END-TO-END MPLS CASE-STUDY FOR ALCATEL-LUCENT NIG

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Content

1.1 INTRODUCTION OF 7750 SR FAMILY

The Nokia 7750 SR is a multi-service edge router, based on the same SR OS as other service router product families.

Key characteristics include:

(1) Delivers advanced residential, business, and mobile services on a common IP edge routing platform Deploys for a wide range of functions.

(2) Supports capabilities aimed to minimize service disruption, including non-stop routing, non-stop services, stateful failover of protocols, in-service software upgrades (ISSUs), fast reroute, pseudowire redundancy, along with service assurance and monitoring tools across IP, MPLS, and Ethernet domains.

NOKIA SR FAMILY

Figure 1 7750 SR FAMILY

1.1.1 DESCRIPTION OF 7750 SR-7

7750 SR-7 is a big modular router deployed for service routing. This router could also be referred to as an **Edge router,** or simply as **PE** (Provider Edge) router**.** It could as well be deployed as **Provider** (**P**) router.

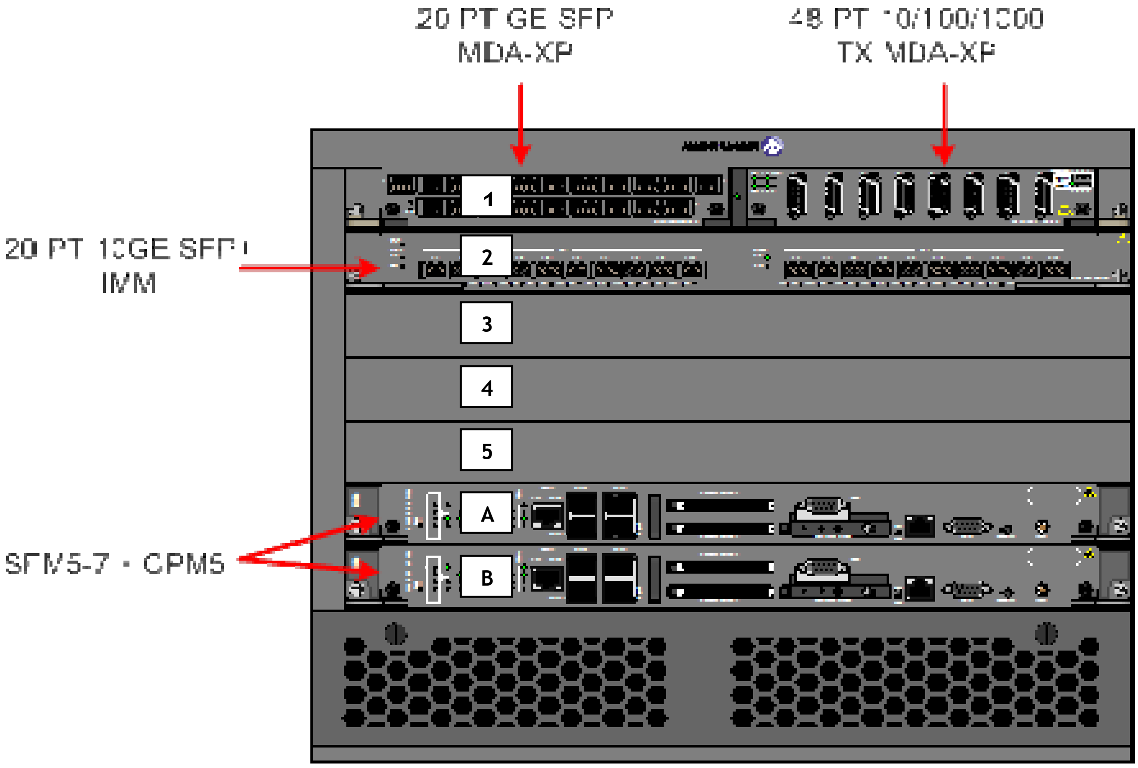


Figure 1 7750 SR-7

As shown above, control cards are installed in slots **A** and **B** operating in Active/Standby mode.

Traffic cards are installed in Slots (**1-5**). These are called **Input and Output Module (IOM)** cards. The slots are counted from top to bottom.

An IOM, IMM, and MDA are cards installed in 7750 SR.

IOM and MDA:
One IOM is installed per slot, and maximum of two **MDA** (Media Dependent Adapter) are fitted into a single IOM.
This is the hierarchy of cards installation: IOM is first installed in an empty slot; MDAs are installed inside the IOM; SFPs are install on MDA's optical ports.

IMM: Alternatively, an **IMM** card can be installed per slot instead of IOM.
IMM and IOM are of the same size as a slot, but the physical difference is IMM card contains ports already, while IOM card does not contain port. The MDA installed on the IOM contains the ports.

Hence, IMM = IOM + two MDA

Most IMM ports are logically grouped into two MDA parts. For example, a 48-port 1Gigabit IMM contains logically two 24-ports MDA.
*** There are other internal system architectural differences between IOM and IMM that are out of the scope of this manual. IMM has an enhanced fabric system that makes it suitable for robust QoS deployment than IOM.*

Port Numbering -> *IOM-slot-no/MDA-no/port-position –on-MDA*
According to SR-7 diagram above:

Slot 1 (IOM with two MDA installed) -> 1st MDA (1/1/1 to 1/1/20), 2nd MDA (1/2/1 to 1/2/48) Note: the MDAs are numbered from left to right.

Slot 2 (20-ports IMM) -> 1st Logical group (2/1/1 to 1/1/10), 2nd Logical group (2/2/1 to 1/2/10). Note: the ports are numbered from left to right.

.
Slot 3, 4 and 5 are empty. As shown above they are covered with dummy plates

1.2 INTRODUCTION OF 7705 SAR FAMILY

The Nokia 7705 SAR is used for multiservice adaptation, aggregation and routing, especially onto a modern Ethernet and IP/MPLS infrastructure, based on the same SR OS as other service router product families. Key characteristics include:

(1) Compact, low-power consumption platform

(2) Indoor and outdoor platforms that deliver highly available services over resilient and flexible network topologies

(3) Suited for aggregation, backhaul and routing of 2G, 3G, and LTE mobile traffic

(4) Resiliency and redundancy, including hitless control and switch failover, synchronization redundancy, network uplink resiliency and power feed redundancy.

SAR FAMILY

Figure 3 7705 SAR FAMILY

1.2.1 DECRIPTION OF 7705 SAR-F

SAR stands for **Service Aggregation Router.**

7705 SAR-F is a compact router (Not modularized, fixed structure and ports positions.

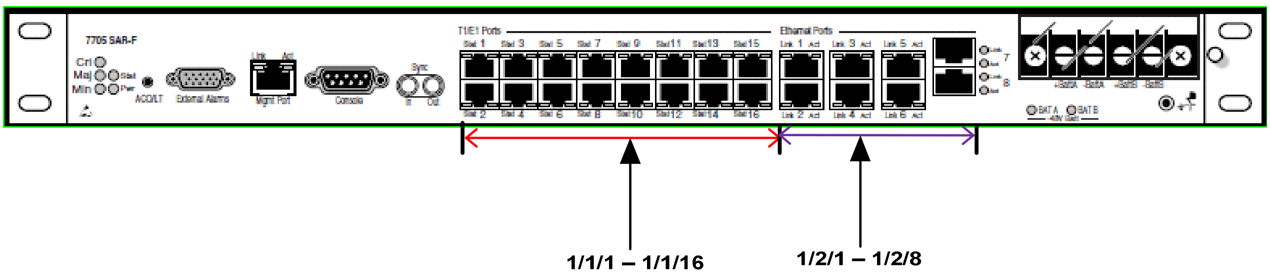


Figure 4 7705 SAR-F

Port Numbering:

SAR-F as compact router, has fixed architecture. It is not modular, hence it has a single logical IOM card which contains two (2) logical MDAs.

The MDA to the left is for E1/TI connection. Each port can be adapted to an E1 or T1.

The MDA to the right is for Ethernet connection. The first six ports of the Ethernet MDA are RJ45 Fast Ethernet (100Mbps) ports; the last two Ethernet ports are optical 1Gbps ports.

- ➔ The E1/T1 ports numbering are from 1/1/1 to 1/1/16. The first number is fixed at 1 because the router has a single logical IOM.
- ➔ The Ethernet ports numbering are from 1/2/1 to 1/2/8

1.2.2 DESCRIPTION OF 7705 SAR-8

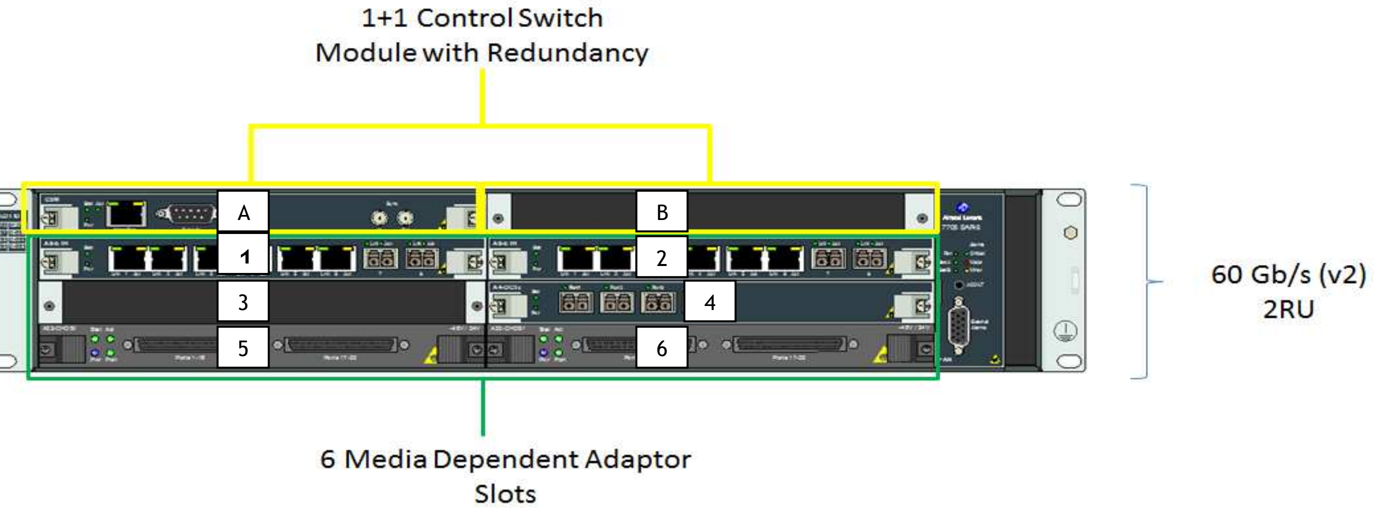


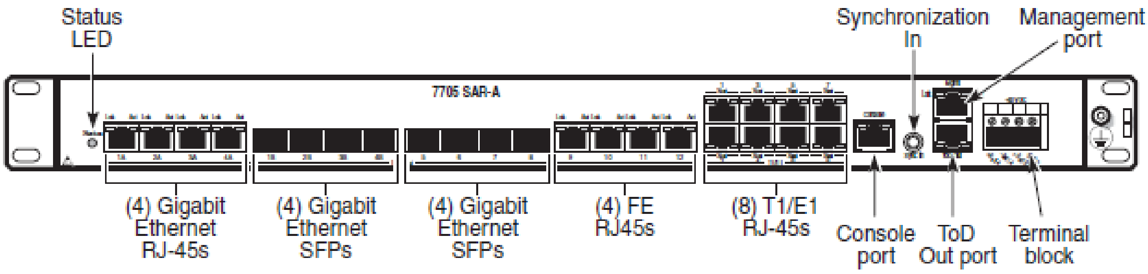
Figure 5 7705 SAR-8

7705 SAR-8 can be installed in sites with more ports requirements. For example sites with more than 8E1 requirements.
It has slots A and B which houses control cards, operating in active/standby mode.
It has six (6) traffic slots (See above 1 to 6) which houses the MDAs; an MDA contains data ports for connection. The slots are counted from left to right, from top row to down row.

Port Numbering -> *1/MDA-no/port-position-on-MDA*
*** 7705 SARs are routers with a single fixed IOM build up i.e. the whole chassis is a single IOM. Hence the first portion above is constant as 1.*
According to router diagram above:
Slot 1 (8-port MDA 1) -> 1/1/1 to 1/1/8
Slot 2 (8-port MDA 2) -> 1/2/1 to 1/2/8
Slot 3 -> Empty
Slot 4 (4-port MDA 4) -> 1/4/1 – 1/4/4
Slot 5 (2x16 E1 MDA 5) ->1/5/1 to 1/5/32
Slot 6 (2x16 E1 MDA 6) ->1/6/1 to 1/6/32

2.1 CONNECTING TO NOKIA ROUTERS

2.1.1 CONNECTION VIA CONSOLE



7705 SAR-A Port Connectors

Figure 6 7705 SAR-A Interfaces

Use any terminal emulation software - e.g. Putty, HyperTerminal, SecuredCRT etc.
Configure new session using appropriate "Serial line" and following settings:

Speed	115200
Data bits	8
Stop bits	1
Parity	None
Flow control	None

Make sure you select the appropriate COM port. The selected COM port must be the USB port your serial cable is connected to.

TYPE OF CONSOLE CABLE NEEDED FOR EACH SET OF ROUTERS

7750 SR-7	DB-9 Female to DB-9 Female Serial cable
7750 SR-a4	DB-9 Female to DB-9 Female Serial cable
7705 SAR-Wx	RJ45 to DB-9 Female Serial cable
7705 SAR-A	RJ45 to DB-9 Female Serial cable
7750 SAR-8	DB-9 Female to Female Serial cable
7210 SAS-R	RJ45 to DB-9 Female Serial cable

Note:

- A Serial to USB converter would be needed if your laptop is having a USB port.
- Make sure you select the appropriate COM port. The selected COM port must be the USB port your serial cable is connected to.
- You may need to install the Serial to USB converter software driver in order for the connection to work.

Below is an example of the console connection settings on Secured-CRT.

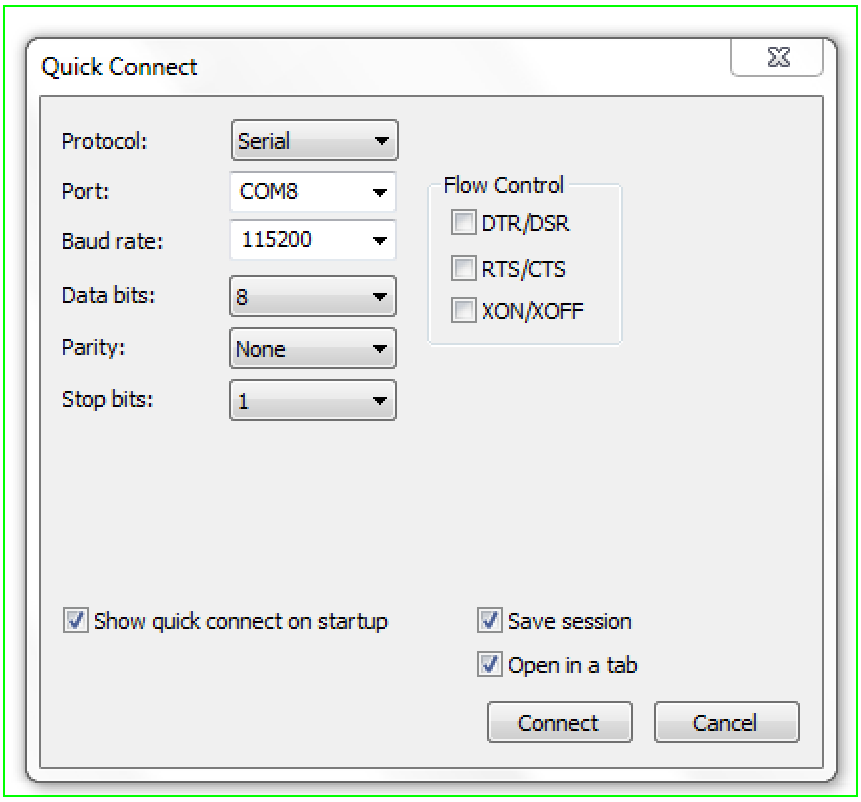


Figure 7 Serial Setting for Console Connection

Note**: ***If by default the RTS/CTS box is checked make sure it is unchecked.***

Based on above, the console cable is placed on COM8 port.

You can confirm this by navigating to the Ports (COM & LPT) on your laptop as shown below:

Control-Pane -> System -> Device-Manager -> Ports (COM & LPT).

Figure 8 RJ45 to DB-9 Female serial cable

Figure 9 DB-9 Female to DB-9 Female serial cable

Default log-in user/password for all the routers:

Login	admin
Password	admin

2.1.2 CONNECTION VIA MGT PORT

Connection to Nokia routers can be done via Management port after setting an IP address for the management interface under BOF (Basic Option File).

STEPS TO CONNECT TO ROUTER VIA MGT PORT

(1) Log unto router via console as described above

(2) Assign as IP subnet to the management interface under BOF and do a BOF save. Example 192.168.1.1/24. See config below:

A:SM-TZDARAGG1# bof address 192.168.1.1/24 active
A:SM-TZDARAGG1# bof save

(3) Verify that IP address is added and save changes:

A:SM-TZDARAGG1# show bof

```
=============================================================
BOF (Memory)
=============================================================
   primary-image    cf3:\TiMOS-12.0.R5
   primary-config   cf3:\config.cfg
   address          192.168.1.1/24 active
   autonegotiate
   duplex           full
   speed            100
   wait             3
   persist          on
console-speed    115200
=============================================================
```

A:SM-TZDARAGG1# admin save

(4) Enable telnet and SSH on the router.

A:SM-TZDARAGG1# configure system security telnet-server
A:SM-TZDARAGG1# configure system security ssh preserve-key
A:SM-TZDARAGG1# configure system security ssh no server-shutdown

(5) Assign an IP address to your laptop in same subnet with management interface. From above example, set your laptop IP as 192.168.1.2/24.
(6) Open a DOS window on your laptop and ensure you can ping 192.168.1.1.
(7) Use a terminal emulation software e.g. SecuredCRT to telnet or SSH to management IP. In this example, 192.168.1.1. See below:

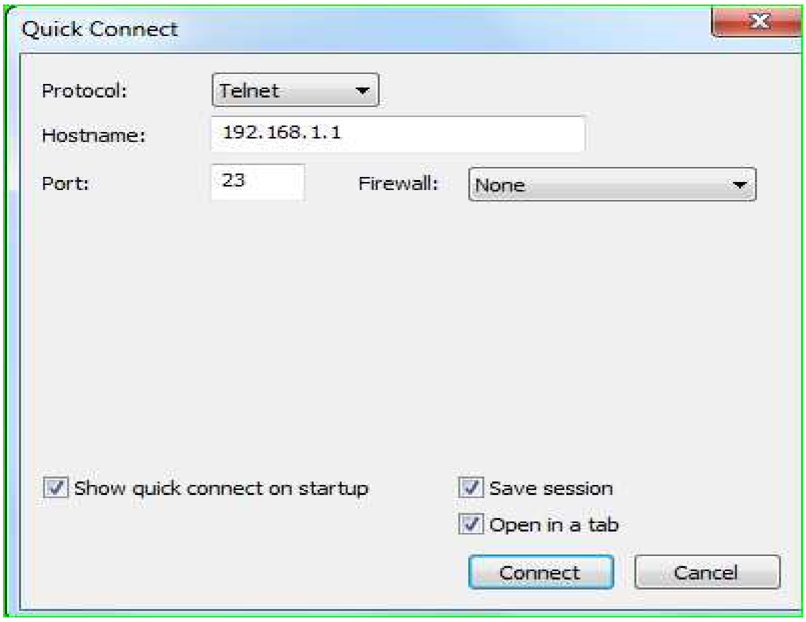


Figure 10 Setting for Connection via Management Interface

(8) When you login prompt comes up, enter the user and password. Default is admin/admin.

** *Management interface IP can only be added or edited under BOF by connecting to the router via console. This is a security measure to prevent unauthorized access.*

3.1 NOKIA ROUTER COMMISIONING

Commissioning is the act of deploying basic configuration on the router so as to make integration possible. Commissioning precedes integration.
This stage is very important because if the router is commissioned with the right basic config, integration becomes successful.

Commissioning entails five basic items:

➔ **Basic system configuration**: These are Access, SNMP, pre-login-message, ntp etc. Basic system parameters help to identify the node on the network, control access to the node, enable the node for remote management, define Pre-login messages etc.

➔ **Card Provisioning**: The need for this is based on router type.

- If the router contains removable IOM and MDA cards, the cards must be provisioned before they are active. Examples are 7705SAR-8, 7705SAR-18, and all 7750SR family.
- If the router is a non-modularized (compacted) router, the IOM and MDA are inbuilt and can't be removed. Hence the cards don't need provisioning. The system activates them automatically. Once a card inserted in a slot is provisioned, the slot becomes adapted based on the card-type inserted. Even if the original provisioned card is removed, any other card of same type would work when inserted.

➔ **Port configuration**: After the MDAs are provisioned, its ports become available for use. Based on the work order, selected ports are configured with basic parameters like negotiation, encapsulation, efm-oam, speed etc. Basic config ports are normally set to network or hybrid mode because they shall be bound to a router interface.

➔ **Router interface:** Interfaces are defined under routing context. An interface is not operational except it is assigned an IP address and a port.
There is an intrinsic interface called "**system**". It is automatically defined on the router. It's the default loopback interface used by system protocols like Link-State routing protocols, MPLS, PTP etc. The system interface is assigned a **/32** IP address to make it operational.

➔ **Routing**: A routing protocol is configured (e.g. ISIS or OSPF) to make the router reachable over multiple hops away. This makes the network to converge and all routers system IP becomes reachable from any other router on the network. This is the essence of integration.

We are moving into the task of commissioning in the next section.

3.1.1 COMMISSIONING TASK

➔ The diagram below is the architecture of the local lab setup.
➔ The task is to commission routers at site A, B, and C
➔ All the routers have blank config files.
➔ The task involves port, interface, routing configuration of the routers.
➔ The commissioning be successful it all the routers' system IPs are reachable from any of the router. This is a sign that the network is fully converged.

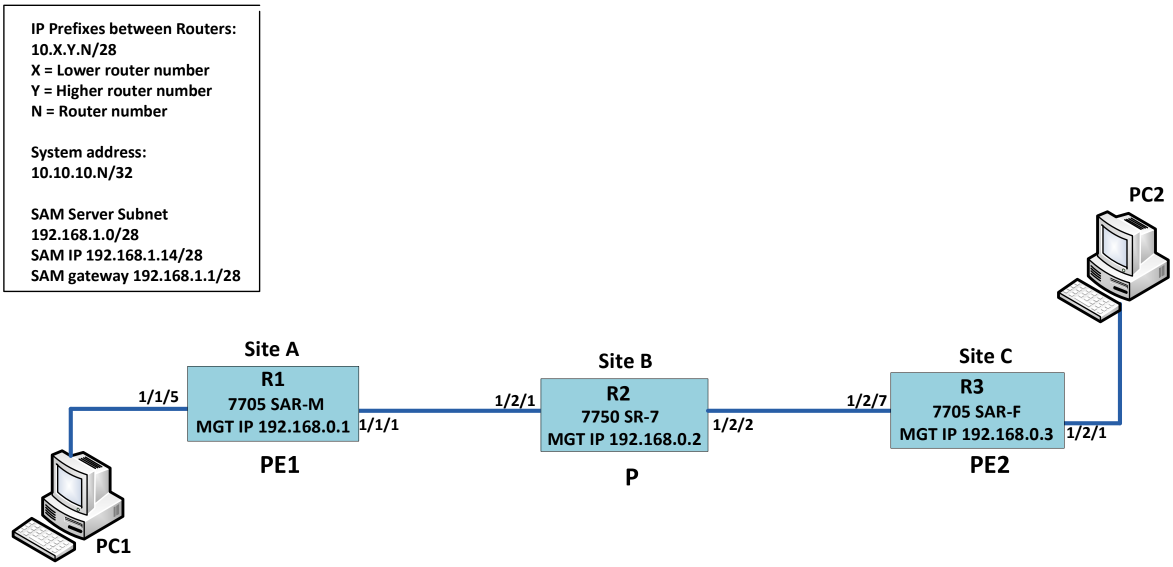


Figure 11 Commissioning Lab

Note ** Below are steps to commission R1 and R2 so that the link between R1 and R2 will become operational. The Trainees will continue with the commissioning to bring up the link between R2 and R3.

<u>STEP 1</u>

BASIC SYSTEM CONFIGURTATION

Parameters: System Name, SNMP, Pre-Login message, Access (SSH, Telnet, FTP), and Time Server.

➔ **SITE A SAR-M Basic System Configuration**:

NS1530F0627# **configure system name** "R1-SAR-M-SiteA”
R1-SAR-F-SiteA# **configure system snmp packet-size** 9216
R1-SAR-F-SiteA# **configure system snmp** no shutdown
R1-SAR-F-SiteA# **configure system login-control pre-login-message** "This Router is...."
R1-SAR-F-SiteA# **configure system time ntp server** 192.168.1.14 **prefer**
R1-SAR-F-SiteA# **configure system time ntp** no shutdown
R1-SAR-F-SiteA# **configure system security** telnet-server
R1-SAR-F-SiteA# **configure system security** ftp-server
R1-SAR-F-SiteA# **configure system security ssh** no server-shutdown

➔ **SITE B Basic System Configuration**:

The configuration is the same as SITE A except for system name. Example for Site B:

NS121566740# **configure system name** "R2-SR-7-SiteB"
R2-SR-7-SiteB#

Note ** NS1530F0627 is the chassis part number. The factory default system name of router with blank configuration appears as the chassis part number.

STEP 2

CARDS PROVISIONING

➔ **SITE A Cards Provisioning:**

Site A has a SAR-M. SAR-F is non-modular, compacted router with single IOM chassis and two compacted MDAs. All compacted, non-modular routers don't need card provisioning.
There cards are automatically picked up by the system.

➔ **SITE B SR-7 Card Provisioning:**

Since 7750 SR-7 is a modular router with removable cards, its IOMs and MDAs must be provisioned. The snapshot below shows the provisioning of first IOM and its two MDAs:

```
*A:R2-P1# configure card 1 card-type "iom3-xp"
*A:R2-P1# configure card 1 mda 1 mda-type "m1-10gb-xp-xfp"
*A:R2-P1# configure card 1 mda 2 mda-type "m10-1gb-xp-sfp"
*A:R2-P1#
*A:R2-P1# show card 1

===============================================================================
Card 1
===============================================================================
Slot    Provisioned Type                            Admin Operational   Comments
            Equipped Type (if different)            State State
-------------------------------------------------------------------------------
1       iom3-xp                                     up    up
===============================================================================
*A:R2-P1# show mda

===============================================================================
MDA Summary
===============================================================================
Slot  Mda   Provisioned Type                            Admin     Operational
              Equipped Type (if different)              State     State
-------------------------------------------------------------------------------
1     1     m1-10gb-xp-xfp                              up        up
      2     m10-1gb-xp-sfp                              up        up
===============================================================================
*A:R2-P1# █
```

Note** The card-type and mda-type must be the same as the inserted card and mda respectively. If the card-type or mda-type provisioned is not the same as the inserted card or mda, the card or mda will fail to boot, unless the provisioned card-type matches the inserted card type.

*Before the start of Provisioning, the inserted card-type can be viewed by running the command: "**Show card**" and "**show mda**". The inserted card or mda appears as "**Equipped Card**" or "**Equipped MDA.** These commands allow you to pick the right equipped card or mda".*

STEP 3

PORTS CONFIGURATION

➔ **SITE A SAR-M Ports Configuration:**

- Site A connects to Site B over port 1/1/1; it connects to the user PC1 over port 1/1/5. Hence we are going to configure port 1/1/1 and port 1/1/5 on the SAR-M.

(1) Port 1/1/1: This port connects to port 1/2/1of Site B.
R1-SAR-M-SiteA# **configure port 1/1/1 description** "SITE-A-SAR-M-1/1/1: Site-B-SR-7-1/2/1"
R1-SAR-M-SiteA# **configure port 1/1/1 ethernet mode** network
R1-SAR-M-SiteA# **configure port 1/1/1 ethernet mtu** 9212
R1-SAR-M-SiteA# **configure port 1/1/1 ethernet hold-time up** 5
R1-SAR-M-SiteA# **configure port 1/1/1 ethernet** autonegotiate
R1-SAR-M-SiteA# **configure port 1/1/1** no shutdown

(2) Port 1/1/5: This port terminates on the user PC1.
R1-SAR-M-SiteA# **configure port 1/1/5 description** "to-PC1"
R1-SAR-M-SiteA# **configure port 1/2/7 ethernet mode** access
R1-SAR-M-SiteA# **configure port 1/2/7 ethernet encap-type** null
R1-SAR-M-SiteA# **configure port 1/2/7 ethernet mtu** 1514
R1-SAR-M-SiteA# **configure port 1/2/7 ethernet** autonegotiate
R1-SAR-M-SiteA# **configure port 1/2/7** no shutdown

➔ **SITE B SR-7 Ports Configuration:**

- Site A connects to Site B over port 1/2/1; it connects to site C over port 1/2/2. Hence we are going to configure port 1/1/1 and port 1/2/2 on the SR-7.

(1) Port 1/2/1: This port connects to port 1/1/1 of Site A.
R2-SR-7-SiteB# **configure port 1/2/1 description** "SITE-B-SR-7-1/2/1: Site-A-SAR-M-1/1/1"
R2-SR-7-SiteB# **configure port 1/2/1 ethernet mode** network
R2-SR-7-SiteB# **configure port 1/2/1 ethernet mtu** 9212
R2-SR-7-SiteB# **configure port 1/2/1 ethernet hold-time up** 5
R2-SR-7-SiteB# **configure port 1/2/1 ethernet** autonegotiate
R2-SR-7-SiteB# **configure port 1/2/1 ethernet** efm-oam hold-time 5
R2-SR-7-SiteB# **configure port 1/2/1 ethernet** efm-oam no shutdown
R2-SR-7-SiteB# **configure port 1/2/1** no shutdown

(2) Port 1/2/2: This port connects to port 1/2/7of Site C.
R2-SR-7-SiteB# **configure port 1/2/2 description** "SITE-B-SR-7-1/2/2: Site-A-SAR-F-1/2/7"
R2-SR-7-SiteB# **configure port 1/2/2 ethernet mode** network
R2-SR-7-SiteB# **configure port 1/2/2 ethernet encap-type** dot1q
R2-SR-7-SiteB# **configure port 1/2/2 ethernet mtu** 9212
R2-SR-7-SiteB# **configure port 1/2/2 ethernet hold-time up** 5
R2-SR-7-SiteB# **configure port 1/2/2 ethernet** autonegotiate limited
R2-SR-7-SiteB# **configure port 1/2/2** no shutdown

STEP 4

ROUTER INTERFACES CONFIGURATION

➔ **SITE A SAR-F Router Interfaces Configuration:**

- Site A connects to Site B over port 1/1/1. Hence we are going to create a router interface on the router, while corresponding ports is bound to interface. The system interface is assigned a /32 IP address.

(1) **Interface system**

R1-SAR-M-SiteA# **configure router interface system address** 10.10.10.1/32

(2) **Interface towards Site-B**

R1-SAR-M-SiteA# **configure router interface** "to-SITE-B-SR-7" **address** 10.1.2.1/28
R1-SAR-M-SiteA# **configure router interface "to-SITE-B-SR-7"** port 1/1/1

➔ **SITE B SR-7 Router Interfaces Configuration:**

➔ Site B connects to Site A over port 1/2/1. Hence we are going to create a router interface on the router, while corresponding ports is bound to interface. The system interface is assigned a /32 IP address.

(1) **Interface system**

R2-SR-7-SiteB# **configure router interface system address** 10.10.10.2/32

(2) **Interface towards Site-A**

R2-SR-7-SiteB# **configure router interface** "to-SITE-A-SAR-M" **address** 10.1.2.2/28
R2-SR-7-SiteB# **configure router interface "to-SITE-A-SAR-M"** port 1/2/1

<u>**STEP 5**</u>

ROUTING CONFIGURATION

➔ **SITE A SAR-M Routing Configuration:**

- All the router interfaces above are configured under ISIS.
- If any interface is omitted, adjacency is not formed over that interface with the neighbor.

Important part of the routing protocol configuration is show below:

R1-SAR-M-SiteA# **configure router isis** area-id 49.2400
R1-SAR-M-SiteA# **configure router isis** traffic-engineering
R1-SAR-M-SiteA# **configure router isis level-capability** level-2
R1-SAR-M-SiteA# **configure router isis level 2** wide-metrics-only
R1-SAR-M-SiteA# **configure router isis** interface "system"
R1-SAR-M-SiteA>config>router>if# **exit all**
R1-SAR-M-SiteA# **configure router isis** interface "to-SITE-B-SR-7"
R1-SAR-M-SiteA>config>router>if# **interface-type** point-to-point
R1-SAR-M-SiteA>config>router>if# **exit all**

➔ **SITE B SR-7 Routing Configuration:**

- All the router interfaces above are configured under ISIS.
- If any interface is omitted, adjacency is not formed over that interface with the neighbor.

Important part of the routing protocol configuration is show below:

R2-SR-7-SiteB# **configure router isis** area-id 49.2400
R2-SR-7-SiteB# **configure router isis** traffic-engineering
R2-SR-7-SiteB# **configure router isis level-capability** level-2
R2-SR-7-SiteB# **configure router isis level 2** wide-metrics-only
R2-SR-7-SiteB# **configure router isis** interface "system"
R2-SR-7-SiteB>config>router>if# **exit all**
R2-SR-7-SiteB# **configure router isis** interface "to-SITE-A-SAR-M"
R2-SR-7-SiteB>config>router>if# **interface-type** point-to-point
R2-SR-7-SiteB>config>router>if# **exit all**

After the STEPS 1 to 5 are done on all routers 1, 2 and 3, the network is converged. All routers will have same Topology Table, from which they build an ISIS routing table in the Control Cards. The routing table is populated into the IOM or traffic card as Forwarding Information Base.
Every router will be able to ping all other routers' system IPs.

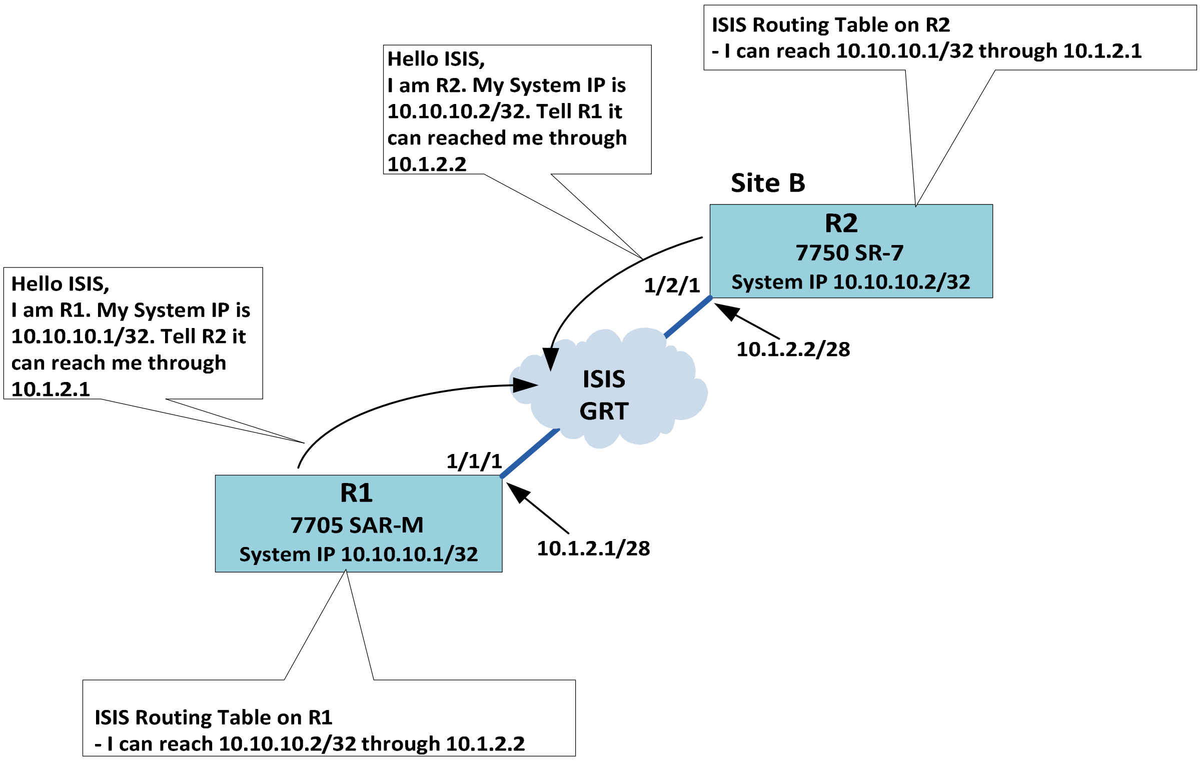


Figure 12 ISIS Routing Process between R1 and R2

Remark:

- After all the above is complete, R1 will be able to ping the system IP of R2 via ISIS.

<u>STEP 7</u>

SYNCHRONIZATION OF REDUNDANT CPM AND CONFIGURATION SAVE

Synchronization of the Control Processor Module (CPM) is peculiar to routers with active and standby control cards. The aim of synchronization is to make the state of the image and config files the same on the active and standby CPM.

- ➔ You can synchronize the config file only, or synchronize both image and config files. The latter takes more time to execute than the former.

  A:R2-SR-7-SiteB# **configure redundancy synchronize** config //config file only
  A:R2-SR-7-SiteB# **configure redundancy synchronize** boot-env //image and config files

After executing the above configuration, *subsequent* "**admin save**" will synchronize the active/standby CPM files.

Note** The above commands are mutually exclusive. That means it is either one or the other. If any is executed, it overwrites any existing one.

- ➔ If you don't want the router to add the redundant configuration to its running config, you can do a real-time synchronization by issuing the command below:

  A:R2-SR-7-SiteB# **admin redundancy synchronize** config //config file only
  A:R2-SR-7-SiteB# **admin redundancy synchronize** boot-env //image and config files

Note** The above "admin redundancy…" commands performs real-time CLI synchronization but it is not added to the router's running configuration. Hence subsequent "admin save" doesn't synchronize the active/standby CPM.
You must issue the "configure redundancy…." Command to effectively add the configuration to router's running config, so that subsequent "admin save" will synchronize the redundant CPM cards.

4.0 COMMISSIONING AND INTEGRATION VERIFICATION AND TROUBLESHOOTING

This section talks about some handy commands that can be used for verification and troubleshoting purpose during commissioning and integration:

4.1 PROVISIONING VERIFICATION

(A) *A:R2-P1# **show card**

```
===============================================================================
Card Summary
===============================================================================
Slot   Provisioned Type                    Admin Operational   Comments
         Equipped Type (if different)        State State
-------------------------------------------------------------------------------
1     iom3-xp                           up    up
A     sfm3-7                            up    up/active
B     sfm3-7                            up    up/standby
===============================================================================
```

Inference: Card 1 was successfully provisoned and active.

(B) A:R2-P1# show card

```
===============================================================================
Card Summary
===============================================================================
Slot   Provisioned Type                    Admin Operational   Comments
         Equipped Type (if different)        State State
-------------------------------------------------------------------------------
1     iom3-xp-b                         up     failed
        iom3-xp
A     sfm3-7                            up    up/active
B     sfm3-7                            up    up/standby
===============================================================================
```

Inference: Card 1 failed to boot after provisioning.

Actions to take:

- Check if provsioned card type = Equiped type
- If provisioned card type = equipped card type, remove and re-insert the card.

"**show card 1 detail**" gives more info about why the failure occurred.

(C) A:R2-P1# show mda

```
===============================================================================
MDA Summary
===============================================================================
Slot  Mda   Provisioned Type                    Admin     Operational
            Equipped Type (if different)         State     State
-------------------------------------------------------------------------------
1     1     m1-10gb-xp-xfp                       up        failed
              m2-10gb-xp-xfp
      2     m10-1gb-xp-sfp                       up        up
```

Inference: Mda 1 on Card 1 failed to boot after provisioning.
Mda 2 on Card 2 was succesfully provisioned

Actions to take:

- Check if provsioned mda type = Equiped type
- Remove and re-insert the failed mda

4.2 PORT VERIFICATION

(A) A:R2-P1# show port 1/2/2

```
*A:R2-P1>config>port# show port 1/2/2

===============================================================================
Ethernet Interface
===============================================================================
Description          : 10/100/Gig Ethernet SFP
Interface            : 1/2/2                      Oper Speed       : 1 Gbps
Link-level           : Ethernet                   Config Speed     : 1 Gbps
Admin State          : up                         Oper Duplex      : full
Oper State           : up                         Config Duplex    : full
Physical Link        : Yes                        MTU              : 9212
Single Fiber Mode    : No                         Min Frame Length : 64 Bytes
IfIndex              : 37814272                   Hold time up     : 0 seconds
Last State Change    : 04/05/2016 06:14:22        Hold time down   : 0 seconds
Last Cleared Time    : N/A                        DDM Events       : Enabled
Phys State Chng Cnt: 7

Configured Mode      : network                    Encap Type       : null
Dot1Q Ethertype      : 0x8100                     QinQ Ethertype   : 0x8100
```

Inference: Port is up/up: This means the physical layer and ethernet layer are fine.

- Port is up/down: This means physical or Ethernet layer is not okay.
- Port is down/down: An Administrator shut down the port

(B) A:R2-P1>config>port# show port

```
===============================================================================
Ports on Slot 1
===============================================================================
Port      Admin Link Port    Cfg  Oper LAG/ Port Port Port  C/QS/S/XFP/
Id        State      State   MTU  MTU  Bndl Mode Encp Type  MDIMDX
-------------------------------------------------------------------------------
1/1/1     Down  No   Down    9212 9212  - netw null xgige  10GBASE-LR  10*
1/2/1     Up    No   Down    9212 9212  - netw null xcme   GIGE-SX
1/2/2     Up    Yes  LinkUp  9212 9212  - netw null xcme   GIGE-LX  10KM
1/2/3     Up    Yes  Up      9212 9212  - netw null xcme   GIGE-LX  10KM
```

Inference: Link is partially up. A protocol is hindering it from fully coming up.

Action to take: Check for any protocol configured under the port. EFM-OAM is a very good example that can cause this kind of issue. Disable protocol and see if link comes up fully.

(C) EFM-OAM issue on 7750 SR

```
*A:R2-P1# show port 1/2/2

===============================================================================
Ethernet Interface
===============================================================================
Description        : 10/100/Gig Ethernet SFP
Interface          : 1/2/2                  Oper Speed       : N/A
Link-level         : Ethernet               Config Speed     : 1 Gbps
Admin State        : up                     Oper Duplex      : N/A
Oper State         : down                   Config Duplex    : full
Reason Down        : efmOamDown
Physical Link      : Yes                    MTU              : 9212
Single Fiber Mode  : No                     Min Frame Length : 64 Bytes
IfIndex            : 37814272               Hold time up     : 0 seconds
Last State Change  : 04/05/2016 06:01:11    Hold time down   : 0 seconds
Last Cleared Time  : N/A                    DDM Events       : Enabled
Phys State Chng Cnt: 7

Configured Mode    : network                Encap Type       : null
Dot1Q Ethertype    : 0x8100                 QinQ Ethertype   : 0x8100
PBB Ethertype      : 0x88e7
Ing. Pool % Rate   : 100                    Egr. Pool % Rate : 100
Ing. Pool Policy   : n/a
```

Inference: Mismatch of EFM-OAM configuration. This can be as a result of EFM-OAM configured on one peer, while it is absent on the other.

Action to take: Make EFM-OAM to match on both peer

(D) Port DDM table: SFP OK.

```
*A:R2-P1# show port 1/2/2 | match Transceiver post-lines 10
Transceiver Data

Transceiver Type     : SFP
Model Number         : 3HE00028CAAA01   ALA   IPUIBDLDAA
TX Laser Wavelength: 1310 nm                 Diag Capable     : yes
Connector Code       : LC                    Vendor OUI       : 00:0b:40
Manufacture date     : 2012/06/13            Media            : Ethernet
Serial Number        : L12F08623
Part Number          : TRF5736AVLB4L8
Optical Compliance : GIGE-LX
Link Length support: 10km for SMF

===============================================================================
Transceiver Digital Diagnostic Monitoring (DDM), Internally Calibrated
===============================================================================
                              Value  High Alarm  High Warn   Low Warn  Low Alarm
-------------------------------------------------------------------------------
Temperature (C)               +41.0    +100.0      +95.0      -40.0      -45.0
Supply Voltage (V)             3.28      3.60       3.50       3.10       3.00
Tx Bias Current (mA)           11.4      80.0       70.0        3.0        2.0
Tx Output Power (dBm)         -5.54     -1.00      -2.00     -10.50     -11.50
Rx Optical Power (avg dBm)    -4.80      0.27      -0.73     -18.73     -19.75
===============================================================================

*A:R2-P1#
```

Inference: SFP inserted in port 1/2/2 is okay. It part-no and other characteristics can be viewed with this command. Or simply “show port 1/2/2”

(E) Port DDM table: LOS.

```
A:R2-P1# show port 1/2/1 | match Transceiver post-lines 10
Transceiver Data

Transceiver Type    : SFP
Model Number        : CLEIXXXXXX702073784
TX Laser Wavelength: 850 nm                          Diag Capable      : yes
Connector Code      : LC                             Vendor OUI        : 00:90:65
Manufacture date    : 2011/11/16                     Media             : Ethernet
Serial Number       : PLM1JUD
Part Number         : FTLF8519P2BTL-AW
Optical Compliance : GIGE-SX
Link Length support: 550m for OM2 50u MMF; 280m for OM1 62.5u MMF

===============================================================================
Transceiver Digital Diagnostic Monitoring (DDM), Externally Calibrated
===============================================================================
                              Value  High Alarm  High Warn   Low Warn  Low Alarm
-------------------------------------------------------------------------------
Temperature (C)               +21.0      +88.0      +85.0      -40.0      -43.0
Supply Voltage (V)             3.29       3.56       3.46       3.13       3.04
Tx Bias Current (mA)            5.4       13.5       13.0        3.0        2.5
Tx Output Power (dBm)         -5.49       2.00       0.00      -9.50     -11.51
Rx Optical Power (avg dBm)   -30.00       2.00       0.00    -17.01!    -19.03!
===============================================================================

A:R2-P1# █
```

Inference: SFP inserted in port 1/2/1 is having low receive level. The Alarm indicates that the low receive threshold was crossed. This is an indication that no signal is received from the peer because the link is down. It is equivalent to **LOS** in transmission.
Value can range from **-28.00 to -40.00**

(F) Port Traffic Monitoring:

```
*A:R2-P1# monitor port 1/2/2 interval 3 repeat 3

===============================================================================
Monitor statistics for Port 1/2/2
===============================================================================
                                                   Input                 Output
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
At time t = 0 sec (Base Statistics)
-------------------------------------------------------------------------------
Octets                                          70966037               43170756
Packets                                           745008                 494012
Errors                                                 0                      0

-------------------------------------------------------------------------------
At time t = 3 sec (Mode: Delta)
-------------------------------------------------------------------------------
Octets                                              2402                   2504
Packets                                               35                     36
Errors                                                 0                      0

-------------------------------------------------------------------------------
At time t = 6 sec (Mode: Delta)
-------------------------------------------------------------------------------
Octets                                              2212                   2086
Packets                                               34                     32
Errors                                                 0                      0

-------------------------------------------------------------------------------
At time t = 9 sec (Mode: Delta)
-------------------------------------------------------------------------------
Octets                                              2802                   2244
Packets                                               38                     34
Errors                                                 0                      0

===============================================================================
*A:R2-P1#
```

Inference: This port is sending and receiving traffic from the peer. No error recorded. This is a useful tool when troubleshooting across MW link where port UP doesn't mean port is sending and receiving traffic.

4.3 ROUTER AND ROUTING VERIFICATION

(A) Router Interface Verification:

```
*A:R2-P1>config>port# show router interface

===============================================================================
Interface Table (Router: Base)
===============================================================================
Interface-Name                   Adm         Opr(v4/v6)  Mode    Port/SapId
   IP-Address                                                    PfxState
-------------------------------------------------------------------------------
system                           Up          Up/--       Network system
   10.10.10.2/32                                                 n/a
to-R3                            Up          Down/--     Network 1/2/1
   10.1.2.2/28                                                   n/a
to-R1                            Up          Up/--       Network 1/2/2
   10.2.3.2/28                                                   n/a
to-SAM                           Up          Down/--     IES     1/2/4
   192.168.2.1/28                                                n/a
toR4                             Up          Down/--     Network 1/2/3
   10.2.4.2/28                                                   n/a
-------------------------------------------------------------------------------
Interfaces : 5
===============================================================================
*A:R2-P1>config>port#
```

Inference: Interface to-R1 is UP/UP. System interface is always UP/UP as long as it has a valid /32 IP address. An unnumbered system interface will be down.
Other interfaces are down because R3 and R4 are not configured yet.
IES Service advertised its interfaces to Global Routing Table by default.

(B) ISIS Verification

```
*A:R1-P2# show router isis adjacency

===============================================================================
ISIS Adjacency
===============================================================================
System ID                Usage State Hold Interface                     MT Enab
-------------------------------------------------------------------------------
R3-PE1                   L2    Up    26   toR3                          No
R4-PE2                   L1    Up    21   toR4                          No
R4-PE2                   L2    Up    21   toR4                          No
R2-P1                    L1    Up    20   toR2                          No
R2-P1                    L2    Up    20   toR2                          No
-------------------------------------------------------------------------------
Adjacencies : 5
===============================================================================
*A:R1-P2#
*A:R1-P2#
*A:R1-P2# show router isis interface

===============================================================================
ISIS Interfaces
===============================================================================
Interface                        Level CircID  Oper State   L1/L2 Metric
-------------------------------------------------------------------------------
system                           L1L2  1       Up           0/0
toR3                             L1L2  2       Up           10/10
toR4                             L1L2  3       Up           10/10
toR2                             L1L2  4       Up           10/10
-------------------------------------------------------------------------------
Interfaces : 4
===============================================================================
*A:R1-P2#
*A:R1-P2#
```

```
*A:R2-P1# show router route-table

===============================================================================
Route Table (Router: Base)
===============================================================================
Dest Prefix[Flags]                            Type    Proto     Age        Pref
      Next Hop[Interface Name]                                    Metric
-------------------------------------------------------------------------------
10.1.2.0/28                                   Local   Local     00h09m02s  0
       to R1                                                       0
10.1.3.0/28                                   Remote  ISIS      00h09m01s  15
       10.1.2.1                                                    20
10.1.4.0/28                                   Remote  ISIS      00h09m01s  15
       10.1.2.1                                                    20
10.2.3.0/28                                   Local   Local     04d17h39m  0
       to R3                                                       0
10.2.4.0/28                                   Local   Local     04d18h23m  0
       toR4                                                        0
10.3.4.0/28                                   Remote  ISIS      04d16h07m  15
       10.2.3.3                                                    20
10.10.10.1/32                                 Remote  ISIS      00h09m01s  15
       10.1.2.1                                                    10
10.10.10.2/32                                 Local   Local     04d18h25m  0
       system                                                      0
10.10.10.3/32                                 Remote  ISIS      04d16h07m  15
       10.2.3.3                                                    10
10.10.10.4/32                                 Remote  ISIS      04d16h15m  15
       10.2.4.4                                                    10
-------------------------------------------------------------------------------
```

5.0 MPLS AND SERVICES OVERVIEW

5.1 MPLS OVERVIEW

MPLS means **Multi-Protocol Label Switching:** It allows packets to be forwarded based on a label that is embedded in the packet header.

The main advantages of MPLS over IP routing and other Tunneling protocols are:

- MPLS is a fast switching method
- MPLS can help to avoid hyper-aggregation that is common to IP routing.
- MPLS has a fast fault recovery mechanism. It can be less than 50ms.
- MPLS can support many services over a single converged network.

5.1.1 MPLS DEVICE TERMINOLOGIES

The network diagram below shows the various devices that can be present in an MPLS network

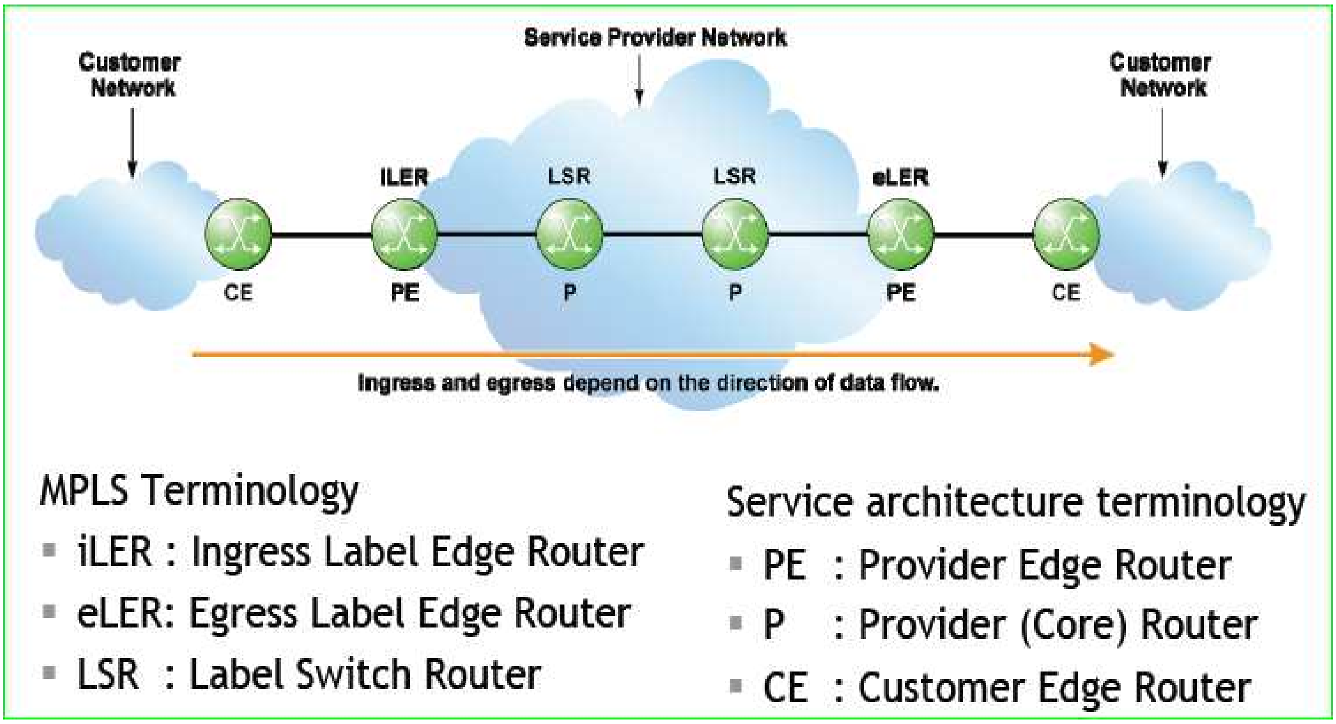


Figure 13 MPLS Devices

- **CE (Customer Edge) Device**: This device resides in the customer's network. It connects to the customer's Edge device. It's typically unaware of MPLS.

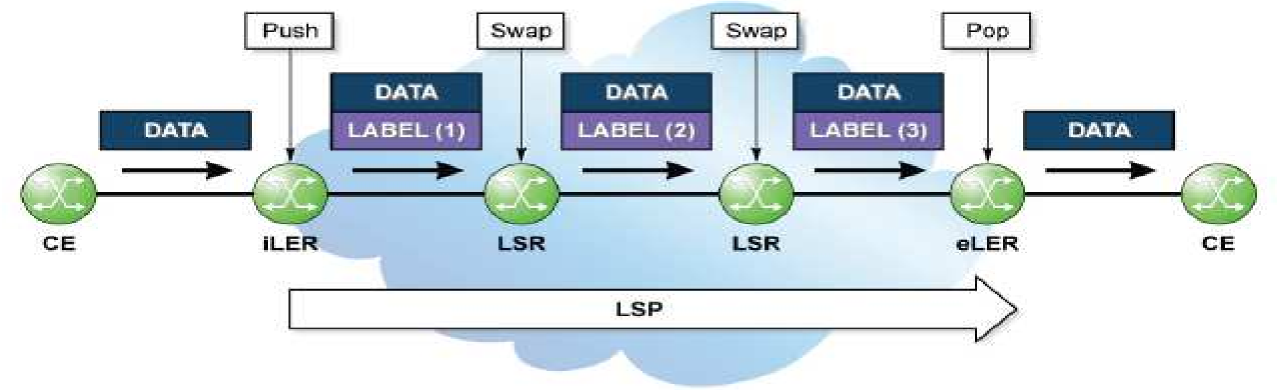
- **PE (Provider Edge) Device**: This device resides at the edge of the Provider's network and it's MPLS aware. It is operated by the ISP. It has at least one connection to the customer's device, and has at least one connection to the Provider core. It's a layer of adaptation, where customer's various traffic types are adapted to the tunneled across the provider's network. Hence it's a multi media layer. It serves as gateway to the customer's layer 3 traffic.

- **P (Provider Edge) Device**: This device resides in the core of the Provider's network and it's MPLS aware. It's takes the MPLS traffic from the PE device and transfers it to the next P, or exit PE router. Normally, P routers have fast switching ability in order to switch heavy traffic so that latency can be minimized in the core.

- **LER (Label Edge Router)**: This router is equivalent to the PE router. It is positioned at the boundary between the MPLS unaware customer device and the provider's core.
  Two categories of this router are:
  (1) **iLER (Ingress Label Edge Router)**: it is at the ingress of the provider's network. It receives an unlabeled packet from the customer, pushes a label on it, and forwards the labeled packet to the next-hop.
  (2) **eLER (Egress Label Edge Router)**: it is at the egress of the provider's network. It receives a labeled packet from the PE or P router, pops the label, and forwards the unlabeled packet to the customer.
  Note: the term ingress or egress depends on the direction of flow of customer's traffic across provider's network.
- **LSR (Label Switched Router)**: This device resides in the provider's network between iLER and eLER routers. It typically does label swapping. It receives a labeled MPLS traffic, replaces the incoming label with an outgoing label, and forward the labeled traffic to the next-hop.

5.1.2 DESCRIPTION OF MPLS OPERATION

The diagram below shows an end to end LSP in an MPLS network:



- LSP – Label Switched Path
- An LSP is a logical entity that represents the MPLS label connection between Label Edge Routers.
- Another commonly used synonymous term is transport tunnel.

Figure 14 MPLS LSP

Before the brief description of MPLS operation, there is need to be farmiliar with these terminologies:

- **LSP (Label Switching Path):** This is a sequence of labels used to forward data from iLER to eLER. It is unidirectional. Hence for a bidirectional data flow, LSP has to be defined from point A to B, and from B to A.

- **FEC (Forwarding Equivalence Class)**: This is a particular customer's prefix that needs to be forwarded from the iLER to eLER across the MPLS core.

MPLS OPERATION

From the diagram in Figure 14, a data is to be sent from CE to CE, over the LSP.
- The data arrives at the ingress PE router, known as the iLER.
- The iLER identifies the data and insert a label unto it. This operation is known as **Label Push.**
- After Push operation, the data is forwarded to the LSR.
- The LSR identifies the label on the data, and replaces the label with another label. This operation is known as **Label Swap.**
- After the swap, the labeled data is forwarded to the next LSR. This LSR does another swap of the label, then forward the labeled data to the eLER.
- The eLER identifies the label and removes the label. This operation is known as **Label POP**.
- After popping the label, the unlabelled data is forwarded to the CE..

5.1.3 MPLS LABEL DISTRIBUTION

Prior to the forwarding of customer's data across the MPLS infrastructure, label to be used for forwarding must have been pre-distributed between various MPLS routers. Label distribution is done in the control plane, while labeled data forwarding is done in the data plane.

MPLS uses two protocols to distribute labels. These are **Label Distribution Protocol (LDP)** and **Resource Reservation Protocol with Traffic engineering (RSVP-TE**).

5.1.4 LABEL DISTRIBUTION PROTOCOL (LDP)

- If LDP is configured on the network, label distribution resumes immediately after IGP has converged.
- A particular router assigns a label per prefix in its routing table; it distributes this label to **ALL** its LDP neighbors.
- Every LDP router stores the labels received from its neighbors in table called **LABEL INFORMATION BASE (LIB)**.
- This label distribution continues until all the routers have exchanged labels per prefix with all neighbors.
- With LDP being used, it is obvious that each router will have more than one label per prefix in its **LIB** as long as it has multiple neighbors.
- The routers selects only one label per prefix to be used to forwards traffic based on which router is the next-hop for the prefix in the routing table. The router installs this info in the **LABEL FORWARDING INFORMATION BASE (LFIB)**.
- The **sequence of labels** used for the forwarding of a particular prefix from iLER to eLER constitutes the **LSP**.

- The label distribution for a prefix is from eLER to iLER (upstream); while the forwarding of data using the labels is from iLER to eLER (downstream).

5.1.5 RESOURCE RESERVATION PROTOCOL (RSVP)

- The method used by RSVP to distribute label is a bit complex than the LDP.
- The iLER sends a PATH message down to the eLER. The PATH message contains a request for label for a prefix. This PATH messages however transverses LSR routers.
Every LSR directs the PATH message towards the eLER.
- The eLER responds by sending a RESV message to the iLER. The RESV messages transverses the LSR.
- As the RESV messages moves from router to router, a label is being reserved for the prefix on the eLER and LSR for the prefix.

In order to get more information on LDP and RSVP, please refer to the Alcatel-Lucent Multiprotocol Label Switching Student Guide.

5.2 SERVICE OVERVIEW

The main use of MPLS is to provide tunnels to convey traffic of various customers services provisoned on the Edge routers.
As discussed in the previous section, we have LDP and RSVP label distribution protocols. These protocols eventually build an LDP and RSVP tunnels to convey customers traffic from one service point to the other accross the provider's MPLS infrastructure.
We have other tunnels. These are SDP and BGP tunnels.
BGP tunnel is beyond the scope of this material. Meanwhile, LDP, RSVP and SDP tunnels configuration and usage shall be achieved during the practical class.

5.2.1 LAYER 3 VPN SERVICE.

An MPLS layer 3 VPN service is VPRN.
In this kind of services, there is routing between the customer's CE and the PE. The routing conveys traffic into the VRF that the ISP or Provider has provisioned for the partcular customer. Once the traffic is passed into the VRF, it is MPLS encapsulated with tranport label and service label and sent across the core to the other PEs.
The transport label is the LDP or RSVP label, which is swapped at every LSR.
The service label is signaled by MP-BGP. Since the MPLS core is not BGP aware, the service label is preserved across the MPLS core.
The service label is only popped at the egress PE.

5.2.2 LAYER 2 VPN SERVICES.

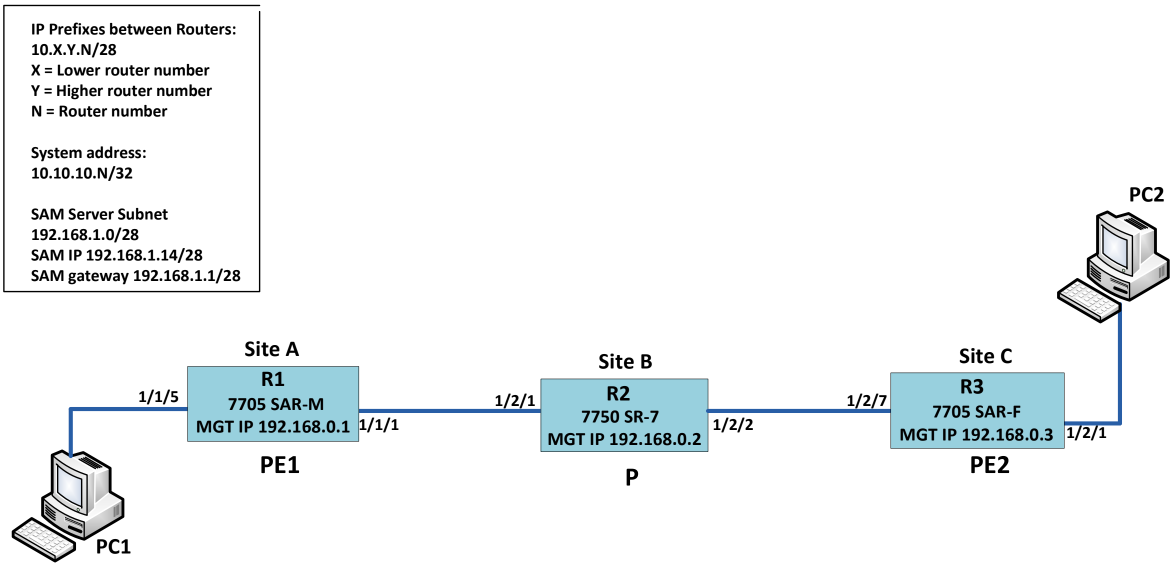
MPLS layer 2 services are called Pseudowires (**Epipe**, **Apipe**, **Fpipe**, **Cpipe**) and Virtual Leased Line (VPLS).
In this kind of service, there is no routing between the CE and PE. Rather, the CE connects to the PE at layer 2.
Once the traffic from the customer gets to the PE router layer 2 service SAP, it is MPLS encapsulated with transport label and service label.
In this case of layer 2, the service label is signaled with Targeted-LDP.
The customers at both ends of the CEs view the connection as a point-to-point connection.
For **Epipe and VPLS**, the remote customers' IPs are in the same subnet. Hence it looks like they are connected to a Hub and Switch on same LAN.
For Apipe and Fpipe, the customers communicating over the MPLS core view their connections as if they are connected to same ATM or Frame-relay Switch.

Please refer to the Alcatel-Lucent Service Architecture for more detail on Services.

5.3 MPLS IMPLEMENTATION

With reference to the **Figure 11** (see below), we shall proceed where we stopped at section 3.1.1. The following tasks shall be achieved here:

- Provision MPLS on R1and R2: All the network and system interfaces shall be bound to MPLS on all routers. **Don't forget to enable RSVP**.
- Configure LDP on all routers: All the network interfaces shall be bound to LDP.
- Configure LSP and SDP on PE router (R1 and R3).



MPLS IMPLEMENTATION

➔ Step 1: Bind network interface(s) to MPLS

SITE A SAR-M MPLS configuration:

Note ** By default, the system interface is bound to MPLS:

R1-SAR-M-SiteA# **configure router mpls**
R1-SAR-M-SiteA>**config>router>mpls# info**

```
---------------------------------------------
        interface "system"
        exit
---------------------------------------------
```

We shall continue by adding the defined interface(s) under router context:

R1-SAR-M-SiteA>**config>router>mpls# interface** "to-SITE-B-SR-7"
R1-SAR-M-SiteA>**config>router>mpls>if# exit all**
R1-SAR-M-SiteA#

SITE B SR-7 MPLS Configuration:

R2-SR-7-SiteB# **configure router mpls**
R2-SR-7-SiteB>**config>router>mpls# interface** "to-SITE-A-SAR-M"
R2-SR-7-SiteB**>config>router>mpls>if# exit all**

➔ Step 2: Enable RSVP

SITE A SAR-M RSVP ENABLING:

By default, all MPLS interfaces are automatically added to RSVP context. But you must enable RSVP by using "**no shutdown**". Common mistake is to leave RSVP disabled.

Note ** RSVP is under "router context"

R1-SAR-M-SiteA**# configure router**
R1-SAR-M-SiteA**>configure>router# rsvp**
R1-SAR-M-SiteA**>configure>router>rsvp# info**

```
----------------------------------------------
        shutdown
        interface "system"
        exit
        interface "to-SITE-B-SR-7"
        exit
----------------------------------------------
```

R1-SAR-M-SiteA **>config>router>rsvp#** no shutdown
R1-SAR-M-SiteA **>config>router>rsvp#** exit all

SITE B SR-7 RSVP ENABLING:

R2-SR-7-SiteB**>configure router rsvp** no shutdown
R2-SR-7-SiteB**#**

➔ Step 3: Configure LDP

SITE A SAR-M LDP CONFIGURATION

LDP can be found under "**router context**".

Bind all the router or network interface(s) to LDP. The interfaces are added to the "**interface-parameters**" context of LDP:

R1-SAR-M-SiteA >**configure router ldp**
R1-SAR-M-SiteA **>config>router>ldp# info**

```
----------------------------------------------
        interface-parameters
        exit
        targeted-session
        exit
----------------------------------------------
```

R1-SAR-M-SiteA **>config>router>ldp# interface-parameters**
R1-SAR-M-SiteA **>config>router>ldp>if-params#** interface "to-SITE-B-SR-7"
R1-SAR-M-SiteA **>config>router>ldp>if-params# exit all**
R1-SAR-M-SiteA #

SITE B SR-7 LDP CONFIGURATION

R2-SR-7-SiteB **>configure router ldp interface-parameters**
R1-SAR-M-SiteA **>config>router>ldp>if-params# interface** "to-SITE-A-SAR-M"
R1-SAR-M-SiteA **>config>router>ldp>if-params# exit all**

Note ** Before proceeding to **STEP 4**, we must implement all previous configuration on R3. This is because subsequent configurations pertain to only PE routers (R1 and R3).

After complete Port, Router interface, MPLS, LDP configuration have been completed on R1, R2, and R3, we can use the following commands to verify our configuration:

- **show router ldp interface**
- **show router ldp discovery**
- **show router ldp session**
- **show router mpls interface**
- **show router rsvp interface**
- **show router rsvp neighbor**
- **show router rsvp session**

➔ Step 4: Configure LSP

SITE A SAR-M LSP CONFIGURATION

- LSP means **Label Switching Path**. It must be configured if the label distribution protocol is RSVP.
- But LDP don't need it. You must first provision a "**PATH**"; this PATH will be bound to the LSP.
- LSP is configure between the PE routers; its destination is the peer PE router's system IP.
- Everything is done under MPLS context.

R1-SAR-M-SiteA>**config>router>mpls# path** "loose"   // no hop defined.
R1-SAR-M-SiteA>**config>router>mpls>path$ no shutdown**
R1-SAR-M-SiteA# **config>router>mpls>path$ back**
R1-SAR-M-SiteA# **config>router>mpls#**
R1-SAR-M-SiteA# **config>router>mpls# lsp** "to-R3"
R1-SAR-M-SiteA# **config>router>mpls>lsp# to** 10.10.10.3
R1-SAR-M-SiteA# **config>router>mpls>lsp# primary** loose
R1-SAR-M-SiteA# **config>router>mpls>lsp#primary$ back**
R1-SAR-M-SiteA# **config>router>mpls>lsp# cspf**   // needed for traffic engineering
R1-SAR-M-SiteA# **config>router>mpls>lsp# secondary "…"**   // needed for backup
R1-SAR-M-SiteA# **config>router>mpls>lsp# no shutdown**

SITE C SAR-F LSP CONFIGURATION

R3-SAR-F-SiteC>**config>router>mpls# path** "loose"   // no hop defined.
R3-SAR-F-SiteC >**config>router>mpls>path$ no shutdown**
R3-SAR-F-SiteC # **config>router>mpls>path$ back**
R3-SAR-F-SiteC # **config>router>mpls#**
R3-SAR-F-SiteC # **config>router>mpls# lsp** "to-R1"
R3-SAR-F-SiteC # **config>router>mpls>lsp# to** 10.10.10.1
R3-SAR-F-SiteC # **config>router>mpls>lsp# primary** loose

R3-SAR-F-SiteC # **config>router>mpls>lsp#primary$ back**

R3-SAR-F-SiteC # **config>router>mpls>lsp# cspf** // needed for traffic engineering

R3-SAR-F-SiteC # **config>router>mpls>lsp# secondary "…"** // needed for backup

R3-SAR-F-SiteC # **config>router>mpls>lsp# no shutdown**

5.4 SERVICE IMPLEMENTATION

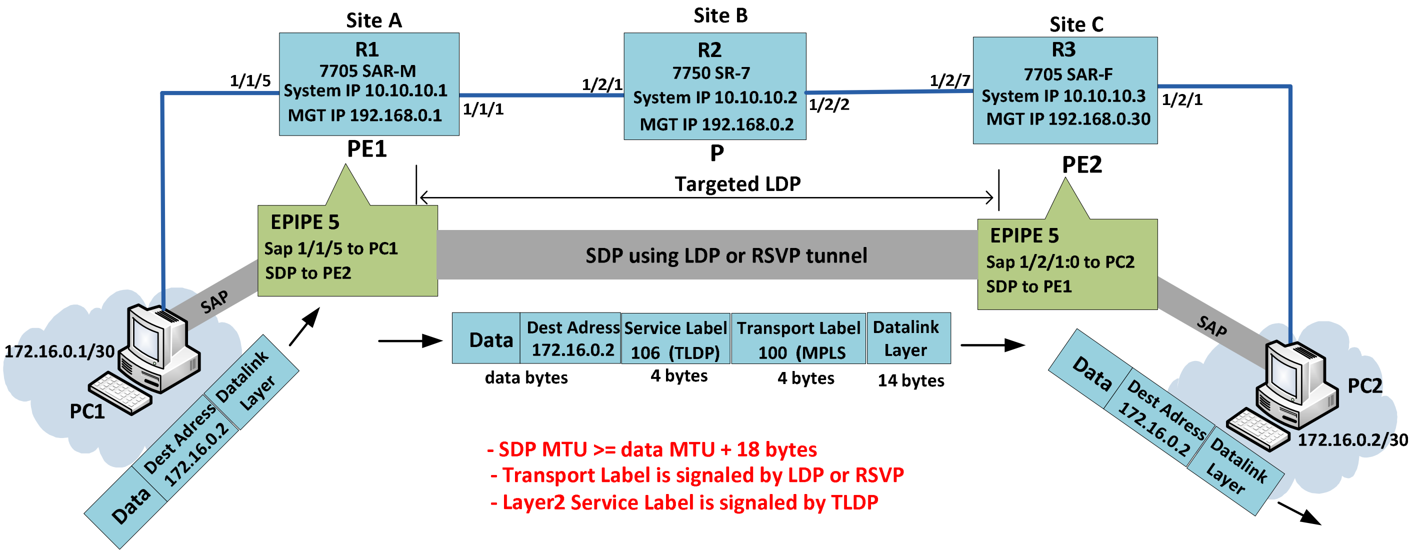


Figure 15 Layer 2 EPIPE Service Architecture

With reference to the **Figure 15** (see above), we are going to provision an EPIPE service on the PE routers to transport customer's traffic from PC1 to PC2.
Requirements to provision a distributed Layer 2 service are:

- Configure SDP (Service Distribution Point) between PE1 and PE2.
  Note ** SDP isn't required in the core; it's only configured at edge.
- Make ready the ports facing the PC1 and PC2 to be used as SAPs.
- Configure Epipe on PE1 and PE2 and bind SAP and SDP to the Epipe.

➔ Step 1: Configure SDP on PE1(R1) and PE2(R2)

- SDP means **Service Distribution Point**. It is the logical point where MPLS encapsulated data are being aggregated and transferred to the core.
- SDP makes use of network port to move traffic.
- SDP uses on **RSVP** or **LDP** tunnel to convey traffic from one point to another.
- SDP is used to signal the service label via an **LDP** protocol called **Targeted-LDP**.
- Two types of SDPs are Spoke-SDP and Mesh-SDP. Spoke SDP is used for layer 2 connection.
- An SDP must be bound to a service before it can be used.
- SDP is found under service context.
- SDP is unidirectional i.e. you must configure it at both ends.

SITE A SAR-M SDP CONFIGURATION

(A) SDP Using LDP Tunnel:

R1-SAR-M-SiteA>**configure service sdp** 5 **mpls create** //take note of MPLS and create keyword.
R1-SAR-M-SiteA>**config>service>sdp# description** "SDP to PE2"
R1-SAR-M-SiteA>**config>service>sdp# far-end** 10.10.10.3 //R3 system IP
R1-SAR-M-SiteA>**config>service>sdp# ldp** // LDP tunnel used
R1-SAR-M-SiteA>**config>service>sdp# signaling on** //It is ON by default. Targeted LDP used.
R1-SAR-M-SiteA>**config>service>sdp# no shutdown**

(B) SDP Using RSVP Tunnel:

R1-SAR-M-SiteA>**configure service sdp** 5 **mpls create** //take note of MPLS and create keyword.
R1-SAR-M-SiteA>**config>service>sdp# description** "SDP to PE2"
R1-SAR-M-SiteA>**config>service>sdp# far-end** 10.10.10.3 //R3 system IP
R1-SAR-M-SiteA>**config>service>sdp# lsp** "to-R3" // RSVP tunnel used
R1-SAR-M-SiteA>**config>service>sdp# signaling on** //It is ON by default. Targeted LDP used.
R1-SAR-M-SiteA>**config>service>sdp# no shutdown**

SITE C SAR-F SDP CONFIGURATION

(A) SDP Using LDP Tunnel:

R3-SAR-F-SiteC >**configure service sdp** 5 **mpls create** //take note of MPLS and create keyword.
R3-SAR-F-SiteC >**config>service>sdp# description** "SDP to PE1"
R3-SAR-F-SiteC >**config>service>sdp# far-end** 10.10.10.1 //R1 system IP
R3-SAR-F-SiteC >**config>service>sdp# ldp** // LDP tunnel used
R3-SAR-F-SiteC >**config>service>sdp# signaling on** //It is ON by default. Targeted LDP used.
R3-SAR-F-SiteC >**config>service>sdp# no shutdown**

(B) SDP Using RSVP Tunnel:

R3-SAR-F-SiteC >**configure service sdp** 5 **mpls create** //take note of MPLS and create keyword.
R3-SAR-F-SiteC >**config>service>sdp# description** "SDP to PE1"
R3-SAR-F-SiteC >**config>service>sdp# far-end** 10.10.10.1 //R1 system IP
R3-SAR-F-SiteC >**config>service>sdp# lsp** "to-R1" // RSVP tunnel used
R3-SAR-F-SiteC >**config>service>sdp# signaling on** //It is ON by default. Targeted LDP used.
R3-SAR-F-SiteC >**config>service>sdp# no shutdown**

5.4.1 EPIPE SERVICE IMPLEMENTATION

➔ Step 2: Provision Epipe service on PE1(R1) and PE2(R2)

- **Epipe** is a layer 2 **Point to Point**, **Pseudowire** used for conveying Ethernet traffic., though it can be interwork with other layer 2 pseudowire services like ATM and Frame-relay.
- All Pipe services have maximum of two entries. Either two SAPs, one SAP and one SDP, or two SDPs. You can create end-points to break this rule, but this is beyond the scope of this class.

SITE A SAR-M EPIPE CONFIGURATION:

R1-SAR-M-SiteA>**configure service vpls** 5 **customer** 1 **create**
R1-SAR-M-SiteA>**config>service>epipe# description** "Epipe to PE2"
R1-SAR-M-SiteA>**config>service>epipe# service-mtu** 1514 //must not exceed SDP or port MTU.
R1-SAR-M-SiteA>**config>service>epipe# sap** 1/1/5 **create** //Access connection point
R1-SAR-M-SiteA>**config>service>epipe>sap$ back**
R1-SAR-M-SiteA>**config>service>epipe# spoke-sdp** 5:5 **create** // SDP being used.
R1-SAR-M-SiteA>**config>service>epipe>sdp$ back**
R1-SAR-M-SiteA>**config>service>epipe# no shutdown**

SITE C SAR-F EPIPE CONFIGURATION:

R3-SAR-F-SiteC >**configure service epipe** 5 **customer** 1 **create**
R3-SAR-F-SiteC >**config>service>epipe# description** “Epipe to PE1”
R3-SAR-F-SiteC >**config>service>epipe# service-mtu** 1514 //must not exceed SDP or port MTU.
R3-SAR-F-SiteC >**config>service>epipe# sap** 1/2/1:0 **create** //Access connection point
R3-SAR-F-SiteC >**config>service>epipe>sap$ back**
R3-SAR-F-SiteC >**config>service>epipe# spoke-sdp** 5:5 **create** // SDP being used.
R3-SAR-F-SiteC >**config>service>epipe>sdp$ back**
R3-SAR-F-SiteC >**config>service>epipe# no shutdown**

// VPLS Service in the next page

5.4.2 VPLS SERVICE IMPLEMENTATION

VPLS mean **Virtual Private LAN Switch.** It's a layer 2 Multipoint virtual service. It emulates the LAN switch. Hence, users connected to a VPLS services on PE routers geographicaly far apart see themselves as connected to a local LAN switch.

➔ Step 1: Configure SDP on PE1(R1) and PE2(R2)

- We are going to make use of the SDP (SDP 5) configured in the previous section for EPIPE.

➔ Step 2: Provision VPLS service on PE1(R1) and PE2(R2)

- **VPLS** is a layer 2 Multipoint service used for conveying Ethernet traffic.
- Unlike **PIPES** that can accommodate two Entries only, VPLS can accommodate many users. Hence the work **multipoint.**
- Unlike EPIPE that doesn't have a MAC address table, **VPLS** keeps track of MAC address of users.

SITE A SAR-M VPLS CONFIGURATION:

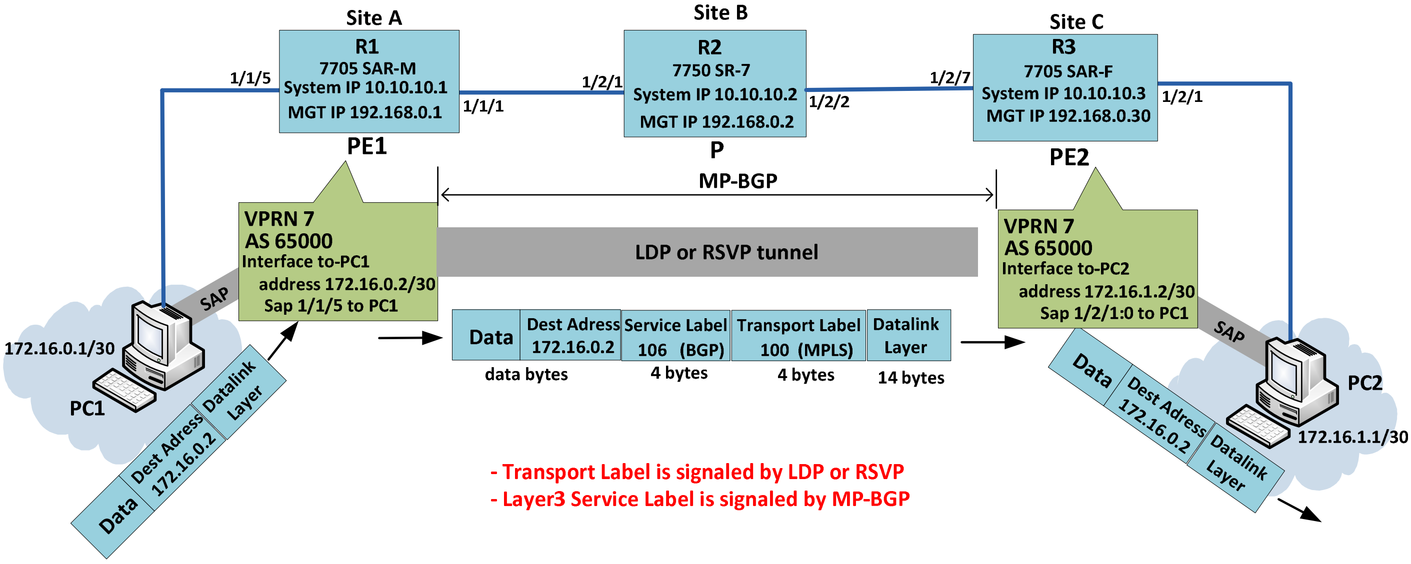
R1-SAR-M-SiteA>**configure service vpls** 6 **customer** 1 **create**
R1-SAR-M-SiteA>**config>service>vpls# description** "VPLS to PE2"
R1-SAR-M-SiteA>**config>service>vpls# service-mtu** 1514 //must not exceed SDP or port MTU.
R1-SAR-M-SiteA>**config>service>vpls# sap** 1/5/1 **create** //Access connection point
R1-SAR-M-SiteA>**config>service>vpls>sap$ back**
R1-SAR-M-SiteA>**config>service>vpls# spoke-sdp** 5:6 **create** // SDP being used.
R1-SAR-M-SiteA>**config>service>vpls>sdp$ back**
R1-SAR-M-SiteA>**config>service>vpls# no shutdown**

SITE C SAR-F VPLS CONFIGURATION:

R3-SAR-F-SiteC >**configure service vpls** 6 **customer** 1 **create**
R3-SAR-F-SiteC >**config>service>vpls# description** "VPLS to PE1"
R3-SAR-F-SiteC >**config>service>vpls# service-mtu** 1514 //must not exceed SDP or port MTU.
R3-SAR-F-SiteC >**config>service>vpls# sap** 1/2/1:0 **create** //Access connection point
R3-SAR-F-SiteC >**config>service>vpls>sap$ back**
R3-SAR-F-SiteC >**config>service>vpls# spoke-sdp** 5:6 **create** // SDP being used.
R3-SAR-F-SiteC >**config>service>vpls>sdp$ back**
R3-SAR-F-SiteC >**config>service>epipe# no shutdown**

5.4.3 VPRN SERVICE IMPLEMENTATION

VPRN mean **Virtual Private Network.** It's a **layer 3** service. It emulates a router. Hence, users connected to a VPRN services on PEs routers geographicaly far apart see themselves as connected to a local router. Refer to the diagram below:



➔ Step 1: Configure MPBGP on PE1(R1) and PE2(R2)

- MPBGP means Mulitprotocol Border Gateway Protocol. This is used to signal layer 3 service Label.
- It is configured on the Edge; the core is not aware of this protocol.
- Since MPBGP may be multi-hops away on both PEs, it relies on RSVP or LDP tunnel to resolve next-hop of system IP of the PE routers.

SITE A SAR-M MP-BGP CONFIGURATION:

R1-SAR-M-SiteA>**configure router bgp**
R1-SAR-M-SiteA>**config>router>bgp# local-as** 65000
R1-SAR-M-SiteA>**config>router>bgp# next-hop-self**
R1-SAR-M-SiteA>**config>router>bgp# family** ipv4 vpn-ipv4
R1-SAR-M-SiteA>**config>router>bgp# group** "to-PE3"
R1-SAR-M-SiteA>**config>router>bgp>grp$ type internal**
R1-SAR-M-SiteA>**config>router>bgp>grp$ neighbor 10.10.10.3**
R1-SAR-M-SiteA>**config>router>bgp>grp$ peer-as** 65000
R1-SAR-M-SiteA>**config>router>bgp>grp$ back**
R1-SAR-M-SiteA>**config>router>bgp# no shutdown**

SITE C SAR-F MP-BGP CONFIGURATION:

R3-SAR-F-SiteC >**configure router bgp**
R3-SAR-F-SiteC >**config>router>bgp# local-as** 65000
R3-SAR-F-SiteC >**config>router>bgp# next-hop-self**
R3-SAR-F-SiteC >**config>router>bgp# family** ipv4 vpn-ipv4
R3-SAR-F-SiteC >**config>router>bgp# group** "to-PE1"

R3-SAR-F-SiteC >**config>router>bgp>grp$ type internal**
R3-SAR-F-SiteC >**config>router>bgp>grp$ neighbor 10.10.10.1**
R3-SAR-F-SiteC >**config>router>bgp>grp$ peer-as** 65000
R3-SAR-F-SiteC >**config>router>bgp>grp$ back**
R3-SAR-F-SiteC >**config>router>bgp# no shutdown**

➔ Step 2: Configure VPRN on PE1(R1) and PE2(R2)

SITE A SAR-M VPRN CONFIGURATION:

R1-SAR-M-SiteA>**configure service vprn** 7 **customer** 1 **create**
R1-SAR-M-SiteA>**config>service>vprn# autonomous-system** 65000
R1-SAR-M-SiteA>**config>service>vprn# route-distinguisher** 65000:7
R1-SAR-M-SiteA>**config>service>vprn# route-target** target:65000:7
R1-SAR-M-SiteA>**config>service>vprn# auto-bind** mpls

R1-SAR-M-SiteA>**config>service>vprn# interface** "to-PC1" **create**
R1-SAR-M-SiteA>**config>service>vprn>if$ address** 172.16.0.1/30
R1-SAR-M-SiteA>**config>service>vprn>if$ sap** 1/1/5 **create**
R1-SAR-M-SiteA>**config>service>vprn>if$ back**
R1-SAR-M-SiteA>**config>service>vprn# no shutdown**

SITE C SAR-F VPRN CONFIGURATION:

R3-SAR-F-SiteC>**configure service vprn** 7 **customer** 1 **create**
R3-SAR-F-SiteC>**config>service>vprn# autonomous-system** 65000
R3-SAR-F-SiteC>**config>service>vprn# route-distinguisher** 65000:7
R3-SAR-F-SiteC>**config>service>vprn# route-target** target:65000:7
R3-SAR-F-SiteC>**config>service>vprn# auto-bind** mpls
R3-SAR-F-SiteC>**config>service>vprn# interface** "to-PC2" **create**
R3-SAR-F-SiteC>**config>service>vprn>if$ address** 172.16.1.1/30
R3-SAR-F-SiteC>**config>service>vprn>if$ sap** 1/2/1:0 **create**
R3-SAR-F-SiteC>**config>service>vprn>if$ back**
R3-SAR-F-SiteC>**config>service>vprn# no shutdown**

6.0 WAREHOUSE COMMISSIONING OF ROUTERS

- Basic configuration and Basic Option files shall be loaded on the routers at the Warehouse before delivery to sites.
- Basic Option File (BOF) contains the URL that points to the location of the basic config file on the router. During system boot, the BOF tells the router where to locate config file.

6.1 DEPLOYING BASIC CONFIG ON REMOVABLE COMPACT FLASH CARDS

- Some routers have **removal compact flash** cards. Hence a **card reader** can be used to directly upload the basic config and the BOF file from a laptop to the compact flash.
- All 7750 SR are in this category. By default, the **CF3** slot houses the compact flash that contains the config.
- 7705 SAR-8 and SAR-18 compact flash cards are removable.

Procedure

- The Flash card is removed from the router and inserted in card reader.
- The Flash reader is connected to a laptop
- The system detects the flash card like a USD drive.
- The basic config file and the BOF files are uploaded to the compact flash.
- The router is started.

6.2 DEPLOYING BASIC CONFIG ON INBUILT COMPACT FLASH CARDS.

Some routers' compact flash cards are **internal**. In this case, **FTP** can be used to upload the BOF and Basic config files to the system. FTP is done from a laptop to the management IP of the router.

Procedure

- Assign an IP address to the management interface of the router. Let's say 192.168.0.1/24.
  R1# **bof**
  R1>bof# **address** 192.168.0.1/24 **active**

  Note** A management IP can only be assigned to the management interface via console connection.

- Assign an IP address to your laptop within management subnet. Let's say 192.168.0.20/24. See example below:

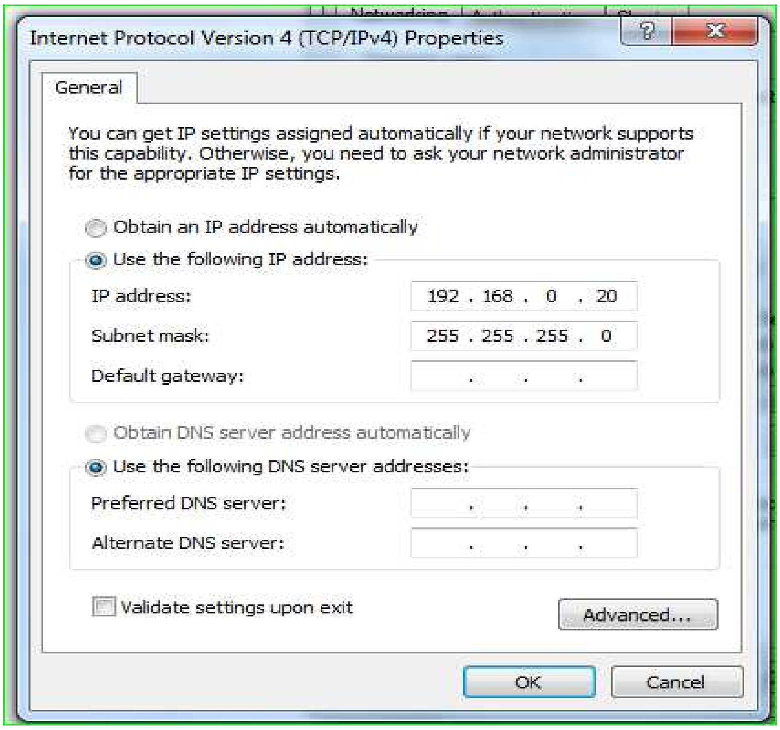


Figure 15 Laptop/PC IP Addressing

- Connect your Laptop to the management interface of the router and verify connectivity by pinging the management IP address from the laptop.

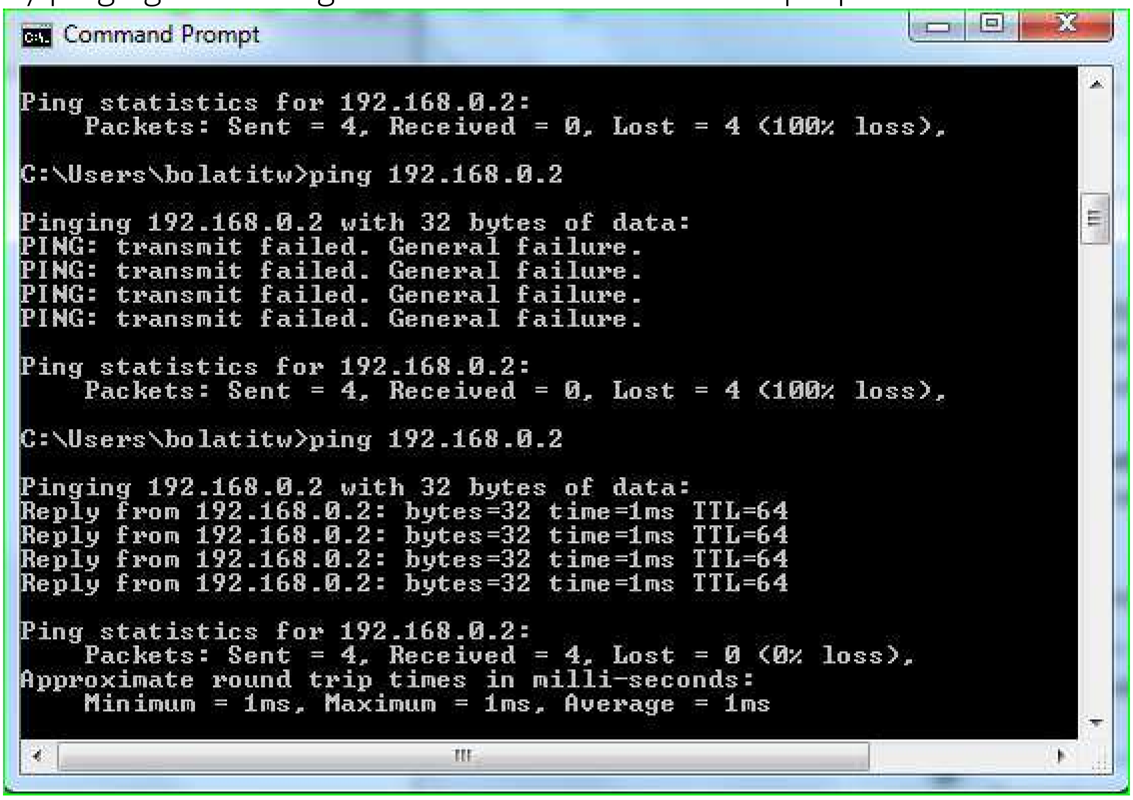


Figure 16 Pings to Router's MGT Port from PC/Laptop

- Move the basic config and BOF files to the desktop, or any other location. Assuming it is moved to the desktop. The file name is R4-Config.cfg and bof.cfg.

- Change to desktop directory on your laptop, or anywhere the files are located and FTP to the management IP of the router.

- Complete the process as decribe below in the snapshot:

```
C:\Users\bolatitw>
C:\Users\bolatitw>
C:\Users\bolatitw>cd Desktop           1

C:\Users\bolatitw\Desktop>ftp 192.168.0.1          2
Connected to 192.168.0.1.
220-TiMOS-B-6.2.R2 both/hops ALCATEL-LUCENT SAR 7705
220-Copyright (c) 2000-2015 Alcatel-Lucent.
220-All rights reserved. All use subject to applicable license agreements.
220-Built on Thu Apr 30 11:43:44 EDT 2015 by csabuild in /rel6.2/b1/R2/panos/mai
n
220-
220 FTP server ready
User (192.168.0.1:(none)): admin        3
331 Password required
Password:
230 User logged in      4
ftp> hash
Hash mark printing On  ftp: (2048 bytes/hash mark) .      5
ftp> prompt
Interactive mode Off .      6
ftp> put R4-Config.cfg      7
200 Port set okay
150 Opening ASCII mode data connection
226 Transfer complete
ftp>
ftp> ls     8
200 Port set okay
150 Opening ASCII mode data connection
boot.ldr
bof.cfg
config.cfg
md5sums.txt
bootlog.txt
nvsys.info
Airtel-Training.cfg
bootlog_prev.txt
bof.cfg.1
config.cfg.1
bof.cfg.2
config.cfg.2
config.cfg.3
config.cfg.4
R4-Config.cfg
bof.cfg.3
Airtel-Training.cfg.1
Airtel-Training.cfg.2
Airtel-Training.cfg.3
Airtel-Training.cfg.4
Airtel-Training.cfg.5
226 Transfer complete
ftp: 327 bytes received in 0.01Seconds 32.70Kbytes/sec.
ftp>
```

Figure 17 FTP Steps

- Do the same to transfer bof.cfg

- Log unto the router and verify that the transffered files are available. You can open the file using “type” to ensure that it is not corrupted.

R4# file
R4>file# **dir** //this will display the content of cf3//
R4>file# **type R4-Config.cfg** // display the content of the file //
R4>file# **type bof.cfg** // display the content of the file //

- Reboot the router.

After reboot, the router makes the basic config file it’s default config file.
The URL of the config file can be edited under BOF.