioning the ICB spokes.

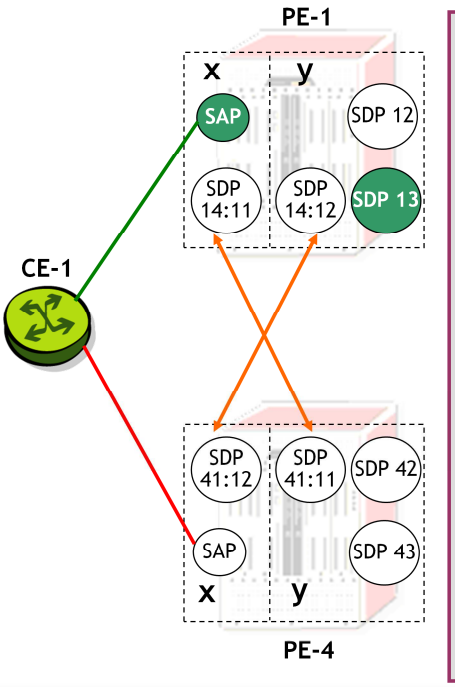
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Similar configuration should be done on all the other PE's.

- Two spoke SDP bindings are created pointing to the same PE.
- The VC-ID's pointing to each other on the two boxes need to match.
- A VC-ID has to be unique per SDP, i.e. it cannot be used twice for the same SDP.
- Therefore two different VC-ID's have been arbitrarily chosen (11&12 in this example).
- Two SDP's pointing to the other PE could be created (i.e. SDP 12 AND SDP13 on PE-1) but this is not necessary as the far-end is the same and can be considered as a waste of resources.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – CLI: Endpoints with ICB Spokes




```
*A:PE1# show service id 10 endpoint

===============================================
Service 10 endpoints
===============================================
Endpoint name       : x
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : lag-1
-----------------------------------------------
Members
-----------------------------------------------
SAP                 : lag-1
Spoke-sdp           : 14:11 Precedence:4 (icb)
===============================================
Endpoint name       : y
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 13:10
-----------------------------------------------
Members
-----------------------------------------------
Spoke-sdp           : 12:10 Precedence:4
Spoke-sdp           : 13:10 Precedence:4
Spoke-sdp           : 14:12 Precedence:4 (icb)
===============================================
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

ICB Spoke SDP's are also added to the "show service id X endpoint" output in which they are denoted as type (icb).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Service States with ICB Spokes

```
*A:PE1# show service service-using

===================================
Services
===================================
ServiceId    Type       Adm    Opr
-----------------------------------
10           Epipe      Up     Up
-----------------------------------
Matching Services : 1
-----------------------------------
```

```
*A:PE2# show service service-using

===================================
Services
===================================
ServiceId    Type       Adm    Opr
-----------------------------------
10           Epipe      Up     Up
-----------------------------------
Matching Services : 1
-----------------------------------
```

```
*A:PE4# show service service-using

===================================
Services
===================================
ServiceId    Type       Adm    Opr
-----------------------------------
10           Epipe      Up     Up
-----------------------------------
Matching Services : 1
-----------------------------------
```

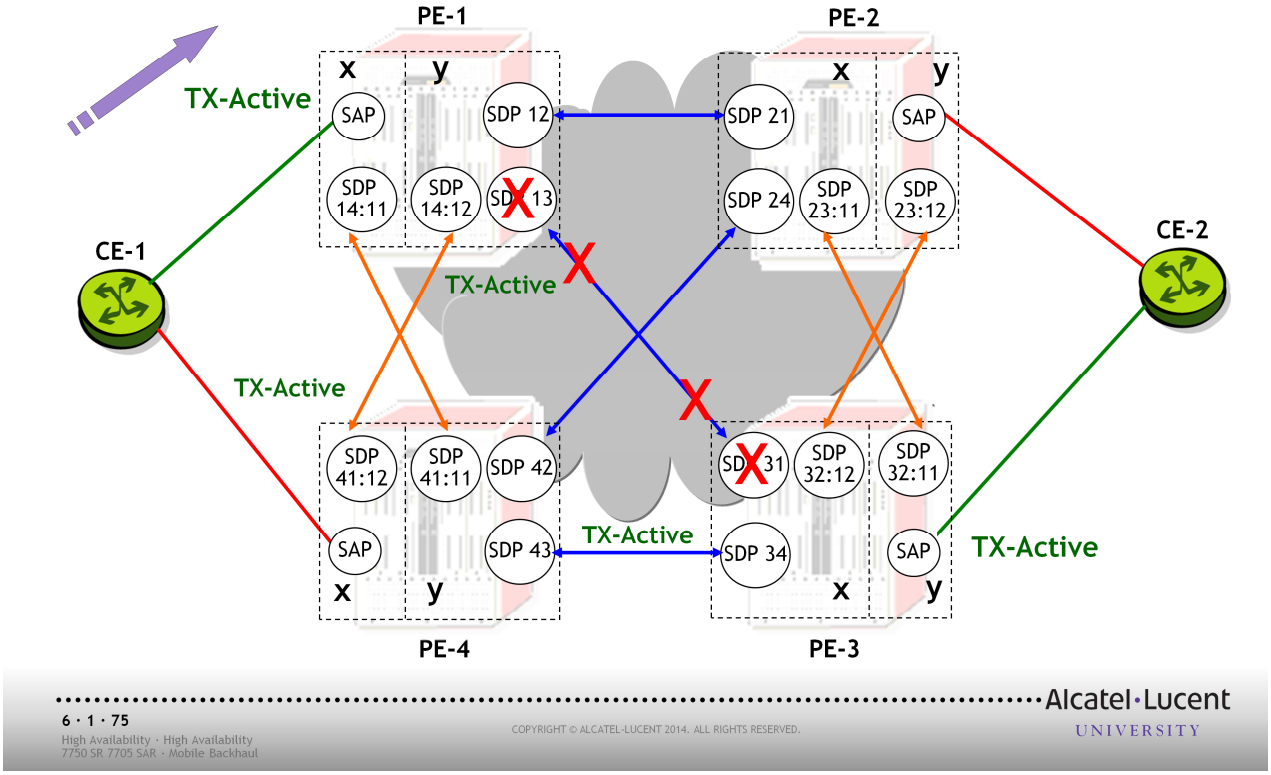
```
*A:PE3# show service service-using

===================================
Services
===================================
ServiceId    Type       Adm    Opr
-----------------------------------
10           Epipe      Up     Up
-----------------------------------
Matching Services : 1
-----------------------------------
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

After introducing the ICB Spokes, the service states on all the PE routers now transition all to operational UP state, regardless of their active/standby SAP status.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: SDP Failure with ICB(1)



(1) SDP's are unidirectional, so traffic flows need to be investigated separately in both directions. We will start by considering a flow from CE-1 to CE-2 in left-to-right direction.

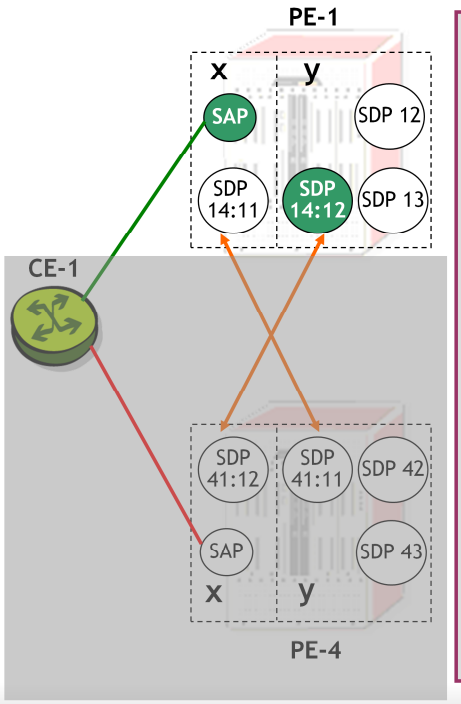
In case of an SDP failure (such as an administrative SDP shutdown), traffic is now switched over the ICB spoke 14:12 to reach PE-3, which has the active LAG on the other end.

Fundamental E-pipe forwarding rules still apply here: If traffic is received from an "x" endpoint, it has to be forwarded to "y" and vice versa.

Since the traffic is received on the SAP in endpoint X on PE-1, it needs to be handed to "y" on the same box and not immediately to the ICB spoke "14:11" in the same endpoint "x".

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – CLI: SDP Failure with ICB – PE1




```
*A:PE1# show service id 10 endpoint

===============================================
Service 10 endpoints
===============================================
Endpoint name       : x
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : lag-1
-----------------------------------------------
Members
-----------------------------------------------
SAP                 : lag-1
Spoke-sdp           : 14:11 Precedence:4 (icb)
===============================================
Endpoint name       : y
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 14:12
-----------------------------------------------
Members
-----------------------------------------------
Spoke-sdp           : 12:10 Precedence:4
Spoke-sdp           : 13:10 Precedence:4
Spoke-sdp           : 14:12 Precedence:4 (icb)
===============================================
```

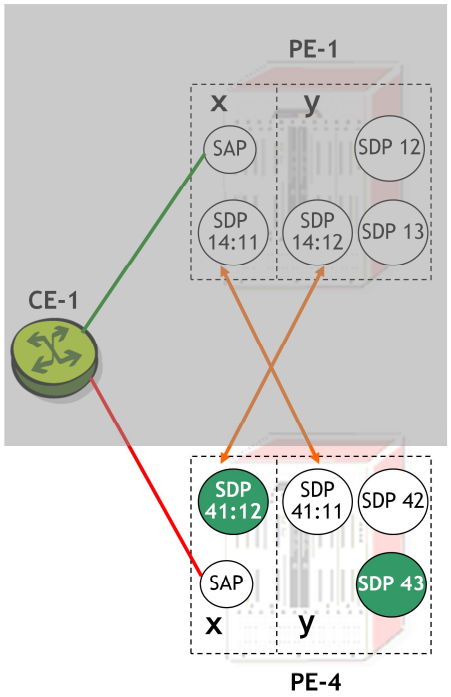

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

To trace the path of traffic flow, “show service id x endpoint” command can again serve to be useful here.

Checking on PE-1, it is visible that traffic is received on LAG-1 in endpoint x and delivered via ICB spoke 14:12 in endpoint y to PE-4.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – CLI: SDP Failure with ICB – PE4



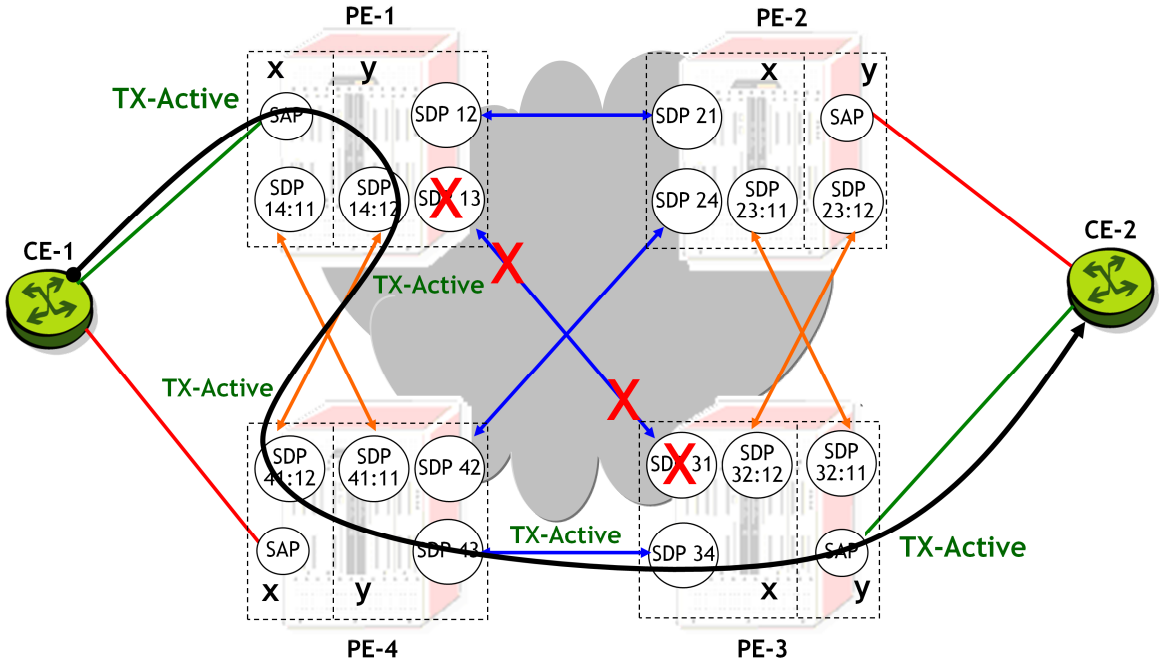

```
*A:PE4# show service id 10 endpoint

===============================================
Service 10 endpoints
===============================================
Endpoint name       : x
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 41:12
-----------------------------------------------
Members
-----------------------------------------------
SAP                 : lag-1
Spoke-sdp           : 41:12 Precedence:4 (icb)
===============================================
Endpoint name       : y
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 43:10
-----------------------------------------------
Members
-----------------------------------------------
Spoke-sdp           : 41:11 Precedence:4 (icb)
Spoke-sdp           : 42:10 Precedence:4
Spoke-sdp           : 43:10 Precedence:4
===============================================
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

On PE-4, traffic is received on ICB spoke 41:12 in endpoint x and delivered to PE-3 via SDP 43:10 in endpoint y.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

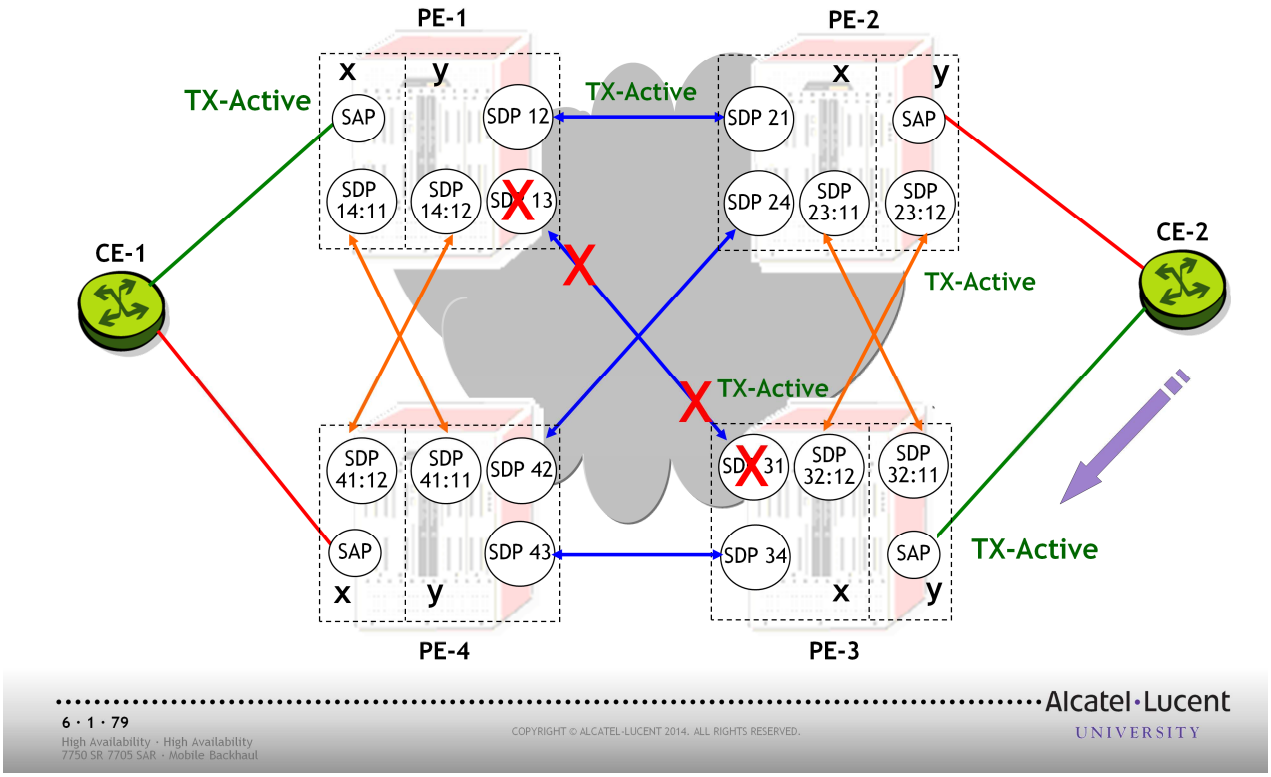
PW Redundancy – Convergence: SDP Failure with ICB(1)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: SDP Failure with ICB(2)



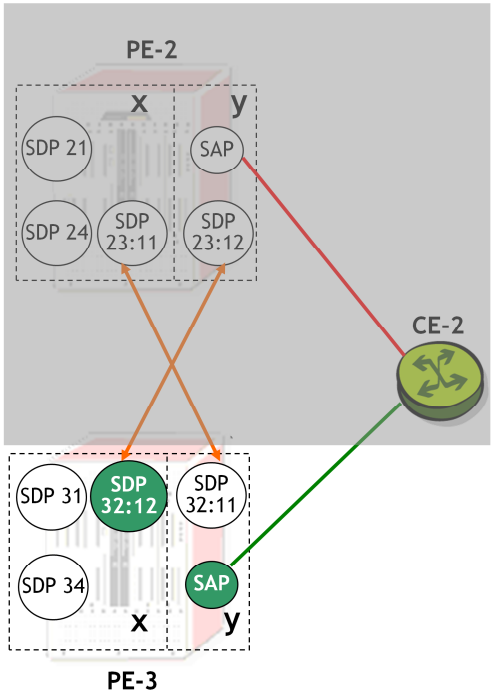
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

(2) For traffic flow from CE-2 to CE-1, i.e. in right-to-left direction, traffic is now switched over the ICB spoke 32:12 to reach PE-1 which has the active SAP on the other end.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – CLI: SDP Failure with ICB – PE3

```
*A:PE3# show service id 10 endpoint

===============================================
Service 10 endpoints
===============================================
Endpoint name       : x
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 32:12
-----------------------------------------------
Members
-----------------------------------------------
Spoke-sdp           : 31:10 Precedence:4
Spoke-sdp           : 32:12 Precedence:4 (icb)
Spoke-sdp           : 34:10 Precedence:4
===============================================
Endpoint name       : y
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : lag-1
-----------------------------------------------
Members
-----------------------------------------------
SAP                 : lag-1
Spoke-sdp           : 32:11 Precedence:4 (icb)
===============================================
```



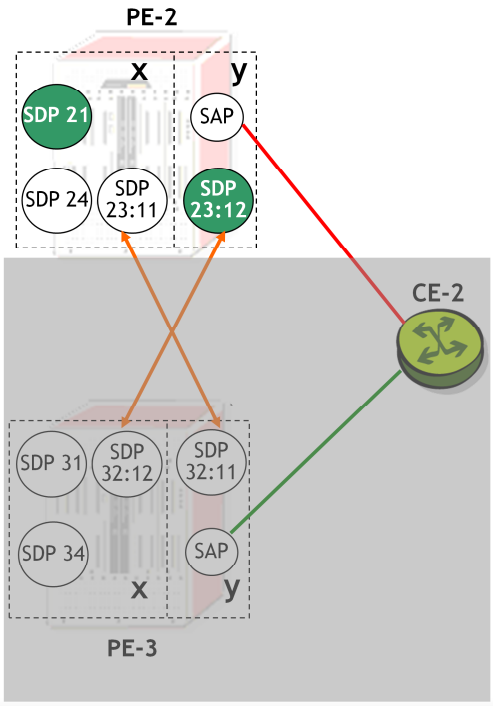
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Checking on PE-3, it is visible that traffic is received on LAG-1 in endpoint y and delivered via ICB spoke 32:12 in endpoint x to PE-2.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – CLI: SDP Failure with ICB – PE2

```
*A:PE2# show service id 10 endpoint

===============================================
Service 10 endpoints
===============================================
Endpoint name       : x
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 21:10
-----------------------------------------------
Members
-----------------------------------------------
Spoke-sdp           : 21:10 Precedence:4
Spoke-sdp           : 23:11 Precedence:4 (icb)
Spoke-sdp           : 24:10 Precedence:4
===============================================
Endpoint name       : y
Revert time         : 0
Act Hold Delay      : 0
Tx Active           : 23:12
-----------------------------------------------
Members
-----------------------------------------------
SAP                 : lag-1
Spoke-sdp           : 23:12 Precedence:4 (icb)
===============================================
```

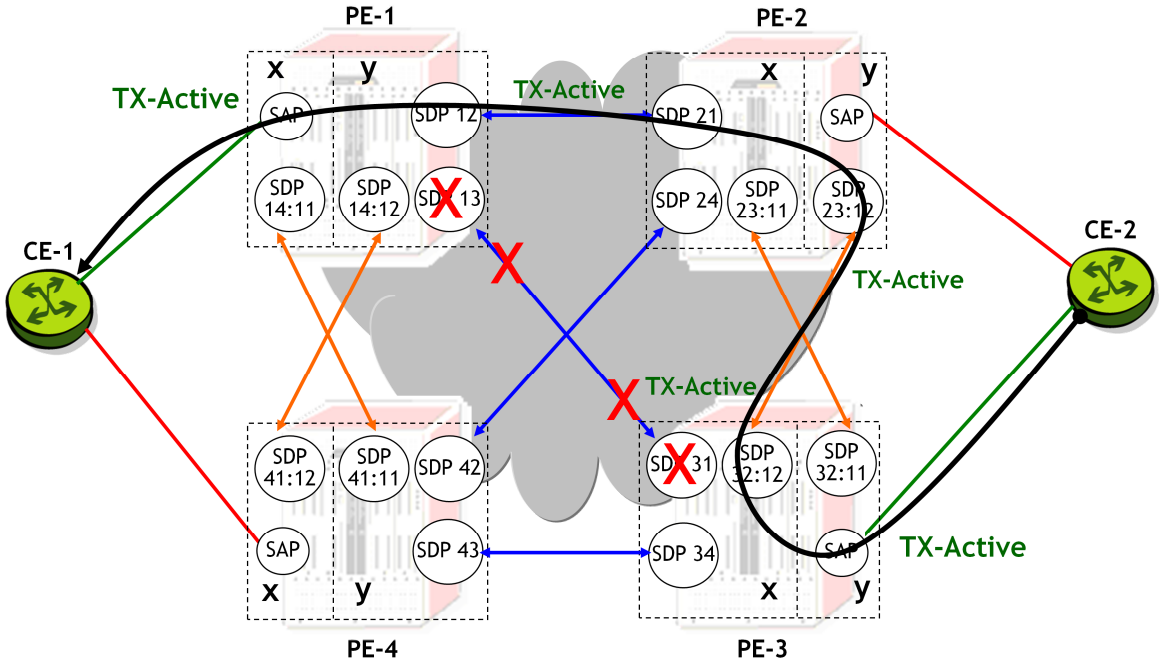


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

On PE-2, traffic is received on ICB spoke 23:12 in endpoint y and delivered to PE-1 via SDP 21:10 in endpoint x.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

PW Redundancy – Convergence: SDP Failure with ICB(2)



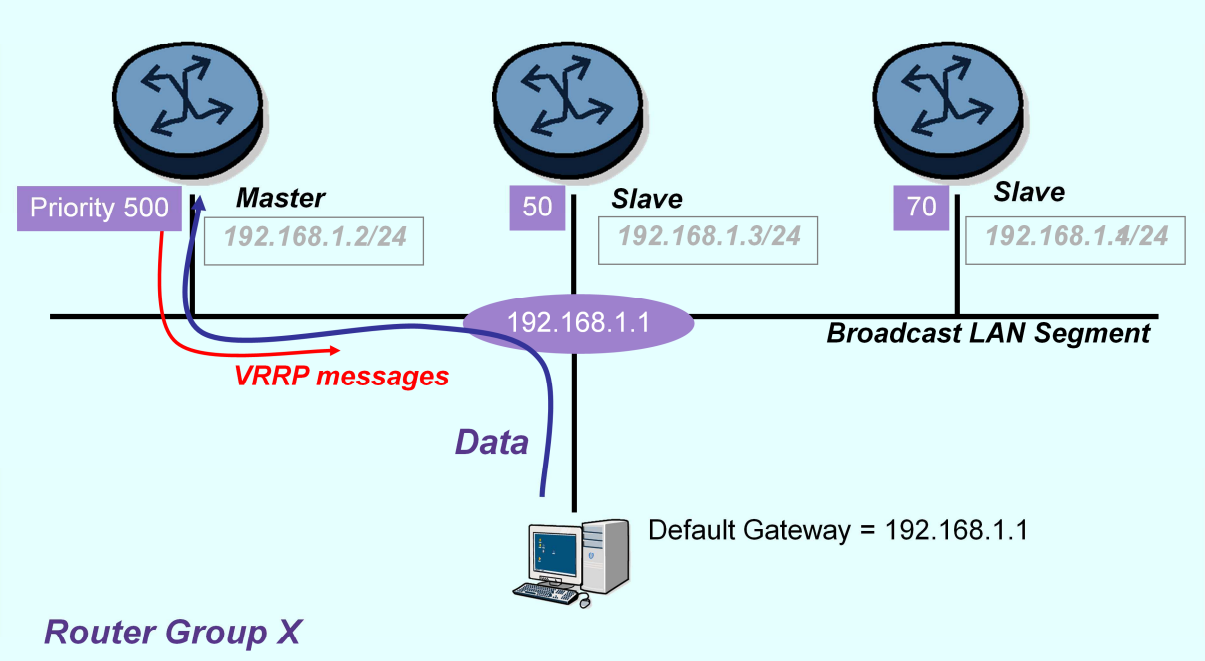
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.
TER36075_V3.1-SG-English-Ed1 Module 6.1 Edition 1

8 Virtual Router Redundancy Protocol (VRRP)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

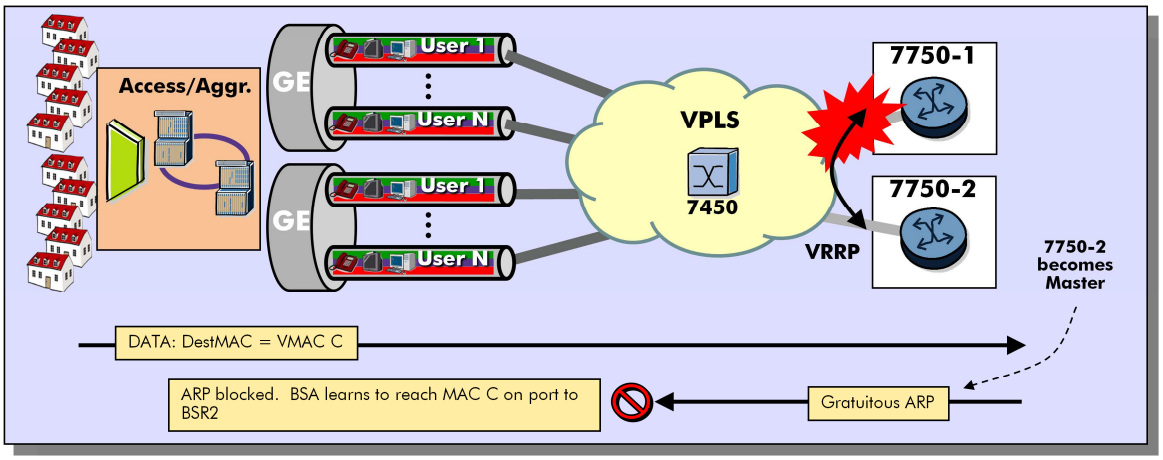
VRRP Virtual Router Redundancy Protocol



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VRRP Access Side



VRRP: Virtual Router Redundancy Protocol

Home PCs have a default gateway to send all traffic to.

This BSR could become unavailable => all connectivity is dropped

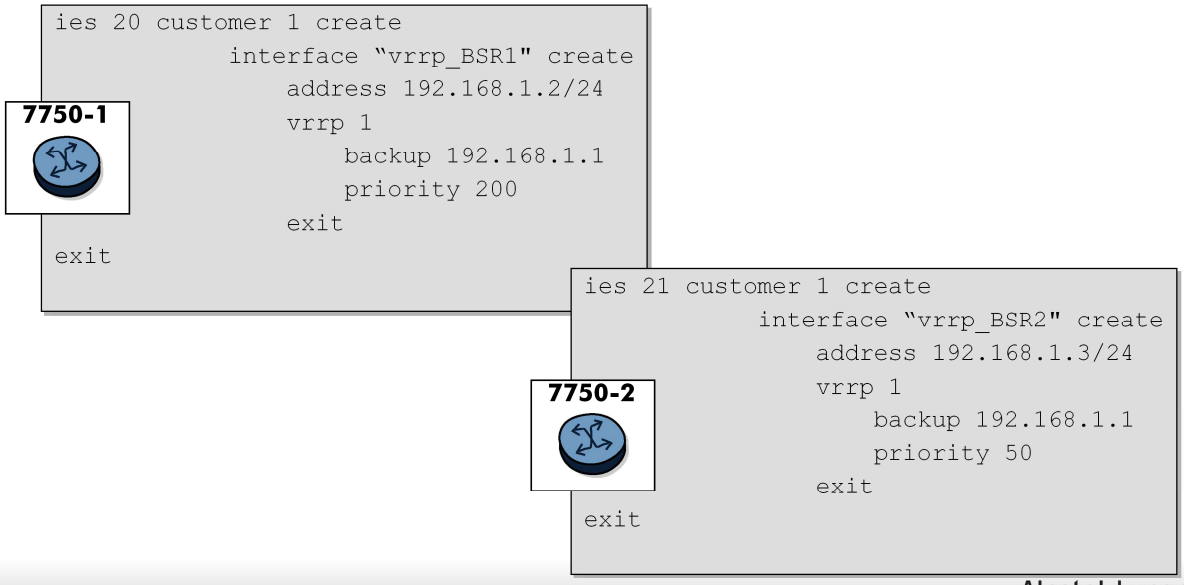
Solution: Have a redundant slave BSR next to master BSR that takes over when master fails.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VRRP Access Side

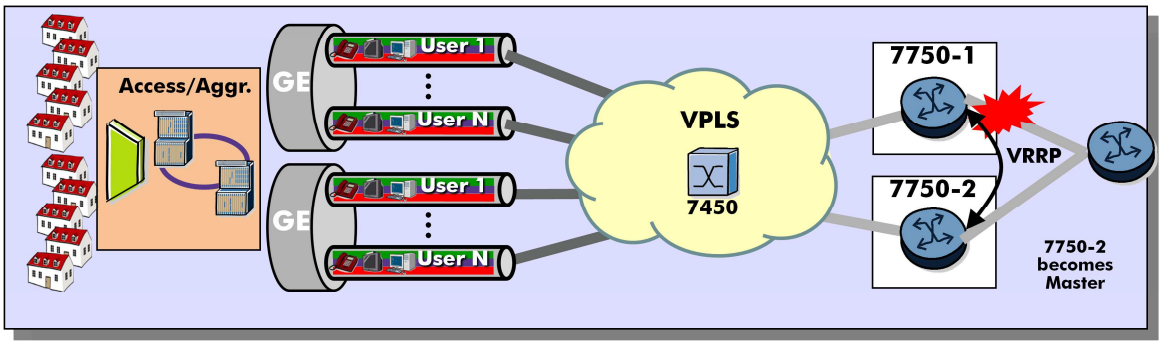
VRRP is configured between L3 Interfaces on different BSR's
Highest priority becomes the VRRP Master



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VRRP Network Side



VRRP: Virtual Router Redundancy Protocol

Backbone P router has a next-hop pointing to BSR 1

This BSR could become unavailable => all connectivity is dropped

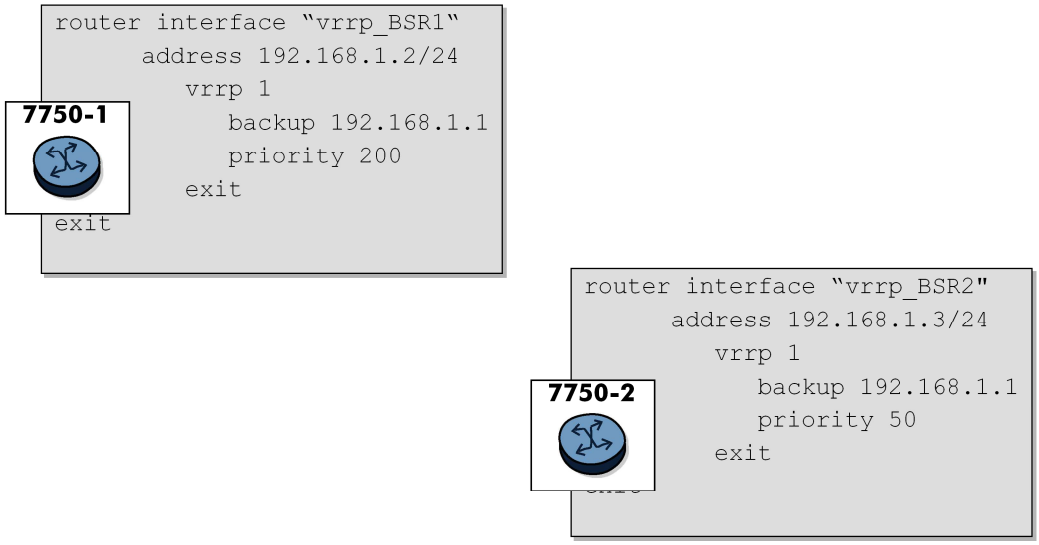
Solution: Have a redundant slave BSR next to master BSR that takes over when master fails.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VRRP Network Side

VRRP is configured between L3 Interfaces on different BSR's
Highest priority becomes the VRRP Master



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VRRP Policy

VRRP runs over a LAN and monitors master activity

When the master disappears, the next slave in line will become the master

Other events can trigger a switchover from slave to master

These events can be configured with a VRRP policy

```
configure vrrp policy 10
   priority-event
         route-unknown 172.31.78.0/24
         priority 201 explicit
   exit
exit
```

In this example when a certain subnet further in the network becomes unavailable, the slave becomes master

```
router interface "vrrp_BSR2"
      address 192.168.1.3/24
         vrrp 1
            backup 192.168.1.1
            priority 50
            policy 10
         exit
exit
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
High Availability

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 7
Ethernet OAM

Module 1
Ethernet OAM

TER36075_V3.1-SG-English-Ed1 Module 7.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives



Upon completion of this module, you should be able to:

- Describe the Ethernet OAM principles
- List the Ethernet CFM OAM components
- Identify the Ethernet CFM OAM functionality and tests
- Describe the EFM OAM functionality and operations

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

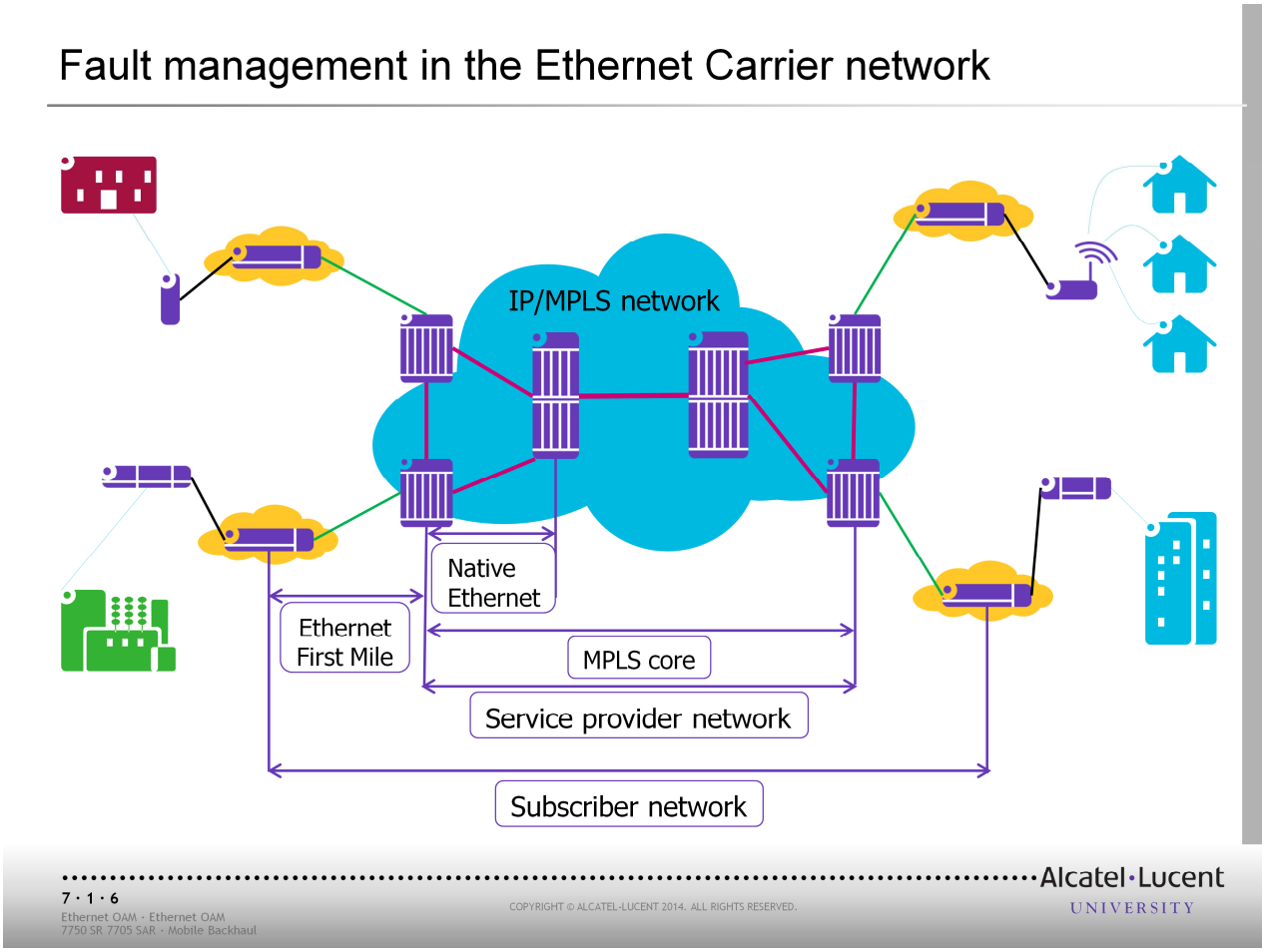
Table of Contents

	Page
1 — Service OAM overview	**7**
2 — Ethernet CFM OAM components	**11**
3 — Ethernet CFM OAM operations	**19**
4 — Ethernet in the First Mile OAM	**27**
5 — MPLS-Transport Profile (TP)	**33**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Service OAM overview

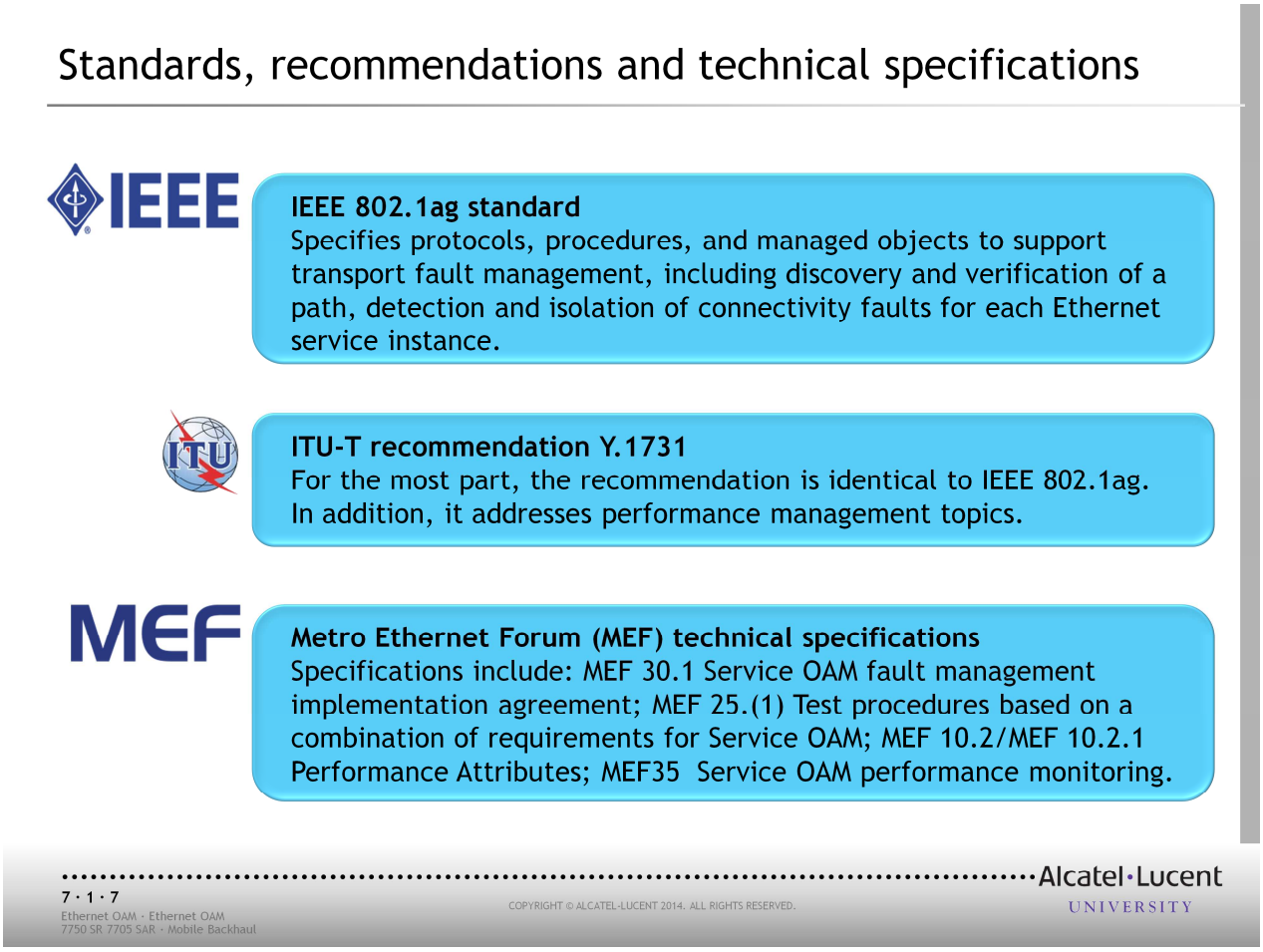
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Today's complex networks and service deployments require reliable mechanisms to quickly isolate and manage failures. The responsibilities for monitoring and managing network segments are divided among the entities to which the segments belong. The Ethernet service OAM kit includes tools that can accurately localize problems in the network so that an automatic or manual action can be taken.

The service OAM tool kit is based on the contribution of recognized organizations, which have been working in close cooperation to develop complementary and compatible standards, recommendations and technical specifications for multi-domain Ethernet Service OAM.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



The organizations have collaborated closely to work out interoperability issues among common functions. Their contribution is based on years of experience that can be applied to the technology to facilitate a better understanding of the following OAM-related topics:

- architectural components
- complexity and risks
- tool kit components and deployment options.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service OAM overview

Service OAM architectural considerations
The Service OAM architecture is based on the standards, recommendations and specifications outlined on the previous slide. The OAM architectural considerations define the OAM tool kit behavior and functionality applicable to Carrier Ethernet, with suggested defaults.

Fault management
The Service OAM kit deploys tools to locate and isolate fault conditions. The tools perform on-demand testing of connectivity and service continuity, as well as path validation. They also check proactively network segment connectivity with optional network convergence.

Performance monitoring
The Service OAM performance monitoring tools capture key performance metrics. They perform on-demand monitoring of services and network segments of concern over time, as well as proactive reporting of measurements of network segments and services.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This slide provides a high-level service OAM overview, as well as descriptions of the fault management and performance monitoring functions, as defined in the IEEE, ITU-T and MEF contributions.

The IEEE, ITU-T and MEF continue their collaboration on improving the tool interoperability and on adding new functions.

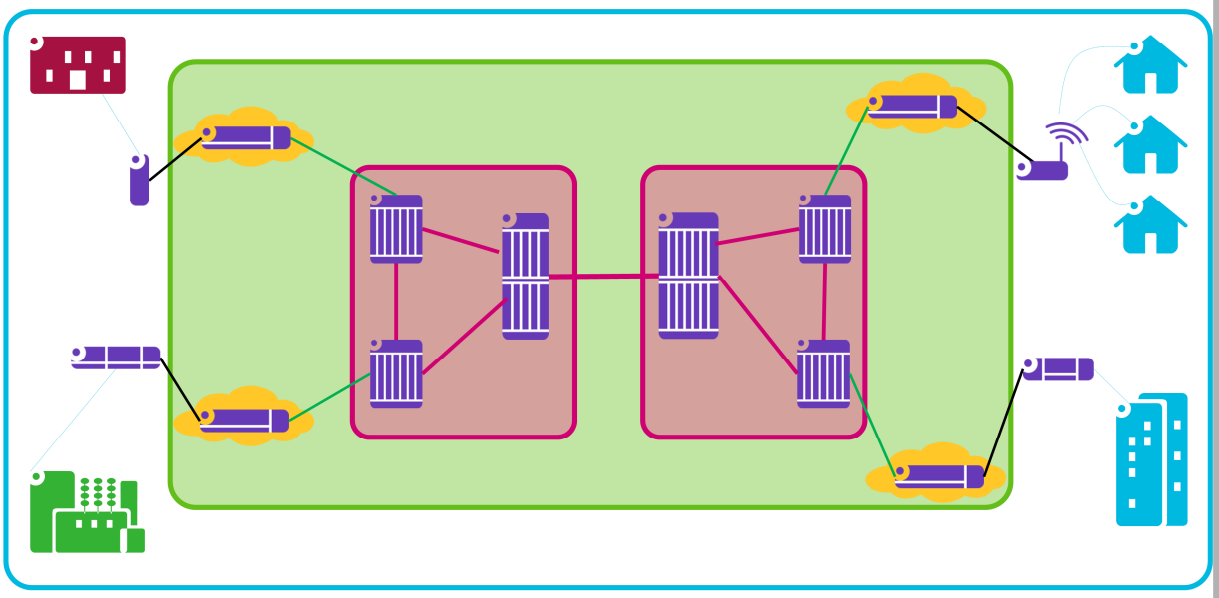
The next section describes the Service OAM components.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Ethernet CFM OAM components

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Hierarchical model



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The service OAM implements a hierarchical model that includes domains or entities with administrative scope and reach. The principles that govern the definition of components include the following:

•The wider-scope components are transparent to the narrower-scope components.

•The end-to-end network is divided into areas of responsibilities or roles.

•The network areas include endpoints that define closed management groups.

•The definition of areas of responsibilities or roles is based on segments of the end-to-end network.

This slide shows an end-to-end network divided into administrative domains or management entities.

The next slide describes the service OAM components.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

CFM OAM components

IEEE 802.1ag name	ITU-T Y.1731 name	Function
Maintenance Domain (MD)	Maintenance Entity (ME)	Administrative scope and reach
Maintenance Domain Level	MEG Level	Numerical identifier of the domain
Maintenance Association (MA)	Maintenance Entity Group (MEG)	Grouping of service endpoints
Maintenance Association Endpoint (MEP)	MEG Endpoint (MEP)	Terminating and origination endpoints
Maintenance Association Intermediate Point (MIP)	MEG Intermediate Point (MIP)	Management points between endpoints

The SR-OS service OAM implements the IEEE 802.1ag standard and uses its terminology

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This slide describes the service OAM components, as defined in the IEEE, ITU-T and MEF contributions to the service OAM architecture and functionality. The IEEE 802.1ag standard, ITU-T Y.1731 recommendation and MEF specifications are complementary. However, the SR-OS implements the service OAM tool kit according to the concepts and principles of the IEEE 802.1ag standard, also referred to as the Ethernet Continuity Fault Management (CFM) standard. The standard provides for consistent service monitoring and tools to isolate faults and to verify connectivity between two points.

The standard includes concepts such as the following:

•Maintenance Domains and Associations used to define the scope of CFM operations

•relationship between Maintenance Domains and services that are being monitored or tested

•protocols and procedures to maintain and diagnose connectivity problems

•provisions for future expansion of service OAM functionality

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Ethernet CFM terminology

Term	Expansion	Definition
MD	Maintenance Domain	A network or part of a network (set of Ethernet network elements or ports) controlled by an operator, and for which connectivity faults can be managed. MD boundaries are set by MEPs. In the SR-OS CLI command, it is identified by an md-index from 1 to 4294967295.
MD Level	Maintenance Domain Level	A user-configured value of 0 to 7 representing the hierarchy level of a given MD within a CFM architecture. The value 7 is the highest MD level, and 0 is the lowest.
MA	Maintenance Association	A grouping of MEs that need to be managed as part of a given service. In the SR-OS CLI command, it is identified by an ma-index value from 1 to 4294967295.
MEP	Maintenance Association End Point	An edge point that can terminate, respond to, or initiate OAM messages for a configured MA-MD combination
ME	Maintenance Entity	An Ethernet port or endpoint that is managed as part of Ethernet CFM OAM. An endpoint can be a SAP or a spoke-SDP object.
MIP	Maintenance Association Intermediate Point	An intermediate point that can forward or respond to OAM messages initiated by MEPs in the same MD. Connectivity fault management (CFM) messages intended for other MIPs or MEPs are transparent to MIPs. The 7705 SAR does not supports MIPs.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The table provided on this slide builds on the concepts introduced on the previous slide, and defines commonly used Ethernet CFM terms. To apply the service OAM tools, you need to configure the Ethernet CFM components such as a Maintenance Domain Level, Maintenance Associations, and Maintenance Association End points. You perform these operations in the **`configure>eth-cfm`** context of the SR-OS CLI.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ETH-CFM SR-OS configuration

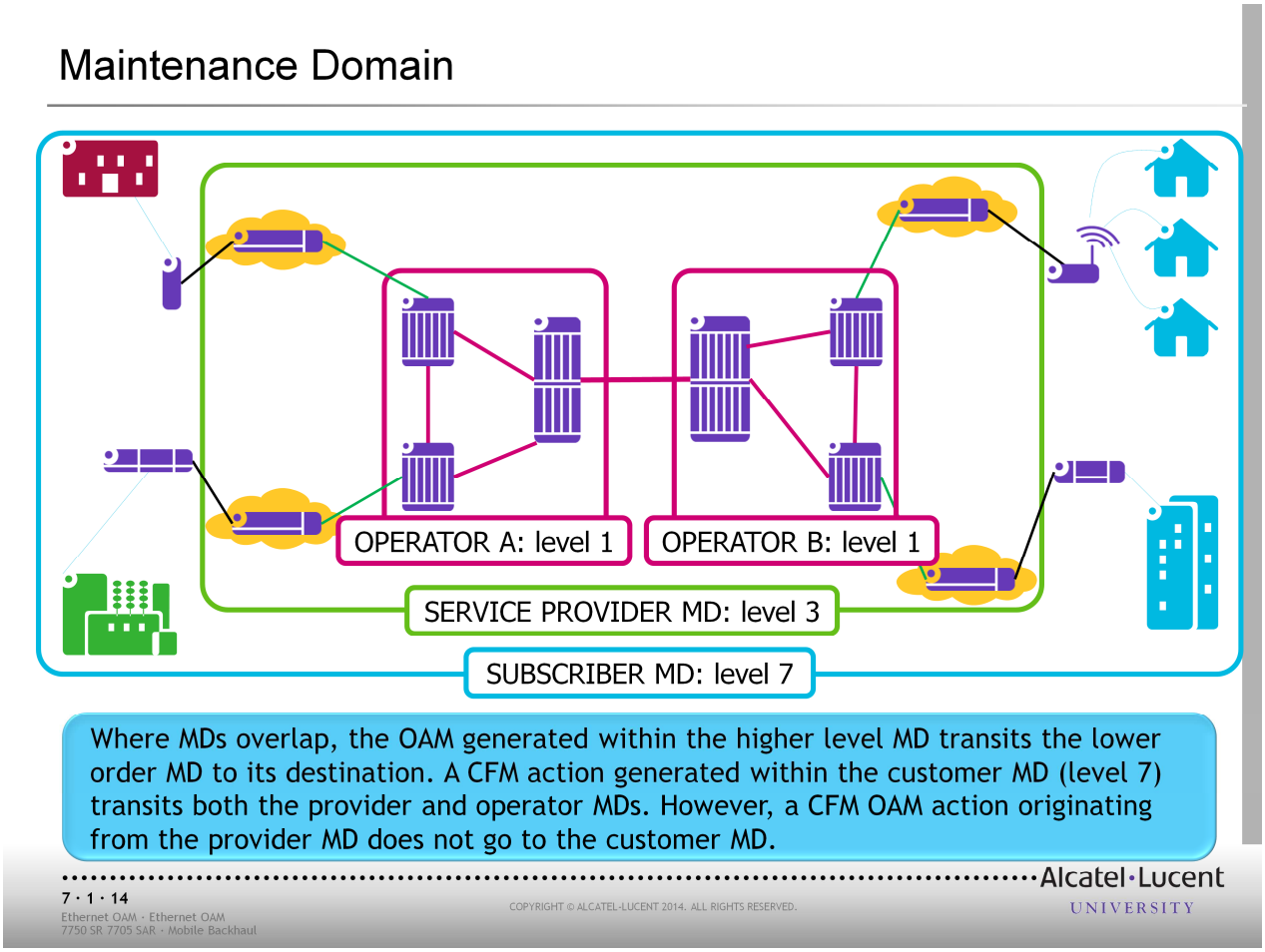
```
A:PE1# configure eth-cfm
  - eth-cfm

 [no] domain           + Configure Connectivity Fault Management domain parameters
      redundancy       + Configure Connectivity Fault Management Redundancy parameters
      slm              + Configure Connectivity Fault Management Synthetic Loss Measurement
parameters
      system           + Configure Connectivity Fault Management General System parameters

A:PE1>config>eth-cfm# domain
  - domain <md-index> [format {dns|mac|none|string}] [name <md-name>] level
    <level>
  - domain <md-index>
  - no domain <md-index>

 <md-index>            : [1..4294967295]
 <dns|mac|none|stri*>  : keywords - format of the md-name: Default string
                           dns           - dns name format
                           mac           - X:X:X:X:X:X-u
                                           X - [0..FF]h
                                           u - [0..65535]d
                           none          - no name specified
                           string        - ascii string
 <md-name>             : Maintenance Domain Name (1..43 characters)
 <level>               : [0..7]


 [no] association      +  Configure a Maintenance Association for the Domain
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This slide gives you an idea of the commands required to configure the Ethernet CFM tools in the SR-OS CLI. Detailed configuration information is provided in the lab associated with this module.

The output captured on this slide shows the **`configure>eth-cfm`** context of the SR-OS CLI, which gives you access to the ETH CFM configuration commands. First, you need to configure a maintenance domain. The SR-OS CLI context of a configured maintenance domain allows you to create and configure a maintenance association and its parameters.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Now let us review the Ethernet CFM components. This slide describes the Maintenance Domain component.

The Ethernet CFM (ETH-CFM) mechanism is based on the principle that maintenance actions are contained within a defined scope, or service. The admin scope component is the Maintenance Domain (MD). An MD is a provider-defined administrative container used to define the scope, reach and boundary for the fault monitoring actions of the application. The MD is identified by a name and a level that you can define in the SR-OS.

The IEEE 802.1ag specifies 8 MD levels ranging from 0 to 7, with 0 being the lowest level and 7 being the highest level. Higher numbered levels indicate larger spans within the network. An end-to-end network includes the following MD types:

•The subscriber MD extends between routers, usually including the SAPs, and is assigned level 6 or 7.

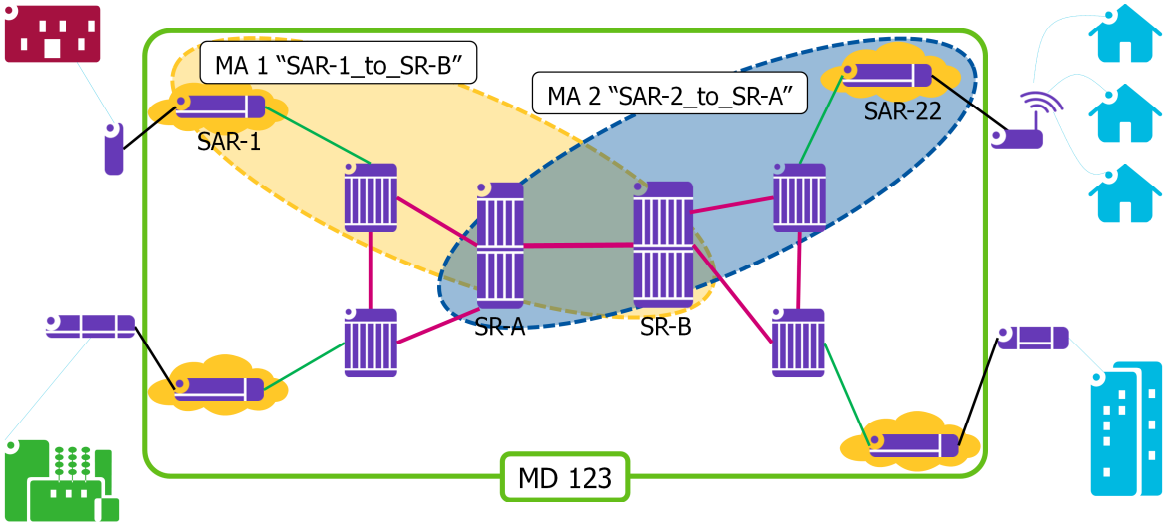
•The service provider MD extends across the core routers, and is usually assigned levels 3 to 5.

•The operator MD typically extends from one provider core to the interface with another provider network, and has the shortest span. The operator MD is usually assigned level 1 or 2.

Where MDs overlap, the OAM generated within the higher level MD transits the lower order MD to its destination. However, a lower order MD OAM action does not transit a higher level MD. A CFM action generated within the customer MD (level 7) transits both the provider and operator MDs. However, a CFM OAM action originating from the provider MD does not go to the customer MD.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Maintenance Association



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A maintenance association is a closed group of management end points. The MA allows service providers to segment their service topology to better isolate fault locations. The ETH-CFM enables this segmentation through the implementation of MAs. Each MD needs to have at least one MA defined within the MD span, even though the service providers can define as many MAs as they require to monitor services within the scaling limits of the SR-OS router.

To create an MA, you need to configure a unique MA ID, format type and name.

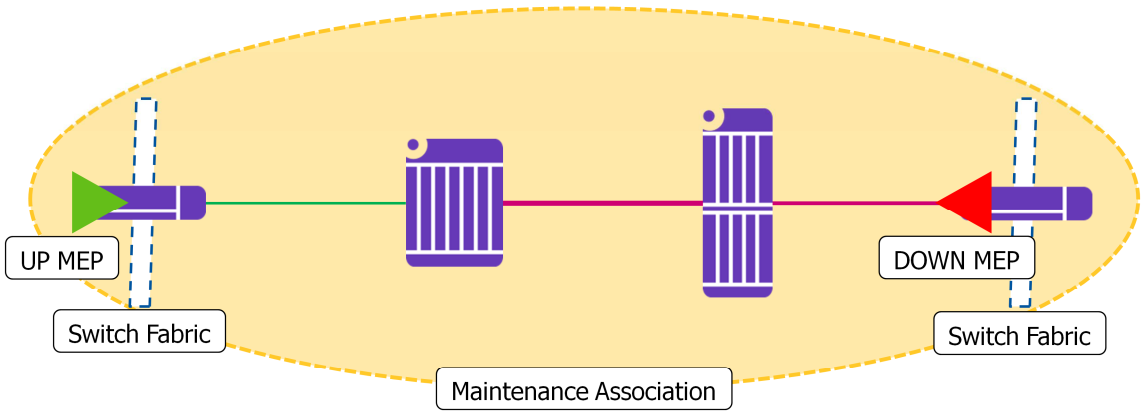
This slide illustrates the segmentation of the service contained within MD 123 into 2 MAs:

•MA 1, named "SAR-1_to_SR-B"

•MA 2, named "SAR-2_to_SR-A"

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Maintenance Association Endpoint



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

We have learned from the previous slides that the MDs and MAs define the span of the ETH-CFM actions. The MEP is a logical construct that processes Ethernet-type 0x8902 frames (SOAM) and prevents them from flowing outside of the scope of responsibility. The MEP originates or terminates all ETH-CFM actions.

A MEP is defined at the limits of an MA and consists of a unique ID, within the range of 0 to 8191. The combination of the MEP ID and MA uniquely identifies the MEP within the MD.

A MEP has an attribute that defines the direction of flow of the Ethernet SOAM frame relative to the router Switch Fabric:

•UP—the ETH-CFM frame is sent into the service (through the Switch Fabric), and away from the entity on which the MEP was created

•DOWN—the ETH-CFM frame is sent out of the service (away from the Switch Fabric) on the entity on which the MEP was created

A MEP has also an Active or Passive side:

•Active—frames are compared to the existing level and processed accordingly

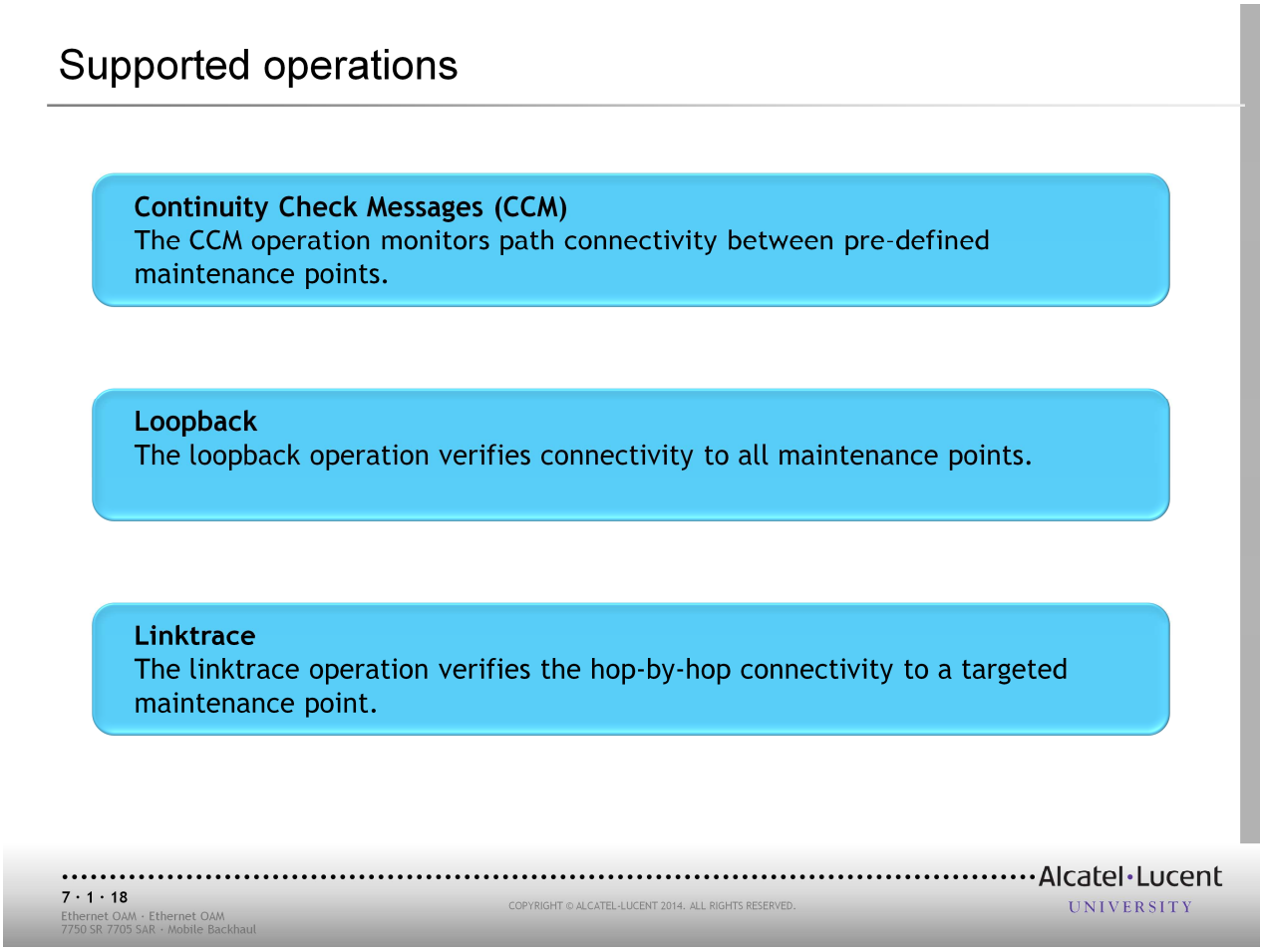
•Passive—packets are passed transparently through the MEP

The MEPs define which Service Access Points (SAPs) or Service Distribution Points (SDPs) actively run the CFM.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 Ethernet CFM OAM operations

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



The IEEE 802.1ag CFM standard addresses the issue of monitoring service continuity within an Ethernet environment. The CFM implementation establishes maintenance boundaries (MDs and MAs) and enables mechanisms to generate, process and terminate CFM packets (MEPs and MIPs). With these components in place, the IEEE 802.1ag CFM defines operations to monitor path status and to provide tools to help isolate failure locations.

The Continuity Fault Management supports the following operations:

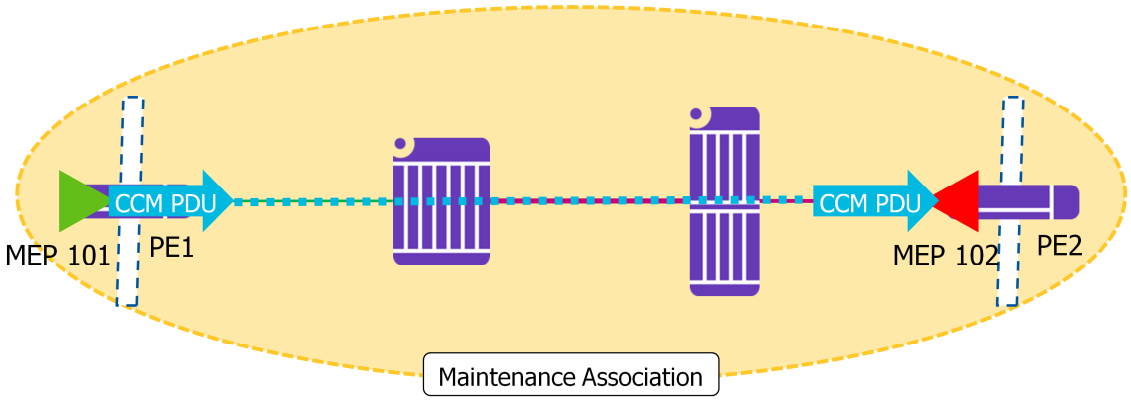
•Continuity Check Messages (CCM)

•Loopback

•Linktrace

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Continuity Check Messages



The CCM is a multicast frame generated by a MEP and sent to its remote MEPs in the same MA. The originating MEP does not require a reply message. To identify faults, the receiving MEP maintains a MEP database with the MAC addresses of the remote MEPs with which it expects to maintain connectivity checking. If there is no CCM from a monitored remote MEP in a preconfigured period, the local (receiving) MEP raises an alarm.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The CFM monitors path connectivity through the use of Continuity Check Messages (CCM). The CCM is 100-byte PDU multicast frame generated by the MEP and sent to all the MEPs in the same MA.

You need to enable the CCM manually in the MEP configuration context. Once enabled, the MEP sends CCM frames at a time interval that can be configured with a value from 10 milliseconds to 600 seconds. The default value is 10 seconds.

The originating MEP does not track the sent frame and does not expect a response from the MEPs to which the frame was sent. Instead, the originating MEP maintains a list of MEPs from which it expects messages (the list of MEPs needs to be manually configured). The originating MEP waits the response for 3.5 CCM intervals (35 milliseconds to 2100 seconds—the default value is 35 seconds). After the wait time expires, the originating MEP declares a fault condition. The wait interval is not configurable—the SR-OS calculates it based on the CCM time interval.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ETH-CC failure conditions

Defect	Low Priority Defect	Description	Cause	Priority
DefNone	N/A	No faults in the association	Normal operations	N/A
DefRDICCM	allDef	Remote Detect Indication	Remote MEP is declaring a fault. This is a unidirectional failure.	1
DefMACStatus (default)	macRemErrXcon	MAC layer issue	A remote MEP indicates that a remote port or interface is not operational.	2
DefRemCCM	remErrXcon	No communication from remote peer	The MEP is not receiving CCMs from a configured peer. MEP	3
DefErrorCCM	errXcon	Local and remote configurations do not match required parameters	The CCM received from a remote MEP has inconsistent timers or lower MD level within the same MA. The MEP receives CCM with its own MEP ID within the same MA.	4
DefXconn	Xcon	Cross Connected Service	The MEP received CCMs from a different MA This can indicate that two services have merged or there is a configuration error, an incorrect association identification.	5

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The IEEE 802.1ag ETH-CFM covers service continuity checking in Ethernet-based networks to signal path failures and help isolate and identify fault conditions. This function is based on CCM frames that originate, are processed or are terminated on MEPs. When a MEP determines that a CCM is invalid, the MEP signals the condition as a alarm.

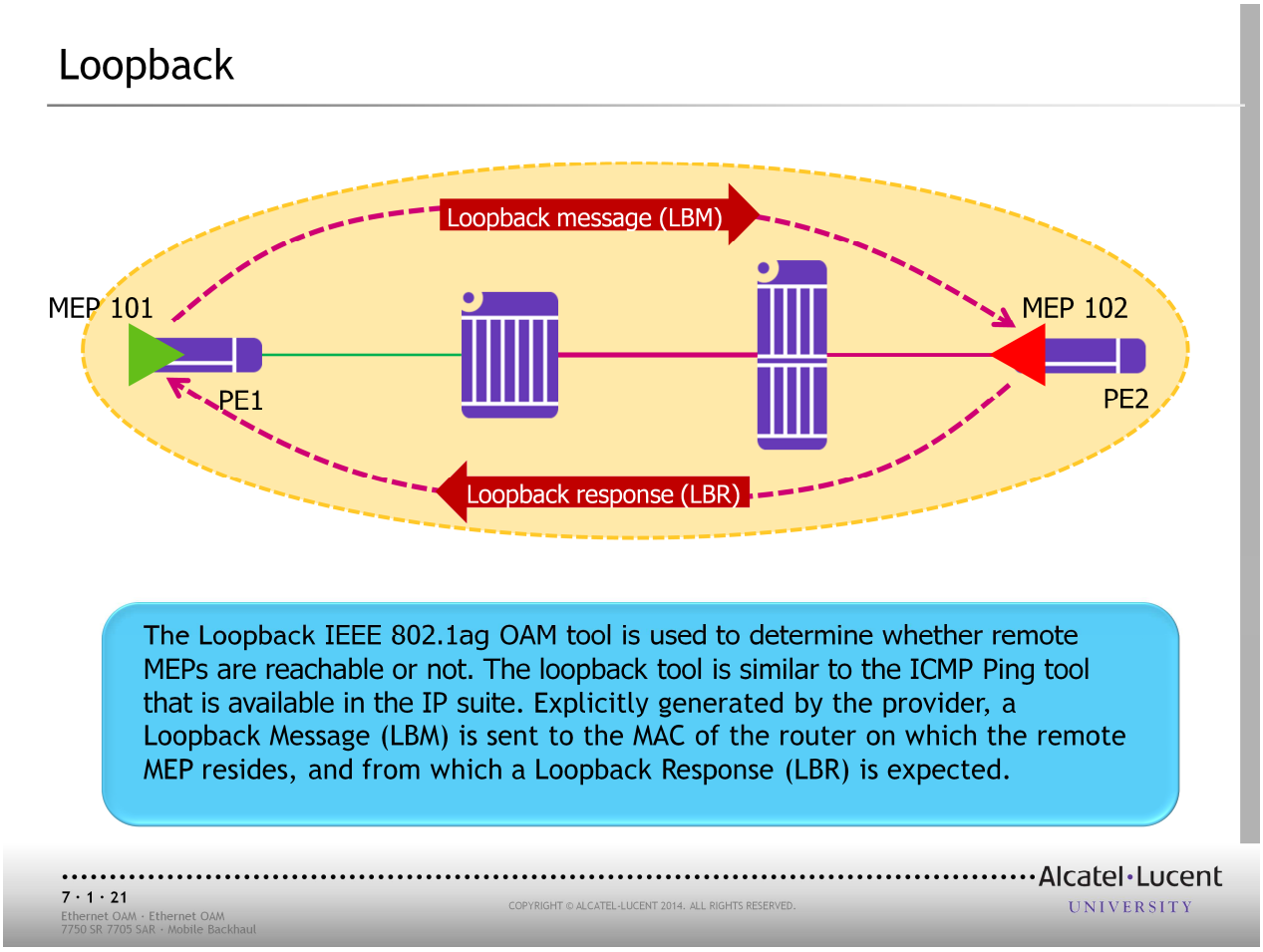
The IEEE 802.1ag standard specifies six failure conditions, described on this slide. Each failure condition is identified by the following attributes: Defect, Low Priority Defect and Priority Level.

The Defect is the fault condition that the system records in the logs, and the Priority Level sets the order in which the defects affect the service. For example, DefRemConn indicates that no CCM is being received from a remote MEP, and DefErrorCCM indicates an incorrect MEP configuration. Low Priority Defect is a label through which the provider can set a minimum level at which alarms are declared. An alarm is raised and a trap is sent if the defect is greater than or equal to the configured Low Priority Defect value. This feature enables providers to declare the alarms that are relevant to their configurations.

You can set this value using the `low-priority-defect` command in one of the following contexts:

- `config>service>epipe>sap>eth-cfm>mep`
- `config>service>epipe>spoke-sdp>eth-cfm>mep`

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Once enabled, the CCM provides continuous path status monitoring. Once the CCM has declared a defect (alarm or fault condition), the service provider needs to determine where the break has occurred and then to take action to restore service as quickly as possible.

The IEEE 802.1ag CFM includes two test utilities to help the provider locate the failure by leveraging the presence of MEPs. These tools are the Loopback and Linktrace operations, which use OAM CFM messages to track the path and identify where the fault has occurred.

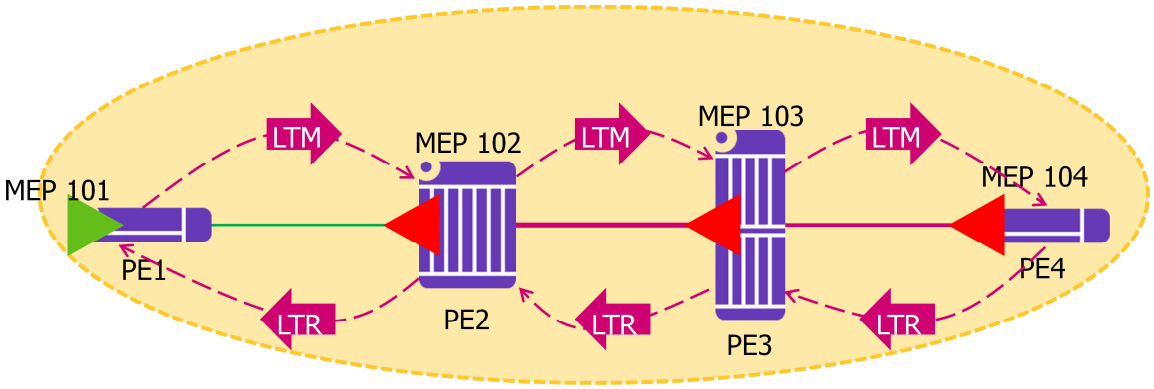
In the slide, an eth-cfm loopback test is generated from the PE1 router targeting the MAC address associated with the remote MEP on PE2. The MAC address can be statically assigned during the configuration procedures for the MEP.

The IEEE 802.1ag ETH-CFM Loopback is a unicast mechanism that targets defined MAC addresses. An individual test is required for each MEP on the service path; this makes isolating the fault location more complex.

The IEEE 802.1ag has provided an enhancement in the form of a multicast Loopback OAM test. When the multicast parameter in used in running the test, the CFM sends an LBM to the multicast MAC 01:80:C2:00:00:3x, where x is the domain level in which the MA is configured. In the case of a multicast Loopback OAM test, all the MEPs respond with the MAC addresses of the NEs on which they are configured.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Linktrace



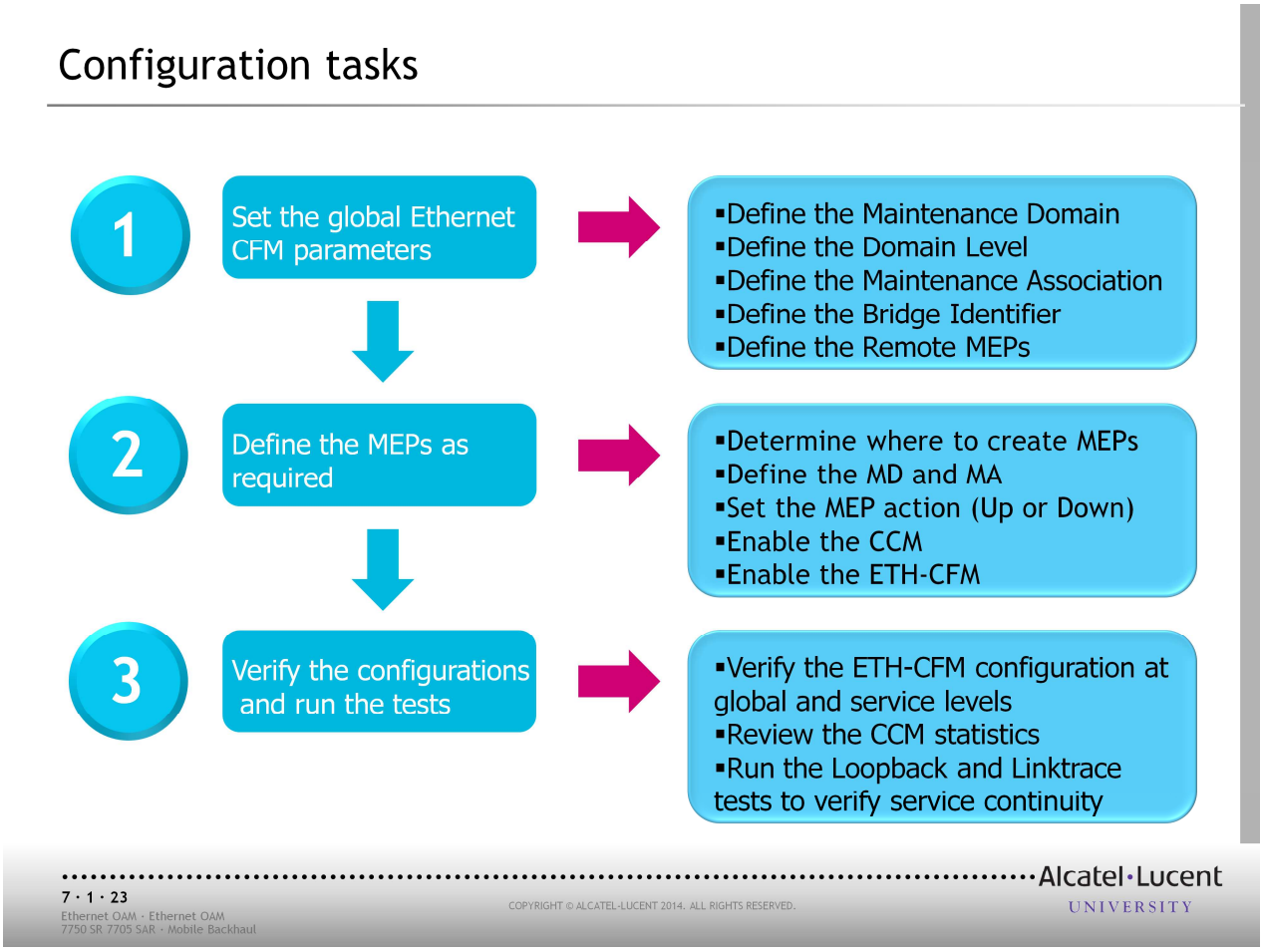
A Linktrace Message (LTM) is originated by a MEP and targeted to a peer MEP in the same MA and within the same MD level. The Linktrace tool is similar to traceroute in the IP suite. The peer MEP responds with a Linktrace Reply (LTR) message after successful inspection of the LTM. The LTMs are multicast, while the LTRs are unicast to the original source.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Linktrace is the second IEEE 802.1ag OAM tool that you can use to isolate failures in the service path. Linktrace allows the provider to determine the hop-by-hop continuity of the path from an originating MEP to a specific MAC address on the service path. The originating message is called the Linktrace Message (LTM), and the response message is called Linktrace Response (LTR).

All the MEPs with MAC addresses that are known by the router with the LTM-originating MEP generate an LTR. The originating router keeps track of all the LTRs and of the hop count to be able to list the responses in the appropriate order, simplifying the results for interpretation.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



This slide provides the high-level configuration steps required to perform the following tasks:

- Enable the IEEE 802.1ag ETH-CFM at the router global context.
- Configure MEPs in the service, as required.
- Verify 802.1ag configuration and run OAM tests to verify service continuity.

The student lab guide provides details about configuration commands and command syntax, as required.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ETH-CFM OAM operations

```
*A:SAR-1# oam eth-cfm
  - eth-cfm

      eth-test        - Issue an eth-cfm eth-test
      linktrace       - Issue an eth-cfm linktrace test
      loopback        - Issue an eth-cfm loopback test
      one-way-delay-* - Issue an eth-cfm one-way-delay-test
      single-ended-l* - Issue an eth-cfm single-ended-loss-test
      two-way-delay-* - Issue an eth-cfm two-way-delay-test
```

```
*A:SAR-1# show eth-cfm
  - eth-cfm

      association     - Show association information
      cfm-stack-table - Summarize all MEPs/MIPs
      domain          - Show domain information
      mep             - Show Maintenance Endpoint (MEP) information
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The commands to run ETH-CFM OAM operations are available in the `oam eth-cfm` SR-OS CLI context.

This slide shows the commands to run eth-cfm OAM tests, and to display information about configured eth-cfm components. For more details about eth-cfm OAM commands, see the lab guide section for this module.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Ethernet OAM Enhancements (SR-OS R12.0 R1 support)

Remote MEP Auto-Discovery:
The optional automatic discovery of remote MEPs (Maintenance Endpoints) using ETH-CC (Continuity Check) PDU (Protocol Data Unit) within an association is supported.

OAM- Performance Management (OAM-PM):
Service OAM performance-monitoring tools used for delay measurement (DMMv1) and synthetic loss measurement (SLM) can be configured to store results in fixed-time-based measurement intervals (15min, 1hr and 24hr) are supported. Delay measurement (Frame Delay, InterFrame Delay and Frame Delay Range) results will be stored in bins that are defined in microseconds by a lower threshold and an upper limit. The Mean Frame Delay is computed over the length of the measurement interval. SLM will track loss, availability and reliability.

ETH-AIS Y.1731:
ETH-AIS (Alarm Indication Signal) can now be triggered or cleared based on the state of the entity on which the DOWN MEP is configured. ETH-AIS pacing has been implemented to make the best use of AIS system resources.

ETH-CFM Tools Enhancement:
Loopback, Linktrace and Continuity Check ETH-CFM (Continuity Fault Management) PDUs can now be configured to include the SenderID TLV (Type-Length-Value). CC-enabled MEPs support configurable Fault Alarm Timers and Fault Reset Timers. Loopback now includes extended parameters and displays output for improved fault detection.

ETH-CFM Squelching:
Protection mechanisms already available for ETH-CFM are improved. ETH-CFM Squelching allows the operator to configure the Maintenance-Domain (MD)/Maintenance-Entity (ME) levels that will be silently dropped on ingress. When a squelch level is configured on an Ethernet SAP or binding, under the eth-cfm hierarchy, any ingress CFM packet that matches the SAP or binding and is equal to the configured squelch levels will be silently discarded. Down MEPs or ingress MIPs can be configured at or below the squelch level. However, squelch processing occurs prior to ETH-CFM processing. Those conflicting MPs will not receive any ETH-CFM frames on ingress.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

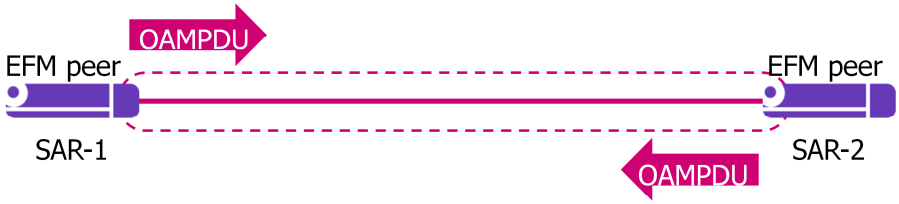
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 Ethernet in the First Mile OAM

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

EFM OAM overview

The IEEE 802.3ah Clause 57 defines the Ethernet in the First Mile (EFM) OAM sublayer, which is a link-level Ethernet OAM mechanism. The 7705 SAR supports the EFM OAM on Ethernet ports configured as network or access ports. The EFM OAM provides mechanisms for monitoring link operations such as remote fault indication and remote loopback control.



The EFM OAM defines a set of events that may impact link operation. The following events are supported:
- Link fault—the PHY layer found a fault in the receive direction of the local DTE
- Dying gasp—an unrecoverable local failure condition has occurred.
- Critical event—an unspecified critical event has occurred.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The EFM OAM gives network operators the ability to monitor the health of the network and to quickly determine the location of failing links or fault conditions.

The EFM OAM provides data link layer mechanisms that complement applications that may reside in higher layers. The OAM information is transported in frames called OAM Protocol Data Units (OAMPDU). The OAMPDUs contain the appropriate control and status information used to monitor, test and troubleshoot EFM OAM-enabled links. The OAMPDUs traverse a single link, being passed between peer OAM entities, and are not forwarded by MAC clients.

The EFM OAM has the following characteristics.

- All EFM OAM, including loopbacks, operate on point-to-point links only.
- The EFM loopbacks are always line loopbacks (line Rx to line Tx).
- When a port is in loopback mode, all frames, except the EFM frames, are discarded.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

EFM OAM configuration




```
*A:SAR-1# configure port 1/1/5 ethernet
*A:SAR-1>config>port>ethernet# efm-oam
  - efm-oam

 [no] accept-remote-* - Enable/disable reaction to loopback control OAMPDUs
 [no] hold-time       - Configure the EFM-OAM hold-time
      mode            - Configure EFM OAM DTE mode
 [no] shutdown        - Enable/disable EFM OAM operation
 [no] transmit-inter* - Configure transmit interval of OAMPDUs
 [no] tunneling       - Enable/disable EFM OAM PDU tunneling
```

```
*A:SAR-1# configure port 1/1/5
*A:SAR-1>config>port# info
----------------------------------------------
        ethernet
            efm-oam
                accept-remote-loopback
                transmit-interval 100 multiplier 5
                no shutdown
            exit
        exit
        no shutdown
----------------------------------------------
```

```
*A:SAR-2# configure port 1/1/7
*A:SAR-2>config>port# info
----------------------------------------------
        ethernet
            efm-oam
                accept-remote-loopback
                transmit-interval 100 multiplier 5
                no shutdown
            exit
        exit
        no shutdown
----------------------------------------------
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

You need to configure the EFM OAM on an Ethernet or network port of each peer NE. The slide shows the SR-OS CLI context for configuring EFH OAM and its parameters. You can configure the following parameters in the `config>port>ethernet# efm-oam` context:

•accept-remote-loopback—this command enables reactions to loopback control OAMPDUs from peers.

•hold-time—this command sets the amount of time that EFM-OAM waits before going from a non-operational state to an operational state.

•mode—this command configures the mode of OAM operation for the Ethernet port: active (default) or passive. An active mode port initiates the negotiation process and continually sends out EFM OAM information PDUs. A passive mode port waits for the peer to initiate the negotiation process, and cannot start monitoring activities (such as loopback) with the peer.

•transmit-interval—this command configures the transmit interval of OAMPDUs.

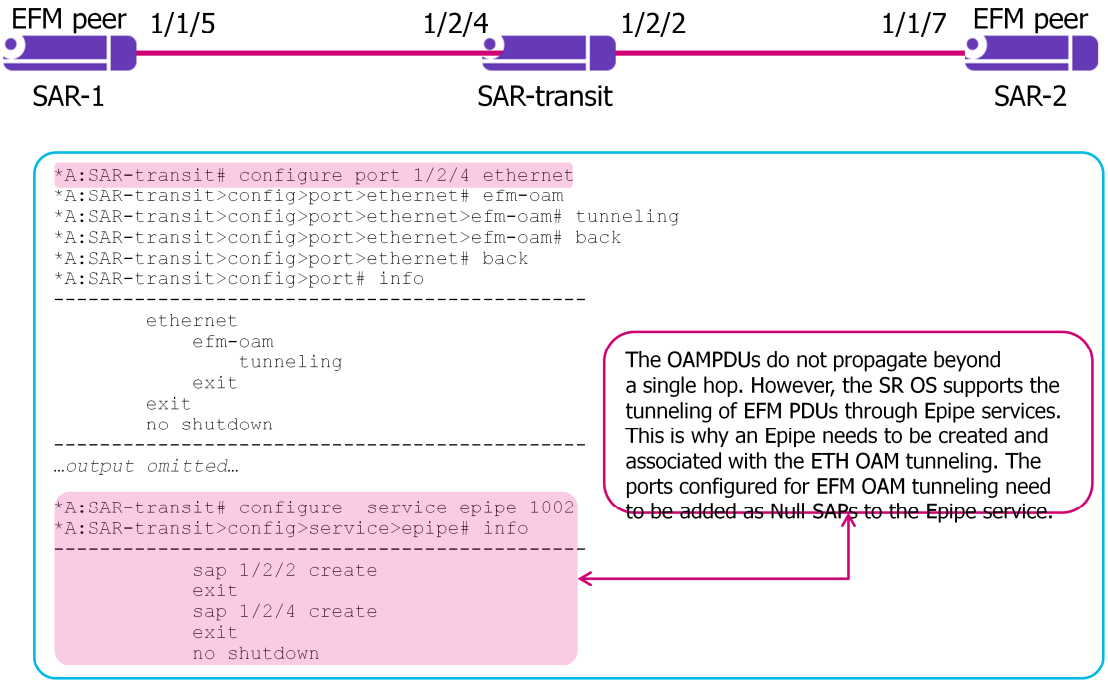
•tunneling—this command enables EFM OAMPDU tunneling.

To enable Ethernet EFM OAM 802.3ah on the port, use the `efm-oam>no shutdown` command.

The slide also shows the ETH OAM configuration on the SAR-1 and SAR-2 NEs.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

EFM OAM tunneling



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The 7705 SAR supports EFM OAM tunneling on a transit router between EFM peer devices. The drawing on this slide shows a new router, SAR-transit, introduced between SAR-1 and SAR-2. The SAR-transit router needs to be configured for the EFM tunneling function so that SAR-1 and SAR-2 can support EFM OAM sessions.

The slide also shows the EFM tunneling configuration for port 1/2/4 of the SAR-transit router. The EFM tunneling configuration for port 1/2/2 is identical, and has been omitted. Consider the following issues when configuring EFM tunneling on SAR-transit:

•The EFM tunneling configuration can be applied only to access ports.

•You need to shut down the EFM OAM on SAR-1 and SAR-2 before enabling tunneling on SAR-transit.

The enabled tunneling feature on SAR-transit allows the PDUs to be mapped to Epipe services so that the OAM frames can be tunneled over MPLS to the far end.

The slide shows the CLI output for an Epipe service created on the SAR-transit router. The ports configured for EFM OAM tunneling have been added as Null SAPs to the Epipe service.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

EFM OAM operations

```
*A:SAR-1# oam efm
  - efm <port-id> local-loopback {start|stop}
  - efm <port-id> remote-loopback {start|stop}

 <port-id>             : slot/mda/port
 <local-loopback>      : Start/stop local-loopback test on a port
 <remote-loopback>     : Start/stop remote-loopback test on a port
```

```
*A:SAR-1# oam efm 1/1/5 remote-loopback start
*A:SAR-1# oam efm 1/1/5 remote-loopback stop
*A:SAR-1# show port 1/1/5 statistics

===============================================================================
Port Statistics on Slot 1
===============================================================================
Port                    Ingress         Ingress         Egress          Egress
Id                      Packets          Octets         Packets         Octets
-------------------------------------------------------------------------------
1/1/5                       669           42816             671          42944
===============================================================================
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The commands to run EFM OAM operations are available in the `oam efm` SR-OS CLI context. The operations that you can run are local-loopback and remote-loopback.

This slide shows the commands for starting and stopping a remote loopback operation, as well as the command to display OAM EFM operation statistics.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

EFM OAM status

```
*A:SAR-1# show port 1/1/5 ethernet efm-oam

===============================================================================
Ethernet Oam (802.3ah)
===============================================================================
Admin State         : up
Oper State          : operational
Mode                : active
Pdu Size            : 1518
Config Revision     : 6
Function Support    : LB
Transmit Interval   : 10000 ms
Multiplier          : 5
Hold Time           : 0
Tunneling           : false
Loop Detected       : false

Peer Mac Address    : 9a:ce:01:01:00:04
Peer Vendor OUI     : 00:16:4d
Peer Vendor Info    : 00:00:00:00
Peer Mode           : active
Peer Pdu Size       : 1518
Peer Cfg Revision   : 4
Peer Support        : LB

Loopback State      : None
Loopback Ignore Rx  : Process
Ignore Efm State    : false

===============================================================================
Ethernet Oam Statistics
===============================================================================
                                                  Input                 Output
-------------------------------------------------------------------------------
Information                                         690                    691
Loopback Control                                      0                      4
Unsupported Codes                                     0                      0
Frames Lost                                                                  0
===============================================================================
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

To view the status of an EFM OAM session, use the command `show port` *`port_number`* `ethernet efm-oam`. The slide shows a sample output for such a command.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

5 MPLS – Transport Profile (TP)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

What is MPLS-TP (MPLS-Transport Profile)?

Objectives as per RFC 5921

Enable MPLS to be deployed in a transport network and operated in a similar manner to that of existing transport technologies

Enable MPLS to support packet transport services with a similar degree of predictability, reliability and OAM to that found in existing transport networks

A subset of MPLS protocols for Layer 1 and Layer 2 only

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

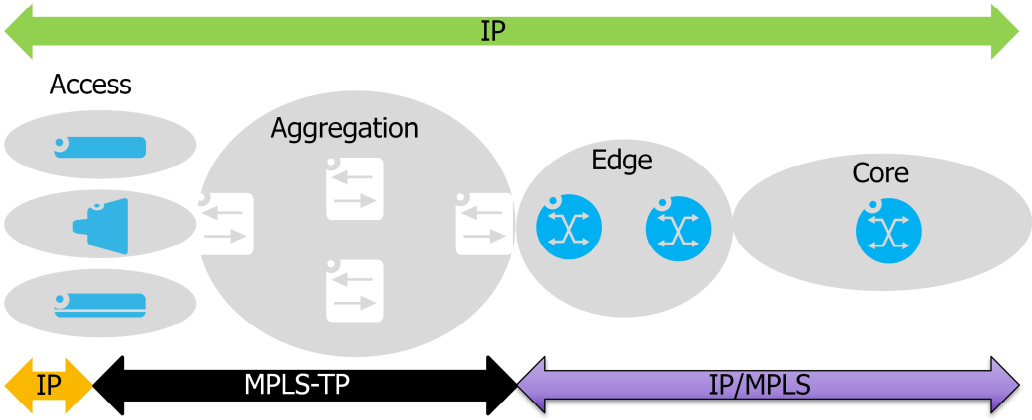
Rationale:

- Transport is evolving to support increasingly packet-based services
  - Past: Pure TDM (SONET/SDH)
  - Present: MSPP (Ethernet over SONET/SDH)
  - Evolving to Packet Transport
- IP/MPLS networks are perceived as complex by some in the transport world
- Keep the layer 2 and layer 3 networks separate
- Lack of native IP support on transport switches
- The alternative is to combine
  - Architectural, management and operational models of Circuit Switched transport networks with Packet switching optimizations
- Proposed Transport Solution: Transport-optimized MPLS (MPLS-TP)
  - MPLS Data Plane
  - Additional OAM and Protection capabilities
- Perceived cheaper solution
  - Additional OAM and Protection capabilities
- Perceived cheaper solution

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

One View of the Relationship between IP/MPLS and MPLS-TP

Access/Aggregation using MPLS-TP



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

MPLS-TP is being promoted for large access/aggregation networks for transport scalability.
IP/MPLS remains in edge and core for services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

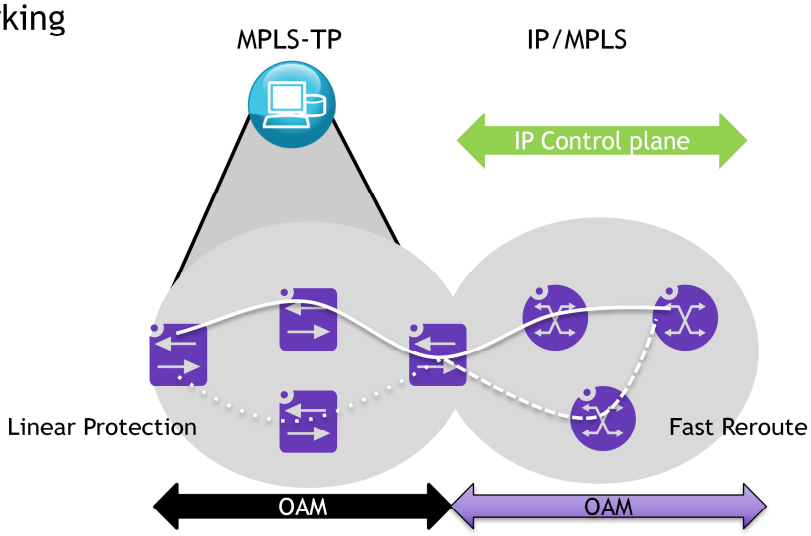
Interworking IP/MPLS with MPLS-TP

Challenges:

No control plane interworking

Data plane (end-to-end OAM) interworking

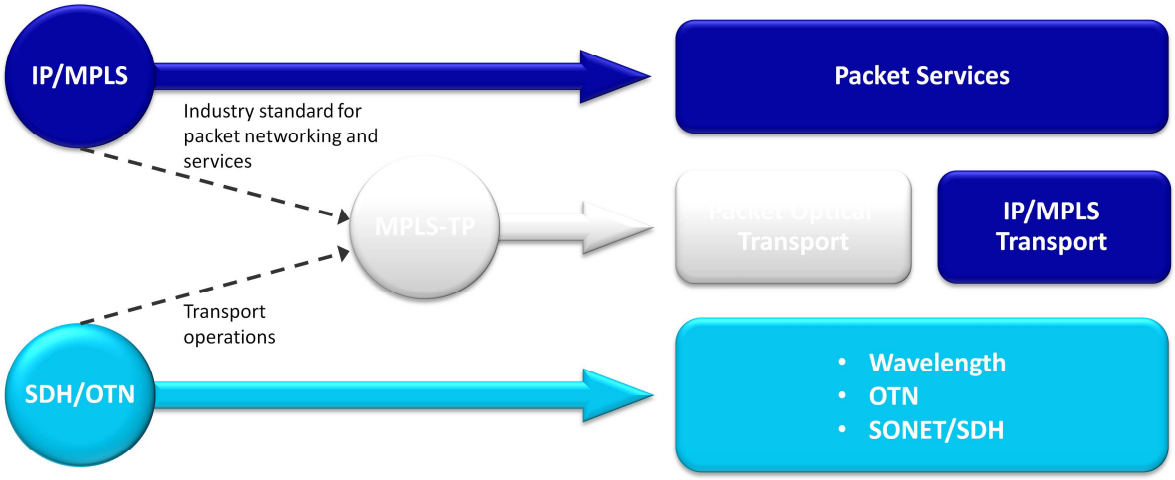
Resiliency interworking



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IP/MPLS offers a Complete Implementation for IP Transformation



Smart Grid relies on IP: Operational Telecom can no longer be transport centric only

IP/MPLS handles both services and transport

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

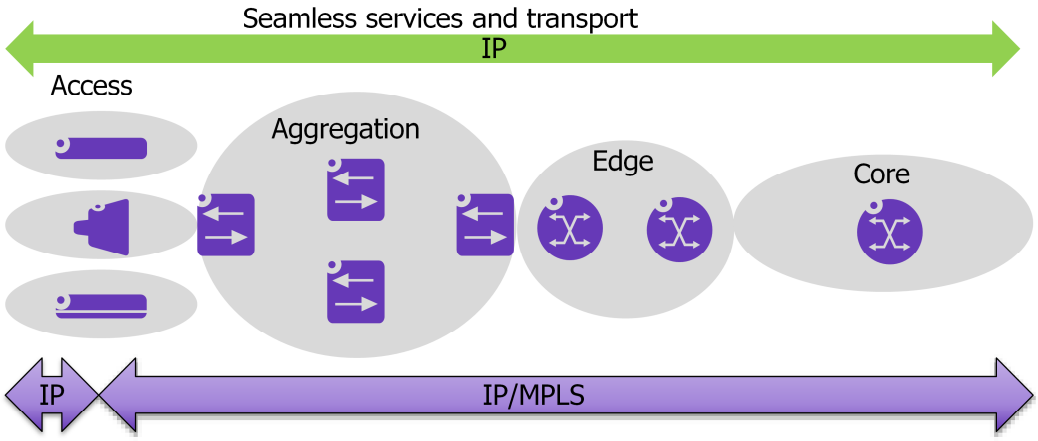
Comparison of IP/MPLS and MPLS-TP for Utility IP Network Transformation

Attribute	IP/MPLS	MPLS-TP
Maturity	Proven, with many utility deployments	Infancy, little or no proven deployment experience for utilities
Standardization	Fully standardized	Some still in progress
Multi-vendor Interoperability	Proven, many	Limited
IP/MPLS MPLS-TP Interworking	Unproven	Unproven
VPN Supported	L1, L2, L3	L1, L2 only (IP routers needed for L3)
Services Supported	Full	Transport only
IP Multicast Delivery	Optimized	None
Protection	FRR or active/standby path	Protection switching
Resiliency against Multiple Network Failures	Dynamically adjust and reroute	Require control plane implementation
Traffic Engineering	Dynamic	Static
Convergence	Common NMS, training, and sparing for L1 to L3	Separate NMS, training, and sparing for L1/L2 and L3
OAM	Single platform for L1 to L3	Separate platform required for L3

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IP/MPLS from the Core to Access



- Easier to build IP/MPLS all the way from core to access for seamless and consistent end-to-end MPLS services and transport
- IP/MPLS provides for multiple transport options:
  - Dynamic signaling, static signaling, static provisioning.
- Less complexity: Common control and data plane functions from end-to-end
  - No need for network segmentation

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Why Alcatel-Lucent IP/MPLS based solution?

Proven support of all utility applications including SCADA and teleprotection

- Live deployment and 3rd party validation
- Being deployed in dozens of utilities worldwide

5620 SAM simplifies end-to-end provisioning, troubleshooting, and proactive SLA performance monitoring

Award winning portfolio for end-to-end core, edge, aggregation, and access requirements

- Support for utility specific interfaces
- Advanced QoS for mission critical traffic guarantee
- Unique High Availability features for resiliency
- Proven single OS across the entire portfolio
- Extensive OAM implementation beyond standard IP/MPLS
- Utility compliant and temperature hardened platforms

Service Portal Express for Utilities

- Using utility specific language to help utilities transition to IP/MPLS and work more efficiently

Tight integration with Optical DWDM and Packet Microwave products

Optimized TCO for combined L1/L2/L3 support and upcoming LTE deployment

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
Ethernet OAM

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 8
QoS

Module 1
Quality of Service

TER36075_V3.1-SG-English-Ed1 Module 8.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to describe:

- The need for Quality of Service
- Alcatel-Lucent 7750 SR Quality of Service Model
- The need for QoS Policies
- Classification mechanisms
- Policing and Shaping mechanism
- Traffic Buffering
- Default Scheduling

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — The need for Quality of Service	**5**
2 — Alcatel-Lucent 7750 SR Quality of Service Model	**9**
3 — The need for QoS Policies	**16**
4 — Classification mechanisms	**25**
5 — Policing and shaping mechanisms	**30**
6 — Traffic Buffering	**34**
7 — Default Scheduling	**37**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 The need for Quality of Service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The need for Quality of Service

In order for traffic to be useful at the receiver end, some **requirements** need to be satisfied (e.g. delay, transmission rate or loss ratio)

Different traffic flows may have different requirements:

- They need to receive differentiated treatment
- Separate buffering and forwarding decisions

Requirements are related to the traffic characteristics, aka traffic **profile** (e.g. expected arrival rate or maximum burst size)

Packets that arrive within the expected profile receive agreed service level; packets out of profile may expect to be dropped or delayed

- **Quality of Service** (QoS): guaranteeing that traffic requirements will be satisfied as long as the traffic remains within the established profile



The concept of Quality of Service

In order for the traffic carried by a network to be useful when it is received at the far end, some requirements need to be satisfied. These requirements may be in terms of the maximum delay or delay variations that individual packets can experience, in terms of the average or peak rate with which packets will flow through the network, or in terms of the maximum percentage of packet losses that can be tolerated by the specific application at hand.

Those requirements are closely related to the traffic characteristics (aka traffic profile), such as the expected average rate with which packets will be generated or the maximum burst size that will be observed.

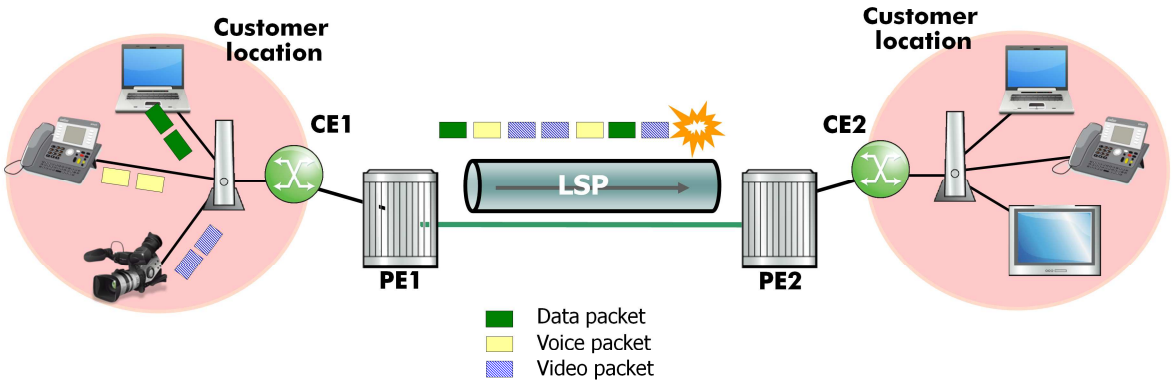
Different traffic flows may have different requirements. For that reason, flows need to receive a differentiated treatment when it comes to buffering and forwarding packets. For instance, packets that have time constraints need to be forwarded before packets that have no such constraints. In addition to that, packets that arrive within the expected profile need to be serviced in such a way that its constraints are satisfied, while packets that arrive out of profile may expect to be dropped or delayed beyond the limits as the network does not have the responsibility to guarantee for them a certain level of service.

Quality of Service (QoS) has to do with guaranteeing that the requirements needed by traffic (in terms of delay, delay variations, throughput and losses) will be satisfied as packets travel inside the network provided that the traffic itself is maintained within the established profile.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Congested networks and QoS

If QoS is not implemented, all packets are affected equally by congestion



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

If we have a network with very high bandwidth and little traffic, there is no need to implement QoS since all packets will be serviced with practically no delay. This may require a great infrastructure investment, however, since the network needs to be over-provisioned in terms of hardware.

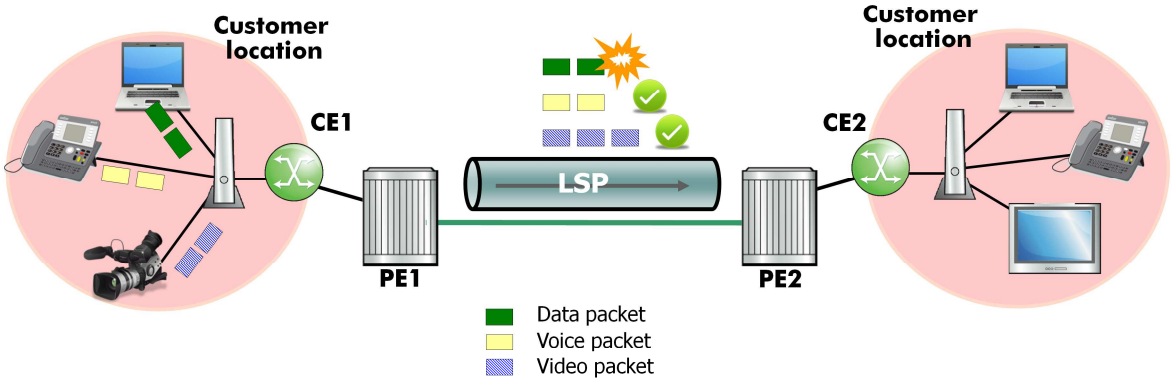
When traffic needs are closer to the network capacity, which provides a better balance between cost and profit, congestion may start to appear. If all packets are treated equally, congestion will affect all types of traffic the same. This is not optimum since, while data traffic (such as e-mail or web downloads) can afford retransmissions without affecting the perceived level of service, voice and video traffic (being real-time applications) are much more sensitive to packet delays, delay variations and losses.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Congested networks and QoS [cont'd]

If QoS is implemented, packets are treated differently, depending on needs

Only low-class packets are affected by congestion



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

In a well-planned QoS-aware network, we can have a controlled balance between traffic needs and network capacity in such a way that delay-sensitive applications will have enough resources guaranteed for the service to have a high quality, and non-delay-sensitive applications that may not have too many resources allocated to them, but which may benefit from the resources that are allocated to other traffic streams but not utilized at a given point in time.

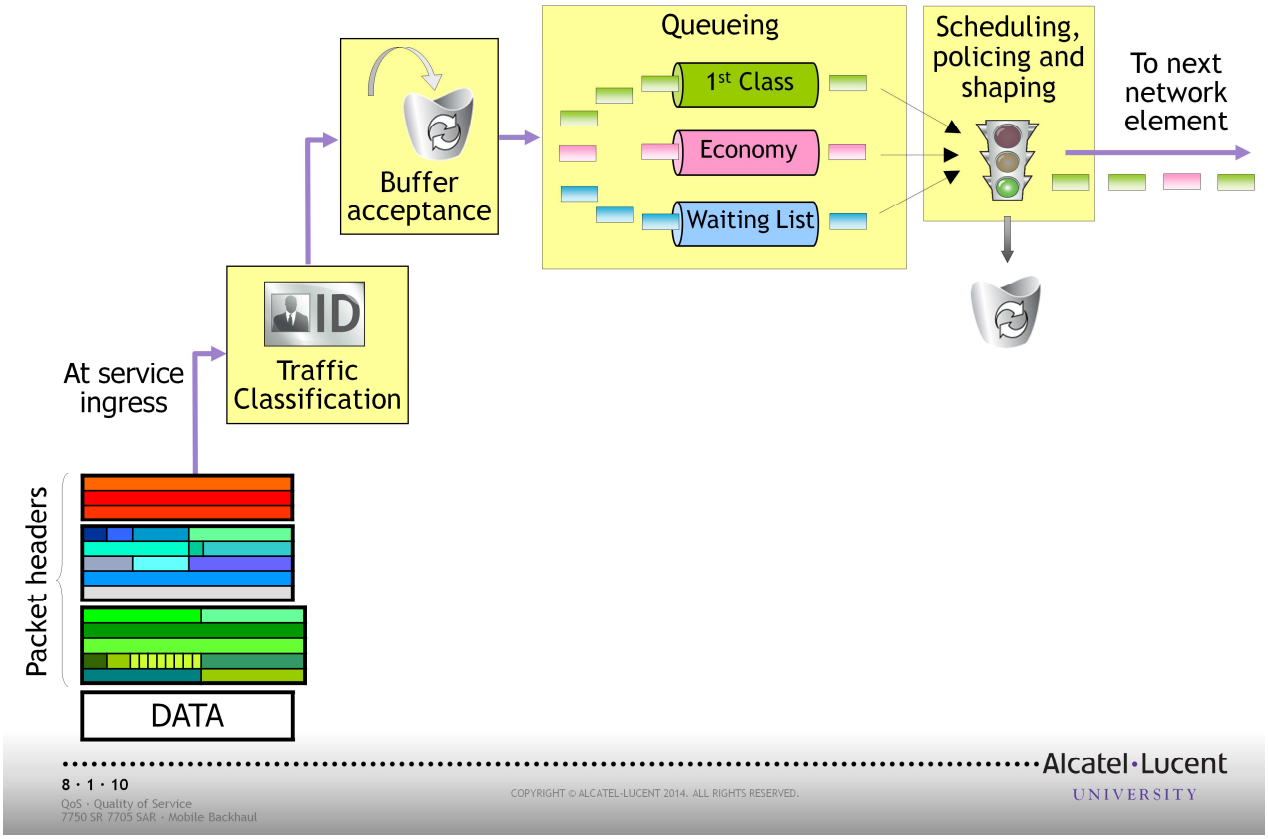
This way, if congestion occurs, delay-sensitive applications will not be affected, and it will be low-class traffic flows which will notice a degradation in the service they are receiving.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Alcatel-Lucent 7750 SR Quality of Service Model

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

QoS Enforcement Sequence



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

QoS components and enforcement sequence

Traffic Classification

As packets arrive at a service ingress (SAP), they need to be classified. This classification will determine how the packet is treated throughout the entire time it remains in the router. Classification can be based on several fields inside the packet's layer 2, 3, or 4 headers. Once a decision is made, the packet will be internally stored with two new attributes called the **forwarding class (FC)** and the queueing **priority**.

Buffer Acceptance

A procedure can be configured to drop some packets if the buffer where they should be stored is getting full, even if there is still some room left. If the buffer occupancy corresponding to the port or MDA card where the packet was received is above a specified threshold, the packet will be dropped with a certain probability (which also depends on the packet's priority) to implicitly inform the source that it should reduce its traffic generation rate to keep congestion from affecting all traffic streams. This method is known as Random Early Discard (RED) or Random Early Detection.

Queueing

If the packet is accepted (not dropped) by RED, it will be enqueued. Separate queues can be configured for the different forwarding classes to avoid time-constrained packets from being delayed by non-time-constrained packets sitting ahead of the queue. Each queue has its own parameters relative to allocated **buffer size** and **rate** (committed and maximum) at which stored packets will be forwarded by the scheduler (**shaping**). The committed and maximum rate parameters are also associated to **policing**, which determines whether a packet will be forwarded or dropped by the scheduler (explained next) and, if forwarded, if it will be marked as in or out of profile.

Scheduling, Policing and Shaping

The scheduler determines the order in which different queues are serviced based on each queue's configured parameters. To make its decision, the scheduler first determines if the packet at the head of each queue (hence the queue itself) is in or out of **profile**. If the arrival rate for a queue is below its committed output rate, the packet is marked in-profile and forwarded; if the arrival rate is above its committed output rate but below its maximum rate, the packet is marked out-of-profile and will be forwarded after all in-profile queues have been serviced (**soft policing**); if the arrival rate is above its maximum rate, the packet is dropped (**hard policing**).

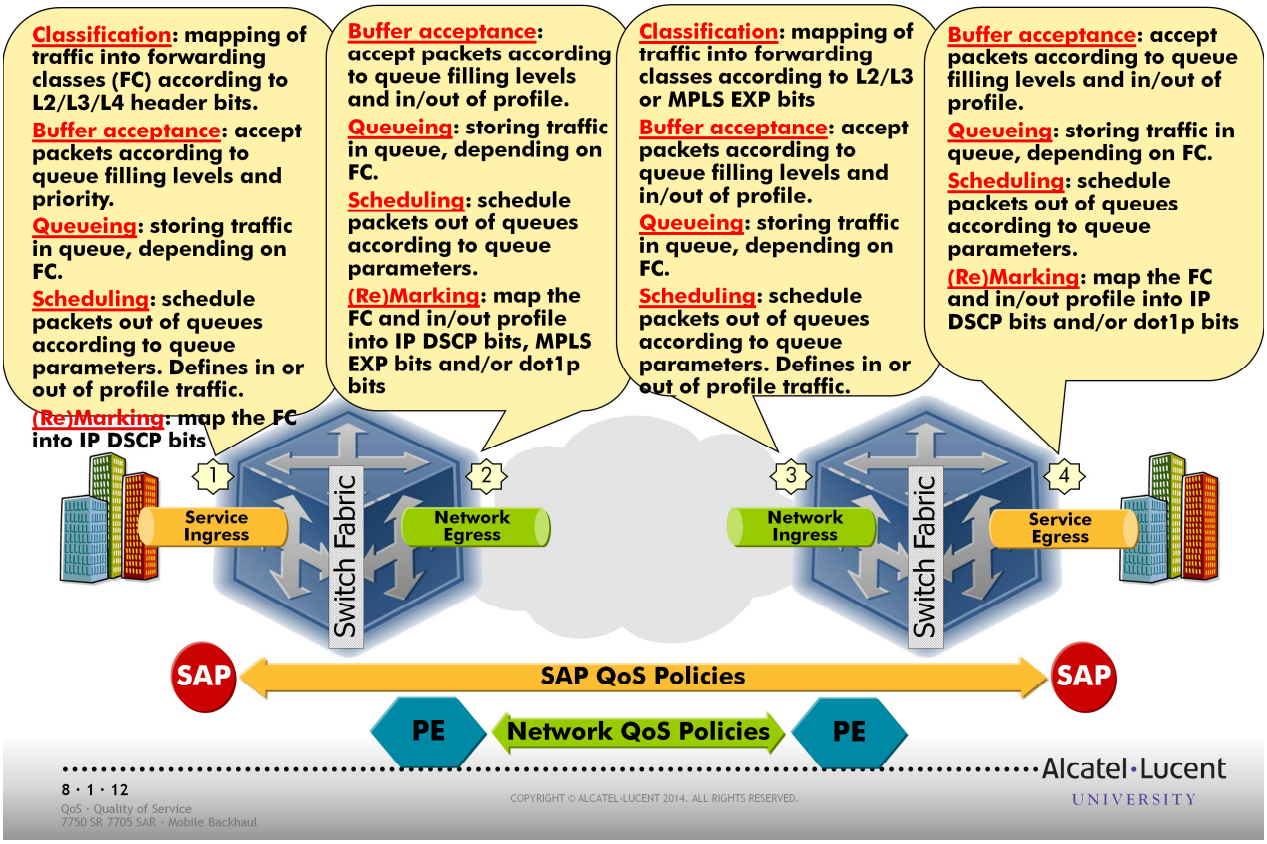
Marking and Re-marking

The packet's layer 2, 3, or 4 headers can be set to specific values (marking) or altered (re-marking) so that the next network element that the packet will visit (e.g. next router) makes consistent decisions with the ones made by the current router. Recall that **FC**, **priority** and **profile** are internal attributes that cannot be transmitted with the packet for other routers to see. That is why standard markings have to be used for that.

A packet goes twice through a similar process on each router, once as it enters the router and once more after it goes across the switch fabric from the port in which it was received (access port if it enters through a SAP or network port if this router is not the ingress PE) to the port that will be used to forward the packet to the next router (network port if this router is not yet the egress PE or access port if it is and the packet will exit the service provider through a SAP). The explanation given above is generic, in the sense that some of these process components may or may not be present depending on the point where the packet is being processed. This is better explained in the next slide.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Network-Wide View On QoS



The need for QoS Policies

The way a packet will be processed at an ingress or egress **SAP** regarding **classification, queueing and (re)marking** is configured by means of **SAP-ingress** or **SAP-egress QoS policies**, respectively. A different policy can be configured for each SAP, depending on the service it belongs to, which allows for specific Service Level Agreements (SLA) to be negotiated with customers.

For a **network interface**, **Network QoS policies** can be used to determine how packets will be **classified** on ingress and how they will be **re-marked** on egress. Still on the network side of a router, specifying how a packet will be **enqueued** once classified is done by means of **Network Queue QoS policies**. In a 7750 SR, buffer pools exist per network port on egress and per MDA on ingress. For that reason Network Queue QoS policies can be applied to an MDA on ingress or egress, and it will have an effect globally on all network ports of the card; if needed, these policies can be applied instead to a specific network port on egress. Notice that these policies cannot be tailored to the needs of a specific service or SAP, since network ports carry aggregate traffic that may belong to multiple services.

Buffer acceptance policies are optional. If needed, they can be configured and applied per buffer pool on the access or network side (at MDA or port level, as explained above).

Scheduling policies are also optional and, if needed, they can be applied to individual SAPs. However, they cannot be applied on the network side of a router; default scheduling is the only option, as explained in the next page.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

The need for QoS Policies – what policies do

Classification implies the association of a packet to a Forwarding Class (FC) based on the values carried in its L2/L3/L4 or MPLS header bits. Classification of a packet is only needed when it first enters the router; that is, at service ingress or network ingress (points 1 and 3 in the figure). FC is an internal attribute that will stay with the packet during all the time it remains inside the router. When the packet arrives at its network or service egress point (points 2 or 4), it is already associated to an FC.

For **Buffer Acceptance**, RED (Random Early Discard) parameters need to be configured, which specify the threshold at which packets will start to be dropped and how fast the dropping probability grows as the buffer occupation increases beyond the thresholds. There are two such probability curves, one for high-priority traffic and another for low-priority traffic. A packet's high/low priority is defined by the priority attribute set on service ingress (point 1 in the figure) or by the fact that the packet is in or out of profile in the other processing points. RED parameters are configured by means of a **Slope Policy**. These policies are applied to buffer pools that exist at the MDA card level (for all access ports or for all network ports, on ingress or egress) or at the port level (for access ports on ingress or egress or for network ports on egress).

For **Queueing**, the different queues to be used need to be created and the corresponding parameters (buffer space and output rate) have to be specified. Also, a mapping between FC values and the existing queues needs to be configured. A queue by default will be classified as expedite (time-constrained) or non-expedite (non-time-constrained or best-effort), depending on the FCs that are mapped to the queue. FC values 4 through 7 (aka H2, EF, H1, NC) are assumed to be expedite, and values 0 through 3 (aka BE, L2, AF, L1) are assumed to be non-expedite. If a combination of expedite and non-expedite FCs are mapped to the same queue, it will be considered non-expedite. Alternatively, a queue can be explicitly classified as being of **type** expedite or non-expedite. Also, queues have two **modes** of operation when it comes to marking packets as in or out of profile. The default option is priority-mode, meaning that a packet's profile is defined by the scheduler based on how fast packets are arriving at the queue as compared to its committed output rate. Another option is to configure a queue to behave in profile-mode, in which case a packet's profile is set before it enters the queue (also affecting RED) and not modified when the packet is scheduled.

Network ports can only do **Default Scheduling**, which means that expedite traffic has a higher priority of being forwarded than non-expedite traffic. In other words, non-expedite packets will be forwarded only if there are no expedite packets waiting in a queue. Out-of-profile traffic has an even lower priority, which means that it will be forwarded only after all in-profile (expedite and non-expedite) traffic has been serviced.

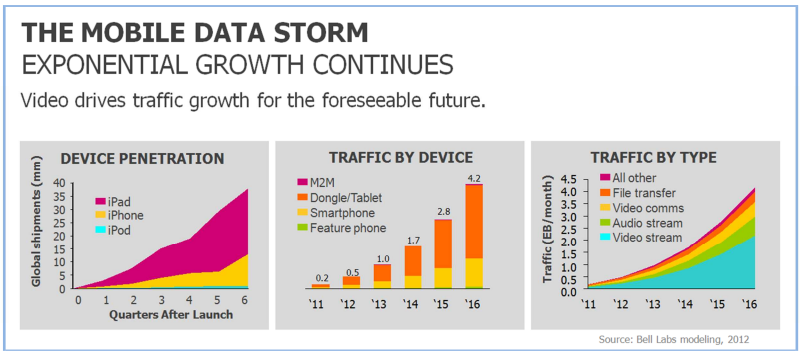
For SAPs, it is possible to configure **Hierarchical Scheduling**, meaning that a fraction of the available bandwidth may be reserved for a subset of queues (not to an individual queue). Several such groups can be created. Queues within each group compete among themselves and the winner competes with the winners of other groups. A hierarchical structure can be created based on this concept by grouping groups of queues to form a new group at a different level. The parameters associated to a Hierarchical Scheduler are configured by means of a **Scheduler Policy**.

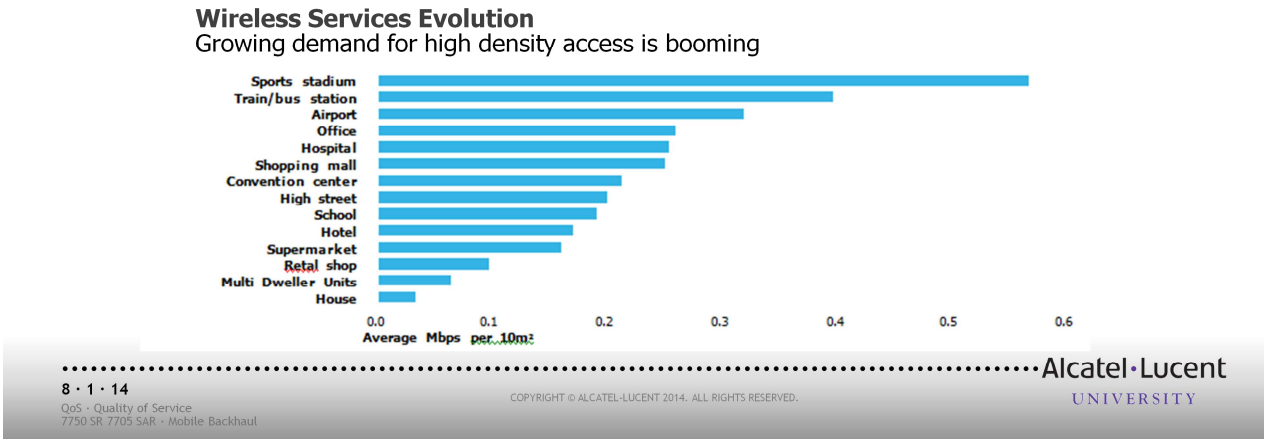
Marking and **Re-marking** implies the configuration of a mapping rule from an FC value to QoS-related fields in the L2, L3 or MPLS headers (Dot1p, DSCP or EXP bits, respectively). It can be thought of as the inverse of classification.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Trends Driving Mobile Backhaul

Growth rates for device adoption and network traffic





Mobile Data Storm

The smart phone explosion and consumption of bandwidth-intensive services such as video drive today's network evolution. How well an MNO provides the connection and delivery of services that support these consumer trends will be the critical factors in customer retention/acquisition and the ability to maintain/grow average revenue per user (ARPU) on tomorrow's mobile networks.

Wireless Services Evolution

These two trends alone reinforce the need for a quality backhaul network. Connecting the mobile access points to the network with sufficient bandwidth to ensure a high-quality user experience is a key element to broaden the consumer base. Perceived network quality will keep current customers and attract new ones. Alcatel-Lucent brings customers a wealth of experience carefully engineering and transforming the backhaul network to overcome quality of service challenges while managing operational costs.

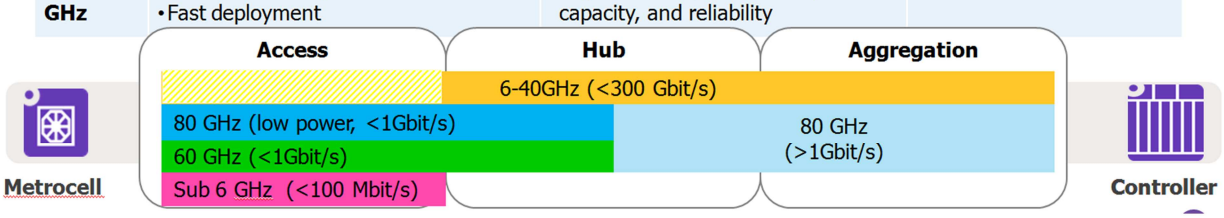
The transformation to an all IP backhaul network is essential to keep up with the bandwidth demands as mobile connections get faster. This transformation can also provide lower operational costs by consolidating legacy interfaces like TDM into larger more flexible IP/MPLS Ethernet connections that can evolve from "any G" wireless standard and properly scale to support deployment of 4G LTE. It is this infrastructure that leads to differentiated service offerings and new revenue opportunities.

The demand for anytime, anywhere connection is only growing, and the demand for seamless mobility in public places is an expectation in today's world.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Wireless Technology Options

	Pros	Cons	Applicability
6-40 GHz	•Moderate Capacity •High availability and QoS performance	•Line-of-Sight (LOS) only •Lead time for licensing	•Aggregation •Hub
80 GHz	•Very high capacity •High availability and QoS performance •Fast deployment (light licensing)	•LOS only	•Access •Hub •Aggregation
60 GHz	•High capacity •High availability and QoS performance •Fast deployment (unlicensed) •Immunity to interference	•LOS only	•Access •Hub
Sub 6 GHz	•NLOS and LOS options •Fast deployment	•Unpredictable performance, capacity, and reliability	•Access



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

As an example, regarding QoS requirements in the Mobile Backhaul context, the slide above displays wireless technology options.

The picture beneath the table shows the typical architecture of a microwave-based network.

From right to left:

- End systems deployed at cell sites (referred to as tails)
- Nodal/hub points grooming the capacity coming from the edge
- Aggregation

This tiered architecture of increasing bandwidths, and reliability, is used in macrocell backhaul today and will also used in metrocell backhaul.

Alcatel-Lucent is envisioning the usage of many wireless technologies in that domain, each with its characteristics:

- In aggregation we have long links (>> 1 km), high performance and service availability. Often a networking layer is also used to provide network based resiliency (e.g. G.8032 for Ethernet rings or IP/MPLS FRR). Here standard frequency bands are requested (6-40 GHz) or the new millimeter wave bands (80 GHz)
- Hub points is where you need to concentrate traffic from many tails on one uplink. The nodal capacity is requested here as well as the support of availability and performance. This is the reason why you still need standard frequencies or the new ones (60/80 GHz). 60 GHz is one of the best options as it is immune to frequencies due to oxygen absorption. The different colors for the 80GHz represents two available options: low power (left hand side, for short links) and high power (right hand side), for longer links and higher capacity
- More options are available in the access. Here we can have 80 GHz, 60 GHz and any type of Wifi or NLOS techniques (e.g. even LTE relay, Wimax, etc.). Wifi is a good option when you need either Non-LOS (NLOS) or Near-LOS (nLOS) support (respectively when the visibility between the two stations is completely obstructed or only partially). This happens because signals at those frequencies (e.g. 2.4, 5.8GHz) bounce against walls [note: never say they go through an obstacle, this does not happen in backhaul]

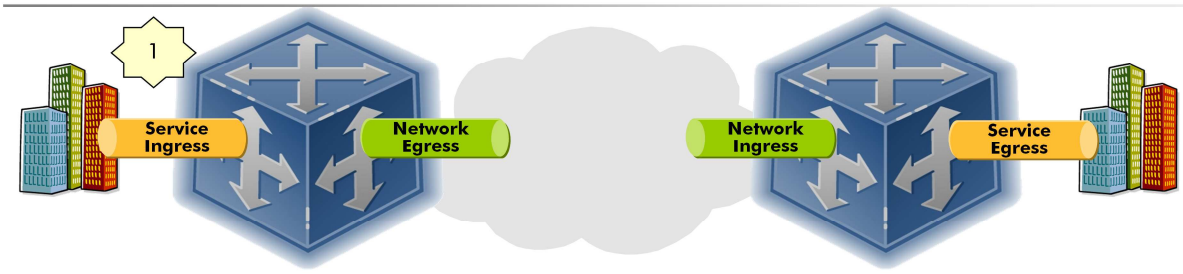
What is key is Alcatel-Lucent's capability of integrating **all of these technologies** under the same product portfolio (9500 MPR/ 7705 SAR) and management framework (5620 SAM)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 The need for QoS Policies

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service (SAP) Ingress



SAP-ingress QoS policy:

- Maps traffic to a forwarding class based on user-defined match criteria and assigns high or low priority status to the packets
- Creates traffic queues, defining:
  - type (expedited, best-effort, auto)
  - mode (priority, profile)
  - allocated buffer size (committed and maximum)
  - rate (committed and maximum) at which stored packets will exit the queue
- Assigns forwarding classes to queues
- Packet re-marking if needed

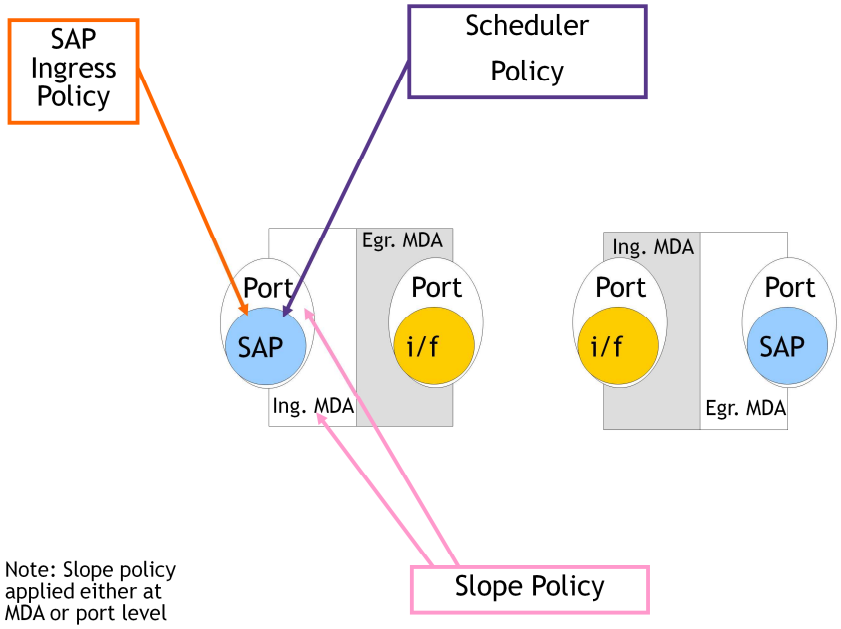
Optionally:

- Scheduler policy
- Slope policy (buffer acceptance)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

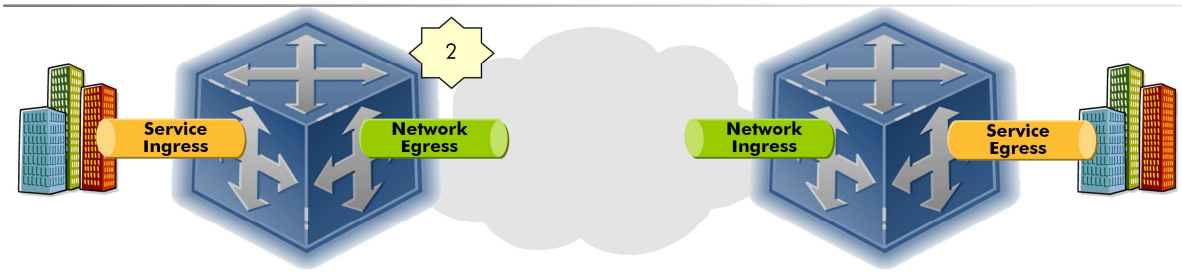
Where to apply the policies – SAP Ingress



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Network Egress



Network-Queue QoS Policy

- Creates traffic queues, defining:
  - type (expedited, best-effort, auto)
  - mode (priority, profile)
  - allocated buffer size (committed and maximum)
  - rate (committed and maximum) at which stored packets will exit the queue
- Assigns forwarding classes to queues

Network QoS Policy

- Re-marks packets before being transmitted towards the next network element

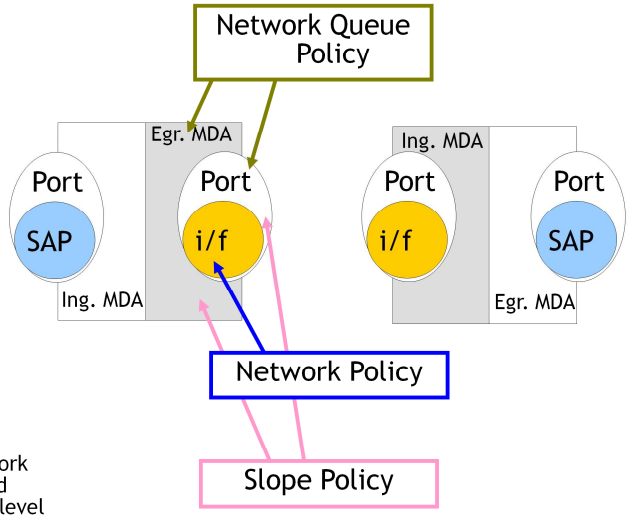
Optionally:

- Slope policy (buffer acceptance)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Where to apply the policies – Network Egress

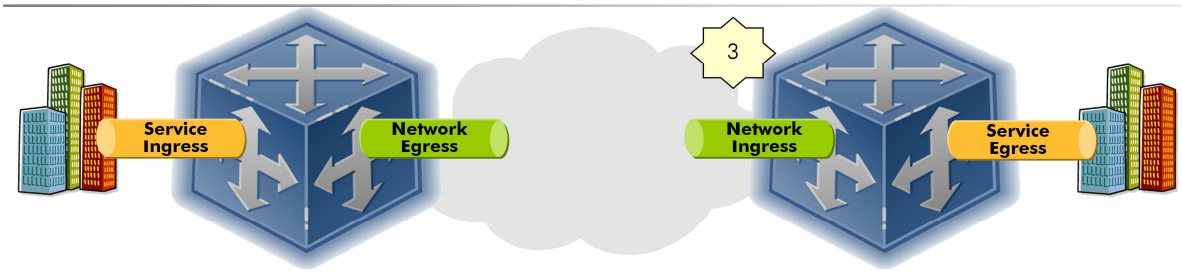


Note: Slope and Network Queue policies applied either at MDA or port level

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Network Ingress



Network QoS policy
- Maps traffic to a forwarding class based on user-defined match criteria

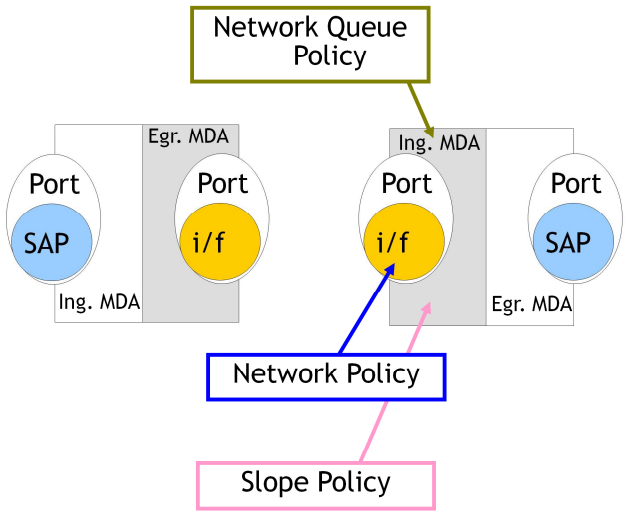
Network-Queue QoS policy
- Creates traffic queues, defining:
  - type (expedited, best-effort, auto)
  - mode (priority, profile)
  - allocated buffer size (committed and maximum)
  - rate (committed and maximum) at which stored packets will exit the queue
- Assigns forwarding classes to queues

Optionally:
- Slope policy (buffer acceptance)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

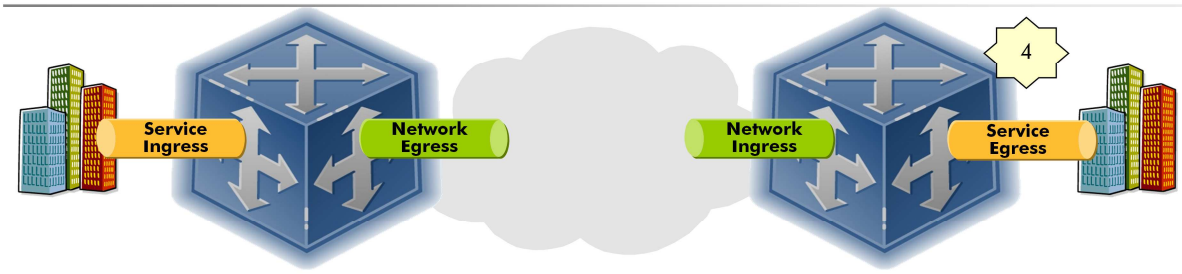
Where to apply the policies – Network Ingress



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service (SAP) Egress



SAP-egress QoS policy:

- Creates traffic queues, defining:
  - type (expedited, best-effort, auto)
  - mode (priority, profile)
  - allocated buffer size (committed and maximum)
  - rate (committed and maximum) at which stored packets will exit the queue
- Assigns forwarding classes to queues
- Re-marks packets before being transmitted towards the next network element

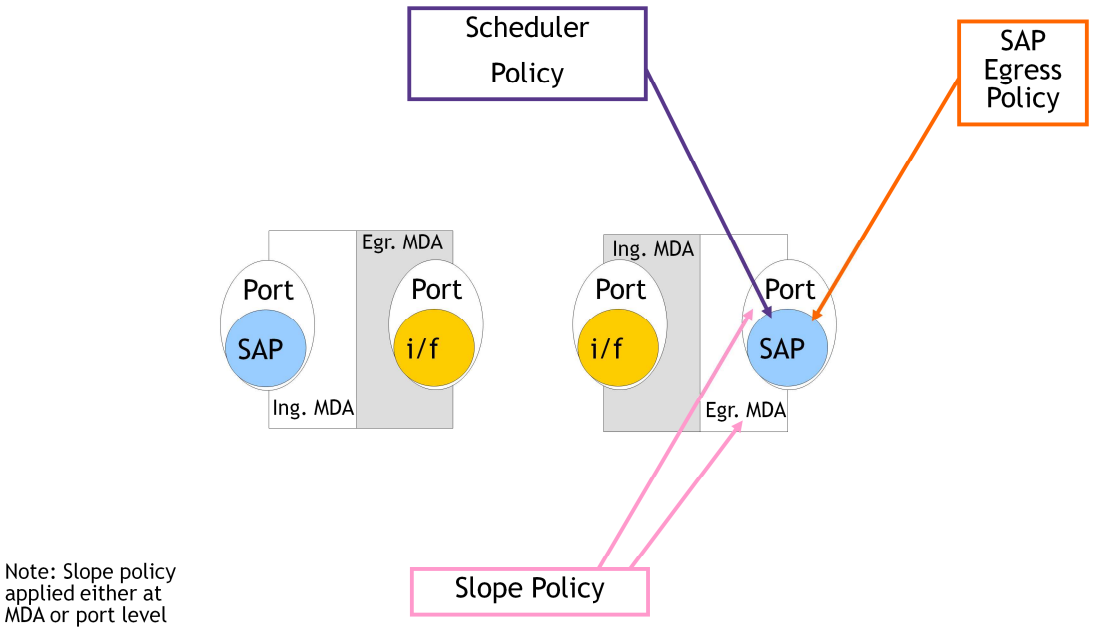
Optionally:

- Scheduler policy
- Slope policy (buffer acceptance)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Where to apply the policies – SAP Egress



Note: Slope policy applied either at MDA or port level

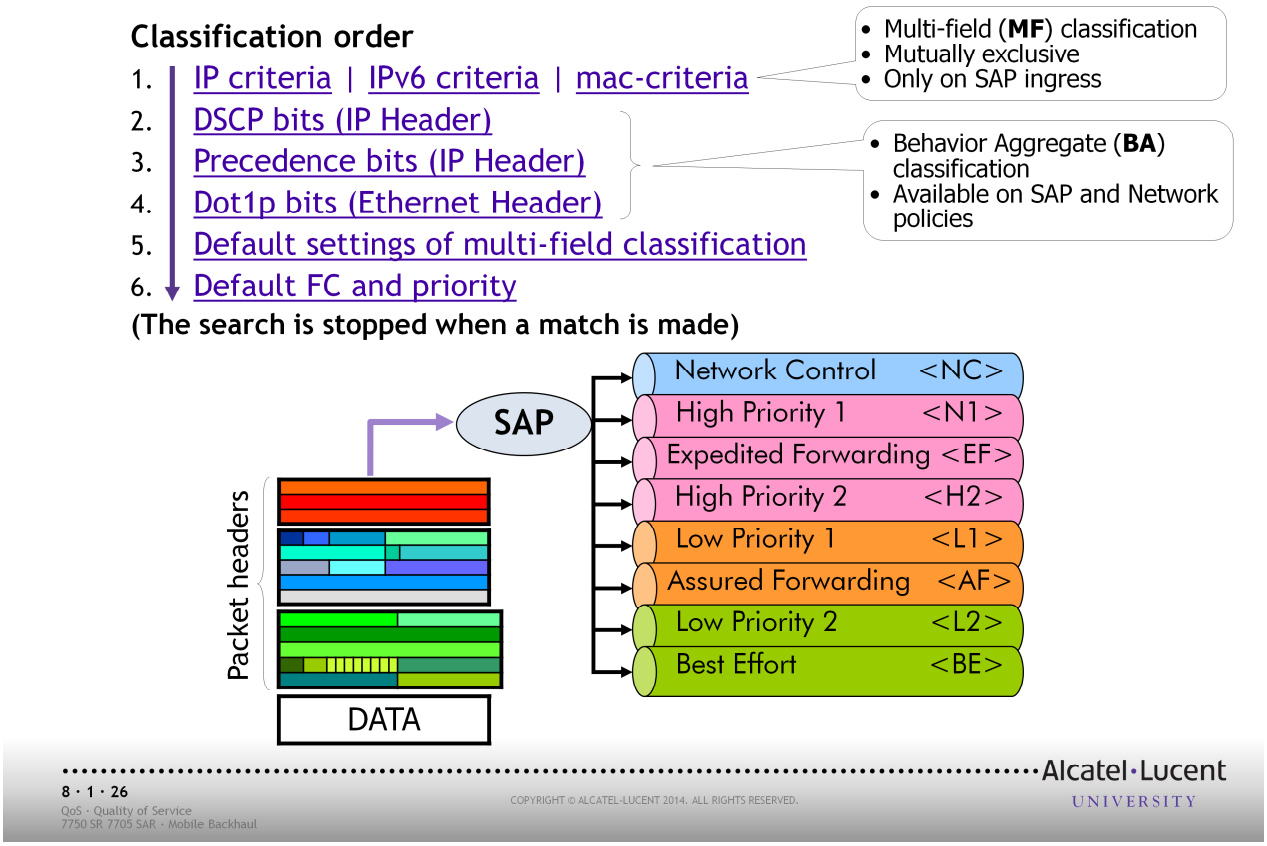
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 Classification Mechanisms

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Classifying Traffic on SAP ingress



As the traffic enters the ingress forwarding complex, datagrams are classified into one out of several forwarding classes as determined by SAP ingress QoS policies. The mapping of traffic to forwarding classes is based on the multi-field classification rules or on the behavior aggregate criteria.

Classification order

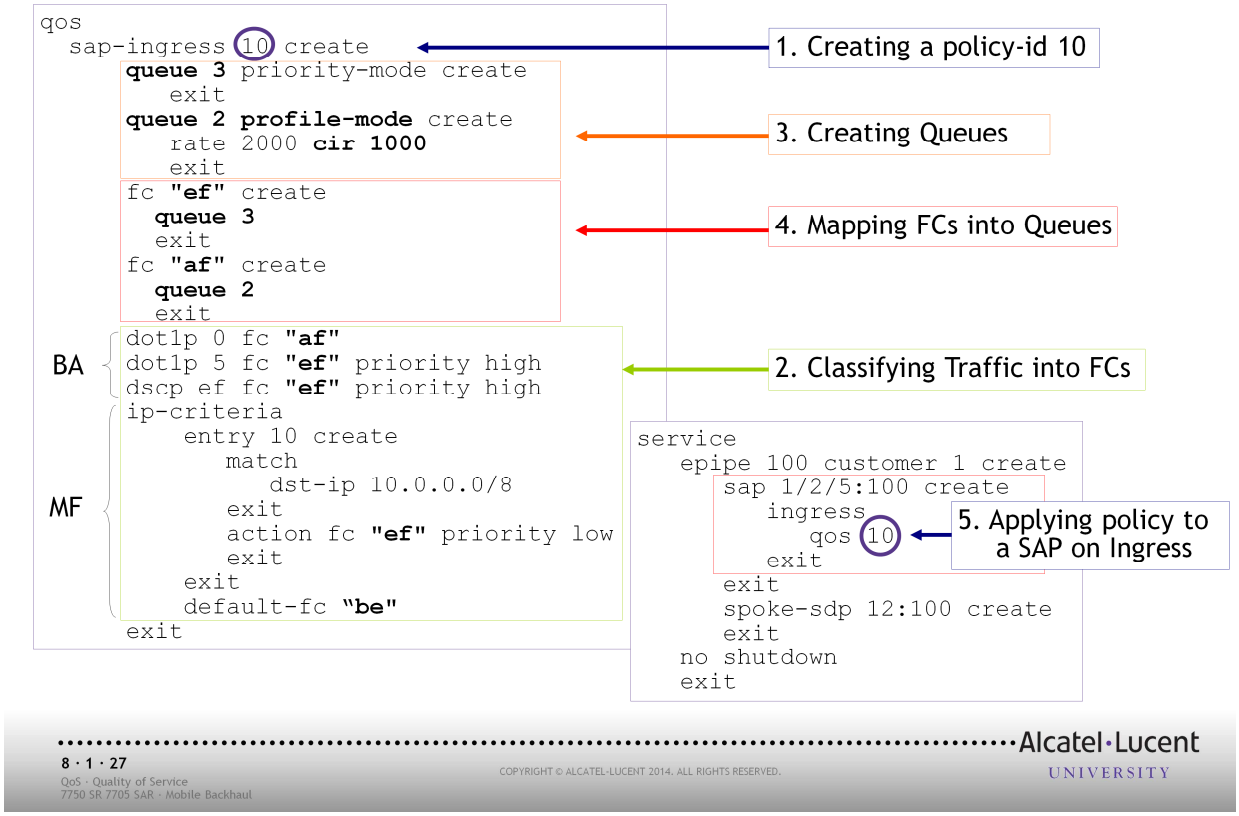
1. IP criteria | IPv6 criteria | mac-criteria
2. DSCP bits (IP Header)
3. Precedence bits (IP Header)
4. Dot1p bits (Ethernet Header)
5. Default settings of multi-field classification
6. Default FC and priority

IP or application match criteria for service ingress traffic:

- Source IP address/prefix
- Destination IP address/prefix
- Source port/range
- Destination port/range
- Protocol type (TCP, UDP, etc.)
- DSCP value
- IP fragment

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAP ingress QoS Policy example



Classifying Traffic:

Incoming traffic is classified by looking into the datagram's different fields.

Network Control	<NC>
High Priority 1	<N1>
Expedited Forwarding	<EF>
High Priority 2	<H2>
Low Priority 1	<L1>
Assured Forwarding	<AF>
Low Priority 2	<L2>
Best Effort	<BE>

Mapping Traffic into Queues:

The classified incoming traffic is then placed into the appropriate queue

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

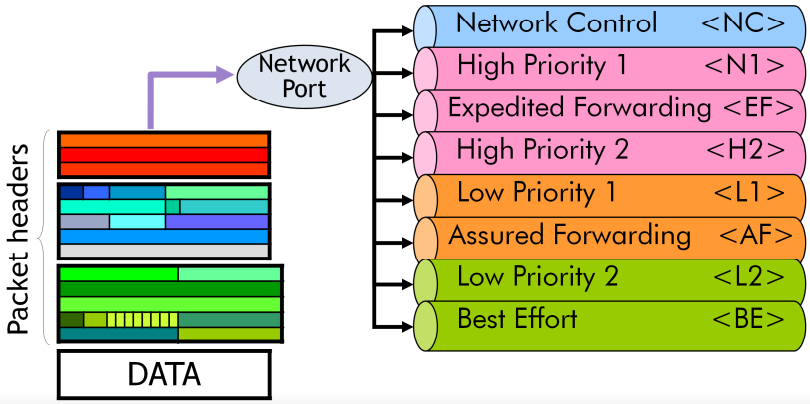
Classifying Traffic on Network Port Ingress

Classification order (based on):

1. EXP bits (MPLS packets)
2. DSCP (IP packets - IES,GRE)
3. Dot1p bits (dot1q network ports)
4. Default action (FC and profile)

Behavior Aggregate (**BA**) classification only

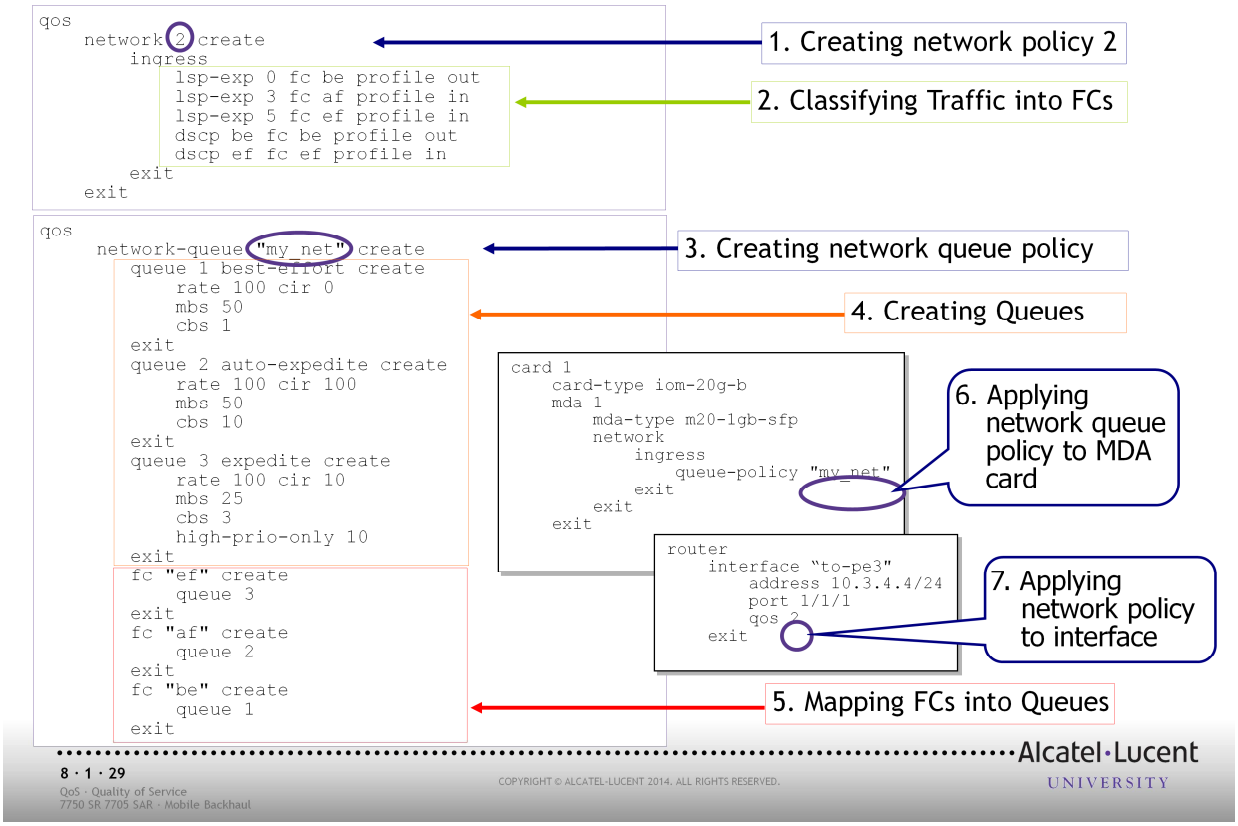
(The search is stopped when a match is made)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Network ingress QoS Policy example



Classifying Traffic:

Incoming traffic is classified by looking into the datagram's different fields.

Network Control	<NC>
High Priority 1	<N1>
Expedited Forwarding	<EF>
High Priority 2	<H2>
Low Priority 1	<L1>
Assured Forwarding	<AF>
Low Priority 2	<L2>
Best Effort	<BE>

Mapping Traffic into Queues:

The classified incoming traffic is then placed into the appropriate queue

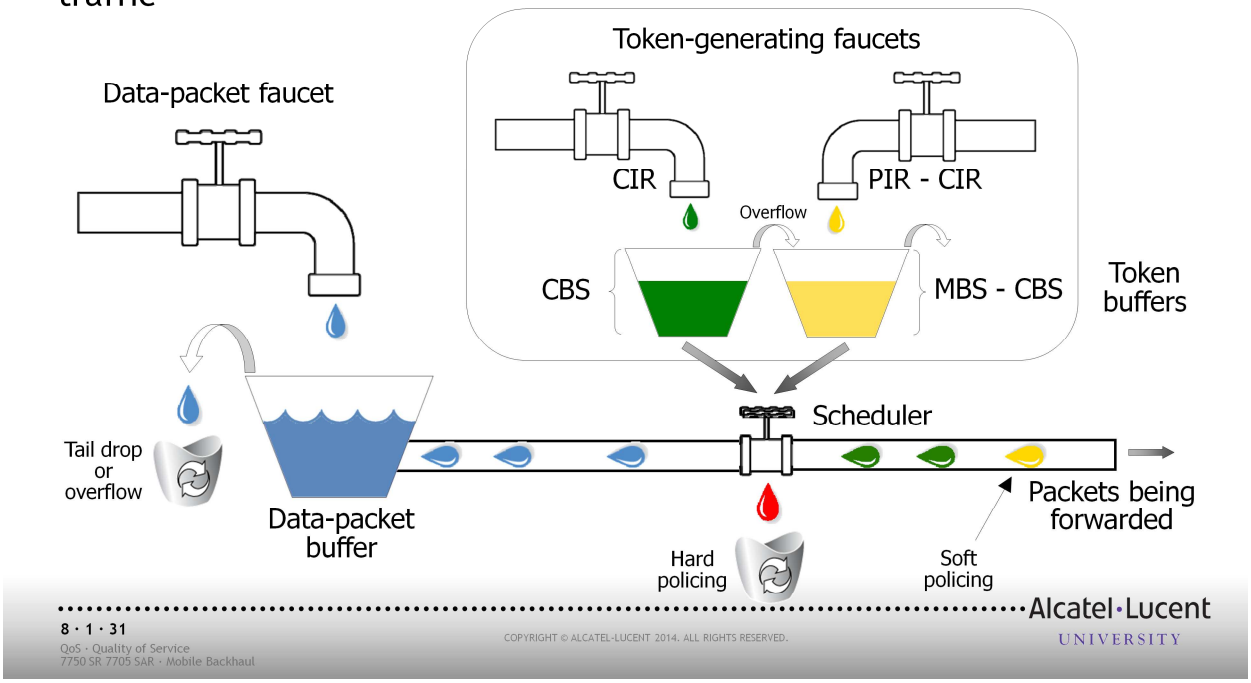
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

5 Policing and Shaping Mechanisms

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Two-rate three-color marker (TR-TCM)

Each queue has a TR-TCM associated to it, which helps shape/police the traffic



Each queue has a Two-rate three-color marker (TR-TCM) associated to it. The **scheduler** is in charge of performing the TR-TCM functions and, based on that, of policing and shaping the data traffic that enters the queue.

As part of the TR-TCM functionalities, there are two token generators and their respective token buffers for each queue. A token is essentially a transmission permit. The green generator issues tokens at a rate equal to the queue's committed information rate (**CIR**) and the yellow one issues tokens at a rate such that both generators together issue tokens at a rate equal to the queue's peak information rate (**PIR**). The green token buffer size is equal to the queue's committed burst size (**CBS**), while the yellow token buffer size is such that, together, both buffers have a combined size equal to the queue's maximum burst size (**MBS**).

When the scheduler needs to establish the profile of a packet, if there are green tokens available, the packet will be considered in-profile and forwarded. If there are no green tokens, but there are yellow tokens, the packet will be considered out-of-profile but it will still be forwarded (**soft policing**). Finally, if there are no tokens (yellow or green) in the buffers, the packet is marked red and discarded (**hard policing**).

If a large burst of packets arrive at the queue at once, the maximum burst size that will be seen at the queue's output will be equal to MBS. This is due to the fact that each packet needs to get a token in order for it to be forwarded, and the maximum number of tokens available at a given time, if both token buffers are full, is MBS.

Based on this method, the scheduler will never forward green packets at a rate higher than CIR and it will not forward packets in general at a rate higher than PIR. In other words, the scheduler controls the shape of the traffic that goes out of the queue (**shaping**).

If CIR = PIR, the TR-TCM becomes a **one-rate three-color marker**; if PIR > CIR but CBS = MBS, then we get a **two-rate two-color marker**; if PIR = CIR and CBS = MBS, then we get a **one-rate two-color marker**.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Queue parameters

Committed Information Rate (CIR)

This is the minimum guaranteed service rate of a queue.

Maximum Information Rate (PIR)

This is the maximum rate at which datagrams can exit a queue.

Committed Burst Size (CBS)

This parameter defines the size of a packet burst that can be generated at once by the customer and that will go through the queue as in-profile packets, provided that the customer has been generating traffic at a rate that does not exceed the CIR (so that the green token buffer is full).

Buffer space in a 7750 SR is subdivided into **reserved** and **shared**. Reserved buffer space can only be used by the queue it belongs to; shared buffer space can be used by any queue, based on competition (FCFS).

The CBS parameter also specifies the amount of buffer space **reserved** for use by the queue. The CBS for a given queue can be configured or the default size can be used. Default values depend on MDA type and port configuration (mode and speed).

Maximum Burst Size (MBS)

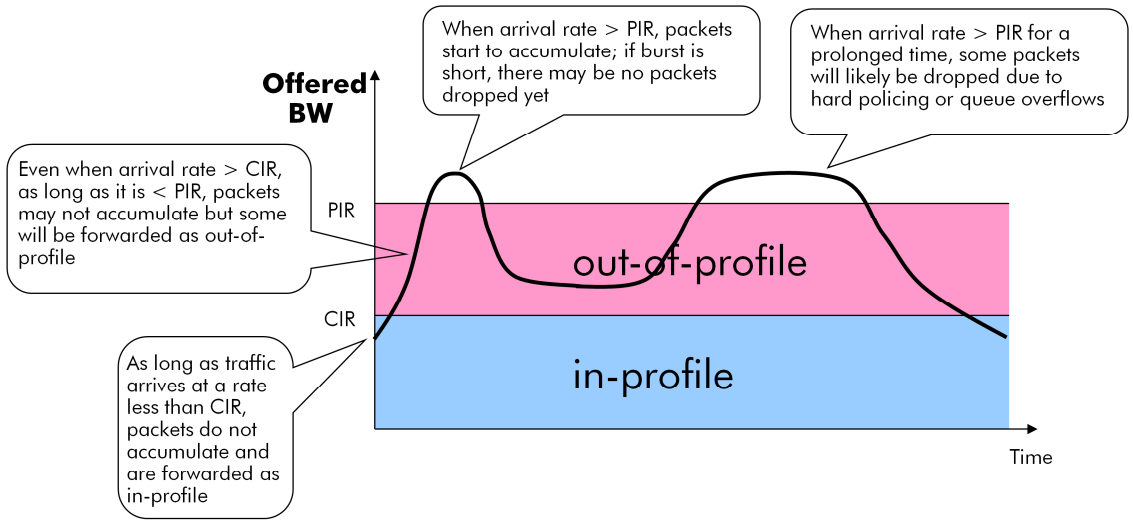
This parameter defines the size of a packet burst that can be generated at once by the customer and that can go through the queue with the guarantee that no packets will be dropped, provided that the customer has been generating traffic at a rate that does not exceed the PIR (so that both token buffers are full). In this case, some of the packets will be forwarded as out-of-profile.

The MBS parameter also specifies the maximum size to which a queue can grow. Once the reserved buffer space for a queue (CBS) has been used up, the queue contends with other queues for additional buffer resources up to its Maximum Burst Size (MBS). This parameter ensures that customers that are exceeding the PIR of a queue will not consume all the available shared buffer resources. The MBS for a given queue can be configured or the default value can be used.

Note that there is a **direct relationship** between the committed and maximum allowed **burst sizes** (token buffer sizes) and the **packet queue size**, namely its reserved buffer space and its maximum buffer size. The rationale behind this is the fact that packets that arrive too fast at the queue are very likely going to be rejected by the hard policing mechanism. Thus, it would not make sense to allocate a large amount of buffer space for the queue to store packets that will not make it through anyway.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

In Profile and Out of Profile Traffic



Packets that arrive in-profile at SAP ingress are guaranteed to be serviced throughout the network

Packets that arrive out-of-profile at SAP ingress may be dropped due to congestion further in the network

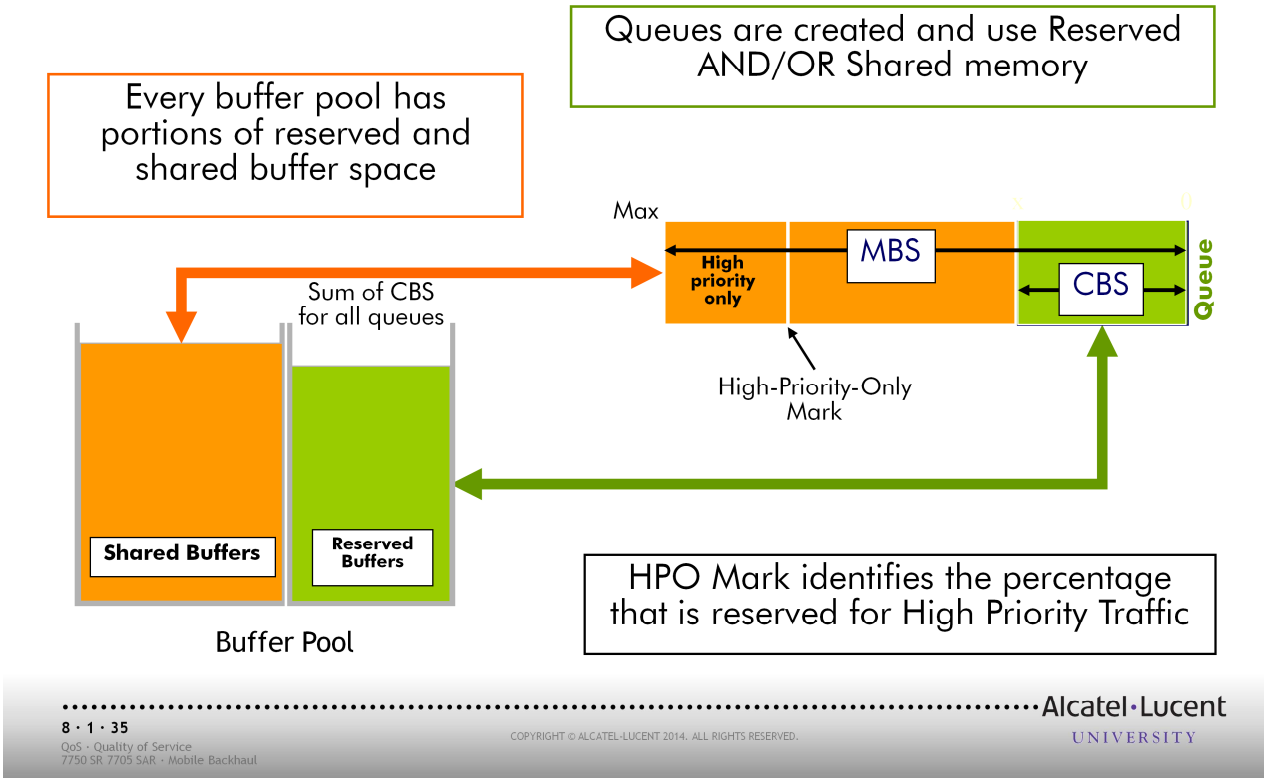
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

6 Traffic Buffering

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Traffic Buffering



Each pool of buffer space has portions of **reserved** and **shared** buffer space. The Committed Burst Size (CBS) is buffer space that is allocated to a specific queue and cannot be used by other queues, even if it is not being consumed by packets at the time. The sum of the CBS values of the queues in a buffer pool represents the **Reserved Buffer Portion** of that pool. The **Shared Buffer Portion** is unreserved memory that can be used on demand by queues who need it temporarily, and freed when not needed so that other queues can use it as well.

Shared Buffer Portion = Total Buffer Pool – Reserved Buffer Portion

In order to guarantee buffer space for queues within a buffer pool, ensure that the sum of the CBS of the queues created does exceed the pool size.

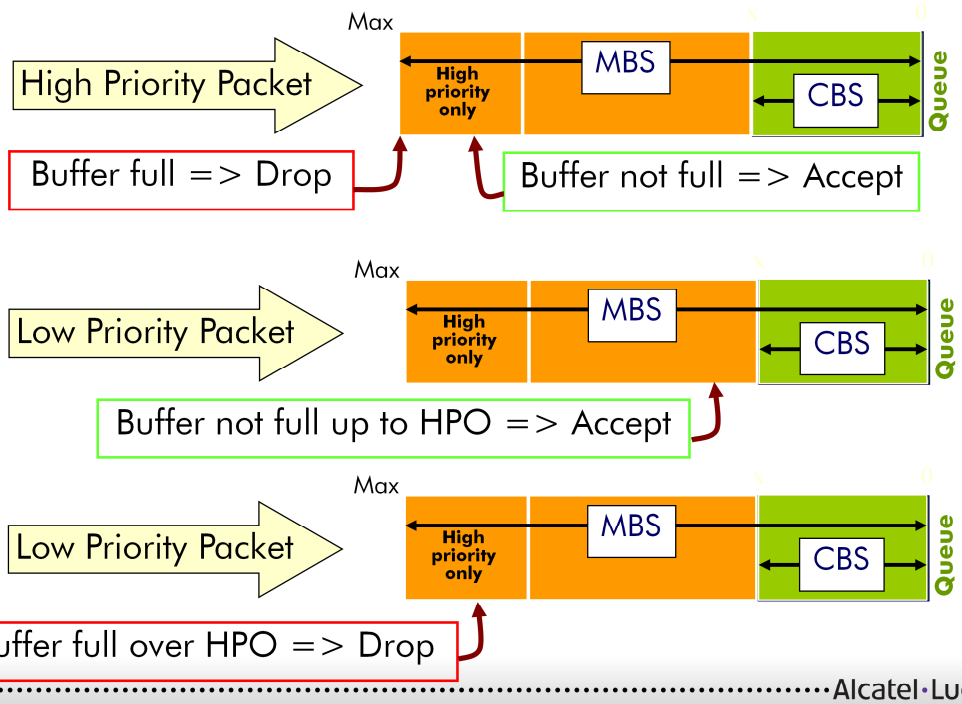
It is possible to create queues that comprise only reserved buffer space, only shared buffer space, or a combination of both. Combining reserved and shared buffer spaces allows an efficient use of memory to cope with occasional traffic bursts, while providing a guaranteed buffer space during normal conditions.

A CBS of 0 means there is no guaranteed buffer space for a queue, and all its buffer space is drawn from the shared portion of the buffer pool.

A certain portion of queue space can be reserved exclusively for high-priority (in-profile) traffic. This is known as the HPO (High-Priority-Only) portion, and is defined as a percentage of MBS. As long as the queue occupancy is less than MBS*(1-HPO), low-priority traffic will still be admitted. If occupancy goes above that threshold, low-priority traffic will be discarded.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

HPO: tail drop (overflow) examples



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

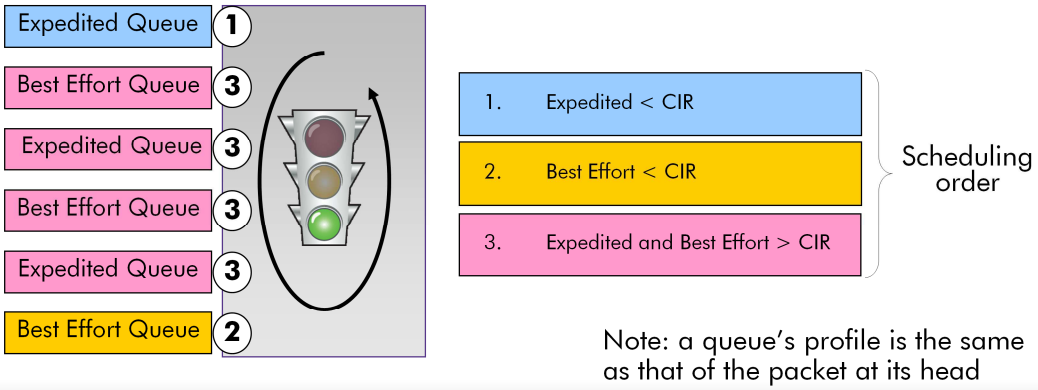
7 Default Scheduling

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Default (Single-Tier) Scheduler

The scheduler is a per-MDA fast moving “arm” that takes the packets out of the queues for transmission

- The highest priority is given to **in-profile expedited** queues
- The second highest priority is given to **in-profile best effort** queues
- The lowest priority is given to **out-of-profile expedited and best effort** queues



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Single Tier Schedulers

Single-tier schedulers are implemented in hardware and are the default method of scheduling queues in the 7750 SR. Queues are scheduled with single-tier scheduling if no explicit hierarchical scheduler policy is defined or applied. There are no explicit configurable parameters for single-tier scheduling other than a queue’s CIR and PIR.

Single tier schedulers serve queues based on the forwarding class of the queue and the operational state of the queue relative to the queue’s CIR and PIR. Queues operating within their CIR values are serviced before queue’s operating above their CIR values with “expedited” forwarding class queues given preference over “non-expedited” forwarding class queues.

Pairs of schedulers send traffic to a switch fabric port, service access port, or network interface.

Queues of the same type are serviced in a round robin fashion.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Differences in QoS between 7705 SAR and 7750 SR

Prior to R3.0, there was only 2-priority scheduling (in-profile and out-of profile).

After R3.0, 4-priority scheduling could be enabled on the Ethernet mda. This is the same scheduling as that of the IOM-3 on the 7750.

In R5.0, the SAR-M Ethernet card has 16-prioirity scheduler enabled by default on the network Ethernet port.

The 7705 SAR does not support H-QoS or Egress port scheduler.

The 7705 SR supports priority-mode only, and not profile-mode queues.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Internal overhead at the SAP or the fabric:

- On the 7750SR, the CIR setting corresponds to data where on the SAR it is data + internal overhead.
- There is also a difference when the packet goes over the fabric.

On network egress, MBS/CBS setting is a percentage of the port on the 7750 SR but a percentage of the mda buffer on the 7705 SAR.

On the 7705 SAR, if a sap-ingress queue size is mbs = cbs = 0, then all ingress traffic to the queue will be dropped at the SAP regardless of the CIR/PIR.

On the 7750 SR, if the ingress traffic rate is below or equal to CIR, all traffic will be forwarded at the SAP.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
Quality of Service

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 1
Overview

TER36075_V3.1-SG-English-Ed1 Module 9.1 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives



Upon completion of this module, you should be able to:

- Services and the Alcatel-Lucent service model
- Service types - VLL, VPLS, IES and VPRN
- Service components
  - Service type
  - Customer
  - Service Access Points (SAP)
  - Service Distribution Points (SDP)
- Service policies (filter, QoS, scheduling, accounting)
- MTU considerations

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — The Alcatel-Lucent service model	**5**
2 — Service types	**9**
3 — Service components	**14**
4 — OAM tools	**35**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 The Alcatel-Lucent service model

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service definition

A **service** in this context is a mechanism to extend the connectivity provided by a private network

Services can be classified into two groups, depending on the extended connectivity they provide:

- Access to the global Internet
- Interconnection between two or more remote locations of the same customer network as if they were co-located

The second service group is known as a Virtual Private Network (VPN).



A service in this context consists of extending the connectivity provided by a private network.

Services can be classified into two groups, depending on the type of extended connectivity they provide:

- Access to the global Internet
- Interconnection between two or more remote locations as if they were co-located

The second service group is known as a **Virtual Private Network (VPN)**. Its name comes from the fact that two or more separate islands of a private network have the service provider in the middle, but they still get the impression that the whole network is private. This is to some extent true because full privacy is maintained from end to end by keeping logically separated flows of data at all times.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service definition [cont'd]

Services can also be classified into two groups, depending on what the service provider carries on behalf of the customer from end to end

- Layer-2 service: the service provider carries entire layer-2 frames from one location to other locations
- Layer-3 service: the service provider network discards the layer-2 header and only carries the IP packet that was inside it

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Services can also be classified into two groups, depending on what the service provider carries on behalf of the customer from end to end.

- Layer-2 service: the service provider network carries the entire layer-2 frames generated by hosts in one location to hosts sitting in other locations
- Layer-3 service: the service provider network discards the layer-2 header received from a customer host and only carries the IP packet that was inside it; layer-2 headers are added to the packet at each hop as needed

Examples of Layer-2 services are:

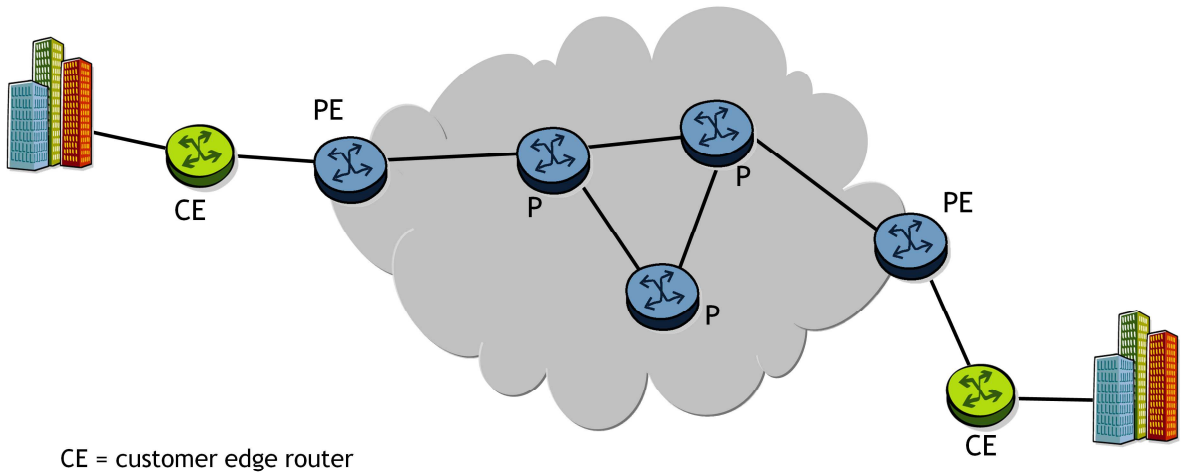
- Virtual Leased Line (VLL), also known as Virtual Private Wire Service (VPWS)
- Virtual Private LAN Service (VPLS)

Examples of Layer-3 services are:

- Virtual Private Routed Network (VPRN)
- Internet Enhanced Service (IES)

VLL, VPLS and VPRN are all examples of VPN. IES is the way access to the Internet can be provided with all the benefits introduced by the service concept, as explained below.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



CE = customer edge router

PE = provider edge router

P = provider router

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Network Components

Customer Edge Devices (CE)

A customer edge (CE) device provides customer access to the service provider network over a data link to one or more provider edge (PE) routers. The end-user typically owns and operates these devices. The CE devices run the routing protocol(s) of the end-user and support the IP address scheme implemented by the end-user. They are unaware of the existence of the MPLS protocol or the VPNs.

CE devices used in Layer 2 VPNs may be an Ethernet switch, in which case they do not need to participate in routing protocols. They must only be aware of VLANs running in the customer network.

Provider Edge Devices (PE)

A PE router is directly connected to the customer edge (CE) devices. In an MPLS network PE routers are Label Edge Routers (LER).

Provider Router (P)

The routers in the provider core network. In an MPLS provider network routers are Label Switched Routers (LSR).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Service types

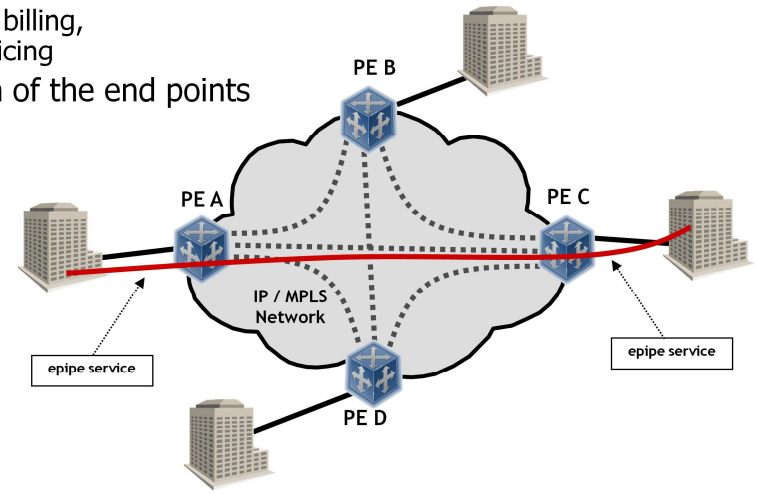
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Virtual Leased Line (VLL) service

A Virtual Leased Line service provides a point to point connection between two nodes

- From the customer's perspective it looks as if a leased link exists between the two locations
- No MAC learning required
- The Service provider can apply billing, ingress/egress shaping and policing

An ePipe is a VLL in which each of the end points is running an Ethernet LAN



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

This service is a Layer 2 point-to-point service commonly known as a Virtual Leased Line (VLL). The Alcatel-Lucent VLL family includes ePipe, aPipe, fPipe, cPipe and iPipe. The VLL service encapsulates customer data and transports it across a service provider's IP or MPLS network in a GRE or MPLS tunnel.

Customer access to the service provider's network is through a Service Access Point (SAP). A VLL service connects two access points (SAP) on the same node (local) or two SAPs on different nodes (remote) through two uni-directional tunnels. In a distributed VLL, each node requires an SDP to provide access to the service tunnel.

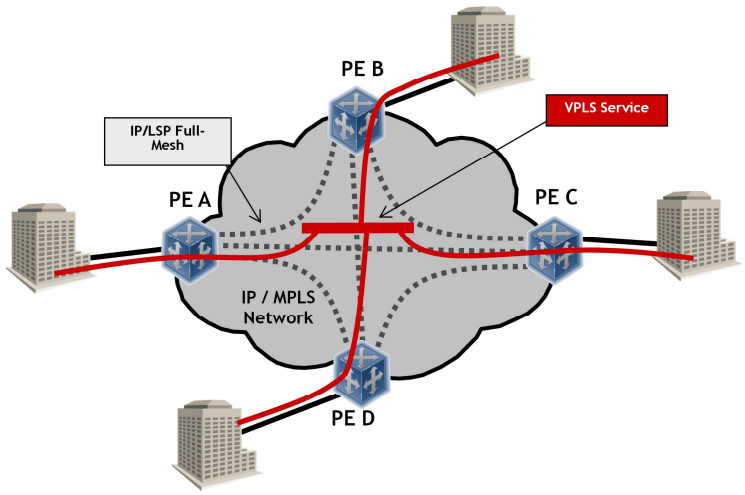
QoS and filter ingress and egress policies can be applied to VLL services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Virtual Private LAN Service (VPLS)

VPLS is a class of VPN that allows the connection of multiple sites in a single bridged domain over a provider managed IP/MPLS network

- From the customer's perspective it looks as if all sites are connected to a single switched VLAN
- The VPLS will do MAC learning
- Service provider can reuse the IP/MPLS infrastructure to offer multiple services
- The Service provider can apply billing, ingress/egress shaping and policing



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A VPLS service can also be local or distributed. It will be local if it connects two access points (SAP) on the same node and it will be distributed if it connects two SAPs on different nodes through two uni-directional tunnels.

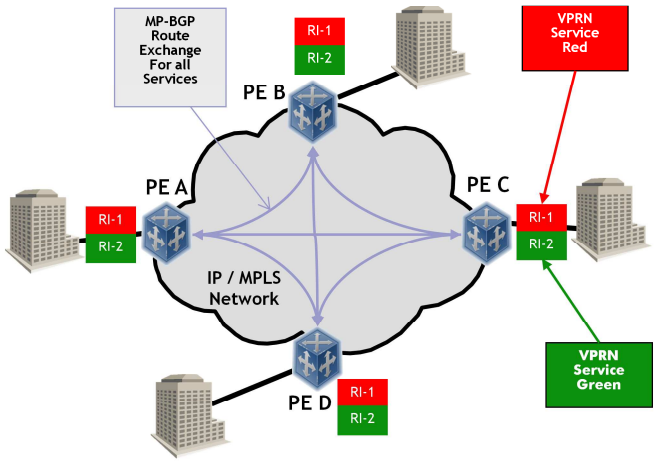
QoS and filter ingress and egress policies can be applied to VPLS services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Virtual Private Routed Network (VPRN)

VPRN is a class of VPN that allows the connection of multiple sites in a routed domain over a provider managed IP/MPLS network:

- From the customer's perspective it looks as if all sites are connected to a private routed network administered by the service provider for that customer only
- The service provider can reuse the IP/MPLS infrastructure to offer multiple services
- Each VPRN appears like an additional routing instance
- Routes for a service between the various PE's are exchanged using MP-BGP



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

RFC 4364, formerly IETF draft-ietf-l3vpn-rfc2547bis-03.txt, details a method of distributing routing information and forwarding data to provide a Layer 3 Virtual Private Networks (VPN) service to end customers.

Each Virtual Private Routed Network (VPRN) consists of a set of customer sites connected to one or more PE routers. Each associated PE router maintains a separate IP forwarding table for each VPRN. Additionally, the PE routers exchange the routing information configured or learned from all customer sites via Multi-Protocol BGP (MP-BGP) peering.

Each route within a VPN is assigned an MPLS label. When BGP distributes a VPN route, it also distributes an MPLS label for that route.

Before a customer data packet travels across the service provider's backbone to the best BGP next-hop in its route towards the destination address, it is encapsulated with the MPLS label that corresponds to the customer's VPN. The MPLS packet is further encapsulated with either another MPLS label or GRE tunnel header, so that it gets tunneled across the backbone to the proper PE router. Each route exchanged by the MP-BGP protocol includes a Route Target (RT) extended community parameter, which identifies the VPRN association. Thus the backbone core routers do not need to know the VPN routes.

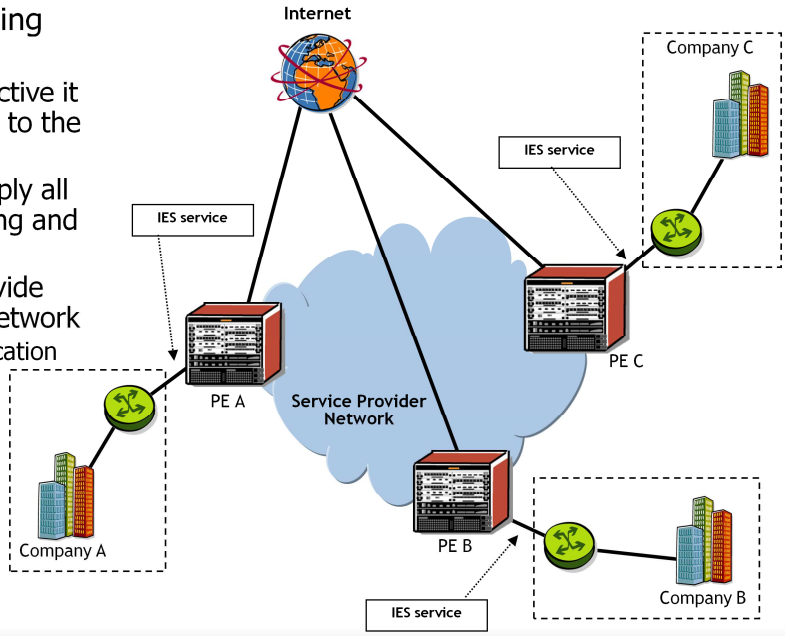
Similar to other VPN services, a VPRN service can also be local or distributed if it involves only one PE or more than one, respectively.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Internet Enhanced Service (IES)

Internet Enhanced Service or IES provides direct internet access for the customer with the following features:

- From the customer's perspective it provides a direct connection to the Internet.
- The Service provider can apply all billing, ingress/egress shaping and policing to the customer.
- IES can also be used to provide access to a private routed network
  - An Ethernet backhaul application



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

An Internet Enhanced Service (IES) is a routed connectivity service where the subscriber communicates with an IP (Layer 3) router interface to send and receive traffic from IP sub-networks other than those included in its own private network. Its main purpose was originally to provide connectivity to the Internet, but the customer can potentially gain access to all IP sub-networks that the service provider has access to, which might include other private networks belonging to the same subscriber (e.g. IP backhaul) or a contents provider (e.g. for video download).

The PE devices can buffer service traffic and shape it to conform to SLA parameters. Buffer allocation is programmable per-service to accommodate different maximum burst sizes (MBS). Each service can use multiple queues to enable shaping, policing and marking of different flows. The PE device can also shape and police on service egress so customers can purchase sub-rate services (e.g. Internet services) with asymmetric SLAs.

Characteristics

- Service Access Points (SAP) are the customer access to the subscriber's network and beyond
- SAPs support multiple encapsulation types including Ethernet null, dot1q and q-in-q, SONET/SDH-IPCP, BCP-null, BCP-dot1q and ATM
- Supports VRRP, Cflowd, secondary IP addresses, and ICMP options on customer IP interfaces
- Interface supports RIP, OSPF, IS-IS, and BGP protocols
- QoS and filter policies can be applied
- Does not require a Service Distribution Point (SDP); traffic is routed rather than being encapsulated in a tunnel
- Support for IPv6 (including IPv6 routing protocols)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 Service components

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SR Service Configuration Model

A service may have the following components:

- **Service type** – defines the type of service that you want
- **Customer** – identifies the customer that the service is associated to
- **Service Access Point (SAP)** – a logical entity that serves as the customer access to the service
- **Service Distribution Point (SDP)** – a unidirectional tunnel that will carry data packets from one PE to another

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

An SDP has to be created first, and then bound to the service. An SDP is not exclusive to a service, but it can be bound to two or more services if needed. To successfully create an SDP, the transport tunnel that will be used has to be specified. This transport tunnel can be RSVP-TE, LDP, or GRE (Generic Router Encapsulation).

When an SDP is bound to a service, a VC ID (Virtual Circuit identifier) needs to be specified. At that point, an additional MPLS label (known as service or VC label) is automatically negotiated by Targeted LDP (TLDP) between the two PEs involved, associated to the VC ID value chosen. The VC ID value has to match on both ends of the SDP.

So, an SDP is a way of binding together the service MPLS label that identifies the service and the transport tunnel, which is the one that actually carries the data packets from end to end.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SR Service Configuration Model - VPN service

A VPN service (VPRN, VPLS or VLL) can be **local**, if it involves only one PE router, or **distributed**, if two or more PE routers collaborate to provide the service

In order to provision a **local** VPN service you need to configure the following components:

- Customer
- Service type
- Service Access Points (SAPs), as needed to connect to the customer sites

For a **distributed** VPN service, additionally, you need a way of telling each PE router how to forward data packets to the other routers that also participate in the VPN; this requires the configuration of:

- Service Distribution Points (SDP), as needed to interconnect PEs



For a distributed VPRN service, the command **auto-bind** can be used to automatically create and bind to the service an SDP toward each of the other PE routers that also participate in the VPN. Both LDP and RSVP-TE existing transport tunnels can be used with this feature.

This is possible for VPRN, and not for the other service types, because in this case an MP-BGP session is established between every pair of PE routers that participate in the service in order for them to exchange routing information (VPN prefixes). So, its peers have been identified. Therefore, when the auto-bind command is issued, SDPs are created from the router to each of the other routers with which there exists an MP-BGP session for the VPN family of prefixes.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SR Service Configuration Model – IES service

In order to provision an IES service you need to configure a:

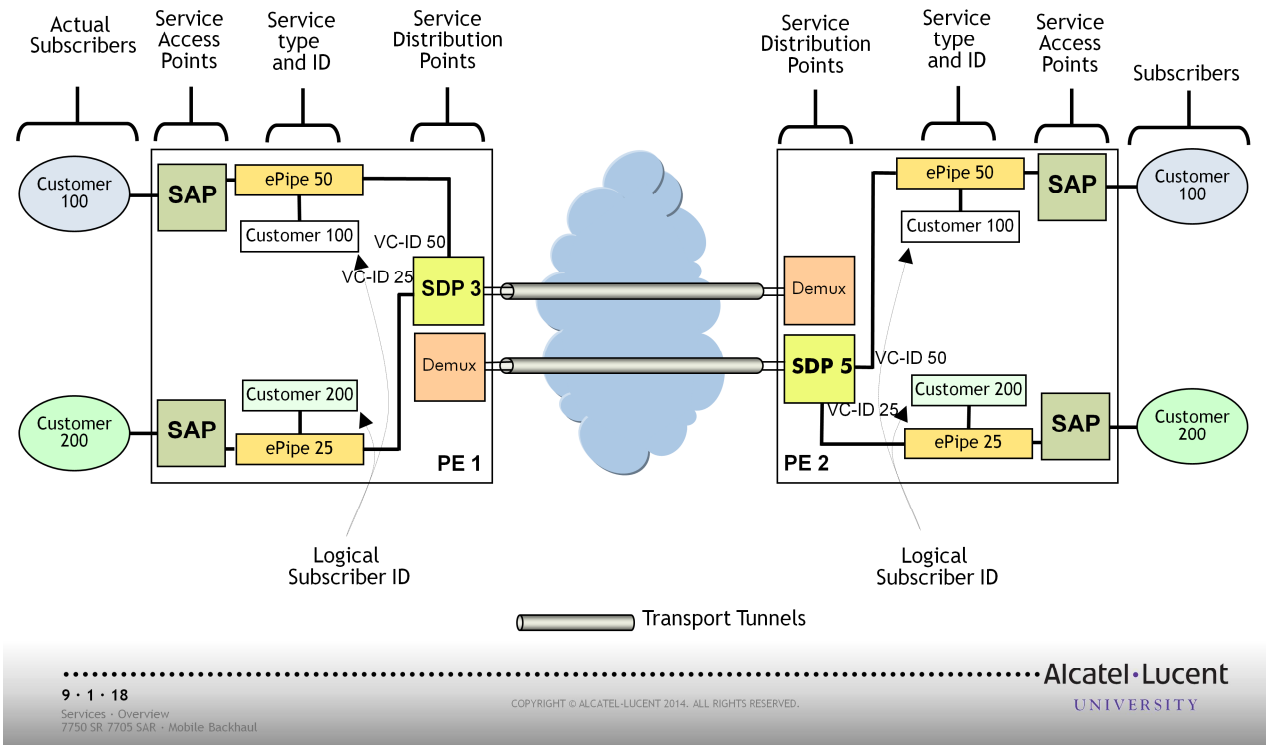
- Customer
- Service type
- Layer-3 interfaces, as needed to connect to the customer sites

Similar to a regular interface, for each IES interface you need to configure:

- an IP address
- a Service Access Point (SAP)

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Service Access Point (SAP)

A SAP is a logical entity that serves as the customer's point of access into a service. Each subscriber service is configured with at least one SAP. A SAP can only be created on a port that has been configured as an **access** port. The default configuration for a port is **network**, which means that you may need to reconfigure a port before you can configure a SAP on it. SAPs for IES and VPRN services are configured on IP interfaces.

Service Distribution Point (SDP)

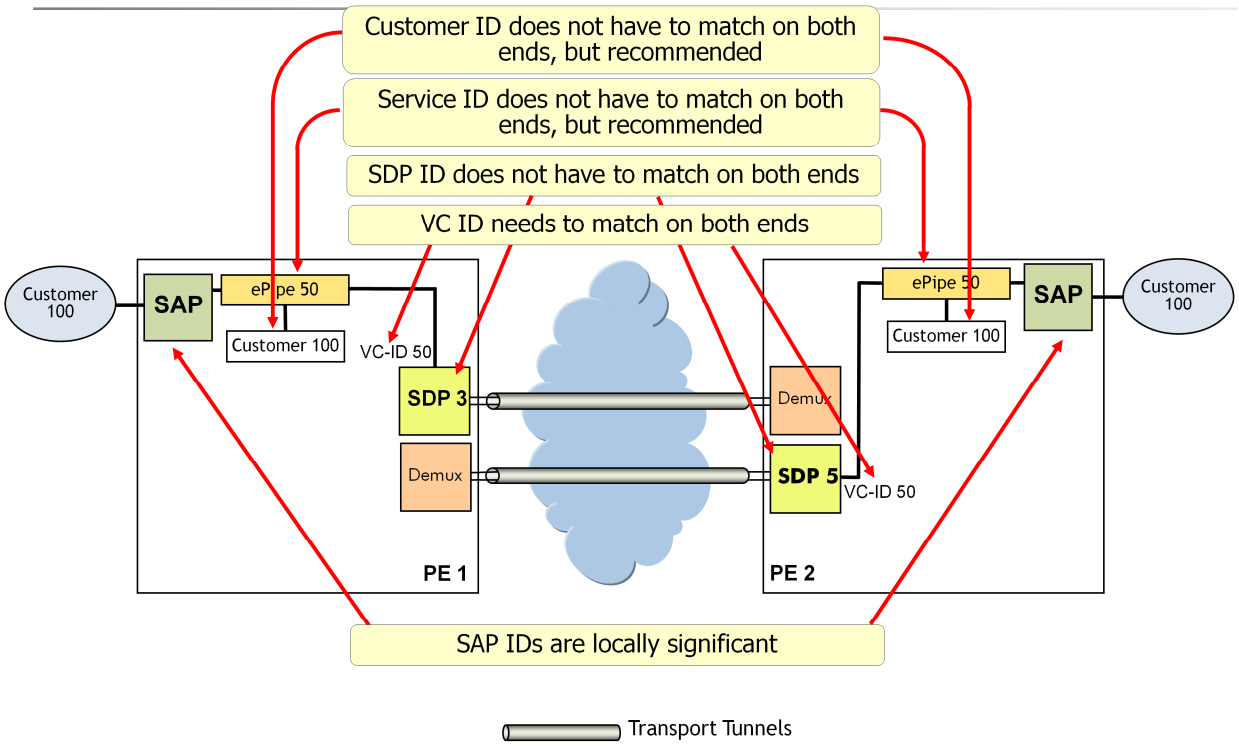
A SDP acts as a logical way of directing data traffic from one router to another through a uni-directional tunnel. When bound to a service, an SDP creates a service tunnel inside the transport tunnel that was associated to it at creation. If an SDP is bound to more than one service, the result is that several service tunnels (one per service) are created and multiplexed inside the same transport tunnel.

In the example, the same SDP is used for both services created on each PE router (e.g. SDP 3 on PE 1). However, different VC-ID values are used when binding the SDP to each service. The SDP negotiates a separate VC label for each service, based on the VC-ID values, effectively creating two service tunnels inside the same transport tunnel.

An SDP originating on one node terminates at a destination node, which then directs incoming packets to the correct egress SAP on that node. A distributed (multi-node) service needs at least one SAP and one SDP on each node. For a service to be bi-directional, a SDP must be provisioned on each direction.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service component IDs



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Customer Configuration

- The Customer component of a service identifies the subscriber that the service is associated to
- The Customer must be configured prior to creating the service
- When a service is created, it must be specified what customer it belongs to
- Once a service has been created, its customer association cannot be modified
- Multiple services can be created for the same customer

- Example:

```
config>service# info
----------------------------------------
customer 5 create
    description "Alcatel Customer"
    contact "John Smith, Technical Support"
    phone "650 555-5100"
exit

epipe 101 customer 5 create
...
----------------------------------------
```

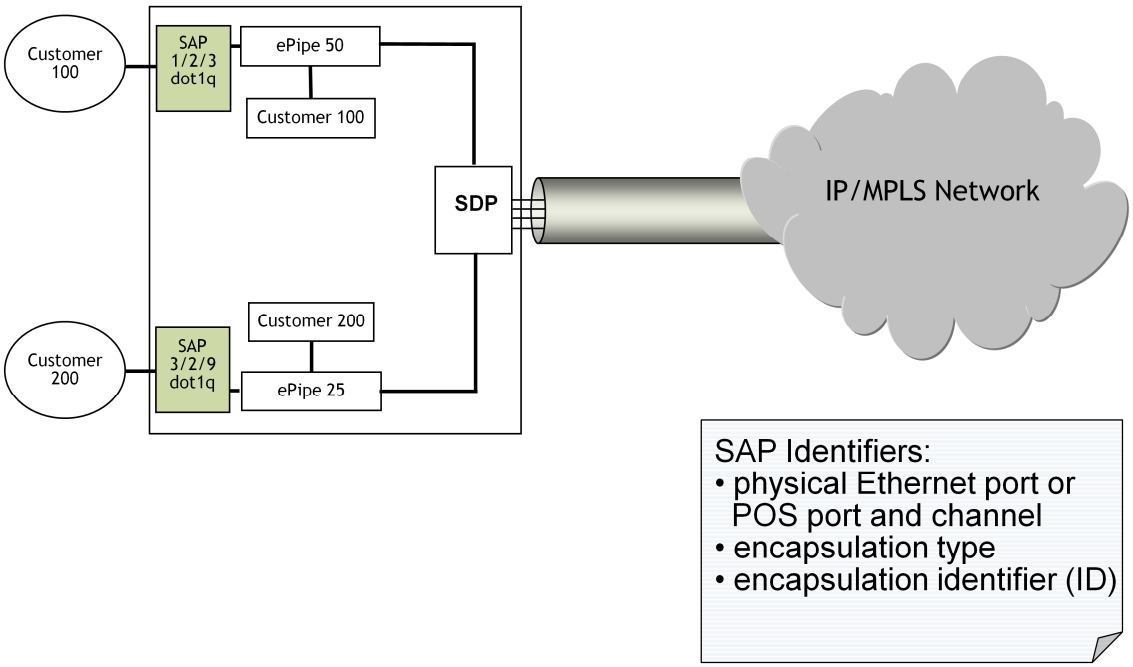
Customer creation

Creation of service associated to customer

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service Access Point (SAP)



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

SAP Characteristics

A SAP is the subscriber-side service entry and exit point for a service.

Depending on the encapsulation used, a physical port or POS channel can have more than one SAP associated with it. Using dot1q and q-in-q encapsulation or POS channels allows support for multiple services on the same port for the same customer or for multiple customers.

A SAP ID is local to a router and is uniquely identified by:

- physical Ethernet port or Packet-Over-SONET/SDH (POS) port and channel
- encapsulation type
- encapsulation identifier (ID)

Examples:

For Dot1Q encapsulation: 1/2/3:100
For QinQ encapsulation: 3/2/9:101.234

SAPs can only be created on ports or channels that are configured as access ports in the physical port context. SAPs cannot be created on ports designated as network ports because these ports have a different set of features enabled in software.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAP Encapsulation Types, Identifiers, and Characteristics

SAP encapsulation provides the router with a way of delineating services. Null means there can only be one service on the port; the other encapsulations (dot1q, q-in-q and ATM) indicate that there can be multiple services per port.

Ethernet

Three encapsulation types are supported on Ethernet access ports:

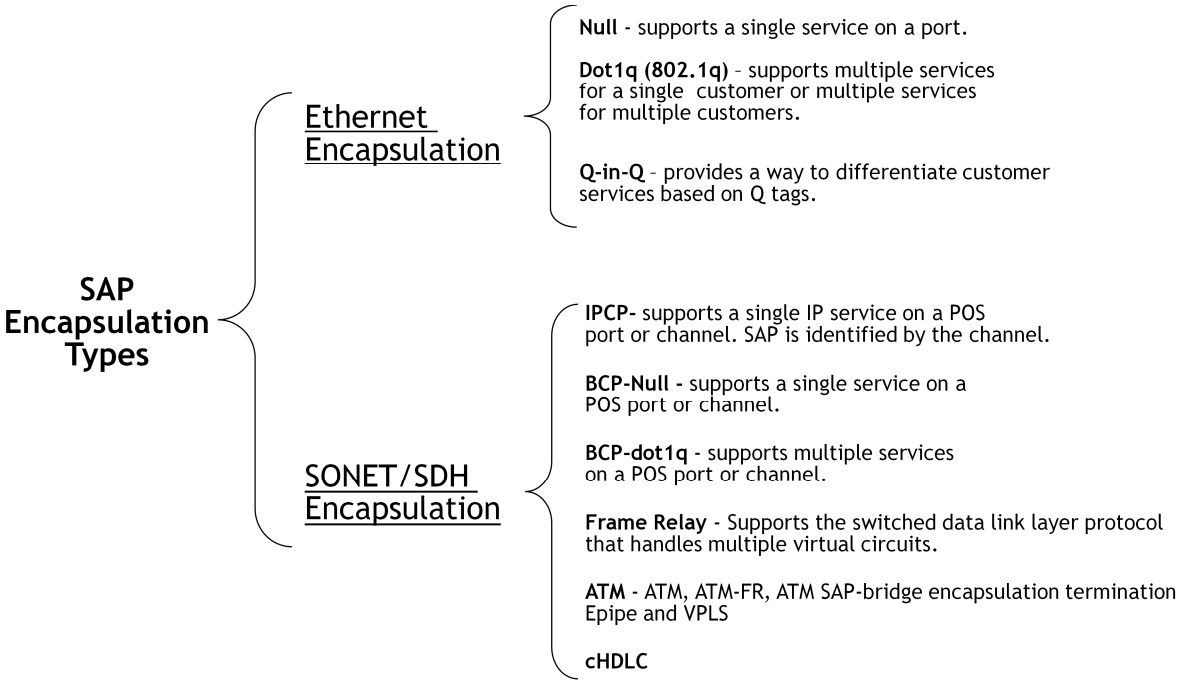
- Null - Supports a single service on the port and is used in situations where there is a single customer edge (CE) device connected to the port. The encapsulation identifier (ID) is set to zero.
- Dot1Q - A single qtag (qtag1) is used to delineate customer services. This tag can have a value from 0-4094. All tags are local to the port where the SAP is bound.
- Q-in-Q – Up to two qtags (qtag1 and qtag2) are used to delineate customer services. Each tag can have a value from 0-4094. All tags can be local to the port where the SAP is bound or the inner label can be transported intact to the destination if the router is configured to do so.

SONET/SDH

- IPCP - Internet Protocol Control Protocol (IPCP) supports a single IP service on a POS port or in the case of a channelized POS port, a single service per channel. Often used for router interconnection using Point-to-Point Protocol (PPP).
- BCP-Null - Bridging Control Protocol (BCP-Null) supports a single IP service on a POS port or in the case of a channelized POS port, a single service per channel. This protocol is used for bridging a single service between two devices using PPP over SONET or SDH.
- BCP-Dot1Q - Supports multiple services on a POS port or channel. This protocol is used for bridging multiple services between two devices using PPP over SONET or SDH. The Dot1Q VLAN tag is used to identify the different services.
- Frame Relay - Supports the switched data link layer protocol that handles multiple virtual circuits.
- ATM - ATM, ATM-FR, ATM SAP-bridge encapsulation termination Epipe and VPLS.
- Cisco HDLC

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAP Encapsulation Types and Identifiers



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

SAP Characteristics

Configuration of SAPs is performed during service configuration or modification. SAPs have the following characteristics:

- A SAP is owned by and associated with the service in which it is created.
- A SAP ID is a local entity and is locally unique to a given device. The same SAP ID value can be used on another router.
- There are no default SAPs. All SAPs must be created.
- The default administrative state for a SAP at creation time is administratively enabled.
- If a port or channel is shut down (either administratively or operationally), SAPs on that port/channel will be operationally out of service.
- When a port/channel has a dot1q or BCP-dot1q encapsulation type, the traffic for the SAP is identified based on a specific IEEE 802.1Q VLAN ID value. The VLAN ID is stripped off at SAP ingress and the appropriate VLAN ID is placed on at SAP egress. As a result, VLAN IDs only have local significance, so the VLAN IDs for a service need not be the same at each SAP.
- Each SAP can have one each of the following policies assigned:
  - Ingress Filter Policy
  - Egress Filter Policy
  - Ingress QoS Policy
  - Egress QoS Policy
  - Accounting Policy

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAP Service Characteristics

EPipe/IPipe:

- SAPs can be defined on Ethernet ports, SONET/SDH or TDM channels

CPipe:

- SAPs can be defined on SONET/SDH, DS3/E3,T1/E1 ports or TDM channels

APipe:

- SAPs can be defined on SONET/SDH, OC3/STM1, T1/E1 ports

VPLS:

- SAPs can be defined on Ethernet or POS (BCP) interfaces

IES:

- SAPs can be defined on Ethernet ports, SONET/SDH or TDM channels
- SAPs are associated with an IP interface; one SAP per logical interface

VPRN:

- SAPs can be defined on Ethernet ports or SONET/SDH (IPCP) interfaces
- SAPs are associated with an IP interface; one SAP per logical interface

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAP Configuration Considerations

Consider the following when configuring a SAP:

- A SAP ID is locally unique, in other words the same SAP ID value may be used on another device
- A SAP is associated with a single service and can only be configured on an access port
- A port or channel can have more than one SAP configured on it if its encapsulation is different from null
- All SAPs must be explicitly created and are administratively enabled at the time of creation (no default SAPs)
- VLAN IDs have local significance, per port
- A SAP can be configured with an:
  - Ingress and egress filter policy (aka access control lists)
  - Ingress and egress QoS policy
  - Ingress and egress scheduler policy
  - Accounting policy

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service Distribution Point (SDP)

An SDP has to be created first, and then bound to services as needed

When an SDP is created, it is given an **SDP ID**

- The IP address of the PE at the **far end** has to be entered as well
- At creation time, the type of transport tunnel to be used is specified: **MPLS** or **GRE**
- If MPLS is chosen, it has to be defined if the transport tunnel will be the one created by **LDP** or a particular **LSP** signaled via RSVP

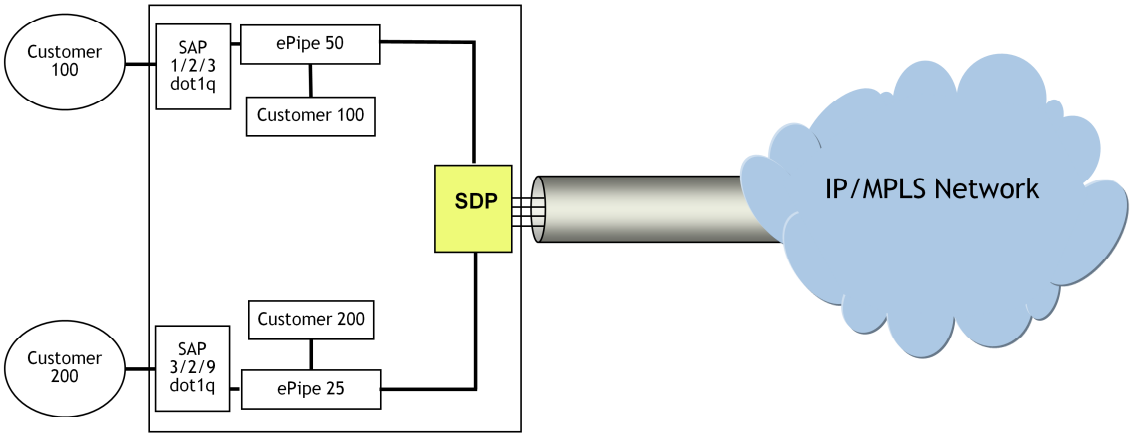
When the SDP is bound to a VLL or IES service, a **VC ID** (Virtual Circuit identifier) needs to be specified

- An additional MPLS label (known as service or VC label) is negotiated by Targeted LDP between the two PEs involved, associated to the VC ID

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service Distribution Point (SDP) Characteristics



- SDP IDs are locally unique; the same SDP ID can be used on another device
- SDPs use the System IP address to identify far end destinations
- SDP is not specific to one service; many services can use the same SDP
- All services bound to an SDP must use the same type of encapsulation (GRE, MPLS, or LDP)
- Operations on an SDP will affect all services that are bound to that SDP

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

A service distribution point (SDP) acts as a logical way of directing traffic from one device to another through a uni-directional service tunnel. An SDP is not specific to one service, but many services can be multiplexed inside the same SDP.

An SDP terminates on a de-multiplexor where the service that a packet belongs to is identified and a forwarding decision is made. When multiple nodes participate in a service, each node must have at least one SAP configured and must be linked to each of the other nodes by two uni-directional SDPs.

The SDP must be created before a VPN service can be configured. The SDP must then be bound to the service in order for data traffic to be directed to the far-end inside the service tunnel.

Accounting

For every SDP, it is possible to collect statistics on a per-service basis about the number of octets forwarded/dropped, independently at ingress and egress. Statistics are available via local show commands or a management system.

An accounting file can also be created to collect SDP statistics and provide a way to bill customers or partners on a per-SDP per-byte basis.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SDP Encapsulation Types

GRE
- Encapsulates traffic in an IP/GRE header; appears like an IP packet
- Low control plane overhead, higher data plane overhead
- Uses normal IP routing to find a path

MPLS
- Uses LDP or RSVP for label signaling
- Auto-bind available to simplify configuration in VPRN services
- LDP uses an IGP configuration to find its path
- RSVP
  - Requires manual configuration of each LSP
  - Path can be specified explicitly or based on constraints
  - May reserve bandwidth
  - Can use Fast Reroute to speed up convergence in case of failures

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

One type of tunnel uses an IP Generic Routed Encapsulation (GRE) tunnel. GRE does not specify a specific path to the Service Edge Router. A GRE-based SDP uses the underlying IGP routing table to find the best next hop to the far end Service Edge Router.

Another type of tunnel uses Multi-Protocol Label Switching (MPLS) encapsulation. A Service supports both signalled (LDP or RSVP-TE) and non-signalled Label Switched Paths (LSPs) through the network. Non-signalled paths are manually defined at each hop through the network. Signalled paths are configured only at the end nodes and communicated via protocol from end to end using LDP or RSVP-TE. A signalled path may be explicitly configured or dynamically derived using the constrained shortest path first (CSPF) algorithm and data from OSPF-TE or ISIS-TE traffic engineering databases (TED).

SDPs are created and then bound to services. Many services may be bound to a single SDP. The operational and administrative state of the SDP controls the state of the SDP binding to the service.

Generic Routing Encapsulation

- Low control plane overhead, higher data plane overhead
- Uses an IGP (eg. OSPF, IS-IS) to find a path from edge to edge
- Convergence depends on the IGP

MPLS

- Uses Label Switched Paths (LSP) (may use primary and secondary paths for protection).
- Paths can be manually configured or signalled using LDP or RSVP-TE

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SDP Configuration Considerations

Consider the following SDP characteristics:

- SDPs can be created as either GRE or MPLS
- Each multi-site service must have an SDP defined for every remote PE to provide VLL, VPLS, and VPRN services
- SDPs are not automatically associated with any service when they are created; an SDP must be explicitly bound to services as needed
- An SDP is not specific or exclusive to any one service or any type of service; an SDP can be bound to one or more services
- In order to configure an MPLS SDP, an MPLS infrastructure must be in place
- In the SDP configuration, automatic ingress and egress labeling (targeted LDP) is enabled by default; ingress and egress VC (service) labels are signaled over a TLDP connection between two PE routers when the SDP is bound to the specific service

Note: if signaling on an SDP is disabled, VC (service) labels must be manually configured.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Configuring SDPs

```
config>service>sdp sdp-id [gre | mpls]
        description description-string
        far-end ip-addr
        keep-alive
        ldp (only for MPLS SDPs)
        lsp lsp-name [lsp-name] (only for
              MPLS SDPs)
        signaling {off|tldp}
        no shutdown
```

Creating an SDP for MPLS (RSVP-TE)

```
config>service# sdp 8 mpls create
config>service>sdp# far-end 10.10.10.104
config>service>sdp# lsp "to-104"
config>service>sdp# no shutdown
```

Creating an SDP with MPLS (LDP)

```
config>service# sdp 104 mpls create
config>service>sdp# far-end 10.10.10.94
config>service>sdp# ldp
config>service>sdp# no shutdown
config>service>sdp# exit
```

Creating an SDP with GRE

```
config>service# sdp 122 create
config>service>sdp$ far-end 10.10.10.122
config>service>sdp$ no shutdown
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Creating an SDP for MPLS (RSVP-TE)

```
config>service# sdp 8 mpls create
config>service>sdp# description "MPLS-10.10.10.104"
config>service>sdp# far-end 10.10.10.104
config>service>sdp# lsp "to-104"
config>service>sdp# no shutdown
```

Creating an SDP for MPLS (LDP)

```
config>service# sdp 104 mpls create
config>service>sdp# description "MPLS-10.10.10.94"
config>service>sdp# far-end 10.10.10.94
config>service>sdp# ldp
config>service>sdp# no shutdown
```

Creating an SDP for GRE

```
config>service# sdp 2 create    <- Note that if MPLS is not specified, the SDP is based on GRE by default
config>service>sdp# description "to-GRE-10.10.10.104"
config>service>sdp# far-end "10.10.10.104"
config>service>sdp# no shutdown
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Maximum Transfer Unit (MTU) Considerations

- Port MTU: Determines the maximum packet size on a given physical wire.
- Service MTU: Associated with a service and determines the maximum packet size that can be sent from the customer across the service.
- SDP Path MTU: Determines the maximum packet size that can be sent over the SDP between its endpoints.
- VC-MTU: Derived from Service MTU and negotiated by T-LDP when the service is bound to an SDP; determines the maximum IP payload size that can be carried inside the SDP for that specific service.
- IP-MTU: Used by IES and VPRN interfaces for spoke-SDP terminations; should be equal to the VC-MTU of the spoked Epipe/VPLS.

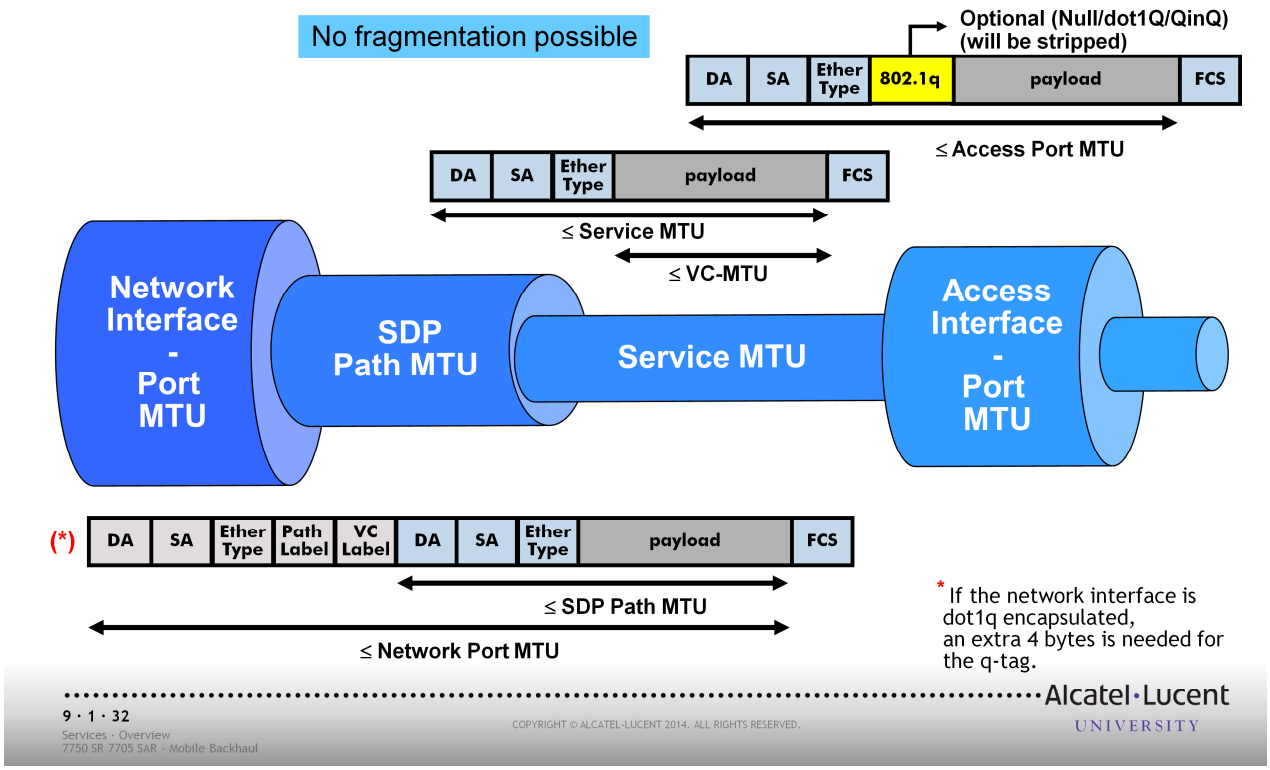


Service MTUs must match in order for spoke or mesh SDPs to become operationally UP, even if SDP MTUs match. A special case is a spoke-sdp to an IES service from a VPLS service.

Service providers should select a large backbone MTU for all links internal to their backbone. The selected MTU needs to be supported on all platforms in the backbone. A POS MTU value of 4470 is a suggested minimum, a larger value such as 9000 would be even better. An MTU value of 9000 is supported by most vendors and would allow a jumbo-frame service of 8000 or more bytes to those customers who want it.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L2 Service MTUs (Ethernet)



The Physical MTU on an Ethernet access interface needs to be set to at least:

- 1514 with mode-access and encap-type null
  - 1500 + 14 Ethernet Frame header
- 1518 with mode-access and encap-type dot1q
  - 1500 + 14 Ethernet Frame header + 4 dot1q tag
- 1522 with mode-access and encap-type qinq
  - 1500 + 14 Ethernet Frame header + 4 (first q-tag) + 4 (second q-tag)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MTU considerations for L2 services (Ethernet) – customer access side

Default value for an **access-port MTU**:

- Access port MTU = (Layer 2 header + VLAN encapsulation) + (L3 header + payload) = $\begin{cases} 1514 & \text{Null encap} \\ 1518 & \text{Dot1Q} \\ 1522 & \text{QinQ} \end{cases}$

Default value for the **service MTU** associated to a layer-2 service (VLL, VPLS):

- Service MTU = Layer 2 header + (L3 header + payload) = 14 + 1500 = 1514

Default values are designed to be compatible; if the service MTU needs to be increased by customer request, the access port MTU must be changed accordingly

The following inequality has to be satisfied at all times:

- Access port MTU ≥ Service MTU + VLAN encapsulation

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The service MTU value represents what has to be carried from end to end on behalf of the service.

The access-port MTU value, on the other hand, represents what has to be carried from end to end (service MTU) plus the service-delimiting VLAN tags that are only locally-significant and are removed on receipt.

An Ethernet layer-2 header is 14 bytes long. VLAN encapsulation requires 4 extra bytes if it is Dot1Q or 8 extra bytes if it is QinQ. It is assumed that the maximum IP packet that will be transmitted, including IP header, is 1500 bytes long. If larger IP packets are anticipated, it has to be reflected in the configuration.

The service MTU value is not used in L3 services (IES, VPRN) in general, except when a L2 service is terminated on them by means of a spoke-sdp.

Useful commands:

To change the service MTU:

```
configure service [vpls|epipe|apipe|ipipe|fpipe] service-id service-mtu [1..9194]
```

To change the port MTU:

```
configure port x/x/x ethernet mtu [512..9212]
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

MTU considerations for L2 services (Ethernet) – core network side

Default value for the **SDP path MTU**:

- SDP path MTU = Network port MTU – Layer 2 header in core network – 2 * MPLS label size
  = Network port MTU – 14 – 8 = Network port MTU – 22

Default value for a **network-port MTU** depends on the port type. For instance:

- 10/100 Ethernet 1514
- Other Ethernet 9212
- PoS Channel 9208

You must ensure that the SDP Path MTU is large enough for the services it carries

The following inequality has to be satisfied at all times:

- SDP path MTU ≥ Service MTU

The recommended way to change the SDP Path MTU, if needed, is to do it indirectly by changing the network-port MTU

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The SDP path MTU can be configured to have a different value from the default value described above, however, it is better to leave it unchanged and thus work with realistic expectations. The SDP path MTU is limited by the network port MTU. Enough room is reserved for two MPLS labels, but more may be needed if, for instance, facility backup fast re-route is configured or if LDP-over-RSVP is used for multi-area traffic engineering; this has to be taken into account when provisioning the network for services.

When creating an SDP between two PEs, they do not have to agree on the path MTU value in order for the SDP to come up. They do not have to agree on the delivery method either (protocol used to negotiate transport tunnel labels: GRE, LDP or RSVP). The only requirement is for at least one SDP to be created on each end (PE) so that a T-LDP session is started on both ends.

When binding an SDP to a service the SDP path MTU does not have to be equal to the service MTU; it only has to be large enough.

Service providers should select large MTU values for their backbone network ports. This reduces the need to change the configuration when services are created. Best practice for backbone MTU is 4470<MTU<9000 (or 9100/9200 if supported).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 OAM tools

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SDP Diagnostics – SDP-Ping

SDP-Ping

- Tests for uni-directional or round trip connectivity
- Configurable parameters:
  - Message size (default is 40 bytes)
  - Timeout (default is 5 seconds)
  - Number of messages to send (default is 1)
  - Interval (default is 1 second)
  - Originating SDP ID
  - Responding SDP ID (optional)
  - Forwarding class and in/out-of-profile of the OAM message



SDP Ping performs in-band uni-directional or round-trip connectivity tests on SDPs. The SDP Ping OAM packets follow the same path as data traffic within the service. The SDP Ping response can be received out-of-band in the control plane, or in-band using the data plane for a round-trip test.

A unidirectional SDP Ping tests:

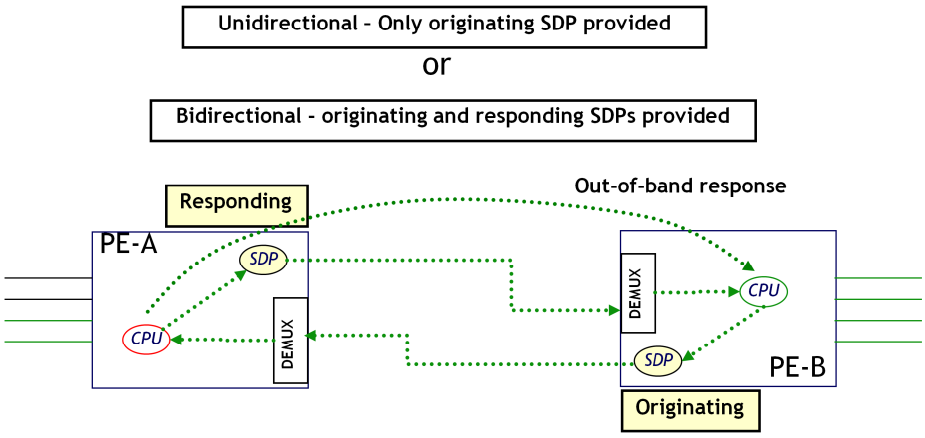
- Egress SDP encapsulation
- Ability to reach the far-end IP address of the SDP ID within the SDP encapsulation
- Path MTU to the far-end IP address over the SDP ID
- Forwarding class mapping between the near-end SDP ID encapsulation and the far-end
- tunnel termination

A round-trip SDP Ping specifies a local egress SDP ID and an expected remote SDP ID. SDP round trip testing is an extension of SDP connectivity testing with the additional ability to test:

- Remote SDP encapsulation
- Potential service round trip time
- Round trip path MTU
- Round trip forwarding class mapping

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SDP-Ping



Syntax:

```
sdp-ping orig-sdp-id [resp-sdp resp-sdp-id]
    [fc fc-name [profile {in | out}]] [timeout seconds]
    [interval seconds] [size octets] [count send-count]
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Originating SDP ID

The SDP-ID to be used by SDP-Ping. The far-end address of the specified SDP-ID is the expected **responder-id** within each reply received. The specified SDP-ID defines the encapsulation of the SDP tunnel encapsulation used to reach the far end, IP/GRE or MPLS.

Responding SDP ID

Optional parameter is used to specify the return SDP-ID to be used by the far-end for the message reply for round trip SDP connectivity testing.

Forwarding Class Name

The forwarding class of the SDP encapsulation. The state can be specified as in or out-of-profile.

Timeout

The amount of time that the device will wait for a message reply after sending a message request.

Interval

Defines the minimum amount of time that must expire before the next message request is sent.

Size

OAM message size in octets.

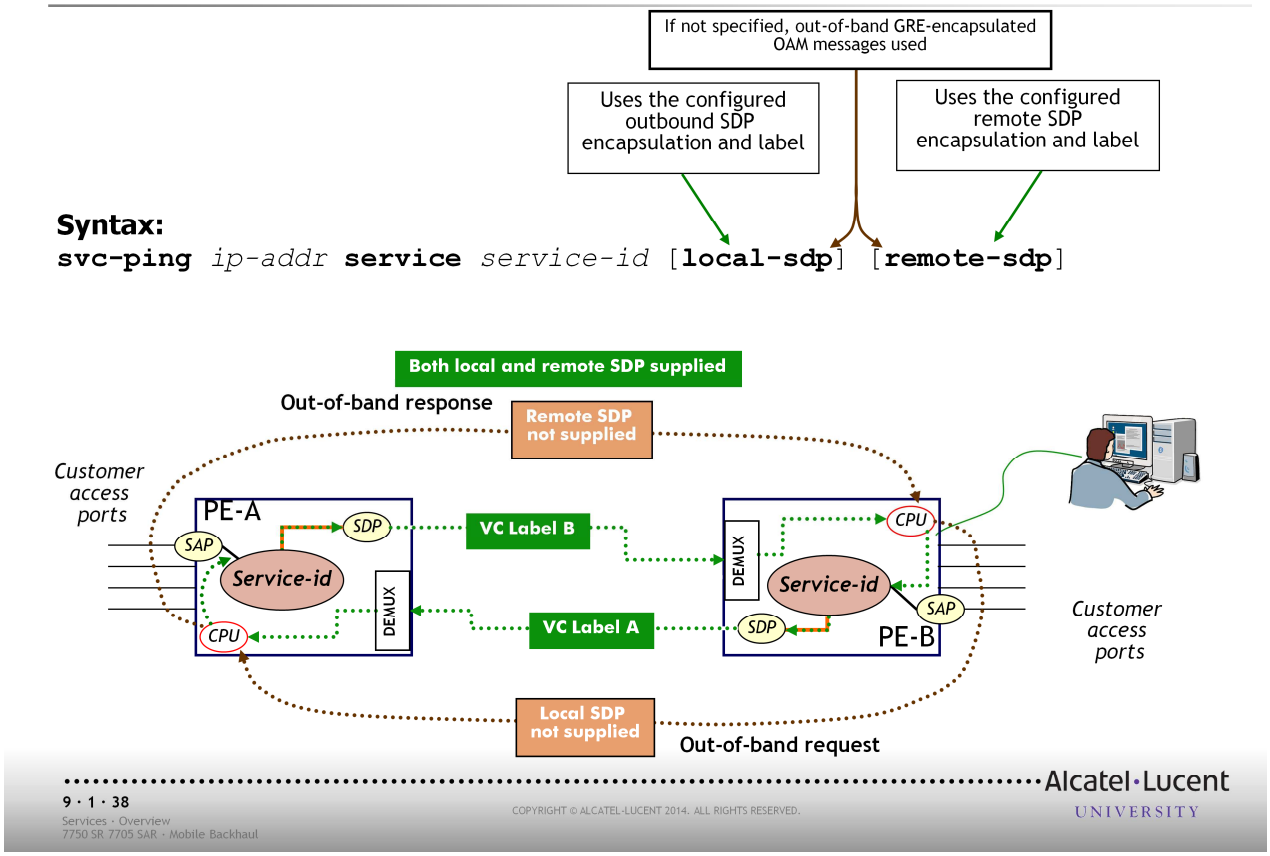
Count

The number of messages to send. Each message request must either timeout or receive a reply before the next message request is sent. The message interval value must be expired before the next message request is sent.

Note: terminate an SDP-Ping test from the CLI use the Ctrl-C keyboard combination.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Service Ping (Svc-Ping)



Parameters

Far-End IP Address

The far end IP address that the service ping packet will be sent to.

DNS-Name

Alternatively, the far end device that the service ping packet will be sent to can be specified using its DNS name (Domain Name Server).

Service-ID

The service ID of the service being tested.

Local-SDP

Specifies that the SVC-Ping request message should be sent using the same service tunnel encapsulation labeling as service traffic: IP/GRE or MPLS. If the local-SDP parameter is not used, the SVC-Ping message is sent using GRE encapsulation with an OAM label.

Remote-SDP

Specifies that the SVC-Ping reply message from the far-end should be sent using the same service tunnel encapsulation labeling as service traffic. If the remote-SDP parameter is not used, the SVC-Ping reply message is sent using GRE encapsulation with an OAM label.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
Overview

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 2
ePipe

TER36075_V3.1-SG-English-Ed1 Module 9.2 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to describe:

- Characteristics and configuration of ePipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — Characteristics of an ePipe service	**5**
2 — Steps to configure an ePipe service	**7**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

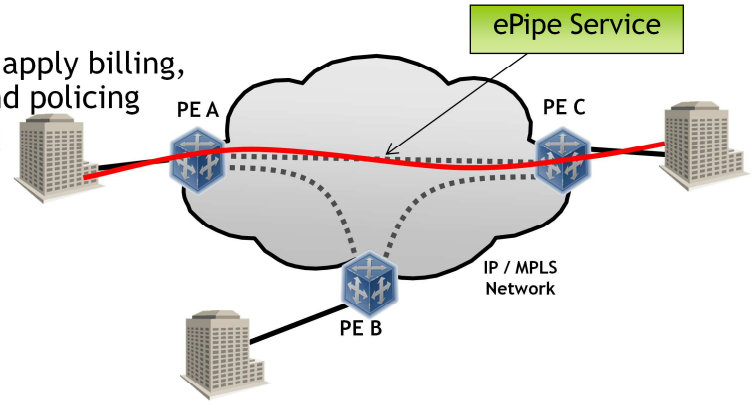
1 Characteristics of an ePipe service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ePipe Service

An ePipe service corresponds to the Virtual Leased Line (VLL) service family

- It provides a point to point connection between two nodes
- From the customer's perspective it operates as a leased line between the two locations
- The Service provider can apply billing, ingress/egress shaping and policing
- No MAC learning required



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Characteristics

- Point-to-point Ethernet service
- Provides same functionality as a private line/leased line service
- Transparent to higher-layer traffic
- Customer data is encapsulated and transported across an IP/MPLS network
- Does not perform any MAC learning
- Troubleshooting aids such as SDP Ping and Service Ping aid in reducing the complexity of setting up and maintaining the service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Steps to configure an ePipe service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Prerequisites

Before any services are provisioned, the following tasks need to be completed:

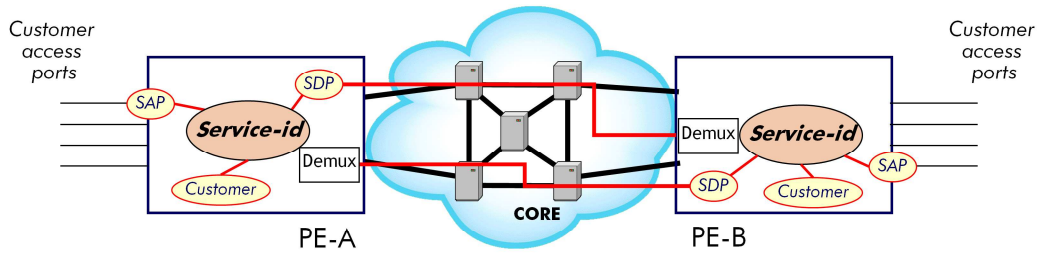
- Build the IP core network (cards, ports, interfaces)
- Configure an IGP (routing protocol)
- Configure MPLS LSPs via LDP or RSVP-TE (not needed if GRE tunnels are used)
- Build a mesh of SDPs interconnecting PEs
- Create customer accounts
- Create template QoS, scheduler, and accounting policies

Only needed for a distributed ePipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Creating an ePipe Service



STEP	Information needed
Create service	Service type: ePipe Service ID Customer ID
Add Service Access Points	Select port and encapsulation IDs Select Filter policies (optional) Select Ingress/Egress QOS Policies (optional) Select scheduler policy (optional) Select Accounting Policy (optional)
Add Service Distribution Points	SDP ID, Virtual Circuit (VC) ID

Only needed for a distributed ePipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Service-specific Tasks Include:

- Creating the service
- Configure interfaces and SAPs; apply optional QoS, filter, accounting, and scheduler policies
- Bind SDP to the service

When an SDP is bound to an ePipe, it is always done so using the spoke option. For VPLS services, one has the option of binding an SDP using the spoke or the mesh option. The rules as to how to forward traffic received on one or the other are explained later.

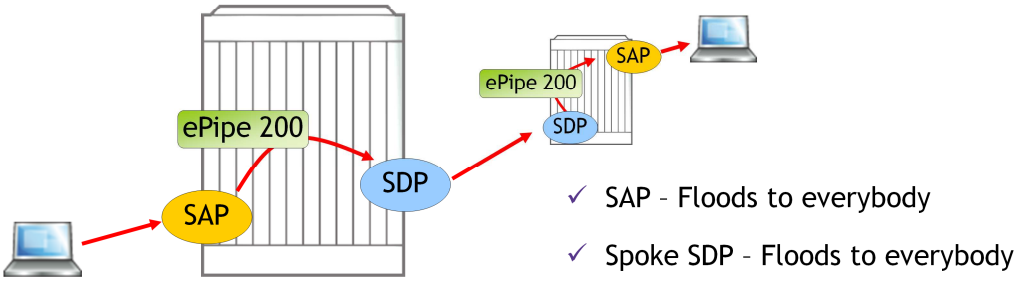
When an SDP is bound to a service, a Virtual Circuit (VC) ID needs to be specified. This is the ID that will be used by TLDP as the FEC (Forwarding Equivalence Class) when it negotiates the service or VC label. The VC ID value configured on one router does not have to be equal to the service ID (although it is good practice), but it does need to match the VC ID value selected on the router located at the far end of the SDP. SDP IDs, however, are allowed to be different.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAPs and Spoke-SDPs

Flooded traffic received on SAPs and spoke SDPs:

- Replicated on all other ports within the service (spoke-SDPs and SAPs)
- Not replicated on the port it was received on



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Generally speaking, when flooded traffic is received on a Spoke SDP it is replicated onto SAPs, other Spoke SDPs, and Mesh SDPs.

Similarly, in general, when flooded traffic is received on a SAP it is replicated onto other SAPs, Spoke SDPs, and Mesh SDPs.

Specifically for an ePipe, since it is a point-to-point service, all traffic received on the Spoke SDP will be forwarded onto the SAP and vice versa.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

SAP Encapsulations for ePipe Services

Port Type	Encapsulation
Ethernet	NULL
Ethernet	Dot1Q
Ethernet	QinQ
SONET / SDH	IPCP
SONET / SDH	BCP-Null
SONET / SDH TDM	BCP-Dot1Q
SONET / SDH TDM	ATM
SONET / SDH FR	FR



Null – Supports a single service on the port. For example, a single customer edge device attached to the port

Dot1q – Supports multiple services on the port. For example, a customer edge device running Virtual LANs

QinQ – Supports tags within tags

IPCP – Internet Protocol Control Protocol is typically used for interconnection using point-to-point protocol (PPP)

Bridging Control Protocol (BCP-null) is typically used for bridging a single service between two devices using PPP over SONET/SDH with an encap ID of 0

Bridging Control Protocol (BCP-dot1q) supports multiple services on the SONET/SDH port/channel

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ePipe Configuration

Creating a customer

Syntax:

```
config>service# customer customer-id create
    contact contact-information
    description description-string
    phone phone-number
```

Example:

```
configure service customer 100 create
config>service>cust$ description "Alcatel Customer"
config>service>cust$ contact "John Smith, Technical Support"
config>service>cust$ phone "650 555-5100"
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ePipe Configuration

Creating an ePipe Service:

```
config>service# epipe 5500 customer 100 create
config>service>epipe$ description "epipe service"
config>service>epipe# exit
```

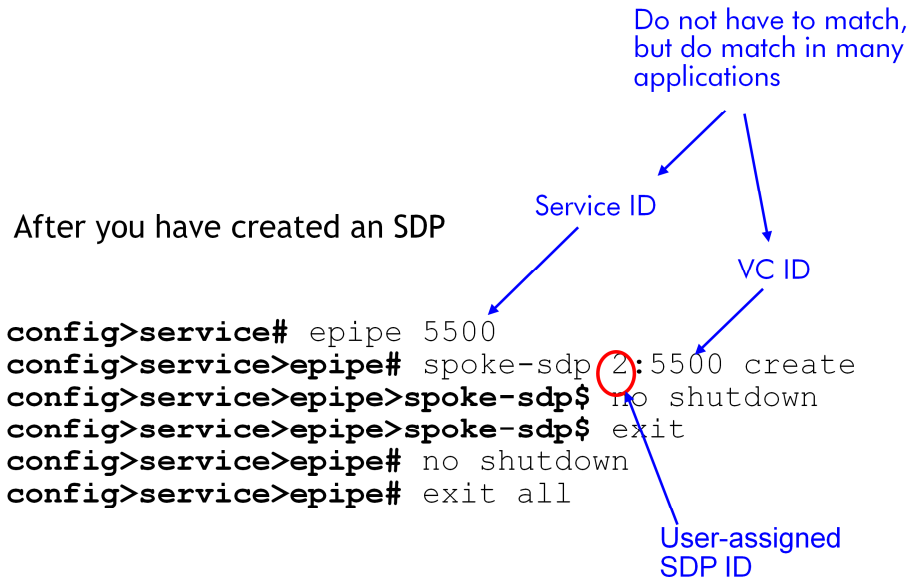
Add SAP and apply Ingress and Egress parameters:

```
config>service# epipe 5500
config>service>epipe# sap 2/1/3:10 create
config>service>epipe>sap# ingress
config>service>epipe>sap>ingress# qos 555
config>service>epipe>sap>ingress# filter ip 1
config>service>epipe>sap>ingress# exit
config>service>epipe>sap# egress
config>service>epipe>sap>egress# qos 627
config>service>epipe>sap>egress# scheduler-policy alpha
config>service>epipe>sap>egress# exit
config>service>epipe>sap#
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ePipe SDP Bindings



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The service ID has local significance. However, the local VC ID must be the same as the one configured on the far-end PE; otherwise the SDP will not become operational as a component of this service.

An SDP may be transferring data packets between dissimilar services on the involved PEs. In other words, the SDP may be a component of an ePipe on one PE and of a VPLS or an IES on the other. As long as the VC IDs match on both ends, the SDP will become operational and function properly.

It is good practice, and it is exactly what is observed in many applications, to set the VC ID to the same value as that of the service ID. Although it is not a requirement, doing so facilitates the analysis of the system and troubleshooting if a problem should arise.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ePipe Service Management

You can perform the following ePipe management tasks:

- Modify the ePipe service
- Disable and re-enable the service
- Delete the ePipe service

To delete an ePipe, all of its components (SAPs and SDPs) need to be deleted first.

- To delete a SAP or an SDP, it has to be disabled (shut down) first, and then removed.

The same applies to the other service types as well.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ePipe Service Management

Modifying

Display the information for the service and select the parameter that you want to modify.

Disabling the Service

You can shut down an ePipe service without deleting the service parameters.

Example:

```
config>service# epipe 2
config>service>epipe# shutdown
config>service>epipe# exit
```

Re-enabling the Service

Example:

```
config>service# epipe 2
config>service>epipe# no shutdown
config>service>epipe# exit
```

Deleting

Perform the following steps prior to deleting an Epipe service:

1. Shut down the SAP.
2. Delete the SAP.
3. Shut down the SDP.
4. Delete the SDP.
5. Shut down the service.

Example:

```
config>service# epipe 2
config>service>epipe# sap 2/1/3:21
config>service>epipe>sap# shutdown
config>service>epipe>sap# exit
config>service>epipe# no sap 2/1/3:21
config>service>epipe# spoke-sdp 2:6000
config>service>epipe>spoke-sdp# shutdown
config>service>epipe>spoke-sdp# exit
config>service>epipe# no spoke-sdp 2:6000
config>service>epipe# shutdown
config>service>epipe# exit
config>service# no epipe 2
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
ePipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 3
iPipe

TER36075_V3.1-SG-English-Ed1 Module 9.3 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to describe:

- Characteristics and configuration of iPipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

Page

1 — Characteristics of an iPipe service **5**
2 — Steps to configure an iPipe service **7**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Characteristics of an iPipe service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

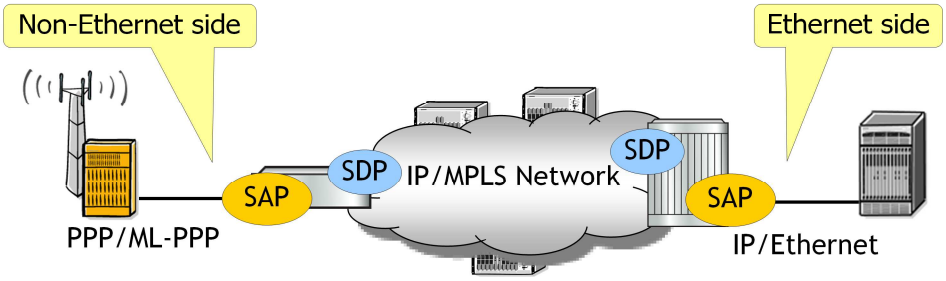
What is an iPipe?

An iPipe belongs to the Virtual Leased Line (VLL) family

It is a point-to-point Layer 2 service

Provides IP connectivity between a CE attached to an Ethernet interface and a CE attached to a non-Ethernet interface (e.g. PPP, ATM, FR)

Requires for both ends to carry IPv4 packets



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

An iPipe belongs to the Virtual Leased Line (VLL) family of services, also known as Virtual Private Wire Services (VPWS).

An iPipe can provides IP connectivity between a host attached to an Ethernet interface with routed IPv4 encapsulation and a host attached to a non-Ethernet interface, such as a point-to-point access circuit (PPP), ATM or Frame Relay.

A typical use of this application is in a Layer 2 VPN when upgrading a hub site to Ethernet while keeping the access side with their existing PPP encapsulation.

Supports:

- Ethernet SAP with Null or dot1p encapsulation
- PPP/ML-PPP SAP with IPCP encapsulation
- ATM SAP
- FR SAP

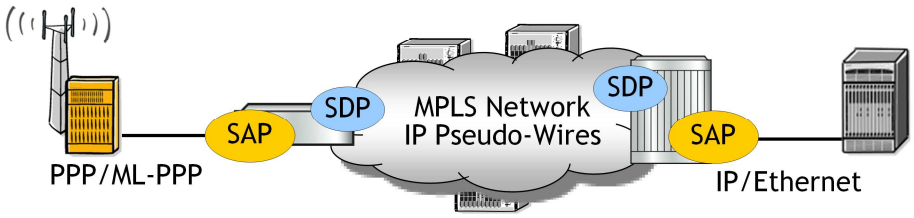
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

What is an iPipe? (continued)

Layer 3 IGP/EGP routing protocols that run over IP can be run over an iPipe (e.g. OSPF, RIP, BGP)

- IS-IS uses Layer 2 for its routing messages and is therefore not supported within an iPipe

A typical example: interim step during migration from PPP to Ethernet network



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ePipe vs. iPipe

ePipe	iPipe
Provides Ethernet VPWS	Provides IP interworking VPWS
Supports bridged encapsulation	Supports routed encapsulation
More network overhead because Ethernet header is transported	Less network overhead because layer-2 header is taken out
Both hosts appear to be the same Ethernet LAN	Both hosts appear to be on the same IP subnet or network
No Mac learning	Mac learning on behalf of non-Ethernet side
Easier to configure	Local & Remote CE IP address configuration is required



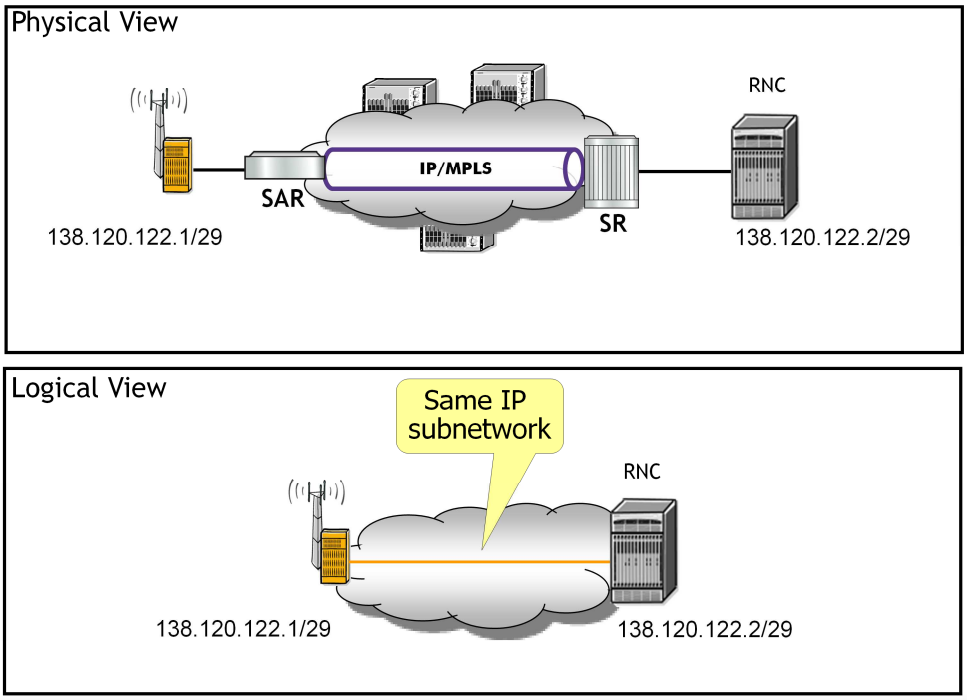
It is worth mentioning that, on 7750 SR, an ePipe can be used for Ethernet VPWS Interworking to provide connectivity between Ethernet and ATM/FR sites where **bridged** encapsulation is being used over the ATM/FR links (i.e. the ATM/FR side actually carries IP/Ethernet frames encapsulated in ATM/FR headers).

Bridged mode encapsulation enables network interworking at layer 2 by allowing the Ethernet frame to be transported across the IP/MPLS intermediary network.

When **routed** encapsulation is used, in which the IP packets are carried using different encapsulation technologies at layer-2, an iPipe is needed to allow service interworking between the two different layer 2 technologies.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Distributed iPipe



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IP packet forwarding: example

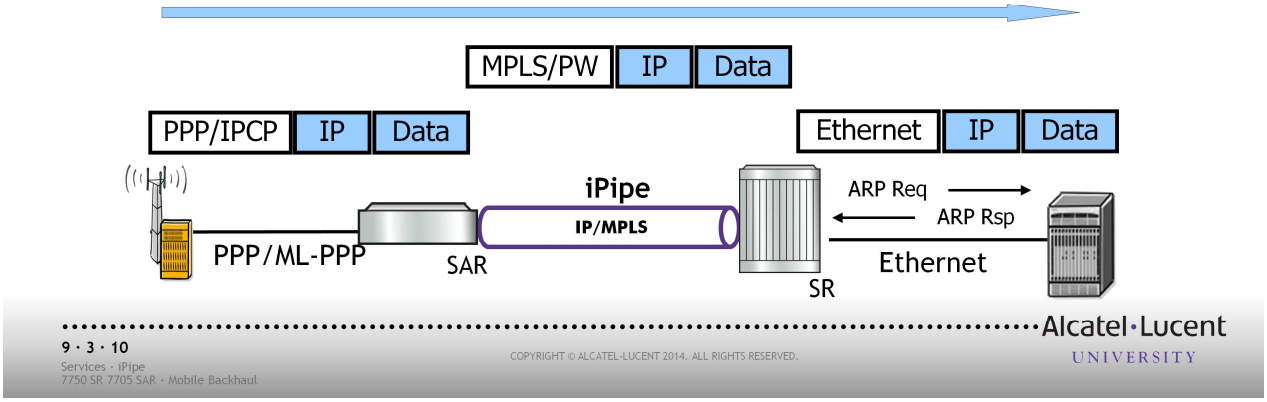
The SAR receives an IP packet on the PPP SAP

The SAR removes the layer-2 header and encapsulates the IP packet directly into a PW without a control word

The SR receives packet and removes the PW encapsulation

The SR validates the IP destination address of the received packet and adds Ethernet header before delivering to the local CE

- To know the MAC address of local CE, the SR will send ARP request



In this example, there is wireless base station (NodeB) that needs to send data traffic to its Radio Network Controller (RNC). Both will be referred to generically as CE (Customer Edge device). Next to the NodeB there is a Service Access Router (SAR), and next to the RNC there is a more powerful Service Router (SR).

To forward unicast frames destined to the RNC, the SR needs to know the RNC MAC address. When the iPipe SAP is first configured and administratively enabled, the SR sends an ARP request message for the RNC MAC address over the Ethernet SAP.

The SR does not flush the ARP cache unless the SAP goes admin or operationally down. To refresh the ARP cache, the SR sends unsolicited ARP requests.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IP packet forwarding: example (continued)

In the opposite direction, if MAC address is unknown to the CE it will ARP and the SR will respond on behalf of CE on the far end

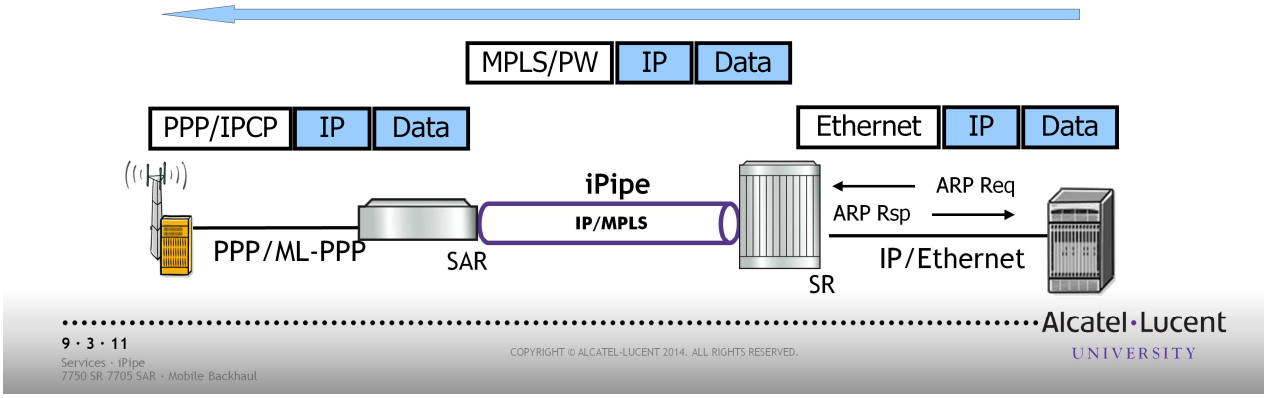
- SR will lend **its chassis MAC address** pretending to be the far-end CE

The SR receives an IP packet on the Ethernet SAP

The SR removes the layer-2 header and encapsulates the IP packet directly into a PW without a control word

The SAR receives packet and removes the PW encapsulation

The SAR validates the IP destination address of the received packet and adds PPP header before delivering to the local CE



In the opposite direction, if the MAC address is unknown to the CE (RNC), it will send an ARP Request message. Since the CE on the far end is not running Ethernet, the SR will intercept the ARP request and respond to it on behalf of CE at the far end.

The response transmitted by the SR indicates that the MAC address to be associated to the IP address is its chassis MAC address. In a way, the SR pretends to be the far-end CE so that communication can happen.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

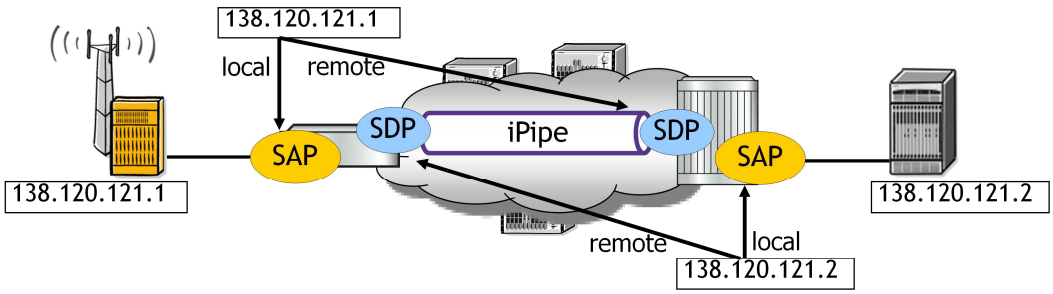
2 Steps to configure an iPipe service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

iPipe Service : Configuration Overview

The following steps are required to configure a distributed iPipe service:

- Configure an iPipe Service with Customer ID
- Configure a SAP and associate it with the iPipe service
  - Assign the local IP address to the SAP
- Configure a spoke-SDP and associate it with iPipe service
  - Assign a remote IP address to the spoke-SDP



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

iPipe Service : Configuration Overview

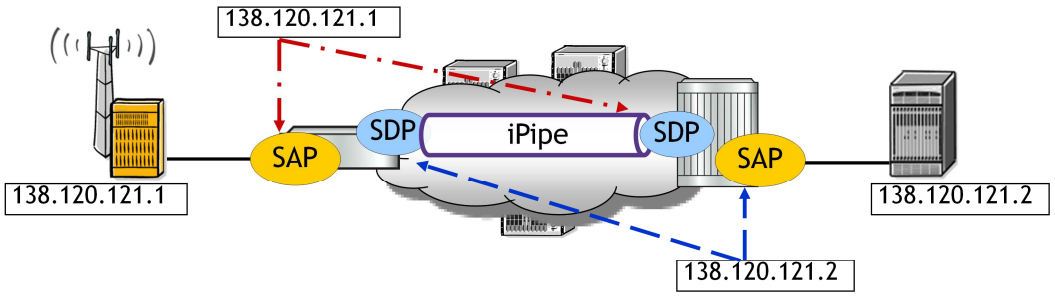
Example

7705 SAR

```
iPipe 400 customer 1 create
   sap 1/1/5 create
        ce-address 138.120.121.1
   spoke-sdp 12:200 create
        ce-address 138.120.121.2
```

7750 SR

```
iPipe 400 customer 1 create
   sap 1/1/2 create
        ce-address 138.120.121.2
   spoke-sdp 21:200 create
        ce-address 138.120.121.1
```



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

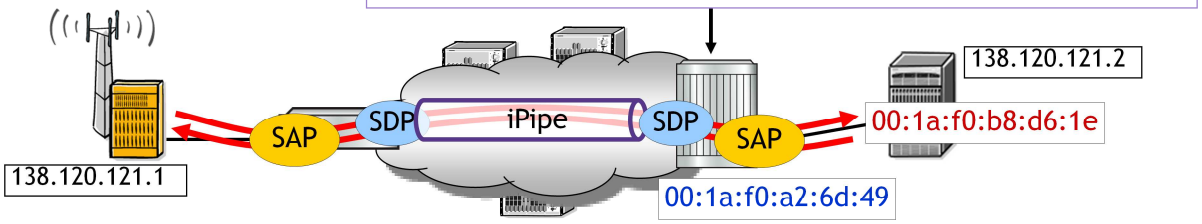
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ARP cache on Ethernet SAP

```
SR>config>service>iPipe# show service id 400 sap 1/1/2
===============================================================
Service Access Points (SAP)
===============================================================
Service Id      : 400
SAP             : 1/1/2                 Encap            : null
Admin State     : Up                    Oper State       : Up
...
Ce IP Address     : 138.120.121.2
SAP MAC Address   : 00:1a:f0:a2:6d:49   Mac Refresh Inter*: 60
---------------------------------------------------------------
iPipe SAP ARP Entry Info
---------------------------------------------------------------
138.120.121.2   00:1a:f0:b8:d6:1e dynamic 00h01m00s
```

```
Ethernet II, Src: 00:1a:f0:a2:6d:49 , Dst: 00:1a:f0:b8:d6:1e null
Internet Protocol, Src: 138.120.121.1 Dst: 138.120.121.2
ICMP Echo (ping) request
```

```
Ethernet II, Src: 00:1a:f0:b8:d6:1e, Dst: 00:1a:f0:a2:6d:49 null
Internet Protocol, Src: 138.120.121.2 Dst: 138.120.121.1
ICMP Echo (ping) reply
```



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Mac-refresh: Refresh ARP cache on Ethernet SAP

The MAC-Refresh timer on the SR router (Ethernet side) is used as the keep-alive mechanism

When the timer expires, the node will ARP again for the MAC address

```
iPipe 400 customer 1 create
   sap 1/1/2 create
         ce-address 138.120.121.2
         mac-refresh 60
   spoke-sdp 21:200 create
         ce-address 138.120.121.1
```

```
SR>config>service>iPipe# show service id 200 sap 1/1/2
===============================================================
Service Access Points (SAP)
===============================================================
Service Id     : 400
SAP            : 1/1/2              Encap            : null
Admin State    : Up                 Oper State       : Up
...
Ce IP Address     : 138.120.121.2
SAP MAC Address   : 00:1a:f0:a2:6d:49   Mac Refresh Inter*: 60
---------------------------------------------------------------
iPipe SAP ARP Entry Info
---------------------------------------------------------------
138.120.121.2   00:1a:f0:b8:d6:1e dynamic   00h01m00s
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Keepalive function optional for broadcast networks to see if the CE is still alive

- This is accomplished by having the PE perform an ARP function on a regular basis
- Keep alive functionality achieved through the use of a configurable MAC refresh timer
- The default value for the timer is 4 hours or 14400 seconds
- When mac-refresh timer expires, the PE initiates an unsolicited ARP to notify the local attached CE

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
iPipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 4
cPipe

TER36075_V3.1-SG-English-Ed1 Module 9.4 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to describe:

- Characteristics and configuration of cPipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

Page

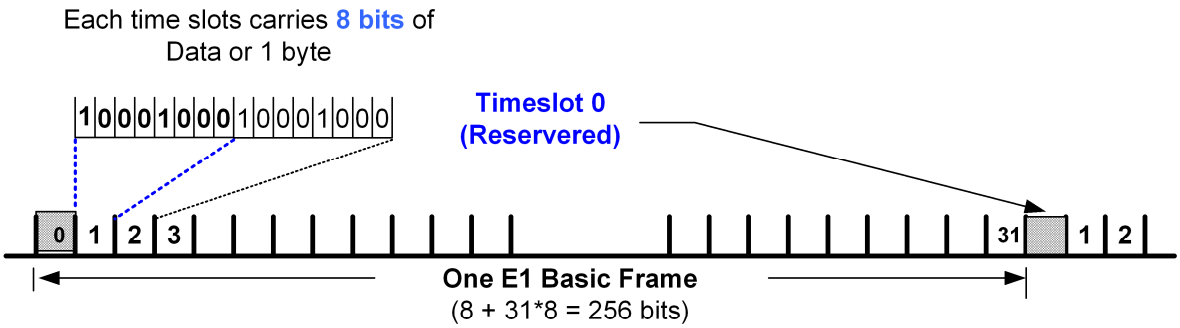
1 — Characteristics of an cPipe service **5**
2 — Steps to configure an cPipe service **7**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Characteristics of a cPipe Service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

E1 Frame



E1 Timeslots are sampled at 8000 times a second
256 bits (32 x 8) x 8000 = 2048Kb/s
Each E1 frame is sent every 125us (1 / 8000 = 125us)
Every 1 millisecond 8 E1 frames are sent (8 x 125us = 1ms)

9 · 4 · 6
Services · cPipe
7750 SR 7705 SAR · Mobile Backhaul
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.
Alcatel·Lucent
UNIVERSITY

Sampled at 8000 because Voice is 4Khz and is sampled at twice the highest frequency therefore 8Khz

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

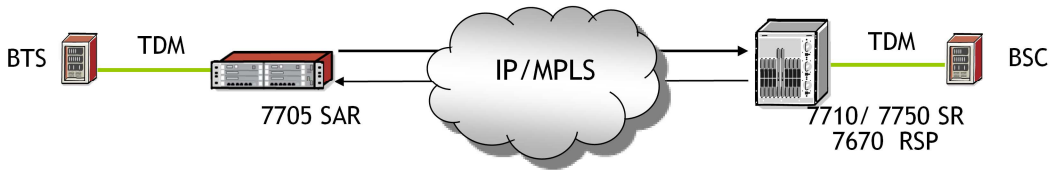
TDM on the 7705 SAR

Facts:

- TDM is used as the transport protocol within existing 2G networks
- Due to the relatively low bit rate of 2G handsets, most cell sites use 1-10 T1/E1s to transport traffic to/from the mobile network
- Each link is leased to carry 2G traffic from the BTS in the tower to the BSC located in the MTSO

The introduction of the 7705 SAR:

- TDM PW capabilities provides the transport service for 2G connectivity between the BTS and BSC



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

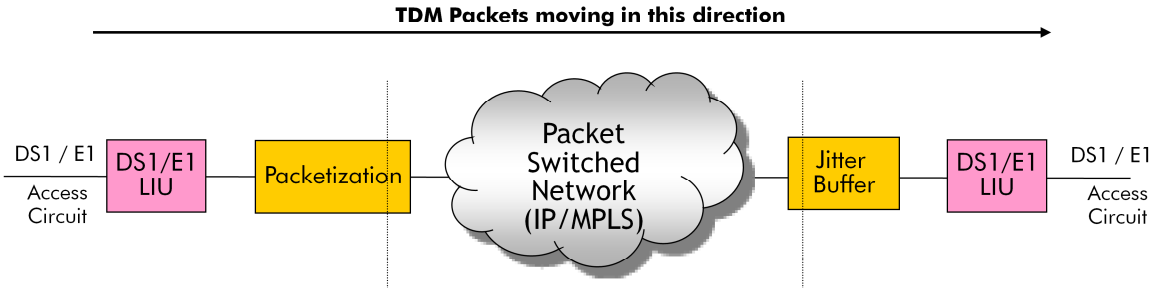
Base Transceiver Station (BTS) – Also known as a mobile phone base station

Base Station Controller (BSC) - Controls a set group of BTSs. Together the BTS and BSC systems are known as the BSS or Base Station System (BSS) . The BSC is vital to the BSS system in that it ensures that subscribers can move freely from one cell to another with no loss in signal strength

Mobile Telephone Switching Office (MTSO) - Similar to a Central Office (CO) only the MTSO controls the operation of the cellular network

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 SAR End-to-End TDM Transport Model



Packetization

- As TDM traffic from the Access Circuit (AC) is received, it is packetized and transmitted into the PSN
- Two modes of operation:
  - CESoPSN (RFC5086) for structured nxDS0/64k channels
  - SAToP (RFC4553) for unstructured T1/E1

Network

- Fixed delay
  - Packet transfer delay based on link speeds and distances from end to end
- Variable delay
  - The number of and type of switches
  - Queuing point in the switches
- QoS is key to ensure effective service delivery

Playout

- TDM PW packets are received from the PSN and stored into its associated configurable jitter buffer
- Play-out of the TDM data back into the AC when it's at least 50% full

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- The size of the packet is driven by the number of frames transported per packet. It defines the packetization delay, i.e. the delay that a frame will incur when sitting in a buffer waiting for the packet to be complete
- The size of the payload can vary. Minimum 8 bytes per transported timeslot. Maximum driven by service MTU
- Smaller packets allow for smaller packetization delays
- Bigger packets allow for more efficient network usage
- This parameter must be carefully chosen based on the application and network environment. If unsure just use the defaults.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

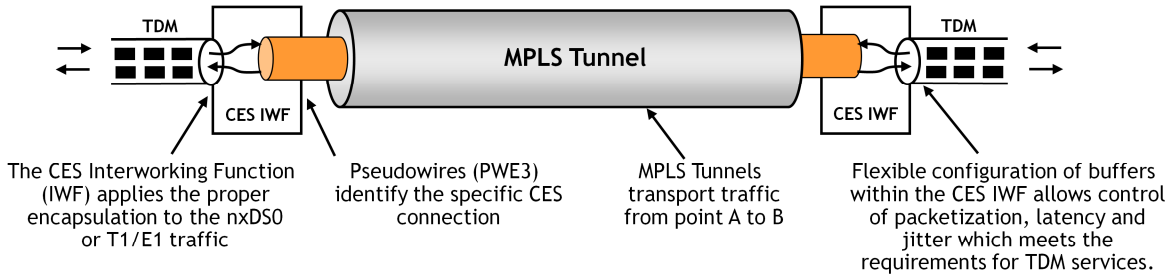
Transport of structured and unstructured connections

The two principal services are used for structured and unstructured connections

- CESoP — Circuit Emulation Service over Packet
  - Provides fractional services (nxDS0)
- SAToP — Structure Agnostic TDM over Packet
  - Provides structured T1/E1 services

These two services are collectively referred to as Circuit Emulation Services (CES)

These services are transported over an MPLS enabled Metro Network using Pseudowire (PWE3) point-to-point tunnels



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

For Private line and leased line applications a fundamental requirement is being able to transport TDM voice and data while maintaining timing and not introducing significant delay and jitter into the path. CESoP and SAToP are fundamental in that respect.

Circuit Emulation Services over PSN (CESoPSN) and Structure-Agnostic TDM over Packet (SAToP) are two types of TDM PW

CESoPSN is a structure-aware emulation for the transport of structured TDM

- Structured mode is supported for DS1, E1 and n*64 kbps
- Full DS1 or E1s can be transported by selecting all 24 DS0 timeslots (channels 1-24) and 32 (channels 2-32) respectively
- Framing bits are reproduced at the far end
- Individual timeslots can be sent to different destinations

SAToP or Structure Agnostic emulation for the transport of Unframed TDM

- Unstructured Mode
- Does not align to any framing
- TDM traffic is packetized and encapsulated in MPLS or GRE (IP) tunnel
- Uplink media: FE/GE or n*T1/E1 MLPPP
- Configurable packetization delay and jitter buffer sizing

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Circuit Emulation

CESoPSN is a structure-aware emulation for the transport of structured TDM

- Structured mode is supported for DS1, E1 and n*64 kbps
- Full DS1 or E1s can be transported by selecting all 24 DS0 timeslots (channels 1-24) and 32 (channels 2-32) respectively
- Framing bits are reproduced at the far end

SAToP or Structure Agnostic emulation for the transport of Unframed TDM

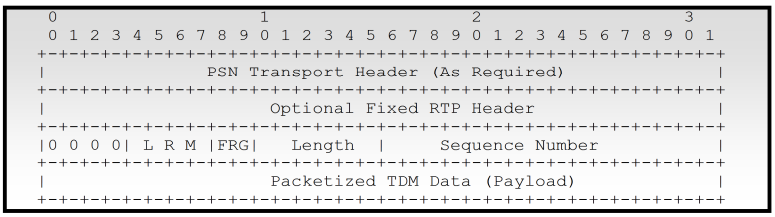
- Unstructured Mode
- Does not align to any framing

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

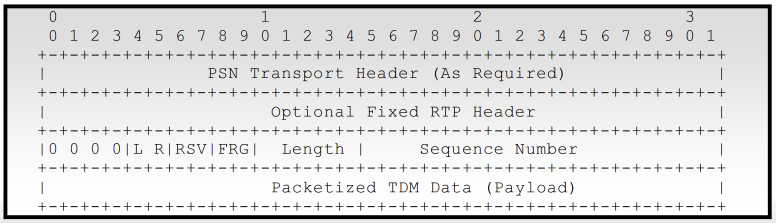
Encapsulation

General format for CESoPSN Encapsulation



- Encapsulated TDM circuits are transported over MPLS tunnels
- The transport header includes the MPLS Tunnel outer label and transport specific information
- Control Word is enabled by default on a C-Pipe

General format for SAToP Encapsulation



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Steps to configure a cPipe Service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 CES Configurations – E1

CESoPSN

```
7705>config>port# info
----------------------------------
   tdm
       e1
           channel-group 1
               encap-type cem
               timeslots 2-32
                  .
                  .
                  .
```

```
7705>config>service# info
----------------------------------
cpipe 901 customer 1 vc-type cesopsn create
            .
            .
            .
```

SAToP

```
7705>config>port# info
----------------------------------
     tdm
         e1
             framing e1-unframed
             channel-group 1
                 encap-type cem
                            .
                            .
                            .
```

```
7705>config>service# info
----------------------------------
cpipe 900 customer 1 vc-type satop-e1 create
            .
            .
            .
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 CES Configurations – T1

CESoPSN

```
7705>config>port# info
----------------------------------
   tdm
       ds1
           channel-group 1
               encap-type cem
               timeslots 1-24
                  .
                  .
                  .
```

```
7705>config>service# info
----------------------------------
cpipe 901 customer 1 vc-type cesopsn create
            .
            .
            .
```

SAToP

```
7705>config>port# info
----------------------------------
     tdm
         ds1
             framing ds1-unframed
             channel-group 1
                 encap-type cem
                                  .
                                  .
                                  .
```

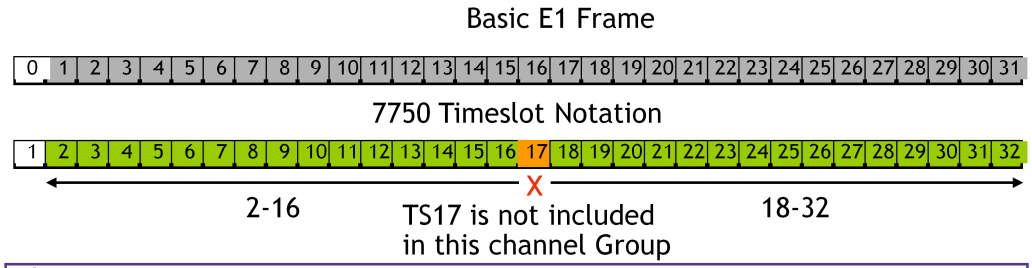
```
7705>config>service# info
----------------------------------
cpipe 900 customer 1 vc-type satop-t1 create
            .
            .
            .
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 Channel Group Timeslots for CESoPSN

- Timeslots within the Channel Group are identified as follows :



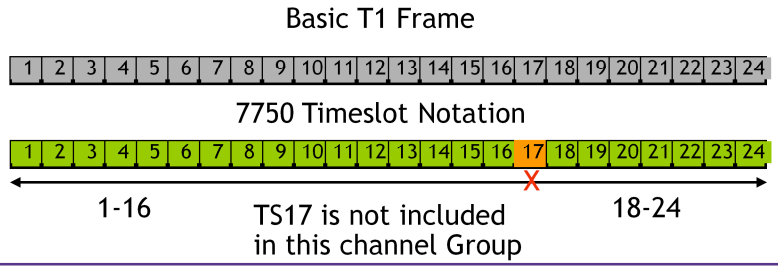

```
tdm
            e1 1.1.1
                clock-source node-timed
                channel-group 1
                    timeslots 2-16,18-32
                    no shutdown
                exit
                no shutdown
            exit
        no shutdown
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7750 Channel Group Timeslots for CESoPSN

- Timeslots within the Channel Group are identified as follows :

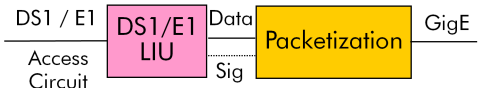



```
tdm
            ds1
                channel-group 1
                    encap-type cem
                    timeslots 1-16, 18-24
                    no shutdown
                exit
                no shutdown
            exit
        exit
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Packet Size vs. Packet Latency



Packet size is user-configurable in bytes. It must be a multiple of the number of timeslots by T1/E1 frame (N)

- Minimum packet size will be based on 8 frames (T1/E1) per packet
- Maximum number for packet size is 1514 bytes

With a smaller packet size, the packetization latency is reduced, however this results in higher overhead as a percentage of the traffic

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Packetization latency can be calculated with the number of timeslots and payload size by the following relationship:

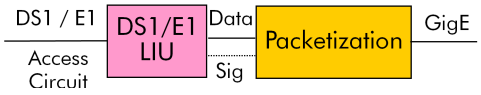
D = 0.125 x F where

- D = packetization latency (ms)
  F = L / N = number of T1/E1 frames/packet (must be integer number)
- L = packet payload size (octets)
- N = number of DS0 channels (timeslots)

Conversely, L can be selected by L = 8xNxD as stated in RFC5086.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

TDM Encapsulation into TDM PW Packets (SAToP, RFC4553)



SAToP support the unstructured circuit emulation service to T1/E1s. The encapsulation process requires the operator to:

1. Select the particular T1/E1 port
   - SAToP operation requires the port setting to be unframed. However, the actual TDM data coming in can be frame or unframed. SAToP will ignore the framing format and transport as a bit stream.
2. Select the payload size
   - The relationship between payload size in bytes (PS) and number of T1/E1 frames/packet (F) is as follows:

     For T1 port, **PS = 24 x F** or

     For E1 port, **PS = 32 x F**

     e.g. SAToP TDM PW with 8 E1 frames/packet

     PS = 32 x 8 frames

     = 256 bytes
   - The number of frames/packet (F) need NOT be a whole number but must be a minimum of 8
   - The payload size (PS) can be up to 1514 bytes

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

- Based on the selected payload size (PS) and each T1/E1 frame is 125 microseconds, the packetization delay (PD) can be calculated as follows:

  PD = **$125x10^{-6}$ x F** or

  = **$125x10^{-6}$ x (PS/24)** for T1 or

  = **$125x10^{-6}$ x (PS/32)** for E1
  - e.g. SAToP TDM PW for E1 with 512 byte payload size

    PD = $125x10^{-6}$ x 512/32

    = 2 ms
  - This represents the delay for the very first timeslot of TDM data from the Access Circuit put into the packet. Every other timeslot/frame of TDM data will be delayed less in the encapsulation process. Since it's a constant bit rate service, the end-to-end latency is the same for the timeslots. The latency just shifts to the jitter buffer end (i.e. timeslots that incur less latency at encapsulation will stay in the jitter buffer longer). To keep consistency for the latency calculation, only the very first timeslot is considered here.
  - The minimum packetization delay in the 7705 is 1 ms
- Similarly, the packet rate in pps (PR) can be calculated as follows:

  PR = **1 / ($125x10^{-6}$ x F)** or

  = **1 / ($125x10^{-6}$ x (PS/24))** for T1 or

  = **1 / ($125x10^{-6}$ x (PS/32))** for E1
  - e.g. SAToP TDM PW for E1 with 512 byte payload size

    PR = 1 / ($125x10^{-6}$ x (512/32))

    = 500 pps
  - The maximum packet rate in the 7705 is 1000 pps

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

CES Calculator

TDM CES Traffic


CES Calculator

Aggregatuion (Frames / Packet) (Must be Multiple of 8)	8
Number of E1 Timeslots	16
Data Payload (Bytes)	128
Padding (bytes)	0
Total Packet Size including overhead (Bytes)	**158**
CES Packetisation Delay (ms)	1
Packets Per Second	1000

Bandwidth

Bitrate	**1264.00**	Kb/s

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Default & Min Packet Sizes (7705)

	Default			Minimum		
Number of Timeslots	Number of Frames per Packet	Packet Size (Bytes)	Packetization Delay (ms)	Number of Frames per Packet	Packet Size (Bytes)	Packetization Delay (ms)
1	64	64	8.00	2	2	0.250
2	32	64	4.00	2	4	0.250
3	32	96	4.00	2	6	0.250
4	32	128	4.00	2	8	0.250
5	16	80	2.00	2	10	0.250
6	16	96	2.00	2	12	0.250
7	16	112	2.00	2	14	0.250
8	16	128	2.00	2	16	0.250
9	16	144	2.00	2	18	0.250
10	16	160	2.00	2	20	0.250
11	16	176	2.00	2	22	0.250
12	16	192	2.00	2	24	0.250
13	16	208	2.00	2	26	0.250
14	16	224	2.00	2	28	0.250
15	16	240	2.00	2	30	0.250

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

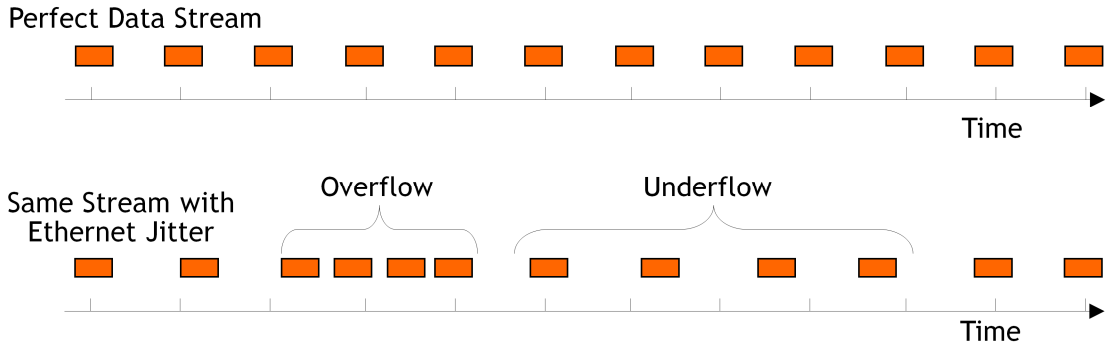
Default & Min Packet Sizes (7705) Continued

	Default			Minimum		
Number of Timeslots	Number of Frames per Packet	Packet Size (Bytes)	Packetization Delay (ms)	Number of Frames per Packet	Packet Size (Bytes)	Packetization Delay (ms)
16	8	128	1.00	2	32	0.250
17	8	136	1.00	2	34	0.250
18	8	144	1.00	2	36	0.250
19	8	152	1.00	2	38	0.250
20	8	160	1.00	2	40	0.250
21	8	168	1.00	2	42	0.250
22	8	176	1.00	2	44	0.250
23	8	184	1.00	2	46	0.250
24	8	192	1.00	2	48	0.250
25	8	200	1.00	2	50	0.250
26	8	208	1.00	2	52	0.250
27	8	216	1.00	2	54	0.250
28	8	224	1.00	2	56	0.250
29	8	232	1.00	2	58	0.250
30	8	240	1.00	2	60	0.250
31	8	248	1.00	2	62	0.250

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Jitter Buffer



Packet jitter is the time difference between when a packet actually arrives and the expected arrival time caused by network congestion, timing drift, or route changes

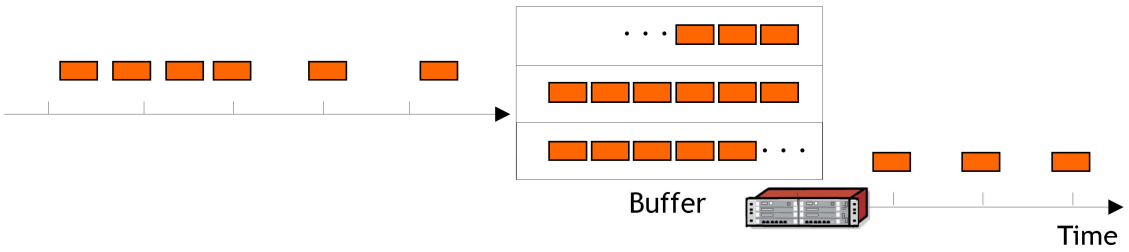
If packets are delayed by the network, some packets arrive in bursts with interpacket delays shorter than when they were transmitted while others are delayed

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Several network impairments prevent IP networks from carrying emulated circuit-switched traffic such as a T1 (1.544 Mb/s signal). A T1 line delivers a constant bit rate stream from node A to some node B on the other side of the network. As packets travel through the network, delay accumulates at each intermediary node. In order to compensate for this delay, node B must use a jitter buffer to further delay packets in order to guarantee that there will always be a packet ready to be transmitted out. Where problems start to arise, however, is that each packet arrives with a different delay. The range of delay in which packets arrive is known as time delay variation (TDV) or jitter. Typically, with a large enough jitter buffer, packets will arrive in time to be useful. In the extreme case, a packet may be discarded if the time delay variation exceeds the maximum the jitter buffer can accommodate.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Jitter Buffer



To smooth the varying input stream arrival times the appliance receiving the packets will buffer the incoming data just enough to accommodate and correct instances where input streams have over/underrun

These buffers (queues) must also be sized appropriately to handle stream fluctuations without delaying the data so much that the receiving end is impacted

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The larger the variation, the larger the buffer that is required to smooth it out since the buffer must be able to handle the maximum tolerated variation. Note that the buffer size is not determined by how much end-to-end delay there is but rather by how much variance there is in delay between packets.

Large buffers become a problem when the additional latency that they add to already delayed packets causes packets to be timed out. Note that this additional latency is bounded by the most delayed packet; slow packets delay every other packet in the buffer, even those that have arrived quickly. An emulated T1 line may already be stressed because of delays inherent in network routing, and additional delay of an adequate jitter buffer may be enough to affect the delivery of real-time data.

For each circuit, the maximum receive jitter buffer is configurable

- Range: 2 -> 250 ms

Playout from this buffer starts when 50% full

- This gives an operational packet delay variance of ½ the max buffer size

The defaults are:

- N=1: 32 ms
- 2<=N<= 4: 16 ms
- 5<=N<= 15: 8 ms
- N>=16: 5 ms

For CESoPSN with CAS, the default jitter buffer is 12 ms for T1 and 8 ms for E1

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Handling packet loss

Proper application of traffic engineering and quality-of-service (QoS) is expected to minimize packet loss, however packets will at times arrive at the egress out of order

- The TDMoIP control word includes a 16-bit sequence number for detecting and handling lost and mis-ordered packets
  - In the case of lost packets, TDMoIP requires insertion of interpolation packets to maintain TDM timing
  - Misordered packets may be either reordered or dropped and interpolated

While the insertion of arbitrary packets may be sufficient to maintain the TDM timing, in voice applications packet loss can cause gaps or errors that result in choppy, annoying, or even unintelligible speech



The precise effect of packet loss on voice quality and the development of packet loss concealment algorithms have been the subject of detailed study in the VoIP community, but their results are not directly applicable to the TDMoIP case. This is because VoIP packets typically contain between 80 samples (10 ms) and 240 samples (30 ms) of the speech signal, while TDMoIP packets may contain only a small number of samples. Since TDMoIP packets are so small, it is acceptable to simply insert a constant value in place of any lost speech samples. Assuming that the input signal is zero-mean (i.e. contains no DC component), minimal distortion is attained when this constant is set to zero. Alternatively, more sophisticated approaches call for optimally predicting the values of missing samples.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
cPipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 5
aPipe

TER36075_V3.1-SG-English-Ed1 Module 9.5 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to describe:

- Characteristics and configuration of an aPipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — Characteristics of an aPipe service	**5**
2 — Steps to configure an aPipe service	**7**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Characteristics of an aPipe service

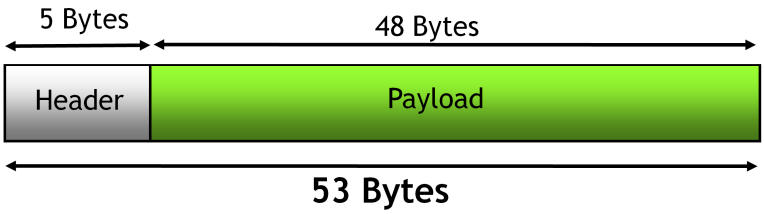
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ATM Cell Format

ATM uses a fixed size cell consisting of 53 Bytes

First 5 Bytes contains header information such as the connection identifier

Remaining 48 Bytes contains the data or Payload



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

What is ATM? ATM was ddesigned for the high-speed transfer of Voice, Video and Data using cell relay technology

Uses small, Fixed-size Cells

Connection-oriented Service

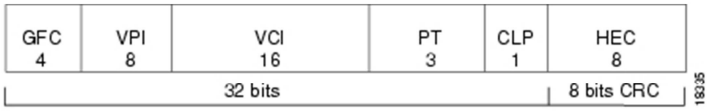
Supports multiple service types

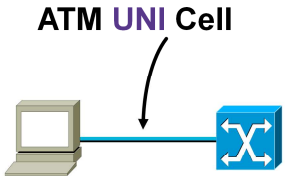
Applicable to LAN and WAN

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ATM Header Format

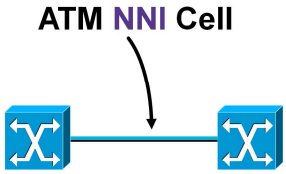
User to Network Interface (UNI) Format





Network to Network Interface (NNI) Format



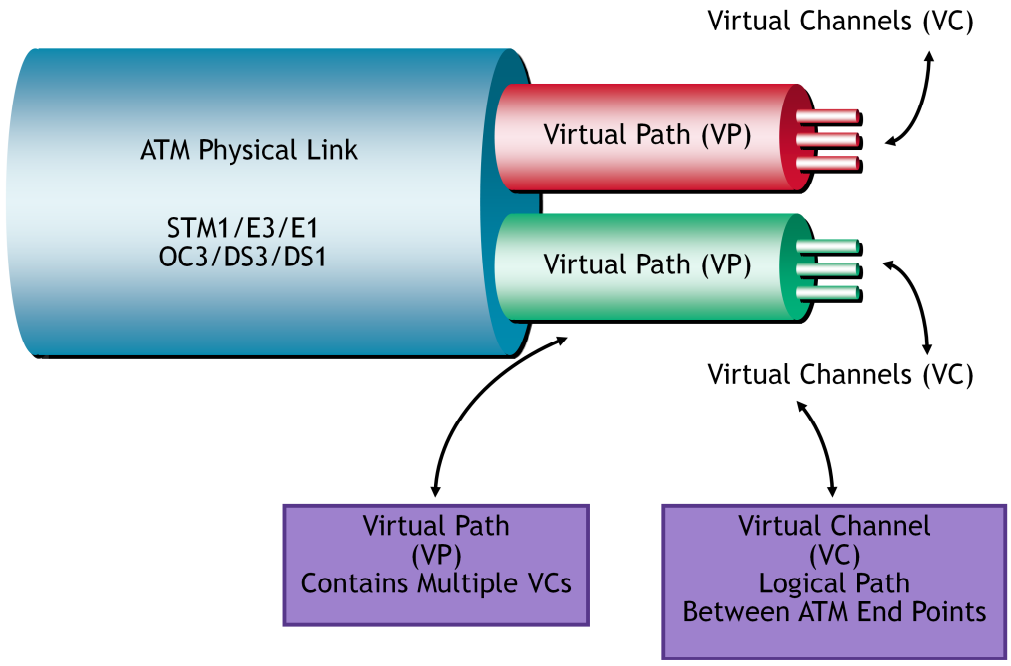


GFC	- Generic Flow Control – Provides Local Functions such as flow control (UNI Only)
VPI	- Virtual Path Identifier
VCI	- Virtual Channel Identifier
PTI	- Payload Type Identifier – Indicates User/Control Data
CLP	- Cell Loss Priority Bit – Indicates whether cell should be discarded
HEC	- Header Error Check – 8 Bit CRC

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Virtual Path and Virtual Channels

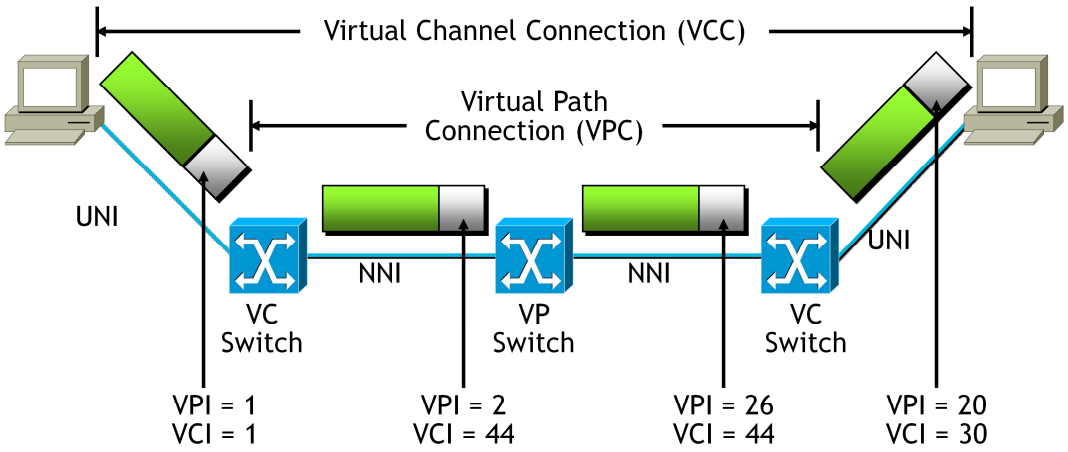


Connection Identifier = VPI/VCI

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Virtual Channels and Virtual Paths



This hop-by-hop forwarding is known as cell relay

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

7705 Supported ATM VC-Types

The VC-type is a 15-bit value that defines the type of VC signaled to the peer

- **ATM-VCC** (Default on the 7705)
  - Virtual Circuit Connection. An ATM connection that is switched based on the cell header's VCI – Requires VPI/VCI identifier to be specified
- **ATM-VPC**
  - Virtual Path Connection. An ATM connection that is switched based on the cell header's VPI – Requires VPI identifier to be specified

The vc-type must be specified at the time of aPipe service creation and cannot be changed without deleting the service first.

```
*A:PoC3B# configure service apipe 10 vc-type atm-vcc customer 1 create
*A:PoC3B>config>service>apipe$
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

MPLS Pseudowire VC-Types

PW type	Description	Reference
0x0001	Frame Relay DLCI (Martini Mode)	[FRAME]
0x0002	ATM AAL5 SDU VCC transport	[ATM]
0x0003	ATM transparent cell transport	[ATM]
0x0004	Ethernet Tagged Mode	[ETH]
0x0005	Ethernet	[ETH]
0x0006	HDLC	[PPPHDLC]
0x0007	PPP	[PPPHDLC]
0x0008	SONET/SDH Circuit Emulation Service Over MPLS	[CEP]
0x0009	**ATM n-to-one VCC cell transport**	**[ATM]**
0x000A	**ATM n-to-one VPC cell transport**	**[ATM]**
0x000B	IP Layer2 Transport	[RFC3032]
0x000C	ATM one-to-one VCC Cell Mode	[ATM]
0x000D	ATM one-to-one VPC Cell Mode	[ATM]
0x000E	ATM AAL5 PDU VCC transport	[ATM]
0x000F	Frame-Relay Port mode	[FRAME]
0x0010	SONET/SDH Circuit Emulation over Packet	[CEP]
0x0011	Structure-agnostic E1 over Packet	[SAToP]
0x0012	Structure-agnostic T1 (DS1) over Packet	[SAToP]
0x0013	Structure-agnostic E3 over Packet	[SAToP]
0x0014	Structure-agnostic T3 (DS3) over Packet	[SAToP]
0x0015	CESoPSN basic mode	[CESoPSN]

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ATM Service Categories

ATM Provides five standard service Categories

Service Category	Typical Application	Traffic Parameters
CBR	Circuit Emulation Services	PCR
RT-VBR	Interactive Multimedia	PCR, SCR, MBS
NRT-VBR	Bursty applications – File Transfers	PCR, SCR, MBS
ABR*	Best Effort service with flow control feedback	PCR, MCR
UBR	LAN Traffic	(no guarantees)

**ABR is not supported on the 7750 or 7705 Products*



CBR – Constant Bit Rate
RT-VBR – Variable Bit Rate Real-Time
NRT-VBR – Variable Bit Rate Non-Real Time
ABR* – Available Bit Rate
UBR – Unspecified Bit Rate

Traffic parameters
- Peak cell rate (PCR)
- Sustainable cell rate (SCR)
- Burst tolerance, conveyed through the maximum burst size (MBS)
- Cell delay variation tolerance (CDVT)
- Minimum cell rate (MCR)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

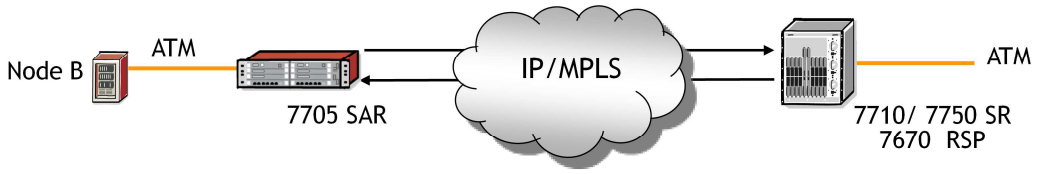
aPipe Overview

aPipe service provides a bi-directional layer 2 connection of ATM service between two users/sites through an IP/MPLS network

aPipe is supported on a T1/E1 ASAP port, E3/DS3 port, OC3/STM1 port, or clear-channel or channelized OC3 port when the port is configured for ATM or IMA

ATM cells received on the ATM SAP are encapsulated into PW packets to be transported over IP/MPLS outer tunnels

Targeted LDP signaling is commonly used to setup the PW



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

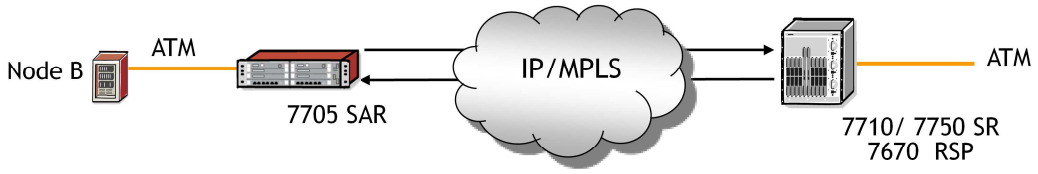
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ATM Cell forwarding

The vc-type of an aPipe specifies which cells will be accepted by the corresponding SAP and carried to the far end via the pseudo-wire

The vc-type can configured upon creation as:

- **atm-cell** (all cells received or cells from a range of VPIs are associated to the SAP)
- **atm-vpc** (cells from an individual VPI are associated to the SAP)
- **atm-vcc** (cells from a specific VPI/VCI combination are associated to the SAP)
- **atm-sdu** (cells from a specific VPI/VCI combination are associated to the SAP, but the higher-layer packet –SDU– is reassembled before forwarding it)



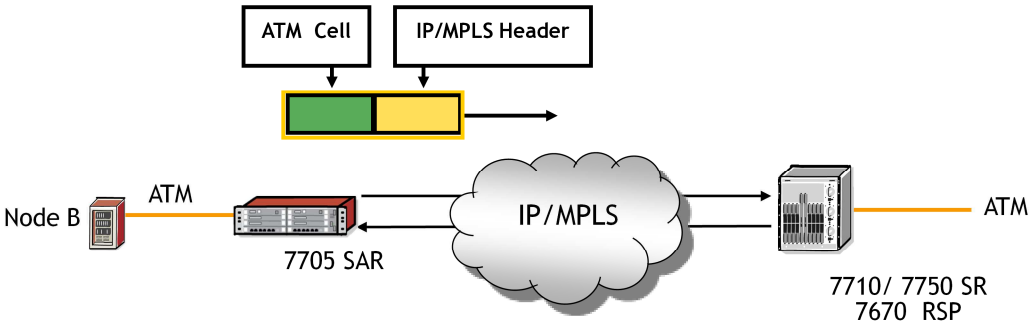
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ATM Cell forwarding

The default operation of an aPipe when the vc-type is configured as atm-vcc, atm-vpc, or atm-cell, is to forward each cell inside a separate pseudo-wire packet

The incurred overhead is large but the end-to-end delay and jitter of each cell are small



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

The default vc-type on a 7705 SAR is atm-vcc. So, by default, the behavior described in the figure will be observed.

The default vc-type on a 7750 SR is atm-sdu, so the behavior described in the figure will not be observed in that case since an entire SDU will be carried inside a VLL payload (unless the SDU exceeds the MTU size, in which case the SDU will be fragmented into a small number of pseudo-wire packets).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

aPipe Packet Structure (Single ATM Cell)

VCC Ethereal Hex Trace (Single Cell)

```
0000   00 03 fa 73 69 01 00 16 4d 65 57 cd 88 47 1f ff
0010   4a ff 1f ff 2b ff 00 00 0c 80 2d aa aa aa aa aa
0020   aa aa aa aa aa aa aa aa aa aa 72 aa aa aa aa aa
0030   aa aa aa aa aa aa aa aa aa aa aa aa aa aa aa aa
0040   aa aa 42 aa aa aa aa aa aa aa
```

Key:

- Ethernet Frame
- MPLS Outer Label
- MPLS Inner Label
- ATM VPI Value = 0
- ATM VCI Value = 200
- ATM Payload Type Identifier
- Payload

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

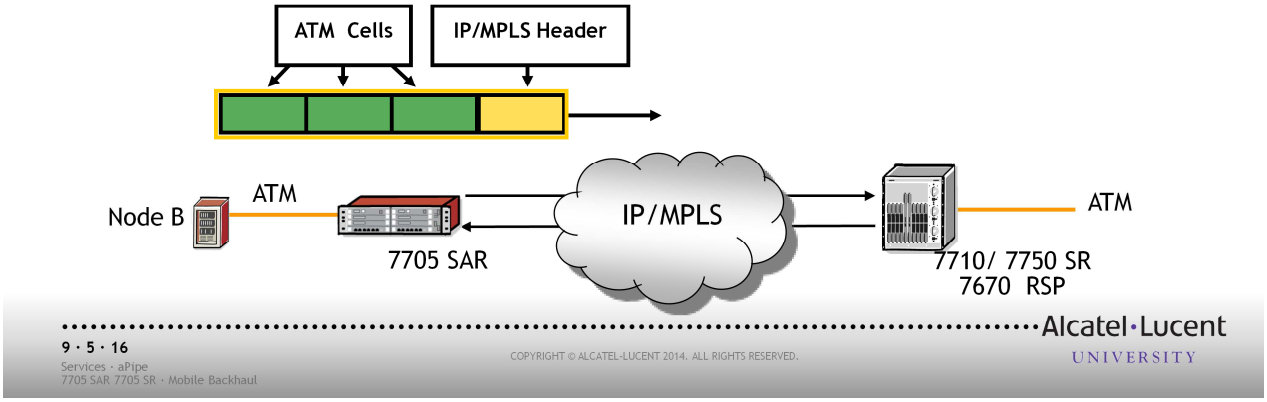
ATM Cell Concatenation

An aPipe can be configured to supports cell concatenation to save on MPLS packet overhead

This behavior is referred to as **ATM N-to-1 cell mode**

Cell concatenation packs more than one ATM cell in a VLL payload (maximum number N of cells is configurable)

When traffic is not sensitive to delay or jitter, the number of cells in a single VLL frame can grow up to the VLL MTU size



This operation mode is known as **N-to-1 cell mode**

The **cell mode** part of the name comes from the fact that ATM cells are carried from end to end, as opposed to the SDU mode in which an entire ATM Service Data Unit (SDU) – e.g. a packet received from the upper layer – is reassembled before being forwarded. In the SDU mode, ATM headers are not transported and the AAL5 overhead is removed on ingress and regenerated on egress before re-fragmenting the SDU to forward it to the customer as ATM cells.

The **N-to-1** part of the name comes from the fact that N (N >= 1) cells may be concatenated together to be forwarded inside the service provider network as a single pseudowire packet. ATM cells are individually forwarded to the customer after exiting the far end of the pseudo-wire.

A SAP working in cell mode can concatenate cells corresponding to a specific VPI/VCI combination, to an individual VPI, to an ATM virtual trunk (a range of VPI values on an ATM port), or simply all cells arriving on a given ATM port.

Thus, the endpoints of an N-to-1 mode VLL can be:

- ATM VCs — VPI/VCI translation is supported (i.e., the VPI/VCI at each endpoint does not need to be the same).
- ATM VPs — VPI translation is supported (i.e., the VPI at each endpoint need not be the same, but the original VCI will be maintained).
- ATM VTs (a VP range) — No VPI/VCI translation is supported (i.e., the VPI/VCI of each cell is maintained across the network).
- ATM ports — No translation is supported (i.e., the VPI/VCI of each cell is maintained across the network).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

aPipe Packet Structure (Multiple ATM Cells)

VPC cell concatenation (hex trace)

```
0000  00 03 fa 73 69 01 00 16 4d 65 57 cd 88 47 1f ff
0010  0a ff 1f ff 7b ff 06 60 03 70 dc 82 95 e5 a7 eb
0020  0a 91 c6 d5 c4 c4 40 21 18 4e 55 86 f4 dc 8a 15
0030  a7 ec 92 df 93 53 30 18 ca 34 bf a2 c7 59 67 8f
0040  ba 0d 6d d8 2d 7d 54 0a 9e 21 06 60 04 20 9e 38
0050  98 88 7f c6 60 94 ed 1e 7c d8 a9 1c 6d 5c 4c 44
0060  02 11 84 e5 58 6f 4d c8 a1 5a 7e c9 2d f9 35 33
0070  01 8c a3 4b fa 2c 75 96 78 fb a0 d6 16 57
```

Key:

- Ethernet Frame
- MPLS Outer Label
- MPLS Inner Label
- ATM VPI Value
- ATM VCI Value
- ATM Payload Type Identifier
- Payload

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

As the cells are being packed, the concatenation can be terminated and the packet is transmitted by whichever occurs first:

- Max-cells is reached:
  - It is the maximum number of ATM cells to concatenate in one packet
  - max-cells <cell-count> : Value [1..29}
- Max-delay timer is expired: maximum delay for ATM cells in hundreds of microseconds
  - max-delay <delay-time> : Value [1…400]
- CLP-change is triggered: allows the CLP change to be an indication to complete the cell concatenation
  - clp-change/ no clp-change

If more than one of the afore mentioned options are configured, the MPLS Packet is sent immediately when the first option is met

Even if none of the above conditions is met, concatenation is terminated and the packet is forwarded when the maximum configured Service MTU is reached or when the last cell of the current SDU is received.

The default Service MTU is set to 1514 bytes. Taking into account N-to-1 mode carries 52 bytes as payload for each 53 byte ATM cell, the maximum cell-range is set to 29

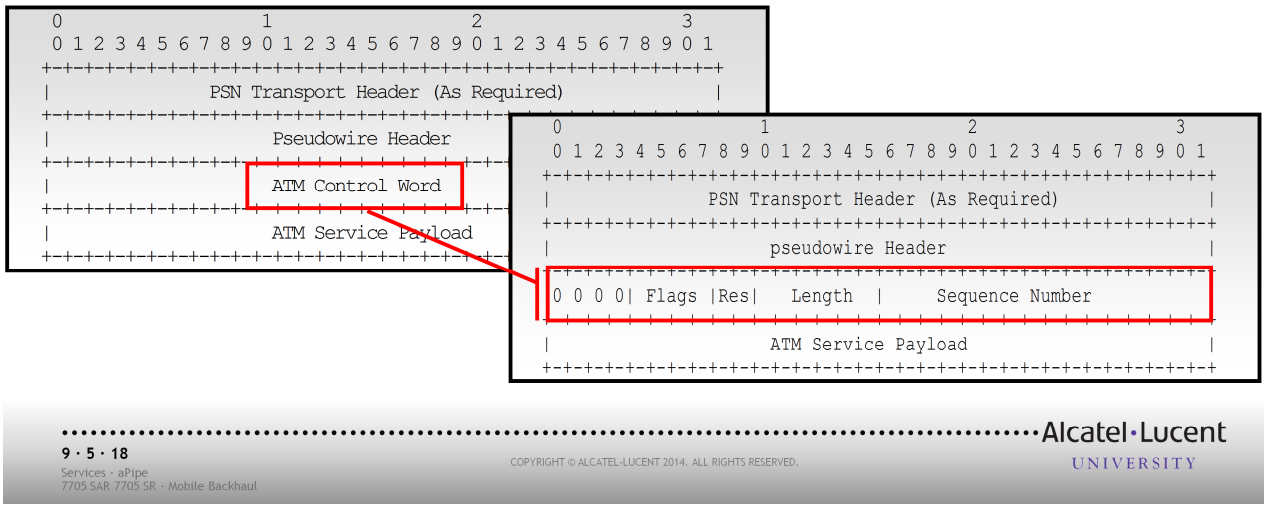
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ATM Encapsulation over PSN – Control Word

If the payload is sensitive to packet misordering it MUST employ a mechanism which prevents packet misordering

The Control Word contains:

- Protocol specific flag bits, generated from the original Layer 2 PDU
- Length bits
- Sequence Numbers



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

As shown above, the ATM Control Word is inserted before the ATM service payload. It may contain a length field and a sequence number field in addition to certain control bits needed to carry the service.

In the above diagram, the first 4 bits MUST be set to 0 to indicate PW data. They MUST be ignored by the receiving PE.

The next 4 bits provide space for carrying protocol-specific flags.

The next 6 bits provide a length field. Note that the length field is not used in the N-to-one mode and it is set to 0. The last 16 bits provide a sequence number that can be used to guarantee ordered packet delivery. The processing of the sequence number field is OPTIONAL.

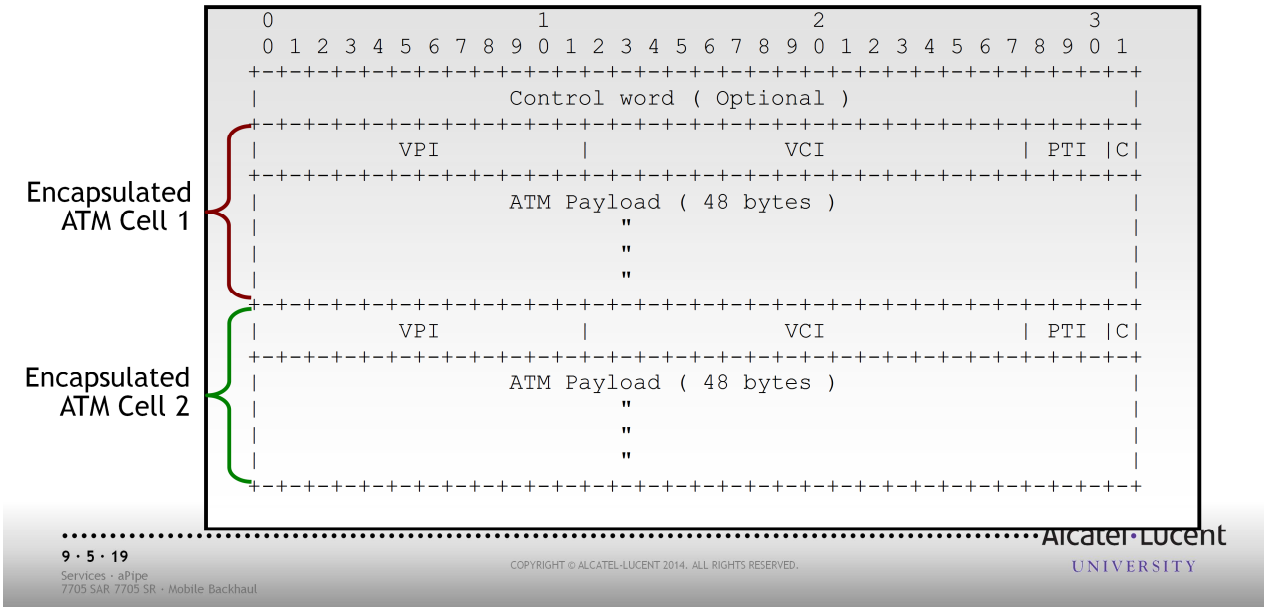
The sequence number space is a 16-bit, unsigned circular space. The sequence number value 0 is used to indicate that the sequence number check algorithm is not used.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ATM Cell Concatenation

The ATM Cell encapsulation consists of the optional control word and one or more ATM cells

Each ATM cell has a 4-byte ATM cell header and a 48-byte ATM cell payload



Max-delay – Amount of time to wait while performing ATM concatenation process

- User configurable in hundreds of microseconds. The delay times are rounded up to one of the following values 1,5,10,50,100,200,300 and 400. **(Default is 400 or 40ms).** Between the values 10 and 50 (1ms and 5ms) a specific value can now be entered on 7705

Max-cells – Maximum number of ATM cells to accumulate into an MPLS Packet

- Max-cells value is limited by the MTU size of the ATM interface, therefore the range for a 7705 is between 1-29 cells and the range on the 7750 is between 1 – 128. (Default is 1 cell)

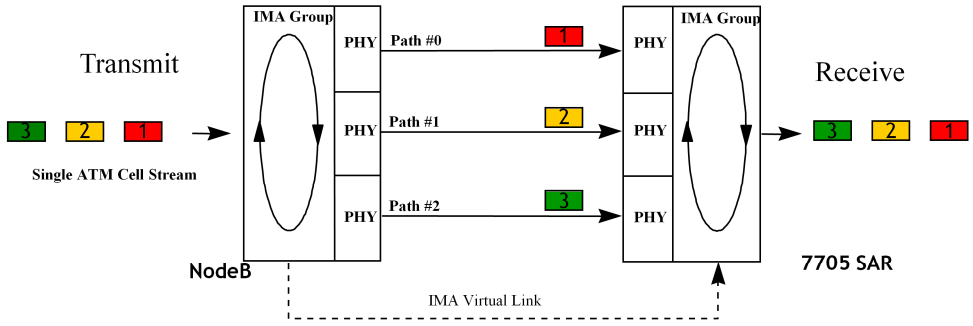
CLP-Change

- Enables the Cell Loss Priority (CLP) change to be an indication to complete the cell concatenation operation

When the first of the above conditions is met the PWE3 frame is sent.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Inverse Multiplexing over ATM (IMA)



IMA is a cell based protocol where an ATM cell stream is inverse-multiplexed across multiple paths to form a higher bandwidth logical link

The “logical link” concept is called an “IMA Group”

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

IMA is a standard developed to address the increasing need for bandwidth greater than the DS1 or E1 link speeds (1.544 or 2.048 Mb/s, respectively) but less than higher link speeds such as DS3 (44.736 Mb/s). IMA combines the transport bandwidth of multiple DS1 or E1 channels in a logical link (called an IMA group) to provide scalable bandwidth.

In the ingress direction:

- Traffic coming on a single card over multiple paths configured as part of a single IMA Group, is converted into a single ATM stream

In the egress direction:

- Single ATM stream (after service functions were applied) is distributed over all paths that are part of an IMA Group (Towards the CE)

The higher layers see only an IMA Group and not individual links, therefore service configuration and management is done using IMA Groups, and not individual links

All IMA member links in a IMA group must be on the same ASAP card.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Document History			
Edition	Date	Author	Remarks
01	YYYY-MM-DD	Last name, first name	First edition

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
aPipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 6
QoS Policies for VLL Services

TER36075_V3.1-SG-English-Ed1 Module 9.6 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives



Upon completion of this module, you should be able to describe:

- Characteristics and configuration of ePipe, iPipe, cPipe and aPipe services
- OAM tools – SDP-Ping, and Service-Ping
- QoS policies:
  - for ePipe, cPipe and aPipe

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — QoS policies for VLL Services	**5**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 QoS policies for VLL Services

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Access Ingress Traffic Classification and Marking

- Classification is the process of identifying a flow and mapping the packets of the flow to a certain pre-set Forwarding Class (FC).
  - By default, all access traffic is mapped to the default FC (“BE” in “sap-ingress 1”)

- ePipe
  - Up to 8 FCs
  - Mapping can be based on the following field and in order,
    - DSCP bits
    - Ethernet Priority bits (Dot1p)
    - Ethernet VLAN (Dot1q)
- cPipe, one FC per SAP
  - CESoPSN, classification is based on channel group
  - SAToP, all the traffic from the specific access port is associated with a single FC

- aPipe, one FC per SAP
  - Traffic from a given VP/VC with the specified Category is mapped to the configured FC

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Forwarding Classes Applied

Traffic Type	Traffic Description	Service Categories	CIR/PIR per VCC(Kbits/s)	Forwarding Class	Dot1p/DSCP	MPLS EXP
UP DS User Plane Delay Sensitive	AMR Voice and CS64PS	rtVBR (AAL2)	120/1600	H1	6	6
UP NDS User Plane Non Delay Sensitive	PS R99	nrtVBR (AAL2)	20/1600	H2	4	4
HSPA	Non Real-time HSPA	UBR (AAL2)	600/1600	BE	0	0
NBAP-c (signaling)	CP	rtVBR (AAL5)	50/100	NC	7	7
NBAP-d (signaling)	CCP	rtVBR (AAL5)	50/100	NC	7	7
ALCAP (signaling)	ALCAP	rtVBR (AAL5)	50/100	NC	7	7
OAM (management)	OAM	UBR+ (AAL5)	200/200	AF	3	3
Clocking pseudowire	Structured TDM clock Signal		1536/1536	NC	7	7
GSM Abis	Profile one		1536/1536	H1	6	6
GSM Abis	Profile two		2816/2816	H1	6	6
IP traffic	IGP trafficIn-band management			NC	*NC2	7



Once traffic is classified, the service ports buffer the streams according to forwarding classes and queuing priority. There are eight different forwarding classes and two queuing priorities. Forwarding classes are independent of the EXP, DSCP, or dot1p ToS fields and can be configured according to an operator's own needs. The port policies map the ToS fields to a specific forwarding class. Depending on the forwarding class and configured information rates, datagrams and queues can be mapped to high or low queuing priority.

The platforms support the concept of in-profile and out-of-profile for queues. Queues are considered in-profile if the traffic rate is less than or equal to the configured CIR. In-profile traffic for a given FC is considered high queuing priority. All traffic past the CIR and less than the PIR is classified as out-of-profile, or low queuing priority. For datagrams, the queuing priority is a temporary priority given on service ingress only.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

QoS Policies for Mobile Backhaul Solutions

Policy type	Forwarding Class	Applicable Traffic
SAP-ingress SAP-egress	BE	HSPA (ATM)
SAP-ingress SAP-egress	NC	NBAP-c (ATM) NBAP-d (ATM) ALCAP (ATM)
SAP-ingress SAP-egress	H1	UP DS (ATM) GSM Abis
SAP-ingress SAP-egress	H2	UP NDS (ATM)
SAP-ingress SAP-egress	AF	OAM (ATM)
SAP-ingress SAP-egress	BE	HSPA (Ethernet)

Policy type	ATM service category	Applicable Traffic
ATM-TD-Profile	UBR	HSPA
ATM-TD-Profile	rtVBR	NBAP-c, NBAP-d, ALCAP UP DS
ATM-TD-Profile	nrtVBR	UP NDS
ATM-TD-Profile	UBR+	OAM
ATM-TD-Profile	rtVBR	IuCS CP
ATM-TD-Profile	CBR	IuCS UP
ATM-TD-Profile	rtVBR	IuPS CP
ATM-TD-Profile	CBR	IuPS UP
ATM-TD-Profile	rtVBR	IuPS UP
ATM-TD-Profile	nrtVBR	IuPS UP
ATM-TD-Profile	UBR	IuPS UP

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Traffic classification at Service/Access ingress is dependent upon the type of access interface. From the perspective of the Service Aggregation Domain, the traffic variants on access interface include TDM, ATM and Ethernet traffic. As a standard approach, QoS policies will be created on all 7705 SARs and 7750 SRs. On the 7450 ESS used for network aggregation, only network policies need to be created. All service (SAP-ingress and SAP-egress) policies are applied at both ends of the point-to-point pseudowire service.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Rate Limiting

Rate-limiting approach	QoS Parameters	Traffic Type	Applies to	Notes
Discard	PIR=CIR=required rate CBS=0, MBS=1	Real-time	Service Ingress	On SR, turn police option on for rate.
Shapless Policing	PIR very high CIR = required rate MBS = CBS ∝ CIR (limit to required) HPO = 100%	Real-time	Network Ingress/Egress Service Egress	No downstream policer to expedite delivery.
Tagging	PIR>CIR=required rate MBS > CBS ∝ CIR 0<HPO<100%	Assured and best effort	Service Ingress	Excessive datagrams tagged
Soft-policing	PIR>CIR=required rate MBS > CBS ∝ CIR 0 < HPO < 100%	Assured and best effort	Network Ingress/Egress Service Egress	Datagrams that are tagged dropped first
Shaping	PIR=CIR=required rate MBS ≥ CBS ∝ CIR	Assured	Network Ingress/Egress Service Egress	Shape traffic to specified rate. Useful if downstream policer exists.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

When traffic arrives at a SAP consistently exceeding a certain rate, maybe a rate negotiated with a service provider, the excess datagrams are dropped. This rate-limiting technique is referred to as policing. Also, bursty traffic may cluster data together such that it becomes SLA non-conforming, yet on average it is. The shaping function stores such non-conforming datagrams in a queue and de-queues them at the conforming rate. Thus shaping can help non-conforming streams pass through a downstream policer.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Ethernet Traffic Treatment

On SAP-ingress, it is expected that Ethernet pseudowire will be capable of transporting differentiated services

- All traffic entering the Ethernet access port will be classified based on their incoming dot1p values and mapped to a corresponding forwarding class
- If dot1p is not supported by all network elements, then classification can be done based on a number of other header fields such as VLAN ID, or MAC address

On SAP-egress, forwarding class can be mapped to a corresponding egress queue. Ethernet traffic on egress will be scheduled based on an aggregate queue-type and profile-based scheduling (identical to all other traffic type treatment on egress)

- The dot1p bit of the Ethernet frame can be remarked on egress

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

TDM Traffic Treatment

For TDM pseudowires that are used for ACR synchronization, map a SAP-ingress policy with a default forwarding class, FC=NC

- The entire channel-group will be mapped to the same forwarding class
- A single expedite queue will be created for all unicast traffic with a CIR/PIR 1536/1536 kbps configured

Traffic engineering of the TDM PW interfaces for ACR synchronization purposes is vital to ensure that the ACR algorithms function as expected

Therefore care must be taken in setting QoS parameters for a CESoPSN PWE3 when it is used as an ACR timing transport link

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

ACR – Adaptive Clock Recovery

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

ATM Traffic Treatment

ATM traffic descriptor QoS policy can be created for each of the ATM service categories per system and applied to ATM VLL (Apipe) SAPs

- These policies can be applied on both ingress and egress

SAP-ingress policies are created per forwarding class

- This can be applied on a per-SAP (VC) basis and thus all traffic within a particular SAP is mapped based on the default-forwarding class configured on the SAP-ingress policy

Matching SAP-egress policies are created per forwarding class required

- This can be applied on a per-SAP (VC) basis and thus all traffic within a particular SAP is mapped to a single queue

The priority at which a queue is serviced will depend on forwarding class/service category mappings

- For example, setting MBS (maximum burst size) to 1% of PIR gives a 10ms depth to the buffer. Queue and scheduler capacity must be managed such that “in-profile traffic (traffic within CIR limits) will be delivered within SLAs. Out-of-profile traffic (traffic within PIR limits) can be buffered up to the default MBS

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
QoS Policies for VLL Services

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 7
VPLS

TER36075_V3.1-SG-English-Ed1 Module 9.7 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives



Upon completion of this module, you should be able to describe:

- Characteristics and benefits of a VPLS service
- Configuration of a VPLS service in SR-OS

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

	Page
1 — Preliminary concepts	**5**
2 — Configuration of a VPLS service	**16**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

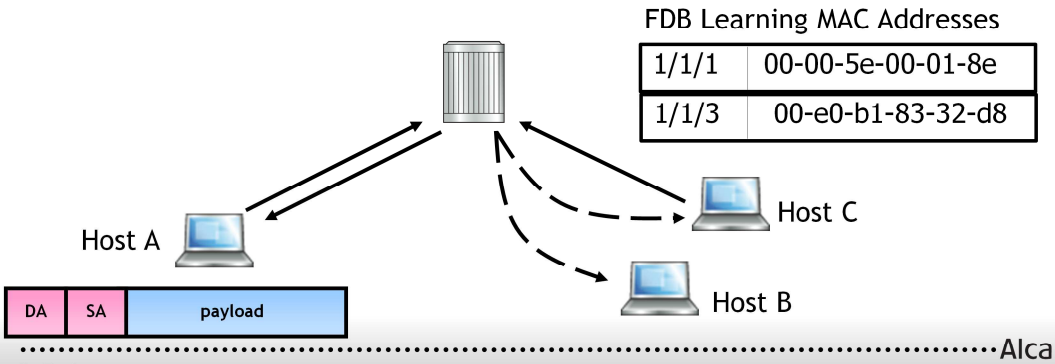
1 — Preliminary concepts

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Populating a Forwarding Database (FDB)

Host A sends a frame to Host C

1. The switch receives a frame on port 1/1/1
   - Host A's MAC address is learned from the frame's Source Address field and is associated with port 1/1/1
2. If the Destination Address is not already in the FDB, the switch floods the frame out all ports except for the source port 1/1/1
3. Host C responds to Host A, and all other devices drop the flooded frame
   - From Host C's response frame, the switch associates Host C's MAC address with port 1/1/3



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

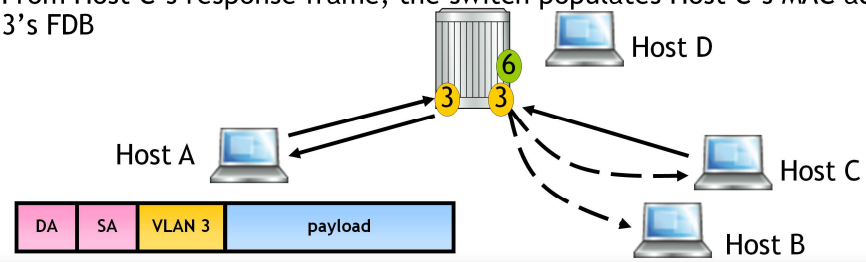
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Forwarding Databases Using Tagging

Virtual LANs (VLANs) are used to split a single switch into multiple virtual switches, each with the ability to service the hosts associated within that VLAN

As an example Hosts A B C are part of VLAN 3, Host D is part of VLAN 6

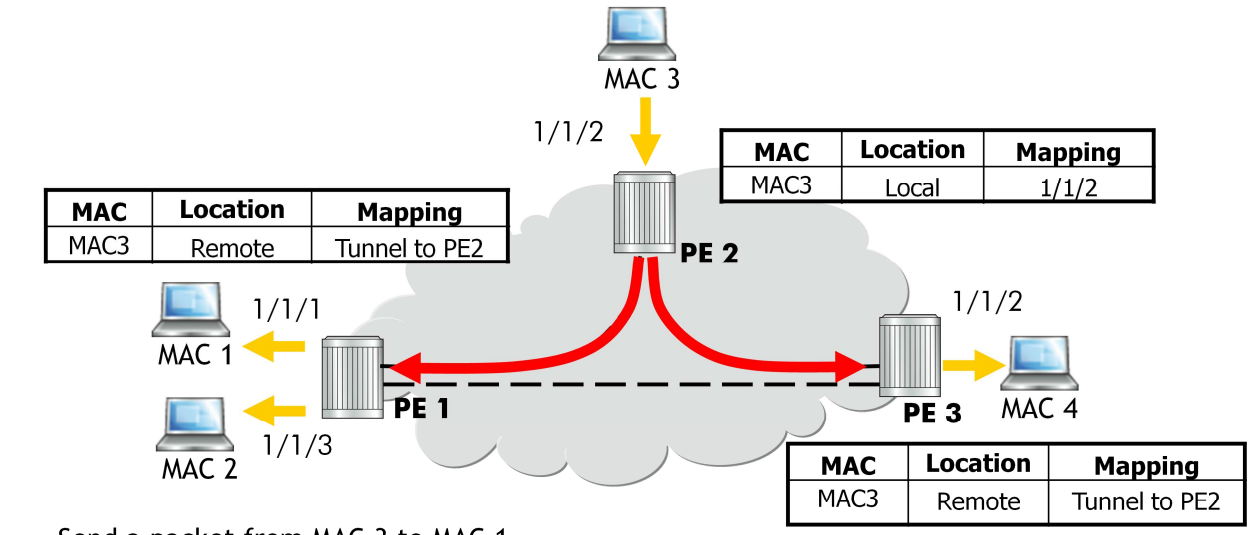
1. The switch receives a frame on port 1/1/1:3 (:3 signifies VLAN 3)
   - Host A's MAC address is learned and is associated with in VLAN 3's FDB
2. If the Destination Address is not already in the FDB, the switch floods the frame out **all ports associated with VLAN 3**
   - Host D will not necessarily receive a copy of the frame; even if it does, it will drop it because it belongs to a different VLAN than his
3. Host C responds to Host A, and all other devices drop the flooded frame
   - From Host C's response frame, the switch populates Host C's MAC address in VLAN 3's FDB



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VPLS Packet Walkthrough - VPLS Learning



Send a packet from MAC 3 to MAC 1

- PE2 learns that MAC 3 is reached on Port 1/1/2
- PE2 floods to PE1 with VC-label pe2-1 and PE3 with VC-label pe2-3
- PE1 learns that MAC 3 is behind PE2
- PE3 learns that MAC 3 is behind PE2
- PE3 sends on Port 1/1/2
- PE1 sends on Port 1/1/1 & 1/1/3

9 · 7 · 8
Services · VPLS
7750 SR 7705 SAR · Mobile Backhaul
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.
Alcatel·Lucent UNIVERSITY

PE routers learn the source MAC addresses of the traffic arriving on their access and network ports.

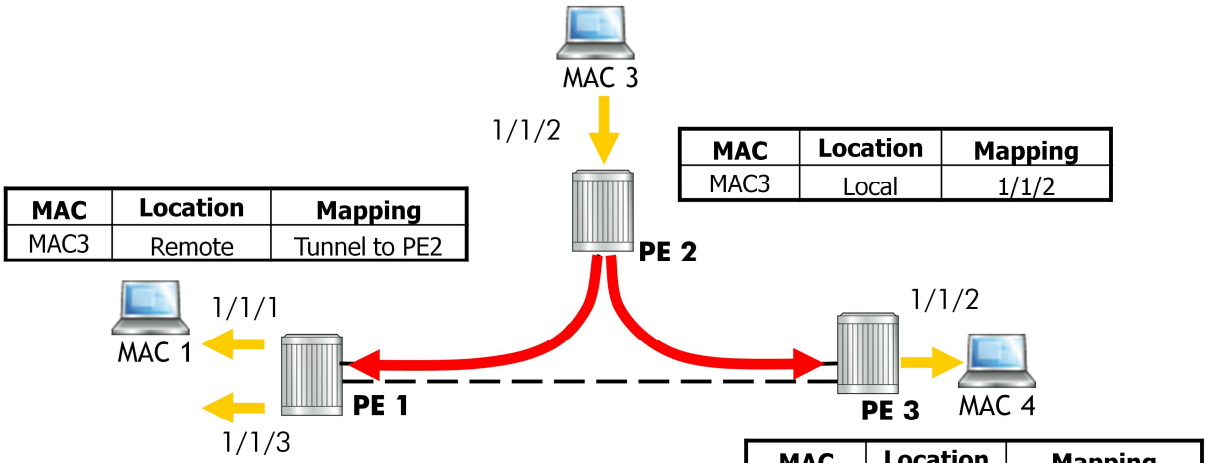
Each PE router maintains a Forwarding Data Base (FDB) for each VPLS service instance and learned MAC addresses are populated in the FDB table of the service.

All traffic is switched based on MAC addresses and forwarded between all participating PE routers using the LSP tunnels.

Unknown packets (i.e. destination MAC address has not been learned) are forwarded on all the LSPs to the participating PE routers for that service until the target station responds and the MAC address is learned by the PE routers associated with that service.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VPLS Packet Walkthrough - VPLS Learning



MAC	Location	Mapping
MAC3	Local	1/1/2

MAC	Location	Mapping
MAC3	Remote	Tunnel to PE2

MAC	Location	Mapping
MAC3	Remote	Tunnel to PE2

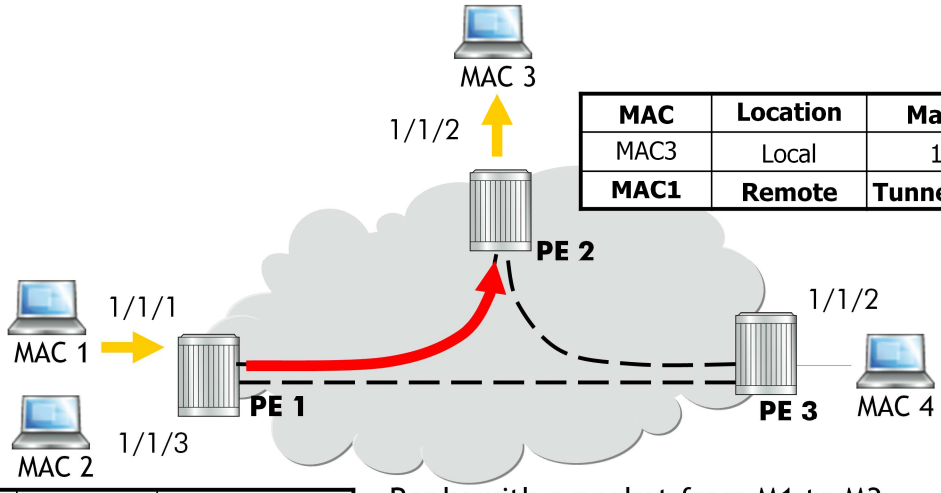
Send a packet from MAC 3 to MAC 1

- PE2 learns that MAC 3 is reached on Port 1/1/2
- PE2 floods to PE1 with VC-label pe2-1 and PE3 with VC-label pe2-3
- PE1 learns that MAC 3 is behind PE2
- PE3 learns that MAC 3 is behind PE2
- PE3 sends on Port 1/1/2
- PE1 sends on Port 1/1/1 & 1/1/3

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VPLS Packet Forwarding



MAC	Location	Mapping
MAC3	Local	1/1/2
MAC1	**Remote**	**Tunnel to PE1**

MAC	Location	Mapping
MAC3	Remote	Tunnel to PE2
MAC1	**Local**	**1/1/1**

Reply with a packet from M1 to M3

- PE1 learns M1 is on Port 1/1/1
- PE1 knows that M3 is reachable via PE2
- PE1 sends to PE2 using VC-label pe1-2
- PE2 learns MAC 1 is reachable via PE1
- PE2 knows that M3 is reachable on Port 1/1/2

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

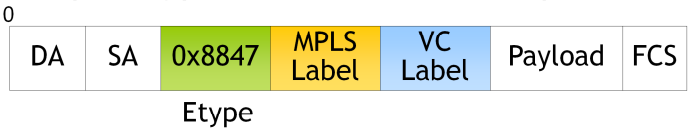
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Ethertype

The Ethertype field describes the payload of the Ethernet frame

Ethertype for some common Protocols	Protocol
0x0800	Internet Protocol, Version 4 (IPv4)
0x0806	Address Resolution Protocol (ARP)
0x8100	VLAN – Tagging (Dot1Q)
0x9100	VLAN – Tagging (QinQ)
0x86DD	IPv6
0x8847	MPLS unicast
0x88a8	Provider Bridging

For example Etype 8847 identifies this packet as Unicast MPLS



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

EtherType numbering generally starts from 0x0800. In the example used, Etype 8847 indicates a unicast MPLS Ethernet frame. When the 7750 SR looks at the Etype field and sees 8847, it immediately proceeds to process the MPLS labels.

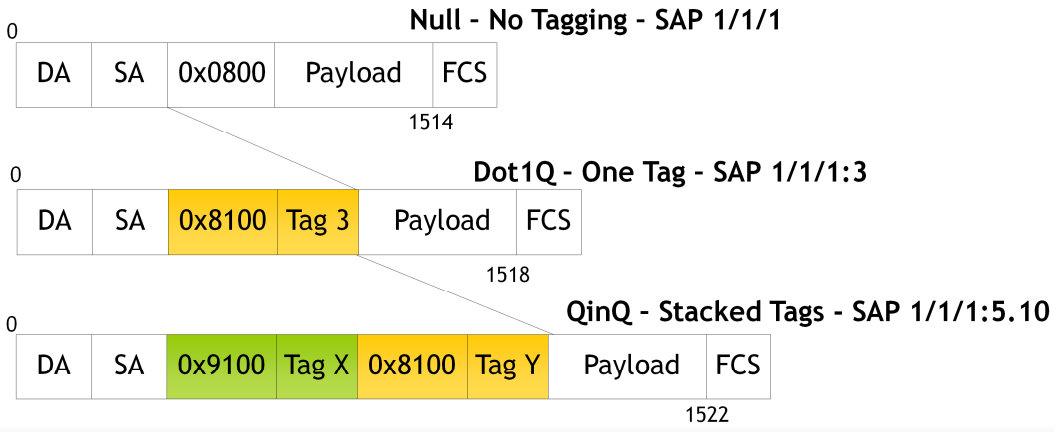
As we have seen, two MPLS labels are included in the service encapsulation when an MPLS SDP is bound to the service.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Ethertype – VLAN tagging

Ethernet port encapsulation type can be configured as one of the following:

- Null Header (Raw Mode), all bits after the 'type' field are treated as data
- Dot1q Header (Single tag header), adds an additional 4 byte "TAG"
- QinQ Header (Two tags header), adds two TAGs after Source Address field



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

When creating a SAP on a port, the selected encapsulation type must be taken into consideration. If it is a Dot1Q port, a VLAN tag value must be specified in addition to indicating the port ID. If the SAP is created over a QinQ port, then two VLAN tag values must be specified in addition to indicating the port ID. Examples:

- Dot1Q – One Tag – SAP 1/1/1:3
- QinQ – Stacked Tags - SAP 1/1/1:5.10

The Physical MTU on an Ethernet access interface also needs to be set accordingly:

- 1514 with encap-type null (1500 + 14 DLC header)
- 1518 with encap-type Dot1Q (1500 + 14 DLC header + 4 dot1q tag)
- 1522 with encap-type QinQ (1500 + 14 DLC header + 4 dot1q tag + 4 additional Q tag)

SAP Ingress:

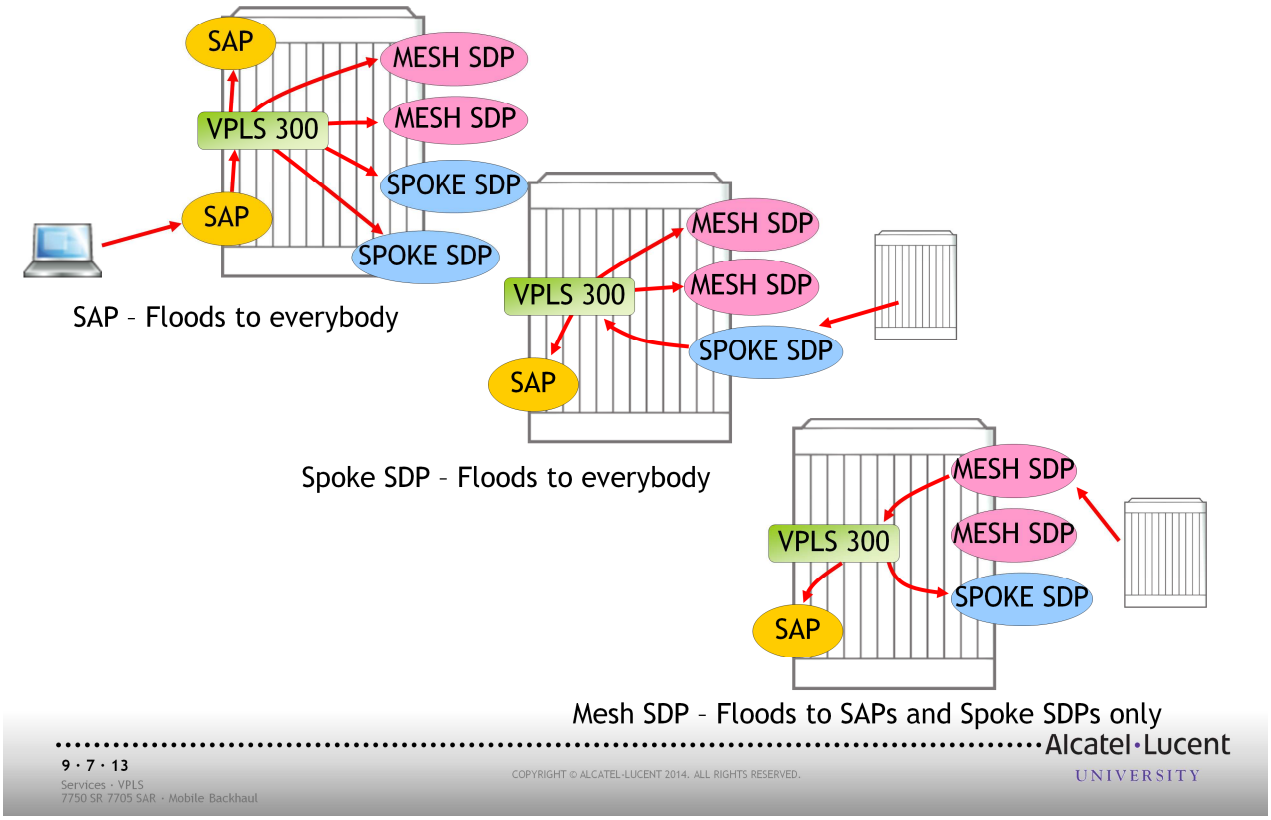
- Any frame received with VLAN tags that do not match one of the SAPs defined on the port, will be dropped
- Tags that are explicitly matched become stripped on ingress
- A wildcard can be used as a SAP defined tag (SAP:* or SAP:X.*), this has a 4-byte impact upon the service MTU as the tag is retained rather that stripped

SAP Egress:

- SAP:X push dot1q-etype and tag X on egress frames
- SAP:X.Y push QinQ-etype and tag X / Dot1q-etype and tag Y on egress
- Default and wildcard SAPs do not regenerate tags on egress

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Flooding Traffic within a VPLS



When the destination MAC address of a frame has already been learned, meaning that there is already an entry for that address in the FDB (Forwarding Data Base), the frame is only forwarded on the egress interface (SAP or SDP) pointed to by the FDB.

However, for a frame that has an unknown unicast destination MAC address or a multicast or broadcast destination MAC address, for which there will be no entry in the FDB, the frame has to be flooded throughout the entire broadcast domain. The following rules apply when flooding a frame is necessary.

- Flooded traffic **received on a SAP** is replicated to other SAPs, Spoke SDPs, and Mesh SDPs
- Flooded traffic **received on a Spoke SDP** is replicated to other SAPs, Spoke SDPs, and Mesh SDPs
- Flooded traffic **received on a Mesh SDP** is replicated to other SAPs, and Spoke SDPs, but is not transmitted on other Mesh SDPs

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VPLS - VC Label

VC-label Signaling between PEs per VPLS service instance

- Each PE automatically initiates a targeted LDP (TLDP) session to the far-end System IP address as soon as an SDP is bound to a layer-2 service
- TLDP is used to negotiate the VC (or service) label that will be used when sending data packets for the service
- TLDP uses the **VC ID** to identify the service tunnel, so it **must match** between PE nodes (best practice is to set **VC ID** the same as the **service ID**)
- The **VC label** allocated by each PE **may be different**

PE1->PE2: For VC-ID 102 Use VC-label 131069

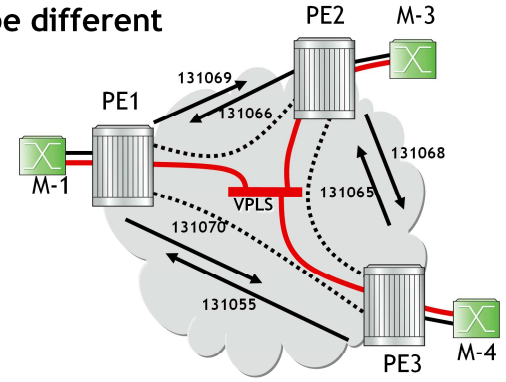
PE2->PE1: For VC-ID 102 Use VC-label 131066

PE1->PE3: For VC-ID 103 Use VC-label 131070

PE3->PE1: For VC-ID 103 Use VC-label 131055

PE2->PE3: For VC-ID 203 Use VC-label 131068

PE3->PE2: For VC-ID 203 Use VC-label 131065



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Customer packets are transported either inside an IP packet (GRE) or inside an MPLS packet.

The packet carries an inner (VC) label that identifies the service the packet belongs to. This label is sometimes referred to as the Martini label which is an MPLS label that identifies the particular service that is being transported through the MPLS tunnel.

When a packet arrives at the destination, the outer IP address or MPLS label is stripped off. At this point the inner label is examined to determine which service the packet belongs to.

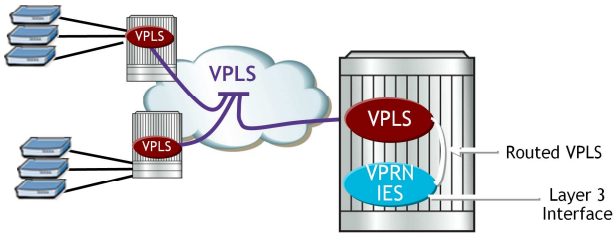
After determining which service the packet belongs to, the customer's Ethernet packet is examined and its MAC address is looked up in a table on the PE to determine which SAP the packet should go to.

VC labels can be assigned manually or automatically using targeted LDP (TLDP). The TLDP protocol is used to dynamically negotiate VC labels between PE's. This method is not error prone and scales much better than manually assigning labels.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Routed VPLS

In order to interconnect a VPLS domain with a Layer 3 domain, e.g. VPLS backhaul to a Layer 3 service, a routed VPLS allows the binding of IP interfaces in IES or VPRN services to be bound to VPLS services.



- Routed-VPLS service:
  - Internal VPLS to IES interface
  - Internal VPLS to VPRN interface

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

See Section 12 – Module – IES for a more detailed example.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

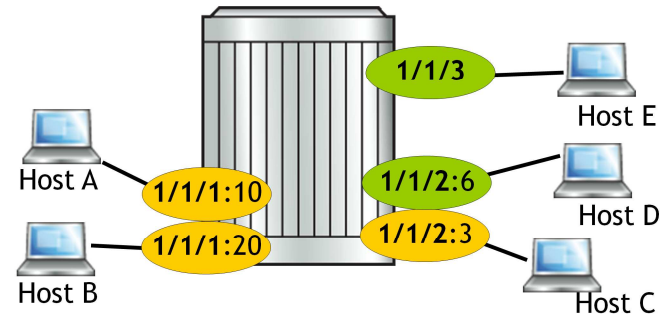
2 — Configuration of a VPLS service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Building a Local Virtual Private LAN Service (VPLS)

Creating a Local VPLS Service, meaning a service that exists solely on a single node:

- Change the ports facing customers to mode access
  - Ethernet mode access
- Enable tagging on the ports, if needed
  - Ethernet encap-type dot1q
- Create Service Access Points (SAPs) within the VPLS service using the desired port/tag
  - VPLS 300
    - sap 1/1/1:10
    - sap 1/1/1:20
    - sap 1/1/2:3
  - VPLS 600
    - sap 1/1/2:6
    - sap 1/1/3





1518

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

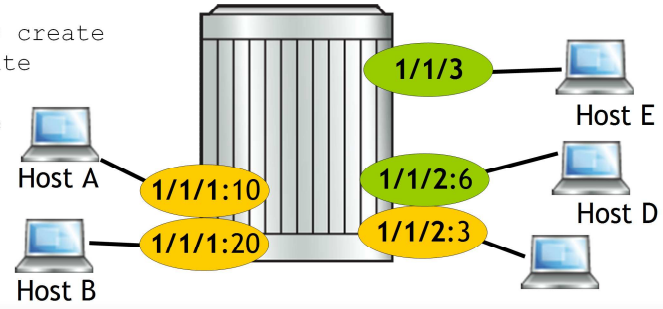
All frames that ingress to a service are compared to the FDB to determine which SAP or SDP the frame is to be forwarded out. If the egressing port is a SAP, the frame will be regenerated with the appropriate tags (dot1Q and QinQ) based on the SAP definition. For example, a dot1q SAP that is provisioned as 1/1/1:3 will have the dot1q tag 3 inserted into all frames that egress that port based on the FDB.

When a wildcard is used, for example 1/1/1:* although the SAP is defined as dot1Q, no additional tags are added on egress.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Building a Local Virtual Private LAN Service (VPLS)

```
config# port 1/1/[1..3] shutdown
config# port 1/1/[1..3] ethernet mode access
config# port 1/1/[1..2] ethernet encap-type dot1q
config# port 1/1/[1..3] no shutdown

config# service vpls 300 customer 200 create
config>service>vpls$ sap 1/1/1:10 create
config>service>vpls>sap$ exit
config>service>vpls$ sap 1/1/1:20 create
config>service>vpls>sap$ exit
config>service>vpls$ sap 1/1/2:3 create
config>service>vpls>sap$ exit
config>service>vpls$ no shutdown
config>service>vpls$ exit

config>service# vpls 600 customer 300 create
config>service>vpls$ sap 1/1/2:6 create
config>service>vpls>sap$ exit
config>service>vpls$ sap 1/1/3 create
config>service>vpls>sap$ exit
config>service>vpls$ no shutdown
```



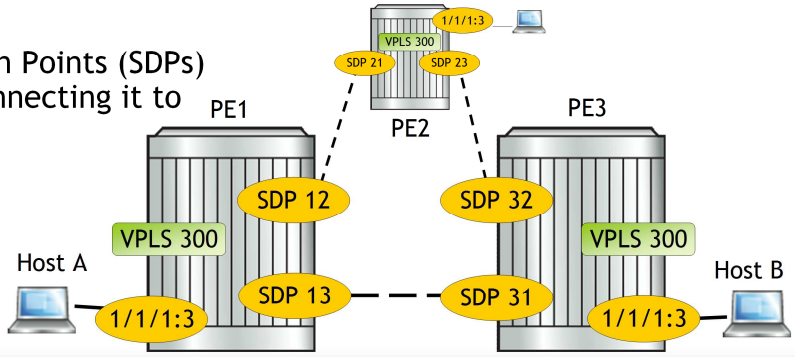
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Building a Distributed Virtual Private LAN Service (VPLS)

Creating a Distributed VPLS Service, meaning a service that involves several PE routers:

- Build a mesh of MPLS LSPs interconnecting PE routers
- Build a mesh of SDPs interconnecting PE routers
- Change the ports facing customers to port mode access
  - Ethernet mode access
- Enable tagging on the access ports, if needed
  - Ethernet encap-type dot1q
- Create Service Access Points (SAPs) within the VPLS service using the desired port/tag
  - VPLS 300
    - sap 1/1/1:3
- Bind Service Distribution Points (SDPs) to the VPLS service, connecting it to other PEs
  - VPLS 300
    - spoke-sdp 12:300
    - spoke-sdp 13:300



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

VPLS Service

For each VPN at each site, a Customer Edge (CE) device connects to the Provider Edge (PE) router via a point-to-point access connection.

Ethernet serves as the framing technology between the CE device and the PE router in the provider's network. Frames can include IEEE 802.1Q Ethernet VLAN tags, which allow customers to segment their networks and assign quality of service priorities to LAN traffic. VPLS also supports "QinQ" encapsulation, where a second VLAN tag is added as a service delimiter. From the customer's perspective, the entire VPN looks like a single Ethernet LAN, with the PE acting as a bridge that switches frames on the basis of their Layer-2 destination MAC addresses.

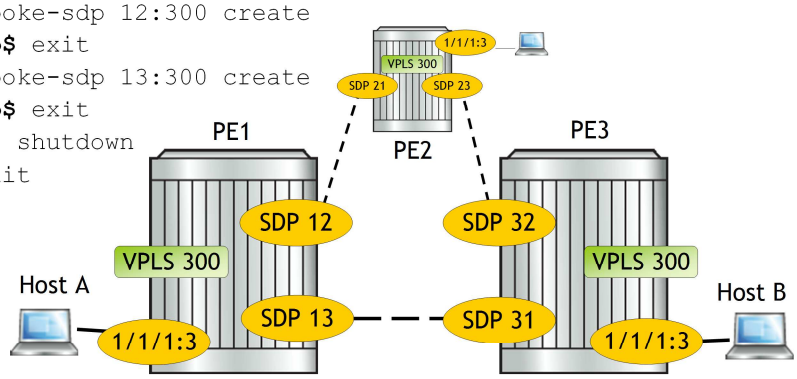
On the provider's side, however, PEs are interconnected with Generic Routing Encapsulation (GRE) and/or Multiprotocol Label Switching (MPLS) tunnels. If PEs are connected using GRE tunnels traffic is encapsulated and routed through the core network using standard IP frame formats and addressing. If PEs are connected using MPLS tunnels traffic is encapsulated in an MPLS frame and transmitted using MPLS labels. MPLS routes can be signaled using RSVP-TE or LDP.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Building a Distributed Virtual Private LAN Service (VPLS)

Configuration on PE1 (similar on other PEs):

```
PE1>config# port 1/1/1 shutdown
PE1>config# port 1/1/1 ethernet mode access
PE1>config# port 1/1/1 ethernet encap-type dot1q
PE1>config# port 1/1/1 no shutdown

PE1>config# service vpls 300 customer 200 create
PE1>config>service>vpls$ sap 1/1/1:3 create
PE1>config>service>vpls>sap$ exit
PE1>config>service>vpls$ spoke-sdp 12:300 create
PE1>config>service>vpls>sdp$ exit
PE1>config>service>vpls$ spoke-sdp 13:300 create
PE1>config>service>vpls>sdp$ exit
PE1>config>service>vpls$ no shutdown
PE1>config>service>vpls$ exit
```



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Core Network

Before a service is provisioned the following tasks should be completed:

- Build the IP or MPLS core network
- Configure routing protocols
- Configure MPLS LSPs (if MPLS used)
- Construct the core SDP service tunnel mesh for the services

Service Administration

- Configure group and user access privileges
- Build templates for QoS, filter and/or accounting policies needed to support core services
- Configure customer accounts

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
VPLS

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 8
IES

TER36075_V3.1-SG-English-Ed1 Module 9.8 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to:

- Features of an Internet Enhanced Service
- Basic configuration of an IES

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

Page

1 — Features of an Internet Enhanced Service **7**
2 — Basic configuration of an IES **18**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 Features of an Internet Enhanced Service

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

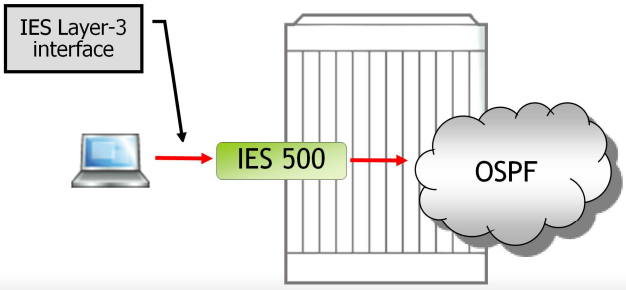
Internet Enhanced Service (IES)

An IES is a routed, layer-3 connectivity service, that can have one or more layer-3 interfaces associated to it

From the customer's point of view, an IES interface is no different from a standard layer-3 interface

- It gives the customer access to the IP networks that the PE router is aware of (the customer can participate in the same routing instance as the PE router)
- IES Interfaces can be included in the following routing protocols: Static, RIP, OSPF, IS-IS, and BGP

From the service provider point of view, however, it allows the application of policies to provide QoS and for accounting/billing



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Internet Enhanced Service (IES) is a routed connectivity service where the subscriber communicates with an IP router interface to send and receive Internet traffic.

An IES:

- Has one or more logical IP routing interfaces, each with its own IP address and connected to one or more customer locations
- Allows customer-facing IP interfaces to participate in the same routing instance used for service network core routing connectivity
- Requires that the IP addressing scheme used by the subscriber be unique relative to other provider addressing schemes and potentially the entire Internet

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Internet Enhanced Service (IES)

A standard layer-3 interface has an IP address and a port associated to it

Similarly, an IES interface has an IP address associated to it and a way of receiving/sending IP packets from/to the customer

There are three alternatives:

- Through a **SAP** if the customer is directly connected to the PE router
- Through an **SDP** if the PE router is connected to the customer via a spoke SDP that originates on another router (coming from an ePipe, iPipe or VPLS service)
- Through a **VPLS** if the same layer-3 interface is used to provide services to several customer locations that belong to the same virtual private LAN

Note: These alternatives apply, not only to IESs , but also to VPRNs (Virtual Private Routed Networks).

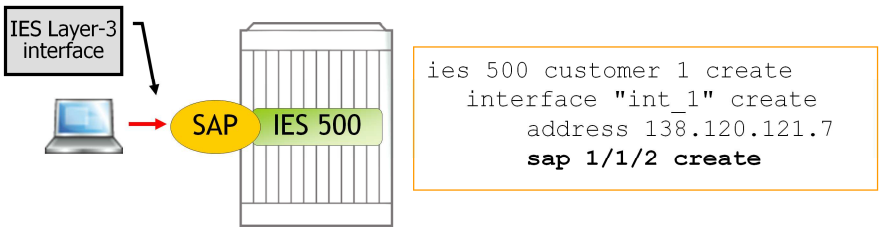
COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Internet Enhanced Service (IES)

First alternative:

- The IES interface is directly connected to the customer through a **SAP**

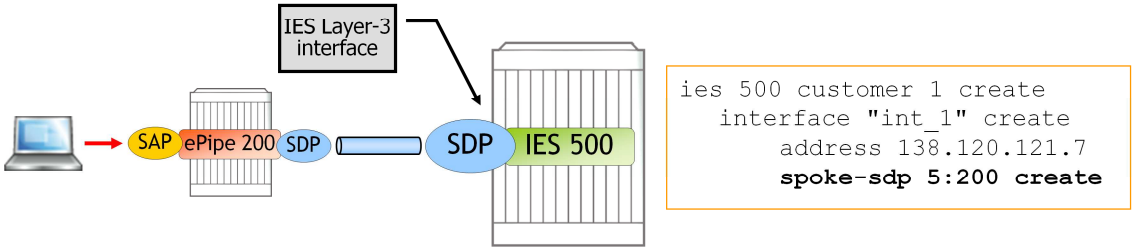


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Second alternative:

- The IES interface is connected to the customer through a spoke **SDP** that originates on another router (coming from an ePipe, iPipe or VPLS service)

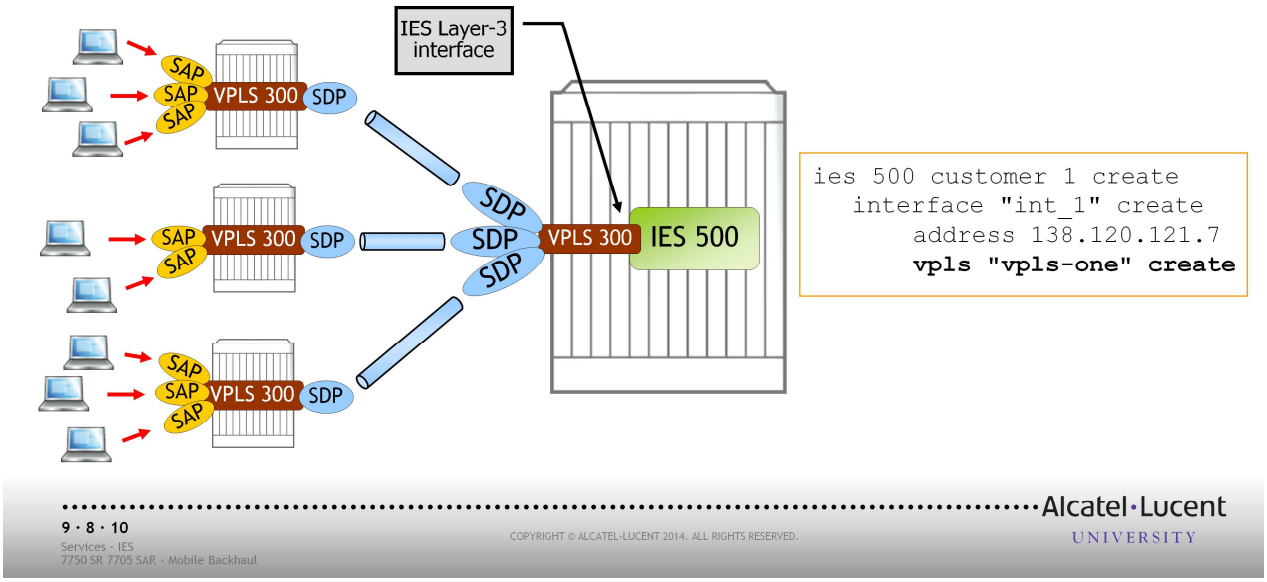


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Third alternative (routed VPLS):

- The IES interface is connected to customers through a **VPLS** that is used to provide services to several customer locations that belong to the same virtual private LAN



In the configuration of this example, all customers see the same IES interface, with the same IP address, as a potential next-hop towards external networks. In addition to that, all customers see each other as participants of the same LAN.

The VPLS, even though it is a service in itself, becomes a component of another service; namely, of the IES layer-3 interface.

This option, known as **routed VPLS**, is available as of software release 9.0. An IES IP interface cannot be bound to a service name unless the system is configured in chassis mode D.

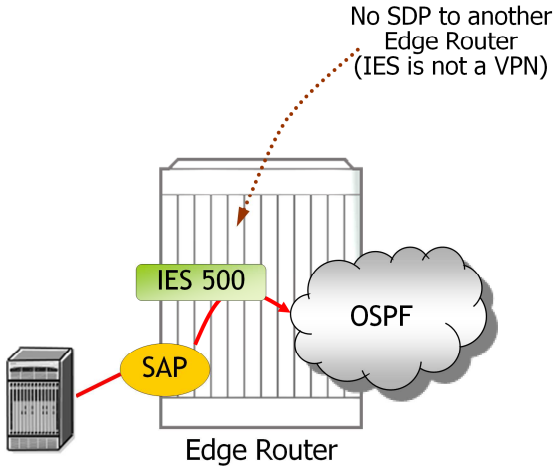
Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IES Routed Connectivity Service Example

Traffic in an IES service is exchanged using an IP interface that can participate in the core routing instance

Contrary to VPNs, an IES does not require the configuration of an SDP to tunnel traffic from one PE to another

```
ies 500 customer 1 create
   interface server create
       address 138.120.121.7
       sap 1/1/2 create

ospf
   area 0.0.0.0
       ...
       interface server
```



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Traffic in an IES service is exchanged using an IP interface that participates in the same routing instance as the core routers. Because of that, contrary to VPNs, an IES does not require the configuration of an SDP to tunnel traffic from one PE to another. An SDP can be configured for a given interface, instead of a SAP, but that is to terminate a spoke-SDP that carries traffic to and from a customer connected through a layer-2 service; this is better explained in the next slide.

Since IES interfaces are part of the core routing domain, a portion of the service provider IP address space can be reserved for IES service provisioning. The reserved portion is user-configurable.

SAP Encapsulations Supported:

- Ethernet: null, dot1q, and q-in-q
- SONET/SDH: IPCP, BCP-null, and BCP-dot1q

IP Interface:

- Most options found on core IP interfaces
- VRRP – for IES with more than one IP interface
- Secondary IP addresses
- ICMP options

Routing Protocols Supported:

- RIP
- OSPF
- IS-IS

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

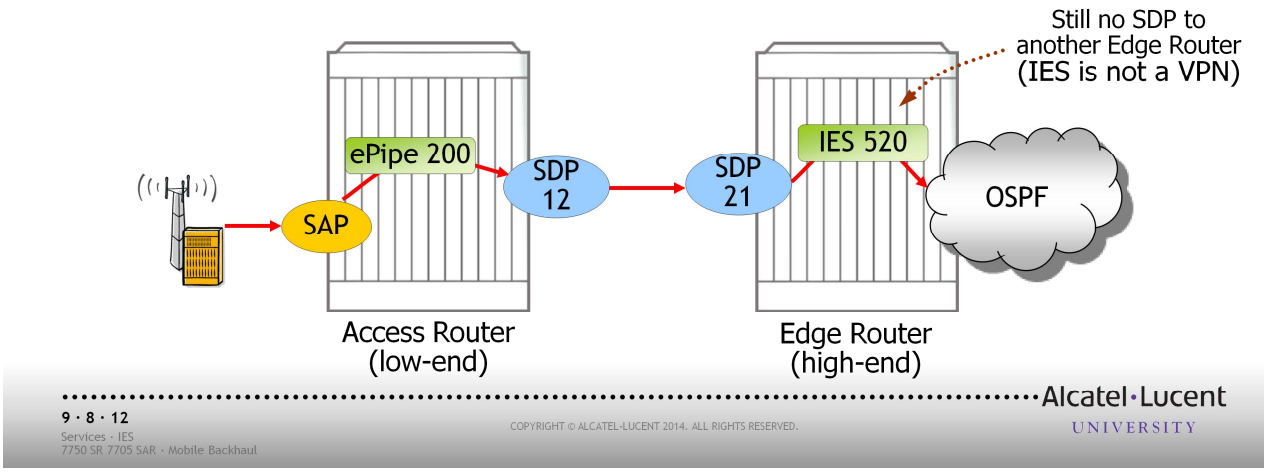
Spoke termination for IES

Instead of configuring a SAP for an IES interface, an SDP can be bound to it

Still connecting customer to core routing, but not directly at the Edge Router but indirectly through a presumably less powerful Access Router

Introduces the ability to cross-connect traffic entering on a spoke SDP to an IES

- A spoke SDP could be tied to an ePipe, an iPipe, or a VPLS service



This feature provides the ability to cross-connect traffic entering on a spoke SDP, used for Layer 2 services (VLLs or VPLS), on to an IES or VPRN service. From a logical point of view the spoke SDP entering on a network port is cross-connected to the layer 3 service as if it had entered via a service SAP. The traffic entering the Layer 3 service via a spoke SDP is handled via network QoS policies rather than an access QoS policies.

Traffic to be terminated on a given IES or VPRN service is identified by the MPLS labels present in the service packet, identifying the transport tunnel and service tunnel.

The SDP IDs on the ePipe and IES sides do not have to match, but the VC IDs need to be the same.

Note:

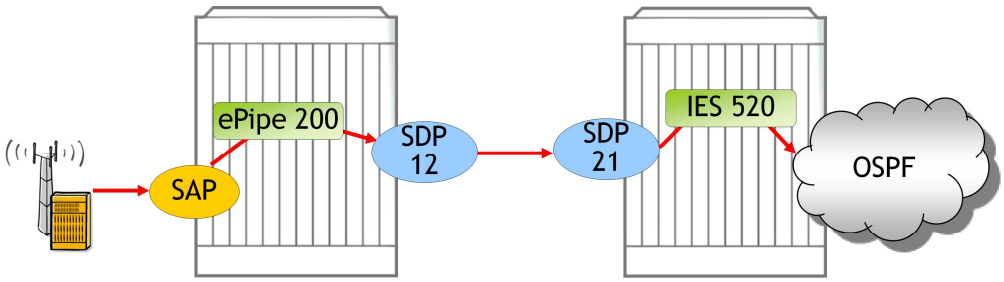
- As of R9.0, only SDPs coming from an Ethernet later-2 service (ePipe or VPLS) or from an iPipe are supported for spoke termination
- ATM and Frame Relay VLLs are not supported
- ECMP is not supported on the SDP tunnel

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Spoke termination for IES - ePipe

```
ies 520 customer 1 create
   interface ePipe200 create
        address 138.120.121.8
        spoke-sdp 21:200 create
        ip-mtu 1500

ospf
   area 0.0.0.0
        ...
        interface ePipe200
```

```
epipe 200 customer 1 create
   sap 1/1/5 create
   spoke-sdp 12:200 create
```



- ✓ Service MTUs must be equal
- ✓ IES can only terminate a spoke-SDP, not a mesh-SDP

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

spoke-sdp sdp-id:vc-id vc-type {ether|ipipe} binds a service to an existing SDP

In this configuration it is important to note that during the VC Label signalling process, if the VC MTU does not match the service will be operationally down.

The command **show service id 520 base** displays the Operational MTU for the IES

The command **show service id 200 base** displays the Operational MTU for the ePipe

The default VC MTU for a layer-2 service (VLL or VPLS), which is the maximum IP payload that the service will carry, is 1500 bytes. That is why the IP-MTU for the IES interface has to be set to the same value.

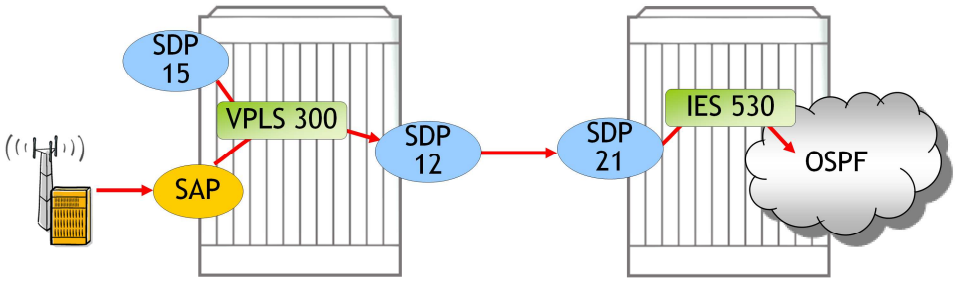
As an alternative to changing the MTU for the IES interface (ip-mtu 1500), the SDP MTU could have been changed (path-mtu 1514) but this would impact all services carried by the SDP. Any service requiring a larger MTU than 1514 would go operationally down.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Spoke termination for IES - VPLS

```
ies 530 customer 1 create
   interface VPLS300 create
        address 138.120.121.9
        spoke-sdp 21:300 create
        ip-mtu 1500

ospf
   area 0.0.0.0
        ...
        interface VPLS300
```

```
vpls 300 customer 1 create
   sap 1/1/5 create
   spoke-sdp 12:300 create
   mesh-sdp 15:300 create
```



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

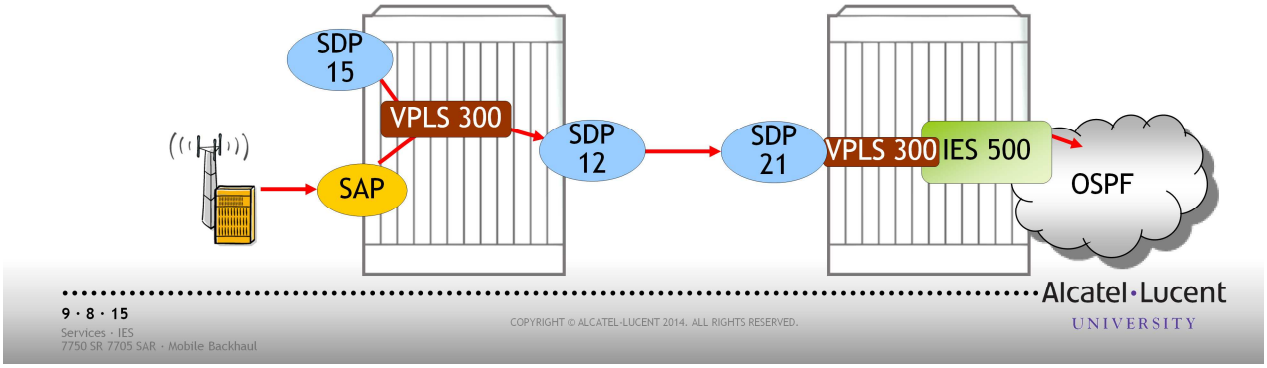
spoke-sdp sdp-id:vc-id vc-type {ether|ipipe} binds a service to an existing SDP

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Routed VPLS

```
vpls 300 customer 1 create
   service-name "vpls-one"
        allow-ip-int-binding
   spoke-sdp 21:300 create
...
ies 530 customer 1 create
   interface VPLS300 create
        address 138.120.121.9
        vpls "vpls-one"
        ip-mtu 1500
...
ospf
   area 0.0.0.0
        ...
        interface VPLS300
```

```
vpls 300 customer 1 create
   sap 1/1/5 create
   spoke-sdp 12:300 create
   mesh-sdp 15:300 create
```



spoke-sdp sdp-id:vc-id vc-type {ether|ipipe} binds a service to an existing SDP

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Basic configuration of an IES

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Configuring an IES

- Create an IES service and associate it with a customer ID
- Create an interface within the IES and associate IP address
  - Define SAP parameters on the interface
    - Select port and encapsulation
  - Alternatively, define SDP parameters on the interface
    - Select SDP and VC-ID
  - As a third option, specify VPLS to be used to connect to subscribers
    - Select VPLS name
- Optional - select QoS policies other than the default (configured in the config>qos context)
- Optional - select filter policies (configured in the config>filter context)
- Optional - select accounting policy (configured in the config>log context)
- Optional - add more interfaces as needed
- Enable the service.



Example:

1. Create an IES service and associate it with a customer ID.

```
config>service# ies 1000 customer 50 create
config>service>ies# description "to-internet"
```

2. Create an interface.

```
config>service>ies$ interface ToWeb create
config>service>ies>if$ address 10.10.36.2/24
```

3. Define SAP parameters on the interface. A SAP is a combination of a port and optional encapsulation parameters which identifies the service access point on the interface and within the ESS. Each SAP must be unique within a router.

```
config>service>ies>if# sap 5/1/3:0 create
```

or

```
config>service>ies>if# spoke-sdp 5:100 create
```

4. Enable the IES.

```
config>service>ies# no shutdown
```

Notes:

- You can configure an IES interface as a loopback interface by issuing the loopback command instead of the sap sap-id command.
- The loopback flag cannot be set on an interface where a SAP is already defined and a SAP cannot be defined on a loopback interface.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

IES Management

You can perform the following management tasks on an IES:

- Disable the service
- Re-enable the service
- Modify service parameters
- Delete the service

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Disabling an IES

You can shut down an IES service without deleting the service parameters.

```
config>service# ies 1000
config>service>ies# shutdown
config>service>ies# exit
```

Re-enabling an IES

```
config>service# ies 1000
config>service>ies# no shutdown
config>service>ies# exit
```

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
IES

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



Section 9
Services

Module 9
VPRN

TER36075_V3.1-SG-English-Ed1 Module 9.9 Edition 1

7750 SR 7705 SAR
Mobile Backhaul
TER36075_V3.1-SG Edition 1

Alcatel·Lucent
UNIVERSITY

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Module objectives

Upon completion of this module, you should be able to:

- The need for layer-3 VPNs
- VPRN setup and configuration
- Packet walkthrough

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Table of Contents

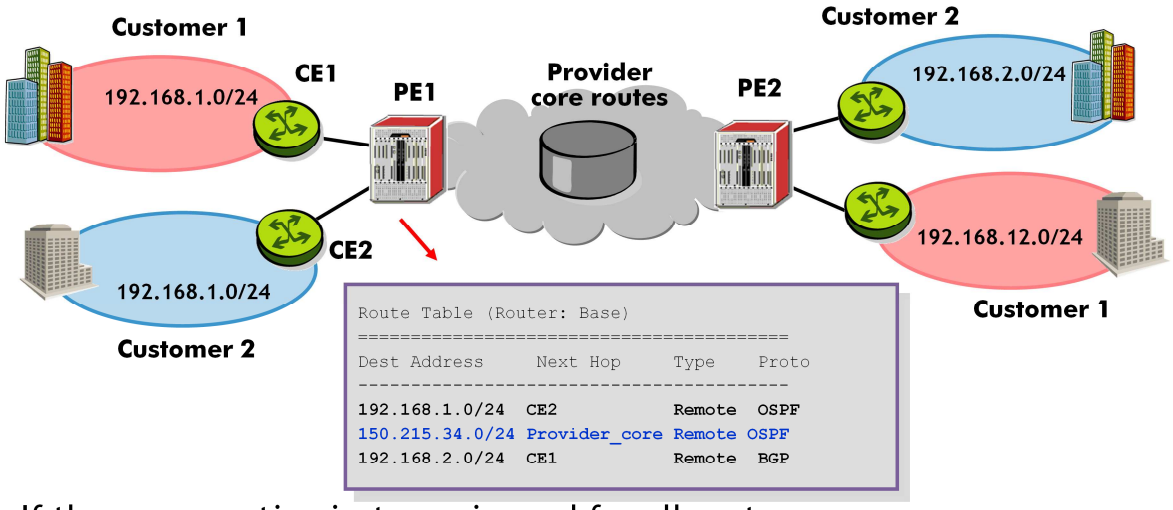
	Page
1 — The need for layer-3 VPNs	**5**
2 — Local vs distributed VPRN	**20**
3 — VPRN setup and configuration	**22**
4 — Packet walkthrough	**32**

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

1 The need for layer-3 VPNs

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Need for VPRNs: Single Routing Table



If the same routing instance is used for all customers:

- All routes are mixed together in a single PE routing table
- There can be conflicts if two customers use overlapping address ranges
- Large amount of information may be exchanged when routing changes

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

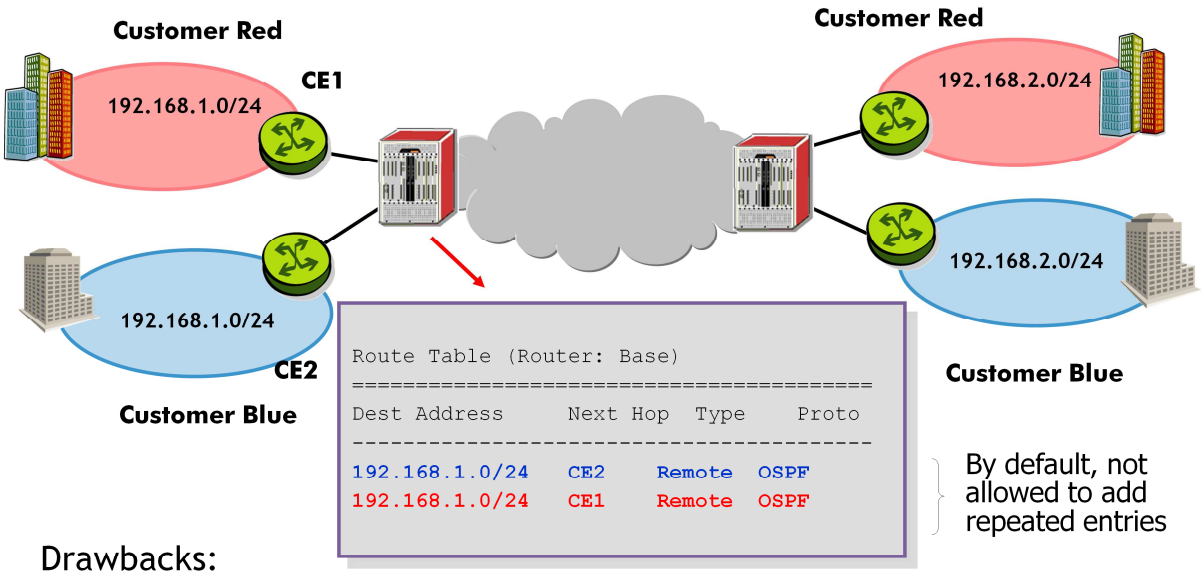
Without the L3 VPN:

- Each customer must use a separate IP address range
- All customer routes are carried natively in the provider core

There is no isolation between the routing information of different customers and there is no isolation of the provider network routes from the customer routes. All routes are mixed in a common routing table on all routers in the provider core network.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Need for VPRNs: Overlapping IP addresses



Drawbacks:

- By default, only the best route is selected in routing table
- If ECMP is enabled, packets from one customers may be forwarded to another
  ⇒ Routing problems

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

By default, it is not allowed to add repeated entries for the same prefix in a route table. So, if two customers are using the same address, only one of them will receive all the traffic addressed for both.

If ECMP is enabled to be able to install two entries in the route table for the same prefix, as shown in the figure, one of them will be selected pseudo-randomly using a hash function when a packet arrives. In this situation, there is still a potential problem since packets from one customers may be forwarded to the other.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

A VPN:

- Provides connectivity between separate sites.
- Is private because it gives the same properties and guarantees as a privately owned network, both in terms of network operations (addressing space, routing) and in terms of packet forwarding (traffic isolation).
- Is virtual because the provider may use the same resources and facilities to provide services to more than one customer.

Main Benefits :

- Simplifies the routing topology at each customer site
- The service provider manages the core network and the customer routes
- Customers receive the redundancy benefits designed into the provider core
- Security is similar to existing layer 2 technologies (ATM or Frame Relay)
- Layer 2 independent - allows different layer 2 connectivity at customer sites
- Allows the use of overlapping private IP address space between different customers

Layer 3 Backbone VPNs are commonly known as Border Gateway Protocol (BGP)/MPLS-based VPNs as per the standard RFC 2547bis, which is co-authored by Alcatel-Lucent. They are also known as Virtual Private Routed Networks (VPRN), Layer 3 MPLS-based VPNs or MPLS-based IP-VPNs.

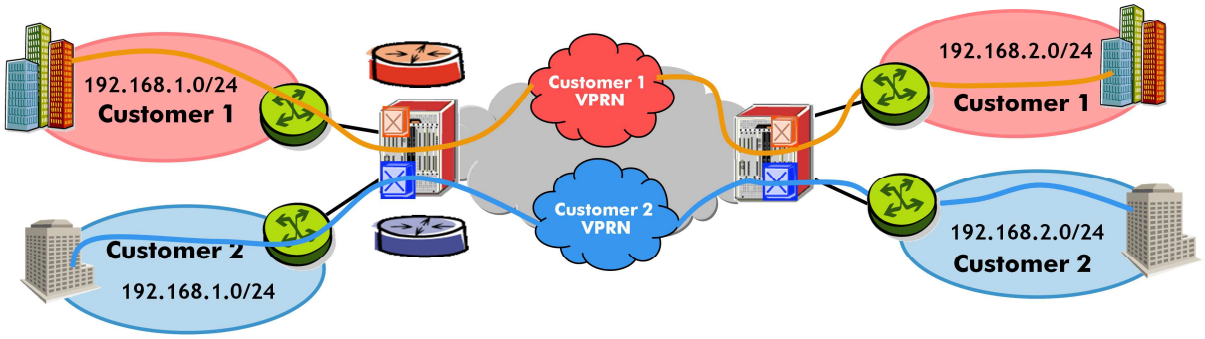
RFC 2547bis is an extension to the original RFC 2547, which details a method of distributing routing information and forwarding data to provide a Layer 3 Virtual Private Network (VPN) service to end customers. Although RFC 2547bis has long been quoted as an industry standard and is used in common terminology to define this class of VPN, this RFC has since been updated as RFC 4364.

RFC 2547bis describes a method to provide a Layer 3 VPN service by providing the following functions to the customer:

- Distribution of the customer’s routing information between sites
- Forwarding of the customer’s data packets to the appropriate destination
- Provision of a secure layer 3 routing connectivity between the various customer sites

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Introduction



VPRN Instance #1
VPRN Instance #2

Route table for VPRN 1
Route table for VPRN 2

- L3 VPN = Alcatel-Lucent VPRN
- Goals :
  - Connectivity between remote customer sites
  - Isolation of routing and traffic from different VPNs
  - Potential use of private address spaces in each site

9 · 9 · 9
Services · VPRN
7750 SR 7705 SAR · Mobile Backhaul

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Alcatel·Lucent UNIVERSITY

At a given PE router, there will be a separate route table for each VPN instance, known as a the Virtual Routing and Forwarding table, or VRF.

Implementation based on RFC 4364 (Formerly RFC 2547bis).

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPNs: Basic Requirements

From a customer's perspective:

- Customer can choose their IP addressing scheme
  - Private addresses, overlapping addresses, etc.
- Transparency: customer equipment is unaware of VPN
- Security: separation of routing information and data among customers
- QoS as defined in an SLA
- Different sites may use different layer-2 access technologies

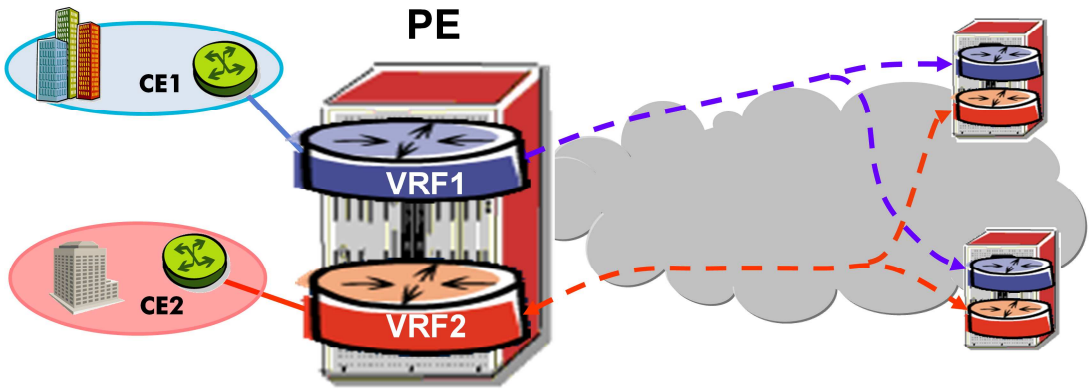
From a provider's perspective:

- Scalability:
  - of the backbone network (signalling, state, etc.)
  - # VPNs/backbone, # sites/VPN, # routes/VPN, etc.
- Ease of provisioning: addition of a site to a VPN, creation of a new VPN, merging of VPNs, etc.

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Virtual Routing and Forwarding instances on the PE



- Each PE router maintains a separate logical routing table for each VPRN
- This table is referred to as a Virtual Routing and Forwarding table (VRF)
- Contains customer destination routes
  - local sites
  - remote sites.
- MP-BGP is used to carry the VPN routes from one PE to the others

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

VPRN services use Virtual Routing and Forwarding tables (VRF) within a PE device to maintain forwarding information on a per site basis. A VRF is a logical private forwarding table created within a PE router.

Each PE may maintain multiple separate VRFs depending on the number of VPRN service instances it has.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

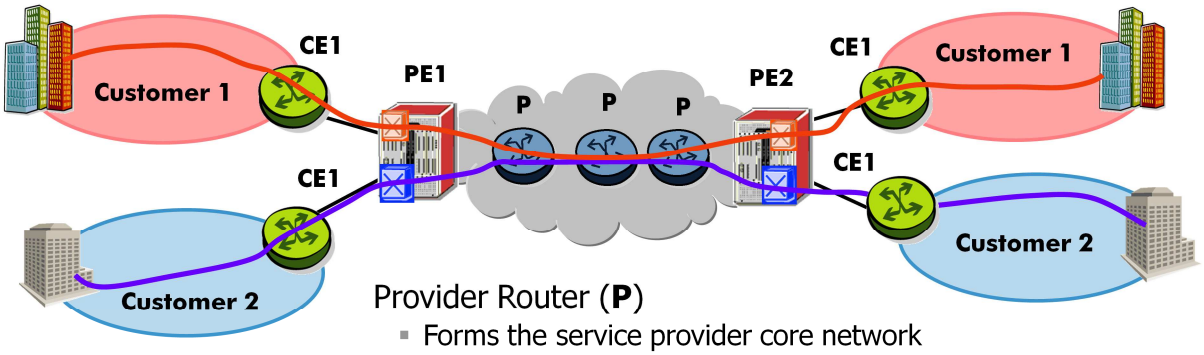
L3VPN: VPRN Terminology – CE, PE, P

Customer Edge Router (**CE**)

- Customer interface to the service provider's network
- Exchange of IP routing information with Corporate and PE routers
- Different protocols possible internally and with the PE

Provider Edge Router (**PE**)

- Interface between the customer and the service provider's network
- Exchanges IP routing information with CE and other PE routers
- MP-BGP is used to carry the VPN routes between PE routers



Provider Router (**P**)

- Forms the service provider core network
- Exchanges IP routing information with PE and P routers
- An IGP (internal gateway protocol) is used to carry the core routes

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Customer Edge (CE) Device

The Customer Edge (CE) router is the interface from the customer site to the service provider network. In the VPRN context, the CE must be layer-3 aware.

The CE also runs a common routing protocol with the service provider router in order to exchange routes with the provider network. This routing protocol may be the same or different than the routing protocol used internally at the customer site or in the provider network.

The CE is typically unaware of the existence of the MPLS protocol or the VPNs, and runs standard IP routing protocols.

Provider Edge (PE) Device

Provider Edge (PE) routers are the devices that provide the interface to the provider network for one or more CE devices, from one or more distinct customers.

Provider (P) Devices

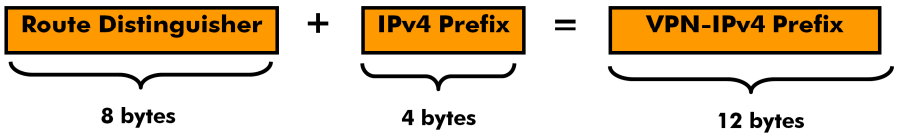
Provider (P) routers are the devices that comprise the internal provider network core. These devices may be connected to other PE or P routers, but do not have any connections to the CE.

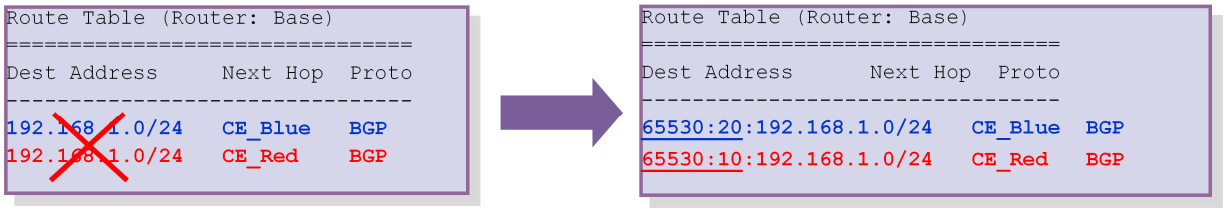
The P routers do not have a direct interface to any CE, but may have direct interfaces to PE routers.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3VPN: Route Distinguisher

- Different customers may use the same IP addresses within their respective networks
- An identifier called the Route Distinguisher (RD) is added to all IPv4 prefixes to ensure that the IP addresses remain unique





Conflict

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Route Distinguisher (RD)

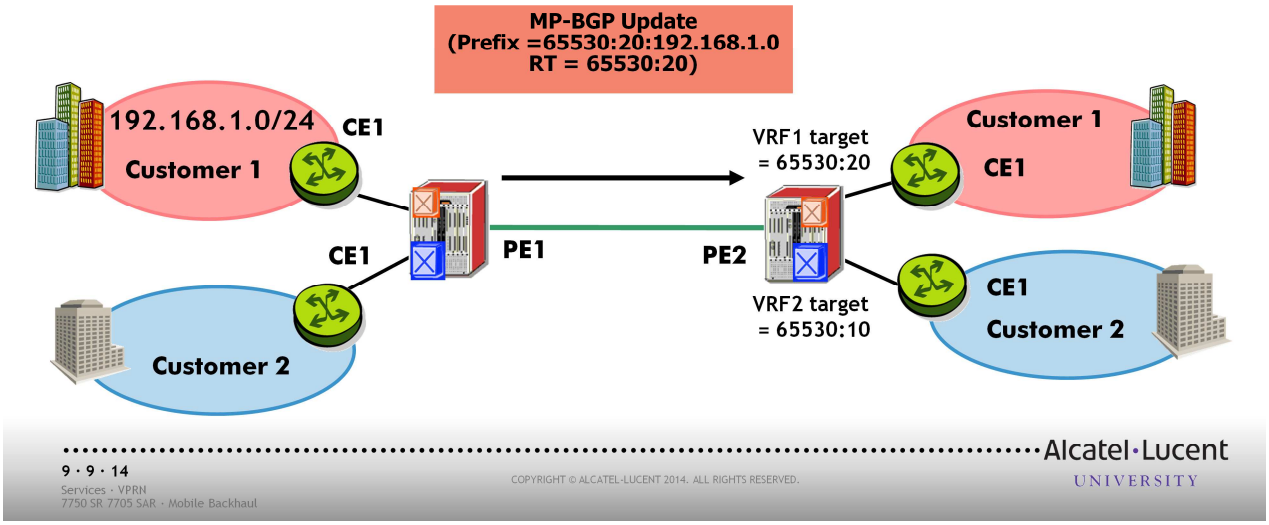
The Route Distinguisher is needed to make the VPN routes unique. This is necessary because all VPN routes are carried in the same routing protocol (MP-BGP).

Different customers may use the same IP addresses within their respective networks. A method is needed to ensure that the IP addresses remain unique when they are distributed across the service provider network. This is achieved by pre-pending the 4-byte IPv4 address with an 8-byte Route Distinguisher to form a new address called the “VPN-IPv4 address”. A distinct RD value can be associated with individual routes or with all routes learned from a particular CE.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3VPN: Which routes go into which VRF ?

- The same set of PEs may need to exchange routes for different VPRNs
- PEs establish a single MP-BGP session for the VPN-IPv4 family of prefixes
- Some mechanism is needed to determine which VRF a route belongs to
  - Mark a route by attaching a MP-BGP extended community attribute: Route Target (RT)
  - In many cases, the RT value chosen will be the same as the RD



Route Target (RT)

The same set of PE routers may need to exchange routes corresponding to different VPRN service instances. In addition to that, to improve scalability PE routers establish a single MP-BGP session for the VPN-IPv4 family of prefixes.

Some mechanism is needed to determine to which VRF a route belongs. A Route Target was defined to address this issue. The Route Target (RT) is the closest approximation to a VPN membership identifier in the VPRN architecture, and identifies to the receiving PE the VRF table that a prefix is associated with.

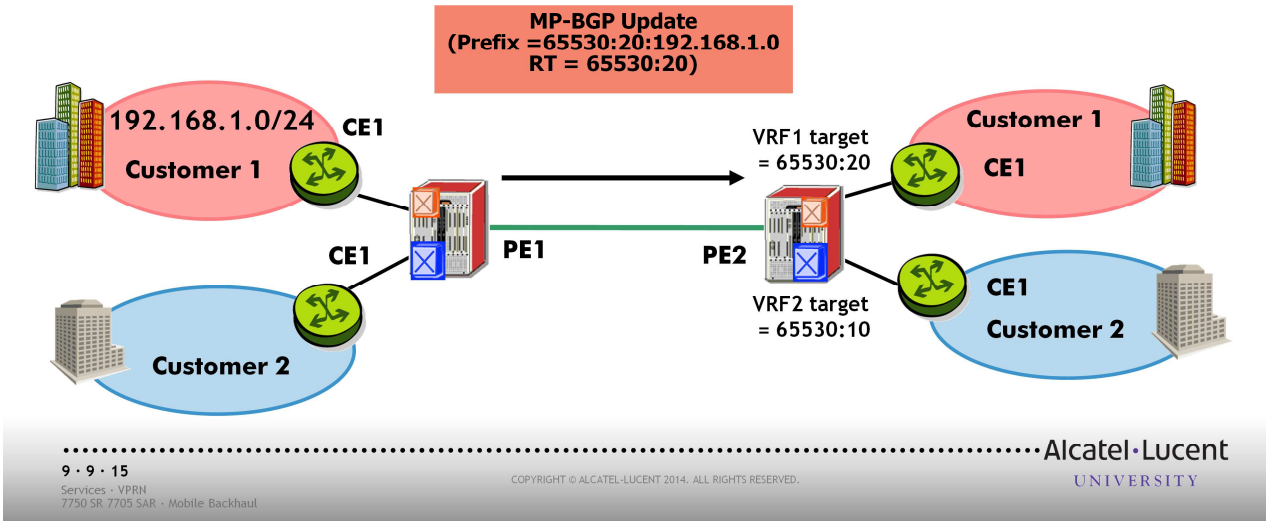
Route Target is a MP-BGP extended community. One or more MP-BGP community attributes may be associated to any route, therefore one or more Route Targets may be associated to any route.

In simple VPN cases and for provisioning consistency, the Route Target value chosen is often the same as the Route Distinguisher value, however they should not be interpreted as meaning the same thing.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3VPN and MP-BGP

- The MultiProtocol BGP (MP-BGP) capability allows routers to carry VPN-IPv4 prefixes, along with the RT as an extended community attribute
- VPN-IPv4 addresses only need to be known by the provider's edge routers



BGP is used with Multiprotocol BGP extensions to distribute VPRN routing information across the service provider's network.

In order to carry VPN-IPv4 prefixes in BGP, support for the additional address family is required. Separate BGP sessions must be enabled between every pair of routers for each of the address families they need to exchange. When BGP is configured or enabled in this fashion, it is referred to as Multiprotocol BGP or MP-BGP.

The Multiprotocol nature of MP-BGP allows the overlapping routing information to be transported across the provider core as VPN-IPv4 addresses. VPRN routes are not distributed as IPv4 routes, but as 12 byte VPN-IPv4 routes consisting of a concatenation of the Route Distinguisher and the IPv4 prefix.

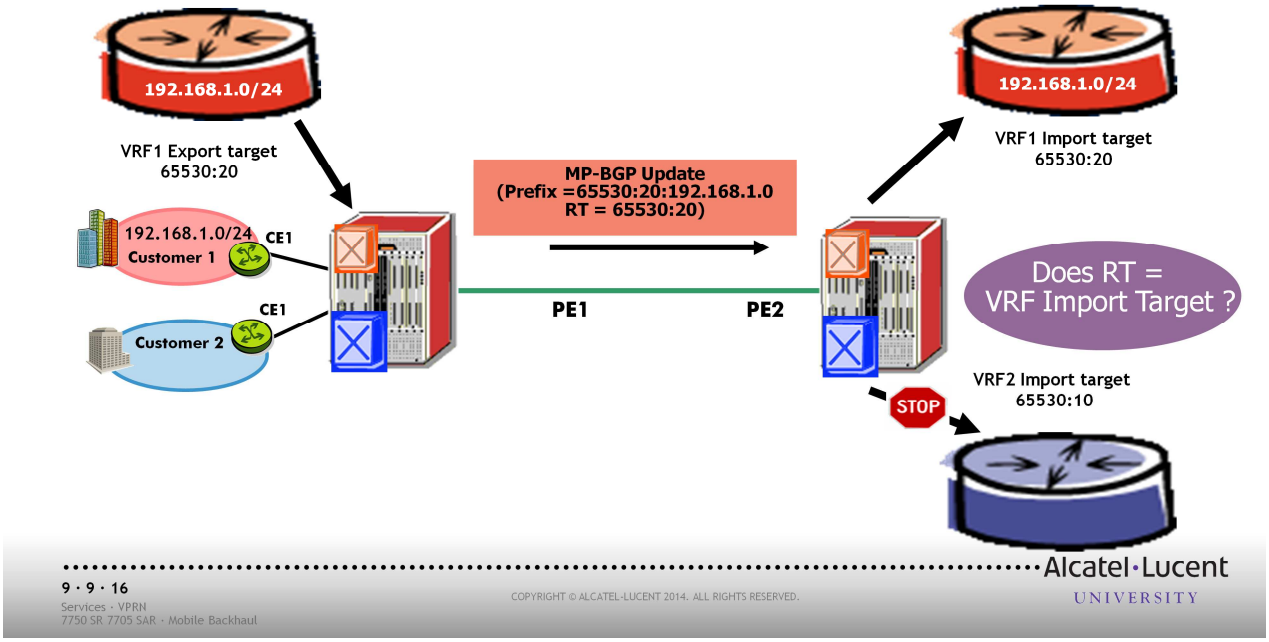
It is important to note that the VPN-IPv4 address family is used only in the control plane when exchanging MP-BGP routing updates between PEs. The data plane remains as standard IPv4. VRFs store IPv4 prefixes without RD or RT values, and all data traffic is carried in standard IPv4 packets.

The customer is unaware of the existence of VPN-IP addresses. The translation between customer IP routes in a particular VPN and VPN-IP routes distributed between provider routers is performed by the PE routers.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Import/Export Policy

- Routes are tagged with one or more RTs
- Routes are carried as VPN-IPv4 routes via MP-BGP to the remote PE



Routes are tagged with a route target value before sharing them with remote PEs due to the VPRN configuration (vrf-target parameter). Alternatively, export policies can be defined to add route target values (community attribute) to a route advertised to remote PEs. Upon receipt of a VPN-IPv4 route, a PE router will by default add the route to the VRF associated to the route target value received with the route. Import policies can be used to decide whether to add a given route to a VRF.

Route isolation between VRFs is accomplished through careful policy administration. An administrator determines the appropriate export and import target relationships.

Since RTs are applied at the time the route is exported, they are called export-RT. In the above example, a single RT is attached to each route.

The decision to import the route into the VRF is done by matching the received routes against locally defined per-VRF import policies expressed in terms of RTs (import-RT). If the Router import RT matches the update RT, it is stripped of the RD and imported into the VRF.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3VPN: Route-distinguisher vs route-target

	RT Route-target	RD Route-distinguisher
Part of VPN-IPv4 prefix	N	Y
Part of BGP attributes	Y	N
Makes a route unique	N	Y
Unique per VRF /VPRN	N	N
Unique per VRF/VPRN per node	N	Y
Only one per VPNv4 route	N	Y
Can be used in policies	Y	N



The route-target is part of the BGP attributes, whereas the route-distinguisher is part of the prefix, also known as Network Layer Reachability Information (NLRI).

RD + subnet/mask makes the NLRI unique. Route-targets can be used by multiple VRF's and thus do not make the NLRIs unique.

One VRF, spread over multiple PEs, can make use of more than one RD and more then one RT. VRF A on PE-1 can have a different RT and RD compared to VRF A on a different PE (PE-B).

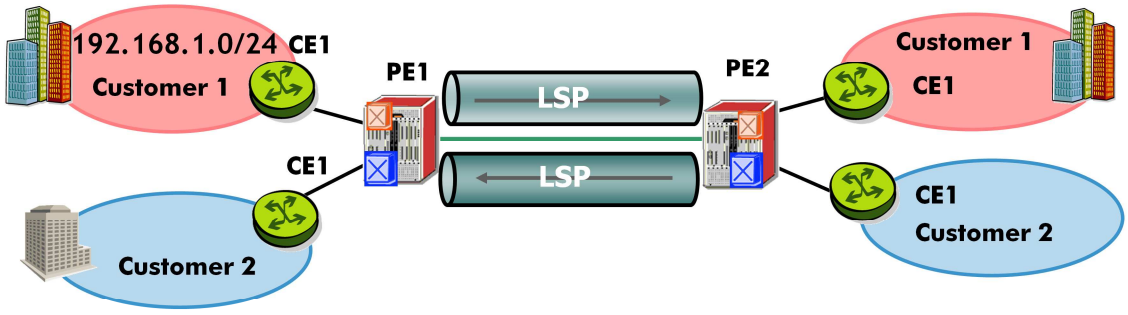
On a PE, a single VRF/VPRN can only assign one RD, but it is possible to use more then one RT.

One VPNv4 route, has only one RD, as part of the NLRI, but can have more then one RT (multiple extended communities can be sent with one NLRI).

Routing policies can check (match) on extended communities and/or add communities as a result of a match condition. RDs can not be used in policies.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Data Plane – Transport Tunnel



Each PE involved in a VPRN must have a tunnel to every other PE participating in the same VPRN service

These tunnels will carry the customer's VPN traffic from one site to another

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

After the establishment of the routing topology in the provider core, a full mesh of transport tunnels must be created between the PE's. In other words, each PE involved in a given VPRN service must be configured with a tunnel to every other PE participating in the same VPRN service in order to transport a customer's VPN traffic from one site to another. The transport tunnel is either an MPLS LSP or a GRE point-to-point tunnel between PE's.

The tunnels serve as the label switched paths the customer packets will take as they cross the provider core network.

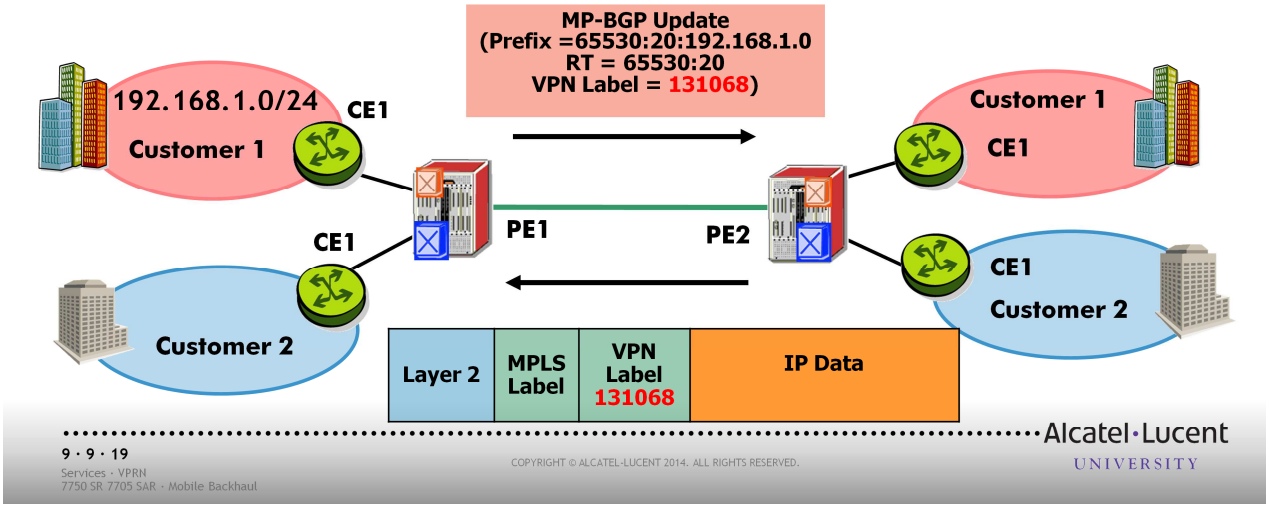
The tunnel is created either through the configuration of an SDP that is bound to the service or using the auto-bind option when creating a VPRN service instance. The auto-bind option is possible for VPRN, and not for the other service types, because in this case an MP-BGP session is established between every pair of PE routers that participate in the service in order for them to exchange routing information (VPN prefixes). So, its peers have been identified. Therefore, when the auto-bind command is issued, SDPs are automatically created from the router to each of the other routers with which there exists an MP-BGP session for the VPN family of prefixes.

If SDP tunnels are used, they must be created prior to the creation of the VPRN services.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: VPN Label

- For data traffic at an egress PE, a decision must be made as to how to forward each packet, depending on the customer it belongs to
- The VPN (service) label distributed by MP-BGP with the route is used for this
  - Associate a label (the VPN label) with a VPN data packet at the ingress PE
  - Demux the traffic based on VPN label at egress PE
- The VPN label in a data packet indicates either:
  - which VRF must be used to resolve the next hop for the destination address, or
  - the next-hop itself (as of Release 9.0.R1)



The purpose of the VPN label is to demultiplex VPN traffic arriving at the PE.

The distribution of the VPN label is done using BGP along with the VPN route information.

The distribution of the VPN tunnel information is automatic and does not require manual intervention.

Prior to Release 9.0.R1, the VPRN implementation allocated one unique (platform-wide) service label per VRF. All IP-VPN routes exported by the PE from a particular VPRN service had the same service label. When the PE received a terminating MPLS packet, the service label value determined the VRF to which the packet belongs. A lookup of the IP packet destination address in the forwarding table of the selected VRF determined the next-hop interface.

Release 9.0.R1 modifies the existing implementation by allowing the service label scheme to be configurable per VPRN as either service label per VRF (the existing scheme and the default in Release 9.0) or service label per next-hop. When a VPRN is configured for service label per next-hop, MPLS allocates one unique (platform-wide) service label for every next-hop IP address of the VPRN. When the PE receives a terminating MPLS packet, it will be forwarded to the next-hop that the service label is associated with, without any VRF lookup.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

2 Local vs distributed VPRN

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

Local vs distributed VPRN

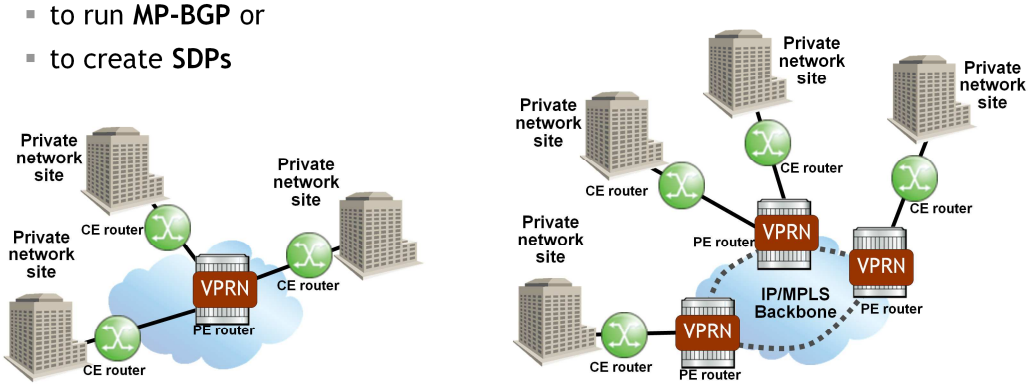
A VPRN can be **local** (only one PE provides the service) or **distributed** (two or more PEs collaborate to provide the service).

In a **distributed** VPRN, each PE needs to:

- establish **MP-BGP** sessions with the other PEs to exchange routing information residing in their respective VRFs
- create **SDPs** towards the other PEs to carry the customer data

In a **local** VPRN, however, there is no need

- to run **MP-BGP** or
- to create **SDPs**



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

In a local service, the PE may still need to run BGP (not MP-BGP) on one or more VPRN interfaces if that is the protocol that the PE and the CE agree to use to exchange local routing information relative to the specific location where the subscriber is situated.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

3 VPRN setup and configuration

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

VPRN configuration steps

The following configuration steps are needed for an operational VPRN:

- Establish MP-BGP sessions between PE routers that participate in VPRN
  - Family of prefixes is VPN-IPv4
- Create VPRN
  - Associate to customer
  - Specify Route Distinguisher (RD) and Route Target (RT)
  - Create transport tunnels (individual SDPs to other PEs or auto-bind)
  - Create interfaces, as needed, to interact with customer sites *
  - Configure the routing protocol used to exchange routing information with customer

Only required for distributed VPRN

* Note: VPRN interface configuration requires exactly the same steps as creating an interface for an IES service

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Creating an interface for a VPRN requires exactly the same steps as creating an interface for an IES service. Namely, the following components are needed:

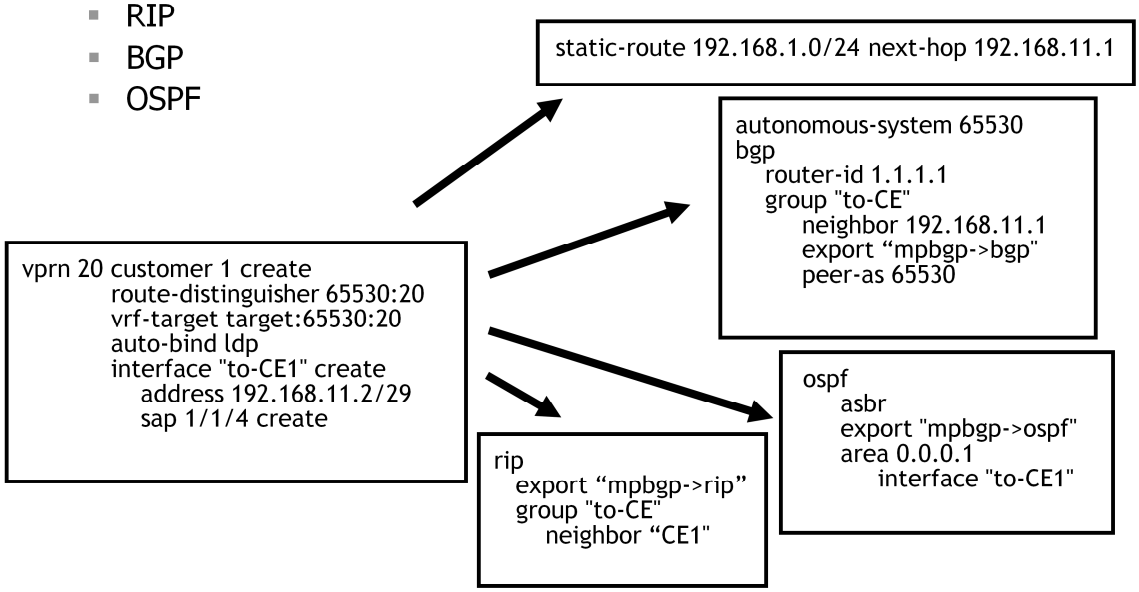
- Interface name
- Interface IP address
- A way of receiving/sending IP packets from/to the customer. For this, there are three alternatives:
  - Through a **SAP** if the customer is directly connected to the PE router
  - Through an **SDP** if the PE router is connected to the customer via a spoke SDP that originates on another router (coming from an ePipe, iPipe or VPLS service)
  - Through a **VPLS** if the same layer-3 interface is used to provide services to several customer locations that belong to the same virtual private LAN (routed VPLS)

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: CE to PE Route Distribution

The following route distribution options are available on the 7750 SR:

- Static routes
- RIP
- BGP
- OSPF



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

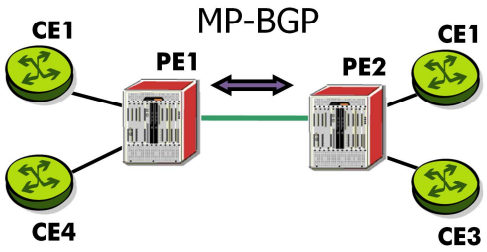
PE to CE Routing

Every prefix that is learned by the PE through the routing protocol it is running with its neighboring CE, will be automatically installed in the VRF and shared with other PE routers via MP-BGP. However, the prefixes that are learned by the PE through MP-BGP, advertised by remote PEs, are not automatically shared with the CE. An export policy is needed to control what is shared and what is not.

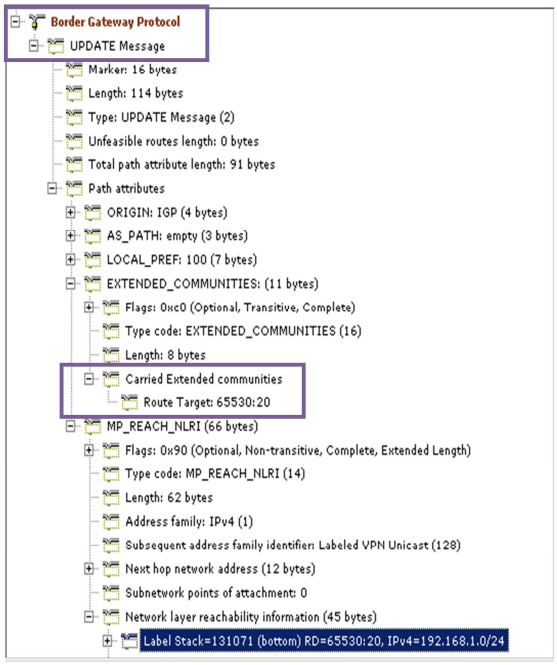
If static routes are configured at the PE towards the CE, they will be shared with other PEs via MP-BGP. However, if there is no dynamic routing protocol running between PE and CE, the routes learned by the PE through MP-BGP, advertised by remote PEs, will not be shared with the CE; in this case, the CE will have to rely on a default route to the PE.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3VPN: PE to PE Route Distribution



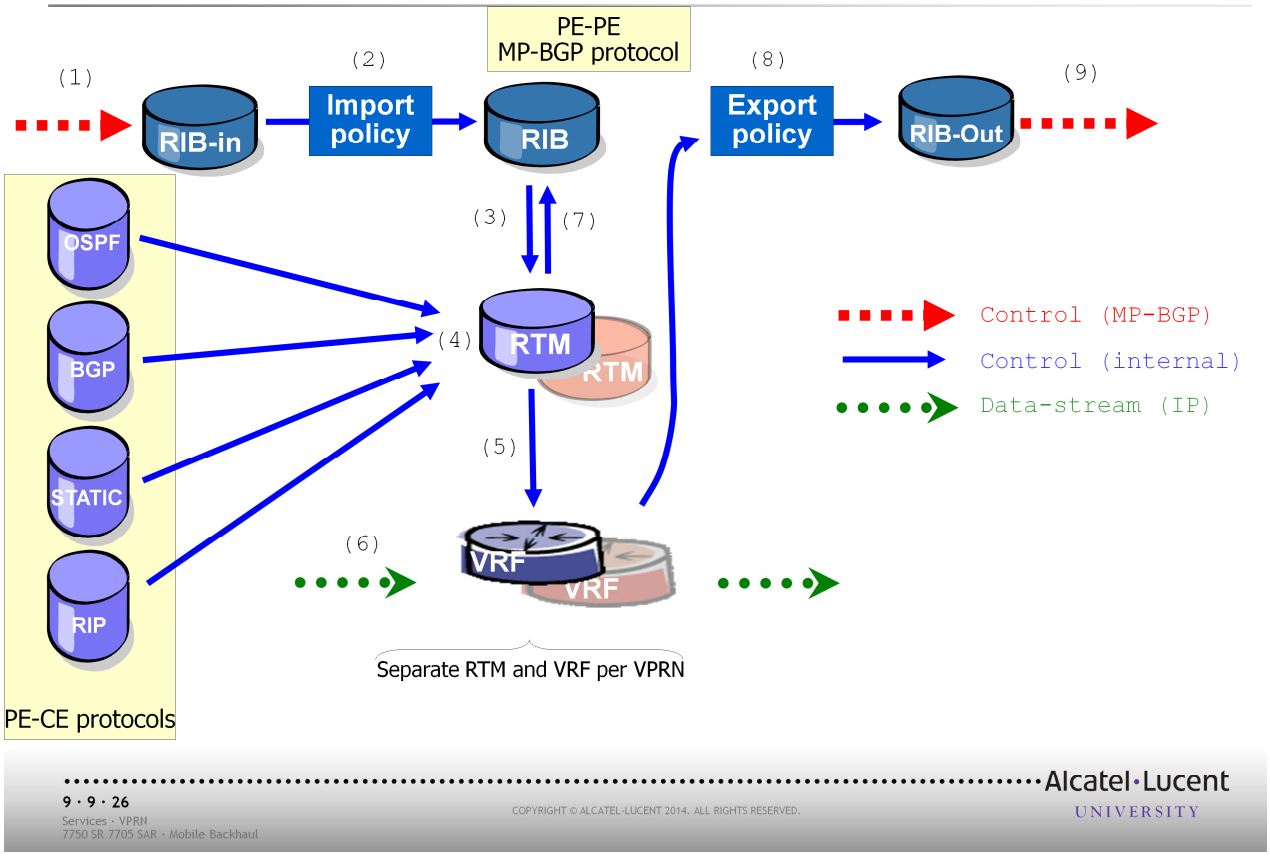

```
config router
    autonomous-system 65530
    bgp
        family vpn-ipv4
        group "bgp-core"
            peer-as 65530
            neighbor 2.2.2.2
```



COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3VPN: Populating a VRF



1. A **MP-BGP** process receives updates from its peers and collects them in the RIB-IN (RIB stands for Routing Information Base).
2. After applying import policies (if configured) to reject unwanted prefixes, the best routes selected based on BGP criteria are sent to the RIB.
3. All routes in the RIB are offered to the RTM (Route Table Manager).
4. The RTM collects the routes received from MP-BGP peers and also those discovered by the routing protocols that are running between the PE and CE (it could be OSPF, BGP, RIP or static). It selects from those the ones that will be used based on preference values among protocols. Note that there will be a separate RTM per VPRN.
5. If a route is selected by the RTM to be used to forward data packets, it will be installed in the corresponding VRF and downloaded on all forwarding complexes of the IOM.
6. At this point, the selected routes can be used to make forwarding decisions for data packets. Incoming IP traffic will do LPM (longest prefix match) on the VRF to make a forwarding decision.
7. MP-BGP routes that were selected by the RTM to be used are marked as such in the RIB.
8. By default, all routes marked as used in the MP-BGP RIB will be copied into the RIB-OUT database to be advertised to the MP-BGP peers. Likewise, routes discovered by means of the PE-CE protocols that are chosen by the RTM will by default be copied into the RIB-OUT database. Export policies can be created to keep some of these routes from ending up in the RIB-OUT and from being advertised to MP-BGP peers.
9. Prefixes in the RIB-OUT are shared with MP-BGP peers.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3VPN: Monitoring a VRF

Verify the VPRN routing table of the PE

```
PE1# show router 20 route-table
===============================================================================
Route Table (Service: 20)
===============================================================================
Dest Prefix          Type    Proto    Age         Pref Metric
       Next Hop[Interface Name]
-------------------------------------------------------------------------------
192.168.2.0/24       Remote  BGP VPN  01d01h48m   170  0
       2.2.2.2
192.168.1.0/24       Remote  OSPF     01d01h48m   150  1
       192.168.11.1
192.168.11.0/29      Local   Local    01d01h48m   0    0
       to-CE1
-------------------------------------------------------------------------------
No. of Routes: 3
===============================================================================
PE1#
```



The **show router <service-id> route-table** command (in this case PE1) is used to verify the contents of the routing instance for the specified service.

As shown above, this table should contain customer routes such as physical links to the CE devices, system interfaces of the CE devices and internal customer networks.

The prefixes received from the local CE will be learned via the configured PE-CE protocol, in this case OSPF, and the prefixes received from the remote CE will be learned via the BGP VPN (MP-BGP) protocol.

Notice that in the VRF, the RD and RT have been removed before the prefix is imported into the VRF table.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Monitoring MP-BGP learned routes (RIB-In)

To find out the VPN label and the Route Target:

- No command like :
  - #show router bgp rib-in
- Possible commands
  - # show router bgp routes vpn-ipv4
  - # show router bgp neighbor 1.1.1.1 received-routes vpn-ipv4
  - # show router bgp routes 65530:20:192.168.1.0/24 detail

```
A:PE2# show router bgp routes 65530:20:192.168.1.0/24 detail
===============================================================
BGP Router ID : 2.2.2.2        AS : 65530   Local AS : 65530
===============================================================
Status codes  : u - used, s - suppressed, h - history, d - decayed,
* - valid  Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best
===============================================================
BGP Routes
Network       : 192.168.1.0/24
Nexthop       : 1.1.1.1
Route Dist.   : 65530:20              VPN Label     : 131070
From          : 1.1.1.1
Res. Nexthop  : 192.168.12.1
Local Pref.   : 100                   Interface Name : pe2-1
Aggregator AS : none                  Aggregator    : none
Atomic Aggr.  : Not Atomic            MED           : 1
Community     : target:65530:20
Cluster       : No Cluster Members
Originator Id : None                  Peer Router Id : 1.1.1.1
Flags         : Used  Valid  Best  IGP
AS-Path       : No As-Path
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

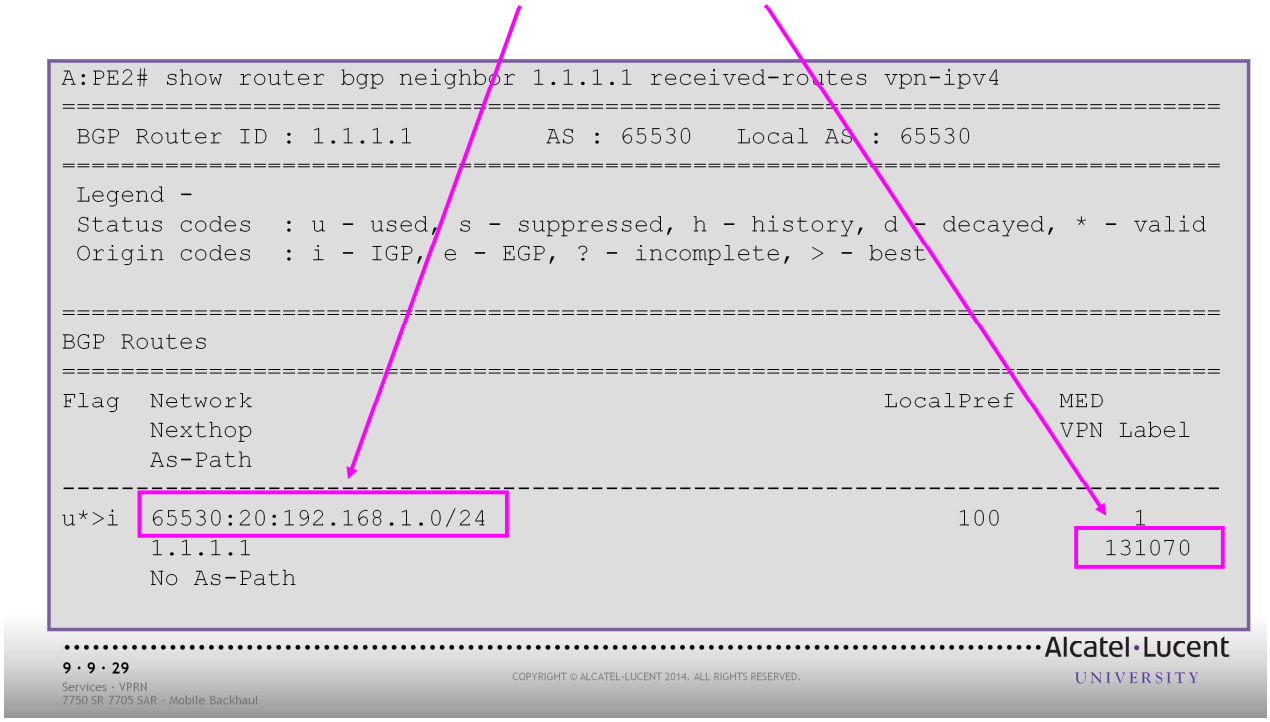
show router bgp routes 65530:20:192.168.1.0/24 details

This command shows all routes with this prefix that are received. Per route, there is an output on the original and modified path attributes. The route is displayed with its original attributes, as it was received from its peer before applying the import policies (if configured). If no import policies are configured, the original and modified attributes are equal.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Monitoring MP-BGP learned routes (RIB-In)

BGP updates carry the Route Distinguisher and VPN Label, identifying the remote VRF



show router bgp neighbor < . . . > received-routes

This command shows all routes that are received from this BGP-peer. There is no “detail” option available for this, so for more detailed information, a “per-route” display needs to be done.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Monitoring MP-BGP advertised routes (RIB-Out)

No command like :

#show router bgp rib-out

Two possible commands

show router bgp neighbor 1.1.1.1 advertised-routes vpn-ipv4

show router bgp routes 65530:20:192.168.2.0/24 hunt

```
A:PE2# show router bgp neighbor 1.1.1.1 advertised-routes vpn-ipv4
===============================================================================
 BGP Router ID : 2.2.2.2         AS : 65530   Local AS : 65530
===============================================================================
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best
===============================================================================
BGP Routes
===============================================================================
Flag  Network                                          LocalPref   MED
      Nexthop                                                      VPN Label
      As-Path
-------------------------------------------------------------------------------
i     65530:20:192.168.2.0/24                                  100         1
      10.1.1.22                                                        131057
      No As-Path
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

show router bgp neighbor < . . . > advertised-routes

This command shows all routes that are advertised to this BGP-peer. There's no "detail" option available for this, so for more detailed information, a "per-route" display needs to be done

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Monitoring MP-BGP advertised routes (RIB-Out)

BGP updates carry the VPN label and the RT which identifies the remote VRF

```
PE1# show router bgp routes 65530:20:192.168.1.0/24 hunt
===============================================================================
 BGP Router ID : 1.1.1.1         AS : 65530   Local AS : 65530
===============================================================================
 Legend -Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best
-------------------------------------------------------------------------------
BGP Routes - RIB Out
===============================================================================
Network        : 192.168.1.0/24
Nexthop        : 2.2.2.2
Route Dist.    : 65530:20              VPN Label      : 131057
To             : 2.2.2.2
Res. Nexthop   : n/a
Local Pref.    : 100                   Interface Name : NotAvailable
Aggregator AS  : none                  Aggregator     : none
Atomic Aggr.   : Not Atomic            MED            : 1
Community      : target:65530:20
Cluster        : No Cluster Members
Originator Id  : None                  Peer Router Id : 2.2.2.2
Origin         : IGP
AS-Path        : No As-Path
===============================================================================
PE1#
```


COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

show router bgp routes 200:20:192.168.1.0/24 hunt

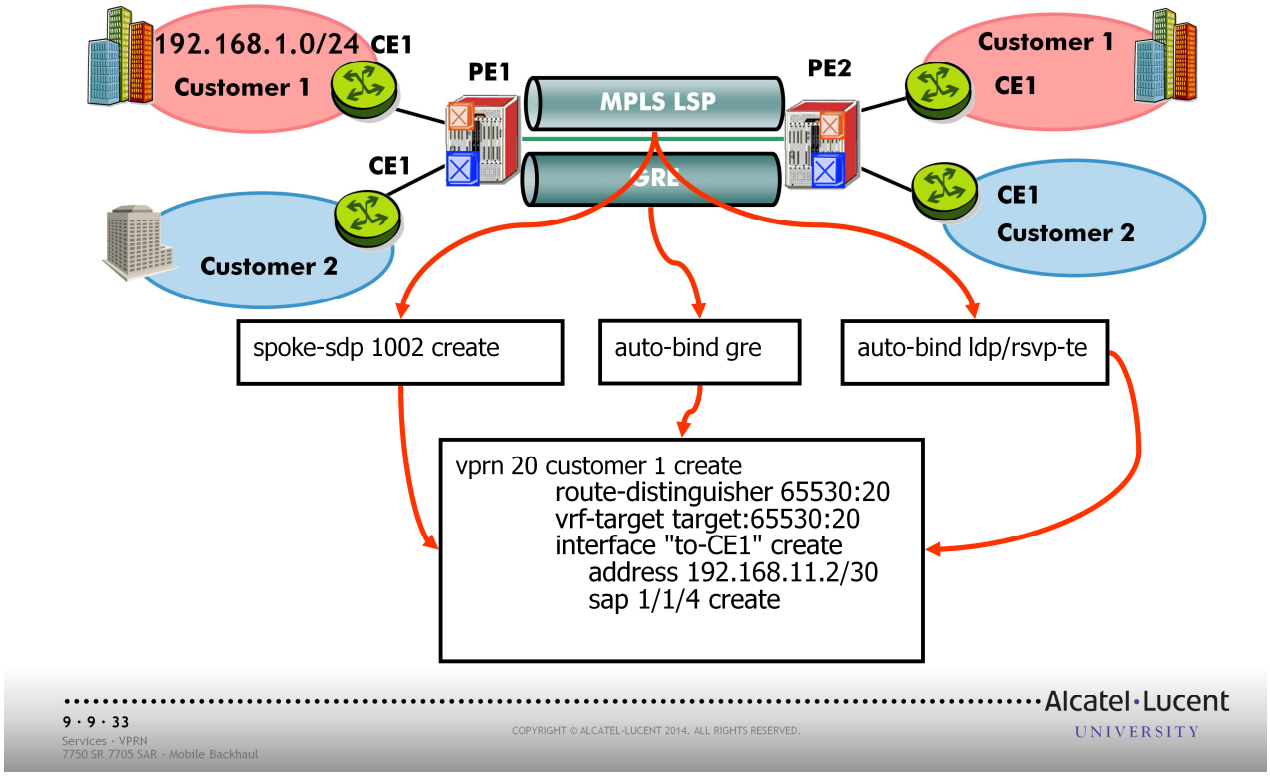
This command shows all peers that have received this route. There is an output of the route-per-peer, after applying potential export-policies. Since export policies can be applied on a per-peer basis, the routes can have a different content, that's why they are displayed per-peer.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

4 Packet walkthrough

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Data Plane – Transport Tunnel



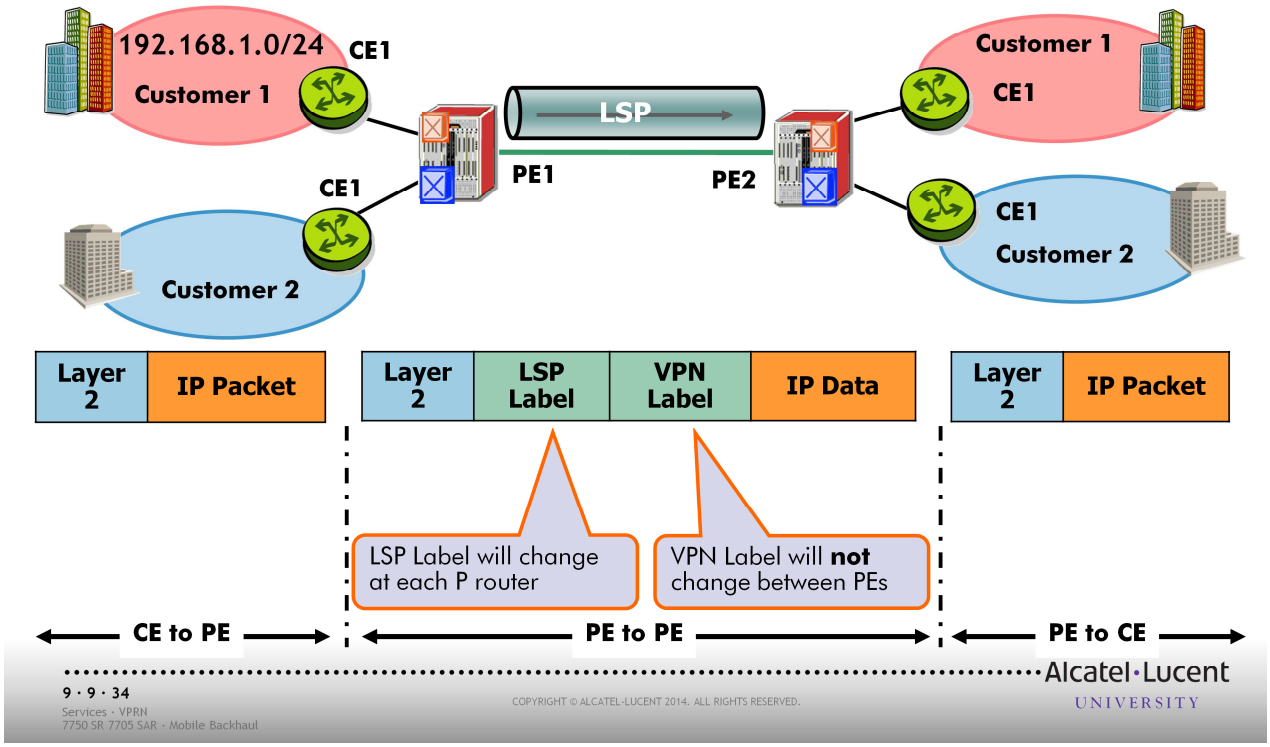
Each PE involved in a given VPRN service must be configured with a tunnel to every other PE participating in the same VPRN service in order to transport a customer's VPN traffic from one site to another. The transport tunnel is either an MPLS LSP or a GRE point-to-point tunnel between PE's.

The tunnel is created either through the configuration of an SDP or using the auto-bind option. When the auto-bind command is issued, SDPs are created from the router to each of the other routers with which there exists an MP-BGP session for the VPN family of prefixes.

If SDP tunnels are used, they must be created prior to the creation of the VPRN services and then bound using the spoke-sdp option.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

L3 VPN: Forwarding Traffic



Shown above are the data packet formats visible in an MPLS network. Note that the packet is a standard IP packet to which MPLS labels have been inserted in the provider core. The Route Distinguisher and the Route Target are not used in the data plane.

Between the PE and the CE, only unlabeled data packets should be seen.

From PE to PE in the provider core, customer VPRN traffic will have a label stack consisting of 2 MPLS labels. The outer label (LSP label) is used to propagate the packet from PE to PE across the provider core. The inner label (VPN label) identifies the VPRN to the egress PE.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.



End of module
VPRN

COPYRIGHT © ALCATEL-LUCENT 2014. ALL RIGHTS RESERVED.

Copyright © 2014 Alcatel-Lucent. All Rights Reserved.

This page is left blank intentionally

All Rights Reserved © Alcatel-Lucent 2014

Congratulations
You have finished the training

Your feedback is appreciated!
Please feel free to Email your comments to:

training.feedback@alcatel-lucent.com

Please include the training reference in your email (see cover page)

Thank you!