MINT 709

Project Course

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Lab 1

Cisco Call Manager express

Introduction:

Analog phone lines use the properties of electricity to convey changes in voice over cabling, while Voice over IP (VoIP) defines a way to carry voice calls over an IP network. This process of converting the analog wave into digital includes digitizing the signal using Nyquist theorem which is you can accurately reproduce an audio signal by sampling at twice the highest frequency. The Nyquist theorem is able to reproduce frequencies from 300–4,000 Hz. this means sampling 8,000 times (2 * 4000) every second. Then each sample is given a numeric value this process is called quantization. Utilizing the existing data network to send VoIP traffic allows an inexpensive voice communication. Also integrating Data and Voice over common transport results is seamless voice networks, which means that the voice traffic is crossing company's network rather than exiting PSTN and caters to various offices like data.

Pre-Lab:

1- What are various types of analog and digital ports or connection used to send voice signals and payload?

FXS, FXO, T1, E1

2- What is the role of CDP in IP Phone boot operation?

Cisco IP phone receives voice VLAN configuration from the switch

3- What is the function of RTP? What is the difference between RTP and RTCP?

RTP: adds time stamps and sequence numbers to the header information. This allows the remote device to put the packets back in order when it receives them at the remote end.
RTCP: statistics reporting, delivers statistics between two devices participating in the call.

4- What parameter in DHCP configuration set is required to point towards TFTP server, please write the full command?

Option 150
option 150 ip 172.16.1.1

5- What are various digit manipulation methods supported on Cisco platforms?

Num-exp
atomatic digit strip
voice translation
prefic digits
forward digits

6- What is the function of DSP?

DSPs offload the processing responsibility for voice-related tasks from the processor of the router

7- Explain the IP phone boot process?

- The Cisco IP Phone connects to an Ethernet switch port. If the IP phone and switch support PoE, the IP phone receives power through either Cisco-proprietary PoE or 802.3af PoE.
- As the Cisco IP Phone powers on, the Cisco switch delivers voice VLAN information to the IP phone using CDP as a delivery mechanism. The Cisco IP Phone now knows what VLAN it should use.
- The Cisco IP Phone sends a DHCP request asking for an IP address on its voice VLAN.
- The DHCP server responds with an IP address offer. When the Cisco IP Phone accepts the offer, it receives all the DHCP options that go along with the DHCP request. DHCP options include items such as default gateway, DNS server information, domain name information, and so on. In the case of Cisco IP Phones, a unique DHCP option is included, known as Option 150. This option directs the IP phone to a TFTP server
- After the Cisco IP Phone has the IP address of the TFTP server, it contacts the TFTP server and downloads its configuration file. Included in the configuration file is a list of valid call processing agents
- The Cisco IP Phone attempts to contact the first call processing server (the primary server) listed in its configuration file to register. If this fails, the IP phone moves to the next server in the configuration file. This process continues until the IP phone registers successfully or the list of call processing agents is exhausted.

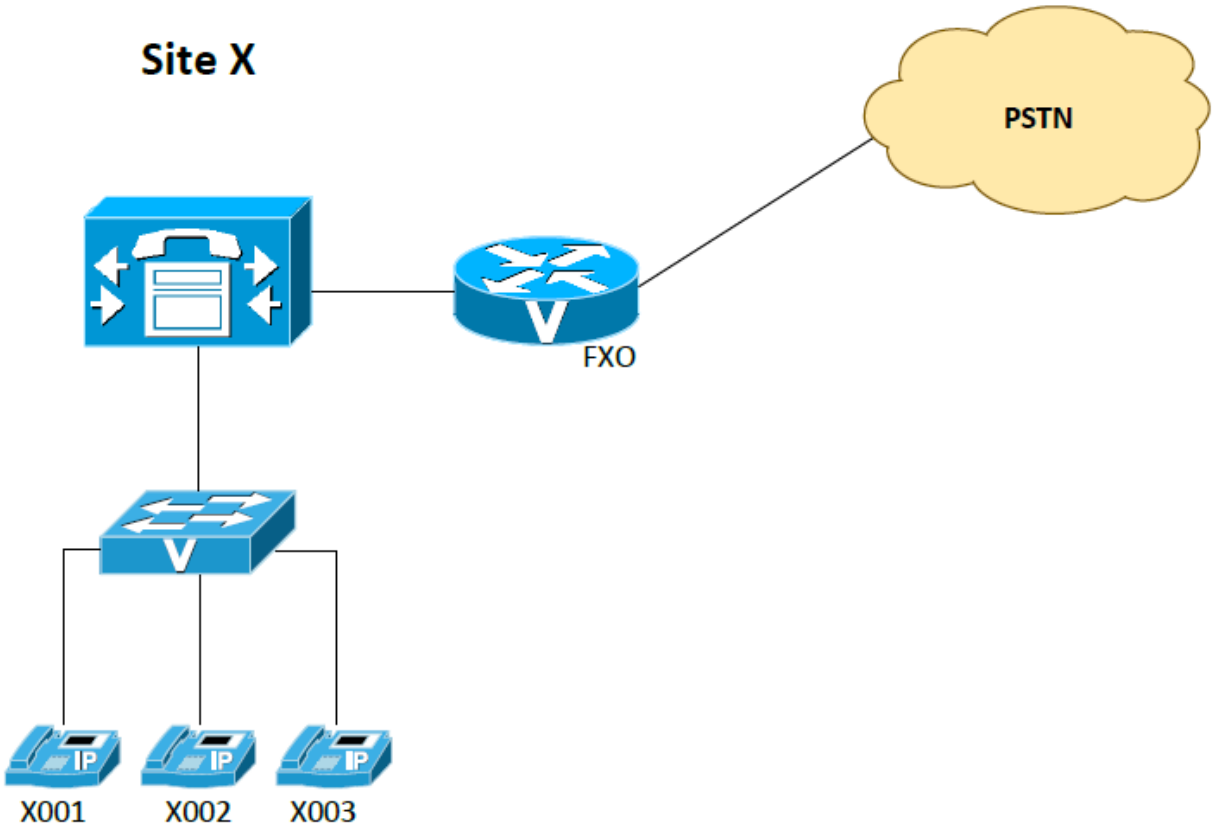
8- What is Private Line Automatic Ringdown?

Ports configured with PLAR capabilities automatically dial a number as soon as the port detects an off-hook signal. The most obvious use for PLAR configurations is emergency phones in locations such as company elevators or parking garages

Lab Scenario:

In this lab, you will configure Cisco Call Manager Express for single site deployment and then later on connect to remote sites with connection over WAN and on PSTN as backup. Initially configure each branch setup individually which includes setting up CME, PoE switch and an FXO router, make external calls e.g. to your cell phone. Later on, with coordination from another team, modify dial peer with necessary configuration to call to another branch office i.e. to branch setup of your mate.

Lab Diagram 1:



Lab IP Addressing:

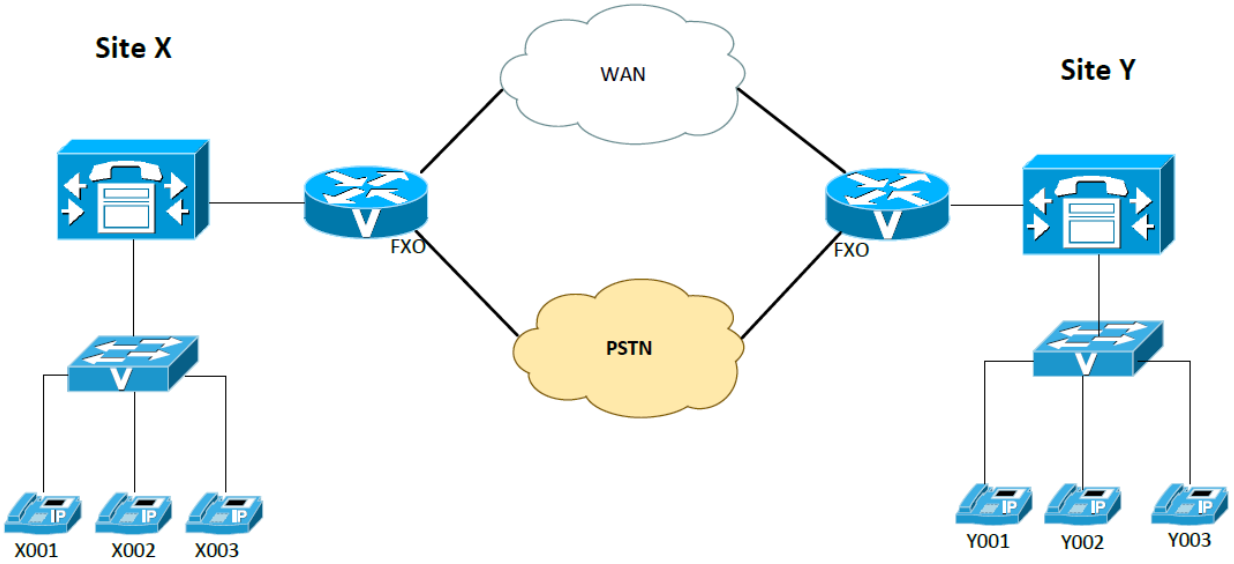
Node	IP
Voice VLAN	X (Rack number)
Data VLAN	X+1
Voice Subnet	192.168.X.0/24
Data Subnet	192.168.X+1.0/24
CME to FXO	10.0.X.0/30

Procedure:

1- Configure the routers and the switch with appropriate VLANs and IP addresses as per the table above.
2- Configure CME as Router on Stick (RoS) to felicitate communication between Voice and Data VLAN.
3- Configure IGP (OSPF area X) on branch setup.
4- Configure CME router as DHCP server, create pool to assign IP addresses to all phones. Don't allow addresses .1 - .20 to be handed out in the subnet. Ensure the proper default router and TFTP server options are chosen.
5- Configure CME as TFTP server, first extract the files (sent through email) to flash memory of the router.
6- Configure Telephony services:
    a) Allow a maximum of 5 phones and maximum of 10 extensions.
    b) Do not forget to generate XML files for IP phones using create cnf files command
    c) Create dual line extensions, e.g. X001, X002 and X003, label them Sales, Marketing, and <yourname> respectively.
    d) Make sure calls to Sales and Marketing gets forwarded to your number (X003) if not answered after 10 seconds.
    e) Ensure that phones display their time and date in the following formats:
    ** Time: Display 24-hour time in the same time zone as the router.
    ** Date format should be "dd-mm-yy".
    f) Create IP phones or ephones and then note down the MAC address of each phone and manually bind it to the ephones.
7- Configure a local directory on CME; all the names you assigned to extension numbers should be visible in local directory on your IP phone. To verify this, hit Directory button on your IP phone and select local directory.
8- Now configure relevant dialpeers on CME router and FXO router so that all the IP phones should be able to dial out to your cell phone and you should also be able to receive external calls from mobile to your extension number i.e. X003.

Hint: For this task, configure dialpeers from CME to FXO and vice versa, then configure FXO

Lab Diagram 2:



9- Now connect your FXO router to another student's FXO, run OSPF (area 0) and make sure you route table is fully populated.
10- Configure a direct dialpeer between two CMEs to dial extension numbers. On FXO router, configure dialpeer to connect to remote branch through WAN and PSTN with first preference to WAN dialpeer.
11- Configure appropriate 'translation rules' on CME so that call can be routed through PSTN in case WAN link is not available, apply this translation rule to dialpeer as well.
12- Make test calls between the two branches, disable the WAN link and make sure calls between branches are still successful.
13- Configure Directed Call Park Feature. The call park number to be used is X111. Only extension/DN "X001" should be able to park the call at this number. This phone should receive notifications twice every 20 seconds if the parked call is not retrieved. Post 40 seconds, the call should transfer back to the DN which parked the call. In case this DN is busy, the call should be sent to DN "X002".
14- Configure the CME so IP Phones to ring simultaneously when call arrives on number X100.
15- Configure the “CUCME1” IP Phone(s) to be in different groups. They should be able to pick up a call on each other’s phone without physically going over to the ringing phone.
16- Using COR list configure CME router in such a way that only Phone X001 should be able to receive calls from the other branch phones.

Deliverables:

- Diagram of the lab with IP address also mention rack you worked.
- Running configuration of all devices.
- Output of Power granted to each IP Phones.
- Please write down the exact command you used to extract files from TFTP server including the source and destination file names and whole path, And output of flash memory containing the necessary IP Phone firmware files, use dir flash: command.
- Output of all ephones registered to the CME, use show ephone registered brief.
- Make call from Marketing to your extension X003 and provide output of Show call active voice brief and show call active voice compact on CME.
- Call from any extension to your mobile, is the call successful? Provide output of Show call active voice brief and show call active voice compact on CME and FXO router.
- Output of routing table on CME and FXO.
- Call from your Marketing number to your mate's Sales number, and provide output of Show call active voice brief and show call active voice compact on CME.
- Disconnect the WAN link, dial the same number, observe the number change on your IP phone's screen, and provide debug dialpeer output of your FXO router for this call.
- Call from the other branch to X001 and then to X002 after configure the COR list, and show the difference between them.

Instructions to follow at the end of each lab

- Make sure you erase your configuration from NVRAM of the devices used.
- Do not save any of the configurations in flash memory.
- All cables must be unplugged and secured in the box.
- There must not be any kind of garbage around the desk or racks after you are done with lab.

```
CME#show run
Building configuration...


Current configuration : 3805 bytes
!
! Last configuration change at 12:52:21 UTC Sun Apr 3 2016
! NVRAM config last updated at 18:55:46 UTC Fri Apr 1 2016
! NVRAM config last updated at 18:55:46 UTC Fri Apr 1 2016
version 15.3
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CME
!
!
ip dhcp excluded-address 192.168.6.1 192.168.6.10
ip dhcp excluded-address 192.168.7.1 192.168.7.10
!
ip dhcp pool voice-scope
 network 192.168.6.0 255.255.255.0
 default-router 192.168.6.1
 option 150 ip 192.168.6.1
!
ip dhcp pool data-scope
 network 192.168.7.0 255.255.255.0
 default-router 192.168.7.1
!
interface GigabitEthernet0/0
 ip address 15.1.6.1 255.255.255.252
 duplex auto
 speed auto
!
interface GigabitEthernet0/1.6
 encapsulation dot1Q 6
 ip address 192.168.6.1 255.255.255.0
!
interface GigabitEthernet0/1.7
 encapsulation dot1Q 7
 ip address 192.168.7.1 255.255.255.0
!
interface GigabitEthernet0/2
 ip address 10.0.0.1 255.255.255.0
 duplex auto
 speed auto
!
!
```

```
!
router ospf 1
 network 15.1.6.0 0.0.0.3 area 1
!
!
tftp-server flash:apps41.9-4-2ES9.sbn
tftp-server flash:cnu41.9-4-2ES9.sbn
tftp-server flash:cvm41sccp.9-4-2ES9.sbn
tftp-server flash:dsp41.9-4-2ES9.sbn
tftp-server flash:jar41sccp.9-4-2ES9.sbn
tftp-server flash:SCCP41.9-4-2SR1-1S.loads
tftp-server flash:term41.default.loads
tftp-server flash:term61.default.loads
!
!
dial-peer voice 1 voip
 destination-pattern 9T
 session target ipv4:15.1.6.2
!
dial-peer voice 2 voip
 preference 1
 destination-pattern 2...
 session target ipv4:15.1.6.2
!
dial-peer voice 3 voip
 destination-pattern 2...
 session target ipv4:15.1.2.1
!
!
!
!
telephony-service
 max-ephones 5
 max-dn 10
 ip source-address 192.168.6.1 port 2000
 service dnis dir-lookup
 load 7941 flash:SCCP41.9-4-2SR1-1S
 max-conferences 8 gain -6
 transfer-system full-consult
 directory entry 1 6001 name Sales
 directory entry 2 6002 name Marketing
 directory entry 3 6003 name Tim Majani
 create cnf-files version-stamp 7960 Apr 01 2016 14:44:24
!
!
ephone-dn  1  dual-line
 number 6001
 description Sales
```

```
 name Sales
 call-forward noan 6003 timeout 10
!
!
ephone-dn  2  dual-line
 number 6002
 description Marketing
 name Marketing
 call-forward noan 6003 timeout 10
!
!
ephone-dn  3  dual-line
 number 6003
 description Tim
 name Tim, Majani
!
!
ephone  1
 mac-address 001B.D512.6D2D
 button  1:1
!
!
!
ephone  2
 mac-address 001B.D52C.396C
 button  1:2
!
!
!
ephone  3
 mac-address 001B.0512.F3C3
 button  1:3
!
!
!
!
```

```
FX0 #show run
!
hostname FX0
!
voice translation-rule 1
 rule 1 /2.../ /97802481582/
!
!
voice translation-profile tim
 translate called 1
!
!
interface FastEthernet0/0
 ip address 15.1.6.2 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 ip address 11.1.6.2 255.255.255.252
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 11.1.6.0 0.0.0.3 area 1
 network 15.1.6.0 0.0.0.3 area 1
!
ip http server
ip classless
!
!
!
voice-port 1/0/0
 connection plar opx 6001
!
voice-port 1/0/1
!
!
!
dial-peer voice 2 pots
 destination-pattern 9T
 port 1/0/0
 forward-digits all
!
dial-peer voice 3 pots
 translation-profile outgoing tim
 destination-pattern 2...
 port 1/0/0
```

```
!
dial-peer voice 1 voip
 destination-pattern 6...
 session target ipv4:15.1.6.1
!
!
line con 0
line aux 0
line vty 0 4
!
!
end
```

Switch #show run

```
Building configuration...

!
hostname Switch
!
!
interface FastEthernet0
 no ip address
!
interface GigabitEthernet0/1
 switchport access vlan 7
 switchport voice vlan 6
 spanning-tree portfast
!
interface GigabitEthernet0/2
 switchport access vlan 7
 switchport voice vlan 6
 spanning-tree portfast
!
interface GigabitEthernet0/3
 switchport access vlan 7
 switchport voice vlan 6
 spanning-tree portfast
!
interface GigabitEthernet0/4
 switchport access vlan 7
 switchport voice vlan 6
 spanning-tree portfast
!
!
interface GigabitEthernet0/24
 switchport trunk encapsulation dot1q
```

```
 switchport mode trunk
!
end
```

Switch # show vlan brief

```
VLAN Name                              Status    Ports
---- --------------------------------- --------- -------------------------------
1    default                           active    Gi0/5, Gi0/6, Gi0/7, Gi0/8
                                                 Gi0/9, Gi0/10, Gi0/11, Gi0/12
                                                 Gi0/13, Gi0/14, Gi0/15, Gi0/16
                                                 Gi0/17, Gi0/18, Gi0/19, Gi0/20
                                                 Gi0/21, Gi0/22, Gi0/23
6    VLAN0006                          active    Gi0/1, Gi0/2, Gi0/3, Gi0/4
7    VLAN0007                          active    Gi0/1, Gi0/2, Gi0/3, Gi0/4
1002 fddi-default                      act/unsup
1003 token-ring-default                act/unsup
1004 fddinet-default                   act/unsup
1005 trnet-default                     act/unsup
```

Switch #show power inline

```
Available:495.0(w)  Used:20.3(w)  Remaining:474.7(w)

Interface Admin  Oper       Power   Device              Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi0/1     auto   on         7.0     IP Phone 7941       2     30.0
Gi0/2     auto   on         7.0     IP Phone 7941       2     30.0
Gi0/3     auto   off        0.0     n/a                 n/a   30.0
Gi0/4     auto   on         6.3     IP Phone 7941       2     30.0
Gi0/5     auto   off        0.0     n/a                 n/a   30.0
Gi0/6     auto   off        0.0     n/a                 n/a   30.0
Gi0/7     auto   off        0.0     n/a                 n/a   30.0
Gi0/8     auto   off        0.0     n/a                 n/a   30.0
Gi0/9     auto   off        0.0     n/a                 n/a   30.0
Gi0/10    auto   off        0.0     n/a                 n/a   30.0
Gi0/11    auto   off        0.0     n/a                 n/a   30.0
Gi0/12    auto   off        0.0     n/a                 n/a   30.0
Gi0/13    auto   off        0.0     n/a                 n/a   30.0
Gi0/14    auto   off        0.0     n/a                 n/a   30.0
Gi0/15    auto   off        0.0     n/a                 n/a   30.0
Gi0/16    auto   off        0.0     n/a                 n/a   30.0
Gi0/17    auto   off        0.0     n/a                 n/a   30.0
Gi0/18    auto   off        0.0     n/a                 n/a   30.0
Gi0/19    auto   off        0.0     n/a                 n/a   30.0
Interface Admin  Oper       Power   Device              Class Max
```

```
                    (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi0/20    auto   off        0.0     n/a                 n/a   30.0
Gi0/21    auto   off        0.0     n/a                 n/a   30.0
Gi0/22    auto   off        0.0     n/a                 n/a   30.0
Gi0/23    auto   off        0.0     n/a                 n/a   30.0
Gi0/24    auto   off        0.0     n/a                 n/a   30.0
Switch-SideA#
```

1) Output of power granted to each phone

```
Switch-SideA#show power inline
Available:495.0(w)  Used:20.3(w)  Remaining:474.7(w)

Interface Admin  Oper       Power   Device              Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi0/1     auto   on         7.0     IP Phone 7941       2     30.0
Gi0/2     auto   on         7.0     IP Phone 7941       2     30.0
Gi0/3     auto   off        0.0     n/a                 n/a   30.0
Gi0/4     auto   on         6.3     IP Phone 7941       2     30.0
Gi0/5     auto   off        0.0     n/a                 n/a   30.0
Gi0/6     auto   off        0.0     n/a                 n/a   30.0
Gi0/7     auto   off        0.0     n/a                 n/a   30.0
Gi0/8     auto   off        0.0     n/a                 n/a   30.0
Gi0/9     auto   off        0.0     n/a                 n/a   30.0
Gi0/10    auto   off        0.0     n/a                 n/a   30.0
```

2) The flash memory was not compatible, so I configure my laptop as TFTP server and use copy tftp: flash:

```
Voip-SideA#dir flash:
Directory of flash0:/

  1  -rw-    79917508  Aug 19 2013 07:37:36 +00:00  c2900-universalk9_npe-mz.SPA.153-1.T1.bin
  2  -rw-        3064  Aug 19 2013 07:44:22 +00:00  cpconfig-29xx.cfg
  3  -rw-     3156347  Apr 1 2016 20:01:12 +00:00  apps41.9-4-2ES9.sbn
  4  drw-           0  Aug 19 2013 07:44:34 +00:00  ccpexp
240  -rw-        2464  Aug 19 2013 07:46:16 +00:00  home.shtml
241  -rw-      230985  Jan 13 2014 21:36:38 +00:00  jar41sip.8-2-2ES1.sbn
247  -rw-      557154  Apr 1 2016 20:01:38 +00:00  cnu41.9-4-2ES9.sbn
246  -rw-     2217256  Apr 1 2016 20:01:56 +00:00  cvm41sccp.9-4-2ES9.sbn
245  -rw-      562005  Apr 1 2016 20:02:08 +00:00  dsp41.9-4-2ES9.sbn
244  -rw-     1630052  Apr 1 2016 20:02:24 +00:00  jar41sccp.9-4-2ES9.sbn
243  -rw-         646  Apr 1 2016 20:02:32 +00:00  SCCP41.9-4-2SR1-1S.loads
242  -rw-         642  Apr 1 2016 20:02:44 +00:00  term41.default.loads
248  -rw-         585  Jan 14 2014 00:00:38 +00:00  XMLDefault.cnf.xml
249  drw-           0  Jan 15 2015 16:01:28 +00:00  7940
255  drw-           0  Jan 15 2015 16:01:48 +00:00  7941
264  drw-           0  Jan 15 2015 16:30:28 +00:00  its
401  -rw-        2121  Sep 22 2015 11:07:42 +00:00  sam
402  -rw-         642  Apr 1 2016 20:02:56 +00:00  term61.default.loads
```

3) Registered ephone

Voip-SideA#show ephone registered

ephone-1[0] Mac:001B.D512.6D2D TCP socket:[1] activeLine:0 whisperLine:0 REGISTERED in SCCP ver 22/17 max_streams=5

mediaActive:0 whisper_mediaActive:0 startMedia:0 offhook:0 ringing:0 reset:0 reset_sent:0 paging 0 debug:0 caps:8
IP:192.168.6.11 * 49152 7941 keepalive 7 max_line 2 available_line 2
button 1: cw:1 ccw:(0 0)
dn 1 number 6001 CH1 IDLE CH2 IDLE
Preferred Codec: g711ulaw
Lpcor Type: none

ephone-2[1] Mac:001B.D52C.396C TCP socket:[3] activeLine:0 whisperLine:0 REGISTERED in SCCP ver 22/17 max_streams=5
mediaActive:0 whisper_mediaActive:0 startMedia:0 offhook:0 ringing:0 reset:0 reset_sent:0 paging 0 debug:0 caps:8
IP:192.168.6.12 * 49152 7941 keepalive 6 max_line 2 available_line 2
button 1: cw:1 ccw:(0 0)
dn 2 number 6002 CH1 IDLE CH2 IDLE
Preferred Codec: g711ulaw
Lpcor Type: none
Voip-SideA#show ip route

4) Call from one ip phone to another (sorry I do have only two working phones) the call is from 6002 to 6001
CME-SideA#show call active voice brief
<ID>: <CallID> <start>ms.<index> (<start>) +<connect> pid:<peer_id> <dir> <addr> <state>
dur hh:mm:ss tx:<packets>/<bytes> rx:<packets>/<bytes> dscp:<packets violation> media:<packets violation> audio tos:<audio tos value> video tos:<video tos value>
IP <ip>:<udp> rtt:<time>ms pl:<play>/<gap>ms lost:<lost>/<early>/<late>
delay:<last>/<min>/<max>ms <codec> <textrelay> <transcoded

media inactive detected:<y/n> media cntrl rcvd:<y/n> timestamp:<time>

long duration call detected:<y/n> long duration call duration :<sec> timestamp:<time>
MODEMPASS <method> buf:<fills>/<drains> loss <overall%> <multipkt>/<corrected>
last <buf event time>s dur:<Min>/<Max>s
FR <protocol> [int dlci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
<codec> (payload size)
ATM <protocol> [int vpi/vci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
<codec> (payload size)
Tele <int> (callID) [channel_id] tx:<tot>/<v>/<fax>ms <codec> noise:<l> acom:<l> i/o:<l>/<l> dBm
MODEMRELAY info:<rcvd>/<sent>/<resent> xid:<rcvd>/<sent> total:<rcvd>/<sent>/<drops>
speeds(bps): local <rx>/<tx> remote <rx>/<tx>
Proxy <ip>:<audio udp>,<video udp>,<tcp0>,<tcp1>,<tcp2>,<tcp3> endpt: <type>/<manf>
bw: <req>/<act> codec: <audio>/<video>
tx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>
rx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>

Telephony call-legs: 2
SIP call-legs: 0
H323 call-legs: 0
Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2
1406 : 216 173075340ms.1 (13:32:47.916 UTC Sun Apr 3 2016) +3930 pid:20002 Answer 6002 active
dur 00:00:02 tx:0/0 rx:0/0 dscp:0 media:0 audio tos:0x0 video tos:0x0
Tele 50/0/2 (216) [50/0/2.0] tx:0/0/0ms g711ulaw noise:0 acom:0 i/0:0/0 dBm

1406 : 217 173077720ms.1 (13:32:50.296 UTC Sun Apr 3 2016) +1550 pid:20001 Originate 6001 active
dur 00:00:02 tx:227/7264 rx:125/3990 dscp:0 media:0 audio tos:0x0 video tos:0x0
Tele 50/0/1 (217) [50/0/1.0] tx:4540/4540/0ms g711ulaw noise:0 acom:0 i/0:0/0 dBm

Telephony call-legs: 2
SIP call-legs: 0
H323 call-legs: 0
Call agent controlled call-legs: 0

```
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2

CME-SideA#show call active voice compact
 <callID>  A/O FAX T<sec> Codec      type       Peer Address      IP R<ip>:<udp>
Total call-legs: 2
      216 ANS     T24    g711ulaw    TELE       P6002
      217 ORG     T24    g711ulaw    TELE       P6001

CME-SideA#
```

5) Call from 6001 to mobile (I do not have Alberta cellphone so I used the 7804921930)

On the CME router

```
CME-SideA#show call active voice brief
<ID>: <CallID> <start>ms.<index> (<start>) +<connect> pid:<peer_id> <dir> <addr> <state>
  dur hh:mm:ss tx:<packets>/<bytes> rx:<packets>/<bytes> dscp:<packets violation> media:<packets violation> audio tos:<audio tos
value> video tos:<video tos value>
 IP <ip>:<udp> rtt:<time>ms pl:<play>/<gap>ms lost:<lost>/<early>/<late>
  delay:<last>/<min>/<max>ms <codec> <textrelay> <transcoded

 media inactive detected:<y/n> media cntrl rcvd:<y/n> timestamp:<time>

 long duration call detected:<y/n> long duration call duration :<sec> timestamp:<time>
  MODEMPASS <method> buf:<fills>/<drains> loss <overall%> <multipkt>/<corrected>
   last <buf event time>s dur:<Min>/<Max>s
 FR <protocol> [int dlci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
  <codec> (payload size)
 ATM <protocol> [int vpi/vci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
  <codec> (payload size)
 Tele <int> (callID) [channel_id] tx:<tot>/<v>/<fax>ms <codec> noise:<l> acom:<l> i/o:<l>/<l> dBm
  MODEMRELAY info:<rcvd>/<sent>/<resent> xid:<rcvd>/<sent> total:<rcvd>/<sent>/<drops>
       speeds(bps): local <rx>/<tx> remote <rx>/<tx>
 Proxy <ip>:<audio udp>,<video udp>,<tcp0>,<tcp1>,<tcp2>,<tcp3> endpt: <type>/<manf>
 bw: <req>/<act> codec: <audio>/<video>
  tx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>
 rx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>



Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2
1418 : 224 173305520ms.1 (13:36:38.096 UTC Sun Apr 3 2016) +21870 pid:20001 Answer 6001 active
 dur 00:00:26 tx:1232/39424 rx:803/25666 dscp:0 media:0 audio tos:0x0 video tos:0x0
 Tele 50/0/1 (224) [50/0/1.0] tx:24640/24640/0ms g729r8 noise:0 acom:0  i/0:0/0 dBm

1418 : 225 173323830ms.1 (13:36:56.406 UTC Sun Apr 3 2016) +3560 pid:1 Originate 97804921930 active
 dur 00:00:26 tx:1294/25880 rx:875/17375 dscp:0 media:0 audio tos:0xB8 video tos:0x0
 IP 15.1.6.2:16630 SRTP: off rtt:0ms pl:16060/0ms lost:0/0/0 delay:0/0/0ms g729r8 TextRelay: off Transcoded: No
 media inactive detected:n media contrl rcvd:n/a timestamp:n/a
 long duration call detected:n long duration call duration:n/a timestamp:n/a


Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
```

Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2

CME-SideA#show call active voice compact
<callID> A/O FAX T<sec> Codec type Peer Address IP R<ip>:<udp>
Total call-legs: 2
224 ANS T34 g729r8 TELE P6001
225 ORG T34 g729r8 VOIP P97804921930 15.1.6.2:16630

On the FXO router

FX0-SideA#show call active voice brief
<ID>: <start>hs.<index> +<connect> pid:<peer_id> <dir> <addr> <state>
dur hh:mm:ss tx:<packets>/<bytes> rx:<packets>/<bytes>
IP <ip>:<udp> rtt:<time>ms pl:<play>/<gap>ms lost:<lost>/<early>/<late>
delay:<last>/<min>/<max>ms <codec>
MODEMPASS <method> buf:<fills>/<drains> loss <overall%> <multipkt>/<corrected>
last <buf event time>s dur:<Min>/<Max>s
FR <protocol> [int dlci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
<codec> (payload size)
ATM <protocol> [int vpi/vci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
<codec> (payload size)
Tele <int> (callID) [channel_id] tx:<tot>/<v>/<fax>ms <codec> noise:<l> acom:<l> i/o:<l>/<l> dBm
MODEMRELAY info:<rcvd>/<sent>/<resent> xid:<rcvd>/<sent> total:<rcvd>/<sent>/<drops>
speeds(bps): local <rx>/<tx> remote <rx>/<tx>
Proxy <ip>:<audio udp>,<video udp>,<tcp0>,<tcp1>,<tcp2>,<tcp3> endpt: <type>/<manf>
bw: <req>/<act> codec: <audio>/<video>
tx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>
rx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>

Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
MGCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2
1418 : 164447750ms.1 +3540 pid:1 Answer 6001 active
dur 00:00:48 tx:1744/34669 rx:2435/48700
IP 15.1.6.1:16536 rtt:1ms pl:47360/0ms lost:0/0/0 delay:60/60/70ms g729r8

1418 : 164447770ms.1 +3510 pid:2 Originate 97804921930 active
dur 00:00:48 tx:2436/48720 rx:1745/34689
Tele 1/0/0 (104) [1/0/0] tx:48860/34770/0ms g729r8 noise:-55 acom:25 i/0:-53/-35 dBm

Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
MGCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2

FX0-SideA#show call active voice compact
G<id> A/O FAX T<sec> Codec type Peer Address IP R<ip>:<udp>
Total call-legs: 2
G1418 ANS T54 g729r8 VOIP P6001 15.1.6.1:16536
G1418 ORG T54 g729r8 TELE P97804921930

Que 1: The main difference is that the call went out through the voice gateway
Que2: Calling from 7804921930

FX0-SideA#show call active voice compact

```
G<id>  A/O FAX T<sec> Codec      type  Peer Address      IP R<ip>:<udp>
Total call-legs: 2
G11E3  ANS     T18    g729r8     TELE  P
G11E3  ORG     T18    g729r8     VOIP  P6001        15.1.6.1:16540
```

No Number showed up because there is no caller ID feature enabled

6) Routing table on CME and FXO

```
CME-SideA#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      11.0.0.0/30 is subnetted, 1 subnets
O        11.1.6.0 [110/2] via 15.1.6.2, 00:01:07, GigabitEthernet0/0
      15.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
O        15.1.2.0/30 [110/3] via 15.1.6.2, 00:00:18, GigabitEthernet0/0
C        15.1.6.0/30 is directly connected, GigabitEthernet0/0
L        15.1.6.1/32 is directly connected, GigabitEthernet0/0
      192.168.6.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.6.0/24 is directly connected, GigabitEthernet0/1.6
L        192.168.6.1/32 is directly connected, GigabitEthernet0/1.6
      192.168.7.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.7.0/24 is directly connected, GigabitEthernet0/1.7
L        192.168.7.1/32 is directly connected, GigabitEthernet0/1.7
CME-SideA#
```

```
FX0-SideA#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-
       ia - IS-IS inter area, * - candidate default, U - per-user static ro
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     11.0.0.0/30 is subnetted, 1 subnets
C       11.1.6.0 is directly connected, FastEthernet0/1
     15.0.0.0/30 is subnetted, 2 subnets
C       15.1.6.0 is directly connected, FastEthernet0/0
O       15.1.2.0 [110/2] via 11.1.6.1, 00:00:45, FastEthernet0/1
FX0-SideA#
```

7) Call from 6001 to 2003

```
CME #show call active voice brief
<ID>: <CallID> <start>ms.<index> (<start>) +<connect> pid:<peer_id> <dir> <addr> <state>
  dur hh:mm:ss tx:<packets>/<bytes> rx:<packets>/<bytes> dscp:<packets violation> media:<packets violation> audio tos:<audio tos
value> video tos:<video tos value>
 IP <ip>:<udp> rtt:<time>ms pl:<play>/<gap>ms lost:<lost>/<early>/<late>
  delay:<last>/<min>/<max>ms <codec> <textrelay> <transcoded

 media inactive detected:<y/n> media cntrl rcvd:<y/n> timestamp:<time>
```

long duration call detected:<y/n> long duration call duration :<sec> timestamp:<time>
MODEMPASS <method> buf:<fills>/<drains> loss <overall%> <multipkt>/<corrected>
last <buf event time>s dur:<Min>/<Max>s
FR <protocol> [int dlci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
<codec> (payload size)
ATM <protocol> [int vpi/vci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
<codec> (payload size)
Tele <int> (callID) [channel_id] tx:<tot>/<v>/<fax>ms <codec> noise:<l> acom:<l> i/o:<l>/<l> dBm
MODEMRELAY info:<rcvd>/<sent>/<resent> xid:<rcvd>/<sent> total:<rcvd>/<sent>/<drops>
speeds(bps): local <rx>/<tx> remote <rx>/<tx>
Proxy <ip>:<audio udp>,<video udp>,<tcp0>,<tcp1>,<tcp2>,<tcp3> endpt: <type>/<manf>
bw: <req>/<act> codec: <audio>/<video>
tx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>
rx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>

Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2
1429 : 231 176355210ms.1 (14:27:27.788 UTC Sun Apr 3 2016) +3030 pid:20001 Answer 6001 active
dur 00:00:42 tx:1989/63648 rx:1985/63520 dscp:0 media:0 audio tos:0x0 video tos:0x0
Tele 50/0/1 (231) [50/0/1.0] tx:39780/39780/0ms g729r8 noise:0 acom:0 i/0:0/0 dBm

1429 : 232 176357080ms.1 (14:27:29.658 UTC Sun Apr 3 2016) +1160 pid:3 Originate 2003 active
dur 00:00:42 tx:2100/42000 rx:2097/41940 dscp:0 media:0 audio tos:0xB8 video tos:0x0
IP 15.1.2.1:16444 SRTP: off rtt:0ms pl:34700/0ms lost:0/0/0 delay:0/0/0ms g729r8 TextRelay: off Transcoded: No
media inactive detected:n media contrl rcvd:n/a timestamp:n/a
long duration call detected:n long duration call duration:n/a timestamp:n/a

Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2

CME #show call active voice compact
<callID> A/O FAX T<sec> Codec type Peer Address IP R<ip>:<udp>
Total call-legs: 2
231 ANS T50 g729r8 TELE P6001
232 ORG T50 g729r8 VOIP P2003 15.1.2.1:16444

8) Call from 6001 to 2003 with the WAN link is down

FX0-SideA#debug dialpeer
dialpeer detailed info debugging is on
FX0-SideA#
*Mar 2 22:34:21.788: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastE
thernet0/1, changed state to down
*Mar 2 22:34:21.792: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.11.1 on FastEt
hernet0/1 from FULL to DOWN, Neighbor Down: Interface down or detached
FX0-SideA#
FX0-SideA#
*Mar 2 22:34:48.784: Inside dpMatchCore:
*Mar 2 22:34:48.784: destination pattn: 2003 expanded string: 2003
*Mar 2 22:34:48.784: Inside dpMatchCore:
*Mar 2 22:34:48.784: destination pattn: 6001 expanded string: 6001
*Mar 2 22:34:48.784: Inside dpMatchCore:

```
*Mar  2 22:34:48.788:  destination pattn: 6001 expanded string: 6001
*Mar  2 22:34:48.788: MatchNextPeer: Peer 1 matched
*Mar  2 22:34:48.792:  Inside dpMatchCore:
*Mar  2 22:34:48.792:  destination pattn: 2003 expanded string: 2003
*Mar  2 22:34:48.792:  Inside dpMatchCore:
*Mar  2 22:34:48.792:  destination pattn: 6001 expanded string: 6001
*Mar  2 22:34:48.792:  Inside dpMatchCore:
*Mar  2 22:34:48.792:  destination pattn: 6001 expanded string: 6001
*Mar  2 22:34:48.792: MatchNextPeer: Peer 1 matched
*Mar  2 22:34:48.796:  Inside dpMatchCore:
*Mar  2 22:34:48.796:  destination pattn: 2003 expanded string: 2003
*Mar  2 22:34:48.796:  Inside dpMatchCore:
*Mar  2 22:34:48.796:  destination pattn: 6001 expanded string: 6001
*Mar  2 22:34:48.796:  Inside dpMatchCore:
*Mar  2 22:34:48.796:  destination pattn: 6001 expanded string: 6001
*Mar  2 22:34:48.796: MatchNextPeer: Peer 1 matched
*Mar  2 22:34:48.804:  Inside dpMatchPeersMoreArg
*Mar  2 22:34:48.804: dpMatchPeersMoreArg: Match Dest. pattern; called (200
3)
*Mar  2 22:34:48.804:  Inside dpMatchCore:
*Mar  2 22:34:48.804:  destination pattn: 2003 expanded string: 2003
*Mar  2 22:34:48.804: MatchNextPeer: Peer 3 matched
*Mar  2 22:34:48.804: dpMatchPeersMoreArg: Result=0 after MATCH_ORIGINATE
*Mar  2 22:34:48.816: dp_check_and_notify_all_dp_state peer_tag 2
*Mar  2 22:34:48.816:  dpCheckTerminationStatus: Connection mode is not nor
mal
*Mar  2 22:34:48.816: dp_check_and_notify_all_dp_state tag 2 prev_state 1 c
urr_state 1
*Mar  2 22:34:48.816: dpSendTransitionEvent sending 0xFFFFFFFF event
*Mar  2 22:34:48.816: dp_check_and_notify_all_dp_state peer_tag 3
*Mar  2 22:34:48.816:  dpCheckTerminationStatus: Connection mode is not nor
mal
*Mar  2 22:34:48.816: dp_check_and_notify_all_dp_state tag 3 prev_state 1 c
urr_state 1
*Mar  2 22:34:48.816: dpSendTransitionEvent sending 0xFFFFFFFF event
```

Lab 2

Cisco Unified Call Manager
Multisite WAN with Centralized Call-Processing (With SRST)

Introduction:

Cisco Unified Call Manager or CUCM is one of the core solutions Cisco has come up with for IP Telephony. CUCM provides full feature set integrating audio, video, data, and mobility products and application. CUCM lies on Call Control layer of the Cisco UC Model's four standard layers. Unlike older versions of Call Manager, modern CUCM versions run as an appliance, thus underlying operating system is secured and cannot be modified. In clustered environment, CUCM can provide support for up to 30,000 SCCP or SIP IP Phones. Recent CUCM versions are supported in VMWare ESXi environment.

Cisco Unified Communications Manager provides signaling and call control services to Cisco integrated telephony applications as well as to third-party applications. It performs the following primary functions:

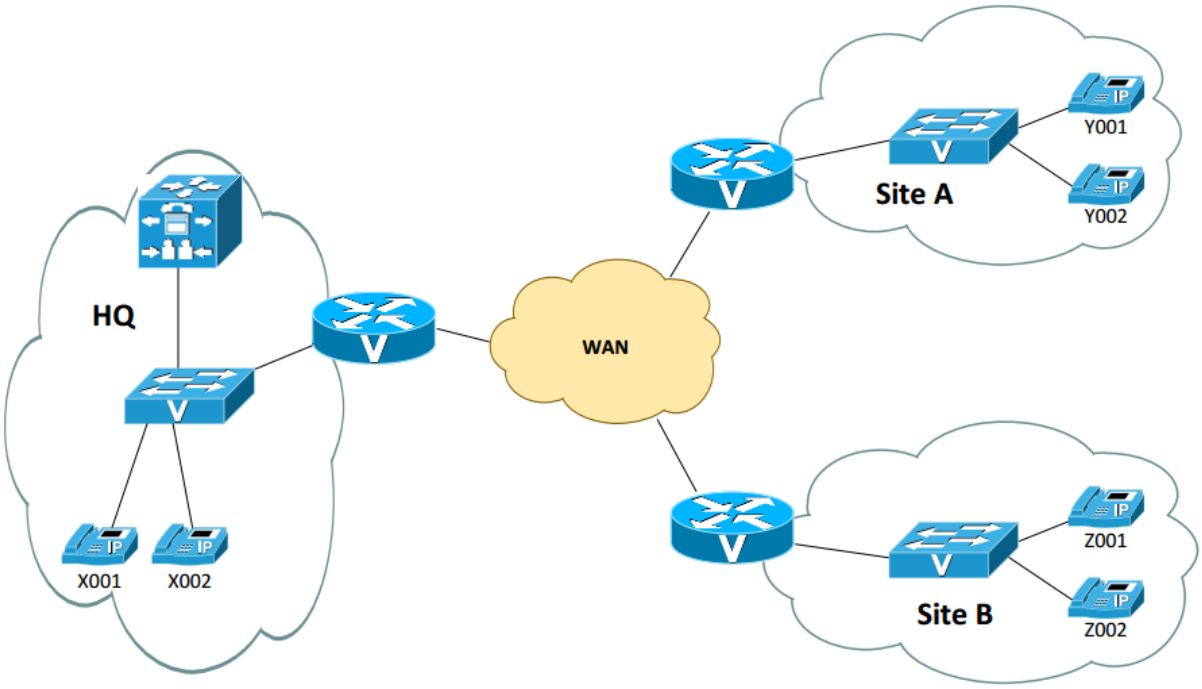
- Call processing
- Signaling and device control
- Dial plan administration
- Phone feature administration
- Directory services
- Operations, administration, management, and provisioning (OAM&P)
- Programming interface to external voice-processing applications such as Cisco IP Communicator, Cisco Unified IP Interactive Voice Response (IP IVR), and Cisco Unified Communications Manager Attendant Console

Pre-Lab:

1. What are basic functions CUCM provides?
2. How many servers can be in a CUCM cluster?
3. What are necessary services for Call manager to function and which page they can be
4. enabled from?
5. What is the difference between enterprise parameters and service parameters in CUCM?
6. Which command is used to get TFTP setting from the call manager server on a site gateway?
7. Which command at gateway can be used to point IP Phones to get DHCP configuration from
8. remote device.
9. What are the essential parameters to configure a Cisco IP Phone in CUCM?
10. What is a device pool and what features set it provides to devices?

11. What is partition and Calling Search Space (CSS) used for in CUCM?
12. What is the default connection monitor duration and where it can be modified?

Lab Diagram



IP Addressing

Node	IP
CUCM	192.168.1.X
HQ Gateway to CUCM	192.168.1.0/24
HQ to SW-HQ	Voice VLAN X1.1.1.1/24
	Data VLAN X2.1.1.1/24
SiteA to SW-A	Voice VLAN X3.1.1.1/24
	Data VLAN X4.1.1.1/24
SiteB to SW-B	Voice VLAN X5.1.1.1/24
	Data VLAN X6.1.1.1/24
WAN	X.1.1.0/29

Procedure

A- Install and setup CUCM

1. Install VMware ESXi on bare metal server
2. Use given ISO image and install CUCM 11.5 on VMware ESXi hypervisor on server.
   Hint: to access ESXi, first install VMware vSphere client
3. Assign hostname as CUCM-X and IP address as given, also do the installation without DNS.
4. Point CUCM towards a reliable NTP server.
   Hint: You may setup gateway router as NTP server with stratum at least 2.
5. Set various passwords asked during the installation and remember them to access CUCM.
6. Identify necessary services and activate them from serviceability page.
7. Remove DNS reliance from server option and enterprise parameters.
8. Configure IP Phones; at least one per location, you can install Cisco Softphone CIPC in your laptop.

B- Setup gateways and switches at all three locations HQ, Site A and Site B

1- Assign IP addresses as stated in the table
2- Configure sub-interfaces with IP helper address and encryption
3- Configure DHCP pool for voice and data
4- Configure switches with trunks and VLANs
5- Configure IGP on entire network (OSPF area 100)
6- Connect IP phones and check if they are getting IP address from their gateway
7- Check if the IP phones are registered to CUCM and are getting proper extensions
8- Check if they can call each other

C- Configure SRST

1- Configure SRST references and Device Pool for all three sites
2- Modify IP phone settings, assign respective device pool to IP phones according to their location.
3- Configure gateway to support survivability in case CUCM is unreachable i.e configure CUCM to SRST switchover.
4- Test SRST by shutting down call manager service from serviceability page, also note down the approximate time for the switch over from CUCM to gateway and vice versa.
5- Reduce the switch over time.
6- Make sure each phone registers with its gateway and retain the same extensions.
7- Configure dial-peers for each site and check call coverage.

Deliverables

Before enabling SRST:

1- Running configuration of all routers. Just include interfaces, OSPF and DHCP configuration.
2- Show vlan brief on all switches.
3- Show power inline output of all switches.
4- Show cdp neighbors output on all switches.
5- Show ip dhcp binding output on all gateways.
6- Show ip route ospf output on all gateways.
7- CUCM serviceability page screenshot after activating necessary services.
8- CUCM enterprise parameters: screenshot of Phone URL parameters.
9- IP Phone registration screenshot along with their assigned extensions.
Hint: Filter as directory number in 'Find phone where' and click on find.

After enabling SRST:

10- CUCM SRST references screenshot
11- All device pool screenshot
12- Gateway SRST fallback configuration
13- Output of show ephone registered on all gateways.
14- What is the result of branch to branch calling?
15- Does call completes? If No, what are the root cause and what configuration is missing?
16- Dial-peer configuration on all gateways
17- Result of branch to branch calling. e.g. Call from HQ to Site1:
    a. Show call active voice brief at HQ and Site1 gateway.
    b. Show call active voice compact at HQ and Site1 gateway.
18- Restore SRST and provide output of ephone unregistration at HQ gateway.

Instructions to follow at end of each lab:

1- Make sure you erase your configuration from NVRAM of the devices used.
Note: Use TFTP server to copy your configuration if required.
2- Do not save any of the configurations in Flash memory.
3- All cables must be unplugged and secured in the box.
4- There must not be any kind of garbage around the desk or racks after you are done with your lab.

Before enabling SRST:

1) Running Config of routers

```
HQ#show run
ip dhcp excluded-address 61.1.1.1 61.1.1.10
ip dhcp excluded-address 62.1.1.1 62.1.1.10
!
ip dhcp pool voice-scope
 network 61.1.1.0 255.255.255.0
 default-router 61.1.1.1
 option 150 ip 192.168.1.1
!
ip dhcp pool data-scope
 network 62.1.1.0 255.255.255.0
 default-router 62.1.1.1

interface GigabitEthernet0/0
 ip address 6.1.1.3 255.255.255.248
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
!
interface GigabitEthernet0/1.61
 encapsulation dot1Q 61
 ip address 61.1.1.1 255.255.255.0
!
interface GigabitEthernet0/1.62
 encapsulation dot1Q 62
 ip address 62.1.1.1 255.255.255.0
!
interface GigabitEthernet0/2
 ip address 192.168.1.2 255.255.255.0
 duplex auto
 speed auto
!
!
router ospf 1
 network 6.1.1.0 0.0.0.7 area 6
 network 61.1.1.0 0.0.0.255 area 6
 network 192.168.1.0 0.0.0.255 area 6


Site1#show run
ip dhcp excluded-address 63.1.1.1 63.1.1.10
ip dhcp excluded-address 64.1.1.1 64.1.1.10
!
ip dhcp pool voice-scope
 network 63.1.1.0 255.255.255.0
 default-router 63.1.1.1
 option 150 ip 192.168.1.1
!
ip dhcp pool data-scope
 network 64.1.1.0 255.255.255.0
 default-router 64.1.1.1
!
interface GigabitEthernet0/0
 ip address 6.1.1.1 255.255.255.248
 duplex auto
 speed auto
!
```

```
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
!
interface GigabitEthernet0/1.63
 encapsulation dot1Q 63
 ip address 63.1.1.1 255.255.255.0
!
interface GigabitEthernet0/1.64
 encapsulation dot1Q 64
 ip address 64.1.1.1 255.255.255.0
!
router ospf 1
 network 6.1.1.0 0.0.0.7 area 6
 network 63.1.1.0 0.0.0.255 area 6
```

```
Site2#show run
ip dhcp excluded-address 65.1.1.1 65.1.1.10
ip dhcp excluded-address 66.1.1.1 66.1.1.10
!
ip dhcp pool voice-scope
 network 65.1.1.0 255.255.255.0
 default-router 65.1.1.1
 option 150 ip 192.168.1.1
!
ip dhcp pool data-scope
 network 66.1.1.0 255.255.255.0
 default-router 66.1.1.1

interface GigabitEthernet0/0
 ip address 6.1.1.2 255.255.255.248
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
!
interface GigabitEthernet0/1.65
 encapsulation dot1Q 65
 ip address 65.1.1.1 255.255.255.0
!
interface GigabitEthernet0/1.66
 encapsulation dot1Q 66
 ip address 66.1.1.1 255.255.255.0
!
router ospf 1
 network 6.1.1.0 0.0.0.7 area 6
 network 65.1.1.0 0.0.0.255 area 6
```

2) Show vlan on the switch: Please note was add vlan 24 to connect my laptop to the CUCM.

```
VLAN Name                              Status    Ports
---- --------------------------------- --------- -------------------------------
1    default                           active    Gi0/4, Gi0/8, Gi0/15, Gi0/16
                                                 Gi0/17, Gi0/18, Gi0/19, Gi0/20
                                                 Gi0/21
24   VLAN0024                          active    Gi0/12, Gi0/13, Gi0/14
61   Voice-HQ                          active    Gi0/10, Gi0/11
62   Data-HQ                           active    Gi0/10, Gi0/11
63   Voice-Site1                       active    Gi0/2, Gi0/3
```

```
64   Data-Site1                  active    Gi0/2, Gi0/3
65   Voice-Site2                 active    Gi0/6, Gi0/7
66   Data-Site2                  active    Gi0/6, Gi0/7
100  WAN                         active    Gi0/22, Gi0/23, Gi0/24
1002 fddi-default                act/unsup
1003 token-ring-default          act/unsup
1004 fddinet-default             act/unsup
1005 trnet-default               act/unsup
Switch#
```

3) Show power inline:

```
Switch#show power inline
Available:495.0(w)  Used:18.9(w)  Remaining:476.1(w)

Interface Admin  Oper       Power   Device              Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi0/1     auto   off        0.0     n/a                 n/a   30.0
Gi0/2     auto   on         6.3     IP Phone 7941       2     30.0
Gi0/3     auto   off        0.0     n/a                 n/a   30.0
Gi0/4     auto   off        0.0     n/a                 n/a   30.0
Gi0/5     auto   off        0.0     n/a                 n/a   30.0
Gi0/6     auto   on         6.3     IP Phone 7941       2     30.0
Gi0/7     auto   off        0.0     n/a                 n/a   30.0
Gi0/8     auto   off        0.0     n/a                 n/a   30.0
Gi0/9     auto   off        0.0     n/a                 n/a   30.0
Gi0/10    auto   on         6.3     IP Phone 7941       2     30.0
Gi0/11    auto   off        0.0     n/a                 n/a   30.0
Gi0/12    auto   off        0.0     n/a                 n/a   30.0
Gi0/13    auto   off        0.0     n/a                 n/a   30.0
Gi0/14    auto   off        0.0     n/a                 n/a   30.0
Gi0/15    auto   off        0.0     n/a                 n/a   30.0
Gi0/16    auto   off        0.0     n/a                 n/a   30.0
Gi0/17    auto   off        0.0     n/a                 n/a   30.0
Gi0/18    auto   off        0.0     n/a                 n/a   30.0
Gi0/19    auto   off        0.0     n/a                 n/a   30.0
Interface Admin  Oper       Power   Device              Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi0/20    auto   off        0.0     n/a                 n/a   30.0
Gi0/21    auto   off        0.0     n/a                 n/a   30.0
Gi0/22    auto   off        0.0     n/a                 n/a   30.0
Gi0/23    auto   off        0.0     n/a                 n/a   30.0
Gi0/24    auto   off        0.0     n/a                 n/a   30.0
```

4) Show CDP neighbours on the switch

```
Switch#show cdp neighbors

Device ID       Local Intrfce     Holdtme    Capability  Platform  Port ID
HQ              Gig 0/14          146           R S I  CISCO2921 Gig 0/2
HQ              Gig 0/9           163           R S I  CISCO2921 Gig 0/1
HQ              Gig 0/24          147           R S I  CISCO2921 Gig 0/0
Site2           Gig 0/5           171           R S I  CISCO2921 Gig 0/1
Site2           Gig 0/23          138           R S I  CISCO2921 Gig 0/0
Site1           Gig 0/22          136           R B S I CISCO2901 Gig 0/0
Site1           Gig 0/1           158           R B S I CISCO2901 Gig 0/1
Switch          Gig 0/12          134             S I   WS-C3560X Gig 0/23
SEP001BD52C4058  Gig 0/6           133           H P M  IP Phone  Port 1
SEP001BD5126D2D  Gig 0/10          139           H P M  IP Phone  Port 1
SEP001BD52C396C  Gig 0/2           139           H P M  IP Phone  Port 1
```

5) Show ip DHCP binding ‘

HQ#show ip dhcp binding
Bindings from all pools not associated with VRF:
61.1.1.11 0100.1bd5.126d.2d Apr 05 2016 09:52 PM Automatic
61.1.1.12 0100.0750.d54f.a6 Apr 05 2016 09:37 PM Automatic
62.1.1.11 0120.8984.37be.de Apr 05 2016 06:48 PM Automatic

Site1#show ip dhcp binding
Bindings from all pools not associated with VRF:
63.1.1.12 0100.1bd5.2c39.6c Apr 05 2016 09:52 PM Automatic
64.1.1.11 0120.8984.37be.de Apr 05 2016 06:43 PM Automatic
Site1#

Site2#show ip dhcp binding
Bindings from all pools not associated with VRF:
65.1.1.11 0100.1bd5.2c39.6c Apr 05 2016 06:45 PM Automatic
65.1.1.12 0100.1bd5.2c40.58 Apr 05 2016 09:55 PM Automatic
66.1.1.11 0120.8984.37be.de Apr 05 2016 06:46 PM Automatic

6) Show IP route ospf

HQ#show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
+ - replicated route, % - next hop override

Gateway of last resort is not set

63.0.0.0/24 is subnetted, 1 subnets
O 63.1.1.0 [110/2] via 6.1.1.1, 01:05:05, GigabitEthernet0/0
65.0.0.0/24 is subnetted, 1 subnets
O 65.1.1.0 [110/2] via 6.1.1.2, 01:01:29, GigabitEthernet0/0

Site1#show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
a - application route
+ - replicated route, % - next hop override

Gateway of last resort is not set

61.0.0.0/24 is subnetted, 1 subnets
O 61.1.1.0 [110/2] via 6.1.1.3, 01:03:26, GigabitEthernet0/0
65.0.0.0/24 is subnetted, 1 subnets
O 65.1.1.0 [110/2] via 6.1.1.2, 01:02:28, GigabitEthernet0/0
O 192.168.1.0/24 [110/2] via 6.1.1.3, 02:47:59, GigabitEthernet0/0
Site1#

Site2#show ip route ospf

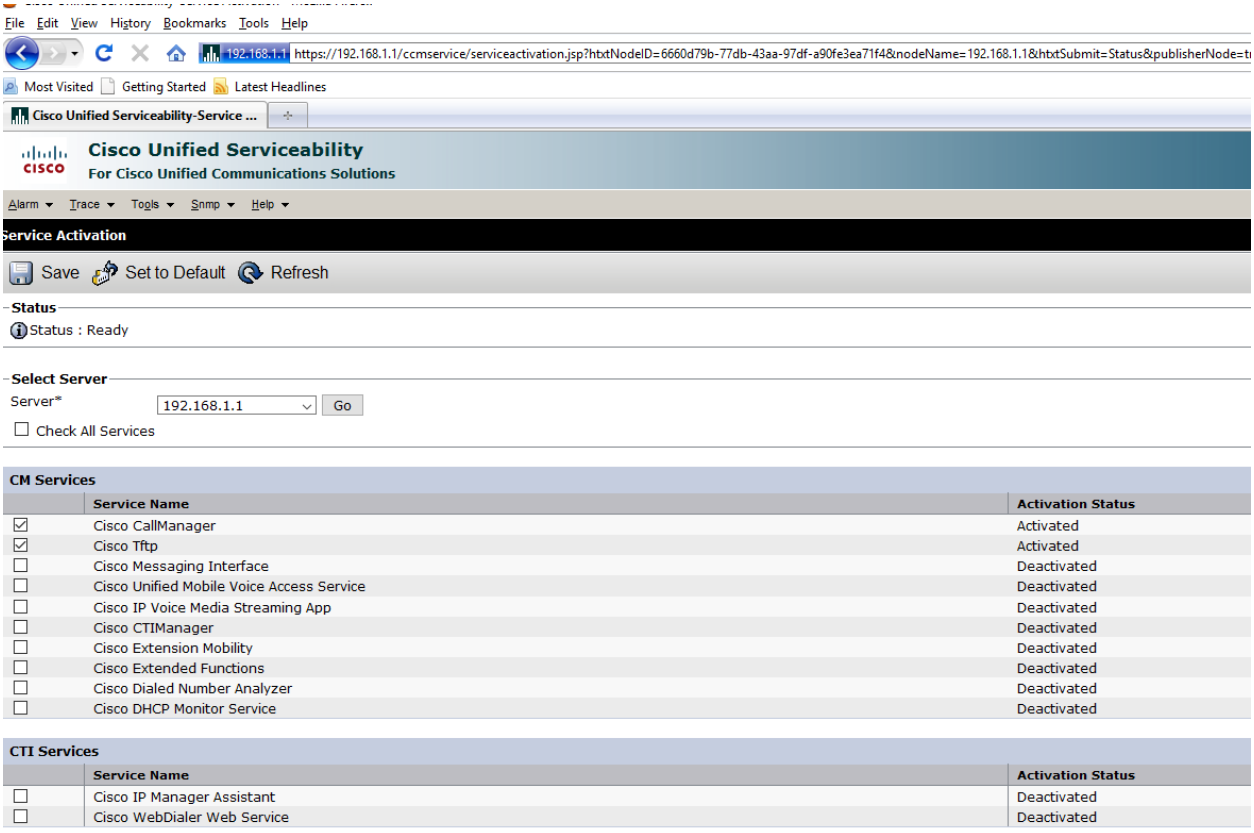
Router#show ip route ospf

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
a - application route
+ - replicated route, % - next hop override

Gateway of last resort is not set

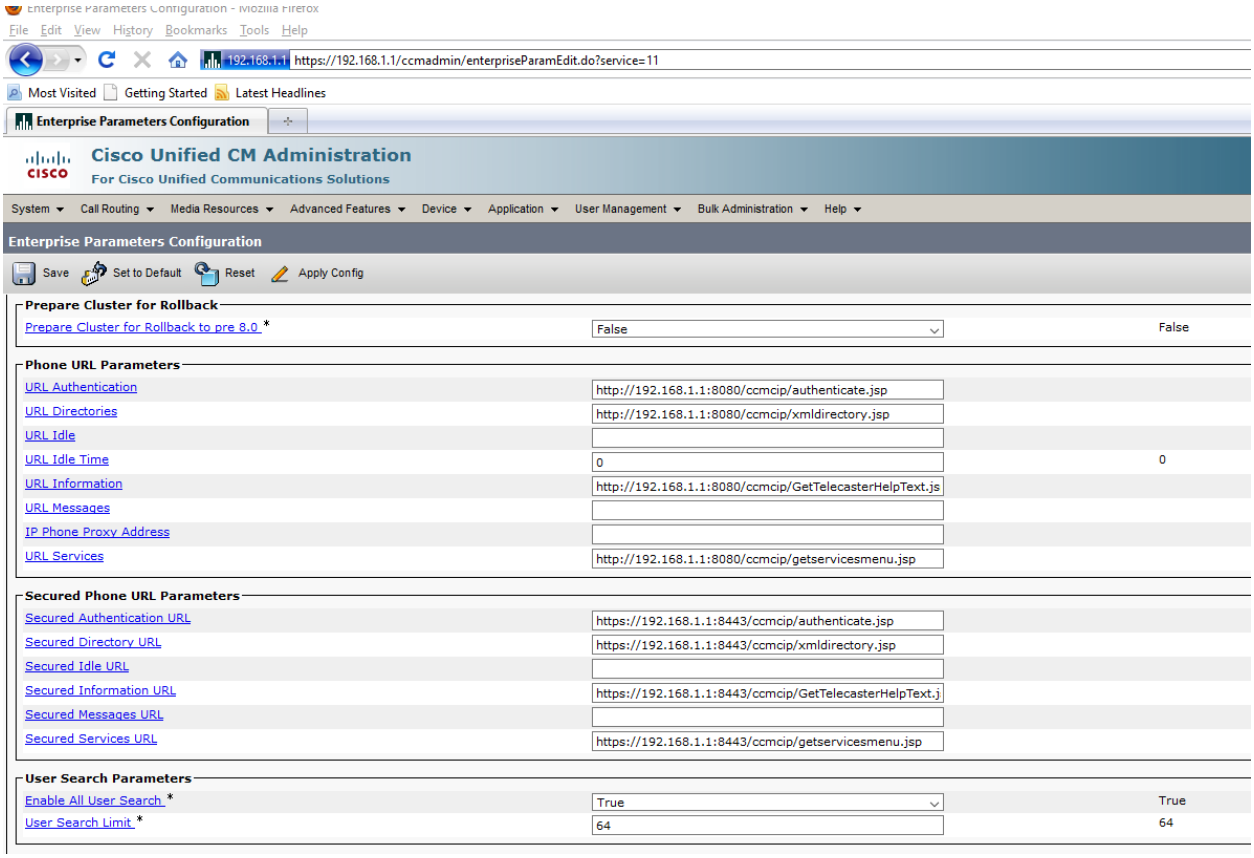
61.0.0.0/24 is subnetted, 1 subnets
O 61.1.1.0 [110/2] via 6.1.1.3, 00:02:26, GigabitEthernet0/0
63.0.0.0/24 is subnetted, 1 subnets
O 63.1.1.0 [110/2] via 6.1.1.1, 00:02:26, GigabitEthernet0/0
O 192.168.1.0/24 [110/2] via 6.1.1.3, 00:02:26, GigabitEthernet0/0

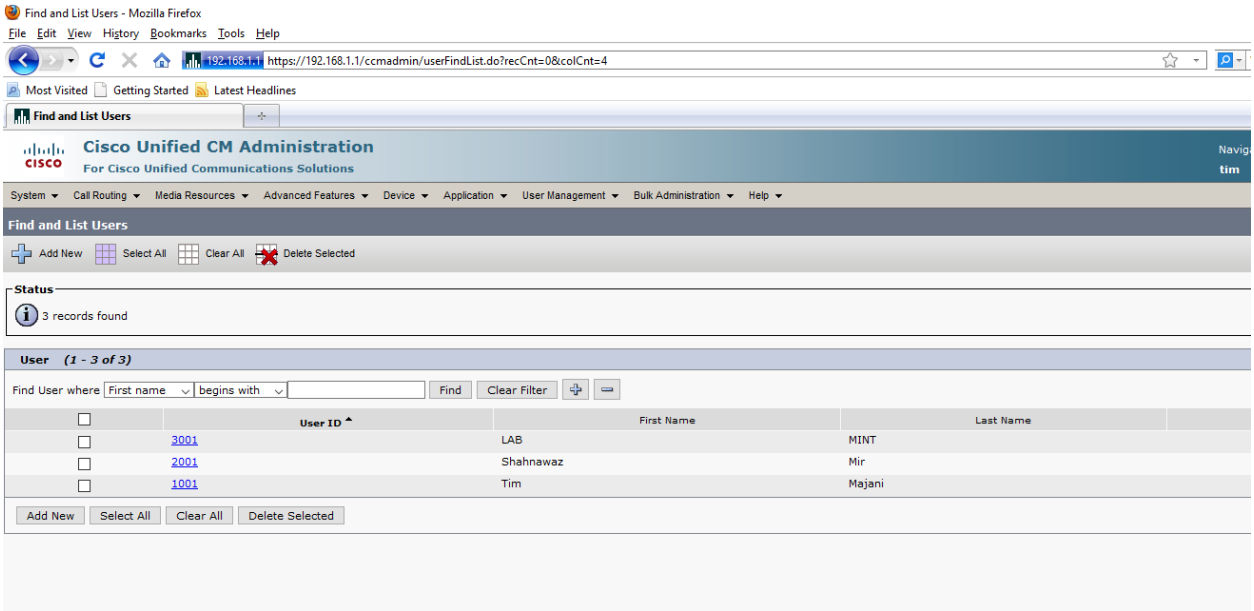
7)

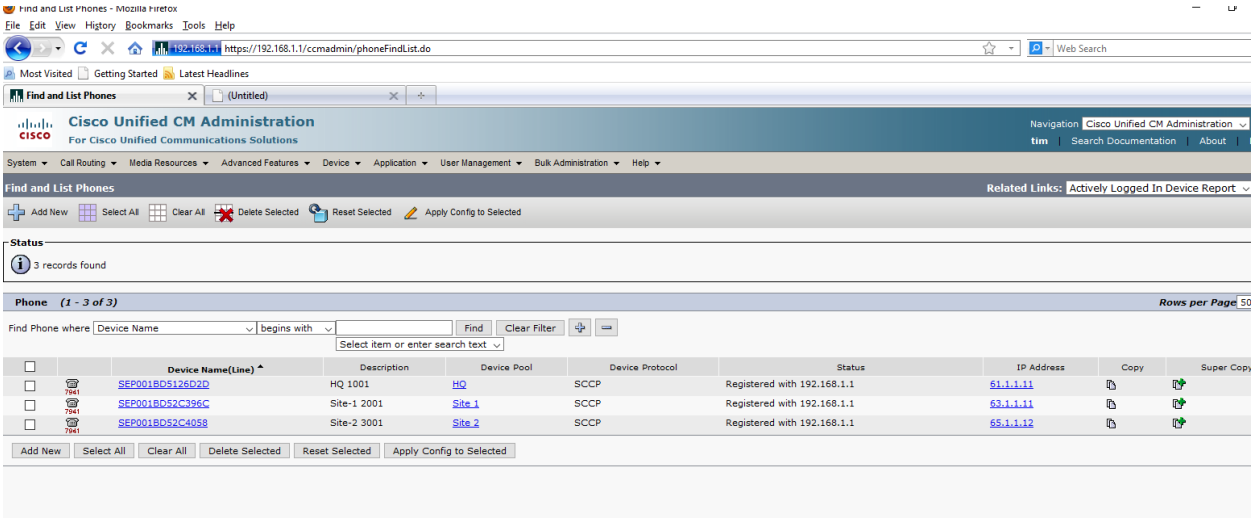


8)

9)

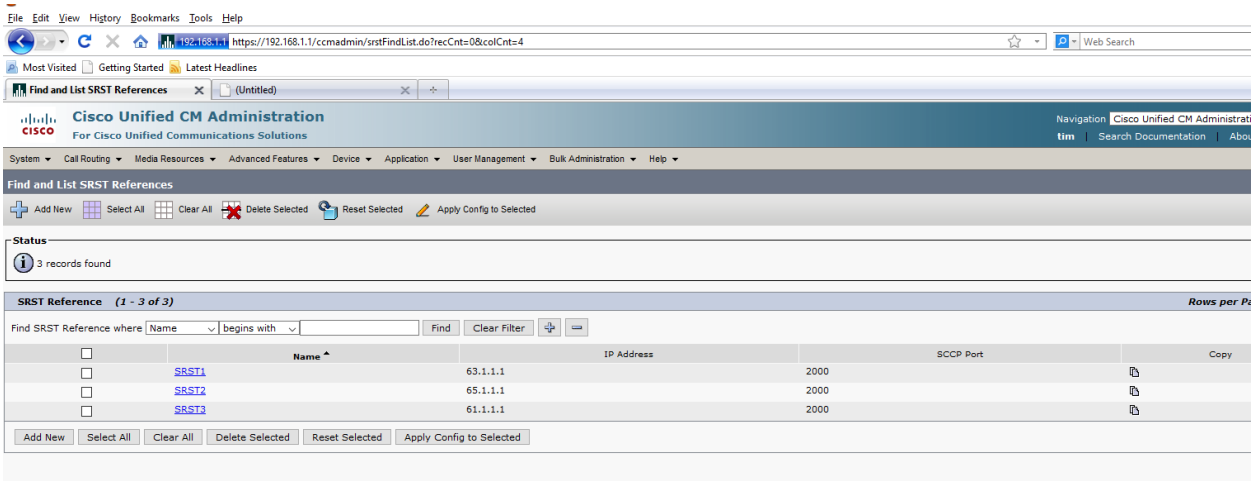

Enterprise Parameters Configuration - Mozilla Firefox
File Edit View History Bookmarks Tools Help
https://192.168.1.1/ccmadmin/enterpriseParamEdit.do?service=11
Most Visited Getting Started Latest Headlines
Enterprise Parameters Configuration
Cisco Unified CM Administration
For Cisco Unified Communications Solutions
System Call Routing Media Resources Advanced Features Device Application User Management Bulk Administration Help
Enterprise Parameters Configuration
Save Set to Default Reset Apply Config
Prepare Cluster for Rollback
Prepare Cluster for Rollback to pre 8.0 * False False
Phone URL Parameters
URL Authentication http://192.168.1.1:8080/ccmcip/authenticate.jsp
URL Directories http://192.168.1.1:8080/ccmcip/xmldirectory.jsp
URL Idle
URL Idle Time 0 0
URL Information http://192.168.1.1:8080/ccmcip/GetTelecasterHelpText.js
URL Messages
IP Phone Proxy Address
URL Services http://192.168.1.1:8080/ccmcip/getservicesmenu.jsp
Secured Phone URL Parameters
Secured Authentication URL https://192.168.1.1:8443/ccmcip/authenticate.jsp
Secured Directory URL https://192.168.1.1:8443/ccmcip/xmldirectory.jsp
Secured Idle URL
Secured Information URL https://192.168.1.1:8443/ccmcip/GetTelecasterHelpText.j
Secured Messages URL
Secured Services URL https://192.168.1.1:8443/ccmcip/getservicesmenu.jsp
User Search Parameters
Enable All User Search * True True
User Search Limit * 64 64


Find and List Users - Mozilla Firefox
File Edit View History Bookmarks Tools Help
https://192.168.1.1/ccmadmin/userFindList.do?recCnt=0&colCnt=4
Most Visited Getting Started Latest Headlines
Find and List Users
Cisco Unified CM Administration
For Cisco Unified Communications Solutions
System Call Routing Media Resources Advanced Features Device Application User Management Bulk Administration Help
Find and List Users
Add New Select All Clear All Delete Selected
Status
3 records found
User (1 - 3 of 3)
Find User where First name begins with Find Clear Filter
User ID First Name Last Name
3001 LAB MINT
2001 Shahnawaz Mir
1001 Tim Majani
Add New Select All Clear All Delete Selected

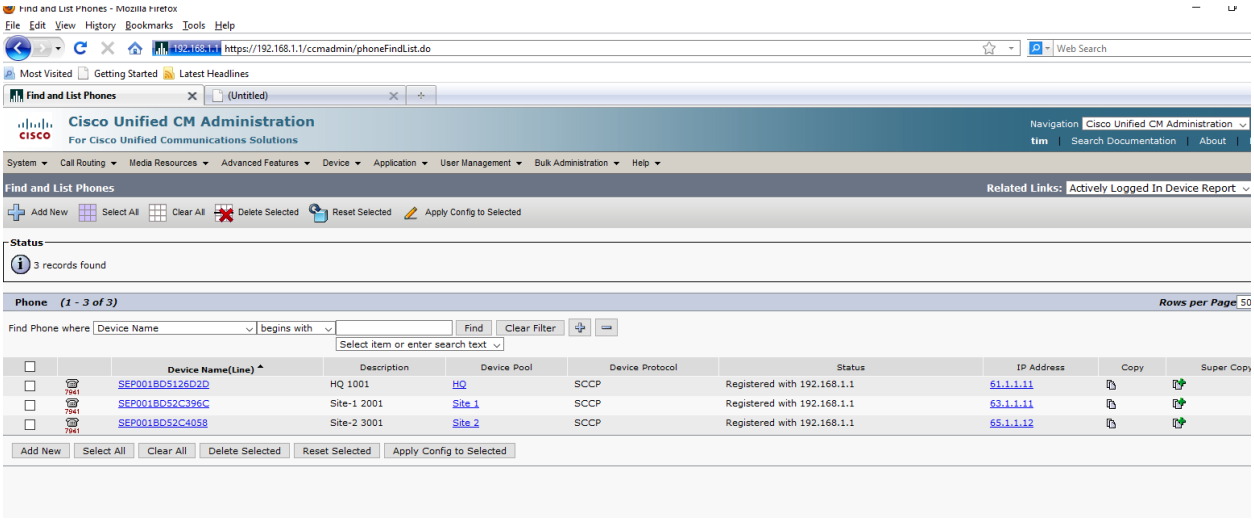


After enabling SRST:

1) CUCM SRST references screenshot



2) All device pool screenshot



3) Gateway SRST fallback configuration

Site 1

```
call-manager-fallback
 max-conferences 8 gain -6
 transfer-system full-consult
 ip source-address 63.1.1.1 port 2000
 max-ephones 5
 max-dn 5
```

Site 2

```
call-manager-fallback
 max-conferences 8 gain -6
 transfer-system full-consult
 ip source-address 65.1.1.1 port 2000
 max-ephones 5
 max-dn 5
```

HQ

```
call-manager-fallback
 max-conferences 8 gain -6
 transfer-system full-consult
 ip source-address 61.1.1.1 port 2000
 max-ephones 5
 max-dn 5
```

4) Output of show ephone registered on all gateways.

```
HQ#show ephone registered

ephone-1[0] Mac:001B.D512.6D2D TCP socket:[1] activeLine:0 whisperLine:0 REGISTERED in SCCP ver 19/17 max_streams=5
mediaActive:0 whisper_mediaActive:0 startMedia:0 offhook:0 ringing:0 reset:0 reset_sent:0 paging 0 debug:0 caps:11
IP:61.1.1.11 * 51727 7941  keepalive 63 max_line 2 available_line 2
button 1: cw:1 ccw:(0)
```

```
 dn 1  number 1001  CM Fallback CH1   IDLE
Preferred Codec: g711ulaw
Lpcor Type: none
HQ#
```

```
Site2#show ephone registered

ephone-1[0] Mac:001B.D52C.4058 TCP socket:[1] activeLine:0 whisperLine:0 REGISTERED in SCCP ver 19/17 max_streams=5
mediaActive:0 whisper_mediaActive:0 startMedia:0 offhook:0 ringing:0 reset:0 reset_sent:0 paging 0 debug:0 caps:11
IP:65.1.1.12 * 50747 7941  keepalive 3 max_line 2 available_line 2
button 1: cw:1 ccw:(0)
 dn 1  number 3001  CM Fallback CH1   IDLE
Preferred Codec: g711ulaw
Lpcor Type: none
```

```
Site1#show ephone registered

ephone-1[0] Mac:001B.D52C.396C TCP socket:[1] activeLine:0 whisperLine:0 REGISTERED in SCCP ver 19/17 max_streams=5
mediaActive:0 whisper_mediaActive:0 startMedia:0 offhook:0 ringing:0 reset:0 reset_sent:0 paging 0 debug:0 caps:11
IP:63.1.1.12 * 51816 7941  keepalive 1 max_line 2 available_line 2
button 1: cw:1 ccw:(0)
 dn 1  number 2001  CM Fallback CH1   IDLE
Preferred Codec: g711ulaw
Lpcor Type: none
Site1#
```

5) What is the result of branch to branch calling?

Calls were successful unless you are referring the dial peer which I already created

6) Dial-peer configuration on all gateways

HQ:

```
dial-peer voice 2 voip
 destination-pattern 3...
 session target ipv4:6.1.1.2
!
dial-peer voice 3 voip
 destination-pattern 2...
 session target ipv4:6.1.1.1
```

Site1 :

```
dial-peer voice 1 voip
 destination-pattern 1...
 session target ipv4:6.1.1.3
!
dial-peer voice 2 voip
 destination-pattern 3...
 session target ipv4:6.1.1.2
```

Site2:

```
dial-peer voice 1 voip
 destination-pattern 2...
 session target ipv4:6.1.1.1
!
```

```
dial-peer voice 2 voip
 destination-pattern 1...
 session target ipv4:6.1.1.3
```

7) Result of branch to branch calling. e.g. Call from HQ to Site1:

```
Site1#show call active voice brief
<ID>: <CallID> <start>ms.<index> (<start>) +<connect> pid:<peer_id> <dir> <addr> <state>
  dur hh:mm:ss tx:<packets>/<bytes> rx:<packets>/<bytes> dscp:<packets violation> media:<packets violation> audio tos:<audio tos
value> video tos:<video tos value>
 IP <ip>:<udp> rtt:<time>ms pl:<play>/<gap>ms lost:<lost>/<early>/<late>
  delay:<last>/<min>/<max>ms <codec> <textrelay> <transcoded

 media inactive detected:<y/n> media cntrl rcvd:<y/n> timestamp:<time>

 long duration call detected:<y/n> long duration call duration :<sec> timestamp:<time>
  MODEMPASS <method> buf:<fills>/<drains> loss <overall%> <multipkt>/<corrected>
   last <buf event time>s dur:<Min>/<Max>s
 FR <protocol> [int dlci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
  <codec> (payload size)
 ATM <protocol> [int vpi/vci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
  <codec> (payload size)
 Tele <int> (callID) [channel_id] tx:<tot>/<v>/<fax>ms <codec> noise:<l> acom:<l> i/o:<l>/<l> dBm
  MODEMRELAY info:<rcvd>/<sent>/<resent> xid:<rcvd>/<sent> total:<rcvd>/<sent>/<drops>
        speeds(bps): local <rx>/<tx> remote <rx>/<tx>
 Proxy <ip>:<audio udp>,<video udp>,<tcp0>,<tcp1>,<tcp2>,<tcp3> endpt: <type>/<manf>
 bw: <req>/<act> codec: <audio>/<video>
  tx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>
 rx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>



Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2
11F9 : 10 1235180ms.1 (*02:30:53.011 UTC Tue Apr 5 2016) +2260 pid:1 Answer 1001 active
 dur 00:00:35 tx:1757/35140 rx:1759/35180 dscp:0 media:0 audio tos:0xB8 video tos:0x0
 IP 6.1.1.3:31512 SRTP: off rtt:0ms pl:29040/0ms lost:0/0/0 delay:0/0/0ms g729r8 TextRelay: off Transcoded: No
 media inactive detected:n media contrl rcvd:n/a timestamp:n/a
 long duration call detected:n long duration call duration:n/a timestamp:n/a

11F9 : 11 1235190ms.1 (*02:30:53.021 UTC Tue Apr 5 2016) +2250 pid:20001 Originate 2001 active
 dur 00:00:35 tx:1701/54432 rx:1702/54464 dscp:0 media:0 audio tos:0x0 video tos:0x0
 Tele 50/0/1 (11) [50/0/1.0] tx:34020/34020/0ms g729r8 noise:0 acom:0  i/0:0/0 dBm


Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2


Site1#show call active voice brief
<ID>: <CallID> <start>ms.<index> (<start>) +<connect> pid:<peer_id> <dir> <addr> <state>
  dur hh:mm:ss tx:<packets>/<bytes> rx:<packets>/<bytes> dscp:<packets violation> media:<packets violation> audio tos:<audio tos
value> video tos:<video tos value>
 IP <ip>:<udp> rtt:<time>ms pl:<play>/<gap>ms lost:<lost>/<early>/<late>
```

```
 delay:<last>/<min>/<max>ms <codec> <textrelay> <transcoded

 media inactive detected:<y/n> media cntrl rcvd:<y/n> timestamp:<time>

 long duration call detected:<y/n> long duration call duration :<sec> timestamp:<time>
  MODEMPASS <method> buf:<fills>/<drains> loss <overall%> <multipkt>/<corrected>
   last <buf event time>s dur:<Min>/<Max>s
 FR <protocol> [int dlci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
  <codec> (payload size)
 ATM <protocol> [int vpi/vci cid] vad:<y/n> dtmf:<y/n> seq:<y/n>
  <codec> (payload size)
 Tele <int> (callID) [channel_id] tx:<tot>/<v>/<fax>ms <codec> noise:<l> acom:<l> i/o:<l>/<l> dBm
  MODEMRELAY info:<rcvd>/<sent>/<resent> xid:<rcvd>/<sent> total:<rcvd>/<sent>/<drops>
        speeds(bps): local <rx>/<tx> remote <rx>/<tx>
 Proxy <ip>:<audio udp>,<video udp>,<tcp0>,<tcp1>,<tcp2>,<tcp3> endpt: <type>/<manf>
 bw: <req>/<act> codec: <audio>/<video>
  tx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>
 rx: <audio pkts>/<audio bytes>,<video pkts>/<video bytes>,<t120 pkts>/<t120 bytes>



Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2
11F9 : 10 1235180ms.1 (*02:30:53.005 UTC Tue Apr 5 2016) +2260 pid:1 Answer 1001 active
 dur 00:02:09 tx:6450/129000 rx:6452/129040 dscp:0 media:0 audio tos:0xB8 video tos:0x0
 IP 6.1.1.3:31512 SRTP: off rtt:0ms pl:124040/0ms lost:0/0/0 delay:0/0/0ms g729r8 TextRelay: off Transcoded: No
 media inactive detected:n media contrl rcvd:n/a timestamp:n/a
 long duration call detected:n long duration call duration:n/a timestamp:n/a

11F9 : 11 1235190ms.1 (*02:30:53.015 UTC Tue Apr 5 2016) +2250 pid:20001 Originate 2001 active
 dur 00:02:09 tx:6201/198432 rx:6202/198464 dscp:0 media:0 audio tos:0x0 video tos:0x0
 Tele 50/0/1 (11) [50/0/1.0] tx:124020/124020/0ms g729r8 noise:0 acom:0  i/0:0/0 dBm


Telephony call-legs: 1
SIP call-legs: 0
H323 call-legs: 1
Call agent controlled call-legs: 0
SCCP call-legs: 0
Multicast call-legs: 0
Total call-legs: 2



HQ#show call active voice compact
 <callID>  A/O FAX T<sec> Codec      type       Peer Address      IP R<ip>:<udp>
Total call-legs: 2
      10 ANS     T72    g729r8     TELE       P1001
      11 ORG     T72    g729r8     VOIP       P2001        6.1.1.1:16392



Site1#show call active voice compact
 <callID>  A/O FAX T<sec> Codec      type       Peer Address      IP R<ip>:<udp>
Total call-legs: 2
      10 ANS     T111   g729r8     VOIP       P1001        6.1.1.3:31512
      11 ORG     T111   g729r8     TELE       P2001
```

8) Restore SRST and provide output of ephone unregistration at HQ gateway.

HQ(config-cm-fallback)#
Apr 5 02:41:00.807: %IPPHONE-6-UNREGISTER_NORMAL: ephone-1:SEP001BD5126D2D IP:61.1.1.12 Socket:1 DeviceType:Phone has unregistered normally.

Site2#
*Apr 5 02:38:18.299: %IPPHONE-6-UNREGISTER_NORMAL: ephone-1:SEP001BD52C4058 IP: 65.1.1.11 Socket:2 DeviceType:Phone has unregistered normally.

Site1#
*Apr 5 02:36:11.779: %IPPHONE-6-UNREGISTER_NORMAL: ephone-1:SEP001BD52C396C IP:63.1.1.12 Socket:1 DeviceType:Phone has unregistered normally.

Lab 3
Elastix -SIP

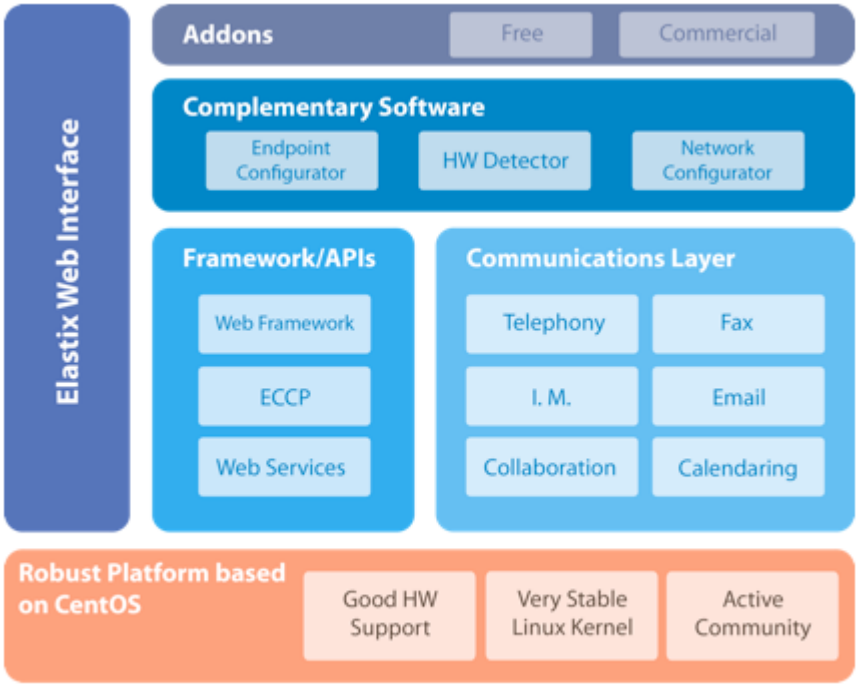
Introduction:

Elastix is an open source distribution of a Unified Communications Server that integrates different communications technologies in a single package, such as:

- PBX
- Fax
- Email
- Instant Messaging (IM)
- Calendar
- Collaboration

Elastix implements a great deal of its operation on four very important programs, which are Asterisk, Hylafax, Postfix and Openfire. These programs respectively give the PBX, Fax, Email and Instant Messaging functionality. The operating system is based on the popular Linux server-focused distro called CentOS.

The different Elastix components and their relationship to each other can be observed in the following figure:



General schematic of Elastix components

Pre-lab:

1. What is SIP?

2. What is the default port that SIP used? In which file, we can modify it?

3. What are the five SIP facets that are used to establishing and terminate multimedia communications and explain each briefly?

4. What is a SIP URI and explain the fields within the following URI sip:MINT:MINTLAB@192.168.1.100:5060;

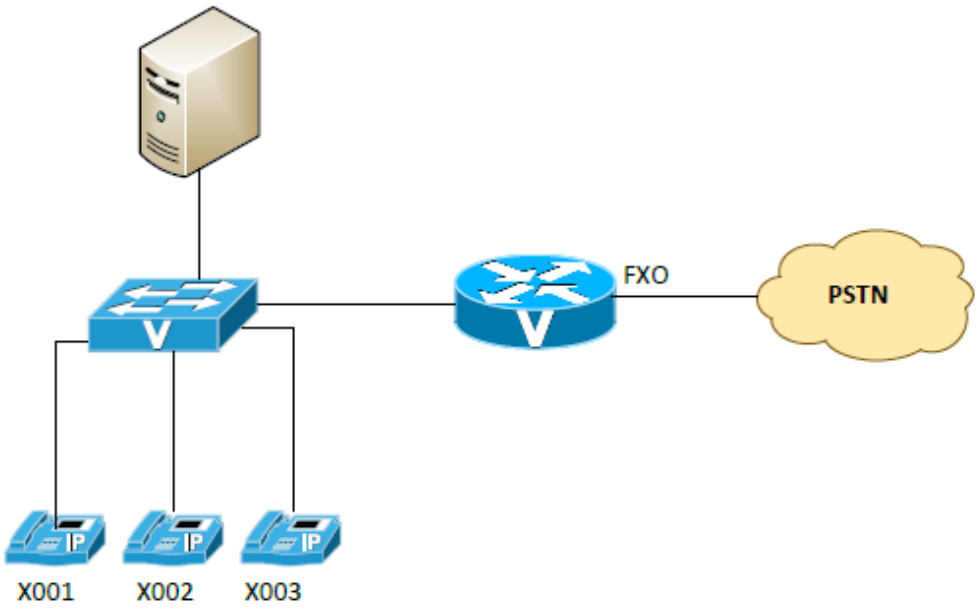
5. What are the different categories of status codes used on SIP? What is an UA on SIP?

6. What is a SIP Proxy server, SIP Redirect server, Location SIP Server and SIP Registrar server?

7. Name the five types of SIP methods that Cisco routers can generate and respond to and briefly explain each of them.

8. Which Layer 4 protocol does SIP support and which is used for SIP and SIPS and also which is the SIP default port?

Lab Diagram



Procedure:

1. Configure the FXO Router with a DHCP pool and provide the required options to provision a Cisco IP Phone. (Use subnet 192.168.X.0/24 over VLAN 1 to make it simple). Also, configure TFTP server on this router as Cisco phone might have trouble with TFTP server running on Elastix Server.

2. Install Xlite soft phone on your laptop.

3. Investigate which files you need to use to be able to provision Cisco 7960 and place them into the tftp directory on FXO router

4. Verify, modify and provision the required XML files to configure the Cisco 7960 IP Phone. You will be using Xlite extensions number your number X001, "sales 1" X002 and "Sales 2" X003

5. Configure all extensions on Elastix server
   a. Run sip show peers to show that all three phones are registered
   b. Place a phone call between them and capture the log for one test call

6. Configure Ring group so when calling sales both sales extension will ring simultaneously

7. Configure the Cisco Mid router (Cisco - FXO) to accept SIP trunks and connect one of the FXO to one of the four PSTN lines in the MINT Lab. Sip show peers to confirm that the SIP trunk is up.

8. Configure the Cisco FXO router to send all incoming calls to the IVR (Recording will be provided). Configure the IVR to dial the ring group for sales and your extension for receptionist.

9. Configure Elastix to send all the outgoing calls to the Cisco FXO router.

10. Place an external call (dial your own cell phone number) and then return the call dialing the PSTN number of the MINT Lab line used and the call has to be forwarded to IVR.

11. Configure voice mail for each extension and you should be receiving Voice mails in your email.

12. Configure follow me for your extension so after six rings the call automatically go to your cellphone, make a test call

Deliverables:

- Cisco FXO router's configuration.
- Screen shots of extensions, trunks, outbound route, and inbound route on Elastix server.
- Demonstration of IVR.
- Copy of email containing voicemail.
- Attach *.cnf files which you copied to router's flash.
- Include demonstration of IVR by adding screenshots of IVR config, system recordings and output from Elastix Server console while IVR is playing.
  Hint: You should see "Playing 'custom\yourfilename' output.
- Output from Elastix console of the follow me test call

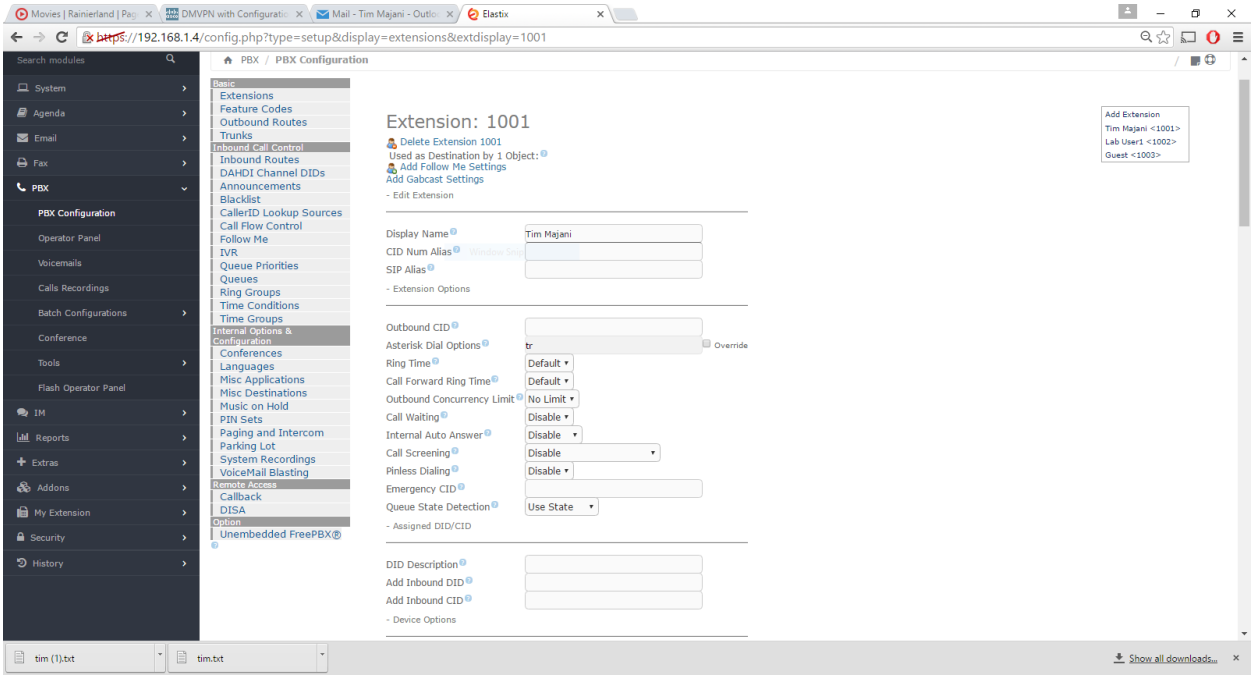
Instructions to follow at end of each lab:

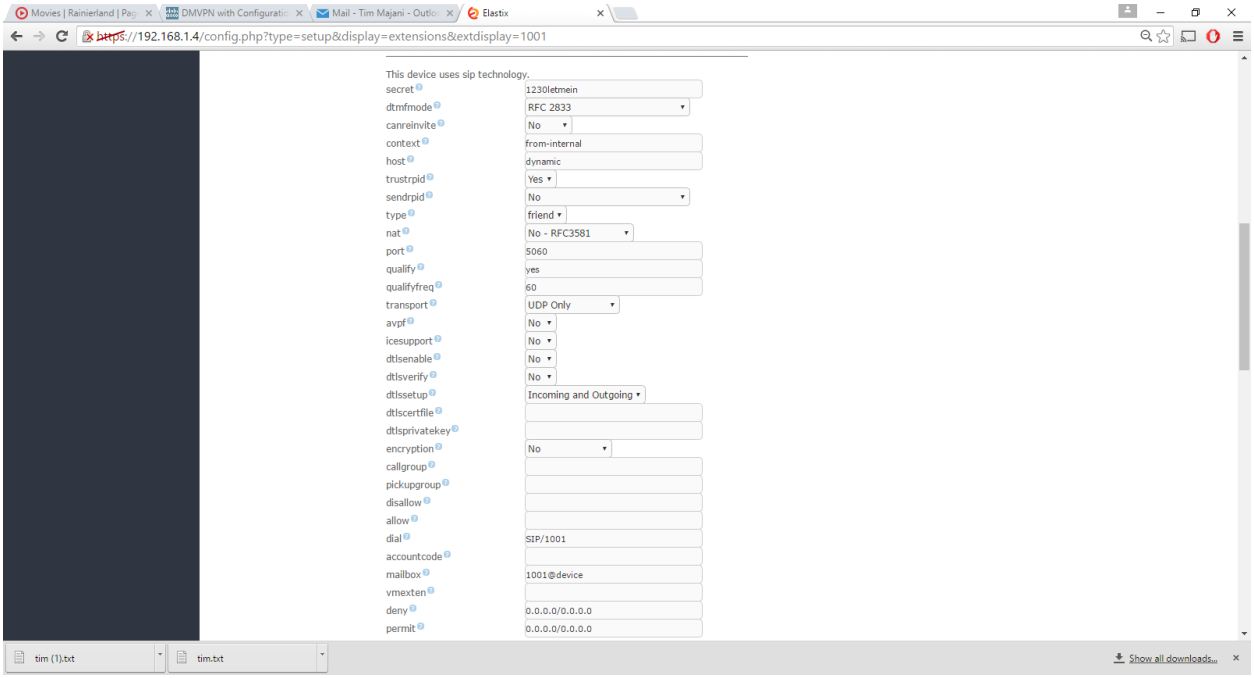
1) Make sure you erase your configuration from NVRAM of the devices used.
Note: Use TFTP server to copy your configuration if required.
2) Do not save any of the configurations in Flash memory.
3) All cables must be unplugged and secured in the box.
4) There must not be any kind of garbage around the desk or racks after you are done with your lab.

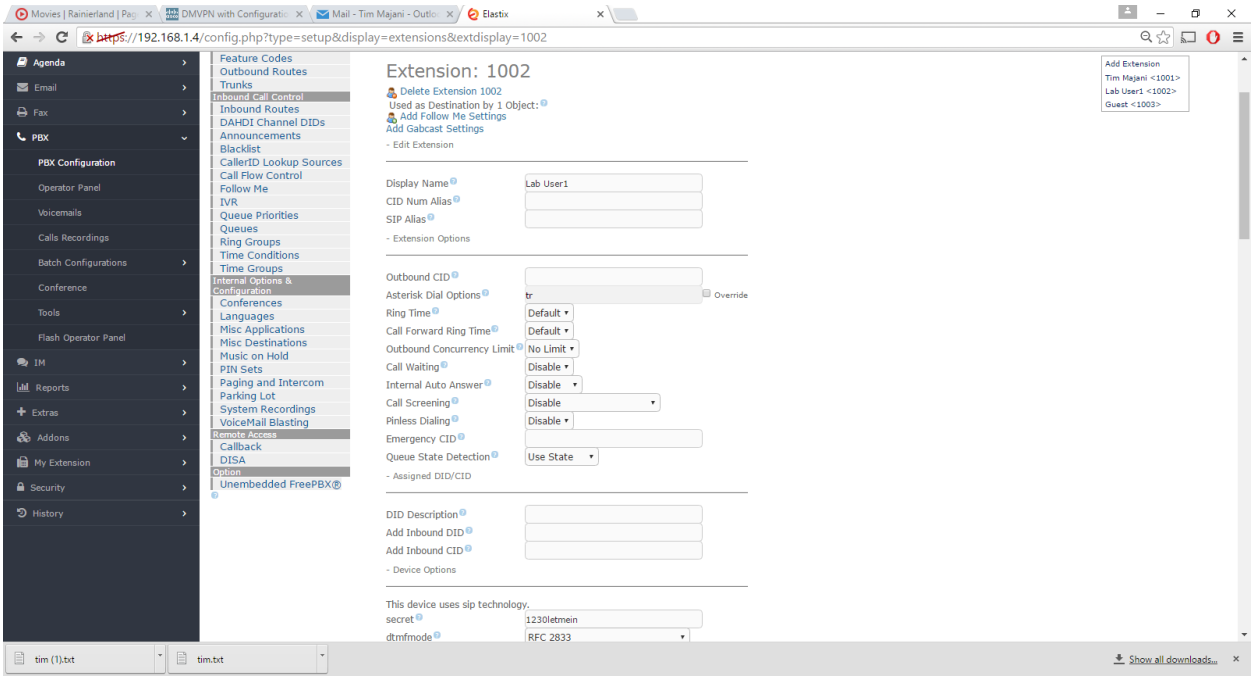
1) Cisco FXO router's configuration.

```
FXO-Router#show run
Building configuration...
! Last configuration change at 15:30:55 UTC Tue Apr 5 2016
!
hostname FXO-Router
!
ip dhcp excluded-address 192.168.1.1 192.168.1.10
ip dhcp excluded-address 192.168.1.254
!
ip dhcp pool voice-scope
  network 192.168.1.0 255.255.255.0
  default-router 192.168.1.254
  option 150 ip 192.168.1.4
!
voice service voip
 sip
!
interface FastEthernet0/0
 ip address 192.168.1.254 255.255.255.0
 duplex auto
 speed auto
!
voice-port 1/0/0
 connection plar opx 1001
!
voice-port 1/0/1
!
dial-peer voice 2 pots
 destination-pattern 9T
 port 1/0/0
 forward-digits all
!
dial-peer voice 10 voip
 destination-pattern 1...
 session protocol sipv2
 session target ipv4:192.168.1.4:5060
 session transport udp
 dtmf-relay rtp-nte
 codec g711ulaw
!
sip-ua
 max-forwards 5
 retry response 5
 retry bye 5
 retry cancel 5
 sip-server ipv4:192.168.1.4:5060
```

!
!
FXO-Router#


https://192.168.1.4/config.php?type=setup&display=extensions&extdisplay=1001
PBX / PBX Configuration
Extension: 1001
Delete Extension 1001
Used as Destination by 1 Object:
Add Follow Me Settings
Add Gabcast Settings
- Edit Extension
Display Name
CID Num Alias
SIP Alias
- Extension Options
Outbound CID
Asterisk Dial Options
Ring Time
Call Forward Ring Time
Outbound Concurrency Limit
Call Waiting
Internal Auto Answer
Call Screening
Pinless Dialing
Emergency CID
Queue State Detection
- Assigned DID/CID
DID Description
Add Inbound DID
Add Inbound CID
- Device Options
Add Extension
Tim Majani <1001>
Lab User1 <1002>
Guest <1003>


https://192.168.1.4/config.php?type=setup&display=extensions&extdisplay=1001
This device uses sip technology.
secret
dtmfmode
canreinvite
context
host
trustrpid
sendrpid
type
nat
port
qualify
qualifyfreq
transport
avpf
icesupport
dtlsenable
dtlsverify
dtlssetup
dtlscertfile
dtlsprivatekey
encryption
callgroup
pickupgroup
disallow
allow
dial
accountcode
mailbox
vmexten
deny
permit


https://192.168.1.4/config.php?type=setup&display=extensions&extdisplay=1002
Agenda
Email
Fax
PBX
PBX Configuration
Operator Panel
Voicemails
Calls Recordings
Batch Configurations
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Security
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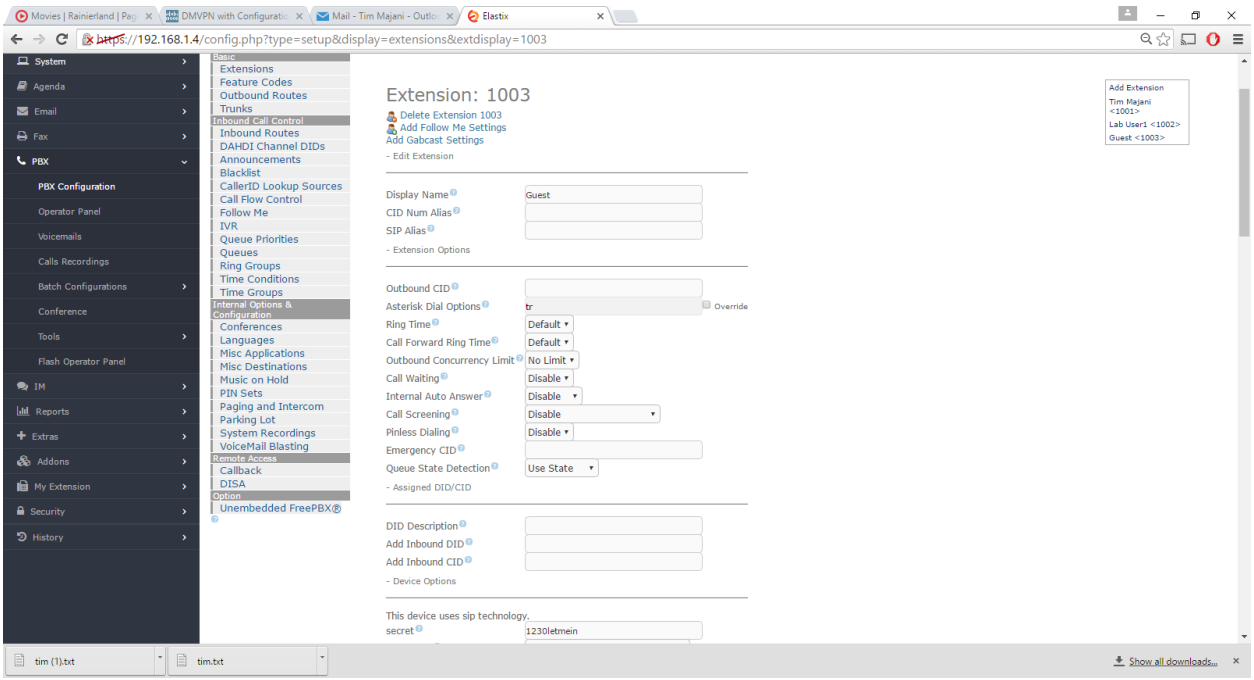
Outbound Routes
Trunks
Inbound Call Control
Inbound Routes
DAHDI Channel DIDs
Announcements
Blacklist
CallerID Lookup Sources
Call Flow Control
Follow Me
IVR
Queue Priorities
Queues
Ring Groups
Time Conditions
Time Groups
Internal Options & Configuration
Conferences
Languages
Misc Applications
Misc Destinations
Music on Hold
PIN Sets
Paging and Intercom
Parking Lot
System Recordings
VoiceMail Blasting
Remote Access
Callback
DISA
Option
Unembedded FreePBX®
Extension: 1002
Delete Extension 1002
Used as Destination by 1 Object:
Add Follow Me Settings
Add Gabcast Settings
- Edit Extension
Display Name
Lab User1
CID Num Alias
SIP Alias
- Extension Options
Outbound CID
Asterisk Dial Options
tr
Override
Ring Time
Default
Call Forward Ring Time
Default
Outbound Concurrency Limit
No Limit
Call Waiting
Disable
Internal Auto Answer
Disable
Call Screening
Disable
Pinless Dialing
Disable
Emergency CID
Queue State Detection
Use State
- Assigned DID/CID
DID Description
Add Inbound DID
Add Inbound CID
- Device Options
This device uses sip technology.
secret
1230letmein
dtmfmode
RFC 2833
Add Extension
Tim Majani <1001>
Lab User1 <1002>
Guest <1003>
tim (1).txt
tim.txt
Show all downloads...


https://192.168.1.4/config.php?type=setup&display=extensions&extdisplay=1003
System
Agenda
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PBX Configuration
Operator Panel
Voicemails
Calls Recordings
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Trunks
Inbound Call Control
Inbound Routes
DAHDI Channel DIDs
Announcements
Blacklist
CallerID Lookup Sources
Call Flow Control
Follow Me
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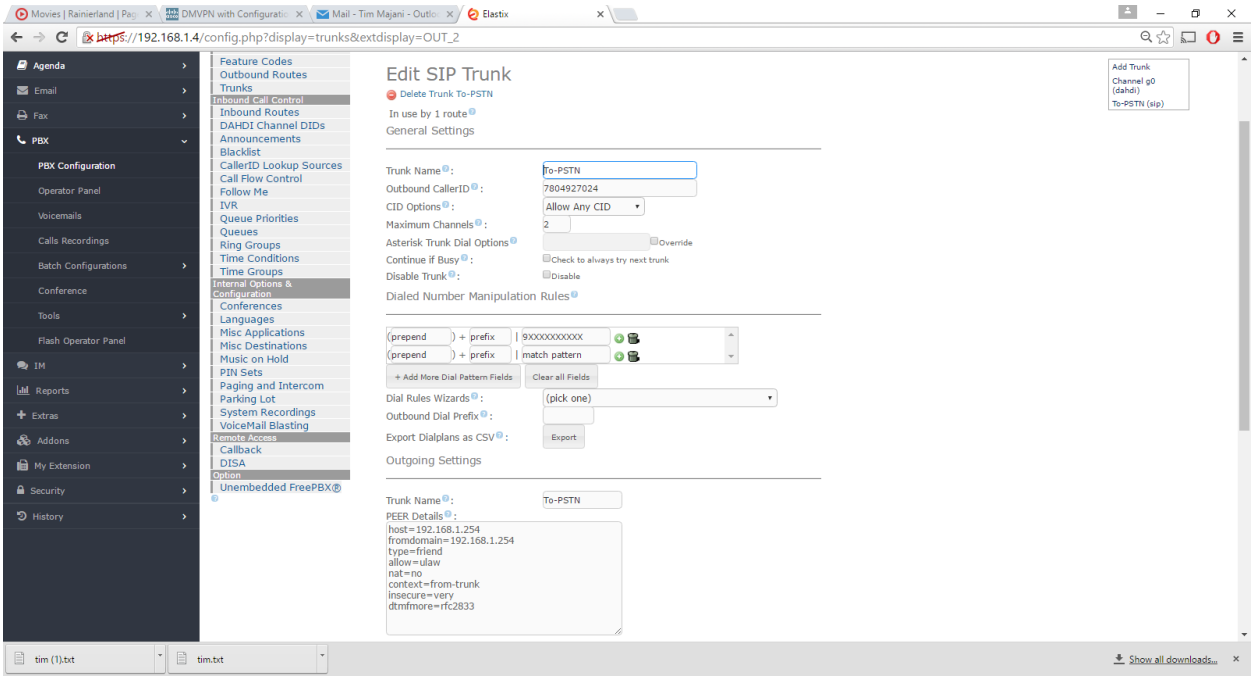
Time Groups
Internal Options & Configuration
Conferences
Languages
Misc Applications
Misc Destinations
Music on Hold
PIN Sets
Paging and Intercom
Parking Lot
System Recordings
VoiceMail Blasting
Remote Access
Callback
DISA
Option
Unembedded FreePBX®
Extension: 1003
Delete Extension 1003
Add Follow Me Settings
Add Gabcast Settings
- Edit Extension
Display Name
Guest
CID Num Alias
SIP Alias
- Extension Options
Outbound CID
Asterisk Dial Options
tr
Override
Ring Time
Default
Call Forward Ring Time
Default
Outbound Concurrency Limit
No Limit
Call Waiting
Disable
Internal Auto Answer
Disable
Call Screening
Disable
Pinless Dialing
Disable
Emergency CID
Queue State Detection
Use State
- Assigned DID/CID
DID Description
Add Inbound DID
Add Inbound CID
- Device Options
This device uses sip technology.
secret
1230letmein
Add Extension
Tim Majani <1001>
Lab User1 <1002>
Guest <1003>
tim (1).txt
tim.txt
Show all downloads...


Movies | Rainierland | Pag
DMVPN with Configuratio
Mail - Tim Majani - Outlo
Elastix
https://192.168.1.4/config.php?display=trunks&extdisplay=OUT_2
Agenda
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PBX Configuration
Operator Panel
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Calls Recordings
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Inbound Routes
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Internal Options & Configuration
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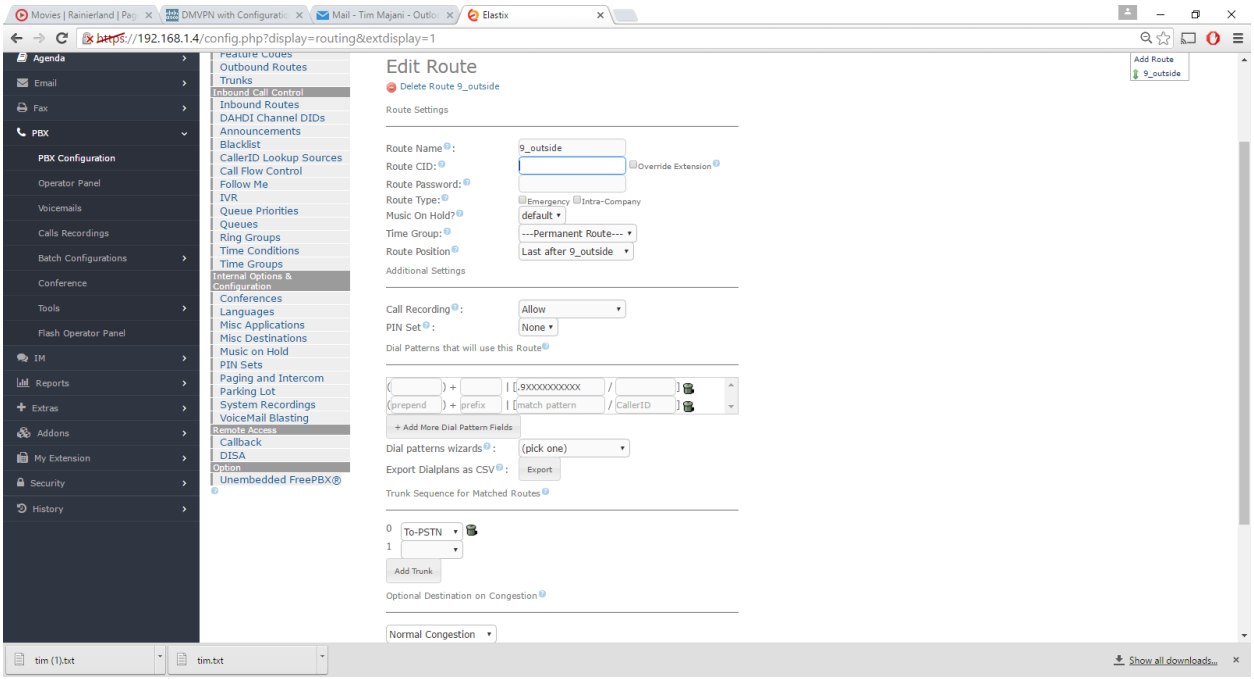
Misc Applications
Misc Destinations
Music on Hold
PIN Sets
Paging and Intercom
Parking Lot
System Recordings
VoiceMail Blasting
Remote Access
Callback
DISA
Option
Unembedded FreePBX®
Edit SIP Trunk
Delete Trunk To-PSTN
In use by 1 route
General Settings
Trunk Name:
To-PSTN
Outbound CallerID:
7804927024
CID Options:
Allow Any CID
Maximum Channels:
2
Asterisk Trunk Dial Options:
Override
Continue if Busy:
Check to always try next trunk
Disable Trunk:
Disable
Dialed Number Manipulation Rules
(prepend) + prefix | 9XXXXXXXXXX
(prepend) + prefix | match pattern
+ Add More Dial Pattern Fields
Clear all Fields
Dial Rules Wizards:
(pick one)
Outbound Dial Prefix:
Export Dialplans as CSV:
Export
Outgoing Settings
Trunk Name:
To-PSTN
PEER Details:
host=192.168.1.254
fromdomain=192.168.1.254
type=friend
allow=ulaw
nat=no
context=from-trunk
insecure=very
dtmfmore=rfc2833
Add Trunk
Channel g0
(dahdi)
To-PSTN (sip)
tim (1).txt
tim.txt
Show all downloads...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DMVPN with Configuratio
Mail - Tim Majani - Outlo
Elastix
https://192.168.1.4/config.php?display=routing&extdisplay=1
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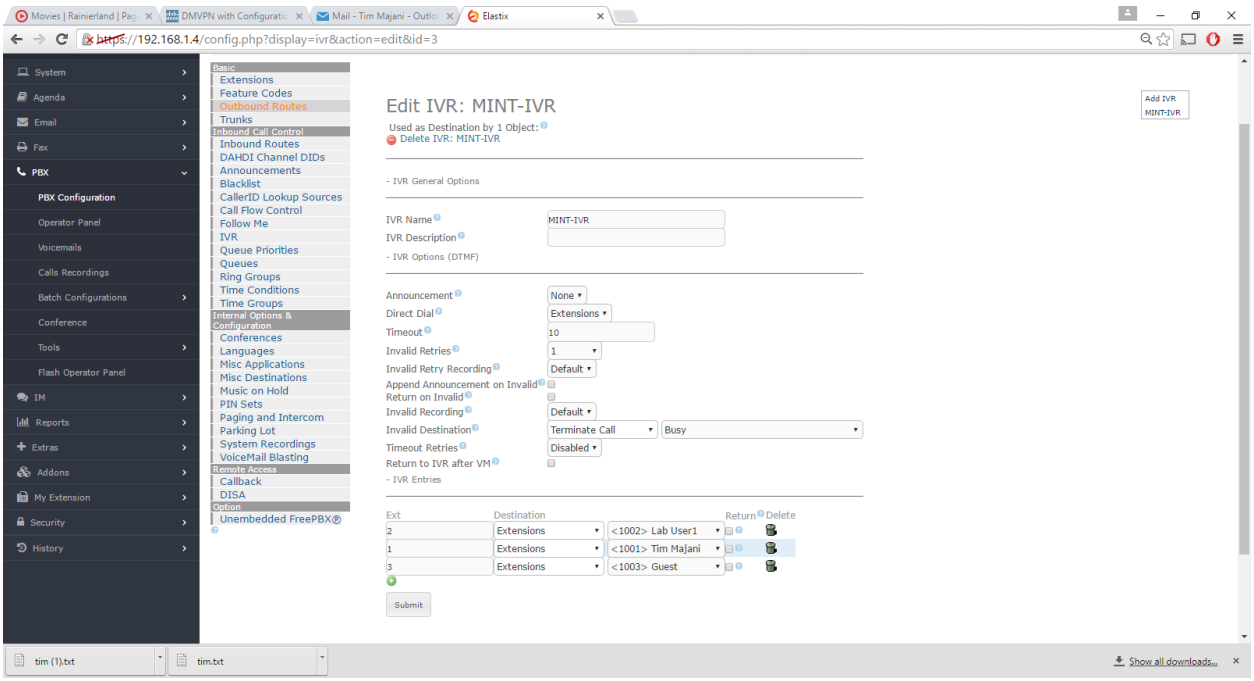
Misc Destinations
Music on Hold
PIN Sets
Paging and Intercom
Parking Lot
System Recordings
VoiceMail Blasting
Remote Access
Callback
DISA
Option
Unembedded FreePBX®
Edit Route
Delete Route 9_outside
Route Settings
Route Name:
9_outside
Route CID:
Override Extension
Route Password:
Route Type:
Emergency
Intra-Company
Music On Hold?
default
Time Group:
---Permanent Route---
Route Position:
Last after 9_outside
Additional Settings
Call Recording:
Allow
PIN Set:
None
Dial Patterns that will use this Route
( ) + | [9XXXXXXXXXX /]
(prepend) + prefix | [match pattern / CallerID]
+ Add More Dial Pattern Fields
Dial patterns wizards:
(pick one)
Export Dialplans as CSV:
Export
Trunk Sequence for Matched Routes
0 To-PSTN
1
Add Trunk
Optional Destination on Congestion
Normal Congestion
Add Route
9_outside
tim (1).txt
tim.txt
Show all downloads...


https://192.168.1.4/config.php?display=ivr&action=edit&id=3
System
Agenda
Email
Fax
PBX
PBX Configuration
Operator Panel
Voicemails
Calls Recordings
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Paging and Intercom
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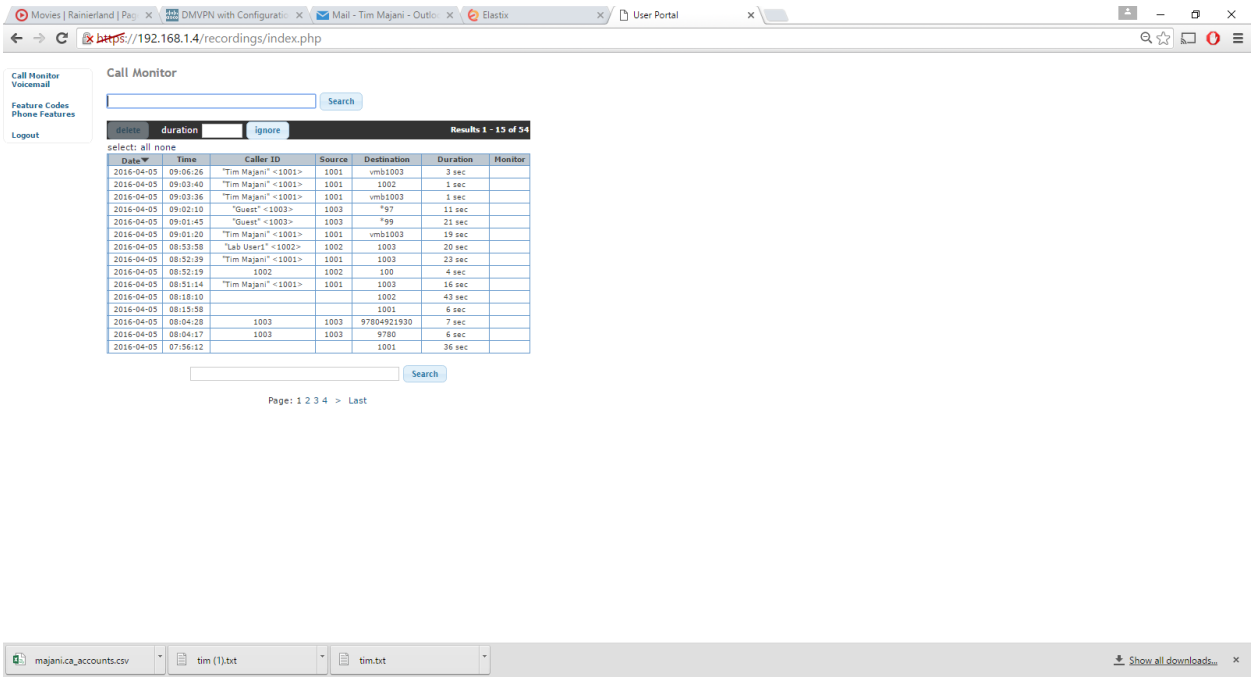
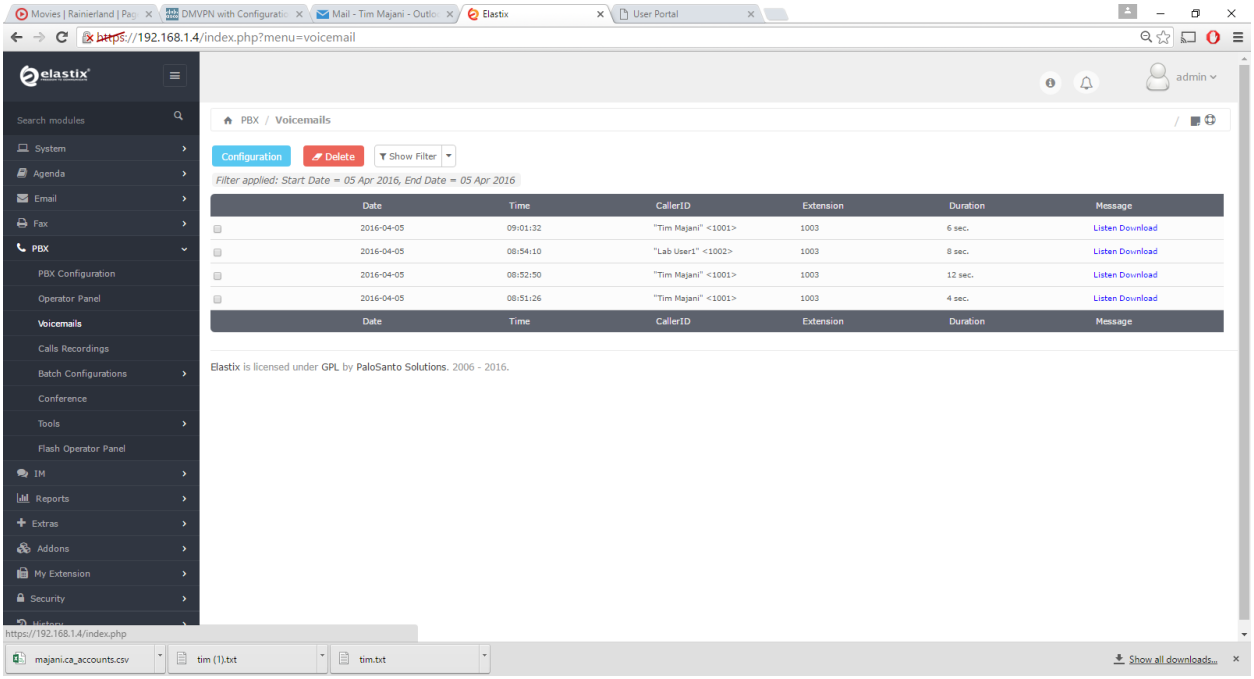
System Recordings
VoiceMail Blasting
Remote Access
Callback
DISA
Option
Unembedded FreePBX®
Edit IVR: MINT-IVR
Used as Destination by 1 Object:
Delete IVR: MINT-IVR
Add IVR
MINT-IVR
- IVR General Options
IVR Name
MINT-IVR
IVR Description
- IVR Options (DTMF)
Announcement
None
Direct Dial
Extensions
Timeout
10
Invalid Retries
1
Invalid Retry Recording
Default
Append Announcement on Invalid
Return on Invalid
Invalid Recording
Default
Invalid Destination
Terminate Call
Busy
Timeout Retries
Disabled
Return to IVR after VM
- IVR Entries
Ext
Destination
Return
Delete
2
Extensions
<1002> Lab User1
1
Extensions
<1001> Tim Majani
3
Extensions
<1003> Guest
Submit
tim (1).txt
tim.txt
Show all downloads...


https://192.168.1.4/recordings/index.php
User Portal
Call Monitor Voicemail
Feature Codes Phone Features
Logout
Call Monitor
Search
delete
duration
ignore
Results 1 - 15 of 54
select: all none
Date
Time
Caller ID
Source
Destination
Duration
Monitor
2016-04-05 09:06:26 "Tim Majani" <1001> 1001 vmb1003 3 sec
2016-04-05 09:03:40 "Tim Majani" <1001> 1001 1002 1 sec
2016-04-05 09:03:36 "Tim Majani" <1001> 1001 vmb1003 1 sec
2016-04-05 09:02:10 "Guest" <1003> 1003 *97 11 sec
2016-04-05 09:01:45 "Guest" <1003> 1003 *99 21 sec
2016-04-05 09:01:20 "Tim Majani" <1001> 1001 vmb1003 19 sec
2016-04-05 08:53:58 "Lab User1" <1002> 1002 1003 20 sec
2016-04-05 08:52:39 "Tim Majani" <1001> 1001 1003 23 sec
2016-04-05 08:52:19 1002 1002 100 4 sec
2016-04-05 08:51:14 "Tim Majani" <1001> 1001 1003 16 sec
2016-04-05 08:18:10 1002 43 sec
2016-04-05 08:15:58 1001 6 sec
2016-04-05 08:04:28 1003 1003 97804921930 7 sec
2016-04-05 08:04:17 1003 1003 9780 6 sec
2016-04-05 07:56:12 1001 36 sec
Search
Page: 1 2 3 4 > Last
majani.ca_accounts.csv
tim (1).txt
tim.txt
Show all downloads...


Movies | Rainierland | Pag
DMVPN with Configuratio
Mail - Tim Majani - Outlo
Elastix
User Portal
https://192.168.1.4/index.php?menu=voicemail
elastix
admin
Search modules
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PBX Configuration
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Voicemails
Calls Recordings
Batch Configurations
Conference
Tools
Flash Operator Panel
IM
Reports
Extras
Addons
My Extension
Security
PBX / Voicemails
Configuration
Delete
Show Filter
Filter applied: Start Date = 05 Apr 2016, End Date = 05 Apr 2016
Date Time CallerID Extension Duration Message
2016-04-05 09:01:32 "Tim Majani" <1001> 1003 6 sec. Listen Download
2016-04-05 08:54:10 "Lab User1" <1002> 1003 8 sec. Listen Download
2016-04-05 08:52:50 "Tim Majani" <1001> 1003 12 sec. Listen Download
2016-04-05 08:51:26 "Tim Majani" <1001> 1003 4 sec. Listen Download
Date Time CallerID Extension Duration Message
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https://192.168.1.4/index.php
majani.ca_accounts.csv
tim (1).txt
tim.txt
Show all downloads...

```
<?xml version="1.0"?>
<device>
    <deviceProtocol>SIP</deviceProtocol>
    <sshUserId>root</sshUserId>
    <sshPassword>cisco</sshPassword>
    <devicePool>
        <dateTimeSetting>
            <dateTemplate>D-M-Y</dateTemplate>
            <timeZone>Mountain Standard/Daylight Time</timeZone>
            <ntps>
                <ntp>
                    <name>192.168.1.4</name>
                    <ntpMode>Unicast</ntpMode>
                </ntp>
            </ntps>
        </dateTimeSetting>
        <callManagerGroup>
            <members>
                <member priority="0">
                    <callManager>
                        <processNodeName>192.168.1.4</processNodeName>
                        <ports>
                            <sipPort>5060</sipPort>
                        </ports>
                    </callManager>
                </member>
            </members>
        </callManagerGroup>
    </devicePool>
    <sipProfile>
        <sipProxies>
            <registerWithProxy>true</registerWithProxy>
        </sipProxies>
        <preferredCodec>g711alaw</preferredCodec>
        <phoneLabel>Tim Majani</phoneLabel>
        <sipLines>
            <line button="1">
                <featureID>9</featureID>
                <featureLabel>1001</featureLabel>
                <proxy>192.168.1.4</proxy>
                <proxyPort>5060</proxyPort>
                <authName>1001</authName>
                <displayName>1001</displayName>
                <name>1001</name>
                <authPassword>1230letmein</authPassword>
                <messageWaitingLampPolicy>3</messageWaitingLampPolicy>
                <messagesNumber>4000</messagesNumber>
            </line>
        </sipLines>
        <dialTemplate>dialplan.xml</dialTemplate>
    </sipProfile>
    <loadInformation>SIP41.8-5-4S</loadInformation>
    <networkLocale>US</networkLocale>
    <networkLocaleInfo>
        <name>US</name>
        <version>5.0(2)a</version>
    </networkLocaleInfo>
    <directoryURL>http://192.168.1.4/cisco/directory</directoryURL>
    <servicesURL>http://192.168.1.4/cisco/directory</servicesURL>
    <sshAccess>1</sshAccess>
    <sshPort>22</sshPort>
    <webAccess>1</webAccess>
```

Call from External to extension 1001

```
localhost*CLI>
  == Using SIP RTP TOS bits 184
  == Using SIP RTP CoS mark 5
    -- Executing [1001@from-trunk:1] Set("SIP/To-PSTN-00000077", "__RINGTIMER=15") in new stack
    -- Executing [1001@from-trunk:2] Macro("SIP/To-PSTN-00000077", "exten-vm,novm,1001,0,0,0") in new stack
    -- Executing [s@macro-exten-vm:1] Macro("SIP/To-PSTN-00000077", "user-callerid,") in new stack
    -- Executing [s@macro-user-callerid:1] Set("SIP/To-PSTN-00000077", "TOUCH_MONITOR=1459864572.119") in new stack
    -- Executing [s@macro-user-callerid:2] Set("SIP/To-PSTN-00000077", "AMPUSER=") in new stack
    -- Executing [s@macro-user-callerid:3] GotoIf("SIP/To-PSTN-00000077", "0?report") in new stack
    -- Executing [s@macro-user-callerid:4] ExecIf("SIP/To-PSTN-00000077", "1?Set(REALCALLERIDNUM=)") in new stack
    -- Executing [s@macro-user-callerid:5] Set("SIP/To-PSTN-00000077", "AMPUSER=") in new stack
    -- Executing [s@macro-user-callerid:6] GotoIf("SIP/To-PSTN-00000077", "0?limit") in new stack
    -- Executing [s@macro-user-callerid:7] Set("SIP/To-PSTN-00000077", "AMPUSERCIDNAME=") in new stack
    -- Executing [s@macro-user-callerid:8] GotoIf("SIP/To-PSTN-00000077", "1?report") in new stack
    -- Goto (macro-user-callerid,s,15)
    -- Executing [s@macro-user-callerid:15] GotoIf("SIP/To-PSTN-00000077", "0?continue") in new stack
    -- Executing [s@macro-user-callerid:16] Set("SIP/To-PSTN-00000077", "__TTL=64") in new stack
    -- Executing [s@macro-user-callerid:17] GotoIf("SIP/To-PSTN-00000077", "1?continue") in new stack
    -- Goto (macro-user-callerid,s,28)
    -- Executing [s@macro-user-callerid:28] Set("SIP/To-PSTN-00000077", "CALLERID(number)=") in new stack
    -- Executing [s@macro-user-callerid:29] Set("SIP/To-PSTN-00000077", "CALLERID(name)=") in new stack
    -- Executing [s@macro-user-callerid:30] Set("SIP/To-PSTN-00000077", "CDR(cnum)=") in new stack
    -- Executing [s@macro-user-callerid:31] Set("SIP/To-PSTN-00000077", "CDR(cnam)=") in new stack
    -- Executing [s@macro-user-callerid:32] Set("SIP/To-PSTN-00000077", "CHANNEL(language)=en") in new stack
    -- Executing [s@macro-exten-vm:2] Set("SIP/To-PSTN-00000077", "RingGroupMethod=none") in new stack
    -- Executing [s@macro-exten-vm:3] Set("SIP/To-PSTN-00000077", "__EXTTOCALL=1001") in new stack
    -- Executing [s@macro-exten-vm:4] Set("SIP/To-PSTN-00000077", "__PICKUPMARK=1001") in new stack
    -- Executing [s@macro-exten-vm:5] Set("SIP/To-PSTN-00000077", "RT=") in new stack
    -- Executing [s@macro-exten-vm:6] Gosub("SIP/To-PSTN-00000077", "sub-record-check,s,1(exten,1001,)") in new stack
    -- Executing [s@sub-record-check:1] Set("SIP/To-PSTN-00000077", "REC_POLICY_MODE_SAVE=") in new stack
    -- Executing [s@sub-record-check:2] GotoIf("SIP/To-PSTN-00000077", "1?check") in new stack
    -- Goto (sub-record-check,s,7)
    -- Executing [s@sub-record-check:7] Set("SIP/To-PSTN-00000077", "__MON_FMT=wav") in new stack
    -- Executing [s@sub-record-check:8] GotoIf("SIP/To-PSTN-00000077", "1?next") in new stack
    -- Goto (sub-record-check,s,11)
    -- Executing [s@sub-record-check:11] ExecIf("SIP/To-PSTN-00000077", "0?Return()") in new stack
    -- Executing [s@sub-record-check:12] ExecIf("SIP/To-PSTN-00000077", "0?Set(__REC_POLICY_MODE=)") in new stack
    -- Executing [s@sub-record-check:13] GotoIf("SIP/To-PSTN-00000077", "0?exten,1") in new stack
    -- Executing [s@sub-record-check:14] Set("SIP/To-PSTN-00000077", "__REC_STATUS=INITIALIZED") in new stack
    -- Executing [s@sub-record-check:15] Set("SIP/To-PSTN-00000077", "NOW=1459864572") in new stack
    -- Executing [s@sub-record-check:16] Set("SIP/To-PSTN-00000077", "__DAY=05") in new stack
    -- Executing [s@sub-record-check:17] Set("SIP/To-PSTN-00000077", "__MONTH=04") in new stack
    -- Executing [s@sub-record-check:18] Set("SIP/To-PSTN-00000077", "__YEAR=2016") in new stack
    -- Executing [s@sub-record-check:19] Set("SIP/To-PSTN-00000077", "__TIMESTR=20160405-075612") in new stack
    -- Executing [s@sub-record-check:20] Set("SIP/To-PSTN-00000077", "__FROMEXTEN=unknown") in new stack
    -- Executing [s@sub-record-check:21] Set("SIP/To-PSTN-00000077", "__CALLFILENAME=exten-1001-unknown-20160405-
075612-1459864572.119") in new stack
    -- Executing [s@sub-record-check:22] Goto("SIP/To-PSTN-00000077", "exten,1") in new stack
    -- Goto (sub-record-check,exten,1)
    -- Executing [exten@sub-record-check:1] GotoIf("SIP/To-PSTN-00000077", "0?callee") in new stack
    -- Executing [exten@sub-record-check:2] Set("SIP/To-PSTN-00000077", "__REC_POLICY_MODE=dontcare") in new stack
    -- Executing [exten@sub-record-check:3] GotoIf("SIP/To-PSTN-00000077", "1?caller") in new stack
    -- Goto (sub-record-check,exten,10)
    -- Executing [exten@sub-record-check:10] Set("SIP/To-PSTN-00000077", "__REC_POLICY_MODE=") in new stack
```

-- Executing [exten@sub-record-check:11] GosubIf("SIP/To-PSTN-00000077", "0?record,1(exten,1001,unknown)") in new stack
-- Executing [exten@sub-record-check:12] Return("SIP/To-PSTN-00000077", "") in new stack
-- Executing [s@macro-exten-vm:7] Macro("SIP/To-PSTN-00000077", "dial-one,,tr,1001") in new stack
-- Executing [s@macro-dial-one:1] Set("SIP/To-PSTN-00000077", "DEXTEN=1001") in new stack
-- Executing [s@macro-dial-one:2] Set("SIP/To-PSTN-00000077", "DIALSTATUS_CW=") in new stack
-- Executing [s@macro-dial-one:3] GosubIf("SIP/To-PSTN-00000077", "0?screen,1()") in new stack
-- Executing [s@macro-dial-one:4] GosubIf("SIP/To-PSTN-00000077", "0?cf,1()") in new stack
-- Executing [s@macro-dial-one:5] GotoIf("SIP/To-PSTN-00000077", "1?skip1") in new stack
-- Goto (macro-dial-one,s,8)
-- Executing [s@macro-dial-one:8] GotoIf("SIP/To-PSTN-00000077", "0?nodial") in new stack
-- Executing [s@macro-dial-one:9] GotoIf("SIP/To-PSTN-00000077", "0?continue") in new stack
-- Executing [s@macro-dial-one:10] Set("SIP/To-PSTN-00000077", "EXTHASCW=") in new stack
-- Executing [s@macro-dial-one:11] GotoIf("SIP/To-PSTN-00000077", "1?next1:cwinusebusy") in new stack
-- Goto (macro-dial-one,s,12)
-- Executing [s@macro-dial-one:12] GotoIf("SIP/To-PSTN-00000077", "0?docfu:skip3") in new stack
-- Goto (macro-dial-one,s,16)
-- Executing [s@macro-dial-one:16] GotoIf("SIP/To-PSTN-00000077", "1?next2:continue") in new stack
-- Goto (macro-dial-one,s,17)
-- Executing [s@macro-dial-one:17] GotoIf("SIP/To-PSTN-00000077", "1?continue") in new stack
-- Goto (macro-dial-one,s,25)
-- Executing [s@macro-dial-one:25] GotoIf("SIP/To-PSTN-00000077", "0?nodial") in new stack
-- Executing [s@macro-dial-one:26] GosubIf("SIP/To-PSTN-00000077", "1?dstring,1():dlocal,1()") in new stack
-- Executing [dstring@macro-dial-one:1] Set("SIP/To-PSTN-00000077", "DSTRING=") in new stack
-- Executing [dstring@macro-dial-one:2] Set("SIP/To-PSTN-00000077", "DEVICES=1001") in new stack
-- Executing [dstring@macro-dial-one:3] ExecIf("SIP/To-PSTN-00000077", "0?Return()") in new stack
-- Executing [dstring@macro-dial-one:4] ExecIf("SIP/To-PSTN-00000077", "0?Set(DEVICES=001)") in new stack
-- Executing [dstring@macro-dial-one:5] Set("SIP/To-PSTN-00000077", "LOOPCNT=1") in new stack
-- Executing [dstring@macro-dial-one:6] Set("SIP/To-PSTN-00000077", "ITER=1") in new stack
-- Executing [dstring@macro-dial-one:7] Set("SIP/To-PSTN-00000077", "THISDIAL=SIP/1001") in new stack
-- Executing [dstring@macro-dial-one:8] GosubIf("SIP/To-PSTN-00000077", "1?zap2dahdi,1()") in new stack
-- Executing [zap2dahdi@macro-dial-one:1] ExecIf("SIP/To-PSTN-00000077", "0?Return()") in new stack
-- Executing [zap2dahdi@macro-dial-one:2] Set("SIP/To-PSTN-00000077", "NEWDIAL=") in new stack
-- Executing [zap2dahdi@macro-dial-one:3] Set("SIP/To-PSTN-00000077", "LOOPCNT2=1") in new stack
-- Executing [zap2dahdi@macro-dial-one:4] Set("SIP/To-PSTN-00000077", "ITER2=1") in new stack
-- Executing [zap2dahdi@macro-dial-one:5] Set("SIP/To-PSTN-00000077", "THISPART2=SIP/1001") in new stack
-- Executing [zap2dahdi@macro-dial-one:6] ExecIf("SIP/To-PSTN-00000077", "0?Set(THISPART2=DAHDI/1001)") in new stack
-- Executing [zap2dahdi@macro-dial-one:7] Set("SIP/To-PSTN-00000077", "NEWDIAL=SIP/1001&") in new stack
-- Executing [zap2dahdi@macro-dial-one:8] Set("SIP/To-PSTN-00000077", "ITER2=2") in new stack
-- Executing [zap2dahdi@macro-dial-one:9] GotoIf("SIP/To-PSTN-00000077", "0?begin2") in new stack
-- Executing [zap2dahdi@macro-dial-one:10] Set("SIP/To-PSTN-00000077", "THISDIAL=SIP/1001") in new stack
-- Executing [zap2dahdi@macro-dial-one:11] Return("SIP/To-PSTN-00000077", "") in new stack
-- Executing [dstring@macro-dial-one:9] Set("SIP/To-PSTN-00000077", "DSTRING=SIP/1001&") in new stack
-- Executing [dstring@macro-dial-one:10] Set("SIP/To-PSTN-00000077", "ITER=2") in new stack
-- Executing [dstring@macro-dial-one:11] GotoIf("SIP/To-PSTN-00000077", "0?begin") in new stack
-- Executing [dstring@macro-dial-one:12] Set("SIP/To-PSTN-00000077", "DSTRING=SIP/1001") in new stack
-- Executing [dstring@macro-dial-one:13] Return("SIP/To-PSTN-00000077", "") in new stack
-- Executing [s@macro-dial-one:27] GotoIf("SIP/To-PSTN-00000077", "0?nodial") in new stack
-- Executing [s@macro-dial-one:28] GotoIf("SIP/To-PSTN-00000077", "0?skiptrace") in new stack
-- Executing [s@macro-dial-one:29] GosubIf("SIP/To-PSTN-00000077", "0?ctset,1():ctclear,1()") in new stack
-- Executing [ctclear@macro-dial-one:1] NoOp("SIP/To-PSTN-00000077", "Deleting: CALLTRACE/1001 ") in new stack
-- Executing [ctclear@macro-dial-one:2] Return("SIP/To-PSTN-00000077", "") in new stack
-- Executing [s@macro-dial-one:30] Set("SIP/To-PSTN-00000077", "D_OPTIONS=tr") in new stack
-- Executing [s@macro-dial-one:31] ExecIf("SIP/To-PSTN-00000077", "0?SIPAddHeader(Alert-Info:)") in new stack
-- Executing [s@macro-dial-one:32] ExecIf("SIP/To-PSTN-00000077", "0?SIPAddHeader()") in new stack
-- Executing [s@macro-dial-one:33] ExecIf("SIP/To-PSTN-00000077", "0?Set(CHANNEL(musicclass)=)") in new stack
-- Executing [s@macro-dial-one:34] GosubIf("SIP/To-PSTN-00000077", "0?qwait,1()") in new stack
-- Executing [s@macro-dial-one:35] Set("SIP/To-PSTN-00000077", "__CWIGNORE=") in new stack

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  -- Executing [s@macro-dial-one:36] Set("SIP/To-PSTN-00000077", "__KEEPCID=TRUE") in new stack
  -- Executing [s@macro-dial-one:37] GotoIf("SIP/To-PSTN-00000077", "0?usegoto,1") in new stack
  -- Executing [s@macro-dial-one:38] GotoIf("SIP/To-PSTN-00000077", "1?godial") in new stack
  -- Goto (macro-dial-one,s,43)
  -- Executing [s@macro-dial-one:43] Dial("SIP/To-PSTN-00000077", "SIP/1001,,tr") in new stack
 == Using SIP RTP TOS bits 184
 == Using SIP RTP CoS mark 5
  -- Called SIP/1001
  -- SIP/1001-00000078 is ringing
 == Spawn extension (macro-dial-one, s, 43) exited non-zero on 'SIP/To-PSTN-00000077' in macro 'dial-one'
 == Spawn extension (macro-exten-vm, s, 7) exited non-zero on 'SIP/To-PSTN-00000077' in macro 'exten-vm'
 == Spawn extension (from-trunk, 1001, 2) exited non-zero on 'SIP/To-PSTN-00000077'
  -- Executing [h@from-trunk:1] Macro("SIP/To-PSTN-00000077", "hangupcall,") in new stack
  -- Executing [s@macro-hangupcall:1] GotoIf("SIP/To-PSTN-00000077", "1?endmixmoncheck") in new stack
  -- Goto (macro-hangupcall,s,9)
  -- Executing [s@macro-hangupcall:9] NoOp("SIP/To-PSTN-00000077", "End of MIXMON check") in new stack
  -- Executing [s@macro-hangupcall:10] GotoIf("SIP/To-PSTN-00000077", "1?nomeetmemon") in new stack
  -- Goto (macro-hangupcall,s,28)
  -- Executing [s@macro-hangupcall:28] NoOp("SIP/To-PSTN-00000077", "End of MEETME check") in new stack
  -- Executing [s@macro-hangupcall:29] GotoIf("SIP/To-PSTN-00000077", "1?noautomon") in new stack
  -- Goto (macro-hangupcall,s,34)
  -- Executing [s@macro-hangupcall:34] NoOp("SIP/To-PSTN-00000077", "TOUCH_MONITOR_OUTPUT=") in new stack
  -- Executing [s@macro-hangupcall:35] GotoIf("SIP/To-PSTN-00000077", "1?noautomon2") in new stack
  -- Goto (macro-hangupcall,s,41)
  -- Executing [s@macro-hangupcall:41] NoOp("SIP/To-PSTN-00000077", "MONITOR_FILENAME=") in new stack
  -- Executing [s@macro-hangupcall:42] GotoIf("SIP/To-PSTN-00000077", "1?noautomon3") in new stack
  -- Goto (macro-hangupcall,s,48)
  -- Executing [s@macro-hangupcall:48] NoOp("SIP/To-PSTN-00000077", "MIXMONITOR_FILENAME=") in new stack
  -- Executing [s@macro-hangupcall:49] GotoIf("SIP/To-PSTN-00000077", "1?noautomon4") in new stack
  -- Goto (macro-hangupcall,s,51)
  -- Executing [s@macro-hangupcall:51] NoOp("SIP/To-PSTN-00000077", "ONETOUCH_RECFILE=") in new stack
  -- Executing [s@macro-hangupcall:52] GotoIf("SIP/To-PSTN-00000077", "1?skiprg") in new stack
  -- Goto (macro-hangupcall,s,55)
  -- Executing [s@macro-hangupcall:55] GotoIf("SIP/To-PSTN-00000077", "1?skipblkvm") in new stack
  -- Goto (macro-hangupcall,s,58)
  -- Executing [s@macro-hangupcall:58] GotoIf("SIP/To-PSTN-00000077", "1?theend") in new stack
  -- Goto (macro-hangupcall,s,60)
  -- Executing [s@macro-hangupcall:60] AGI("SIP/To-PSTN-00000077", "hangup.agi") in new stack
  -- Launched AGI Script /var/lib/asterisk/agi-bin/hangup.agi
  -- <SIP/To-PSTN-00000077>AGI Script hangup.agi completed, returning 0
  -- Executing [s@macro-hangupcall:61] Hangup("SIP/To-PSTN-00000077", "") in new stack
 == Spawn extension (macro-hangupcall, s, 61) exited non-zero on 'SIP/To-PSTN-00000077' in macro 'hangupcall'
 == Spawn extension (from-trunk, h, 1) exited non-zero on 'SIP/To-PSTN-00000077'
localhost*CLI>
```

Call from Internal to external

```
ocalhost*CLI>
  == Using SIP RTP TOS bits 184
  == Using SIP RTP CoS mark 5
    -- Executing [9780@from-internal:1] Macro("SIP/1003-00000079", "user-callerid,LIMIT,EXTERNAL,") in new stack
    -- Executing [s@macro-user-callerid:1] Set("SIP/1003-00000079", "TOUCH_MONITOR=1459865057.121") in new stack
    -- Executing [s@macro-user-callerid:2] Set("SIP/1003-00000079", "AMPUSER=1003") in new stack
    -- Executing [s@macro-user-callerid:3] GotoIf("SIP/1003-00000079", "0?report") in new stack
    -- Executing [s@macro-user-callerid:4] ExecIf("SIP/1003-00000079", "1?Set(REALCALLERIDNUM=1003)") in new stack
    -- Executing [s@macro-user-callerid:5] Set("SIP/1003-00000079", "AMPUSER=1003") in new stack
    -- Executing [s@macro-user-callerid:6] GotoIf("SIP/1003-00000079", "0?limit") in new stack
    -- Executing [s@macro-user-callerid:7] Set("SIP/1003-00000079", "AMPUSERCIDNAME=Guest") in new stack
    -- Executing [s@macro-user-callerid:8] GotoIf("SIP/1003-00000079", "0?report") in new stack
    -- Executing [s@macro-user-callerid:9] Set("SIP/1003-00000079", "AMPUSERCID=1003") in new stack
    -- Executing [s@macro-user-callerid:10] Set("SIP/1003-00000079", "__DIAL_OPTIONS=tr") in new stack
    -- Executing [s@macro-user-callerid:11] Set("SIP/1003-00000079", "CALLERID(all)="Guest" <1003>") in new stack
    -- Executing [s@macro-user-callerid:12] GotoIf("SIP/1003-00000079", "0?limit") in new stack
    -- Executing [s@macro-user-callerid:13] ExecIf("SIP/1003-00000079", "1?Set(GROUP(concurrency_limit)=1003)") in new stack
    -- Executing [s@macro-user-callerid:14] ExecIf("SIP/1003-00000079", "0?Set(CHANNEL(language)=)") in new stack
    -- Executing [s@macro-user-callerid:15] GotoIf("SIP/1003-00000079", "1?continue") in new stack
    -- Goto (macro-user-callerid,s,28)
    -- Executing [s@macro-user-callerid:28] Set("SIP/1003-00000079", "CALLERID(number)=1003") in new stack
    -- Executing [s@macro-user-callerid:29] Set("SIP/1003-00000079", "CALLERID(name)=Guest") in new stack
    -- Executing [s@macro-user-callerid:30] Set("SIP/1003-00000079", "CDR(cnum)=1003") in new stack
    -- Executing [s@macro-user-callerid:31] Set("SIP/1003-00000079", "CDR(cnam)=Guest") in new stack
    -- Executing [s@macro-user-callerid:32] Set("SIP/1003-00000079", "CHANNEL(language)=en") in new stack
    -- Executing [9780@from-internal:2] Set("SIP/1003-00000079", "MOHCLASS=default") in new stack
    -- Executing [9780@from-internal:3] Set("SIP/1003-00000079", "_NODEST=") in new stack
    -- Executing [9780@from-internal:4] Gosub("SIP/1003-00000079", "sub-record-check,s,1(out,9780,)") in new stack
    -- Executing [s@sub-record-check:1] Set("SIP/1003-00000079", "REC_POLICY_MODE_SAVE=") in new stack
    -- Executing [s@sub-record-check:2] GotoIf("SIP/1003-00000079", "1?check") in new stack
    -- Goto (sub-record-check,s,7)
    -- Executing [s@sub-record-check:7] Set("SIP/1003-00000079", "__MON_FMT=wav") in new stack
    -- Executing [s@sub-record-check:8] GotoIf("SIP/1003-00000079", "1?next") in new stack
    -- Goto (sub-record-check,s,11)
    -- Executing [s@sub-record-check:11] ExecIf("SIP/1003-00000079", "0?Return()") in new stack
    -- Executing [s@sub-record-check:12] ExecIf("SIP/1003-00000079", "0?Set(__REC_POLICY_MODE=)") in new stack
    -- Executing [s@sub-record-check:13] GotoIf("SIP/1003-00000079", "0?out,1") in new stack
    -- Executing [s@sub-record-check:14] Set("SIP/1003-00000079", "__REC_STATUS=INITIALIZED") in new stack
    -- Executing [s@sub-record-check:15] Set("SIP/1003-00000079", "NOW=1459865057") in new stack
    -- Executing [s@sub-record-check:16] Set("SIP/1003-00000079", "__DAY=05") in new stack
    -- Executing [s@sub-record-check:17] Set("SIP/1003-00000079", "__MONTH=04") in new stack
    -- Executing [s@sub-record-check:18] Set("SIP/1003-00000079", "__YEAR=2016") in new stack
    -- Executing [s@sub-record-check:19] Set("SIP/1003-00000079", "__TIMESTR=20160405-080417") in new stack
    -- Executing [s@sub-record-check:20] Set("SIP/1003-00000079", "__FROMEXTEN=1003") in new stack
    -- Executing [s@sub-record-check:21] Set("SIP/1003-00000079", "__CALLFILENAME=out-9780-1003-20160405-080417-
1459865057.121") in new stack
    -- Executing [s@sub-record-check:22] Goto("SIP/1003-00000079", "out,1") in new stack
    -- Goto (sub-record-check,out,1)
    -- Executing [out@sub-record-check:1] ExecIf("SIP/1003-00000079", "1?Set(__REC_POLICY_MODE=dontcare)") in new stack
    -- Executing [out@sub-record-check:2] GosubIf("SIP/1003-00000079", "0?record,1(exten,9780,1003)") in new stack
    -- Executing [out@sub-record-check:3] Return("SIP/1003-00000079", "") in new stack
    -- Executing [9780@from-internal:5] Macro("SIP/1003-00000079", "dialout-trunk,2,9780,,off") in new stack
    -- Executing [s@macro-dialout-trunk:1] Set("SIP/1003-00000079", "DIAL_TRUNK=2") in new stack
    -- Executing [s@macro-dialout-trunk:2] GosubIf("SIP/1003-00000079", "0?sub-pincheck,s,1()") in new stack
    -- Executing [s@macro-dialout-trunk:3] GotoIf("SIP/1003-00000079", "0?disabletrunk,1") in new stack
```

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   -- Executing [s@macro-dialout-trunk:4] Set("SIP/1003-00000079", "DIAL_NUMBER=9780") in new stack
   -- Executing [s@macro-dialout-trunk:5] Set("SIP/1003-00000079", "DIAL_TRUNK_OPTIONS=tr") in new stack
   -- Executing [s@macro-dialout-trunk:6] Set("SIP/1003-00000079", "OUTBOUND_GROUP=OUT_2") in new stack
   -- Executing [s@macro-dialout-trunk:7] GotoIf("SIP/1003-00000079", "0?nomax") in new stack
   -- Executing [s@macro-dialout-trunk:8] GotoIf("SIP/1003-00000079", "0?chanfull") in new stack
   -- Executing [s@macro-dialout-trunk:9] GotoIf("SIP/1003-00000079", "0?skipoutcid") in new stack
   -- Executing [s@macro-dialout-trunk:10] Set("SIP/1003-00000079", "DIAL_TRUNK_OPTIONS=") in new stack
   -- Executing [s@macro-dialout-trunk:11] Macro("SIP/1003-00000079", "outbound-callerid,2") in new stack
   -- Executing [s@macro-outbound-callerid:1] ExecIf("SIP/1003-00000079", "0?Set(CALLERPRES()=)") in new stack
   -- Executing [s@macro-outbound-callerid:2] ExecIf("SIP/1003-00000079", "0?Set(REALCALLERIDNUM=1003)") in new stack
   -- Executing [s@macro-outbound-callerid:3] GotoIf("SIP/1003-00000079", "1?normcid") in new stack
   -- Goto (macro-outbound-callerid,s,6)
   -- Executing [s@macro-outbound-callerid:6] Set("SIP/1003-00000079", "USEROUTCID=") in new stack
   -- Executing [s@macro-outbound-callerid:7] Set("SIP/1003-00000079", "EMERGENCYCID=") in new stack
   -- Executing [s@macro-outbound-callerid:8] Set("SIP/1003-00000079", "TRUNKOUTCID=7804927024") in new stack
   -- Executing [s@macro-outbound-callerid:9] GotoIf("SIP/1003-00000079", "1?trunkcid") in new stack
   -- Goto (macro-outbound-callerid,s,14)
   -- Executing [s@macro-outbound-callerid:14] ExecIf("SIP/1003-00000079", "1?Set(CALLERID(all)=7804927024)") in new stack
   -- Executing [s@macro-outbound-callerid:15] ExecIf("SIP/1003-00000079", "0?Set(CALLERID(all)=)") in new stack
   -- Executing [s@macro-outbound-callerid:16] ExecIf("SIP/1003-00000079", "0?Set(CALLERID(all)=)") in new stack
   -- Executing [s@macro-outbound-callerid:17] ExecIf("SIP/1003-00000079", "0?Set(CALLERPRES()=prohib_passed_screen)") in
new stack
   -- Executing [s@macro-outbound-callerid:18] Set("SIP/1003-00000079", "CDR(outbound_cnum)=7804927024") in new stack
   -- Executing [s@macro-outbound-callerid:19] Set("SIP/1003-00000079", "CDR(outbound_cnam)=") in new stack
   -- Executing [s@macro-dialout-trunk:12] GosubIf("SIP/1003-00000079", "1?sub-flp-2,s,1()") in new stack
   -- Executing [s@sub-flp-2:1] ExecIf("SIP/1003-00000079", "0?Return()") in new stack
   -- Executing [s@sub-flp-2:2] Return("SIP/1003-00000079", "") in new stack
   -- Executing [s@macro-dialout-trunk:13] Set("SIP/1003-00000079", "OUTNUM=9780") in new stack
   -- Executing [s@macro-dialout-trunk:14] Set("SIP/1003-00000079", "custom=SIP/To-PSTN") in new stack
   -- Executing [s@macro-dialout-trunk:15] ExecIf("SIP/1003-00000079", "0?Set(DIAL_TRUNK_OPTIONS=M(setmusic^default))")
in new stack
   -- Executing [s@macro-dialout-trunk:16] ExecIf("SIP/1003-00000079", "0?Set(DIAL_TRUNK_OPTIONS=M(confirm))") in new
stack
   -- Executing [s@macro-dialout-trunk:17] Macro("SIP/1003-00000079", "dialout-trunk-predial-hook,") in new stack
   -- Executing [s@macro-dialout-trunk-predial-hook:1] MacroExit("SIP/1003-00000079", "") in new stack
   -- Executing [s@macro-dialout-trunk:18] GotoIf("SIP/1003-00000079", "0?bypass,1") in new stack
   -- Executing [s@macro-dialout-trunk:19] ExecIf("SIP/1003-00000079", "1?Set(CONNECTEDLINE(num,i)=9780)") in new stack
   -- Executing [s@macro-dialout-trunk:20] ExecIf("SIP/1003-00000079", "1?Set(CONNECTEDLINE(name,i)=CID:7804927024)") in
new stack
   -- Executing [s@macro-dialout-trunk:21] GotoIf("SIP/1003-00000079", "0?customtrunk") in new stack
   -- Executing [s@macro-dialout-trunk:22] Dial("SIP/1003-00000079", "SIP/To-PSTN/9780,300,") in new stack
  == Using SIP RTP TOS bits 184
  == Using SIP RTP CoS mark 5
   -- Called SIP/To-PSTN/9780
   -- SIP/To-PSTN-0000007a is making progress passing it to SIP/1003-00000079
      > 0x7feef00d84f0 -- Probation passed - setting RTP source address to 192.168.1.254:19504
   -- SIP/To-PSTN-0000007a answered SIP/1003-00000079
      > 0x7feef80518d0 -- Probation passed - setting RTP source address to 192.168.1.22:19494
   -- Executing [h@macro-dialout-trunk:1] Macro("SIP/1003-00000079", "hangupcall,") in new stack
   -- Executing [s@macro-hangupcall:1] GotoIf("SIP/1003-00000079", "1?endmixmoncheck") in new stack
   -- Goto (macro-hangupcall,s,9)
   -- Executing [s@macro-hangupcall:9] NoOp("SIP/1003-00000079", "End of MIXMON check") in new stack
   -- Executing [s@macro-hangupcall:10] GotoIf("SIP/1003-00000079", "1?nomeetmemon") in new stack
   -- Goto (macro-hangupcall,s,28)
   -- Executing [s@macro-hangupcall:28] NoOp("SIP/1003-00000079", "End of MEETME check") in new stack
   -- Executing [s@macro-hangupcall:29] GotoIf("SIP/1003-00000079", "1?noautomon") in new stack
   -- Goto (macro-hangupcall,s,34)
   -- Executing [s@macro-hangupcall:34] NoOp("SIP/1003-00000079", "TOUCH_MONITOR_OUTPUT=") in new stack
```

```
  -- Executing [s@macro-hangupcall:35] GotoIf("SIP/1003-00000079", "1?noautomon2") in new stack
  -- Goto (macro-hangupcall,s,41)
  -- Executing [s@macro-hangupcall:41] NoOp("SIP/1003-00000079", "MONITOR_FILENAME=") in new stack
  -- Executing [s@macro-hangupcall:42] GotoIf("SIP/1003-00000079", "1?noautomon3") in new stack
  -- Goto (macro-hangupcall,s,48)
  -- Executing [s@macro-hangupcall:48] NoOp("SIP/1003-00000079", "MIXMONITOR_FILENAME=") in new stack
  -- Executing [s@macro-hangupcall:49] GotoIf("SIP/1003-00000079", "1?noautomon4") in new stack
  -- Goto (macro-hangupcall,s,51)
  -- Executing [s@macro-hangupcall:51] NoOp("SIP/1003-00000079", "ONETOUCH_RECFILE=") in new stack
  -- Executing [s@macro-hangupcall:52] GotoIf("SIP/1003-00000079", "1?skiprg") in new stack
  -- Goto (macro-hangupcall,s,55)
  -- Executing [s@macro-hangupcall:55] GotoIf("SIP/1003-00000079", "1?skipblkvm") in new stack
  -- Goto (macro-hangupcall,s,58)
  -- Executing [s@macro-hangupcall:58] GotoIf("SIP/1003-00000079", "1?theend") in new stack
  -- Goto (macro-hangupcall,s,60)
  -- Executing [s@macro-hangupcall:60] AGI("SIP/1003-00000079", "hangup.agi") in new stack
  -- Launched AGI Script /var/lib/asterisk/agi-bin/hangup.agi
  -- <SIP/1003-00000079>AGI Script hangup.agi completed, returning 0
  -- Executing [s@macro-hangupcall:61] Hangup("SIP/1003-00000079", "") in new stack
 == Spawn extension (macro-hangupcall, s, 61) exited non-zero on 'SIP/1003-00000079' in macro 'hangupcall'
 == Spawn extension (macro-dialout-trunk, h, 1) exited non-zero on 'SIP/1003-00000079'
 == Spawn extension (macro-dialout-trunk, s, 22) exited non-zero on 'SIP/1003-00000079' in macro 'dialout-trunk'
 == Spawn extension (from-internal, 9780, 5) exited non-zero on 'SIP/1003-00000079'
 == Using SIP RTP TOS bits 184
 == Using SIP RTP CoS mark 5
  -- Executing [97804921930@from-internal:1] Macro("SIP/1003-0000007b", "user-callerid,LIMIT,EXTERNAL,") in new stack
  -- Executing [s@macro-user-callerid:1] Set("SIP/1003-0000007b", "TOUCH_MONITOR=1459865068.123") in new stack
  -- Executing [s@macro-user-callerid:2] Set("SIP/1003-0000007b", "AMPUSER=1003") in new stack
  -- Executing [s@macro-user-callerid:3] GotoIf("SIP/1003-0000007b", "0?report") in new stack
  -- Executing [s@macro-user-callerid:4] ExecIf("SIP/1003-0000007b", "1?Set(REALCALLERIDNUM=1003)") in new stack
  -- Executing [s@macro-user-callerid:5] Set("SIP/1003-0000007b", "AMPUSER=1003") in new stack
  -- Executing [s@macro-user-callerid:6] GotoIf("SIP/1003-0000007b", "0?limit") in new stack
  -- Executing [s@macro-user-callerid:7] Set("SIP/1003-0000007b", "AMPUSERCIDNAME=Guest") in new stack
  -- Executing [s@macro-user-callerid:8] GotoIf("SIP/1003-0000007b", "0?report") in new stack
  -- Executing [s@macro-user-callerid:9] Set("SIP/1003-0000007b", "AMPUSERCID=1003") in new stack
  -- Executing [s@macro-user-callerid:10] Set("SIP/1003-0000007b", "__DIAL_OPTIONS=tr") in new stack
  -- Executing [s@macro-user-callerid:11] Set("SIP/1003-0000007b", "CALLERID(all)="Guest" <1003>") in new stack
  -- Executing [s@macro-user-callerid:12] GotoIf("SIP/1003-0000007b", "0?limit") in new stack
  -- Executing [s@macro-user-callerid:13] ExecIf("SIP/1003-0000007b", "1?Set(GROUP(concurrency_limit)=1003)") in new stack
  -- Executing [s@macro-user-callerid:14] ExecIf("SIP/1003-0000007b", "0?Set(CHANNEL(language)=)") in new stack
  -- Executing [s@macro-user-callerid:15] GotoIf("SIP/1003-0000007b", "1?continue") in new stack
  -- Goto (macro-user-callerid,s,28)
  -- Executing [s@macro-user-callerid:28] Set("SIP/1003-0000007b", "CALLERID(number)=1003") in new stack
  -- Executing [s@macro-user-callerid:29] Set("SIP/1003-0000007b", "CALLERID(name)=Guest") in new stack
  -- Executing [s@macro-user-callerid:30] Set("SIP/1003-0000007b", "CDR(cnum)=1003") in new stack
  -- Executing [s@macro-user-callerid:31] Set("SIP/1003-0000007b", "CDR(cnam)=Guest") in new stack
  -- Executing [s@macro-user-callerid:32] Set("SIP/1003-0000007b", "CHANNEL(language)=en") in new stack
  -- Executing [97804921930@from-internal:2] Set("SIP/1003-0000007b", "MOHCLASS=default") in new stack
  -- Executing [97804921930@from-internal:3] Set("SIP/1003-0000007b", "_NODEST=") in new stack
  -- Executing [97804921930@from-internal:4] Gosub("SIP/1003-0000007b", "sub-record-check,s,1(out,97804921930,)") in
new stack
  -- Executing [s@sub-record-check:1] Set("SIP/1003-0000007b", "REC_POLICY_MODE_SAVE=") in new stack
  -- Executing [s@sub-record-check:2] GotoIf("SIP/1003-0000007b", "1?check") in new stack
  -- Goto (sub-record-check,s,7)
  -- Executing [s@sub-record-check:7] Set("SIP/1003-0000007b", "__MON_FMT=wav") in new stack
  -- Executing [s@sub-record-check:8] GotoIf("SIP/1003-0000007b", "1?next") in new stack
  -- Goto (sub-record-check,s,11)
  -- Executing [s@sub-record-check:11] ExecIf("SIP/1003-0000007b", "0?Return()") in new stack
```

-- Executing [s@sub-record-check:12] ExecIf("SIP/1003-0000007b", "0?Set(__REC_POLICY_MODE=)") in new stack
-- Executing [s@sub-record-check:13] GotoIf("SIP/1003-0000007b", "0?out,1") in new stack
-- Executing [s@sub-record-check:14] Set("SIP/1003-0000007b", "__REC_STATUS=INITIALIZED") in new stack
-- Executing [s@sub-record-check:15] Set("SIP/1003-0000007b", "NOW=1459865068") in new stack
-- Executing [s@sub-record-check:16] Set("SIP/1003-0000007b", "__DAY=05") in new stack
-- Executing [s@sub-record-check:17] Set("SIP/1003-0000007b", "__MONTH=04") in new stack
-- Executing [s@sub-record-check:18] Set("SIP/1003-0000007b", "__YEAR=2016") in new stack
-- Executing [s@sub-record-check:19] Set("SIP/1003-0000007b", "__TIMESTR=20160405-080428") in new stack
-- Executing [s@sub-record-check:20] Set("SIP/1003-0000007b", "__FROMEXTEN=1003") in new stack
-- Executing [s@sub-record-check:21] Set("SIP/1003-0000007b", "__CALLFILENAME=out-97804921930-1003-20160405-080428-1459865068.123") in new stack
-- Executing [s@sub-record-check:22] Goto("SIP/1003-0000007b", "out,1") in new stack
-- Goto (sub-record-check,out,1)
-- Executing [out@sub-record-check:1] ExecIf("SIP/1003-0000007b", "1?Set(__REC_POLICY_MODE=dontcare)") in new stack
-- Executing [out@sub-record-check:2] GosubIf("SIP/1003-0000007b", "0?record,1(exten,97804921930,1003)") in new stack
-- Executing [out@sub-record-check:3] Return("SIP/1003-0000007b", "") in new stack
-- Executing [97804921930@from-internal:5] Macro("SIP/1003-0000007b", "dialout-trunk,2,97804921930,,off") in new stack
-- Executing [s@macro-dialout-trunk:1] Set("SIP/1003-0000007b", "DIAL_TRUNK=2") in new stack
-- Executing [s@macro-dialout-trunk:2] GosubIf("SIP/1003-0000007b", "0?sub-pincheck,s,1()") in new stack
-- Executing [s@macro-dialout-trunk:3] GotoIf("SIP/1003-0000007b", "0?disabletrunk,1") in new stack
-- Executing [s@macro-dialout-trunk:4] Set("SIP/1003-0000007b", "DIAL_NUMBER=97804921930") in new stack
-- Executing [s@macro-dialout-trunk:5] Set("SIP/1003-0000007b", "DIAL_TRUNK_OPTIONS=tr") in new stack
-- Executing [s@macro-dialout-trunk:6] Set("SIP/1003-0000007b", "OUTBOUND_GROUP=OUT_2") in new stack
-- Executing [s@macro-dialout-trunk:7] GotoIf("SIP/1003-0000007b", "0?nomax") in new stack
-- Executing [s@macro-dialout-trunk:8] GotoIf("SIP/1003-0000007b", "0?chanfull") in new stack
-- Executing [s@macro-dialout-trunk:9] GotoIf("SIP/1003-0000007b", "0?skipoutcid") in new stack
-- Executing [s@macro-dialout-trunk:10] Set("SIP/1003-0000007b", "DIAL_TRUNK_OPTIONS=") in new stack
-- Executing [s@macro-dialout-trunk:11] Macro("SIP/1003-0000007b", "outbound-callerid,2") in new stack
-- Executing [s@macro-outbound-callerid:1] ExecIf("SIP/1003-0000007b", "0?Set(CALLERPRES()=)") in new stack
-- Executing [s@macro-outbound-callerid:2] ExecIf("SIP/1003-0000007b", "0?Set(REALCALLERIDNUM=1003)") in new stack
-- Executing [s@macro-outbound-callerid:3] GotoIf("SIP/1003-0000007b", "1?normcid") in new stack
-- Goto (macro-outbound-callerid,s,6)
-- Executing [s@macro-outbound-callerid:6] Set("SIP/1003-0000007b", "USEROUTCID=") in new stack
-- Executing [s@macro-outbound-callerid:7] Set("SIP/1003-0000007b", "EMERGENCYCID=") in new stack
-- Executing [s@macro-outbound-callerid:8] Set("SIP/1003-0000007b", "TRUNKOUTCID=7804927024") in new stack
-- Executing [s@macro-outbound-callerid:9] GotoIf("SIP/1003-0000007b", "1?trunkcid") in new stack
-- Goto (macro-outbound-callerid,s,14)
-- Executing [s@macro-outbound-callerid:14] ExecIf("SIP/1003-0000007b", "1?Set(CALLERID(all)=7804927024)") in new stack
-- Executing [s@macro-outbound-callerid:15] ExecIf("SIP/1003-0000007b", "0?Set(CALLERID(all)=)") in new stack
-- Executing [s@macro-outbound-callerid:16] ExecIf("SIP/1003-0000007b", "0?Set(CALLERID(all)=)") in new stack
-- Executing [s@macro-outbound-callerid:17] ExecIf("SIP/1003-0000007b", "0?Set(CALLERPRES()=prohib_passed_screen)") in new stack
-- Executing [s@macro-outbound-callerid:18] Set("SIP/1003-0000007b", "CDR(outbound_cnum)=7804927024") in new stack
-- Executing [s@macro-outbound-callerid:19] Set("SIP/1003-0000007b", "CDR(outbound_cnam)=") in new stack
-- Executing [s@macro-dialout-trunk:12] GosubIf("SIP/1003-0000007b", "1?sub-flp-2,s,1()") in new stack
-- Executing [s@sub-flp-2:1] ExecIf("SIP/1003-0000007b", "1?Return()") in new stack
-- Executing [s@macro-dialout-trunk:13] Set("SIP/1003-0000007b", "OUTNUM=97804921930") in new stack
-- Executing [s@macro-dialout-trunk:14] Set("SIP/1003-0000007b", "custom=SIP/To-PSTN") in new stack
-- Executing [s@macro-dialout-trunk:15] ExecIf("SIP/1003-0000007b", "0?Set(DIAL_TRUNK_OPTIONS=M(setmusic^default))") in new stack
-- Executing [s@macro-dialout-trunk:16] ExecIf("SIP/1003-0000007b", "0?Set(DIAL_TRUNK_OPTIONS=M(confirm))") in new stack
-- Executing [s@macro-dialout-trunk:17] Macro("SIP/1003-0000007b", "dialout-trunk-predial-hook,") in new stack
-- Executing [s@macro-dialout-trunk-predial-hook:1] MacroExit("SIP/1003-0000007b", "") in new stack
-- Executing [s@macro-dialout-trunk:18] GotoIf("SIP/1003-0000007b", "0?bypass,1") in new stack
-- Executing [s@macro-dialout-trunk:19] ExecIf("SIP/1003-0000007b", "1?Set(CONNECTEDLINE(num,i)=97804921930)") in new stack

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  -- Executing [s@macro-dialout-trunk:20] ExecIf("SIP/1003-0000007b", "1?Set(CONNECTEDLINE(name,i)=CID:7804927024)")
in new stack
  -- Executing [s@macro-dialout-trunk:21] GotoIf("SIP/1003-0000007b", "0?customtrunk") in new stack
  -- Executing [s@macro-dialout-trunk:22] Dial("SIP/1003-0000007b", "SIP/To-PSTN/97804921930,300,") in new stack
 == Using SIP RTP TOS bits 184
 == Using SIP RTP CoS mark 5
  -- Called SIP/To-PSTN/97804921930
  -- SIP/To-PSTN-0000007c is making progress passing it to SIP/1003-0000007b
    > 0x7feef0101070 -- Probation passed - setting RTP source address to 192.168.1.254:16802
  -- SIP/To-PSTN-0000007c answered SIP/1003-0000007b
    > 0x7feef805b5d0 -- Probation passed - setting RTP source address to 192.168.1.22:31180
  -- Executing [h@macro-dialout-trunk:1] Macro("SIP/1003-0000007b", "hangupcall,") in new stack
  -- Executing [s@macro-hangupcall:1] GotoIf("SIP/1003-0000007b", "1?endmixmoncheck") in new stack
  -- Goto (macro-hangupcall,s,9)
  -- Executing [s@macro-hangupcall:9] NoOp("SIP/1003-0000007b", "End of MIXMON check") in new stack
  -- Executing [s@macro-hangupcall:10] GotoIf("SIP/1003-0000007b", "1?nomeetmemon") in new stack
  -- Goto (macro-hangupcall,s,28)
  -- Executing [s@macro-hangupcall:28] NoOp("SIP/1003-0000007b", "End of MEETME check") in new stack
  -- Executing [s@macro-hangupcall:29] GotoIf("SIP/1003-0000007b", "1?noautomon") in new stack
  -- Goto (macro-hangupcall,s,34)
  -- Executing [s@macro-hangupcall:34] NoOp("SIP/1003-0000007b", "TOUCH_MONITOR_OUTPUT=") in new stack
  -- Executing [s@macro-hangupcall:35] GotoIf("SIP/1003-0000007b", "1?noautomon2") in new stack
  -- Goto (macro-hangupcall,s,41)
  -- Executing [s@macro-hangupcall:41] NoOp("SIP/1003-0000007b", "MONITOR_FILENAME=") in new stack
  -- Executing [s@macro-hangupcall:42] GotoIf("SIP/1003-0000007b", "1?noautomon3") in new stack
  -- Goto (macro-hangupcall,s,48)
  -- Executing [s@macro-hangupcall:48] NoOp("SIP/1003-0000007b", "MIXMONITOR_FILENAME=") in new stack
  -- Executing [s@macro-hangupcall:49] GotoIf("SIP/1003-0000007b", "1?noautomon4") in new stack
  -- Goto (macro-hangupcall,s,51)
  -- Executing [s@macro-hangupcall:51] NoOp("SIP/1003-0000007b", "ONETOUCH_RECFILE=") in new stack
  -- Executing [s@macro-hangupcall:52] GotoIf("SIP/1003-0000007b", "1?skiprg") in new stack
  -- Goto (macro-hangupcall,s,55)
  -- Executing [s@macro-hangupcall:55] GotoIf("SIP/1003-0000007b", "1?skipblkvm") in new stack
  -- Goto (macro-hangupcall,s,58)
  -- Executing [s@macro-hangupcall:58] GotoIf("SIP/1003-0000007b", "1?theend") in new stack
  -- Goto (macro-hangupcall,s,60)
  -- Executing [s@macro-hangupcall:60] AGI("SIP/1003-0000007b", "hangup.agi") in new stack
  -- Launched AGI Script /var/lib/asterisk/agi-bin/hangup.agi
  -- <SIP/1003-0000007b>AGI Script hangup.agi completed, returning 0
  -- Executing [s@macro-hangupcall:61] Hangup("SIP/1003-0000007b", "") in new stack
 == Spawn extension (macro-hangupcall, s, 61) exited non-zero on 'SIP/1003-0000007b' in macro 'hangupcall'
 == Spawn extension (macro-dialout-trunk, h, 1) exited non-zero on 'SIP/1003-0000007b'
 == Spawn extension (macro-dialout-trunk, s, 22) exited non-zero on 'SIP/1003-0000007b' in macro 'dialout-trunk'
 == Spawn extension (from-internal, 97804921930, 5) exited non-zero on 'SIP/1003-0000007b'
```

IVR: you dial 1 to go to 1001 and so on here he is what happened:

```
localhost*CLI>
  == Using SIP RTP TOS bits 184
  == Using SIP RTP CoS mark 5
    -- Executing [1001@from-trunk:1] Set("SIP/To-PSTN-000000b3", "__FROM_DID=1001") in new stack
    -- Executing [1001@from-trunk:2] Gosub("SIP/To-PSTN-000000b3", "app-blacklist-check,s,1()") in new stack
    -- Executing [s@app-blacklist-check:1] GotoIf("SIP/To-PSTN-000000b3", "0?blacklisted") in new stack
    -- Executing [s@app-blacklist-check:2] Set("SIP/To-PSTN-000000b3", "CALLED_BLACKLIST=1") in new stack
    -- Executing [s@app-blacklist-check:3] Return("SIP/To-PSTN-000000b3", "") in new stack
    -- Executing [1001@from-trunk:3] Set("SIP/To-PSTN-000000b3", "CDR(did)=1001") in new stack
    -- Executing [1001@from-trunk:4] ExecIf("SIP/To-PSTN-000000b3", "1 ?Set(CALLERID(name)=)") in new stack
    -- Executing [1001@from-trunk:5] Set("SIP/To-PSTN-000000b3", "CHANNEL(musicclass)=default") in new stack
    -- Executing [1001@from-trunk:6] Set("SIP/To-PSTN-000000b3", "__MOHCLASS=default") in new stack
    -- Executing [1001@from-trunk:7] Set("SIP/To-PSTN-000000b3", "__CALLINGPRES_SV=allowed_not_screened") in new stack
    -- Executing [1001@from-trunk:8] Set("SIP/To-PSTN-000000b3", "CALLERPRES()=allowed_not_screened") in new stack
    -- Executing [1001@from-trunk:9] Goto("SIP/To-PSTN-000000b3", "ivr-3,s,1") in new stack
    -- Goto (ivr-3,s,1)
    -- Executing [s@ivr-3:1] Set("SIP/To-PSTN-000000b3", "TIMEOUT_LOOPCOUNT=0") in new stack
    -- Executing [s@ivr-3:2] Set("SIP/To-PSTN-000000b3", "INVALID_LOOPCOUNT=0") in new stack
    -- Executing [s@ivr-3:3] Set("SIP/To-PSTN-000000b3", "_IVR_CONTEXT_ivr-3=") in new stack
    -- Executing [s@ivr-3:4] Set("SIP/To-PSTN-000000b3", "_IVR_CONTEXT=ivr-3") in new stack
    -- Executing [s@ivr-3:5] Set("SIP/To-PSTN-000000b3", "__IVR_RETVM=") in new stack
    -- Executing [s@ivr-3:6] GotoIf("SIP/To-PSTN-000000b3", "0?skip") in new stack
    -- Executing [s@ivr-3:7] Answer("SIP/To-PSTN-000000b3", "") in new stack
       > 0x7feef803f190 -- Probation passed - setting RTP source address to 192.168.1.254:18704
    -- Executing [s@ivr-3:8] Wait("SIP/To-PSTN-000000b3", "1") in new stack
    -- Executing [s@ivr-3:9] Set("SIP/To-PSTN-000000b3", "IVR_MSG=") in new stack
    -- Executing [s@ivr-3:10] Set("SIP/To-PSTN-000000b3", "TIMEOUT(digit)=3") in new stack
    -- Digit timeout set to 3.000
    -- Executing [s@ivr-3:11] ExecIf("SIP/To-PSTN-000000b3", "0?Background()") in new stack
    -- Executing [s@ivr-3:12] WaitExten("SIP/To-PSTN-000000b3", "3,") in new stack
  == CDR updated on SIP/To-PSTN-000000b3
    -- Executing [2@ivr-3:1] Goto("SIP/To-PSTN-000000b3", "from-did-direct,1002,1") in new stack
    -- Goto (from-did-direct,1002,1)
    -- Executing [1002@from-did-direct:1] Set("SIP/To-PSTN-000000b3", "__RINGTIMER=15") in new stack
    -- Executing [1002@from-did-direct:2] Macro("SIP/To-PSTN-000000b3", "exten-vm,novm,1002,0,0,0") in new stack
    -- Executing [s@macro-exten-vm:1] Macro("SIP/To-PSTN-000000b3", "user-callerid,") in new stack
    -- Executing [s@macro-user-callerid:1] Set("SIP/To-PSTN-000000b3", "TOUCH_MONITOR=1459870409.179") in new stack
    -- Executing [s@macro-user-callerid:2] Set("SIP/To-PSTN-000000b3", "AMPUSER=") in new stack
    -- Executing [s@macro-user-callerid:3] GotoIf("SIP/To-PSTN-000000b3", "0?report") in new stack
    -- Executing [s@macro-user-callerid:4] ExecIf("SIP/To-PSTN-000000b3", "1?Set(REALCALLERIDNUM=)") in new stack
    -- Executing [s@macro-user-callerid:5] Set("SIP/To-PSTN-000000b3", "AMPUSER=") in new stack
    -- Executing [s@macro-user-callerid:6] GotoIf("SIP/To-PSTN-000000b3", "0?limit") in new stack
    -- Executing [s@macro-user-callerid:7] Set("SIP/To-PSTN-000000b3", "AMPUSERCIDNAME=") in new stack
    -- Executing [s@macro-user-callerid:8] GotoIf("SIP/To-PSTN-000000b3", "1?report") in new stack
    -- Goto (macro-user-callerid,s,15)
    -- Executing [s@macro-user-callerid:15] GotoIf("SIP/To-PSTN-000000b3", "0?continue") in new stack
    -- Executing [s@macro-user-callerid:16] Set("SIP/To-PSTN-000000b3", "__TTL=64") in new stack
    -- Executing [s@macro-user-callerid:17] GotoIf("SIP/To-PSTN-000000b3", "1?continue") in new stack
    -- Goto (macro-user-callerid,s,28)
    -- Executing [s@macro-user-callerid:28] Set("SIP/To-PSTN-000000b3", "CALLERID(number)=") in new stack
    -- Executing [s@macro-user-callerid:29] Set("SIP/To-PSTN-000000b3", "CALLERID(name)=") in new stack
    -- Executing [s@macro-user-callerid:30] Set("SIP/To-PSTN-000000b3", "CDR(cnum)=") in new stack
    -- Executing [s@macro-user-callerid:31] Set("SIP/To-PSTN-000000b3", "CDR(cnam)=") in new stack
```

-- Executing [s@macro-user-callerid:32] Set("SIP/To-PSTN-000000b3", "CHANNEL(language)=en") in new stack
-- Executing [s@macro-exten-vm:2] Set("SIP/To-PSTN-000000b3", "RingGroupMethod=none") in new stack
-- Executing [s@macro-exten-vm:3] Set("SIP/To-PSTN-000000b3", "__EXTTOCALL=1002") in new stack
-- Executing [s@macro-exten-vm:4] Set("SIP/To-PSTN-000000b3", "__PICKUPMARK=1002") in new stack
-- Executing [s@macro-exten-vm:5] Set("SIP/To-PSTN-000000b3", "RT=") in new stack
-- Executing [s@macro-exten-vm:6] Gosub("SIP/To-PSTN-000000b3", "sub-record-check,s,1(exten,1002,)") in new stack
-- Executing [s@sub-record-check:1] Set("SIP/To-PSTN-000000b3", "REC_POLICY_MODE_SAVE=") in new stack
-- Executing [s@sub-record-check:2] GotoIf("SIP/To-PSTN-000000b3", "1?check") in new stack
-- Goto (sub-record-check,s,7)
-- Executing [s@sub-record-check:7] Set("SIP/To-PSTN-000000b3", "__MON_FMT=wav") in new stack
-- Executing [s@sub-record-check:8] GotoIf("SIP/To-PSTN-000000b3", "1?next") in new stack
-- Goto (sub-record-check,s,11)
-- Executing [s@sub-record-check:11] ExecIf("SIP/To-PSTN-000000b3", "0?Return()") in new stack
-- Executing [s@sub-record-check:12] ExecIf("SIP/To-PSTN-000000b3", "0?Set(__REC_POLICY_MODE=)") in new stack
-- Executing [s@sub-record-check:13] GotoIf("SIP/To-PSTN-000000b3", "0?exten,1") in new stack
-- Executing [s@sub-record-check:14] Set("SIP/To-PSTN-000000b3", "__REC_STATUS=INITIALIZED") in new stack
-- Executing [s@sub-record-check:15] Set("SIP/To-PSTN-000000b3", "NOW=1459870413") in new stack
-- Executing [s@sub-record-check:16] Set("SIP/To-PSTN-000000b3", "__DAY=05") in new stack
-- Executing [s@sub-record-check:17] Set("SIP/To-PSTN-000000b3", "__MONTH=04") in new stack
-- Executing [s@sub-record-check:18] Set("SIP/To-PSTN-000000b3", "__YEAR=2016") in new stack
-- Executing [s@sub-record-check:19] Set("SIP/To-PSTN-000000b3", "__TIMESTR=20160405-093333") in new stack
-- Executing [s@sub-record-check:20] Set("SIP/To-PSTN-000000b3", "__FROMEXTEN=unknown") in new stack
-- Executing [s@sub-record-check:21] Set("SIP/To-PSTN-000000b3", "__CALLFILENAME=exten-1002-unknown-20160405-093333-1459870409.179") in new stack
-- Executing [s@sub-record-check:22] Goto("SIP/To-PSTN-000000b3", "exten,1") in new stack
-- Goto (sub-record-check,exten,1)
-- Executing [exten@sub-record-check:1] GotoIf("SIP/To-PSTN-000000b3", "0?callee") in new stack
-- Executing [exten@sub-record-check:2] Set("SIP/To-PSTN-000000b3", "__REC_POLICY_MODE=dontcare") in new stack
-- Executing [exten@sub-record-check:3] GotoIf("SIP/To-PSTN-000000b3", "1?caller") in new stack
-- Goto (sub-record-check,exten,10)
-- Executing [exten@sub-record-check:10] Set("SIP/To-PSTN-000000b3", "__REC_POLICY_MODE=") in new stack
-- Executing [exten@sub-record-check:11] GosubIf("SIP/To-PSTN-000000b3", "0?record,1(exten,1002,unknown)") in new stack
-- Executing [exten@sub-record-check:12] Return("SIP/To-PSTN-000000b3", "") in new stack
-- Executing [s@macro-exten-vm:7] Macro("SIP/To-PSTN-000000b3", "dial-one,,tr,1002") in new stack
-- Executing [s@macro-dial-one:1] Set("SIP/To-PSTN-000000b3", "DEXTEN=1002") in new stack
-- Executing [s@macro-dial-one:2] Set("SIP/To-PSTN-000000b3", "DIALSTATUS_CW=") in new stack
-- Executing [s@macro-dial-one:3] GosubIf("SIP/To-PSTN-000000b3", "0?screen,1()") in new stack
-- Executing [s@macro-dial-one:4] GosubIf("SIP/To-PSTN-000000b3", "0?cf,1()") in new stack
-- Executing [s@macro-dial-one:5] GotoIf("SIP/To-PSTN-000000b3", "1?skip1") in new stack
-- Goto (macro-dial-one,s,8)
-- Executing [s@macro-dial-one:8] GotoIf("SIP/To-PSTN-000000b3", "0?nodial") in new stack
-- Executing [s@macro-dial-one:9] GotoIf("SIP/To-PSTN-000000b3", "0?continue") in new stack
-- Executing [s@macro-dial-one:10] Set("SIP/To-PSTN-000000b3", "EXTHASCW=") in new stack
-- Executing [s@macro-dial-one:11] GotoIf("SIP/To-PSTN-000000b3", "1?next1:cwinusebusy") in new stack
-- Goto (macro-dial-one,s,12)
-- Executing [s@macro-dial-one:12] GotoIf("SIP/To-PSTN-000000b3", "0?docfu:skip3") in new stack
-- Goto (macro-dial-one,s,16)
-- Executing [s@macro-dial-one:16] GotoIf("SIP/To-PSTN-000000b3", "1?next2:continue") in new stack
-- Goto (macro-dial-one,s,17)
-- Executing [s@macro-dial-one:17] GotoIf("SIP/To-PSTN-000000b3", "1?continue") in new stack
-- Goto (macro-dial-one,s,25)
-- Executing [s@macro-dial-one:25] GotoIf("SIP/To-PSTN-000000b3", "0?nodial") in new stack
-- Executing [s@macro-dial-one:26] GosubIf("SIP/To-PSTN-000000b3", "1?dstring,1():dlocal,1()") in new stack
-- Executing [dstring@macro-dial-one:1] Set("SIP/To-PSTN-000000b3", "DSTRING=") in new stack
-- Executing [dstring@macro-dial-one:2] Set("SIP/To-PSTN-000000b3", "DEVICES=1002") in new stack
-- Executing [dstring@macro-dial-one:3] ExecIf("SIP/To-PSTN-000000b3", "0?Return()") in new stack
-- Executing [dstring@macro-dial-one:4] ExecIf("SIP/To-PSTN-000000b3", "0?Set(DEVICES=002)") in new stack

```
   -- Executing [dstring@macro-dial-one:5] Set("SIP/To-PSTN-000000b3", "LOOPCNT=1") in new stack
   -- Executing [dstring@macro-dial-one:6] Set("SIP/To-PSTN-000000b3", "ITER=1") in new stack
   -- Executing [dstring@macro-dial-one:7] Set("SIP/To-PSTN-000000b3", "THISDIAL=SIP/1002") in new stack
   -- Executing [dstring@macro-dial-one:8] GosubIf("SIP/To-PSTN-000000b3", "1?zap2dahdi,1()") in new stack
   -- Executing [zap2dahdi@macro-dial-one:1] ExecIf("SIP/To-PSTN-000000b3", "0?Return()") in new stack
   -- Executing [zap2dahdi@macro-dial-one:2] Set("SIP/To-PSTN-000000b3", "NEWDIAL=") in new stack
   -- Executing [zap2dahdi@macro-dial-one:3] Set("SIP/To-PSTN-000000b3", "LOOPCNT2=1") in new stack
   -- Executing [zap2dahdi@macro-dial-one:4] Set("SIP/To-PSTN-000000b3", "ITER2=1") in new stack
   -- Executing [zap2dahdi@macro-dial-one:5] Set("SIP/To-PSTN-000000b3", "THISPART2=SIP/1002") in new stack
   -- Executing [zap2dahdi@macro-dial-one:6] ExecIf("SIP/To-PSTN-000000b3", "0?Set(THISPART2=DAHDI/1002)") in new stack
   -- Executing [zap2dahdi@macro-dial-one:7] Set("SIP/To-PSTN-000000b3", "NEWDIAL=SIP/1002&") in new stack
   -- Executing [zap2dahdi@macro-dial-one:8] Set("SIP/To-PSTN-000000b3", "ITER2=2") in new stack
   -- Executing [zap2dahdi@macro-dial-one:9] GotoIf("SIP/To-PSTN-000000b3", "0?begin2") in new stack
   -- Executing [zap2dahdi@macro-dial-one:10] Set("SIP/To-PSTN-000000b3", "THISDIAL=SIP/1002") in new stack
   -- Executing [zap2dahdi@macro-dial-one:11] Return("SIP/To-PSTN-000000b3", "") in new stack
   -- Executing [dstring@macro-dial-one:9] Set("SIP/To-PSTN-000000b3", "DSTRING=SIP/1002&") in new stack
   -- Executing [dstring@macro-dial-one:10] Set("SIP/To-PSTN-000000b3", "ITER=2") in new stack
   -- Executing [dstring@macro-dial-one:11] GotoIf("SIP/To-PSTN-000000b3", "0?begin") in new stack
   -- Executing [dstring@macro-dial-one:12] Set("SIP/To-PSTN-000000b3", "DSTRING=SIP/1002") in new stack
   -- Executing [dstring@macro-dial-one:13] Return("SIP/To-PSTN-000000b3", "") in new stack
   -- Executing [s@macro-dial-one:27] GotoIf("SIP/To-PSTN-000000b3", "0?nodial") in new stack
   -- Executing [s@macro-dial-one:28] GotoIf("SIP/To-PSTN-000000b3", "0?skiptrace") in new stack
   -- Executing [s@macro-dial-one:29] GosubIf("SIP/To-PSTN-000000b3", "0?ctset,1():ctclear,1()") in new stack
   -- Executing [ctclear@macro-dial-one:1] NoOp("SIP/To-PSTN-000000b3", "Deleting: CALLTRACE/1002 1003") in new stack
   -- Executing [ctclear@macro-dial-one:2] Return("SIP/To-PSTN-000000b3", "") in new stack
   -- Executing [s@macro-dial-one:30] Set("SIP/To-PSTN-000000b3", "D_OPTIONS=tr") in new stack
   -- Executing [s@macro-dial-one:31] ExecIf("SIP/To-PSTN-000000b3", "0?SIPAddHeader(Alert-Info: )") in new stack
   -- Executing [s@macro-dial-one:32] ExecIf("SIP/To-PSTN-000000b3", "0?SIPAddHeader()") in new stack
   -- Executing [s@macro-dial-one:33] ExecIf("SIP/To-PSTN-000000b3", "1?Set(CHANNEL(musicclass)=default)") in new stack
   -- Executing [s@macro-dial-one:34] GosubIf("SIP/To-PSTN-000000b3", "0?qwait,1()") in new stack
   -- Executing [s@macro-dial-one:35] Set("SIP/To-PSTN-000000b3", "__CWIGNORE=") in new stack
   -- Executing [s@macro-dial-one:36] Set("SIP/To-PSTN-000000b3", "__KEEPCID=TRUE") in new stack
   -- Executing [s@macro-dial-one:37] GotoIf("SIP/To-PSTN-000000b3", "0?usegoto,1") in new stack
   -- Executing [s@macro-dial-one:38] GotoIf("SIP/To-PSTN-000000b3", "1?godial") in new stack
   -- Goto (macro-dial-one,s,43)
   -- Executing [s@macro-dial-one:43] Dial("SIP/To-PSTN-000000b3", "SIP/1002,,tr") in new stack
  == Using SIP RTP TOS bits 184
  == Using SIP RTP CoS mark 5
    -- Called SIP/1002
    -- SIP/1002-000000b4 is ringing
localhost*CLI>
```

Lab 4

MPLS L3-VPN

Introduction:

Multi-Protocol Label Switching MPLS is a label based forwarding technology which uses labels in order to make data forwarding decisions. Labels usually correspond to Layer 3 destination address and can also correspond to other parameters such as quality of service (QOS), source address or Layer 2 circuit. MPLS was designed to support forwarding of other protocols as well.

Prelab:

1. What are the benefits of MPLS-based VPNs?

    - A platform for rapid deployment of additional value-added IP services, including intranets, extranets, voice, multimedia, and network commerce
    - Privacy and security equal to Layer-2 VPNs by constraining the distribution of a VPN's routes to only those routers that are members of that VPN, and by using MPLS for forwarding
    - Seamless integration with customer intranets
    - Increased scalability with thousands of sites per VPN and hundreds of thousands of VPNs per service provider
    - IP Class of Service (CoS) with support for multiple classes of service within a VPN, as well as priorities among VPNs
    - Easy management of VPN membership and rapid deployment of new VPNs
    - Scalable any-to-any connectivity for extended intranets and extranets that encompass multiple businesses

2. Define the format of MPLS label?

    Label - Label Value (Unstructured), 20 bits
    Exp - Experimental Use, 3 bits; currently used as a Class of Service (CoS) field
    S - Bottom of Stack, 1 bit
    TTL - Time to Live, 8 bits

3. What are the two advantages to carrying external routing in BGP rather than in the service provider IGP?

    - Stability so that flapping within a customer site does not affect the backbone.
    - The size of the internal routing structure within the service provider can be kept to a minimum.

4. What is RIB, LIB, FIB, LFIB and CEF, explain the difference between them? How do you display each table:

    - RIB (Routing Information Base) is the route table show ip route
    - FIB (Forwarding Information Base) is the table a router looks at when deciding where to actually forward traffic. In Cisco land, the CEF table is a FIB, show ip cef.
    - LIB (Label Information Base) where the router will keep all known MPLS labels, show mpls ldp bindings
    - LFIB (Label Forwarding Instance Base) table that the router uses to forward labelled packets going through the network, show mpls forwarding-table

5. What is the range of labels that can be assigned and please mention types of reserved labels?

    The range is 0 through (2^20-1). Label values 0-15 are reserved.

6. What are the two major components of MPLS, explain the difference between them?

    - Control plane: takes care of the routing information exchange and the label exchange between adjacent devices
    - Data plane: takes care of the forwarding based on either destination addresses or label, also known as forwarding plane.

7. What is the primary difference between the Label Forwarding Information Base (LFIB) and the Label Information Base (LIB)?

    The LFIB holds only the labels currently in use by the MPLS forwarding component, whereas the LIB holds all labels received from all neighbors.

8. What does Penultimate hop popping means?

    PHP is optimization technique when terminating an LSP by removing the label on the next to last hop, so the last router PE begin to route the packet.

9. When running a dynamic routing protocol between PE and CE, how can the PE identify which routing update belongs to which VRF?

    This is identified by the routing context that is configured on the PE router as an address-family.

10. What are the default values of MPLS hello interval hold timer and back-off timer?

Hello interval = 5 sec (Hello Timer is the interval that hello messages will be sent)
Hold timer= 15 sec (the time that the LDP session will go down if no hellos have been received after the Hold timer expires)
Backoff timer initial 5 sec (If two LSR can't agree on LDP parameters, they will exponentially backoff the session setup until they can agree)

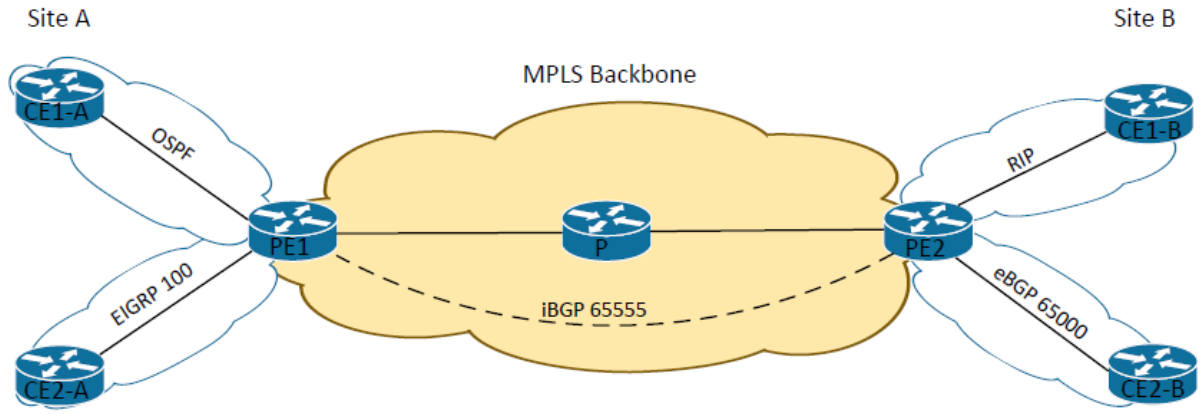
11. Which two tables does the LSR use to hold information that is relevant to the MPLS forwarding component?

    Label Information Base (LIB).
    Label Forwarding Information Base (LFIB).

Lab Scenario:

You are the network engineer working for Internet Service Provider and your task is to provide access between two sites for two different customers over the MPLS network.

Lab Diagram:



Lab IP Addressing:

Node	IP
CE1-A to PE1	192.168.X.0/30
CE2-A to PE1	192.168.X.0/30
PE1 to P	10.0.X.0/30
P to PE2	10.0.X.4/30
PE2 to CE1-B	192.168.X.4/30
PE2 to CE2-B	192.168.X.8/30
PE1 Loopback	1.1.1.1
P Loopback	3.3.3.3
PE2 Loopback	2.2.2.2
CE1-A Loopbacks	5-8.1.1.1
CE2-A Loopbacks	7-10.1.1.1
CE1-B Loopbacks	11-14.1.1.1
CE1-B Loopbacks	15-18.1.1.1

Procedure:

1. Wire all routers as per the lab diagram.

2. Configure IP addresses of all the MPLS backbone interfaces as per the IP address table.

3. Configure loopbacks on all MPLS backbone routers as per the IP address table.

4. On PE1, P and PE2 enable OSPF on the interfaces that belong to the MPLS backbone including the loopbacks.

   PE1#trace 2.2.2.2 source 1.1.1.1

5. On PE1, P1, P2 and PE2 configure the range of labels generated

PE1(config)#mpls label range 100 199
P(config)#mpls label range 200 299
PE2(config)#mpls label range 300 399

6. Make sure CEF is enabled and then enable MPLS globally on PE1, P and PE2 as well as on each MPLS backbone interfaces.

PXX(config)# mpls ip
PXX(config-if)# mpls ip

7. Confirm that LDP neighbors have been established between the MPLS router by running

P#show mpls ldp neighbor all
PE1#show mpls ldp neighbor all
PE2#show mpls ldp neighbor all

What is the LDP router ID for PE1?

P#show mpls ldp neighbor all
```
    Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 3.3.3.3:0
        TCP connection: 1.1.1.1.646 - 3.3.3.3.13734
        State: Oper; Msgs sent/rcvd: 12/12; Downstream
        Up time: 00:04:07
        LDP discovery sources:
          FastEthernet1/0, Src IP addr: 10.0.1.1
        Addresses bound to peer LDP Ident:
          10.0.1.1        1.1.1.1
    Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 3.3.3.3:0
        TCP connection: 2.2.2.2.646 - 3.3.3.3.49438
        State: Oper; Msgs sent/rcvd: 11/11; Downstream
        Up time: 00:03:10
        LDP discovery sources:
          FastEthernet1/1, Src IP addr: 10.0.1.6
        Addresses bound to peer LDP Ident:
          10.0.1.6        2.2.2.2
```

PE1#show mpls ldp neighbor all
```
    Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 1.1.1.1:0
        TCP connection: 3.3.3.3.13734 - 1.1.1.1.646
        State: Oper; Msgs sent/rcvd: 17/16; Downstream
        Up time: 00:07:45
        LDP discovery sources:
          FastEthernet1/0, Src IP addr: 10.0.1.2
        Addresses bound to peer LDP Ident:
          10.0.1.2        10.0.1.5        3.3.3.3
```

PE2#show mpls ldp neighbor

```
    Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 2.2.2.2:0
        TCP connection: 3.3.3.3.49438 - 2.2.2.2.646
        State: Oper; Msgs sent/rcvd: 16/16; Downstream
        Up time: 00:07:16
        LDP discovery sources:
          FastEthernet1/1, Src IP addr: 10.0.1.5
        Addresses bound to peer LDP Ident:
          10.0.1.2        10.0.1.5        3.3.3.3
```

8. Let us see what label PE1 router choose for 2.2.2.2/32. Run and analyze the output of the following commands on each MPLS router

   show mpls ldp bindings 2.2.2.2 32
   show mpls forwarding-table 2.2.2.2

   Run PE1#trace 2.2.2.2 source 1.1.1.1 and make sure that the output match your analysis.

```
PE1#show mpls ldp bindings 2.2.2.2 32
  lib entry: 2.2.2.2/32, rev 4
        local binding:  label: 100
        remote binding: lsr: 3.3.3.3:0, label: 201
```

```
PE1#show mpls forwarding-table 2.2.2.2
Local      Outgoing   Prefix          Bytes Label   Outgoing    Next Hop
Label      Label      or Tunnel Id    Switched      interface
100        201        2.2.2.2/32      0             Fa1/0       10.0.1.2
```

```
PE1#traceroute 2.2.2.2 source 1.1.1.1
Type escape sequence to abort.
Tracing the route to 2.2.2.2
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.1.2 [MPLS: Label 201 Exp 0] 36 msec 24 msec 28 msec
  2 10.0.1.6 64 msec 56 msec 64 msec
```

9. On P run **show mpls ldp bindings local** so you can see all the local labels, analyze the output. What does imp-null means?

```
P#show mpls ldp bindings local
  lib entry: 1.1.1.1/32, rev 2
        local binding:  label: 200
  lib entry: 2.2.2.2/32, rev 4
        local binding:  label: 201
  lib entry: 3.3.3.3/32, rev 6
```

local binding: label: imp-null
lib entry: 10.0.1.0/30, rev 8
local binding: label: imp-null
lib entry: 10.0.1.4/30, rev 10
local binding: label: imp-null

10. In this step, we will see all LDP message related to 2.2.2.2. On P1 create an access-list that only permit 2.2.2.2

Access-list 10 permit 2.2.2.2
Debug mpls ldp bindings prefix-acl 10

Disable and then enable mpls on P by running no mpls ip then mpls ip globally, highlight when P learned about 2.2.2.2/32 and when is added to the table?

LDP Label Information Base (LIB) changes debugging is on for prefix ACL 10
P#
*Nov 27 21:17:06.515: %LDP-5-NBRCHG: LDP Neighbor 1.1.1.1:0 (2) is DOWN (TCP connection closed by peer)
P#
*Nov 27 21:17:10.471: lcon: (default) Assign peer id; 1.1.1.1:0: id 2
*Nov 27 21:17:10.475: %LDP-5-NBRCHG: LDP Neighbor 1.1.1.1:0 (3) is UP
*Nov 27 21:17:10.527: lcon: 1.1.1.1:0: 10.0.1.1 added to addr<->ldp ident map
*Nov 27 21:17:10.531: lcon: 1.1.1.1:0: 1.1.1.1 added to addr<->ldp ident map
*Nov 27 21:17:10.535: LIB: 2.2.2.2/32:: learn binding 103 from 1.1.1.1:0
*Nov 27 21:17:10.539: lcon: tibent(2.2.2.2/32): label 100 from 1.1.1.1:0 impl withdraw
*Nov 27 21:17:10.539: tib: Impl withdraw for 2.2.2.2/32, labels old/new: 100/103
*Nov 27 21:17:10.539: tib: Previous remote label:100 from 1.1.1.1:0, for 2.2.2.2/32 added to queue

*Nov 27 21:17:10.539: LIB: find a binding 100 exists, inst 2 -> inst 3
*Nov 27 21:17:10.539: lcon: tibent(2.2.2.2/32): label 103 from 1.1.1.1:0 added
P#
*Nov 27 21:17:10.539: LIB: next hop for route 2.2.2.2/32(0, 10.0.1.6, Fa1/1) is not mapped to peer 1.1.1.1:0
*Nov 27 21:17:10.539: LIB: skip label announcement for 2.2.2.2/32
*Nov 27 21:17:10.539: tib: Label Rel sent to 1.1.1.1:0, for 2.2.2.2/32, prev remote label:100
*Nov 27 21:17:10.539: ldpx_fwdg: announced path label info for 1.1.1.1/32
*Nov 27 21:17:10.539: ldpx_fwdg: path change upcall event from fwdg
*Nov 27 21:17:10.543: LIB: announced out label 3 for 1.1.1.1/32 (via 10.0.1.1)

11. On P2 analyze the output of the **show mpls ldp discovery detail**
What is the ldp Id? what is the hello interval? what is hold time? what is the transport IP address?

P#show mpls ldp discovery detail
Local LDP Identifier:
3.3.3.3:0
Discovery Sources:
Interfaces:
FastEthernet1/0 (ldp): xmit/recv
Enabled: Interface config
Hello interval: 5000 ms; Transport IP addr: 3.3.3.3

```
    LDP Id: 1.1.1.1:0
      Src IP addr: 10.0.1.1; Transport IP addr: 1.1.1.1
      Hold time: 15 sec; Proposed local/peer: 15/15 sec
      Reachable via 1.1.1.1/32
      Password: not required, none, in use
    Clients: IPv4, mLDP
  FastEthernet1/1 (ldp): xmit/recv
    Enabled: Interface config
    Hello interval: 5000 ms; Transport IP addr: 3.3.3.3
    LDP Id: 2.2.2.2:0
      Src IP addr: 10.0.1.6; Transport IP addr: 2.2.2.2
      Hold time: 15 sec; Proposed local/peer: 15/15 sec
      Reachable via 2.2.2.2/32
      Password: not required, none, in use
    Clients: IPv4, mLDP
```

12. On P change the LDP router-id to the interface facing P1

    P(config)#mpls ldp router-id fa1/1 force

    Confirm that P has new LDP router ID which is the interface IP?

```
P#show mpls ldp discovery detail
 Local LDP Identifier:
    10.0.1.5:0
    Discovery Sources:
    Interfaces:
      FastEthernet1/0 (ldp): xmit/recv
        Enabled: Interface config
        Hello interval: 5000 ms; Transport IP addr: 10.0.1.5
        LDP Id: 1.1.1.1:0
          Src IP addr: 10.0.1.1; Transport IP addr: 1.1.1.1
          Hold time: 15 sec; Proposed local/peer: 15/15 sec
          Reachable via 1.1.1.1/32
          Password: not required, none, in use
        Clients: IPv4, mLDP
      FastEthernet1/1 (ldp): xmit/recv
        Enabled: Interface config
        Hello interval: 5000 ms; Transport IP addr: 10.0.1.5
        LDP Id: 2.2.2.2:0
          Src IP addr: 10.0.1.6; Transport IP addr: 2.2.2.2
          Hold time: 15 sec; Proposed local/peer: 15/15 sec
          Reachable via 2.2.2.2/32
          Password: not required, none, in use
        Clients: IPv4, mLDP
```

13. Configure iBGP between PE1 and PE2 and confirm that neighborship has been established

    PE1(config)#router bgp 65555
    PE1(config-router)#neighbor 2.2.2.2 remote-as 65555
    PE1(config-router)#neighbor 2.2.2.2 update-source lo 0

```
PE2(config)#router bgp 65555
PE2(config-router)#neighbor 1.1.1.1 remote-as 65555
PE2(config-router)#neighbor 1.1.1.1 update-source lo 0
```

```
PE1#show ip bgp summary
BGP router identifier 1.1.1.1, local AS number 65555
BGP table version is 1, main routing table version 1

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
2.2.2.2         4        65555       4       4        1    0    0 00:00:18        0
```

14. Activate VPNv4 capability and extended communities on PE1 and PE2 under BGP

```
PE1(config-router)#address-family vpnv4
PE1(config-router-af)#neighbor 2.2.2.2 activate
PE1(config-router-af)#neighbor 2.2.2.2 send-community extended

PE2(config-router)#address-family vpnv4
PE2(config-router-af)#neighbor 1.1.1.1 activate
PE2(config-router-af)#neighbor 1.1.1.1 send-community extended
```

15. Verify that iBGP neighbor between PE1 and PE2 and the VPNv4 capability is established and analyze the output of

Show ip bgp neighbors
Show ip bgp neighbors | section capabilities

```
PE1#Show ip bgp neighbors | section capabilities
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Address family VPNv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multisession Capability:
    Stateful switchover support enabled: NO for session 1
```

16. On PE1 and PE2 configure VRF for each customer

	PE1	PE2
VRF Name		
CE1	CE1	CE1
CE2	CE2	CE2
Route Distinguisher		

CE1	1.1.1.1:1	2.2.2.2:1
CE2	1.1.1.1:2	2.2.2.2:2
Route Target		
CE1 Export	1.1.1.1:101	2.2.2.2:101
CE1 Import	2.2.2.2:101	1.1.1.1:101
CE2 Export	1.1.1.1:102	2.2.2.2:102
CE2 Import	2.2.2.2:102	1.1.1.1:102

```
PE1(config)#Ip Vrf  CE1
PE1(config-vrf)#Rd 1.1.1.1:1
PE1(config-vrf)#Route-target export 1.1.1.1:101
PE1(config-vrf)#Route-target import 2.2.2.2:101
```

```
PE1(config)#Ip Vrf  CE2
PE1(config-vrf)#Rd 1.1.1.1:2
PE1(config-vrf)#Route-target export 1.1.1.1:102
PE1(config-vrf)#Route-target import 2.2.2.2:102
```

```
PE2(config)#Ip Vrf  CE1
PE2(config-vrf)Rd 2.2.2.2:1
PE2(config-vrf)Route-target export 2.2.2.2:101
PE2(config-vrf)Route-target import 1.1.1.1:101
```

```
PE2(config)#Ip Vrf  CE2
PE2(config-vrf)Rd 2.2.2.2:2
PE2(config-vrf)Route-target export 2.2.2.2:102
PE2(config-vrf)Route-target import 1.1.1.1:102
```

17. On the interfaces of PE1 and PE2 that are facing the customers, allocate each interface connected to a customer to the vrf you configured earlier and the ip addresses

```
PE1(config)#int fa0/0
PE1(config-if)#ip vrf forwarding CE1
PE1(config-if)#ip address 192.168.1.1 255.255.255.252

PE1(config)#int fa1/1
PE1(config-if)#ip vrf forwarding CE2
PE1(config-if)#ip address 192.168.1.1 255.255.255.252

PE2(config)#int fa0/0
PE2(config-if)#ip vrf forwarding CE1
PE2(config-if)#ip address 192.168.1.5 255.255.255.252

PE2(config)#int fa1/0
PE2(config-if)#ip vrf forwarding CE2
```

PE2(config-if)#ip address 192.168.1.9 255.255.255.252

18. Configure IP addresses on CEs routers as per the lab IP addressing table.

19. Analyze the output of the following show commands on PE1 and PE2

Show ip int br (Notice that there are two interfaces with the same IP)
Show vrf
Show ip route vrf CE1 (Notice that there is nothing populated yet except the directly connected routes)

PE1#show ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.1.1	YES	manual	up	up
FastEthernet1/0	10.0.1.1	YES	manual	up	up
FastEthernet1/1	192.168.1.1	YES	manual	up	up
Loopback0	1.1.1.1	YES	manual	up	up

PE2#show vrf

Name	Default RD	Protocols	Interfaces
CE1	2.2.2.2:1	ipv4	Fa0/0
CE2	2.2.2.2:2	ipv4	Fa1/0

PE1#show vrf

Name	Default RD	Protocols	Interfaces
CE1	1.1.1.1:1	ipv4	Fa0/0
CE2	1.1.1.1:2	ipv4	Fa1/1

20. Configure OSPF on CE1-A

CE1-A(config)#router ospf 1
CE1-A(config-router)#network 192.168.1.0 0.0.0.3 area 0
CE1-A(config-router)#network 5.1.1.1 0.0.0.0 area 0
CE1-A(config-router)#network 6.1.1.1 0.0.0.0 area 0
CE1-A(config-router)#network 7.1.1.1 0.0.0.0 area 0
CE1-A(config-router)#network 8.1.1.1 0.0.0.0 area 0

21. Configure EIGRP on CE2-A

CE2-A(config)#router eigrp 100
CE2-A(config-router)#network 192.168.1.0 0.0.0.3
CE2-A(config-router)#network 8.1.1.1 0.0.0.0
CE2-A(config-router)#network 9.1.1.1 0.0.0.0
CE2-A(config-router)#network 10.1.1.1 0.0.0.0
CE2-A(config-router)#network 7.1.1.1 0.0.0.0

22. Configure RIP v2 on CE1-B

```
CE1-B(config)#router rip
CE1-B(config-router)#version 2
CE1-B(config-router)#network 192.168.1.4
CE1-B(config-router)#network 11.1.1.1
CE1-B(config-router)#network 12.1.1.1
CE1-B(config-router)#network 13.1.1.1
CE1-B(config-router)#network 14.1.1.1
```

23. Configure BGP on CE2-B (how will you advertise the loopbacks?)

```
CE2-B(config)#router bgp 65000
CE2-B(config-router)#neighbor 192.168.1.9 remote-as 65555
CE2-B(config-router)#redistribute connected
```

24. On PE1 configure the routing configuration for both VRFs

```
PE1(config)#router ospf 10 vrf CE1
PE1(config-router)#network 192.168.1.0 0.0.0.3 area 0

PE1(config)#router eigrp 100
PE1(config-router)#address-family ipv4 vrf CE2 autonomous-system 100
PE1(config-router-af)#network 192.168.1.0 0.0.0.3
```

25. On PE2 configure the routing for both customers VRFs

```
PE2(config)#router rip
PE2(config-router)#version 2
PE2(config-router)#address-family ipv4 vrf CE1
PE2(config-router-af)#network 192.168.1.4

PE2(config)#router bgp 65555
PE2(config-router)#address-family ipv4 vrf CE2
PE2(config-router-af)#neighbor 192.168.1.10 remote-as 65000
PE2(config-router-af)#neighbor 192.168.1.10 activate
PE2(config-router)#address-family vpnv4
PE2(config-router-af)#neighbor 1.1.1.1 next-hop-self
```

26. On PE1 redistribute both vrf

PE1(config)#router bgp 65555
PE1(config-router)#address-family ipv4 vrf CE1
PE1(config-router-af)#redistribute ospf 10 vrf CE1

PE1(config)#router ospf 10 vrf CE1
PE1(config-router)#redistribute bgp 65555 subnets

PE1(config)#router bgp 65555
PE1(config-router)#address-family ipv4 vrf CE2
PE1(config-router-af)#redistribute eigrp 100

PE1(config)#router eigrp 100
PE1(config-router)#address-family ipv4 vrf CE2 autonomous-system 100
PE1(config-router-af)#redistribute bgp 65555 metric 1 1 1 1 1

Show ip bgp vpnv4 vrf CE1 labels
Show mpls forwarding-table vrf CE1
Show ip cef vrf CE1
show bgp vpnv4 unicast vrf CE1

PE1#show ip bgp vpnv4 vrf CE1 labels
   Network   Next Hop   In label/Out label
Route Distinguisher: 1.1.1.1:1 (CE1)
   5.1.1.1/32   192.168.1.2   100/nolabel
   6.1.1.1/32   192.168.1.2   101/nolabel
   7.1.1.1/32   192.168.1.2   102/nolabel
   8.1.1.1/32   192.168.1.2   106/nolabel
   192.168.1.0/30   0.0.0.0   107/nolabel(CE1)

PE1#show mpls forwarding-table vrf CE1
Local Outgoing Prefix   Bytes Label Outgoing Next Hop
Label Label   or Tunnel Id   Switched   interface
100   No Label 5.1.1.1/32[V]   0   Fa0/0   192.168.1.2
101   No Label 6.1.1.1/32[V]   0   Fa0/0   192.168.1.2
102   No Label 7.1.1.1/32[V]   0   Fa0/0   192.168.1.2
106   No Label 8.1.1.1/32[V]   0   Fa0/0   192.168.1.2
107   No Label 192.168.1.0/30[V] \
                                  0   aggregate/CE1

PE1#show ip cef vrf CE1

```
Prefix              Next Hop            Interface
0.0.0.0/0           no route
0.0.0.0/8           drop
0.0.0.0/32          receive
5.1.1.1/32          192.168.1.2         FastEthernet0/0
6.1.1.1/32          192.168.1.2         FastEthernet0/0
7.1.1.1/32          192.168.1.2         FastEthernet0/0
8.1.1.1/32          192.168.1.2         FastEthernet0/0
127.0.0.0/8         drop
192.168.1.0/30      attached            FastEthernet0/0
192.168.1.0/32      receive             FastEthernet0/0
192.168.1.1/32      receive             FastEthernet0/0
192.168.1.2/32      attached            FastEthernet0/0
192.168.1.3/32      receive             FastEthernet0/0
224.0.0.0/4         drop
224.0.0.0/24        receive
240.0.0.0/4         drop
255.255.255.255/32  receive
```

```
PE1#show bgp vpnv4 unicast vrf CE1
BGP table version is 16, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 1.1.1.1:1 (default for vrf CE1)
 *>  5.1.1.1/32      192.168.1.2              2         32768 ?
 *>  6.1.1.1/32      192.168.1.2              2         32768 ?
 *>  7.1.1.1/32      192.168.1.2              2         32768 ?
 *>  8.1.1.1/32      192.168.1.2              2         32768 ?
 *>  192.168.1.0/30  0.0.0.0                  0         32768 ?
```

27. On PE2 redistribute both VRF

```
PE2(config)#router bgp 65555
PE2(config-router)#address-family ipv4 vrf CE1
PE2(config-router-af)#redistribute rip

PE2(config)#router rip
PE2(config-router)#address-family ipv4 vrf CE1
PE2(config-router-af)#redistribute bgp 65555 metric 5
```

Trace route an overlapping loopback address 7.1.1.1 from CE1 and CE2 on site B to Site A, what is the difference?

```
CE1-B#traceroute 7.1.1.1
Type escape sequence to abort.
Tracing the route to 7.1.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.1.5 40 msec 40 msec 16 msec
  2 10.0.1.5 [MPLS: Labels 200/102 Exp 0] 124 msec 124 msec 116 msec
  3 192.168.1.1 [MPLS: Label 102 Exp 0] 100 msec 80 msec 104 msec
  4 192.168.1.2 124 msec 108 msec 124 msec
```

```
CE2-B#traceroute 7.1.1.1
Type escape sequence to abort.
Tracing the route to 7.1.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.1.9 100 msec 8 msec 28 msec
  2 10.0.1.5 [MPLS: Labels 200/108 Exp 0] 132 msec 92 msec 132 msec
  3 192.168.1.1 [AS 65555] [MPLS: Label 108 Exp 0] 52 msec 60 msec 36 msec
  4 192.168.1.2 [AS 65555] 96 msec 104 msec 108 msec
CE2-B#
```

Deliverables:

- Diagram of the lab with IP addresses and Autonomous system numbers.
- Running configuration of all the routers.
- Show ip route for both VRF at both PE1 and PE2.
- Output of LFIB table on all ISP routers.
- Ping from CE2-A loopback to CE2-B loopback with single packet, and capture mpls packet debug output on P1 and P2 routers. Briefly explain what label have been swapped.
- Output of show ip route on all customer's routers.
- Trace route from CE1-B to 7.1.1.1 and from CE2-B to 7.1.1.1

Instructions to follow at the end of each lab

- Make sure you erase your configuration from NVRAM of the devices used.
- Do not save any of the configurations in flash memory.
- All cables must be unplugged and secured in the box.
- There must not be any kind of garbage around the desk or racks after you are done with lab.

CE1-A#show ip route

```
     5.0.0.0/32 is subnetted, 1 subnets
C       5.1.1.1 is directly connected, Loopback0
     6.0.0.0/32 is subnetted, 1 subnets
C       6.1.1.1 is directly connected, Loopback1
     7.0.0.0/32 is subnetted, 1 subnets
C       7.1.1.1 is directly connected, Loopback2
     8.0.0.0/32 is subnetted, 1 subnets
C       8.1.1.1 is directly connected, Loopback3
     11.0.0.0/32 is subnetted, 1 subnets
O E2    11.1.1.1 [110/1] via 192.168.1.1, 00:01:24, FastEthernet0/0
     12.0.0.0/32 is subnetted, 1 subnets
O E2    12.1.1.1 [110/1] via 192.168.1.1, 00:01:24, FastEthernet0/0
     13.0.0.0/32 is subnetted, 1 subnets
O E2    13.1.1.1 [110/1] via 192.168.1.1, 00:01:24, FastEthernet0/0
     14.0.0.0/32 is subnetted, 1 subnets
O E2    14.1.1.1 [110/1] via 192.168.1.1, 00:01:24, FastEthernet0/0
     192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.1.0/30 is directly connected, FastEthernet0/0
L       192.168.1.2/32 is directly connected, FastEthernet0/0
O E2    192.168.1.4/30 [110/1] via 192.168.1.1, 00:01:24, FastEthernet0/0
```

CE1-A#traceroute 11.1.1.1

```
Type escape sequence to abort.
Tracing the route to 11.1.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.1.1 20 msec 20 msec 32 msec
  2 10.0.1.2 [MPLS: Labels 200/303 Exp 0] 112 msec 104 msec 100 msec
  3 192.168.1.5 [MPLS: Label 303 Exp 0] 100 msec 84 msec 92 msec
  4 192.168.1.6 140 msec 124 msec 116 msec
```

CE1-A#ping 14.1.1.1

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 14.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 112/120/128 ms
```

CE1-B#show ip route

```
     5.0.0.0/32 is subnetted, 1 subnets
R       5.1.1.1 [120/5] via 192.168.1.5, 00:00:23, FastEthernet0/0
     6.0.0.0/32 is subnetted, 1 subnets
R       6.1.1.1 [120/5] via 192.168.1.5, 00:00:23, FastEthernet0/0
     7.0.0.0/32 is subnetted, 1 subnets
R       7.1.1.1 [120/5] via 192.168.1.5, 00:00:23, FastEthernet0/0
     8.0.0.0/32 is subnetted, 1 subnets
R       8.1.1.1 [120/5] via 192.168.1.5, 00:00:23, FastEthernet0/0
     11.0.0.0/32 is subnetted, 1 subnets
```

```
C       11.1.1.1 is directly connected, Loopback0
     12.0.0.0/32 is subnetted, 1 subnets
C       12.1.1.1 is directly connected, Loopback1
     13.0.0.0/32 is subnetted, 1 subnets
C       13.1.1.1 is directly connected, Loopback2
     14.0.0.0/32 is subnetted, 1 subnets
C       14.1.1.1 is directly connected, Loopback3
     192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
R       192.168.1.0/30 [120/5] via 192.168.1.5, 00:00:23, FastEthernet0/0
C       192.168.1.4/30 is directly connected, FastEthernet0/0
L       192.168.1.6/32 is directly connected, FastEthernet0/0
```

CE1-B#traceroute 7.1.1.1

```
Type escape sequence to abort.
Tracing the route to 7.1.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.1.5 32 msec 32 msec 8 msec
  2 10.0.1.5 [MPLS: Labels 201/105 Exp 0] 92 msec 100 msec 96 msec
  3 192.168.1.1 [MPLS: Label 105 Exp 0] 88 msec 104 msec 48 msec
  4 192.168.1.2 96 msec 116 msec 124 msec
```

CE1-B#ping 6.1.1.1

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 6.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 112/117/128 ms
```

CE2-A#show ip route

```
     7.0.0.0/32 is subnetted, 1 subnets
C       7.1.1.1 is directly connected, Loopback0
     8.0.0.0/32 is subnetted, 1 subnets
C       8.1.1.1 is directly connected, Loopback1
     9.0.0.0/32 is subnetted, 1 subnets
C       9.1.1.1 is directly connected, Loopback2
     10.0.0.0/32 is subnetted, 1 subnets
C       10.1.1.1 is directly connected, Loopback3
     15.0.0.0/32 is subnetted, 1 subnets
D EX    15.1.1.1 [170/2560002816] via 192.168.1.1, 00:07:00, FastEthernet1/1
     16.0.0.0/32 is subnetted, 1 subnets
D EX    16.1.1.1 [170/2560002816] via 192.168.1.1, 00:07:00, FastEthernet1/1
     17.0.0.0/32 is subnetted, 1 subnets
D EX    17.1.1.1 [170/2560002816] via 192.168.1.1, 00:07:00, FastEthernet1/1
     18.0.0.0/32 is subnetted, 1 subnets
D EX    18.1.1.1 [170/2560002816] via 192.168.1.1, 00:07:00, FastEthernet1/1
     192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.1.0/30 is directly connected, FastEthernet1/1
L       192.168.1.2/32 is directly connected, FastEthernet1/1
D EX    192.168.1.8/30
        [170/2560002816] via 192.168.1.1, 00:07:00, FastEthernet1/1
```

CE2-A#traceroute 15.1.1.1
Type escape sequence to abort.
Tracing the route to 15.1.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.1.1 36 msec 24 msec 48 msec
  2 10.0.1.2 [MPLS: Labels 200/308 Exp 0] 72 msec 96 msec 108 msec
  3 192.168.1.9 [MPLS: Label 308 Exp 0] 64 msec 76 msec 96 msec
  4 192.168.1.10 92 msec 92 msec 96 msec

CE2-A#ping 17.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 17.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 96/106/120 ms

CE2-B#show ip route

      7.0.0.0/32 is subnetted, 1 subnets
B   7.1.1.1 [20/0] via 192.168.1.9, 00:04:19
      8.0.0.0/32 is subnetted, 1 subnets
B   8.1.1.1 [20/0] via 192.168.1.9, 00:04:19
      9.0.0.0/32 is subnetted, 1 subnets
B   9.1.1.1 [20/0] via 192.168.1.9, 00:04:19
      10.0.0.0/32 is subnetted, 1 subnets
B   10.1.1.1 [20/0] via 192.168.1.9, 00:04:19
      15.0.0.0/32 is subnetted, 1 subnets
C   15.1.1.1 is directly connected, Loopback0
      16.0.0.0/32 is subnetted, 1 subnets
C   16.1.1.1 is directly connected, Loopback1
      17.0.0.0/32 is subnetted, 1 subnets
C   17.1.1.1 is directly connected, Loopback2
      18.0.0.0/32 is subnetted, 1 subnets
C   18.1.1.1 is directly connected, Loopback3
      192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
B   192.168.1.0/30 [20/0] via 192.168.1.9, 00:04:19
C   192.168.1.8/30 is directly connected, FastEthernet1/0
L   192.168.1.10/32 is directly connected, FastEthernet1/0

CE2-B# traceroute 7.1.1.1
Type escape sequence to abort.
Tracing the route to 7.1.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.1.9 32 msec 32 msec 32 msec
  2 10.0.1.5 [MPLS: Labels 201/108 Exp 0] 60 msec 96 msec 92 msec
  3 192.168.1.1 [AS 65555] [MPLS: Label 108 Exp 0] 80 msec 96 msec 84 msec
  4 192.168.1.2 [AS 65555] 92 msec 92 msec 80 msec

CE2-B#ping 8.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 80/98/120 ms

PE1#show ip route

```
     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/3] via 10.0.1.2, 00:12:23, FastEthernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/2] via 10.0.1.2, 00:12:33, FastEthernet1/0
     10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C       10.0.1.0/30 is directly connected, FastEthernet1/0
L       10.0.1.1/32 is directly connected, FastEthernet1/0
O       10.0.1.4/30 [110/2] via 10.0.1.2, 00:12:33, FastEthernet1/0
```

PE1#show ip cef

Prefix	Next Hop	Interface
0.0.0.0/0	no route	
0.0.0.0/8	drop	
0.0.0.0/32	receive	
1.1.1.1/32	receive	Loopback0
2.2.2.2/32	10.0.1.2	FastEthernet1/0
3.3.3.3/32	10.0.1.2	FastEthernet1/0
10.0.1.0/30	attached	FastEthernet1/0
10.0.1.0/32	receive	FastEthernet1/0
10.0.1.1/32	receive	FastEthernet1/0
10.0.1.2/32	attached	FastEthernet1/0
10.0.1.3/32	receive	FastEthernet1/0
10.0.1.4/30	10.0.1.2	FastEthernet1/0
127.0.0.0/8	drop	
224.0.0.0/4	drop	
224.0.0.0/24	receive	
240.0.0.0/4	drop	
255.255.255.255/32	receive	

PE1#show mpls ldp bindings

```
  lib entry: 1.1.1.1/32, rev 4
        local binding:  label: imp-null
        remote binding: lsr: 10.0.1.5:0, label: 201
  lib entry: 2.2.2.2/32, rev 10
        local binding:  label: 102
        remote binding: lsr: 10.0.1.5:0, label: 200
  lib entry: 3.3.3.3/32, rev 6
```

```
        local binding:  label: 100
        remote binding: lsr: 10.0.1.5:0, label: imp-null
  lib entry: 10.0.1.0/30, rev 2
        local binding:  label: imp-null
        remote binding: lsr: 10.0.1.5:0, label: imp-null
  lib entry: 10.0.1.4/30, rev 8
        local binding:  label: 101
        remote binding: lsr: 10.0.1.5:0, label: imp-null
```

PE1#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Label Switched	Outgoing interface	Next Hop
100	Pop Label	3.3.3.3/32	0	Fa1/0	10.0.1.2
101	Pop Label	10.0.1.4/30	0	Fa1/0	10.0.1.2
102	200	2.2.2.2/32	0	Fa1/0	10.0.1.2
103	No Label	5.1.1.1/32[V]	0	Fa0/0	192.168.1.2
104	No Label	6.1.1.1/32[V]	570	Fa0/0	192.168.1.2
105	No Label	7.1.1.1/32[V]	684	Fa0/0	192.168.1.2
106	No Label	8.1.1.1/32[V]	0	Fa0/0	192.168.1.2
107	No Label	192.168.1.0/30[V] \			
		1884	aggregate/CE1		
108	No Label	7.1.1.1/32[V]	684	Fa1/1	192.168.1.2
109	No Label	8.1.1.1/32[V]	570	Fa1/1	192.168.1.2
110	No Label	9.1.1.1/32[V]	0	Fa1/1	192.168.1.2
111	No Label	10.1.1.1/32[V]	0	Fa1/1	192.168.1.2
112	No Label	192.168.1.0/30[V] \			
		1884	aggregate/CE2		

PE1#show ip route vrf CE1

```
     5.0.0.0/32 is subnetted, 1 subnets
O       5.1.1.1 [110/2] via 192.168.1.2, 00:14:13, FastEthernet0/0
     6.0.0.0/32 is subnetted, 1 subnets
O       6.1.1.1 [110/2] via 192.168.1.2, 00:14:13, FastEthernet0/0
     7.0.0.0/32 is subnetted, 1 subnets
O       7.1.1.1 [110/2] via 192.168.1.2, 00:14:13, FastEthernet0/0
     8.0.0.0/32 is subnetted, 1 subnets
O       8.1.1.1 [110/2] via 192.168.1.2, 00:14:13, FastEthernet0/0
     11.0.0.0/32 is subnetted, 1 subnets
B       11.1.1.1 [200/1] via 2.2.2.2, 00:14:00
     12.0.0.0/32 is subnetted, 1 subnets
B       12.1.1.1 [200/1] via 2.2.2.2, 00:14:00
     13.0.0.0/32 is subnetted, 1 subnets
B       13.1.1.1 [200/1] via 2.2.2.2, 00:14:00
     14.0.0.0/32 is subnetted, 1 subnets
B       14.1.1.1 [200/1] via 2.2.2.2, 00:14:00
     192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.1.0/30 is directly connected, FastEthernet0/0
L       192.168.1.1/32 is directly connected, FastEthernet0/0
B       192.168.1.4/30 [200/0] via 2.2.2.2, 00:14:00
```

PE1#show ip route vrf CE2

```
      7.0.0.0/32 is subnetted, 1 subnets
D        7.1.1.1 [90/156160] via 192.168.1.2, 00:15:11, FastEthernet1/1
      8.0.0.0/32 is subnetted, 1 subnets
D        8.1.1.1 [90/156160] via 192.168.1.2, 00:15:11, FastEthernet1/1
      9.0.0.0/32 is subnetted, 1 subnets
D        9.1.1.1 [90/156160] via 192.168.1.2, 00:15:11, FastEthernet1/1
      10.0.0.0/32 is subnetted, 1 subnets
D        10.1.1.1 [90/156160] via 192.168.1.2, 00:15:11, FastEthernet1/1
      15.0.0.0/32 is subnetted, 1 subnets
B        15.1.1.1 [200/0] via 2.2.2.2, 00:14:09
      16.0.0.0/32 is subnetted, 1 subnets
B        16.1.1.1 [200/0] via 2.2.2.2, 00:14:09
      17.0.0.0/32 is subnetted, 1 subnets
B        17.1.1.1 [200/0] via 2.2.2.2, 00:14:09
      18.0.0.0/32 is subnetted, 1 subnets
B        18.1.1.1 [200/0] via 2.2.2.2, 00:14:09
      192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
C        192.168.1.0/30 is directly connected, FastEthernet1/1
L        192.168.1.1/32 is directly connected, FastEthernet1/1
B        192.168.1.8/30 [200/0] via 2.2.2.2, 00:14:09
```

PE1#SHOW VRF

Name	Default RD	Protocols	Interfaces
CE1	1.1.1.1:1	ipv4	Fa0/0
CE2	1.1.1.1:2	ipv4	Fa1/1

PE1#

P#show ip route

```
      1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/2] via 10.0.1.1, 00:16:56, FastEthernet1/0
      2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/2] via 10.0.1.6, 00:16:56, FastEthernet1/1
      3.0.0.0/32 is subnetted, 1 subnets
C        3.3.3.3 is directly connected, Loopback0
      10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C        10.0.1.0/30 is directly connected, FastEthernet1/0
L        10.0.1.2/32 is directly connected, FastEthernet1/0
C        10.0.1.4/30 is directly connected, FastEthernet1/1
L        10.0.1.5/32 is directly connected, FastEthernet1/1
```

P#show ip cef

Prefix	Next Hop	Interface
0.0.0.0/0	no route	
0.0.0.0/8	drop	
0.0.0.0/32	receive	
1.1.1.1/32	10.0.1.1	FastEthernet1/0
2.2.2.2/32	10.0.1.6	FastEthernet1/1
3.3.3.3/32	receive	Loopback0
10.0.1.0/30	attached	FastEthernet1/0
10.0.1.0/32	receive	FastEthernet1/0
10.0.1.1/32	attached	FastEthernet1/0
10.0.1.2/32	receive	FastEthernet1/0
10.0.1.3/32	receive	FastEthernet1/0
10.0.1.4/30	attached	FastEthernet1/1
10.0.1.4/32	receive	FastEthernet1/1
10.0.1.5/32	receive	FastEthernet1/1
10.0.1.6/32	attached	FastEthernet1/1
10.0.1.7/32	receive	FastEthernet1/1
127.0.0.0/8	drop	
224.0.0.0/4	drop	
224.0.0.0/24	receive	
240.0.0.0/4	drop	
255.255.255.255/32	receive	

P#show mpls ldp bindings

```
  lib entry: 1.1.1.1/32, rev 10
        local binding:  label: 201
        remote binding: lsr: 1.1.1.1:0, label: imp-null
        remote binding: lsr: 2.2.2.2:0, label: 302
  lib entry: 2.2.2.2/32, rev 8
        local binding:  label: 200
        remote binding: lsr: 2.2.2.2:0, label: imp-null
        remote binding: lsr: 1.1.1.1:0, label: 102
  lib entry: 3.3.3.3/32, rev 2
        local binding:  label: imp-null
        remote binding: lsr: 2.2.2.2:0, label: 300
        remote binding: lsr: 1.1.1.1:0, label: 100
  lib entry: 10.0.1.0/30, rev 4
        local binding:  label: imp-null
        remote binding: lsr: 2.2.2.2:0, label: 301
        remote binding: lsr: 1.1.1.1:0, label: imp-null
  lib entry: 10.0.1.4/30, rev 6
        local binding:  label: imp-null
        remote binding: lsr: 2.2.2.2:0, label: imp-null
        remote binding: lsr: 1.1.1.1:0, label: 101
```

P#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Label Switched	Outgoing interface	Next Hop
200	Pop Label	2.2.2.2/32	9290	Fa1/1	10.0.1.6
201	Pop Label	1.1.1.1/32	9077	Fa1/0	10.0.1.1

PE2#show ip route vrf CE1

```
      5.0.0.0/32 is subnetted, 1 subnets
B        5.1.1.1 [200/2] via 1.1.1.1, 00:19:28
      6.0.0.0/32 is subnetted, 1 subnets
B        6.1.1.1 [200/2] via 1.1.1.1, 00:19:28
      7.0.0.0/32 is subnetted, 1 subnets
B        7.1.1.1 [200/2] via 1.1.1.1, 00:19:28
      8.0.0.0/32 is subnetted, 1 subnets
B        8.1.1.1 [200/2] via 1.1.1.1, 00:19:28
      11.0.0.0/32 is subnetted, 1 subnets
R        11.1.1.1 [120/1] via 192.168.1.6, 00:00:03, FastEthernet0/0
      12.0.0.0/32 is subnetted, 1 subnets
R        12.1.1.1 [120/1] via 192.168.1.6, 00:00:03, FastEthernet0/0
      13.0.0.0/32 is subnetted, 1 subnets
R        13.1.1.1 [120/1] via 192.168.1.6, 00:00:03, FastEthernet0/0
      14.0.0.0/32 is subnetted, 1 subnets
R        14.1.1.1 [120/1] via 192.168.1.6, 00:00:03, FastEthernet0/0
      192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
B        192.168.1.0/30 [200/0] via 1.1.1.1, 00:19:28
C        192.168.1.4/30 is directly connected, FastEthernet0/0
L        192.168.1.5/32 is directly connected, FastEthernet0/0
```

PE2#show ip route vrf CE2

```
      7.0.0.0/32 is subnetted, 1 subnets
B        7.1.1.1 [200/156160] via 1.1.1.1, 00:19:43
      8.0.0.0/32 is subnetted, 1 subnets
B        8.1.1.1 [200/156160] via 1.1.1.1, 00:19:43
      9.0.0.0/32 is subnetted, 1 subnets
B        9.1.1.1 [200/156160] via 1.1.1.1, 00:19:43
      10.0.0.0/32 is subnetted, 1 subnets
B        10.1.1.1 [200/156160] via 1.1.1.1, 00:19:43
      15.0.0.0/32 is subnetted, 1 subnets
B        15.1.1.1 [20/0] via 192.168.1.10, 00:19:44
      16.0.0.0/32 is subnetted, 1 subnets
B        16.1.1.1 [20/0] via 192.168.1.10, 00:19:44
      17.0.0.0/32 is subnetted, 1 subnets
B        17.1.1.1 [20/0] via 192.168.1.10, 00:19:44
      18.0.0.0/32 is subnetted, 1 subnets
B        18.1.1.1 [20/0] via 192.168.1.10, 00:19:44
      192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
B        192.168.1.0/30 [200/0] via 1.1.1.1, 00:19:43
```

C 192.168.1.8/30 is directly connected, FastEthernet1/0
L 192.168.1.9/32 is directly connected, FastEthernet1/0

PE2#SHOW IP CEF

Prefix	Next Hop	Interface
0.0.0.0/0	no route	
0.0.0.0/8	drop	
0.0.0.0/32	receive	
1.1.1.1/32	10.0.1.5	FastEthernet1/1
2.2.2.2/32	receive	Loopback0
3.3.3.3/32	10.0.1.5	FastEthernet1/1
10.0.1.0/30	10.0.1.5	FastEthernet1/1
10.0.1.4/30	attached	FastEthernet1/1
10.0.1.4/32	receive	FastEthernet1/1
10.0.1.5/32	attached	FastEthernet1/1
10.0.1.6/32	receive	FastEthernet1/1
10.0.1.7/32	receive	FastEthernet1/1
127.0.0.0/8	drop	
224.0.0.0/4	drop	
224.0.0.0/24	receive	
240.0.0.0/4	drop	
255.255.255.255/32	receive	

PE2#show mpls ldp bindings

```
  lib entry: 1.1.1.1/32, rev 10
        local binding:  label: 302
        remote binding: lsr: 10.0.1.5:0, label: 201
  lib entry: 2.2.2.2/32, rev 2
        local binding:  label: imp-null
        remote binding: lsr: 10.0.1.5:0, label: 200
  lib entry: 3.3.3.3/32, rev 6
        local binding:  label: 300
        remote binding: lsr: 10.0.1.5:0, label: imp-null
  lib entry: 10.0.1.0/30, rev 8
        local binding:  label: 301
        remote binding: lsr: 10.0.1.5:0, label: imp-null
  lib entry: 10.0.1.4/30, rev 4
        local binding:  label: imp-null
        remote binding: lsr: 10.0.1.5:0, label: imp-null
```

PE2#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Label Switched	Outgoing interface	Next Hop
300	Pop Label	3.3.3.3/32	0	Fa1/1	10.0.1.5
301	Pop Label	10.0.1.0/30	0	Fa1/1	10.0.1.5
302	201	1.1.1.1/32	0	Fa1/1	10.0.1.5

```
303        No Label   11.1.1.1/32[V]   684          Fa0/0      192.168.1.6
304        No Label   12.1.1.1/32[V]   0            Fa0/0      192.168.1.6
305        No Label   13.1.1.1/32[V]   0            Fa0/0      192.168.1.6
306        No Label   14.1.1.1/32[V]   570          Fa0/0      192.168.1.6
307        No Label   192.168.1.4/30[V]   \
                                 1884         aggregate/CE1
308        No Label   15.1.1.1/32[V]   684          Fa1/0      192.168.1.10
309        No Label   16.1.1.1/32[V]   0            Fa1/0      192.168.1.10
310        No Label   17.1.1.1/32[V]   570          Fa1/0      192.168.1.10
311        No Label   18.1.1.1/32[V]   0            Fa1/0      192.168.1.10
312        No Label   192.168.1.8/30[V]   \
                                 1884         aggregate/CE2
```

```
PE1#show run
!
hostname PE1
!
ip cef
!
ip vrf CE1
 rd 1.1.1.1:1
 route-target export 1.1.1.1:101
 route-target import 2.2.2.2:101
!
ip vrf CE2
 rd 1.1.1.1:2
 route-target export 1.1.1.1:102
 route-target import 2.2.2.2:102
!
mpls label range 100 199
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 ip vrf forwarding CE1
 ip address 192.168.1.1 255.255.255.252
 duplex full
!
interface FastEthernet1/0
 ip address 10.0.1.1 255.255.255.252
 speed auto
 duplex auto
 mpls ip
!
interface FastEthernet1/1
 ip vrf forwarding CE2
 ip address 192.168.1.1 255.255.255.252
```

```
 speed auto
 duplex auto
!
router eigrp 100
 !
 address-family ipv4 vrf CE2 autonomous-system 100
  redistribute bgp 65555 metric 1 1 1 1 1
  network 192.168.1.0 0.0.0.3
 exit-address-family
!
router ospf 10 vrf CE1
 redistribute bgp 65555 subnets
 network 192.168.1.0 0.0.0.3 area 0
!
router ospf 1
 network 1.1.1.1 0.0.0.0 area 0
 network 10.0.1.0 0.0.0.3 area 0
!
router bgp 65555
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 65555
 neighbor 2.2.2.2 update-source Loopback0
 !
 address-family vpnv4
  neighbor 2.2.2.2 activate
  neighbor 2.2.2.2 send-community extended
 exit-address-family
 !
 address-family ipv4 vrf CE1
  redistribute ospf 10
 exit-address-family
 !
 address-family ipv4 vrf CE2
  redistribute eigrp 100
 exit-address-family
```

```
P#show run
!
hostname P
!
ip cef
!
mpls label range 200 299

interface Loopback0
```

```
 ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex full
!
interface FastEthernet1/0
 ip address 10.0.1.2 255.255.255.252
 speed auto
 duplex auto
 mpls ip
!
interface FastEthernet1/1
 ip address 10.0.1.5 255.255.255.252
 speed auto
 duplex auto
 mpls ip
!
router ospf 1
 network 3.3.3.3 0.0.0.0 area 0
 network 10.0.1.0 0.0.0.3 area 0
 network 10.0.1.4 0.0.0.3 area 0
!
access-list 10 permit 2.2.2.2
!
mpls ldp router-id FastEthernet1/1 force
```

```
PE2#show run
!
hostname PE2
!
ip cef
!
ip vrf CE1
 rd 2.2.2.2:1
 route-target export 2.2.2.2:101
 route-target import 1.1.1.1:101
!
ip vrf CE2
 rd 2.2.2.2:2
 route-target export 2.2.2.2:102
 route-target import 1.1.1.1:102
!
mpls label range 300 399
!
interface Loopback0
```

```
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 ip vrf forwarding CE1
 ip address 192.168.1.5 255.255.255.252
 duplex full
!
interface FastEthernet1/0
 ip vrf forwarding CE2
 ip address 192.168.1.9 255.255.255.252
 speed auto
 duplex auto
!
interface FastEthernet1/1
 ip address 10.0.1.6 255.255.255.252
 speed auto
 duplex auto
 mpls ip
!
router ospf 1
 network 2.2.2.2 0.0.0.0 area 0
 network 10.0.1.4 0.0.0.3 area 0
!
router rip
 version 2
 !
 address-family ipv4 vrf CE1
  redistribute bgp 65555 metric 5
  network 192.168.1.0
  no auto-summary
 exit-address-family
!
router bgp 65555
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 65555
 neighbor 1.1.1.1 update-source Loopback0
 !
 address-family vpnv4
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 send-community extended
  neighbor 1.1.1.1 next-hop-self
 exit-address-family
 !
 address-family ipv4 vrf CE1
  redistribute rip
 exit-address-family
 !
 address-family ipv4 vrf CE2
  neighbor 192.168.1.10 remote-as 65000
  neighbor 192.168.1.10 activate
 exit-address-family
```

```
CE1-A#show run
!
hostname CE1-A
!
interface Loopback0
 ip address 5.1.1.1 255.255.255.255
!
interface Loopback1
 ip address 6.1.1.1 255.255.255.255
!
interface Loopback2
 ip address 7.1.1.1 255.255.255.255
!
interface Loopback3
 ip address 8.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 ip address 192.168.1.2 255.255.255.252
 duplex full
!
router ospf 1
 network 5.1.1.1 0.0.0.0 area 0
 network 6.1.1.1 0.0.0.0 area 0
 network 7.1.1.1 0.0.0.0 area 0
 network 8.1.1.1 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.3 area 0
```

```
CE1-B#show run
!
hostname CE1-B
!
interface Loopback0
 ip address 11.1.1.1 255.255.255.255
!
interface Loopback1
 ip address 12.1.1.1 255.255.255.255
!
interface Loopback2
 ip address 13.1.1.1 255.255.255.255
!
interface Loopback3
 ip address 14.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 ip address 192.168.1.6 255.255.255.252
 duplex full
!
router rip
```

```
 version 2
 network 11.0.0.0
 network 12.0.0.0
 network 13.0.0.0
 network 14.0.0.0
 network 192.168.1.0
 no auto-summary
```

CE2-A#show run

```
!
hostname CE2-A
!
interface Loopback0
 ip address 7.1.1.1 255.255.255.255
!
interface Loopback1
 ip address 8.1.1.1 255.255.255.255
!
interface Loopback2
 ip address 9.1.1.1 255.255.255.255
!
interface Loopback3
 ip address 10.1.1.1 255.255.255.255
!
interface FastEthernet1/1
 ip address 192.168.1.2 255.255.255.252
 speed auto
 duplex auto
!
router eigrp 100
 network 7.1.1.1 0.0.0.0
 network 8.1.1.1 0.0.0.0
 network 9.1.1.1 0.0.0.0
 network 10.1.1.1 0.0.0.0
 network 192.168.1.0 0.0.0.3
```

CE2-B#show run

```
!
hostname CE2-B
!
interface Loopback0
 ip address 15.1.1.1 255.255.255.255
!
interface Loopback1
 ip address 16.1.1.1 255.255.255.255
```

```
!
interface Loopback2
 ip address 17.1.1.1 255.255.255.255
!
interface Loopback3
 ip address 18.1.1.1 255.255.255.255
!
interface FastEthernet1/0
 ip address 192.168.1.10 255.255.255.252
 speed auto
 duplex auto
!
router bgp 65000
 bgp log-neighbor-changes
 redistribute connected
 neighbor 192.168.1.9 remote-as 65555
```

Lab 5

Cisco MPLS QOS

Introduction:

Quality of Service has become very popular in recent years. Necessity of implementing QoS arises from the fact that in traditional networks different types of traffic had different dedicated circuits, e.g. for Voice, direct links were established with PSTN network and for data, a direct dedicated link was connected to ISP, but in modern networks, various traffic types are unified on single network. As different traffic types have different requirements for treatment in network, this is the sole reason of wide acceptance of QoS. QoS provides means to prioritize critical traffic over less important traffic and also make sure that it is delivered. A good example where QoS is almost must is VoIP traffic. VoIP traffic needs to be delivered in certain period of time or it is discarded. Therefore, using QoS, VoIP traffic is given higher priority over TFTP or TELNET traffic.
In MPLS networks, QoS works almost the same way as in IP networks; EXP bits in MPLS header are used to carry QoS information. MPLS QoS can either honor or override customer QoS policies. But MPLS QoS is not that granular as IP DSCP is.

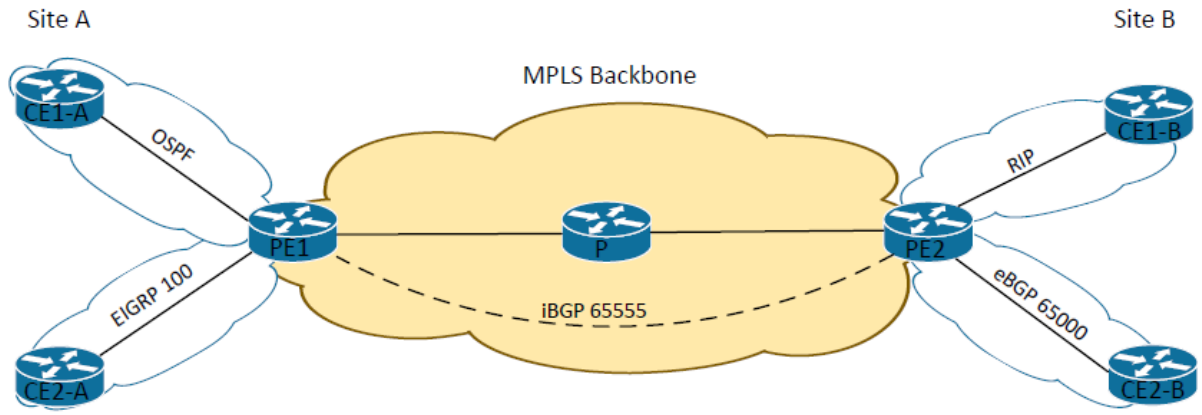
Prelab:

1. What are various QoS factors?
2. What is the most popular way to implement QoS in Cisco IOS?
3. How many bits are assigned to MPLS EXP field and what this field is used for?
4. How IP Precedence values are different from DSCP values of an IP packet?
5. What is the ToS value of Voice RTP stream?
6. What is table map?
7. What are various DiffServ tunneling models? Differentiate them based on the packet forwarding treatment at egress LSR.
8. What is the difference between Implicit Null and Explicit Null?
9. Briefly explain how Explicit-Null plays a vital role in Uniform and Pipe model?

Lab Scenario:

MPLS QoS lab is in continuation to MPLS VPN lab, so setup the scenario as in the previous lab.

Lab Diagram:



Lab IP Addressing:

Node	IP
CE1-A to PE1	192.168.X.0/30
CE2-A to PE1	192.168.X.0/30
PE1 to P	10.0.X.0/30
P to PE2	10.0.X.4/30
PE2 to CE1-B	192.168.X.4/30
PE2 to CE2-B	192.168.X.8/30
PE1 Loopback	1.1.1.1
P Loopback	3.3.3.3
PE2 Loopback	2.2.2.2

CE1-A Loopbacks	5-8.1.1.1
CE2-A Loopbacks	7-10.1.1.1
CE1-B Loopbacks	11-14.1.1.1
CE1-B Loopbacks	15-18.1.1.1

Procedure:

In this lab scenario, you are supposed to analyze default QoS behavior and also implement Pipe model of DiffServ Tunneling models. According to which, service provider will change the LSP DiffServ information according to their core MPLS QoS design and this change will be propagated to all the core routers. And at the end of Service Provider network or MPLS domain, forwarding treatment of the packet will be based on the LSP DiffServ information not tunneled DiffServ information.

Predefined SLA or Service Level Agreement by the service provider is as follows:

Voice (RTP) Traffic : Priority queuing with 15% bandwidth and IP precedence 5 (default).
TFTP Traffic : Guaranteed bandwidth of 1 Mbps and IP precedence 4.
Telnet Traffic : Low Latency Queuing with 2 Mbps priority and IP precedence 3.

1. First make sure that sites can ping each other in their respective VRFs.
2. Create Accounting Class-Maps on customer routers (Configure customer-1 routers only i.e. CE1-A and CE1-B) to match each IP precedence value. Assign them to accounting policymap and implement this policy on incoming direction of customer edge router. Basic purpose of this policy is to verify the counters for different precedence values.

Analyze Default QoS behavior:

3. Now create class-maps and policy-map on CE1-A to classify different types of traffic and modify their IP precedence value as defined in the SLA.
   Note: send packets for each traffic type and observe the MPLS EXP value on P or PE routers. Also, save the results of debug mpls packets for PE1 and P1 routers.
4. Generally, SLA is implemented on all service provider routers, but for this lab scenario, implement it on PE2 router's interface towards CE1-B:
   Create respective class-maps for each traffic type and assign them to respective queues.

Implement Diffserv Pipe tunneling model:

5. At router P1, create class map to match RTP stream and change the topmost MPLS label's experiment value to EXP2.
6. Observe the packet received on PE2 and implement explicit-null on PE2.
7. Now create table map on router PE2 to match mpls EXP bits to QoS group, create class-map to match all possible incoming EXP values and also create policy-map to assign EXP values to QoS group.
8. Now create a class-map to match respective QoS groups for VoIP, Telnet and TFTP traffic and create a policy-map to implement their respective SLA.

Deliverables:

1. Output of ping from customer's one site to another.
2. Output of '*debug MPLS packets'* and '*show policy-map interface* <>' on CE1-A after executing
3. Step 2 of procedure. Which default EXP value is there on MPLS packets?
4. After Step 4 of procedure:
   A. Output of extended ping on CE1-A (for RTP traffic), Telnet access and TFTP transfer.
   B. Output of '*show policy-map interface* <>' on PE2.
   C. Output of debug mpls packets on router PE1, P1 and PE2. Describe the packet received at PE2, how many labels are there in the packet.
   D. Output of *'show running class-map'* and *'show running policy-map'* on CE1-A.
5. Describe the default MPLS QoS behavior and relate that with the output observed at PE2.
6. After step 5, Output of extended ping on CE1-A and debug mpls packets on router P2 and PE2. Describe the difference between output of P2 and PE2 routers in terms of number of labels received and their EXP values.
7. Send traffic for all three types and provide output of *'show policy-map interface'* on PE2 and point out the hits by RTP traffic.
8. Running configuration on all devices, include only those sections which are modified. E.g. For interfaces, only include those interfaces where policy is applied.

Instructions to follow at the end of each lab

1. Make sure you erase your configuration from NVRAM of the devices used.
2. Do not save any of the configurations in flash memory.
3. All cables must be unplugged and secured in the box.
4. There must not be any kind of garbage around the desk or racks after you are done with lab.

1) Ping from Customer1 from one site to the other

```
CE1-A#ping 10.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
CE1-A#
```

2) Output of show policy-map

CE1-A#show policy-map interface g0/0
GigabitEthernet0/0

Service-policy input: Tim

Class-map: Precedence-0 (match-all)
50 packets, 5700 bytes
5 minute offered rate 0000 bps
Match: ip precedence 0

Class-map: Precedence-1 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 1

Class-map: Precedence-2 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 2

Class-map: Precedence-3 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 3

Class-map: Precedence-4 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 4

Class-map: Precedence-5 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 5

Class-map: Precedence-6 (match-all)
474 packets, 59724 bytes
5 minute offered rate 0000 bps
Match: ip precedence 6

```
    Class-map: Precedence-7 (match-all)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps
      Match: ip precedence 7

    Class-map: class-default (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: any

  Service-policy output: New-SLA

    Class-map: RTP (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: protocol rtp
        0 packets, 0 bytes
        5 minute rate 0 bps
      QoS Set
        precedence 5
          Packets marked 0

    Class-map: TFTP (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: protocol tftp
        0 packets, 0 bytes
        5 minute rate 0 bps
      QoS Set
        precedence 4
          Packets marked 0

    Class-map: Telnet (match-all)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: protocol telnet
      QoS Set
        precedence 3
          Packets marked 0

    Class-map: class-default (match-any)
      1181 packets, 152424 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: any
CE1-A#
```

```
PE1#
*Apr  8 01:28:36.586: MPLS les: Gi0/0: rx: Len 118 Stack {103 0 252} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:28:36.590: MPLS les: Gi0/0: rx: Len 118 Stack {103 0 252} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:28:36.590: MPLS les: Gi0/0: rx: Len 118 Stack {103 0 252} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:28:36.594: MPLS les: Gi0/0: rx: Len 118 Stack {103 0 252} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:28:36.594: MPLS les: Gi0/0: rx: Len 118 Stack {103 0 252} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
```

```
P1#
Apr  8 01:34:42.365: MPLS les: Gi0/0: rx: Len 122 Stack {201 0 254} {407 0 254} - ipv4 data
Apr  8 01:34:42.365: MPLS les: Gi0/1: tx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data
Apr  8 01:34:42.365: MPLS les: Gi0/1: rx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data
Apr  8 01:34:42.365: MPLS les: Gi0/0: tx: Len 118 Stack {103 0 252} - ipv4 data
Apr  8 01:34:42.369: MPLS les: Gi0/0: rx: Len 122 Stack {201 0 254} {407 0 254} - ipv4 data
Apr  8 01:34:42.369: MPLS les: Gi0/1: tx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data
Apr  8 01:34:42.369: MPLS les: Gi0/1: rx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data
Apr  8 01:34:42.369: MPLS les: Gi0/0: tx: Len 118 Stack {103 0 252} - ipv4 data
Apr  8 01:34:42.369: MPLS les: Gi0/0: rx: Len 122 Stack {201 0 254} {407 0 254} - ipv4 data
Apr  8 01:34:42.369: MPLS les: Gi0/1: tx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data
Apr  8 01:34:42.369: MPLS les: Gi0/1: rx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data
Apr  8 01:34:42.373: MPLS les: Gi0/0: tx: Len 118 Stack {103 0 252} - ipv4 data
Apr  8 01:34:42.373: MPLS les: Gi0/0: rx: Len 122 Stack {201 0 254} {407 0 254} - ipv4 data
Apr  8 01:34:42.373: MPLS les: Gi0/1: tx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data
Apr  8 01:34:42.373: MPLS les: Gi0/1: rx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data
Apr  8 01:34:42.373: MPLS les: Gi0/0: tx: Len 118 Stack {103 0 252} - ipv4 data
Apr  8 01:34:42.373: MPLS les: Gi0/0: rx: Len 122 Stack {201 0 254} {407 0 254} - ipv4 data
Apr  8 01:34:42.373: MPLS les: Gi0/1: tx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data
Apr  8 01:34:42.377: MPLS les: Gi0/1: rx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data
Apr  8 01:34:42.377: MPLS les: Gi0/0: tx: Len 118 Stack {103 0 252} - ipv4 data
Apr  8 01:34:44.997: MPLS les: Gi0/1: rx: Len 77 Stack {200 6 254} - ipv4 data
Apr  8 01:34:45.197: MPLS les: Gi0/0: rx: Len 60 Stack {201 6 255} - ipv4 data
Apr  8 01:34:45.197: MPLS les: Gi0/1: tx: Len 60 Stack {301 6 254} - ipv4 data
```

```
P2#
*Apr  8 01:26:29.989: MPLS les: Gi0/1: rx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.989: MPLS les: Gi0/0: tx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.993: MPLS les: Gi0/0: rx: Len 122 Stack {300 0 254} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.993: MPLS les: Gi0/1: tx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.993: MPLS les: Gi0/1: rx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.993: MPLS les: Gi0/0: tx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.993: MPLS les: Gi0/0: rx: Len 122 Stack {300 0 254} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.993: MPLS les: Gi0/1: tx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.997: MPLS les: Gi0/1: rx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.997: MPLS les: Gi0/0: tx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.997: MPLS les: Gi0/0: rx: Len 122 Stack {300 0 254} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.997: MPLS les: Gi0/1: tx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.997: MPLS les: Gi0/1: rx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:29.997: MPLS les: Gi0/0: tx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:30.001: MPLS les: Gi0/0: rx: Len 122 Stack {300 0 254} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:30.001: MPLS les: Gi0/1: tx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:30.001: MPLS les: Gi0/1: rx: Len 122 Stack {301 0 253} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:30.001: MPLS les: Gi0/0: tx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:26:30.001: MPLS les: Gi0/0: rx: Len 122 Stack {300 0 254} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
*Apr  8 01:26:30.001: MPLS les: Gi0/1: tx: Len 122 Stack {200 0 253} {103 0 254} - ipv4 data s:10.1.1.1 d:192.168.6.2 ttl:254 tos:0 prot:1
```

```
PE2#
*Apr  8 01:24:42.689: MPLS les: Gi0/0: rx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:24:42.693: MPLS les: Gi0/0: rx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:24:42.697: MPLS les: Gi0/0: rx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:24:42.697: MPLS les: Gi0/0: rx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:24:42.701: MPLS les: Gi0/0: rx: Len 122 Stack {0 0 252} {407 0 254} - ipv4 data s:192.168.6.2 d:10.1.1.1 ttl:254 tos:0 prot:1
*Apr  8 01:24:44.625: MPLS les: Gi0/0: rx: Len 60 Stack {0 6 253} - ipv4 data s:1.1.1.1 d:2.2.2.2 ttl:255 tos:C0 prot:6
*Apr  8 01:24:47.453: MPLS les: Gi0/0: rx: Len 60 Stack {0 6 255} - ipv4 data s:4.4.4.4 d:2.2.2.2 ttl:255 tos:C0 prot:6
```

3) Telnet/TFTP

CE1-A#show policy-map interface g0/0
GigabitEthernet0/0

Service-policy input: Tim

Class-map: Precedence-0 (match-all)
100 packets, 11400 bytes
5 minute offered rate 0000 bps
Match: ip precedence 0

Class-map: Precedence-1 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 1

Class-map: Precedence-2 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 2

Class-map: Precedence-3 (match-all)
109 packets, 6831 bytes
5 minute offered rate 0000 bps
Match: ip precedence 3

Class-map: Precedence-4 (match-all)
3 packets, 813 bytes
5 minute offered rate 0000 bps
Match: ip precedence 4

Class-map: Precedence-5 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 5

Class-map: Precedence-6 (match-all)
614 packets, 76980 bytes
5 minute offered rate 0000 bps
Match: ip precedence 6

Class-map: Precedence-7 (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps
Match: ip precedence 7

Class-map: class-default (match-any)
0 packets, 0 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: any

Service-policy output: New-SLA

Class-map: RTP (match-any)

```
    0 packets, 0 bytes
    5 minute offered rate 0000 bps, drop rate 0000 bps
    Match: protocol rtp
      0 packets, 0 bytes
      5 minute rate 0 bps
    QoS Set
      precedence 5
        Packets marked 0

  Class-map: TFTP (match-any)
    3 packets, 138 bytes
    5 minute offered rate 0000 bps, drop rate 0000 bps
    Match: protocol tftp
      3 packets, 138 bytes
      5 minute rate 0 bps
    QoS Set
      precedence 4
        Packets marked 3

  Class-map: Telnet (match-all)
    122 packets, 10576 bytes
    5 minute offered rate 0000 bps, drop rate 0000 bps
    Match: protocol telnet
    QoS Set
      precedence 3
        Packets marked 122

  Class-map: class-default (match-any)
    1575 packets, 202896 bytes
    5 minute offered rate 0000 bps, drop rate 0000 bps
    Match: any
CE1-A#



PE2#show policy-map interface g0/2
 GigabitEthernet0/2

  Service-policy output: MPLS-CE1

    queue stats for all priority classes:
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 122/6789

    Class-map: TFTP-QOS (match-all)
      3 packets, 138 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: qos-group 4
```

Queueing
queue limit 64 packets
(queue depth/total drops/no-buffer drops) 0/0/0
(pkts output/bytes output) 3/138
bandwidth 1000 kbps

Class-map: Telnet-QOS (match-all)
122 packets, 6789 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: qos-group 3
Priority: 2000 kbps, burst bytes 50000, b/w exceed drops: 0

Class-map: RTP-QOS (match-all)
0 packets, 0 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: qos-group 2
Priority: 15% (150000 kbps), burst bytes 3750000, b/w exceed drops: 0

Class-map: class-default (match-any)
916 packets, 88817 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: any

queue limit 64 packets
(queue depth/total drops/no-buffer drops) 0/0/0
(pkts output/bytes output) 916/94632
PE2#

```
PE2#
*Apr  8 02:11:13.469: MPLS les: Gi0/0: rx: Len 60 Stack {0 6 255} - ipv4 data s:4.4.4.4 d:2.2.2.2 ttl:255 tos:C0 prot:6
*Apr  8 02:11:22.881: MPLS les: Gi0/0: rx: Len 60 Stack {0 6 253} - ipv4 data s:1.1.1.1 d:2.2.2.2 ttl:255 tos:C0 prot:6
*Apr  8 02:11:24.953: MPLS les: Gi0/0: rx: Len 68 Stack {0 6 252} {408 6 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:C0 prot:6
*Apr  8 02:11:24.957: MPLS les: Gi0/0: rx: Len 68 Stack {0 6 252} {408 6 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:C0 prot:6
*Apr  8 02:11:24.957: MPLS les: Gi0/0: rx: Len 74 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:24.957: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:24.961: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:24.961: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:24.961: MPLS les: Gi0/0: rx: Len 71 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:24.961: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:24.961: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:24.961: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:25.161: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:30.781: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:30.949: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:31.189: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:31.557: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:31.661: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:31.789: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:31.965: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:32.197: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:32.397: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:35.245: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:35.445: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:35.461: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:35.621: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:35.821: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:35.909: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:36.013: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:36.013: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
*Apr  8 02:11:36.013: MPLS les: Gi0/0: rx: Len 68 Stack {0 3 252} {408 3 254} - ipv4 data s:192.168.6.2 d:192.168.7.2 ttl:254 tos:60 prot:6
```

```
PE1#
*Apr  8 02:19:33.350: MPLS les: Gi0/0: rx: Len 64 Stack {103 6 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:C0 prot:6
*Apr  8 02:19:33.354: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:33.354: MPLS les: Gi0/0: rx: Len 70 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:33.358: MPLS les: Gi0/0: rx: Len 100 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:33.358: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:33.358: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:33.358: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:33.358: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:33.358: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:33.558: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:39.346: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:39.782: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:40.058: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:40.362: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:40.594: MPLS les: Gi0/0: rx: Len 66 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:43.642: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:43.858: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:44.018: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:44.218: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:44.306: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:44.406: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:44.406: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
*Apr  8 02:19:44.410: MPLS les: Gi0/0: rx: Len 64 Stack {103 3 252} - ipv4 data s:192.168.7.2 d:192.168.6.2 ttl:254 tos:60 prot:6
```

```
CE1-A#show running-config class-map
Building configuration...

Current configuration : 604 bytes
!
class-map match-any TFTP
 match protocol tftp
class-map match-all Telnet
 match protocol telnet
class-map match-all Precedence-5
 match ip precedence 5
class-map match-all Precedence-4
 match ip precedence 4
class-map match-all Precedence-7
 match ip precedence 7
class-map match-all Precedence-6
 match ip precedence 6
class-map match-all Precedence-1
 match ip precedence 1
class-map match-all Precedence-0
 match ip precedence 0
class-map match-all Precedence-3
 match ip precedence 3
class-map match-all Precedence-2
 match ip precedence 2
class-map match-any RTP
 match protocol rtp
end

CE1-A#show running-config pol
CE1-A#show running-config policy-map
Building configuration...
```

```
Current configuration : 307 bytes
!
policy-map New-SLA
 class RTP
  set ip precedence 5
 class TFTP
  set ip precedence 4
 class Telnet
  set ip precedence 3
policy-map Tim
 class Precedence-0
 class Precedence-1
 class Precedence-2
 class Precedence-3
 class Precedence-4
 class Precedence-5
 class Precedence-6
 class Precedence-7
!
end
```

P1

```
Apr  8 02:22:26.233: MPLS les: Gi0/1: rx: Len 68 Stack {200 3 253} {103 3 254} - ipv4 data
Apr  8 02:22:26.233: MPLS les: Gi0/0: tx: Len 64 Stack {103 3 252} - ipv4 data
Apr  8 02:22:26.393: MPLS les: Gi0/0: rx: Len 68 Stack {201 3 254} {408 3 254} - ipv4 data
Apr  8 02:22:26.393: MPLS les: Gi0/1: tx: Len 68 Stack {301 3 253} {408 3 254} - ipv4 data
Apr  8 02:22:26.393: MPLS les: Gi0/1: rx: Len 68 Stack {200 3 253} {103 3 254} - ipv4 data
Apr  8 02:22:26.393: MPLS les: Gi0/0: tx: Len 64 Stack {103 3 252} - ipv4 data
Apr  8 02:22:26.593: MPLS les: Gi0/0: rx: Len 68 Stack {201 3 254} {408 3 254} - ipv4 data
Apr  8 02:22:26.593: MPLS les: Gi0/1: tx: Len 68 Stack {301 3 253} {408 3 254} - ipv4 data
Apr  8 02:22:26.593: MPLS les: Gi0/1: rx: Len 68 Stack {200 3 253} {103 3 254} - ipv4 data
Apr  8 02:22:26.593: MPLS les: Gi0/0: tx: Len 64 Stack {103 3 252} - ipv4 data
Apr  8 02:22:26.681: MPLS les: Gi0/0: rx: Len 68 Stack {201 3 254} {408 3 254} - ipv4 data
Apr  8 02:22:26.681: MPLS les: Gi0/1: tx: Len 68 Stack {301 3 253} {408 3 254} - ipv4 data
Apr  8 02:22:26.681: MPLS les: Gi0/1: rx: Len 68 Stack {200 3 253} {103 3 254} - ipv4 data
Apr  8 02:22:26.681: MPLS les: Gi0/0: tx: Len 64 Stack {103 3 252} - ipv4 data
Apr  8 02:22:26.781: MPLS les: Gi0/1: rx: Len 68 Stack {200 3 253} {103 3 254} - ipv4 data
Apr  8 02:22:26.781: MPLS les: Gi0/0: tx: Len 64 Stack {103 3 252} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/1: rx: Len 68 Stack {200 3 253} {103 3 254} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/0: tx: Len 64 Stack {103 3 252} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/0: rx: Len 68 Stack {201 3 254} {408 3 254} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/1: tx: Len 68 Stack {301 3 253} {408 3 254} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/0: rx: Len 68 Stack {201 3 254} {408 3 254} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/1: tx: Len 68 Stack {301 3 253} {408 3 254} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/0: rx: Len 68 Stack {201 3 254} {408 3 254} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/1: tx: Len 68 Stack {301 3 253} {408 3 254} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/1: rx: Len 68 Stack {200 3 253} {103 3 254} - ipv4 data
Apr  8 02:22:26.785: MPLS les: Gi0/0: tx: Len 64 Stack {103 3 252} - ipv4 data
Apr  8 02:22:37.637: MPLS les: Gi0/0: rx: Len 77 Stack {201 6 255} - ipv4 data
```

4) Running configuration of all the routers

```
CE1-A#show run
!
!
class-map match-any TFTP
 match protocol tftp
class-map match-all Telnet
 match protocol telnet
class-map match-all Precedence-5
 match ip precedence 5
class-map match-all Precedence-4
 match ip precedence 4
class-map match-all Precedence-7
 match ip precedence 7
class-map match-all Precedence-6
 match ip precedence 6
class-map match-all Precedence-1
 match ip precedence 1
class-map match-all Precedence-0
 match ip precedence 0
class-map match-all Precedence-3
 match ip precedence 3
class-map match-all Precedence-2
 match ip precedence 2
class-map match-any RTP
 match protocol rtp
!
policy-map New-SLA
 class RTP
  set ip precedence 5
 class TFTP
  set ip precedence 4
 class Telnet
  set ip precedence 3
policy-map Tim
 class Precedence-0
 class Precedence-1
 class Precedence-2
 class Precedence-3
 class Precedence-4
 class Precedence-5
 class Precedence-6
 class Precedence-7
!
interface Loopback1
 ip address 5.1.1.1 255.255.255.255
!
```

```
interface Loopback2
 ip address 6.1.1.1 255.255.255.255
!
interface Loopback3
 ip address 7.1.1.1 255.255.255.255
!
interface GigabitEthernet0/0
 ip address 192.168.6.2 255.255.255.192
 duplex auto
 speed auto
 service-policy input Tim
 service-policy output New-SLA
!
!
router rip
 version 2
 network 5.0.0.0
 network 6.0.0.0
 network 7.0.0.0
 network 192.168.6.0
 network 192.168.200.0
 neighbor 192.168.6.1
 no auto-summary
!
```

```
PE1#show run
!
vrf definition CE1
 rd 6:1
 route-target export 6:1
 route-target import 6:1
 !
 address-family ipv4
 exit-address-family
!
vrf definition CE2
 rd 6:2
 route-target export 6:2
 route-target import 6:2
 route-target import 6:1
 !
 address-family ipv4
 exit-address-family
!
!
no aaa new-model
memory-size iomem 10
```

```
!
ip cef
no ipv6 cef
!
mpls label range 100 199
mpls label protocol ldp
!
interface Loopback1
 ip address 1.1.1.1 255.255.255.255
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 10.6.16.2 255.255.255.252
 ip ospf 1 area 6
 duplex auto
 speed auto
 mpls ip
!
interface GigabitEthernet0/1
 vrf forwarding CE1
 ip address 192.168.6.1 255.255.255.192
 duplex auto
 speed auto
!
interface GigabitEthernet0/2
 vrf forwarding CE2
 ip address 192.168.8.1 255.255.255.0
 duplex auto
 speed auto
!
router eigrp 16
 !
 address-family ipv4 vrf CE2 autonomous-system 16
  redistribute bgp 6000 metric 1000 10 255 100 1500
  network 192.168.8.0
 exit-address-family
!
router ospf 1
 router-id 1.1.1.1
 network 1.1.1.1 0.0.0.0 area 6
!
router rip
 version 2
 no auto-summary
 !
```

```
 address-family ipv4 vrf CE1
  redistribute bgp 6000 metric transparent
  network 192.168.6.0
  neighbor 192.168.6.2
  no auto-summary
  version 2
 exit-address-family
!
router bgp 6000
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 6000
 neighbor 2.2.2.2 update-source Loopback1
 !
 address-family ipv4
  neighbor 2.2.2.2 activate
 exit-address-family
 !
 address-family vpnv4
  neighbor 2.2.2.2 activate
  neighbor 2.2.2.2 send-community extended
 exit-address-family
 !
 address-family ipv4 vrf CE1
  redistribute rip
 exit-address-family
 !
 address-family ipv4 vrf CE2
  redistribute eigrp 16
 exit-address-family
!
!
mpls ldp router-id Loopback1
!
login
 transport input all
!
scheduler allocate 20000 1000
!
end

PE1#


P1#show run
ip cef
!
!
mpls label range 200 299
```

```
mpls label protocol ldp
!
class-map match-any RTP-Match
 match mpls experimental topmost 5
!
!
policy-map RTP-Change
 class RTP-Match
  set mpls experimental topmost 2
!
interface Loopback1
 ip address 3.3.3.3 255.255.255.255
!
interface GigabitEthernet0/0
 ip address 10.6.16.1 255.255.255.252
 ip ospf 1 area 6
 duplex auto
 speed auto
 mpls ip
!
interface GigabitEthernet0/1
 ip address 10.6.16.5 255.255.255.252
 duplex auto
 speed auto
 mpls ip
 service-policy output RTP-Change
!
!
router ospf 1
 router-id 3.3.3.3
 network 3.3.3.3 0.0.0.0 area 6
 network 10.6.16.0 0.0.0.3 area 6
 network 10.6.16.4 0.0.0.3 area 6
!
mpls ldp router-id Loopback1
!
```

```
P2#show run
!
ip cef
!
mpls label range 300 399
mpls label protocol ldp
!
!
interface Loopback1
 ip address 4.4.4.4 255.255.255.255
```

```
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 10.6.16.9 255.255.255.252
 duplex auto
 speed auto
 mpls ip
!
interface GigabitEthernet0/1
 ip address 10.6.16.6 255.255.255.252
 duplex auto
 speed auto
 mpls ip
!
!
!
router ospf 1
 router-id 4.4.4.4
 network 4.4.4.4 0.0.0.0 area 6
 network 10.6.16.4 0.0.0.3 area 6
 network 10.6.16.8 0.0.0.3 area 6
!
mpls ldp router-id Loopback1
!
```

```
PE2#show run
!
vrf definition CE1
 rd 6:1
 route-target export 6:1
 route-target import 6:1
 !
 address-family ipv4
 exit-address-family
!
vrf definition CE2
 rd 6:2
 route-target export 6:2
 route-target import 6:2
 route-target import 6:1
 !
 address-family ipv4
```

```
 exit-address-family
!
ip cef
no ipv6 cef
!
table-map Tim-MPLS
 map from  1 to 1
 map from  2 to 2
 map from  3 to 3
 map from  4 to 4
 map from  5 to 5
 map from  6 to 6
 map from  7 to 7
 map from  0 to 0
 default copy
!
mpls label range 400 499
mpls label protocol ldp
mpls ldp explicit-null
!
class-map match-all TFTP-CE1
 match protocol tftp
class-map match-all RTP-QOS
 match qos-group 2
class-map match-all Telnet-CE1
 match protocol telnet
class-map match-any EXP-SLA
 match mpls experimental topmost 0  2  3  4  5
class-map match-any All
 match mpls experimental topmost 0  1  2  3  4  5  6  7
class-map match-all Telnet-QOS
 match qos-group 3
class-map match-any RTP-CE1
 match protocol rtp
 match ip precedence 5
class-map match-all TFTP-QOS
 match qos-group 4
class-map match-all EXP-MPLS-5
 match mpls experimental topmost 5
class-map match-all EXP-MPLS-4
 match mpls experimental topmost 4
class-map match-all EXP-MPLS-3
 match mpls experimental topmost 3
!
policy-map All
 class All
  set qos-group mpls experimental topmost table Tim-MPLS
policy-map MPLS-CE1
```

```
 class TFTP-QOS
  bandwidth 1000
 class Telnet-QOS
  priority 2000
 class RTP-QOS
  priority percent 15
policy-map From-P2
 class EXP-MPLS-4
  set qos-group 4
 class EXP-MPLS-3
  set qos-group 3
 class EXP-MPLS-5
  set qos-group 5
!
!
interface Loopback1
 ip address 2.2.2.2 255.255.255.255
!
interface GigabitEthernet0/0
 ip address 10.6.16.10 255.255.255.252
 ip ospf 1 area 6
 duplex auto
 speed auto
 mpls ip
 service-policy input All
!
interface GigabitEthernet0/1
 vrf forwarding CE2
 ip address 192.168.9.1 255.255.255.0
 duplex auto
 speed auto
!
interface GigabitEthernet0/2
 vrf forwarding CE1
 ip address 192.168.7.1 255.255.255.0
 duplex auto
 speed auto
 service-policy output MPLS-CE1
!
router eigrp 16
 !
 address-family ipv4 vrf CE2 autonomous-system 16
  redistribute bgp 6000 metric 1000 10 255 100 1500
  network 192.168.9.0
 exit-address-family
!
router ospf 7 vrf CE1
 redistribute bgp 6000 subnets
```

```
 network 192.168.7.0 0.0.0.255 area 7
!
router ospf 1
 router-id 2.2.2.2
 network 2.2.2.2 0.0.0.0 area 6
!
router bgp 6000
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 6000
 neighbor 1.1.1.1 update-source Loopback1
 !
 address-family ipv4
  neighbor 1.1.1.1 activate
 exit-address-family
 !
 address-family vpnv4
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 send-community extended
 exit-address-family
 !
 address-family ipv4 vrf CE1
  redistribute ospf 7 match internal external 1 external 2
 exit-address-family
 !
 address-family ipv4 vrf CE2
  redistribute eigrp 16
 exit-address-family
!
mpls ldp router-id Loopback1
!
```

```
CE1-B#
!
ip cef
!
class-map match-any TFTP
 match protocol tftp
class-map match-all Telnet
 match protocol telnet
class-map match-all Precedence-5
 match ip precedence 5
class-map match-all Precedence-4
 match ip precedence 4
class-map match-all Precedence-7
 match ip precedence 7
class-map match-all Precedence-6
```

```
 match ip precedence 6
class-map match-all Precedence-1
 match ip precedence 1
class-map match-all Precedence-0
 match ip precedence 0
class-map match-all Precedence-3
 match ip precedence 3
class-map match-all Precedence-2
 match ip precedence 2
class-map match-any RTP
 match protocol rtp
!
policy-map Tim
 class Precedence-0
 class Precedence-1
 class Precedence-2
 class Precedence-3
 class Precedence-4
 class Precedence-5
 class Precedence-6
 class Precedence-7
policy-map New-SLA
 class RTP
  set ip precedence 5
 class TFTP
  set ip precedence 4
 class Telnet
  set ip precedence 3
!
interface Loopback1
 ip address 8.1.1.1 255.255.255.255
!
interface Loopback2
 ip address 9.1.1.1 255.255.255.255
!
interface Loopback3
 ip address 10.1.1.1 255.255.255.255
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 192.168.7.2 255.255.255.0
 duplex auto
 speed auto
 service-policy input Tim
 service-policy output New-SLA
```

```
!
router ospf 1
 network 8.1.1.1 0.0.0.0 area 7
 network 9.1.1.1 0.0.0.0 area 7
 network 10.1.1.1 0.0.0.0 area 7
 network 192.168.7.0 0.0.0.255 area 7
!
tftp-server flash:7940
tftp-server flash:SCCP41.9-4-2SR1-1S.loads
!
```

Lab 6

MPLS L2VPN

Introduction:

EoMPLS is tunneling mechanism that transports Layer 2 Ethernet frames over an MPLS network. You can connect two Layer 2 networks that are in different locations, without requiring bridges, routers, or switches at the locations.

EoMPLS is one of the AToM transport types. EoMPLS works by encapsulating Ethernet PDUs in MPLS packets and forwarding them across the MPLS network. An Ethernet pseudowire (PW) is used to carry Ethernet/802.3 Protocol Data Units (PDUs) over an MPLS network. This enables service providers to offer "emulated" Ethernet services over existing MPLS networks.

Pre-lab:

1- What are the two mode an Ethernet PW operate? What is the difference between them?

An Ethernet PW operates in one of two modes: "raw mode" or "tagged mode". In tagged mode, each frame MUST contain at least one 802.1Q [802.1Q] VLAN tag, and the tag value is meaningful to the NSPs at the two PW termination points. That is, the two PW termination points must have some agreement (signaled or manually configured) on how to process the tag. On a raw mode PW, a frame MAY contain an 802.1Q VLAN tag, but if it does, the tag is not meaningful to the NSPs, and passes transparently through them.

2- What is the purpose of the control word?

- Provides the ability to sequence individual frames
- Avoidance of equal-cost multiple-path load-balancing
- Operations and Management (OAM) mechanisms

3- Why would a customer choose L2 VPN service?

- Customer have full operational control over their routing neighbours
- Privacy of addressing space - they do not have to be shared with the carrier network
- Customer has a choice of using any routing protocol including non IP based (IPX, AppleTalk)
- Customers could use an Ethernet switch instead of a router as the CPE

4- What is the difference between VPLS and EoMPLS?

EoMPLS is point to point layer 2, while VPLS is point to multi-point

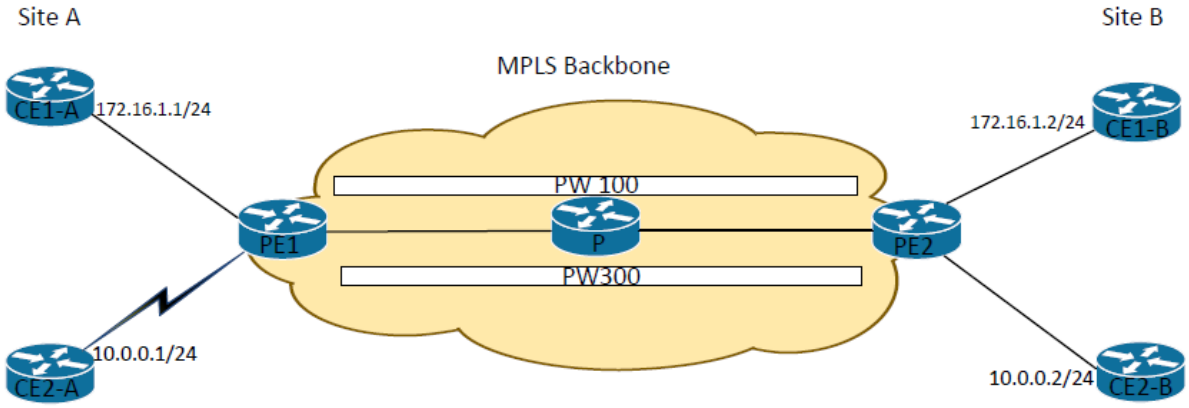
5- How many labels in MPLS core a Pseudo Wire will use? What are they?

Two labels.
Tunnel label, outer label, to forward the packet across the network
VC-based label, to bind L2 interface where packets must be forwarded

Lab Scenario:

You are the network engineer working for Internet Service Provider and your task is to provide Ethernet over MPLS access between two sites for two different customers. One customer is using serial link to the MPLS backbone.

Lab Diagram:



Lab IP Addressing:

Node	IP
CE1-A to CE1-B	172.16.X.0/24
CE2-A TO CE2-B	10.0.X.0/24
PE1 to P	192.168.X.0/30
P to PE2	192.168.X.4/30
P2 to PE2	10.0.X.8/30
PE2 to CE1-B	192.168.X.4/30
PE2 to CE2-B	192.168.X.8/30
PE1 Loopback	1.1.1.1
P Loopback	3.3.3.3
PE2 Loopback	2.2.2.2
CE1-A Loopbacks	5.1.1.1
CE2-A Loopbacks	4.1.1.1
CE1-B Loopbacks	6.1.1.1
CE1-B Loopbacks	7.1.1.1

Procedure:

1. Wire all routers as per the lab diagram.
2. Configure IP addresses of all the MPLS backbone interfaces as per the IP address table.
3. Configure loopbacks on all MPLS backbone routers as per the IP address table.

4. On PE1, P and PE2 enable OSPF on the interfaces that belong to the MPLS backbone including the loopbacks.

5. On PE1, P1, P2 and PE2 configure the range of labels generated

   PE1(config)#mpls label range 100 199
   P1(config)#mpls label range 200 299
   PE2(config)#mpls label range 300 399

6. Make sure CEF is enabled and also enable MPLS globally on PE1, P and PE2 as well as on each MPLS backbone interfaces. Show all LDP neighbors on P?

   PXX(config)# mpls ip
   PXX(config-if)# mpls ip

   P#show mpls ldp neighbor all
   Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 3.3.3.3:0
   a. TCP connection: 1.1.1.1.646 - 3.3.3.3.49058
   b. State: Oper; Msgs sent/rcvd: 18/18; Downstream
   c. Up time: 00:09:07
   d. LDP discovery sources:
   e. FastEthernet1/1, Src IP addr: 192.168.1.1
   f. Addresses bound to peer LDP Ident:
   g. 192.168.1.1 1.1.1.1
   Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 3.3.3.3:0
   h. TCP connection: 2.2.2.2.646 - 3.3.3.3.13876
   i. State: Oper; Msgs sent/rcvd: 18/18; Downstream
   j. Up time: 00:09:07
   k. LDP discovery sources:
   l. FastEthernet1/0, Src IP addr: 192.168.1.6
   m. Addresses bound to peer LDP Ident:
   n. 192.168.1.6 2.2.2.2

7. Configure a MPLS L2VPN between PE1 and PE2 with PW ID 100 to provide connectivity between CE1-A and CE1-B

   xconnect 2.2.2.2 100 encapsulation mpls

8. Configure CE1-A and CE1-B interfaces facing the MPLS core and enable OSPF on both routers to advertise the loopback address to the other site.

9. Verify the connectivity between CE1-A and CE1-B. Also, enable CDP on both CE1 routers and issue show CDP neighbor on CE1-A

   ```
   CE1-A#show cdp neighbors
   ```

```
Capability Codes: R - Router, T - Trans Bridge, B - Source Route
Bridge
                  1. S - Switch, H - Host, I - IGMP, r - Repeater, P -
                     Phone,
                  2. D - Remote, C - CVTA, M - Two-port Mac Relay

Device ID        Local Intrfce     Holdtme    Capability  Platform
Port ID
CE1-B            Fas 0/0           154               R    7206VXR
Fas 0/0

CE1-A#ping 4.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/52/84
ms
CE1-A#
```

10. Run and analyze the following commands on PE1 and PE2? what label stack PE1 is using? What is the MPLS VC remote and local label on PE1?

```
PE1#show mpls l2transport vc

Local intf     Local circuit              Dest address    VC ID
Status
-------------  -------------------------- --------------- ----------
----------
Fa0/0          Ethernet                   2.2.2.2         100
UP


PE1#show mpls l2transport vc detail
Local interface: Fa0/0 up, line protocol up, Ethernet up
Destination address: 2.2.2.2, VC ID: 100, VC status: up
Output interface: Fa1/1, imposed label stack {17 19}
Preferred path: not configured
Default path: active
Next hop: 192.168.1.2
Create time: 00:19:05, last status change time: 00:10:30
Last label FSM state change time: 00:10:30
Signaling protocol: LDP, peer 2.2.2.2:0 up
Targeted Hello: 1.1.1.1(LDP Id) -> 2.2.2.2, LDP is UP
Status TLV support (local/remote)   : enabled/supported
   a. LDP route watch                   : enabled
   b. Label/status state machine        : established, LruRru
   c. Last local dataplane   status rcvd: No fault
   d. Last BFD dataplane     status rcvd: Not sent
   e. Last BFD peer monitor  status rcvd: No fault
   f. Last local AC  circuit status rcvd: No fault
   g. Last local AC  circuit status sent: No fault
   h. Last local PW i/f circ status rcvd: No fault
```

```
   i. Last local LDP TLV     status sent: No fault
   j. Last remote LDP TLV    status rcvd: No fault
   k. Last remote LDP ADJ    status rcvd: No fault
MPLS VC labels: local 19, remote 19
Group ID: local 0, remote 0
MTU: local 1500, remote 1500
Remote interface description:
Sequencing: receive disabled, send disabled
Control Word: On (configured: autosense)
Dataplane:
SSM segment/switch IDs: 4097/4096 (used), PWID: 1
VC statistics:
transit packet totals: receive 129, send 141
transit byte totals:   receive 13271, send 18238
transit packet drops:  receive 0, seq error 0, send 0



PE1#show mpls l2transport binding
Destination Address: 2.2.2.2,VC ID: 100
Local Label:  19
   l. Cbit: 1,     VC Type: Ethernet,    GroupID: 0
   m. MTU: 1500,   Interface Desc: n/a
   n. VCCV: CC Type: CW [1], RA [2], TTL [3]
        i.  CV Type: LSPV [2], BFD/Raw [5]
Remote Label: 19
   o. Cbit: 1,     VC Type: Ethernet,    GroupID: 0
   p. MTU: 1500,   Interface Desc: n/a
   q. VCCV: CC Type: CW [1], RA [2], TTL [3]
        i.  CV Type: LSPV [2], BFD/Raw [5]



PE1#show l2vpn service xconnect all detail
Legend: St=State    XC St=State in the L2VPN Service
Prio=Priority
   r. UP=Up       DN=Down            AD=Admin Down      IA=Inactive
   s. SB=Standby  HS=Hot Standby     RV=Recovering      NH=No
      Hardware
   t. m=manually selected

Interface          Group       Encapsulation                    Prio
St   XC St
---------          -----       -------------                    ----
--   -----
VPWS name: Fa0/0-2, State: UP
Fa0/0              left        Fa0/0:2(Ethernet)                0
UP   UP
                               1. Interworking: none
pw100001           right       2.2.2.2:100(MPLS)                0
UP   UP
                               2. Local VC label 19
                               3. Remote VC label 19
```

11. Configure a MPLS L2VPN between PE1 and PE2 with PW ID 300 to provide connectivity between CE2-A and CE2-B, please note that it is Serial link between CE2-A and PE1

    pseudowire-class UofM
    encapsulation mpls
    interworking ip
    control-word

    encapsulation ppp
    xconnect 2.2.2.2 300 encapsulation mpls pw-class UofM

12. Configure the IP address on the serial interface on CE2-A with encapsulation PPP and the interface on CE1-B facing the MPLS core.

    interface Serial3/0
    ip address 10.0.0.1 255.255.255.0
    encapsulation ppp

13. Verify the connectivity between CE2-A and CE2-B

    CE2-B#ping 10.0.0.1
    Type escape sequence to abort.
    Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:
    !!!!!
    Success rate is 100 percent (5/5), round-trip min/avg/max = 36/44/56 ms
    CE2-B#

14. Run and analyze the following commands on PE1 and PE2, highlight that you have two VC up status, what label stack PE1 is using? What is the MPLS VC remote and local label on PE1?

PE2#show mpls l2transport vc

```
Local intf     Local circuit              Dest address    VC ID
Status
-------------  -------------------------- --------------- ---------- -----
-----
Fa0/0          Ethernet                   1.1.1.1         100        UP
Fa1/1          Ethernet                   1.1.1.1         300        UP
```

PE2#show mpls l2transport vc detail

```
Local interface: Fa0/0 up, line protocol up, Ethernet up
  Destination address: 1.1.1.1, VC ID: 100, VC status: up
    Output interface: Fa1/0, imposed label stack {17 16}
    Preferred path: not configured
    Default path: active
    Next hop: 192.168.1.5
  Create time: 00:29:49, last status change time: 00:28:43
    Last label FSM state change time: 00:28:43
  Signaling protocol: LDP, peer 1.1.1.1:0 up
    Targeted Hello: 2.2.2.2(LDP Id) -> 1.1.1.1, LDP is UP
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No fault
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 16, remote 16
    Group ID: local 0, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On (configured: autosense)
  Dataplane:
    SSM segment/switch IDs: 8195/4096 (used), PWID: 1
  VC statistics:
    transit packet totals: receive 593, send 595
    transit byte totals:   receive 61218, send 76540
    transit packet drops:  receive 0, seq error 0, send 0

Local interface: Fa1/1 up, line protocol up, Ethernet up
  Interworking type is IP
  Destination address: 1.1.1.1, VC ID: 300, VC status: up
    Output interface: Fa1/0, imposed label stack {17 17}
    Preferred path: not configured
    Default path: active
    Next hop: 192.168.1.5
  Create time: 00:29:49, last status change time: 00:28:39
    Last label FSM state change time: 00:28:43
  Signaling protocol: LDP, peer 1.1.1.1:0 up
    Targeted Hello: 2.2.2.2(LDP Id) -> 1.1.1.1, LDP is UP
  Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
```

```
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No fault
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 17, remote 17
    Group ID: local 0, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On
  Dataplane:
    SSM segment/switch IDs: 4098/8193 (used), PWID: 2
  VC statistics:
    transit packet totals: receive 399, send 398
    transit byte totals:   receive 24759, send 35085
    transit packet drops:  receive 0, seq error 0, send 0
```

PE#show mpls l2transport binding

```
PE2#show mpls l2transport binding
  Destination Address: 1.1.1.1,VC ID: 100
    Local Label:  16
        Cbit: 1,    VC Type: Ethernet,    GroupID: 0
        MTU: 1500,   Interface Desc: n/a
        VCCV: CC Type: CW [1], RA [2], TTL [3]
              CV Type: LSPV [2], BFD/Raw [5]
    Remote Label: 16
        Cbit: 1,    VC Type: Ethernet,    GroupID: 0
        MTU: 1500,   Interface Desc: n/a
        VCCV: CC Type: CW [1], RA [2], TTL [3]
              CV Type: LSPV [2], BFD/Raw [5]
  Destination Address: 1.1.1.1,VC ID: 300
    Local Label:  17
        Cbit: 1,    VC Type: IP,    GroupID: 0
        MTU: 1500,   Interface Desc: n/a
        VCCV: CC Type: CW [1], RA [2], TTL [3]
              CV Type: LSPV [2], BFD/Raw [5]
    Remote Label: 17
        Cbit: 1,    VC Type: IP,    GroupID: 0
        MTU: 1500,   Interface Desc: n/a
        VCCV: CC Type: CW [1], RA [2], TTL [3]
              CV Type: LSPV [2], BFD/Raw [5]
```

PE2#show l2vpn service all detail

```
Legend: St=State    XC St=State in the L2VPN Service      Prio=Priority
        UP=Up       DN=Down             AD=Admin Down     IA=Inactive
        SB=Standby  HS=Hot Standby      RV=Recovering     NH=No Hardware
        m=manually selected

  Interface          Group       Encapsulation                   Prio  St
XC St
  ---------          -----       -------------                   ----  --
-----
VPWS name: Fa0/0-2, State: UP
  Fa0/0              left        Fa0/0:2(Ethernet)               0     UP
UP
                                 Interworking: none
  pw100001           right       1.1.1.1:100(MPLS)               0     UP
UP
                                 Local VC label 16
                                 Remote VC label 16

VPWS name: Fa1/1-4, State: UP
  Fa1/1              left        Fa1/1:4(Ethernet)               0     UP
UP
                                 Interworking: ip
  pw100002           right       1.1.1.1:300(MPLS)               0     UP
UP
                                 Local VC label 17
                                 Remote VC label 17
                                 pw-class: UofM


PE1#show l2vpn service all detail
Legend: St=State    XC St=State in the L2VPN Service      Prio=Priority
        UP=Up       DN=Down             AD=Admin Down     IA=Inactive
        SB=Standby  HS=Hot Standby      RV=Recovering     NH=No Hardware
        m=manually selected

  Interface          Group       Encapsulation                   Prio  St
XC St
  ---------          -----       -------------                   ----  --
-----
VPWS name: Fa0/0-2, State: UP
  Fa0/0              left        Fa0/0:2(Ethernet)               0     UP
UP
                                 Interworking: none
  pw100001           right       2.2.2.2:100(MPLS)               0     UP
UP
                                 Local VC label 16
                                 Remote VC label 16

VPWS name: Se3/0, State: UP
  Se3/0              left        Se3/0(PPP)                      0     UP
UP
```

```
                                  Interworking: ip
  pw100002            right       2.2.2.2:300(MPLS)                 0     UP
UP
                                  Local VC label 17
                                  Remote VC label 17
                                  pw-class: UofM
```

Deliverables:

- Diagram of the lab with IP addresses and Autonomous system numbers.
- Running configuration of all the routers.
- The output of the following command on PE1 and PE2
    1- **PE#show mpls l2transport vc**
    2- **PE#show mpls l2transport vc detail**
    3- **PE#show mpls l2transport binding**
    4- **PE#show l2vpn service all detail**
- Successful Ping and trace route from CE2-A to CE2-B
- Successful Ping and traceroute from CE2-A to CE2-B

Instructions to follow at the end of each lab

- Make sure you erase your configuration from NVRAM of the devices used.
- Do not save any of the configurations in flash memory.
- All cables must be unplugged and secured in the box.
- There must not be any kind of garbage around the desk or racks after you are done with lab.

PE2#show run

```
!
hostname PE2
!
ip cef

pseudowire-class UofM
 encapsulation mpls
 interworking ip
 control-word
```

```
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex full
 no keepalive
 xconnect 1.1.1.1 100 encapsulation mpls
!
interface FastEthernet1/0
 ip address 192.168.1.6 255.255.255.252
 speed auto
 duplex auto
 mpls ip
!
interface FastEthernet1/1
 no ip address
 speed auto
 duplex auto
 no keepalive
 xconnect 1.1.1.1 300 encapsulation mpls pw-class UofM
!
router ospf 1
 network 2.2.2.2 0.0.0.0 area 0
 network 192.168.1.4 0.0.0.3 area 0
```

PE1#show run

```
!
hostname PE1
!
ip cef
!
pseudowire-class UofM
 encapsulation mpls
 interworking ip
 control-word
!

interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
```

```
interface FastEthernet0/0
 no ip address
 duplex full
 no keepalive
 xconnect 2.2.2.2 100 encapsulation mpls
!
interface FastEthernet1/1
 ip address 192.168.1.1 255.255.255.252
 speed auto
 duplex auto
 mpls ip
!
interface Serial3/0
 no ip address
 encapsulation ppp
 serial restart-delay 0
 xconnect 2.2.2.2 300 encapsulation mpls pw-class UofM
!
router ospf 1
 network 1.1.1.1 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.3 area 0
```

```
P#show run
!
hostname P
!

!
no aaa new-model
no ip icmp rate-limit unreachable
ip cef
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet1/0
 ip address 192.168.1.5 255.255.255.252
 speed auto
 duplex auto
 mpls ip
!
interface FastEthernet1/1
 ip address 192.168.1.2 255.255.255.252
```

```
 speed auto
 duplex auto
 mpls ip
!
router ospf 1
 network 3.3.3.3 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.3 area 0
 network 192.168.1.4 0.0.0.3 area 0
!
```

CE1-A#show run

```
!
hostname CE1-A
!
ip cef
!
interface Loopback0
 ip address 5.1.1.1 255.255.255.255
!
interface FastEthernet0/0.100
 encapsulation dot1Q 100
 ip address 172.16.1.1 255.255.255.0
!
interface FastEthernet0/0.200
 encapsulation dot1Q 200
 ip address 172.16.2.1 255.255.255.0
!
router ospf 1
 network 5.1.1.1 0.0.0.0 area 0
 network 172.16.1.0 0.0.0.255 area 0
 network 172.16.2.0 0.0.0.255 area 0
!
```

CE1-B#show run

```
!
hostname CE1-B
!
ip cef
!
interface Loopback0
 ip address 4.1.1.1 255.255.255.255
```

```
!
interface FastEthernet0/0.100
 encapsulation dot1Q 100
 ip address 172.16.1.2 255.255.255.0
!
interface FastEthernet0/0.200
 encapsulation dot1Q 200
 ip address 172.16.2.2 255.255.255.0
!
router ospf 1
 network 4.1.1.1 0.0.0.0 area 0
 network 172.16.1.0 0.0.0.255 area 0
 network 172.16.2.0 0.0.0.255 area 0
!
```

CE2-A#show run

```
!
hostname CE2-A
!
ip cef
!
interface Loopback0
 ip address 6.1.1.1 255.255.255.255
!
interface Serial3/0
 ip address 10.0.0.1 255.255.255.0
 encapsulation ppp
 serial restart-delay 0
!
router eigrp 1
 network 6.0.0.0
 network 6.1.1.1 0.0.0.0
 network 10.0.0.0 0.0.0.255
!
```

CE2-B#show run

```
!
```

```
hostname CE2-B
!
ip cef
!
!
interface Loopback0
 ip address 7.1.1.1 255.255.255.0
!
interface FastEthernet1/1
 ip address 10.0.0.2 255.255.255.0
 speed auto
 duplex auto
!
router eigrp 1
 network 7.1.1.1 0.0.0.0
 network 10.0.0.0 0.0.0.255
!
```

Lab 7

MPLS Traffic Engineering

Introduction:

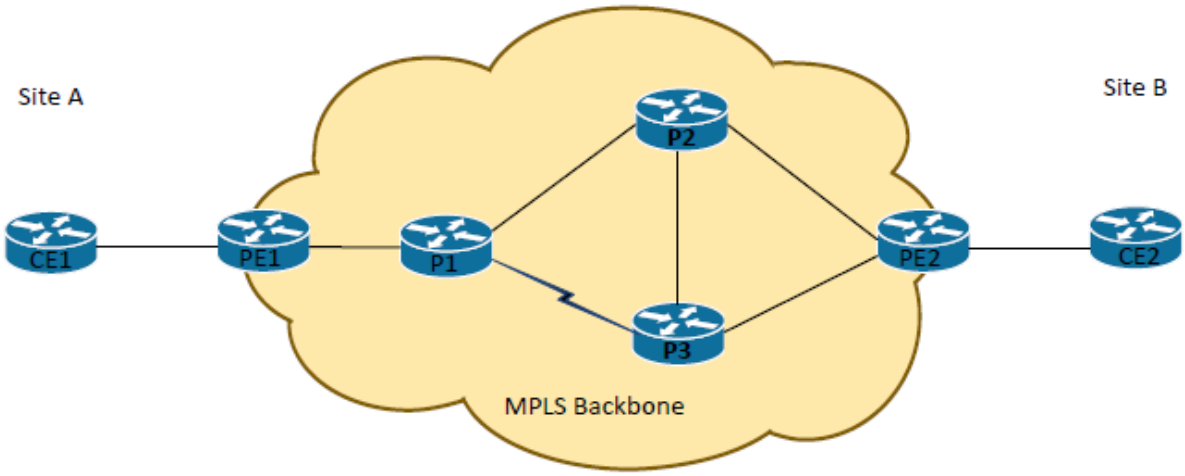
Traffic-engineered networks force packets to follow a particular path, such as an underutilized path. This path is explicitly selected when or before the packet enters the network, rather than being selected by the normal dynamic routing algorithm as the packet travels through the network. In MPLS, a label can be used to represent the route, so the identity of the explicit route need not be carried with the packet. This functionality forms the basis of MPLS traffic engineering.

Link-state IGP routing protocols are used to distribute information about all links in the network. Consequently, every IGP router within the autonomous system obtains a complete picture of all the links and routers in the network. Each router then uses this information to compute the shortest path to every possible target subnet in the network using a shortest-path algorithm. The router then builds a forwarding table, associating an address prefix with the next-hop link. When a packet arrives at a router, the forwarding table is consulted, and the packets are forwarded out on the appropriate link based on the destination IP address. This approach works very well in networks that have a sparse topology. In a network with a densely connected topology, this approach might cause disproportionate network loading. Links that are not on the shortest-path tree remain underutilized despite the presence of heavy traffic loads. This leads to wasted and underutilized bandwidth on service provider trunks that could otherwise be put to good Use.

Prelab:

- Why do we need two or more labels for MPLS TE?
- Why MPLS TE is preferred over earlier TE methods?
- What are the head-end and tail-end routers in MPLS TE?
- Why distance vector routing protocols not used for MPLS TE.
- Briefly explain the extensions made to OSPF and ISIS to support MPLS TE.
- Which LSA type of OSPF is most commonly used for MPLS TE?
- Draw the header structure of OSPF options field and explain the use of O bit.
- Which algorithm is used on the head-end router to define the LSP?
- What is the role of RSVP protocol in MPLS TE?
- What are the functions of RSVP PATH and RSVP RESV messages?
- What are the various TE resources of a link on a network? Hint: e.g. TE Metric.

Lab Diagram:



Lab IP Addressing:

Node	IP
CE1 to PE1	192.168.X.0/30
CE2 to PE2	192.168.X.4/30
PE1 to P1	10.0.X.0/30
P1 to P2	10.0.X.4/30
P1 to P3	10.0.X.8/30
P2 to P3	10.0.X.12/30
P2 to PE2	10.0.X.16/30
P3 to PE2	10.0.X.20/30

PE1 Loopback	1.1.1.1
P1 Loopback	3.3.3.3
P2 Loopback	4.4.4.4
P3 Loopback	5.5.5.5
PE2 Loopback	2.2.2.2

Procedure:

5. Wire all routers as per the lab diagram.

6. Configure IP addressing on ISP network and Customer networks as specified in above table.

7. Configure ISIS level-2 as link-state IGP across ISP network and redistribute connected and static addresses of the customers. You should be able to ping CE2 from CE1? issue Show ip route on PE1 and traceroute CE2 from CE1

```
PE1#show ip route
     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
i L2    2.2.2.2 [115/40] via 10.0.0.2, 00:02:17, FastEthernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
i L2    3.3.3.3 [115/20] via 10.0.0.2, 00:05:07, FastEthernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
i L2    4.4.4.4 [115/30] via 10.0.0.2, 00:04:26, FastEthernet1/0
     5.0.0.0/32 is subnetted, 1 subnets
i L2    5.5.5.5 [115/30] via 10.0.0.2, 00:03:24, FastEthernet1/0
     10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
C       10.0.0.0/30 is directly connected, FastEthernet1/0
L       10.0.0.1/32 is directly connected, FastEthernet1/0
i L2    10.0.0.4/30 [115/20] via 10.0.0.2, 00:05:07, FastEthernet1/0
i L2    10.0.0.8/30 [115/20] via 10.0.0.2, 00:05:07, FastEthernet1/0
i L2    10.0.0.12/30 [115/30] via 10.0.0.2, 00:03:24, FastEthernet1/0
i L2    10.0.0.16/30 [115/30] via 10.0.0.2, 00:02:24, FastEthernet1/0
i L2    10.0.0.20/30 [115/30] via 10.0.0.2, 00:03:24, FastEthernet1/0
     192.168.0.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.0.0/30 is directly connected, FastEthernet0/0
L       192.168.0.2/32 is directly connected, FastEthernet0/0
i L2    192.168.0.4/30 [115/30] via 10.0.0.2, 00:02:17, FastEthernet1/0
```

```
CE1#traceroute 192.168.0.5
Type escape sequence to abort.
Tracing the route to 192.168.0.5
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.0.2 24 msec 16 msec 20 msec
  2 10.0.0.2 44 msec 44 msec 32 msec
  3 10.0.0.10 68 msec 60 msec 56 msec
  4 10.0.0.22 56 msec 80 msec 80 msec
  5    192.168.0.5 64 msec 116 msec 96 msec
```

8. Enable ip cef globally on the ISP routers.

```
PE1#show ip cef
Prefix              Next Hop            Interface
0.0.0.0/0           no route
0.0.0.0/8           drop
0.0.0.0/32          receive
1.1.1.1/32          receive             Loopback0
2.2.2.2/32          10.0.0.2            FastEthernet1/0
3.3.3.3/32          10.0.0.2            FastEthernet1/0
4.4.4.4/32          10.0.0.2            FastEthernet1/0
5.5.5.5/32          10.0.0.2            FastEthernet1/0
10.0.0.0/30         attached            FastEthernet1/0
10.0.0.0/32         receive             FastEthernet1/0
10.0.0.1/32         receive             FastEthernet1/0
10.0.0.2/32         attached            FastEthernet1/0
10.0.0.3/32         receive             FastEthernet1/0
10.0.0.4/30         10.0.0.2            FastEthernet1/0
10.0.0.8/30         10.0.0.2            FastEthernet1/0
10.0.0.12/30        10.0.0.2            FastEthernet1/0
10.0.0.16/30        10.0.0.2            FastEthernet1/0
10.0.0.20/30        10.0.0.2            FastEthernet1/0
127.0.0.0/8         drop
192.168.0.0/30      attached            FastEthernet0/0
192.168.0.0/32      receive             FastEthernet0/0
Prefix              Next Hop            Interface
192.168.0.1/32      attached            FastEthernet0/0
192.168.0.2/32      receive             FastEthernet0/0
192.168.0.3/32      receive             FastEthernet0/0
192.168.0.4/30      10.0.0.2            FastEthernet1/0
224.0.0.0/4         drop
224.0.0.0/24        receive
240.0.0.0/4         drop
255.255.255.255/32  receive
```

9. Run MPLS on all ISP networks, router-id for MPLS should be loopback address on P1 show mpls forwarding-table? What label will be assigned for traffic to CE2?

```
P1#show mpls forwarding-table
Local      Outgoing   Prefix          Bytes Label   Outgoing    Next Hop
Label      Label      or Tunnel Id    Switched      interface
200        Pop Label  1.1.1.1/32      0             Fa1/0       10.0.0.1
201        301        2.2.2.2/32      0             Fa0/0       10.0.0.6
           401        2.2.2.2/32      0             Se3/0       point2point
202        Pop Label  4.4.4.4/32      0             Fa0/0       10.0.0.6
203        Pop Label  5.5.5.5/32      0             Se3/0       point2point
204        Pop Label  10.0.0.12/30     0             Fa0/0       10.0.0.6
           Pop Label  10.0.0.12/30     0             Se3/0       point2point
205        Pop Label  10.0.0.16/30     0             Fa0/0       10.0.0.6
206        Pop Label  10.0.0.20/30     0             Se3/0       point2point
207        Pop Label  192.168.0.0/30   0             Fa1/0       10.0.0.1
208        308        192.168.0.4/30   0             Fa0/0       10.0.0.6
           408        192.168.0.4/30   0             Se3/0       point2point
```

10. Configure MPLS traffic engineering globally and on interface basis in ISP network

11. Configure the ISIS to support MPLS TE. Hint: Choose the metric style as wide.
    1- Issue show mpls traffic-eng link-management summary.
    2- What is the link ID?
    3- What is max reservable bandwidth on the link between PE1 and P1?

```
PE1#show mpls traffic-eng link-management summary
System Information::
  Links Count:          1
  Flooding System:      enabled
IGP Area ID::  isis  level-2
  Flooding Protocol:    ISIS
  Flooding Status:      data flooded
  Periodic Flooding:    enabled (every 60 seconds, next in 53 seconds)
  Flooded Links:        1
  IGP System ID:        1111.1111.1111.00
  MPLS TE Router ID:    1.1.1.1
  Neighbors:            1
Link ID::  Fa1/0 (10.0.0.1)
  Local Intfc ID:       2
  Link Status:
    SRLGs:              None
    Intfc Switching Capability Descriptors:
      Default:          Intfc Switching Cap psc1, Encoding ethernet
    Link Label Type:    Packet
    Physical Bandwidth:   100000 kbits/sec
    Max Res Global BW:    0 kbits/sec (reserved: 100% in, 100% out)
    Max Res Sub BW:       0 kbits/sec (reserved: 100% in, 100% out)
    MPLS TE Link State:   MPLS TE on, RSVP on, admin-up, flooded
    Inbound Admission:    reject-huge
```

```
    Outbound Admission:   allow-if-room
    Link MTU:             IP 1500, MPLS 1500
    Admin. Weight:        10 (IGP)
    IGP Neighbor Count:   1
```

12. Now configure RSVP on each interface participating in MPLS TE LSP process. Hint: Assign the maximum reservable bandwidth as link maximum bandwidth.
13. On P3 run show mpls traffic-eng link-management summary and highlight the physical bandwidth and max reservable bandwidth on all links

```
P3#show mpls traffic-eng link-management summary
System Information::
  Links Count:         3
  Flooding System:     enabled
IGP Area ID::  isis  level-2
  Flooding Protocol:   ISIS
  Flooding Status:     data flooded
  Periodic Flooding:   enabled (every 60 seconds, next in 44 seconds)
  Flooded Links:       3
  IGP System ID:       5555.5555.5555.00
  MPLS TE Router ID:   5.5.5.5
  Neighbors:           3
Link ID::  Fa0/0 (10.0.0.21)
  Local Intfc ID:      1
  Link Status:
    SRLGs:             None
    Intfc Switching Capability Descriptors:
      Default:         Intfc Switching Cap psc1, Encoding ethernet
    Link Label Type:   Packet
    Physical Bandwidth:   100000 kbits/sec
    Max Res Global BW:    100000 kbits/sec (reserved: 0% in, 0% out)
    Max Res Sub BW:       0 kbits/sec (reserved: 100% in, 100% out)
    MPLS TE Link State:   MPLS TE on, RSVP on, admin-up, flooded
    Inbound Admission:    reject-huge
    Outbound Admission:   allow-if-room
    Link MTU:             IP 1500, MPLS 1500
    Admin. Weight:        10 (IGP)
    IGP Neighbor Count:   1
Link ID::  Fa1/0 (10.0.0.14)
  Local Intfc ID:      2
  Link Status:
    SRLGs:             None
    Intfc Switching Capability Descriptors:
      Default:         Intfc Switching Cap psc1, Encoding ethernet
    Link Label Type:   Packet
    Physical Bandwidth:   100000 kbits/sec
    Max Res Global BW:    100000 kbits/sec (reserved: 0% in, 0% out)
    Max Res Sub BW:       0 kbits/sec (reserved: 100% in, 100% out)
    MPLS TE Link State:   MPLS TE on, RSVP on, admin-up, flooded
    Inbound Admission:    reject-huge
    Outbound Admission:   allow-if-room
```

Link MTU: IP 1500, MPLS 1500
Admin. Weight: 10 (IGP)
IGP Neighbor Count: 1
Link ID:: Se3/0 (10.0.0.10)
Local Intfc ID: 5
Link Status:
SRLGs: None
Intfc Switching Capability Descriptors:
Default: Intfc Switching Cap psc1, Encoding packet
Link Label Type: Packet
Physical Bandwidth: 1544 kbits/sec
Max Res Global BW: 1544 kbits/sec (reserved: 0% in, 0% out)
Max Res Sub BW: 0 kbits/sec (reserved: 100% in, 100% out)
MPLS TE Link State: MPLS TE on, RSVP on, admin-up, flooded
Inbound Admission: allow-all
Outbound Admission: allow-if-room
Link MTU: IP 1500, MPLS 1500
Admin. Weight: 10 (IGP)
IGP Neighbor Count: 1

9- Configure MPLS TE tunnel on PE1 as head-end router and terminating on tail-end router PE2 with following parameters:
Bandwidth: 400 KB
Tunnel Destination: Router PE2's loopback
Most preferred Path-option: PE1-P1-P3-PE2
Second Preferred path-option: Dynamic

10- Announce this tunnel into enhanced link state IGP, in current scenario it is, ISIS. Note: At this time,
1- make sure tunnel is UP
2- Confirm that traffic from Customer 1 to customer 2 takes the most preferred tunnel path.
3- Confirm that 400kb is being reserved
4- What is being advertised from PE1?
5- What is the output label for traffic through the tunnel?
6- What is explicit path that tunnel will use?
7- Do trace route and confirm the same label assigned by PE1 and the path P1-P3-PE2?
8- Break the link between P3-PE2, what is the path in this case?
9- Bring the link up again, did the path move back to most preferred one? Why?
10- What can you do so the most preferred tunnel is back to the most preferred path? Apply and confirm?

PE1#show mpls traffic-eng tunnels

P2P TUNNELS/LSPs:

Name: TO-PE2 (Tunnel1) Destination: 2.2.2.2
Status:
Admin: up Oper: up Path: valid Signalling: connected

```
  path option 100, type explicit My-Route (Basis for Setup, path weight 30)
  path option 1000, type dynamic

 Config Parameters:
  Bandwidth: 400      kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
  Metric Type: TE (default)
  AutoRoute: enabled  LockDown: disabled Loadshare: 400 [5000000] bw-based
  auto-bw: disabled
 Active Path Option Parameters:
  State: explicit path option 100 is active
  BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled


 InLabel  :  -
 OutLabel : FastEthernet1/0, 211
 Next Hop : 10.0.0.2
 RSVP Signalling Info:
     Src 1.1.1.1, Dst 2.2.2.2, Tun_Id 1, Tun_Instance 839
  RSVP Path Info:
    My Address: 10.0.0.1
    Explicit Route: 10.0.0.2 10.0.0.10 10.0.0.21 10.0.0.22
                 2.2.2.2
    Record   Route:   NONE
    Tspec: ave rate=400 kbits, burst=1000 bytes, peak rate=400 kbits
  RSVP Resv Info:
    Record   Route:   NONE
    Fspec: ave rate=400 kbits, burst=1000 bytes, peak rate=400 kbits
 History:
  Tunnel:
    Time since created: 2 hours, 2 minutes
    Time since path change: 20 minutes, 53 seconds
    Number of LSP IDs (Tun_Instances) used: 839
  Current LSP: [ID: 839]
    Uptime: 20 minutes, 56 seconds
    Selection: reoptimization
  Prior LSP: [ID: 828]
    ID: path option unknown
    Removal Trigger: reoptimization completed


PE1#show mpls traffic-eng link-management admission-control
P2P LSP:
  LSP ID             UP IF     DOWN IF  PRIORITY STATE          BW (kbps)
1.1.1.1_1->2.2.2.2_1   -         Fa1/0    7/7      Resv Admitted   400        RG

PE1#show mpls traffic-eng link-management advertisements
Flooding Status:      ready
Configured Areas:     1
IGP Area[1] ID::  isis  level-2
  System Information::
    Flooding Protocol:    ISIS
  Header Information::
    IGP System ID:        1111.1111.1111.00
    MPLS TE Router ID:    1.1.1.1
```

```
    Flooded Links:        1
  Link ID::  0 (FastEthernet1/0)
    Link Subnet Type:     Broadcast
    Link IP Address:      10.0.0.1
    Designated Router:    1111.1111.1111.01
    TE metric:            10
    IGP metric:           10
    SRLGs:                None
    Physical Bandwidth:   100000 kbits/sec
    Res. Global BW:       100000 kbits/sec
    Res. Sub BW:          0 kbits/sec
    Downstream::
                          Global Pool    Sub Pool
                          -----------    ----------
      Reservable Bandwidth[0]:        100000          0 kbits/sec
      Reservable Bandwidth[1]:        100000          0 kbits/sec
      Reservable Bandwidth[2]:        100000          0 kbits/sec
      Reservable Bandwidth[3]:        100000          0 kbits/sec
      Reservable Bandwidth[4]:        100000          0 kbits/sec
      Reservable Bandwidth[5]:        100000          0 kbits/sec
      Reservable Bandwidth[6]:        100000          0 kbits/sec
      Reservable Bandwidth[7]:         99600          0 kbits/sec
    Attribute Flags:      0x00000000


PE1#show mpls forwarding-table 192.168.0.6
Local      Outgoing   Prefix          Bytes Label   Outgoing    Next Hop
Label      Label      or Tunnel Id    Switched      interface
109   [T]  No Label   192.168.0.4/30  0             Tu1         point2point

[T]     Forwarding through a LSP tunnel.
        View additional labelling info with the 'detail' option


PE1#show ip rsvp  interface
interface    rsvp      allocated  i/f max  flow max sub max  VRF
Fa1/0        ena       400K       100M     100M     0



PE1#show ip route
      1.0.0.0/32 is subnetted, 1 subnets
C        1.1.1.1 is directly connected, Loopback0
      2.0.0.0/32 is subnetted, 1 subnets
i L2     2.2.2.2 [115/40] via 2.2.2.2, 00:00:37, Tunnel1
      3.0.0.0/32 is subnetted, 1 subnets
i L2     3.3.3.3 [115/20] via 10.0.0.2, 00:00:43, FastEthernet1/0
      4.0.0.0/32 is subnetted, 1 subnets
i L2     4.4.4.4 [115/30] via 10.0.0.2, 00:00:43, FastEthernet1/0
      5.0.0.0/32 is subnetted, 1 subnets
i L2     5.5.5.5 [115/30] via 10.0.0.2, 00:00:43, FastEthernet1/0
      10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
```

```
C        10.0.0.0/30 is directly connected, FastEthernet1/0
L        10.0.0.1/32 is directly connected, FastEthernet1/0
i L2     10.0.0.4/30 [115/20] via 10.0.0.2, 00:00:43, FastEthernet1/0
i L2     10.0.0.8/30 [115/20] via 10.0.0.2, 00:00:43, FastEthernet1/0
i L2     10.0.0.12/30 [115/30] via 10.0.0.2, 00:00:43, FastEthernet1/0
i L2     10.0.0.16/30 [115/30] via 10.0.0.2, 00:00:43, FastEthernet1/0
i L2     10.0.0.20/30 [115/30] via 10.0.0.2, 00:00:43, FastEthernet1/0
      192.168.0.0/24 is variably subnetted, 3 subnets, 2 masks
C        192.168.0.0/30 is directly connected, FastEthernet0/0
L        192.168.0.2/32 is directly connected, FastEthernet0/0
i L2     192.168.0.4/30 [115/30] via 2.2.2.2, 00:00:37, Tunnel1

PE1#show mpls traffic-eng tunnels

P2P TUNNELS/LSPs:

Name: TO-PE2                          (Tunnel1) Destination: 2.2.2.2
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 100, type explicit My-Route (Basis for Setup, path weight 30)
    path option 1000, type dynamic

  Config Parameters:
    Bandwidth: 400      kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled  LockDown: disabled Loadshare: 400 [5000000] bw-based
    auto-bw: disabled
  Active Path Option Parameters:
    State: explicit path option 100 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled


  InLabel  :  -
  OutLabel : FastEthernet1/0, 211
  Next Hop : 10.0.0.2
  RSVP Signalling Info:
       Src 1.1.1.1, Dst 2.2.2.2, Tun_Id 1, Tun_Instance 839
    RSVP Path Info:
      My Address: 10.0.0.1
      Explicit Route: 10.0.0.2 10.0.0.10 10.0.0.21 10.0.0.22
                    2.2.2.2
      Record   Route:   NONE
      Tspec: ave rate=400 kbits, burst=1000 bytes, peak rate=400 kbits
    RSVP Resv Info:
      Record   Route:   NONE
      Fspec: ave rate=400 kbits, burst=1000 bytes, peak rate=400 kbits
  History:
    Tunnel:
      Time since created: 2 hours, 8 minutes
      Time since path change: 26 minutes, 19 seconds
      Number of LSP IDs (Tun_Instances) used: 839
    Current LSP: [ID: 839]
      Uptime: 26 minutes, 22 seconds
      Selection: reoptimization
    Prior LSP: [ID: 828]
      ID: path option unknown
      Removal Trigger: reoptimization completed

CE1#traceroute 192.168.0.6
```

```
Type escape sequence to abort.
Tracing the route to 192.168.0.6
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.0.2 12 msec 12 msec 12 msec
  2 10.0.0.2 [MPLS: Label 211 Exp 0] 64 msec 60 msec 44 msec
  3 10.0.0.10 [MPLS: Label 405 Exp 0] 40 msec 40 msec 48 msec
  4 10.0.0.22 60 msec 52 msec 40 msec
CE1#
```

After Breaking the link between P3-PE2:

```
CE1#traceroute 192.168.0.6
Type escape sequence to abort.
Tracing the route to 192.168.0.6
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.0.2 24 msec 12 msec 8 msec
  2 10.0.0.2 [MPLS: Label 213 Exp 0] 68 msec 44 msec 40 msec
  3 10.0.0.6 [MPLS: Label 312 Exp 0] 52 msec 44 msec 40 msec
  4 10.0.0.18 68 msec 40 msec 40 msec
```

After the link is up we can observe that traffic will not use the most preferred
This is because of the reoptimize timer, default to 1 hour
To fix that you can set the timer to 5 sec using the following command
PE1(config)#mpls traffic-eng reoptimize timers frequency 5

```
CE1#traceroute 192.168.0.6
Type escape sequence to abort.
Tracing the route to 192.168.0.6
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.0.2 40 msec 24 msec 16 msec
  2 10.0.0.2 [MPLS: Label 201 Exp 0] 60 msec 44 msec 48 msec
  3 10.0.0.10 [MPLS: Label 412 Exp 0] 84 msec 40 msec 40 msec
  4 10.0.0.22 64 msec 28 msec 44 msec
CE1#
```

11- Now create a backup MPLS TE LSP at PE1, with following parameters. This tunnel is a worst path and will be used if primary tunnel is down, unless load sharing is enabled:
    - Bandwidth: 500 KB
    - Tunnel Destination: Router PE2's loopback.
    - Most preferred Path-option: Explicitly define as PE1-P1-P3-P2-PE2.

1- Confirm that both tunnels are up
2- Show IP RSVP interface (what happen to the allocated bandwidth and why?)
3- Show mpls raffic-eng tunnels (what is the output label assigned by PE1 for this tunnel 2?)

```
PE1#show ip int br
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        192.168.0.2     YES NVRAM  up                    up
FastEthernet1/0        10.0.0.1        YES NVRAM  up                    up
FastEthernet1/1        unassigned      YES NVRAM  administratively down down
GigabitEthernet2/0     unassigned      YES NVRAM  administratively down down
Loopback0              1.1.1.1         YES NVRAM  up                    up
Tunnel1                1.1.1.1         YES TFTP   up                    up
Tunnel2                1.1.1.1         YES TFTP   up                    up
```

```
PE1#show ip rsvp interface
interface    rsvp      allocated  i/f max  flow max sub max  VRF
Fa1/0        ena       900K       100M     100M     0
```

```
PE1#show mpls traffic-eng tunnels tunnel2

Name: To-PE2-Backup                       (Tunnel2) Destination: 2.2.2.2
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 10, type explicit MINT (Basis for Setup, path weight 40)

  Config Parameters:
    Bandwidth: 500      kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: disabled LockDown: disabled Loadshare: 500 [4000000] bw-based
    auto-bw: disabled
  Active Path Option Parameters:
    State: explicit path option 10 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled


  InLabel  : -
  OutLabel : FastEthernet1/0, 200
  Next Hop : 10.0.0.2
  RSVP Signalling Info:
       Src 1.1.1.1, Dst 2.2.2.2, Tun_Id 2, Tun_Instance 1
    RSVP Path Info:
      My Address: 10.0.0.1
      Explicit Route: 10.0.0.2 10.0.0.10 10.0.0.14 10.0.0.13
                      10.0.0.17 10.0.0.18 2.2.2.2
      Record   Route:   NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
    RSVP Resv Info:
      Record   Route:   NONE
      Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 30 (TE)
    Explicit Route: 10.0.0.1 10.0.0.2 10.0.0.5 10.0.0.6
                    10.0.0.17 10.0.0.18 2.2.2.2
  History:
    Tunnel:
      Time since created: 3 minutes, 21 seconds
      Time since path change: 3 minutes, 20 seconds
      Number of LSP IDs (Tun_Instances) used: 1
    Current LSP: [ID: 1]
      Uptime: 3 minutes, 20 seconds
PE1#
```

Deliverables:

- Diagram of the lab with IP address.
- Running configuration of all the routers
- Output of show ip route isis on PE1 and PE2.
- Output of show isis topology on PE1
- Output of show ip rsvp interface on all ISP routers.
- On PE1, output of show mpls traffic-eng topology <loopback of P1>.

- Output of show mpls traffic-eng tunnels on PE1.
- Note: Highlight the max bandwidth configured and path-option for each tunnel.
- Output of show mpls forwarding-table on PE1.
- Traceroute <PE2's loopback> from Customer 1 and PE1.
- Output of extended Ping from Customer 1 to Customer-2, send only 2 packets.

Instructions to follow at the end of each lab

14. Make sure you erase your configuration from NVRAM of the devices used.
15. Do not save any of the configurations in flash memory.
16. All cables must be unplugged and secured in the box.
17. There must not be any kind of garbage around the desk or racks after you are done with lab.

Deliverable:

```
PE1#show run
!
hostname PE1
!
ip cef
!
mpls label range 100 199
mpls label protocol ldp
mpls traffic-eng tunnels
mpls traffic-eng reoptimize timers frequency 5
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
 ip router isis
!
interface Tunnel1
 description TO-PE2
 ip unnumbered Loopback0
 tunnel mode mpls traffic-eng
 tunnel destination 2.2.2.2
 tunnel mpls traffic-eng autoroute announce
```

```
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 400
 tunnel mpls traffic-eng path-option 100 explicit name My-Route
 tunnel mpls traffic-eng path-option 1000 dynamic
!
interface Tunnel2
 description To-PE2-Backup
 ip unnumbered Loopback0
 ip router isis
 tunnel mode mpls traffic-eng
 tunnel destination 2.2.2.2
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 500
 tunnel mpls traffic-eng path-option 10 explicit name MINT
!
interface FastEthernet0/0
 ip address 192.168.0.2 255.255.255.252
 duplex full
!
interface FastEthernet1/0
 ip address 10.0.0.1 255.255.255.252
 ip router isis
 speed auto
 duplex auto
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
router isis
 net 00.0000.1111.1111.1111.00
 is-type level-2-only
 metric-style wide
 redistribute connected
 redistribute static ip
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
!
ip explicit-path name MINT enable
 next-address 10.0.0.2
 next-address 10.0.0.9
 next-address 10.0.0.10
 next-address 10.0.0.14
 next-address 10.0.0.13
 next-address 10.0.0.17
 next-address 10.0.0.18
!
```

```
ip explicit-path name My-Route enable
 next-address 10.0.0.2
 next-address 10.0.0.9
 next-address 10.0.0.10
 next-address 10.0.0.21
 next-address 10.0.0.22
!
```

PE2#show run

```
!
hostname PE2
!
ip cef
!
mpls label range 500 599
mpls label protocol ldp
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
 ip router isis
!
interface FastEthernet0/0
 ip address 10.0.0.22 255.255.255.252
 ip router isis
 duplex full
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
interface FastEthernet1/0
 ip address 192.168.0.6 255.255.255.252
 speed auto
 duplex auto
!
interface FastEthernet1/1
 ip address 10.0.0.18 255.255.255.252
 ip router isis
 speed auto
 duplex auto
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
router isis
```

```
 net 00.0000.2222.2222.2222.00
 is-type level-2-only
 metric-style wide
 redistribute connected
 redistribute static ip
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
!
```

```
P3#show run
!
hostname P3
!
ip cef
!
mpls label range 400 499
mpls label protocol ldp
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 5.5.5.5 255.255.255.255
 ip router isis
!
interface FastEthernet0/0
 ip address 10.0.0.21 255.255.255.252
 ip router isis
 duplex full
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
interface FastEthernet1/0
 ip address 10.0.0.14 255.255.255.252
 ip router isis
 speed auto
 duplex auto
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
!
```

```
interface Serial3/0
 ip address 10.0.0.10 255.255.255.252
 ip router isis
 mpls ip
 mpls traffic-eng tunnels
 serial restart-delay 0
 ip rsvp bandwidth 1544
!
router isis
 net 00.0000.5555.5555.5555.00
 is-type level-2-only
 metric-style wide
 redistribute connected
 redistribute static ip
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
!
ip forward-protocol nd
!
```

P2#show run

```
!
hostname P2
!
ip cef
!
mpls label range 300 399
mpls label protocol ldp
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
 ip router isis
!
interface FastEthernet0/0
 ip address 10.0.0.6 255.255.255.252
 ip router isis
 duplex full
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
interface FastEthernet1/0
 ip address 10.0.0.13 255.255.255.252
```

```
 ip router isis
 speed auto
 duplex auto
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
interface FastEthernet1/1
 ip address 10.0.0.17 255.255.255.252
 ip router isis
 speed auto
 duplex auto
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
interface GigabitEthernet2/0
 no ip address
 shutdown
 negotiation auto
!
router isis
 net 00.0000.4444.4444.4444.00
 is-type level-2-only
 metric-style wide
 redistribute connected
 redistribute static ip
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
!
```

P1#show run

```
!
hostname P1
!
ip cef
!
mpls label range 200 299
mpls label protocol ldp
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
 ip router isis
!
```

```
interface FastEthernet0/0
 ip address 10.0.0.5 255.255.255.252
 ip router isis
 duplex full
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
interface FastEthernet1/0
 ip address 10.0.0.2 255.255.255.252
 ip router isis
 speed auto
 duplex auto
 mpls ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 100000
!
interface Serial3/0
 ip address 10.0.0.9 255.255.255.252
 ip router isis
 mpls ip
 mpls traffic-eng tunnels
 serial restart-delay 0
 ip rsvp bandwidth 1544
!
!
router isis
 net 00.0000.3333.3333.3333.00
 is-type level-2-only
 metric-style wide
 redistribute connected
 redistribute static ip
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
!
!
!
```

```
CE1#show run
!
hostname CE1
!
ip cef
!
interface FastEthernet0/0
```

```
 ip address 192.168.0.1 255.255.255.252
 duplex full
!
!
ip default-gateway 192.168.0.2
!
ip route 0.0.0.0 0.0.0.0 FastEthernet0/0
!
```

CE2#show run

```
!
hostname CE2
!
interface FastEthernet1/0
 ip address 192.168.0.5 255.255.255.252
 speed auto
 duplex auto
!
!
ip default-gateway 192.168.0.6
!
ip route 0.0.0.0 0.0.0.0 FastEthernet1/0
!
```

PE2#show ip route isis

```
     1.0.0.0/32 is subnetted, 1 subnets
i L2     1.1.1.1 [115/40] via 10.0.0.21, 00:11:15, FastEthernet0/0
                 [115/40] via 10.0.0.17, 00:11:15, FastEthernet1/1
     3.0.0.0/32 is subnetted, 1 subnets
i L2     3.3.3.3 [115/30] via 10.0.0.21, 00:11:15, FastEthernet0/0
                 [115/30] via 10.0.0.17, 00:11:15, FastEthernet1/1
     4.0.0.0/32 is subnetted, 1 subnets
i L2     4.4.4.4 [115/20] via 10.0.0.17, 02:34:35, FastEthernet1/1
     5.0.0.0/32 is subnetted, 1 subnets
i L2     5.5.5.5 [115/20] via 10.0.0.21, 00:11:15, FastEthernet0/0
     10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
i L2     10.0.0.0/30 [115/30] via 10.0.0.21, 00:11:15, FastEthernet0/0
                    [115/30] via 10.0.0.17, 00:11:15, FastEthernet1/1
i L2     10.0.0.4/30 [115/20] via 10.0.0.17, 02:26:00, FastEthernet1/1
i L2     10.0.0.8/30 [115/20] via 10.0.0.21, 00:11:15, FastEthernet0/0
i L2     10.0.0.12/30 [115/20] via 10.0.0.21, 00:11:15, FastEthernet0/0
                      [115/20] via 10.0.0.17, 00:11:15, FastEthernet1/1
```

```
     192.168.0.0/24 is variably subnetted, 3 subnets, 2 masks
i L2     192.168.0.0/30 [115/30] via 10.0.0.21, 00:11:15, FastEthernet0/0
                        [115/30] via 10.0.0.17, 00:11:15, FastEthernet1/1
PE2#
```

```
PE1#show ip route isis
     2.0.0.0/32 is subnetted, 1 subnets
i L2     2.2.2.2 [115/40] via 2.2.2.2, 00:11:39, Tunnel1
     3.0.0.0/32 is subnetted, 1 subnets
i L2     3.3.3.3 [115/20] via 10.0.0.2, 00:11:39, FastEthernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
i L2     4.4.4.4 [115/30] via 10.0.0.2, 00:11:39, FastEthernet1/0
     5.0.0.0/32 is subnetted, 1 subnets
i L2     5.5.5.5 [115/30] via 10.0.0.2, 00:11:39, FastEthernet1/0
     10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
i L2     10.0.0.4/30 [115/20] via 10.0.0.2, 00:11:39, FastEthernet1/0
i L2     10.0.0.8/30 [115/20] via 10.0.0.2, 00:11:39, FastEthernet1/0
i L2     10.0.0.12/30 [115/30] via 10.0.0.2, 00:11:39, FastEthernet1/0
i L2     10.0.0.16/30 [115/30] via 10.0.0.2, 00:11:39, FastEthernet1/0
i L2     10.0.0.20/30 [115/30] via 10.0.0.2, 00:11:39, FastEthernet1/0
     192.168.0.0/24 is variably subnetted, 3 subnets, 2 masks
i L2     192.168.0.4/30 [115/30] via 2.2.2.2, 00:11:39, Tunnel1
PE1#
```

```
PE1#show isis topology
IS-IS TID 0 paths to level-2 routers
System Id          Metric     Next-Hop          Interface   SNPA
PE1                --
PE2                30         PE2               Tu1         *MPLS TE-Tunnel
P1                 10         P1                Fa1/0       ca05.279c.001c
P2                 20         P1                Fa1/0       ca05.279c.001c
P3                 20         P1                Fa1/0       ca05.279c.001c
PE1#
```

```
PE1#show ip rsvp interface
interface    rsvp      allocated  i/f max  flow max sub max  VRF
Fa1/0        ena       900K       100M     100M     0
PE1#
```

```
PE2#show ip rsvp interface
interface    rsvp      allocated  i/f max  flow max sub max  VRF
Fa0/0        ena       0          100M     100M     0
Fa1/1        ena       0          100M     100M     0
```

PE2#

P1#show ip rsvp interface

```
interface    rsvp      allocated  i/f max  flow max sub max  VRF
Fa0/0        ena       0          100M     100M     0
Fa1/0        ena       0          100M     100M     0
Se3/0        ena       900K       1544K    1544K    0
P1#
```

P2#show ip rsvp interface

```
interface    rsvp      allocated  i/f max  flow max sub max  VRF
Fa0/0        ena       0          100M     100M     0
Fa1/0        ena       0          100M     100M     0
Fa1/1        ena       500K       100M     100M     0
P2#
```

P3#show ip rsvp int

```
interface    rsvp      allocated  i/f max  flow max sub max  VRF
Fa0/0        ena       400K       100M     100M     0
Fa1/0        ena       500K       100M     100M     0
Se3/0        ena       0          1544K    1544K    0
P3#
```

PE1#show mpls traffic-eng topology 3.3.3.3

```
IGP Id: 3333.3333.3333.00, MPLS TE Id:3.3.3.3 Router Node  (isis  level-2) id 10
     link[0]: Broadcast, DR: 3333.3333.3333.01, nbr_node_id:11, gen:91
     frag_id: 0, Intf Address: 10.0.0.5
     TE metric: 10, IGP metric: 10, attribute flags: 0x0
     SRLGs: None
     physical_bw: 100000 (kbps), max_reservable_bw_global: 100000 (kbps)
     max_reservable_bw_sub: 0 (kbps)

                         Global Pool       Sub Pool
          Total Allocated   Reservable       Reservable
          BW (kbps)         BW (kbps)        BW (kbps)
          ---------------   -----------      ----------
    bw[0]:          0          100000             0
    bw[1]:          0          100000             0
```

bw[2]:	0	100000	0
bw[3]:	0	100000	0
bw[4]:	0	100000	0
bw[5]:	0	100000	0
bw[6]:	0	100000	0
bw[7]:	0	100000	0

link[1]: Broadcast, DR: 1111.1111.1111.01, nbr_node_id:6, gen:91
frag_id: 0, Intf Address: 10.0.0.2
TE metric: 10, IGP metric: 10, attribute flags: 0x0
SRLGs: None
physical_bw: 100000 (kbps), max_reservable_bw_global: 100000 (kbps)
max_reservable_bw_sub: 0 (kbps)

	Global Pool Total Allocated BW (kbps)	Global Pool Reservable BW (kbps)	Sub Pool Reservable BW (kbps)
bw[0]:	0	100000	0
bw[1]:	0	100000	0
bw[2]:	0	100000	0
bw[3]:	0	100000	0
bw[4]:	0	100000	0
bw[5]:	0	100000	0
bw[6]:	0	100000	0
bw[7]:	0	100000	0

link[2]: Point-to-Point, Nbr IGP Id: 5555.5555.5555.00, nbr_node_id:3, gen:91
frag_id: 0, Intf Address: 10.0.0.9, Nbr Intf Address: 10.0.0.10
TE metric: 10, IGP metric: 10, attribute flags: 0x0
SRLGs: None
physical_bw: 1544 (kbps), max_reservable_bw_global: 1544 (kbps)
max_reservable_bw_sub: 0 (kbps)

	Global Pool Total Allocated BW (kbps)	Global Pool Reservable BW (kbps)	Sub Pool Reservable BW (kbps)
bw[0]:	0	1544	0
bw[1]:	0	1544	0
bw[2]:	0	1544	0
bw[3]:	0	1544	0
bw[4]:	0	1544	0
bw[5]:	0	1544	0
bw[6]:	0	1544	0
bw[7]:	900	644	0

PE1# show mpls traffic-eng tunnels

P2P TUNNELS/LSPs:

Name: TO-PE2 (Tunnel1) Destination: 2.2.2.2
  Status:
    Admin: up Oper: up Path: valid Signalling: connected
    path option 100, type explicit My-Route (Basis for Setup, path weight 30)
    path option 1000, type dynamic

  Config Parameters:
    Bandwidth: 400 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled LockDown: disabled Loadshare: 400 [5000000] bw-based
    auto-bw: disabled
  Active Path Option Parameters:
    State: explicit path option 100 is active
    BandwidthOverride: disabled LockDown: disabled Verbatim: disabled

  InLabel : -
  OutLabel : FastEthernet1/0, 201
  Next Hop : 10.0.0.2
  RSVP Signalling Info:
       Src 1.1.1.1, Dst 2.2.2.2, Tun_Id 1, Tun_Instance 1098
    RSVP Path Info:
      My Address: 10.0.0.1
      Explicit Route: 10.0.0.2 10.0.0.10 10.0.0.21 10.0.0.22
                    2.2.2.2
      Record Route: NONE
      Tspec: ave rate=400 kbits, burst=1000 bytes, peak rate=400 kbits
    RSVP Resv Info:
      Record Route: NONE
      Fspec: ave rate=400 kbits, burst=1000 bytes, peak rate=400 kbits
  History:
    Tunnel:
      Time since created: 2 hours, 39 minutes
      Time since path change: 15 minutes, 40 seconds
      Number of LSP IDs (Tun_Instances) used: 1098
    Current LSP: [ID: 1098]
      Uptime: 15 minutes, 43 seconds
      Selection: reoptimization
    Prior LSP: [ID: 841]
      ID: path option unknown
      Removal Trigger: reoptimization completed

```
Name: To-PE2-Backup                    (Tunnel2) Destination: 2.2.2.2
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 10, type explicit MINT (Basis for Setup, path weight 40)

  Config Parameters:
    Bandwidth: 500      kbps (Global)  Priority: 7  7    Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: disabled LockDown: disabled Loadshare: 500 [4000000] bw-based
    auto-bw: disabled
  Active Path Option Parameters:
    State: explicit path option 10 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled


  InLabel  :  -
  OutLabel : FastEthernet1/0, 200
  Next Hop : 10.0.0.2
  RSVP Signalling Info:
       Src 1.1.1.1, Dst 2.2.2.2, Tun_Id 2, Tun_Instance 1
    RSVP Path Info:
      My Address: 10.0.0.1
      Explicit Route: 10.0.0.2 10.0.0.10 10.0.0.14 10.0.0.13
                      10.0.0.17 10.0.0.18 2.2.2.2
      Record   Route:   NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
    RSVP Resv Info:
      Record   Route:   NONE
      Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
  History:
    Tunnel:
      Time since created: 23 minutes, 26 seconds
      Time since path change: 23 minutes, 25 seconds
      Number of LSP IDs (Tun_Instances) used: 1
    Current LSP: [ID: 1]
      Uptime: 23 minutes, 25 seconds


PE1#show mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing    Next Hop
Label      Label      or Tunnel Id     Switched      interface
100        Pop Label  3.3.3.3/32       0             Fa1/0       10.0.0.2
101        203        4.4.4.4/32       0             Fa1/0       10.0.0.2
102        204        5.5.5.5/32       0             Fa1/0       10.0.0.2
103   [T]  Pop Label  2.2.2.2/32       0             Tu1         point2point
104        Pop Label  10.0.0.4/30      0             Fa1/0       10.0.0.2
```

```
105        Pop Label  10.0.0.8/30      0            Fa1/0      10.0.0.2
106        207        10.0.0.12/30     0            Fa1/0      10.0.0.2
107        208        10.0.0.16/30     0            Fa1/0      10.0.0.2
108        209        10.0.0.20/30     0            Fa1/0      10.0.0.2
109   [T]  No Label   192.168.0.4/30   0            Tu1        point2point

[T]     Forwarding through a LSP tunnel.
        View additional labelling info with the 'detail' option
PE1#
```

```
CE1#traceroute 2.2.2.2
Type escape sequence to abort.
Tracing the route to 2.2.2.2
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.0.2 20 msec 24 msec 8 msec
  2 10.0.0.2 [MPLS: Label 201 Exp 0] 52 msec 52 msec 40 msec
  3 10.0.0.10 [MPLS: Label 412 Exp 0] 52 msec 48 msec 52 msec
  4 10.0.0.22 60 msec 40 msec 40 msec
CE1#
```

```
PE1#traceroute 2.2.2.2
Type escape sequence to abort.
Tracing the route to 2.2.2.2
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.2 [MPLS: Label 201 Exp 0] 56 msec 28 msec 32 msec
  2 10.0.0.10 [MPLS: Label 412 Exp 0] 48 msec 40 msec 40 msec
  3 10.0.0.22 40 msec 40 msec 28 msec
PE1#
```

Lab 8

MPLS L3-VPN Juniper SRX 240

Introduction:

Based on RFC2547bis, BGP Based MPLS Layer 3 VPNs are used by Service Providers to provide VPN Service to their customers. MPLS Layer 3 VPNs use a peer-to-peer model that uses Border Gateway Protocol (BGP) to distribute VPN-related information. This highly scalable, peer-to-peer model allows enterprise subscribers to outsource routing information to service providers, resulting in significant cost savings and a reduction in operational complexity for enterprises. Service providers can then offer value-added services like Quality of Service (QoS) and Traffic Engineering, allowing network convergence that encompasses voice, video, and data. To Configure a Layer-3 VPN, you need to know the following:

VRF

To separate VPN routes from routes in the Internet or those in other VPNs, the PE router creates a separate routing table for each VPN called a VPN routing and forwarding (VRF) table. The PE router creates one VRF table for each VPN that has a connection to a customer edge (CE) router. Any customer or site that belongs to the VPN can access only the routes in the VRF tables for that VPN. Every VRF table has one or more extended community attributes associated with it that identify the route as belonging to a specific collection of routers. One of these, the route target attribute, identifies a collection of sites (VRF tables) to which a PE router distributes routes. The PE router uses the route target to constrain the import of remote routes into its VRF tables.

RD

When customer networks that use private addresses connect to the Internet infrastructure, the private addresses might overlap with the same private addresses used by other network users. MPLS/BGP VPNs solve this problem by adding a route distinguisher. A route distinguisher is a VPN identifier prefix that is added to each address from a particular VPN site, thereby creating an address that is unique both within the VPN and within the Internet.

RT

The route target (RT) extended community attribute is configured with the Target keyword. This attribute is used to identify a set of sites and VRFs that may receive routes that are tagged with the configured route target. Configuring the route target extended attribute with a route allows that route to be placed in the per site forwarding tables that are used for routing traffic that is received from corresponding sites.

Prelab:

1. What is the difference between BGP and MP-BGP?

   The normal version of BGP (Border Gateway Protocol) only supports IPv4 unicast prefixes. MP-BGP (Multiprotocol BGP) supports different address Families: IPv4 unicast. IPv4 multicast. IPv6 unicast, VPLS

2. How many Labels will a VPN Packet in core would comprise of? What are they?

   Normal VPN packet traversing the core would have 2 Labels. One Control Plane Label Generated by MP-BGP, one transport Label generated by LDP/RSVP.

3. What are Extended Communities? How would you configure RD/RT in Juniper?

   An extended community is an 8-octet value that is also divided into two main sections. The first 2 octets of the community encode a type field while the last 6 octets carry a unique set of data in a format defined by the type field. Extended communities provide a larger range for grouping or categorizing communities. set routing-instances route-distinguisher X:X set routing-instances vrf-target target:X:X

4. What instance type would you use in Juniper Junos for a Layer-3 MPLS based VPN?

   Instance Type VRF set routing-instances instance-type vrf

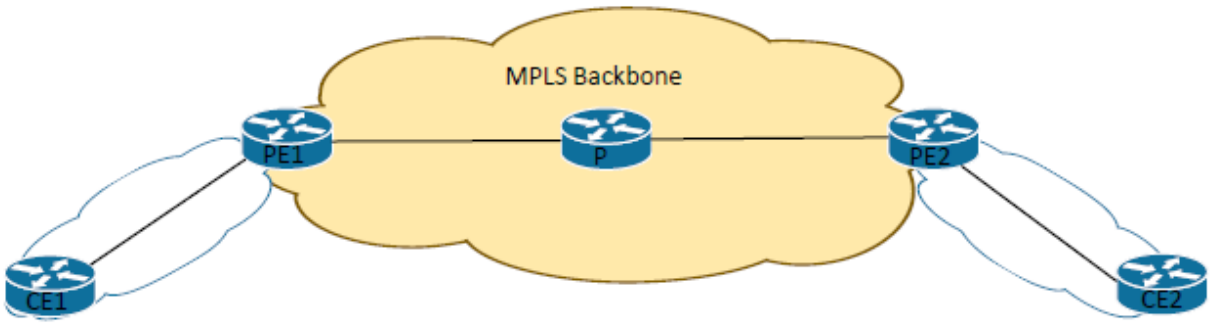
5. What are two Label Distribution Protocols that you configure for MPLS Transport Label Distribution in the core of Provider Network?

   LDP / RSVP

Lab Scenario:

In this lab, you will configure a Point-to-Point Layer-3 VPN between CE1 and CE2 using LDP for MPLS Label Distribution between PE Routers. The core routing protocols will be OSPF/MP-BGP. You will Enable Core with MPLS. Finally, you will use IBGP between the CE and PE and share Routes with Remote CE Site Routers.

Lab Diagram:



Lab IP Addressing:

Node	IP
CE1 to PE1	10.0.X.0/24
PE1 to P	192.168.X.0/30
P to PE2	192.168.X.4/30
PE2 to CE2	11.0.X.0/24
PE1 Loopback	1.1.1.1
P Loopback	3.3.3.3
PE2 Loopback	2.2.2.2
CE1 Loopbacks	101.101.101.101
CE2 Loopbacks	102.102.102.102

Procedure:

Lab is Mainly divided into 3 sections

1. Making Core Ready
2. Making PE-Device Ready for CE Sites
3. Configuring CE to Peer with PE and Route Exchange

18. **Making Core Ready**

Task 1:
Deploy OSPF as IGP for the Entire Core Routers PE1, PE2 and P. Make sure all the interfaces including the loopback interfaces are advertised into OSPF Area 0. Verify you have routes to reach all core Devices from PE1 and PE2.

Deliverable: show ospf neighbor
show route protocol ospf

Task 2:
Configure iBGP between Routers PE1 and PE2. Make sure you are negotiating for the VPNV4 Route exchange capability. Entire core network is in Autonomous system 100. Verify if MP-iBGP session is in Established between PE1 and PE2

Deliverable: show routing-option
Show protocols bgp
Show bgp summary
Show bgp neighbors

Task 3:
Configure protocol MPLS. Make sure you include the Core-Facing interfaces on PE1, PE2,P and loopback interfaces into protocol MPLS Hierarchy. Also, make sure you have "FAMILY MPLS" enabled for respective interfaces.

Deliverable: show interfaces terse

Task 4:
Configure Protocol LDP. Make sure you include the Core-Facing interfaces on PE1,PE2,P and loopback interfaces into protocol LDP Hierarchy. Make sure that you have routes listed in inet.3 Table.

Deliverable: show ldp neighbor
Show route table inet.3 (what label is used for PE2 loopback 2.2.2.2?)
Show route table mpls.0 (what label is being swapped?)
What label is used on P? what is the action? Why?

19. **Making PE Ready for CE sites**

Task 5:
Configure VRF CUST1 on PE1 with instance type as VRF. Make sure you include the CE facing interface. Configure RD as 65000:1 and RT as 65000:1.

Task 6:
Configure VRF CUST1 on PE2 with instance type as VRF. Make sure you include the CE facing interface. Configure RD as 65000:2 and RT as 65000:1.

Task 7:
Configure protocol BGP with CE1's physical address as the neighbor IP. CE1 is in AS# 65000. The protocol configuration should go into VRF CUST1.

Task 8:
Configure protocol BGP with CE2's physical address as the neighbor IP. CE2 is in AS# 65000. The protocol configuration should go into VRF CUST1.

20. **Configuring CE to Peer with PE & Route Exchange**

Task 9:
Configure CE1 to peer with PE1 physical IP Address via BGP. Write a policy to export Loopback address of CE1 via policy EXPORTLO. CE1 is AS# 65000. Make sure CE1 has neighbor in ESTABLISHED state with PE1 and advertising the Loopback.

Task 10:
Configure CE2 to peer with PE2 physical IP Address via BGP. Write a policy to export Loopback address of CE2 via policy EXPORTLO. CE2 is AS# 65000. Make sure CE2 has neighbor in ESTABLISHED state with PE2 and advertising the Loopback.

Deliverable: on CE1 show bgp summary

Task 11:
Configure AS-OVERRIDE on PE1 and PE2 as Both CE sites are in Same AS# 65000 which by default will not advertise CE1 routes to CE2 and vice-versa. Make sure Routes are exchanged and populated in CE1 and CE2.

Deliverable: On PE1 show route advertising-protocol bgp 2.2.2.2
show route 102.102.102.102 details
(what is the label operation? What is the label X advertised by bgp peer PE2?)
On PE2 show route table mpls.0 detail label X (what is the operation operation)

Task 12:
Ping CE1 loopback from CE2 and CE2 loopback from CE1.

Deliverables:

21. Diagram of the lab with IP addresses and Autonomous system numbers.
22. Running configuration of all the routers.
23. Routing tables on CE1 and CE2
24. Successful ping from CE1 loopback to CE2 loopback

Instructions to follow at the end of each lab

25. Make sure you erase your configuration on the devices used.
26. Do not save any of the configurations in flash memory.
27. All cables must be unplugged and secured in the box.
28. There must not be any kind of garbage around the desk or racks after you are done with lab.

Detailed Lab Solution:

Task 1

Deploy OSPF as IGP for the Entire Core Routers PE1,PE2 and P. Make sure all the interfaces including the loopback interfaces are advertised into OSPF Area 0. Verify you have routes to reach all core Devices from PE1 and PE2.

On PE1/PE2/P

```
lab@srx# set protocols ospf area 0 interface all

lab@srx# show protocols ospf
area 0.0.0.0 {
    interface all;
}
```

```
lab@srxpe1> show ospf neighbor
Address          Interface              State     ID               Pri  Dead
192.168.1.2      ge-3/2/4.12            Full      3.3.3.3          128    37
```

```
lab@srx:pe1> show route protocol ospf

inet.0: 10 destinations, 10 routes (10 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

2.2.2.2/32          *[OSPF/10] 00:00:28, metric 2
                     > to 192.168.1.2 via ge-3/2/4.12
3.3.3.3/32          *[OSPF/10] 00:00:33, metric 1
                     > to 192.168.1.2 via ge-3/2/4.12
192.168.1.4/30      *[OSPF/10] 00:00:33, metric 2
                     > to 192.168.1.2 via ge-3/2/4.12
224.0.0.5/32        *[OSPF/10] 00:01:24, metric 1
                       MultiRecv
```

Task 2

Configure iBGP between Routers PE1 and PE2. Make sure you are negotiating for the VPNV4 Route exchange capability. Entire core network is in Autonomous system 100. Verify if MP-iBGP session is in Established between PE1 and PE2

PE1

```
set protocols bgp group ibgp local-address 1.1.1.1

set protocols bgp group ibgp family inet-vpn unicast

set protocols bgp group ibgp neighbor 2.2.2.2 peer-as 100

set routing-options autonomous-system 100
```

PE2

```
set protocols bgp group ibgp local-address 2.2.2.2

set protocols bgp group ibgp family inet-vpn unicast

set protocols bgp group ibgp neighbor 1.1.1.1 peer-as 100

set routing-options autonomous-system 100
```

```
[edit]
lab@srx:pe1# show routing-options
autonomous-system 100;

[edit]
lab@srx:pe1# show protocols bgp
group ibgp {
    local-address 1.1.1.1;
    family inet-vpn {
        unicast;
    }
    neighbor 2.2.2.2 {
        peer-as 100;
    }
}

[edit]
lab@srx:pe1# run show bgp summary
Groups: 1 Peers: 1 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
bgp.l3vpn.0
                       0          0          0          0          0          0
Peer                     AS      InPkt     OutPkt    OutQ   Flaps Last Up/Dwn State|#Active/Received/Accepted/Damped...
2.2.2.2                 100          7          8       0       0        2:35 Establ
  bgp.l3vpn.0: 0/0/0/0

[edit]
lab@srx:pe1# run show bgp neighbor
Peer: 2.2.2.2+59847 AS 100     Local: 1.1.1.1+179 AS 100
  Group: ibgp                  Routing-Instance: master
  Type: Internal    State: Established    Flags: <Sync>
  Last State: OpenConfirm   Last Event: RecvKeepAlive
  Last Error: None
  Options: <Preference LocalAddress AddressFamily PeerAS Rib-group Refresh>
  Address families configured: inet-vpn-unicast
  Local Address: 1.1.1.1 Holdtime: 90 Preference: 170
  Number of flaps: 0
  Peer ID: 2.2.2.2         Local ID: 1.1.1.1          Active Holdtime: 90
  Keepalive Interval: 30         Group index: 0    Peer index: 0
  BFD: disabled, down
  NLRI for restart configured on peer: inet-vpn-unicast
  NLRI advertised by peer: inet-vpn-unicast
  NLRI for this session: inet-vpn-unicast
  Peer supports Refresh capability (2)
  Stale routes from peer are kept for: 300
  Peer does not support Restarter functionality
  NLRI that restart is negotiated for: inet-vpn-unicast
  Peer supports 4 byte AS extension (peer-as 100)
  Peer does not support Addpath
  Table bgp.l3vpn.0
    RIB State: BGP restart is complete
    RIB State: VPN restart is complete
    Send state: not advertising
    Active prefixes:              0
    Received prefixes:            0
    Accepted prefixes:            0
    Suppressed due to damping:    0
  Last traffic (seconds): Received 18   Sent 19   Checked 68
  Input messages:  Total 7      Updates 0       Refreshes 0     Octets 173
  Output messages: Total 8      Updates 0       Refreshes 0     Octets 192
```

```
[edit]
lab@srx:pe2# show routing-options
autonomous-system 100;

[edit]
lab@srx:pe2# show protocols bgp
group ibgp {
    local-address 2.2.2.2;
    family inet-vpn {
        unicast;
    }
    neighbor 1.1.1.1 {
        peer-as 100;
    }
}

[edit]
lab@srx:pe2# run show bgp summary
Groups: 1 Peers: 1 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
bgp.l3vpn.0
                       0          0          0          0          0          0
Peer                     AS      InPkt     OutPkt    OutQ   Flaps Last Up/Dwn State|#Active/Received/Accepted/Damped...
1.1.1.1                 100          1          3       0       0          24 Establ
  bgp.l3vpn.0: 0/0/0/0

[edit]
lab@srx:pe2# run show bgp neighbor
Peer: 1.1.1.1+179 AS 100      Local: 2.2.2.2+59847 AS 100
  Group: ibgp                 Routing-Instance: master
  Type: Internal    State: Established    Flags: <Sync>
  Last State: OpenConfirm   Last Event: RecvKeepAlive
  Last Error: None
  Options: <Preference LocalAddress AddressFamily PeerAS Rib-group Refresh>
  Address families configured: inet-vpn-unicast
  Local Address: 2.2.2.2 Holdtime: 90 Preference: 170
  Number of flaps: 0
  Peer ID: 1.1.1.1         Local ID: 2.2.2.2          Active Holdtime: 90
  Keepalive Interval: 30         Group index: 0    Peer index: 0
  BFD: disabled, down
  NLRI for restart configured on peer: inet-vpn-unicast
  NLRI advertised by peer: inet-vpn-unicast
  NLRI for this session: inet-vpn-unicast
  Peer supports Refresh capability (2)
  Stale routes from peer are kept for: 300
  Peer does not support Restarter functionality
  NLRI that restart is negotiated for: inet-vpn-unicast
  Peer supports 4 byte AS extension (peer-as 100)
  Peer does not support Addpath
  Table bgp.l3vpn.0
    RIB State: BGP restart is complete
    RIB State: VPN restart is complete
    Send state: not advertising
    Active prefixes:              0
    Received prefixes:            0
    Accepted prefixes:            0
    Suppressed due to damping:    0
  Last traffic (seconds): Received 0    Sent 29   Checked 29
  Input messages:  Total 2      Updates 0       Refreshes 0     Octets 38
  Output messages: Total 3      Updates 0       Refreshes 0     Octets 97
```

Task 3

Configure protocol MPLS. Make sure you include the Core-Facing interfaces on PE1, PE2 and P and loopback interfaces into protocol MPLS Hierarchy. Also, make sure you have “FAMILY MPLS” enabled for respective interfaces.

PE1

```
lab@srx# set interfaces ge-3/2/4.12 family mpls

lab@srx# set interfaces lo0.0 family mpls
```

PE2

```
lab@srx# set interfaces ge-3/2/4.23 family mpls

lab@srx# set interfaces lo0.0 family mpls
```

P

```
lab@srx# set interfaces ge-3/2/5.12 family mpls
```

```
lab@srx# set interfaces ge-3/2/5.23 family mpls

lab@srx# set interfaces lo0.0 family mpls



lab@srx:pe1> show interfaces terse
Interface               Admin Link Proto    Local                 Remote
ge-3/2/4
ge-3/2/4.12             up    up   inet     192.168.1.1/30
                                    mpls
                                    multiservice
ge-3/2/6
ge-3/2/6.101            up    up   inet     10.0.0.1/24
                                    multiservice
lo0
lo0.0                   up    up   inet     1.1.1.1             --> 0/0
                                    mpls
```

Task 4

Configure Protocol LDP. Make sure you include the Core-Facing interfaces on PE1,PE2 and P and loopback interfaces into protocol LDP Hierarchy. Make sure that you have routes listed in inet.3 Table.

On PE1/PE2/P

```
#set protocols ldp interface all


lab@srx:pe1> show ldp neighbor
Address            Interface          Label space ID         Hold time
192.168.1.2        ge-3/2/4.12        3.3.3.3:0                12

lab@srx:p> show ldp neighbor
Address            Interface          Label space ID         Hold time
192.168.1.1        ge-3/2/5.12        1.1.1.1:0                14
192.168.1.6        ge-3/2/5.23        2.2.2.2:0                13

lab@srx:pe2> show ldp neighbor
Address            Interface          Label space ID         Hold time
192.168.1.5        ge-3/2/4.23        3.3.3.3:0                13
```

Label assigned to PE2 loopback from PE1 Perspective

```
lab@srx:pe1> show route table inet.3

inet.3: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

2.2.2.2/32          *[LDP/9] 00:02:31, metric 1
                     > to 192.168.1.2 via ge-3/2/4.12, Push 299792 ----- Remote PE
3.3.3.3/32          *[LDP/9] 00:03:37, metric 1
                     > to 192.168.1.2 via ge-3/2/4.12

lab@srx:pe1> show route table mpls.0
```

```
mpls.0: 7 destinations, 7 routes (7 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 00:04:54, metric 1
                      Receive
1                  *[MPLS/0] 00:04:54, metric 1
                      Receive
2                  *[MPLS/0] 00:04:54, metric 1
                      Receive
13                 *[MPLS/0] 00:04:54, metric 1
                      Receive
299776             *[LDP/9] 00:04:12, metric 1
                    > to 192.168.1.2 via ge-3/2/4.12, Pop
299776(S=0)        *[LDP/9] 00:04:12, metric 1
                    > to 192.168.1.2 via ge-3/2/4.12, Pop
299792             *[LDP/9] 00:03:06, metric 1
                    > to 192.168.1.2 via ge-3/2/4.12, Swap 299792 -----Getting Swapped

Let's see this label on PHP Router, P


inet.3: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

1.1.1.1/32         *[LDP/9] 00:05:53, metric 1
                    > to 192.168.1.1 via ge-3/2/5.12
2.2.2.2/32         *[LDP/9] 00:04:47, metric 1
                    > to 192.168.1.6 via ge-3/2/5.23

lab@srx:p> show route table mpls.0

mpls.0: 8 destinations, 8 routes (8 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 00:06:07, metric 1
                      Receive
1                  *[MPLS/0] 00:06:07, metric 1
                      Receive
2                  *[MPLS/0] 00:06:07, metric 1
                      Receive
13                 *[MPLS/0] 00:06:07, metric 1
                      Receive
299776             *[LDP/9] 00:06:06, metric 1
                    > to 192.168.1.1 via ge-3/2/5.12, Pop
299776(S=0)        *[LDP/9] 00:06:06, metric 1
                    > to 192.168.1.1 via ge-3/2/5.12, Pop
299792             *[LDP/9] 00:05:00, metric 1
                    > to 192.168.1.6 via ge-3/2/5.23, Pop  ---Action is to POP
299792(S=0)        *[LDP/9] 00:05:00, metric 1
                    > to 192.168.1.6 via ge-3/2/5.23, Pop
```

Task 5

Configure VRF CUST1 on PE1 with instance type as VRF. Make sure you include the CE facing interface. Configure RD as 65000:1 and RT as 65000:1.

Task 6

Configure VRF CUST1 on PE2 with instance type as VRF. Make sure you include the CE facing interface. Configure RD as 65000:2 and RT as 65000:1.

PE1

```
set routing-instances CUST1 instance-type vrf
```

```
set routing-instances CUST1 interface ge-3/2/6.101
set routing-instances CUST1 route-distinguisher 65000:1
set routing-instances CUST1 vrf-target target:65000:1
```

```
PE2
set routing-instances CUST1 instance-type vrf
set routing-instances CUST1 interface ge-3/2/6.102
set routing-instances CUST1 route-distinguisher 65000:1
set routing-instances CUST1 vrf-target target:65000:1
```

Task 7

Configure protocol BGP with CE1's physical address as the neighbor IP. CE1 is in AS# 65000. The protocol configuration should go into VRF CUST1.

Task 8

Configure protocol BGP with CE2's physical address as the neighbor IP. CE2 is in AS# 65000. The protocol configuration should go into VRF CUST1.

```
PE1

set routing-instances CUST1 routing-options autonomous-system 100
set routing-instances CUST1 protocols bgp group ebgp neighbor 10.0.0.100 peer-as 65000

PE2

set routing-instances CUST1 routing-options autonomous-system 100
set routing-instances CUST1 protocols bgp group ebgp neighbor 11.0.0.100 peer-as 65000
```

Task 9

Configure CE1 to peer with PE1 physical IP Address via BGP. Write a policy to export Loopback address of CE1 via policy EXPORTLO. CE1 is AS# 65000. Make sure CE1 has neighbor in ESTABLISHED state with PE1 and advertising the Loopback

Task 10

Configure CE2 to peer with PE2 physical IP Address via BGP. Write a policy to export Loopback address of CE2 via policy EXPORTLO. CE2 is AS# 65000. Make sure CE2 has neighbor in ESTABLISHED state with PE2 and advertising the Loopback

CE1

```
set routing-options autonomous-system 65000

set protocols bgp group ebgp neighbor 10.0.0.1 peer-as 100

set protocols bgp group ebgp export EXPORTO

set policy-options policy-statement EXPORTO term 1 from protocol direct

set policy-options policy-statement EXPORTO term 1 from interface lo0.0

set policy-options policy-statement EXPORTO term 1 then accept
```

CE2

```
set routing-options autonomous-system 100

set protocols bgp group ebgp neighbor 11.0.0.1 peer-as 100

set protocols bgp group ebgp export EXPORTO

set policy-options policy-statement EXPORTO term 1 from protocol direct

set policy-options policy-statement EXPORTO term 1 from interface lo0.0

set policy-options policy-statement EXPORTO term 1 then accept
```

```
lab@srx:ce1> show bgp summary
Groups: 1 Peers: 1 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
inet.0
                       1          1          0          0          0          0
Peer                     AS      InPkt     OutPkt    OutQ   Flaps Last Up/Dwn State|#Active/Received/Accepted/Damped...
10.0.0.1                100         27         26       0       0       10:23 1/1/1/0              0/0/0/0
```

```
lab@srx:pe1> show bgp summary
Groups: 2 Peers: 2 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
bgp.l3vpn.0
                       2          2          0          0          0          0
Peer                     AS      InPkt     OutPkt    OutQ   Flaps Last Up/Dwn State|#Active/Received/Accepted/Damped...
2.2.2.2                 100        232        236       0       0     1:41:17 Establ
  bgp.l3vpn.0: 2/2/2/0
  CUST1.inet.0: 2/2/2/0
10.0.0.100            65000         23         25       0       0        9:34 Establ
  CUST1.inet.0: 1/1/1/0

lab@srx:pe1>
```

```
lab@srx:ce2> show bgp summary
Groups: 1 Peers: 1 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
inet.0
                       1          1          0          0          0          0
Peer                     AS      InPkt     OutPkt    OutQ   Flaps Last Up/Dwn State|#Active/Received/Accepted/Damped...
11.0.0.1                100          6          7       0       0        1:36 1/1/1/0              0/0/0/0
```

```
lab@srx:pe2> show bgp summary
Groups: 2 Peers: 2 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
bgp.l3vpn.0
                       2          2          0          0          0          0
Peer                     AS      InPkt     OutPkt    OutQ   Flaps Last Up/Dwn State|#Active/Received/Accepted/Damped...
1.1.1.1                 100        231        227       0       0     1:39:18 Establ
  bgp.l3vpn.0: 2/2/2/0
  CUST1.inet.0: 2/2/2/0
11.0.0.100            65000          4          4       0       0          23 Establ
  CUST1.inet.0: 1/1/1/0
```

Task 11

Configure **AS-OVERRIDE** on PE1 and PE2 as Both CE sites are in Same AS# 65000 which by default will not advertise CE1 routes to CE2 and vice-versa. Make sure Routes are exchanged and populated in CE1 and CE2

```
lab@srx:pe1# set routing-instances CUST1 protocols bgp group ebgp neighbor 10.0.0.100 as-override

lab@srx:pe2# set routing-instances CUST1 protocols bgp group ebgp neighbor 11.0.0.100 as-override
```

```
lab@srx:pe1> show route advertising-protocol bgp 2.2.2.2

CUST1.inet.0: 5 destinations, 5 routes (5 active, 0 holddown, 0 hidden)
  Prefix                  Nexthop              MED     Lclpref    AS path
* 10.0.0.0/24             Self                         100        I
* 101.101.101.101/32      Self                         100        65000 I

lab@srx:pe1> show route table bgp.l3vpn.0 terse

bgp.l3vpn.0: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

A V Destination        P Prf   Metric 1   Metric 2  Next hop        AS path
    65000:2:11.0.0.0/24
* ?                    B 170        100                           I
  unverified                                      >9.9.12.2
    65000:2:102.102.102.102/32
* ?                    B 170        100                           65000 I
  unverified                                      >9.9.12.2
```

```
lab@srx:pe2> show route advertising-protocol bgp 1.1.1.1

CUST1.inet.0: 5 destinations, 5 routes (5 active, 0 holddown, 0 hidden)
  Prefix                  Nexthop              MED     Lclpref    AS path
* 11.0.0.0/24             Self                         100        I
* 102.102.102.102/32      Self                         100        65000 I
```

Labels assigned for traffic from CE1 to CE2, CE1 Trying to reach 102.102.102.102 Which is on CE2 via MPLS LAYER3 VPN

```
lab@srx:ce1> show route 102.102.102.102


inet.0: 5 destinations, 5 routes (5 active, 0 holddown, 0 hidden)

+ = Active Route, - = Last Active, * = Both

102.102.102.102/32 *[BGP/170] 00:02:34, localpref 100

                      AS path: 100 100 I, validation-state: unverified

                    > to 10.0.0.1 via ge-3/2/7.101
```

```
lab@srx:pe1> show route 102.102.102.102 detail

CUST1.inet.0: 5 destinations, 5 routes (5 active, 0 holddown, 0 hidden)
102.102.102.102/32 (1 entry, 1 announced)
        *BGP    Preference: 170/-101
                Route Distinguisher: 65000:1
                Next hop type: Indirect
                Address: 0x97a0a10
                Next-hop reference count: 6
                Source: 2.2.2.2
                Next hop type: Router, Next hop index: 892
                Next hop: 192.168.1.2 via ge-3/2/4.12, selected
                Label operation: Push 299808, Push 299792(top)
                Label TTL action: prop-ttl, prop-ttl(top)
                Load balance label: Label 299808: None; Label 299792: None;
                Session Id: 0x152
```

```
                Protocol next hop: 2.2.2.2
                Label operation: Push 299808
                Label TTL action: prop-ttl
                Load balance label: Label 299808: None;
                Indirect next hop: 0x98e4000 1048575 INH Session ID: 0x15a
                State: <Secondary Active Int Ext ProtectionCand>
                Local AS:   100 Peer AS:   100
                Age: 3:55       Metric2: 1
                Validation State: unverified
                Task: BGP_100.2.2.2.2+62055
                Announcement bits (2): 0-BGP_RT_Background 1-KRT
                AS path: 65000 I
                Communities: target:65000:1
                Import Accepted
                VPN Label: 299808 ----------> This is VPN Label, Advertised by BGP Peer PE2
                Localpref: 100
                Router ID: 2.2.2.2
                Primary Routing Table bgp.l3vpn.0



lab@srx:pe2> show route 102.102.102.102 detail

CUST1.inet.0: 5 destinations, 5 routes (5 active, 0 holddown, 0 hidden)
102.102.102.102/32 (1 entry, 1 announced)
        *BGP    Preference: 170/-101
                Next hop type: Router, Next hop index: 887
                Address: 0x97a0ab0
                Next-hop reference count: 3
                Source: 11.0.0.100
                Next hop: 11.0.0.100 via ge-3/2/6.102, selected
                Session Id: 0x159
                State: <Active Ext>
                Peer AS: 65000
                Age: 5:52
                Validation State: unverified
                Task: BGP_65000.11.0.0.100+59449
                Announcement bits (2): 0-BGP_RT_Background 1-KRT
                AS path: 65000 I
                Accepted
                Localpref: 100
                Router ID: 102.102.102.102


lab@srx:pe2> show route table mpls.0 detail label 299808

mpls.0: 8 destinations, 8 routes (8 active, 0 holddown, 0 hidden)
299808 (1 entry, 1 announced)
        *VPN    Preference: 170
                Next hop type: Router, Next hop index: 891
                Address: 0x97a0b50
                Next-hop reference count: 2
                Source: 11.0.0.100
                Next hop: 11.0.0.100 via ge-3/2/6.102, selected
                Label operation: Pop
                Load balance label: None;
                Session Id: 0x159
                State: <Active Int Ext>
                Local AS:   100
```

Task 12

Ping CE1 loopback from CE2 and CE2 loopback from CE1.

```
lab@srx:ce1> ping 102.102.102.102
PING 102.102.102.102 (102.102.102.102): 56 data bytes
64 bytes from 102.102.102.102: icmp_seq=0 ttl=61 time=0.731 ms
64 bytes from 102.102.102.102: icmp_seq=1 ttl=61 time=0.646 ms
```

```
lab@srx:ce2> ping 101.101.101.101
PING 101.101.101.101 (101.101.101.101): 56 data bytes
64 bytes from 101.101.101.101: icmp_seq=0 ttl=61 time=0.725 ms
64 bytes from 101.101.101.101: icmp_seq=1 ttl=61 time=0.656 ms
^C
    101.101.101.101 ping statistics
```

Lab 9

Juniper MPLS TE

Introduction:

MPLS traffic engineering provides an integrated approach to traffic engineering. With MPLS, traffic engineering capabilities are integrated into Layer 3, which optimizes the routing of IP traffic, given the constraints imposed by backbone capacity and topology.

Currently, some ISPs base their services on an overlay model. In the overlay model, transmission facilities are managed by Layer 2 switching. The routers see only a fully meshed virtual topology, making most destinations appear one hop away. If you use the explicit Layer 2 transit layer, you can precisely control the ways in which traffic uses available bandwidth. However, the overlay model has a number of disadvantages. MPLS traffic engineering provides a way to achieve the same traffic engineering benefits of the overlay model without needing to run a separate network, and without needing a non-scalable, full mesh of router interconnects.

MPLS is an integration of Layer 2 and Layer 3 technologies. By making traditional Layer 2 features available to Layer 3, MPLS enables traffic engineering. Thus, you can offer in a one-tier network what now can be achieved only by overlaying a Layer 3 network on a Layer 2 network.

MPLS traffic engineering automatically establishes and maintains LSPs across the backbone, using RSVP. The path used by a given LSP at any point in time is determined based on the LSP resource requirements and network resources, such as bandwidth. Available resources are flooded via extensions to a link-state based Interior Gateway Protocol (IGP).

Paths for LSPs are calculated at the LSP head based on a fit between required and available resources (constraint-based routing). The IGP automatically routes the traffic onto these LSPs. Typically, a packet crossing the MPLS traffic engineering backbone travels on a single LSP that connects the ingress point to the egress point.

Explicit Path
The MPLS traffic engineering Internet Protocol (IP) explicit address exclusion feature provides a means to exclude a link or node from the path for an MPLS traffic engineering label-switched path (LSP). You also have the facility to include a specific Interface/Path for an MPLS LSP.

Standby LSP
A cutover to the secondary path can be made before RSVP learns that an LSP is down. There can be significant delays between the time the first failure is detected by protocol machinery (which can be an interface down, a neighbor becoming unreachable, a route becoming unreachable, or a transient routing loop being detected) and the time an LSP actually fails (which requires a

timeout of soft state information between adjacent RSVP routers). When topology failures occur, hot-standby secondary paths can usually achieve the smallest cutover delays with minimal disruptions to user traffic.

Fast-Reroute
Fast reroute provides redundancy for an LSP path. When you enable fast reroute, detours are precomputed and pre-established along the LSP. In case of a network failure on the current LSP path, traffic is quickly routed to one of the detours. Each detour is established by an upstream node to avoid the link toward the immediate downstream node and the immediate downstream node itself.

Fast reroute protects traffic against any single point of failure between the ingress and egress routers (or switches). If there are multiple failures along an LSP, fast reroute itself might fail. Also, fast reroute does not protect against failure of the ingress or egress routers.

Fast reroute is a short-term patch to reduce packet loss. Because detour computation might not reserve adequate bandwidth, the detours might introduce congestion on the alternate links. The ingress router is the only router that is fully aware of LSP policy constraints and, therefore, is the only router able to come up with adequate long-term alternate paths.

Pre-lab:

1. What knob would enable TED database for OSPF?

   Set protocols OSPF traffic-engineering

2. How many ways you can define the type of ERO Next-Hop?

   Strict & Loose

3. At what levels Traffic Protections can be done?

   Link Level, Node Level, Node-Link Level.

4. What is the option to pre-signal the Secondary path of the LSP along with the Primary?

   Configure the Path to be a Standby

5. Does LDP support TE? Which protocol uses TE Database?

   No, LDP does not support TE. You need to have RSVP to utilize TE.

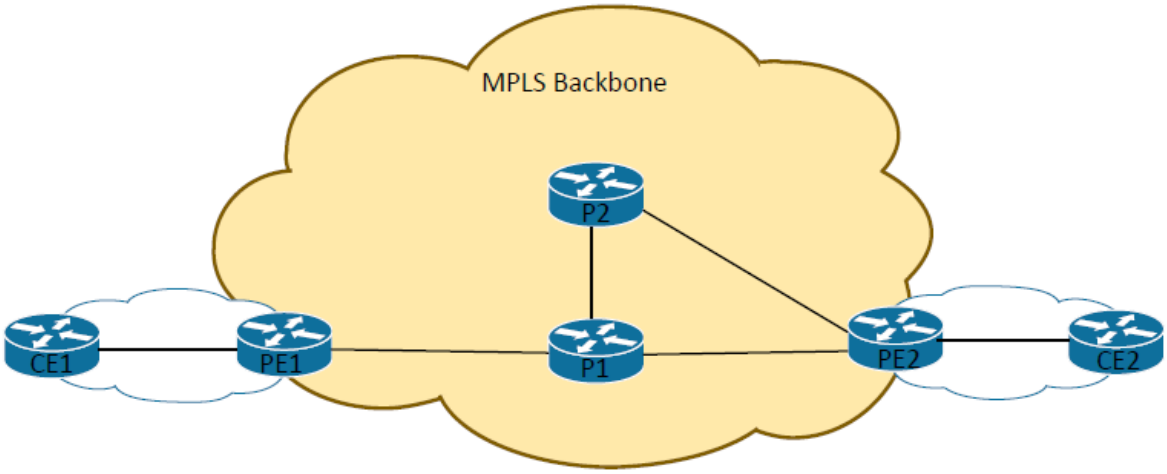
6. What would you do if you want to switch the LSP from Secondary to Primary after a Path Failure in Primary?

   Re-Optimize the LSP.

Lab Scenario:

In this lab, you will enable core with MPLS/OSPF area 0 with Traffic Engineering, we will be using RSVP protocol as a labeling protocol, configure a Bi-Directional LSP and ERO with Primary and Secondary Standby Paths and finally test Fast-Reroute Feature.

Lab Diagram:



Lab IP Addressing:

Node	IP
CE1 to PE1	10.0.X.0/24
PE2 to CE2	11.0.X.0/24
PE1 to P1	192.168.X.0/30
P1 to PE2	192.168.X.4/30
P1 to P2	192.168.X.8/30
P2 to PE2	192.168.X.12/30

PE2 to CE1-B	192.168.X.4/30
PE2 to CE2-B	192.168.X.8/30
PE1 Loopback	1.1.1.1
P1 Loopback	3.3.3.3
P2 Loopback	4.4.4.4
PE2 Loopback	2.2.2.2
CE1 Loopbacks	101.101.101.101
CE2 Loopbacks	102.102.102.102

Procedure:

1. Configure OSPF in Area 0 for Routers PE1/PE2/P1/P2. Enable Traffic Engineering for OSPF.

   set protocols ospf traffic-engineering
   set protocols ospf area 0.0.0.0 interface all

```
lab@srx:pe1> show ospf database opaque-area

    OSPF database, Area 0.0.0.0
 Type       ID               Adv Rtr           Seq      Age  Opt  Cksum  Len
OpaqArea*1.0.0.1          1.1.1.1         0x80000021   794  0x22 0xef17  28
OpaqArea 1.0.0.1          2.2.2.2         0x80000020  1924  0x22 0xf50a  28
OpaqArea 1.0.0.1          3.3.3.3         0x80000021    25  0x22 0xf7fe  28
OpaqArea 1.0.0.1          4.4.4.4         0x80000020  1607  0x22 0xfdf1  28
OpaqArea*1.0.0.3          1.1.1.1         0x80000020  2292  0x22 0xe30c 124
OpaqArea 1.0.0.3          3.3.3.3         0x80000020  2425  0x22 0xc521 124
OpaqArea 1.0.0.3          4.4.4.4         0x80000020  1007  0x22 0x4989 124
OpaqArea 1.0.0.4          2.2.2.2         0x8000001f  2928  0x22 0x4e84 124
OpaqArea 1.0.0.4          3.3.3.3         0x80000020  1825  0x22 0x3f97 124
OpaqArea 1.0.0.4          4.4.4.4         0x8000001f  2807  0x22 0xf3d7 124
```

2. Configure RSVP to include all the Core Interfaces on PE1/PE2/P1/P2. Make sure Interfaces on PE1 has re-servable bandwidth of 50% of the interface.

   set protocols rsvp interface all

```
[edit]
lab@srx:pe1# run show rsvp interface brief
RSVP interface: 4 active
                    Active Subscr- Static      Available   Reserved    Highwater
Interface   State resv   iption  BW          BW          BW          mark
ge-3/2/4.12 Up         1   100%  1000Mbps    1000Mbps    0bps        0bps
ge-3/2/6.101Up         0   100%  1000Mbps    1000Mbps    0bps        0bps
```

Set protocols rsvp interface all reliable bandwidth 500000

```
lab@srx:pe1# set protocols rsvp interface all reliable bandwidth 500000

[edit]
lab@srx:pe1# commit
commit complete

[edit]
lab@srx:pe1# run show rsvp interface brief
RSVP interface: 4 active
                    Active Subscr- Static      Available   Reserved    Highwater
Interface   State resv   iption  BW          BW          BW          mark
ge-3/2/4.12 Up         1   100%  500kbps     500kbps     0bps        0bps
ge-3/2/6.101Up         0   100%  500kbps     500kbps     0bps        0bps
```

3. Configure MPLS to all the core Interfaces on PE1/PE2/P1/P2.

   set protocols mpls interface all

```
lab@srx:pe2> show mpls interface detail
Interface: ge-3/2/4.23
  State: Dn
  Administrative group: <none>
  Maximum labels: 3
  Static protection revert time: 5 seconds
  Always mark connection protection tlv: Disabled
  Switch away lsps : Disabled
Interface: ge-3/2/6.102
  State: Dn
  Administrative group: <none>
  Maximum labels: 3
  Static protection revert time: 5 seconds
  Always mark connection protection tlv: Disabled
  Switch away lsps : Disabled
Interface: ge-3/2/5.24
  State: Up
  Administrative group: <none>
  Maximum labels: 3
  Static protection revert time: 5 seconds
  Always mark connection protection tlv: Disabled
  Switch away lsps : Disabled
```

4. Configure an LSP from PE1 (1.1.1.1) to PE2 (2.2.2.2) and PE2 (2.2.2.2) to PE1 (1.1.1.1), what are the label for traffic going through both LSP? Show RSVP neighbors on all MPLS core routers?

set protocols mpls label-switched-path to-pe2 to 2.2.2.2
set protocols mpls interface all

```
[edit]
lab@srx:pe1# run show mpls lsp
Ingress LSP: 1 sessions
To              From            State Rt P     ActivePath       LSPname
2.2.2.2         1.1.1.1         Up     0 *                      to-pe2
Total 1 displayed, Up 1, Down 0

Egress LSP: 0 sessions
Total 0 displayed, Up 0, Down 0

Transit LSP: 0 sessions
Total 0 displayed, Up 0, Down 0

[edit]
lab@srx:pe1# run show mpls lsp extensive
Ingress LSP: 1 sessions

2.2.2.2
  From: 1.1.1.1, State: Up, ActiveRoute: 0, LSPname: to-pe2
  ActivePath:  (primary)
  LSPtype: Static Configured, Penultimate hop popping
  LoadBalance: Random
  Encoding type: Packet, Switching type: Packet, GPID: IPv4
 *Primary                    State: Up
    Priorities: 7 0
    SmartOptimizeTimer: 180
    Computed ERO (S [L] denotes strict [loose] hops): (CSPF metric: 2)
 192.168.1.2 S 192.168.1.6 S
    Received RRO (ProtectionFlag 1=Available 2=InUse 4=B/W 8=Node 10=SoftPreempt 20=Node-ID):
          192.168.1.2 192.168.1.6
    5 Dec  3 14:42:59.813 Selected as active path
    4 Dec  3 14:42:59.813 Record Route:  192.168.1.2 192.168.1.6
    3 Dec  3 14:42:59.809 Up
    2 Dec  3 14:42:59.732 Originate Call
    1 Dec  3 14:42:59.731 CSPF: computation result accepted  192.168.1.2 192.168.1.6
  Created: Sat Dec  3 14:43:00 2016
Total 1 displayed, Up 1, Down 0

Egress LSP: 0 sessions
Total 0 displayed, Up 0, Down 0

Transit LSP: 0 sessions
Total 0 displayed, Up 0, Down 0

[edit]
lab@srx:pe1#
```

```
[edit]
lab@srx:pe1# run show route table inet.3

inet.3: 1 destinations, 1 routes (1 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

2.2.2.2/32         *[RSVP/7/1] 1d 06:55:28, metric 3
                    > to 192.168.1.2 via ge-3/2/4.12, label-switched-path to-pe2

[edit]
```

```
lab@srx:pe1> show rsvp session
Ingress RSVP: 1 sessions
To              From            State   Rt Style Labelin Labelout LSPname
2.2.2.2         1.1.1.1         Up       0  1 FF       -   299952 to-pe2
Total 1 displayed, Up 1, Down 0

Egress RSVP: 1 sessions
To              From            State   Rt Style Labelin Labelout LSPname
1.1.1.1         2.2.2.2         Up       0  1 FF       3        - to-pe1
Total 1 displayed, Up 1, Down 0

Transit RSVP: 0 sessions
Total 0 displayed, Up 0, Down 0

lab@srx:pe1>
lab@srx:pe1> show rsvp session detail
Ingress RSVP: 1 sessions

2.2.2.2
  From: 1.1.1.1, LSPstate: Up, ActiveRoute: 0
  LSPname: to-pe2, LSPpath: Secondary
  LSPtype: Static Configured
  Suggested label received: -, Suggested label sent: -
  Recovery label received: -, Recovery label sent: 299952
  Resv style: 1 FF, Label in: -, Label out: 299952
  Time left:    -, Since: Sun Dec  4 07:23:36 2016
  Tspec: rate 0bps size 0bps peak Infbps m 20 M 1500
  Port number: sender 7 receiver 22969 protocol 0
  PATH rcvfrom: localclient
  Adspec: sent MTU 1500
  Path MTU: received 1500
  PATH sentto: 192.168.1.2 (ge-3/2/4.12) 2519 pkts
  RESV rcvfrom: 192.168.1.2 (ge-3/2/4.12) 2520 pkts, Entropy label: No
  Explct route: 192.168.1.2 192.168.1.10 192.168.1.14
  Record route: <self> 192.168.1.2 192.168.1.10 192.168.1.14
Total 1 displayed, Up 1, Down 0

Egress RSVP: 1 sessions

1.1.1.1
  From: 2.2.2.2, LSPstate: Up, ActiveRoute: 0
  LSPname: to-pe1, LSPpath: Primary
  Suggested label received: -, Suggested label sent: -
  Recovery label received: -, Recovery label sent: -
  Resv style: 1 FF, Label in: 3, Label out: -
  Time left:  124, Since: Sun Dec  4 07:48:04 2016
  Tspec: rate 0bps size 0bps peak Infbps m 20 M 1500
  Port number: sender 8 receiver 7738 protocol 0
  FastReroute desired
  PATH rcvfrom: 192.168.1.2 (ge-3/2/4.12) 2481 pkts
  Adspec: received MTU 1500
  PATH sentto: localclient
  RESV rcvfrom: localclient , Entropy label: No
  Record route: 192.168.1.14 192.168.1.10 192.168.1.2 <self>
Total 1 displayed, Up 1, Down 0

Transit RSVP: 0 sessions
Total 0 displayed, Up 0, Down 0

lab@srx:pe1>
```

set protocols mpls label-switched-path to-pe1 to 1.1.1.1
set protocols mpls interface all

```
[edit]
lab@srx:pe2# run show mpls lsp ingress
Ingress LSP: 1 sessions
To              From            State Rt P     ActivePath       LSPname
1.1.1.1         2.2.2.2         Up     0 *                       to-pe1
Total 1 displayed, Up 1, Down 0

[edit]
lab@srx:pe2# run show mpls lsp ingress extensive
Ingress LSP: 1 sessions

1.1.1.1
  From: 2.2.2.2, State: Up, ActiveRoute: 0, LSPname: to-pe1
  ActivePath:  (primary)
  LSPtype: Static Configured, Penultimate hop popping
  LoadBalance: Random
  Encoding type: Packet, Switching type: Packet, GPID: IPv4
 *Primary                    State: Up
    Priorities: 7 0
    SmartOptimizeTimer: 180
    Computed ERO (S [L] denotes strict [loose] hops): (CSPF metric: 2)
 192.168.1.5 S 192.168.1.1 S
    Received RRO (ProtectionFlag 1=Available 2=InUse 4=B/W 8=Node 10=SoftPreempt 20=Node-ID):
          192.168.1.5 192.168.1.1
    5 Dec  3 14:52:01.438 Selected as active path
    4 Dec  3 14:52:01.437 Record Route:  192.168.1.5 192.168.1.1
    3 Dec  3 14:52:01.437 Up
    2 Dec  3 14:52:01.419 Originate Call
    1 Dec  3 14:52:01.418 CSPF: computation result accepted  192.168.1.5 192.168.1.1
  Created: Sat Dec  3 14:52:02 2016
Total 1 displayed, Up 1, Down 0

[edit]
lab@srx:pe2#
```

```
lab@srx:pe2> show route table inet.3

inet.3: 1 destinations, 1 routes (1 active, 0 holddown, 0 hidden)
Restart Complete
+ = Active Route, - = Last Active, * = Both

1.1.1.1/32          *[RSVP/7/1] 1d 06:55:51, metric 3
                     > to 192.168.1.13 via ge-3/2/5.24, label-switched-path to-pe1
```

```
lab@srx:pe1> show rsvp session detail
Ingress RSVP: 1 sessions

2.2.2.2
  From: 1.1.1.1, LSPstate: Up, ActiveRoute: 0
  LSPname: to-pe2, LSPpath: Secondary
  LSPtype: Static Configured
  Suggested label received: -, Suggested label sent: -
  Recovery label received: -, Recovery label sent: 299952
  Resv style: 1 FF, Label in: -, Label out: 299952
  Time left:    -, Since: Sun Dec  4 07:23:36 2016
  Tspec: rate 0bps size 0bps peak Infbps m 20 M 1500
  Port number: sender 7 receiver 22969 protocol 0
  PATH rcvfrom: localclient
  Adspec: sent MTU 1500
  Path MTU: received 1500
  PATH sentto: 192.168.1.2 (ge-3/2/4.12) 2519 pkts
  RESV rcvfrom: 192.168.1.2 (ge-3/2/4.12) 2520 pkts, Entropy label: No
  Explct route: 192.168.1.2 192.168.1.10 192.168.1.14
  Record route: <self> 192.168.1.2 192.168.1.10 192.168.1.14
Total 1 displayed, Up 1, Down 0

Egress RSVP: 1 sessions

1.1.1.1
  From: 2.2.2.2, LSPstate: Up, ActiveRoute: 0
  LSPname: to-pe1, LSPpath: Primary
  Suggested label received: -, Suggested label sent: -
  Recovery label received: -, Recovery label sent: -
  Resv style: 1 FF, Label in: 3, Label out: -
  Time left:  124, Since: Sun Dec  4 07:48:04 2016
  Tspec: rate 0bps size 0bps peak Infbps m 20 M 1500
  Port number: sender 8 receiver 7738 protocol 0
  FastReroute desired
  PATH rcvfrom: 192.168.1.2 (ge-3/2/4.12) 2481 pkts
  Adspec: received MTU 1500
  PATH sentto: localclient
  RESV rcvfrom: localclient , Entropy label: No
  Record route: 192.168.1.14 192.168.1.10 192.168.1.2 <self>
Total 1 displayed, Up 1, Down 0

Transit RSVP: 0 sessions
Total 0 displayed, Up 0, Down 0

lab@srx:pe1>
```

Let’s take a Look at RSVP Neighbors on PE1/PE2/P1/P2

```
lab@srx:pe1> show rsvp neighbor
RSVP neighbor: 1 learned
Address            Idle Up/Dn LastChange HelloInt HelloTx/Rx MsgRcvd
192.168.1.2           0  1/0    11:25:16        9  4548/4548 1851

lab@srx:pe1> set cli logical-system pe2
```

```
lab@srx:pe2> show rsvp neighbor
RSVP neighbor: 2 learned
Address            Idle Up/Dn LastChange HelloInt HelloTx/Rx MsgRcvd
192.168.1.13          0  1/0     3:53:27        9  1551/1551 628
192.168.1.5           0  1/0     3:53:30        9  1551/1551 629


lab@srx:p1> show rsvp neighbor
RSVP neighbor: 3 learned
Address            Idle Up/Dn LastChange HelloInt HelloTx/Rx MsgRcvd
192.168.1.6           0  1/0     3:53:42        9  1553/1553 634
192.168.1.10          5  1/0     3:53:39        9  1552/1552 628
192.168.1.1           0  1/0     3:53:42        9  1553/1553 944


lab@srx:p2> show rsvp neighbor
RSVP neighbor: 2 learned
Address            Idle Up/Dn LastChange HelloInt HelloTx/Rx MsgRcvd
192.168.1.14         10  1/0     3:53:50        9  1553/1553 631
192.168.1.9          10  1/0     3:53:50        9  1553/1553 628
```

5. Configure a Default Route on CE1 pointing to PE1 and CE2 to PE2. Configure a Static Route on PE1 to CE1 loopback & a static Route to CE2 loopback from PE2. Redistribute the static route on PE2 into OSPF. Finally, Configure Traffic-Engineering MPLS-FORWARDING on PE1 and PE2 so that Forwarding is done by MPLS.

Configuration on CE1

set routing-options static route 0.0.0.0/0 next-hop 10.0.0.1

Configuration on CE2

set routing-options static route 0.0.0.0/0 next-hop 11.0.0.1

Configuration on PE1

set routing-options static route 101.101.101.101/32 next-hop 10.0.0.100
set policy-options policy-statement EXPORTCE term 1 from protocol static
set policy-options policy-statement EXPORTCE term 1 then accept

set protocols ospf export EXPORTCE
set protocols mpls traffic-engineering mpls-forwarding

Configuration on PE2

set routing-options static route 102.102.102.102/32 next-hop 11.0.0.100
set policy-options policy-statement EXPORTCE term 1 from protocol static
set policy-options policy-statement EXPORTCE term 1 then accept

set protocols ospf export EXPORTCE
set protocols mpls traffic-engineering mpls-forwarding

```
lab@srx:ce1> show route protocol static

inet.0: 4 destinations, 4 routes (4 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0.0.0.0/0           *[Static/5] 01:58:08
                     > to 10.0.0.1 via ge-3/2/7.101
```

```
lab@srx:ce2> show route protocol static

inet.0: 4 destinations, 4 routes (4 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0.0.0.0/0           *[Static/5] 01:57:58
                     > to 11.0.0.1 via ge-3/2/7.102
```

```
lab@srx:pe1> show route protocol static

inet.0: 15 destinations, 16 routes (15 active, 1 holddown, 0 hidden)
@ = Routing Use Only, # = Forwarding Use Only
+ = Active Route, - = Last Active, * = Both

101.101.101.101/32 *[Static/5] 01:49:08
                     > to 10.0.0.100 via ge-3/2/6.101
```

```
lab@srx:pe1> show route protocol ospf

inet.0: 15 destinations, 16 routes (15 active, 1 holddown, 0 hidden)
@ = Routing Use Only, # = Forwarding Use Only
+ = Active Route, - = Last Active, * = Both

2.2.2.2/32          @[OSPF/10] 01:44:36, metric 3
                     > to 192.168.1.2 via ge-3/2/4.12
3.3.3.3/32          *[OSPF/10] 01:44:36, metric 1
                     > to 192.168.1.2 via ge-3/2/4.12
4.4.4.4/32          *[OSPF/10] 01:44:36, metric 2
                     > to 192.168.1.2 via ge-3/2/4.12
11.0.0.0/24         *[OSPF/10] 01:44:36, metric 4
                     > to 192.168.1.2 via ge-3/2/4.12
102.102.102.102/32 *[OSPF/150] 01:44:36, metric 0, tag 0
                     > to 192.168.1.2 via ge-3/2/4.12
192.168.1.4/30      *[OSPF/10] 01:44:36, metric 2
                     > to 192.168.1.2 via ge-3/2/4.12
192.168.1.8/30      *[OSPF/10] 01:44:36, metric 2
                     > to 192.168.1.2 via ge-3/2/4.12
192.168.1.12/30     *[OSPF/10] 01:44:36, metric 3
                     > to 192.168.1.2 via ge-3/2/4.12
224.0.0.5/32        *[OSPF/10] 12:06:51, metric 1
                       MultiRecv
```

```
lab@srx:pe2> show route protocol static

inet.0: 16 destinations, 17 routes (16 active, 0 holddown, 0 hidden)
Restart Complete
@ = Routing Use Only, # = Forwarding Use Only
+ = Active Route, - = Last Active, * = Both

102.102.102.102/32 *[Static/5] 01:52:24
                    > to 11.0.0.100 via ge-3/2/6.102
```

```
lab@srx:pe2> show route protocol ospf

inet.0: 16 destinations, 17 routes (16 active, 0 holddown, 0 hidden)
Restart Complete
@ = Routing Use Only, # = Forwarding Use Only
+ = Active Route, - = Last Active, * = Both

1.1.1.1/32          @[OSPF/10] 01:49:07, metric 3
                     > to 192.168.1.13 via ge-3/2/5.24
3.3.3.3/32          *[OSPF/10] 01:49:07, metric 2
                     > to 192.168.1.13 via ge-3/2/5.24
4.4.4.4/32          *[OSPF/10] 01:49:07, metric 1
                     > to 192.168.1.13 via ge-3/2/5.24
10.0.0.0/24         *[OSPF/10] 01:49:07, metric 4
                     > to 192.168.1.13 via ge-3/2/5.24
101.101.101.101/32 *[OSPF/150] 01:49:07, metric 0, tag 0
                     > to 192.168.1.13 via ge-3/2/5.24
192.168.1.0/30      *[OSPF/10] 01:49:07, metric 3
                     > to 192.168.1.13 via ge-3/2/5.24
192.168.1.4/30      *[OSPF/10] 01:49:07, metric 3
                     > to 192.168.1.13 via ge-3/2/5.24
192.168.1.8/30      *[OSPF/10] 01:49:07, metric 2
                     > to 192.168.1.13 via ge-3/2/5.24
224.0.0.5/32        *[OSPF/10] 12:11:35, metric 1
                       MultiRecv
```

6. Configure an Explicit Path ERO – PATH1 as Primary Path to include PE1-P1-PE2 and PATH2 as secondary Path to PE1-P1-P2-PE2 for LSP to-PE1 on PE1. Make sure you Secondary PATH is in STANDBY state.
   PATH1 ERO Parameters -- 192.168.1.2 , 192.168.1.6
   PATH2 ERO Parameters – 192.168.1.2, 192.168.1.10, 192.168.1.14
   1- After creating both primary and secondary paths, disable the primary path and confirm it switch to the secondary path.
   2- On CE1 run traceroute to CE2 and confirm the label in both primary and secondary paths.

   set protocols mpls label-switched-path to-pe2 primary PATH1
   set protocols mpls path PATH1 192.168.1.2
   set protocols mpls path PATH1 192.168.1.6

```
lab@srx:pe1> show mpls lsp ingress
Ingress LSP: 1 sessions
To              From            State Rt P    ActivePath          LSPname
2.2.2.2         1.1.1.1         Up     0 *    PATH1               to-pe2
Total 1 displayed, Up 1, Down 0

lab@srx:pe1> show mpls lsp extensive ingress
Ingress LSP: 1 sessions

2.2.2.2
  From: 1.1.1.1, State: Up, ActiveRoute: 0, LSPname: to-pe2
  ActivePath: PATH1 (primary)
  LSPtype: Static Configured, Penultimate hop popping
  LoadBalance: Random
  Encoding type: Packet, Switching type: Packet, GPID: IPv4
 *Primary   PATH1              State: Up
    Priorities: 7 0
    SmartOptimizeTimer: 180
    Computed ERO (S [L] denotes strict [loose] hops): (CSPF metric: 2)
 192.168.1.2 S 192.168.1.6 S
    Received RRO (ProtectionFlag 1=Available 2=InUse 4=B/W 8=Node 10=SoftPreempt 20=Node-ID):
         192.168.1.2 192.168.1.6
   10 Dec  3 15:12:59.400 Record Route:  192.168.1.2 192.168.1.6
    9 Dec  3 15:12:59.400 Up
    8 Dec  3 15:12:59.381 Originate Call
    7 Dec  3 15:12:59.381 CSPF: computation result accepted  192.168.1.2 192.168.1.6
    6 Dec  3 15:12:59.377 Clear Call
    5 Dec  3 14:42:59.813 Selected as active path
    4 Dec  3 14:42:59.813 Record Route:  192.168.1.2 192.168.1.6
    3 Dec  3 14:42:59.809 Up
    2 Dec  3 14:42:59.732 Originate Call
    1 Dec  3 14:42:59.731 CSPF: computation result accepted  192.168.1.2 192.168.1.6
  Created: Sat Dec  3 14:43:00 2016
Total 1 displayed, Up 1, Down 0

lab@srx:pe1>
```

set protocols mpls label-switched-path to-pe2 secondary PATH2 standby
set protocols mpls path PATH2 192.168.1.2
set protocols mpls path PATH2 192.168.1.10
set protocols mpls path PATH2 192.168.1.14

```
[edit]
lab@srx:pe1# run show mpls lsp ingress up
Ingress LSP: 1 sessions
To              From            State Rt P     ActivePath       LSPname
2.2.2.2         1.1.1.1         Up     0 *     PATH1            to-pe2
Total 1 displayed, Up 1, Down 0

[edit]
lab@srx:pe1# run show mpls lsp ingress up extensive
Ingress LSP: 1 sessions

2.2.2.2
  From: 1.1.1.1, State: Up, ActiveRoute: 0, LSPname: to-pe2
  ActivePath: PATH1 (primary)
  LSPtype: Static Configured, Penultimate hop popping
  LoadBalance: Random
  Encoding type: Packet, Switching type: Packet, GPID: IPv4
 *Primary   PATH1            State: Up
    Priorities: 7 0
    SmartOptimizeTimer: 180
    Computed ERO (S [L] denotes strict [loose] hops): (CSPF metric: 2)
 192.168.1.2 S 192.168.1.6 S
    Received RRO (ProtectionFlag 1=Available 2=InUse 4=B/W 8=Node 10=SoftPreempt 20=Node-ID):
          192.168.1.2 192.168.1.6
   10 Dec  3 15:12:59.400 Record Route:  192.168.1.2 192.168.1.6
    9 Dec  3 15:12:59.400 Up
    8 Dec  3 15:12:59.381 Originate Call
    7 Dec  3 15:12:59.381 CSPF: computation result accepted  192.168.1.2 192.168.1.6
    6 Dec  3 15:12:59.377 Clear Call
    5 Dec  3 14:42:59.813 Selected as active path
    4 Dec  3 14:42:59.813 Record Route:  192.168.1.2 192.168.1.6
    3 Dec  3 14:42:59.809 Up
    2 Dec  3 14:42:59.732 Originate Call
    1 Dec  3 14:42:59.731 CSPF: computation result accepted  192.168.1.2 192.168.1.6
  Standby   PATH2            State: Up
    Priorities: 7 0
    SmartOptimizeTimer: 180
    Computed ERO (S [L] denotes strict [loose] hops): (CSPF metric: 3)
 192.168.1.2 S 192.168.1.10 S 192.168.1.14 S
    Received RRO (ProtectionFlag 1=Available 2=InUse 4=B/W 8=Node 10=SoftPreempt 20=Node-ID):
          192.168.1.2 192.168.1.10 192.168.1.14
    4 Dec  4 06:25:22.282 Record Route:  192.168.1.2 192.168.1.10 192.168.1.14
    3 Dec  4 06:25:22.282 Up
    2 Dec  4 06:25:22.250 Originate Call
    1 Dec  4 06:25:22.250 CSPF: computation result accepted  192.168.1.2 192.168.1.10 192.168.1.14
  Created: Sat Dec  3 14:43:00 2016
Total 1 displayed, Up 1, Down 0

[edit]
```

Let’s Disable Primary Path PATH1 to switch to Secondary PATH2

```
[edit]
lab@srx:pe1# deactivate protocols mpls label-switched-path to-pe2 primary PATH1

[edit]
lab@srx:pe1# commit
commit complete

[edit]
lab@srx:pe1# run show mpls lsp ingress
Ingress LSP: 1 sessions
To              From            State Rt P      ActivePath      LSPname
2.2.2.2         1.1.1.1         Up     0        PATH2           to-pe2
Total 1 displayed, Up 1, Down 0

[edit]
lab@srx:pe1# run show mpls lsp extensive
Ingress LSP: 1 sessions

2.2.2.2
  From: 1.1.1.1, State: Up, ActiveRoute: 0, LSPname: to-pe2
  ActivePath: PATH2 (secondary)
  LSPtype: Static Configured, Penultimate hop popping
  LoadBalance: Random
  Encoding type: Packet, Switching type: Packet, GPID: IPv4
*Standby    PATH2           State: Up
    Priorities: 7 0
    SmartOptimizeTimer: 180
    Computed ERO (S [L] denotes strict [loose] hops): (CSPF metric: 3)
 192.168.1.2 S 192.168.1.10 S 192.168.1.14 S
    Received RRO (ProtectionFlag 1=Available 2=InUse 4=B/W 8=Node 10=SoftPreempt 20=Node-ID):
         192.168.1.2 192.168.1.10 192.168.1.14
    5 Dec  4 06:33:32.900 Selected as active path
    4 Dec  4 06:25:22.282 Record Route:  192.168.1.2 192.168.1.10 192.168.1.14
    3 Dec  4 06:25:22.282 Up
    2 Dec  4 06:25:22.250 Originate Call
    1 Dec  4 06:25:22.250 CSPF: computation result accepted  192.168.1.2 192.168.1.10 192.168.1.14
  Created: Sat Dec  3 14:42:59 2016
Total 1 displayed, Up 1, Down 0
```

Tracing Route from CE1 TO PE2

```
lab@srx:ce1> traceroute 2.2.2.2
traceroute to 2.2.2.2 (2.2.2.2), 30 hops max, 48 byte packets
 1  10.0.0.1 (10.0.0.1)  0.437 ms  0.371 ms  0.373 ms
 2  192.168.1.2 (192.168.1.2)  0.574 ms  0.594 ms  0.586 ms
     MPLS Label=299792 CoS=0 TTL=1 S=1
 3  192.168.1.10 (192.168.1.10)  0.640 ms  0.643 ms  0.648 ms
     MPLS Label=299792 CoS=0 TTL=1 S=1
 4  2.2.2.2 (2.2.2.2)  0.655 ms  0.640 ms  0.654 ms
```

Tracing Route from CE2 to PE1

```
lab@srx:ce2> traceroute 1.1.1.1
traceroute to 1.1.1.1 (1.1.1.1), 30 hops max, 48 byte packets
 1  11.0.0.1 (11.0.0.1)  0.458 ms  0.377 ms  0.377 ms
 2  192.168.1.13 (192.168.1.13)  0.574 ms  0.593 ms  0.587 ms
     MPLS Label=299840 CoS=0 TTL=1 S=1
 3  192.168.1.9 (192.168.1.9)  0.638 ms  0.626 ms  0.624 ms
     MPLS Label=299840 CoS=0 TTL=1 S=1
 4  1.1.1.1 (1.1.1.1)  0.687 ms  0.639 ms  0.652 ms
```

7. Configure Fast Re-Route for LSP to-pe1 on PE2. Disable the Primary Interface between P1-PE2 and confirm that a detour was taken

   set protocols mpls label-switched-path to-pe1 to 1.1.1.1
   set protocols mpls label-switched-path to-pe1 fast-reroute

```
[edit]
lab@srx:pe2# run show mpls lsp ingress
Ingress LSP: 1 sessions
To              From            State Rt P     ActivePath       LSPname
1.1.1.1         2.2.2.2         Up     0 *                      to-pe1
Total 1 displayed, Up 1, Down 0


[edit]
lab@srx:pe2# run show mpls lsp ingress extensive
Ingress LSP: 1 sessions

1.1.1.1
  From: 2.2.2.2, State: Up, ActiveRoute: 0, LSPname: to-pe1
  ActivePath:  (primary)
  FastReroute desired
  LSPtype: Static Configured, Penultimate hop popping
  LoadBalance: Random
  Encoding type: Packet, Switching type: Packet, GPID: IPv4
 *Primary                    State: Up
    Priorities: 7 0

[edit]
lab@srx:pe2# run traceroute mpls rsvp to-pe1
  Probe options: retries 3, exp 7

  ttl    Label  Protocol    Address          Previous Hop     Probe Status
    1   300112  RSVP-TE     192.168.1.5      (null)           Success
  FEC-Stack-Sent: RSVP
  ttl    Label  Protocol    Address          Previous Hop     Probe Status
    2        3  RSVP-TE     192.168.1.1      192.168.1.5      Egress
  FEC-Stack-Sent: RSVP

  Path 1 via ge-3/2/4.23 destination 127.0.0.64
```

Let us Disable the Primary Interface between P1-PE2, you can see it from the above Traceroute Output.

```
[edit]
lab@srx:pe2# commit
commit complete

[edit]
lab@srx:pe2# run traceroute mpls rsvp to-pe1
  Probe options: retries 3, exp 7

  ttl    Label  Protocol    Address          Previous Hop     Probe Status
    1   299920  RSVP-TE     192.168.1.13     (null)           Success
  FEC-Stack-Sent: RSVP
  ttl    Label  Protocol    Address          Previous Hop     Probe Status
    2   300144  RSVP-TE     192.168.1.9      192.168.1.13     Success
  FEC-Stack-Sent: RSVP
  ttl    Label  Protocol    Address          Previous Hop     Probe Status
    3        3  RSVP-TE     192.168.1.1      192.168.1.9      Egress
  FEC-Stack-Sent: RSVP

  Path 1 via ge-3/2/5.24 destination 127.0.0.64
```

An Immediate Traceroute will reveal it has indeed taken a Detour, which was signaled earlier.

Deliverables:

29. Diagram of the lab with IP addresses and Autonomous system numbers.
30. Running configuration of all the routers.
31. The output of all the command stated in each step
32. Traceroute from CE1 to CE2

Instructions to follow at the end of each lab

33. Make sure you erase your configuration from NVRAM of the devices used.
34. Do not save any of the configurations in flash memory.
35. All cables must be unplugged and secured in the box.
36. There must not be any kind of garbage around the desk or racks after you are done with lab.

PE1

```
set system root-authentication encrypted-password
"$1$Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-3/2/4 vlan-tagging
set interfaces ge-3/2/6 vlan-tagging
set interfaces ge-3/2/4 unit 12 vlan-id 12
set interfaces ge-3/2/4 unit 12 family inet address 192.168.1.1/30
set interfaces ge-3/2/4 unit 12 family mpls
set interfaces ge-3/2/6 unit 101 vlan-id 101
set interfaces ge-3/2/6 unit 101 family inet address 10.0.0.1/24
set interfaces lo0 unit 0 family inet address 1.1.1.1/32
set interfaces lo0 unit 0 family mpls
set protocols rsvp traceoptions file rsvp.trace
set protocols rsvp traceoptions flag all
set protocols rsvp interface all reliable
set protocols rsvp interface all bandwidth 500k
set protocols mpls traffic-engineering mpls-forwarding
set protocols mpls traceoptions file mplstrace
set protocols mpls traceoptions flag all
set protocols mpls label-switched-path to-pe2 to 2.2.2.2
set protocols mpls label-switched-path to-pe2 primary PATH1
set protocols mpls label-switched-path to-pe2 secondary PATH2 standby
set protocols mpls path PATH1 192.168.1.2
set protocols mpls path PATH1 192.168.1.6
set protocols mpls path PATH2 192.168.1.2
set protocols mpls path PATH2 192.168.1.10
set protocols mpls path PATH2 192.168.1.14
set protocols mpls interface all
set protocols ospf traceoptions file ospf.trace
set protocols ospf traceoptions flag all
set protocols ospf traffic-engineering
set protocols ospf export EXPORTCE
set protocols ospf area 0.0.0.0 interface all
set policy-options policy-statement EXPORTCE term 1 from protocol static
set policy-options policy-statement EXPORTCE term 1 then accept
```

set routing-options static route 101.101.101.101/32 next-hop 10.0.0.100

P1

set system root-authentication encrypted-password
"1Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-3/2/5 vlan-tagging
set interfaces ge-3/2/5 unit 12 vlan-id 12
set interfaces ge-3/2/5 unit 12 family inet address 192.168.1.2/30
set interfaces ge-3/2/5 unit 12 family mpls
set interfaces ge-3/2/5 unit 14 vlan-id 14
set interfaces ge-3/2/5 unit 14 family inet address 192.168.1.9/30
set interfaces ge-3/2/5 unit 14 family mpls
set interfaces ge-3/2/5 unit 23 vlan-id 23
set interfaces ge-3/2/5 unit 23 family inet address 192.168.1.5/30
set interfaces ge-3/2/5 unit 23 family mpls
set interfaces lo0 unit 0 family inet address 3.3.3.3/32
set interfaces lo0 unit 0 family mpls
set protocols rsvp interface all
set protocols mpls interface all
set protocols ospf traffic-engineering
set protocols ospf area 0.0.0.0 interface all

P2

set system root-authentication encrypted-password
"1Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-3/2/4 vlan-tagging

```
set interfaces ge-3/2/4 unit 14 vlan-id 14
set interfaces ge-3/2/4 unit 14 family inet address 192.168.1.10/30
set interfaces ge-3/2/4 unit 14 family mpls
set interfaces ge-3/2/4 unit 24 vlan-id 24
set interfaces ge-3/2/4 unit 24 family inet address 192.168.1.13/30
set interfaces ge-3/2/4 unit 24 family mpls
set interfaces lo0 unit 0 family inet address 4.4.4.4/32
set interfaces lo0 unit 0 family mpls
set protocols rsvp interface all
set protocols mpls interface all
set protocols ospf traffic-engineering
set protocols ospf area 0.0.0.0 interface all
```

PE2

```
set system root-authentication encrypted-password
"$1$Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-3/2/4 vlan-tagging
set interfaces ge-3/2/5 vlan-tagging
set interfaces ge-3/2/6 vlan-tagging
set interfaces ge-3/2/4 unit 23 vlan-id 23
set interfaces ge-3/2/4 unit 23 family inet address 192.168.1.6/30
set interfaces ge-3/2/4 unit 23 family mpls
set interfaces ge-3/2/5 unit 24 vlan-id 24
set interfaces ge-3/2/5 unit 24 family inet address 192.168.1.14/30
set interfaces ge-3/2/5 unit 24 family mpls
set interfaces ge-3/2/6 unit 102 vlan-id 102
set interfaces ge-3/2/6 unit 102 family inet address 11.0.0.1/24
set interfaces lo0 unit 2 family inet address 2.2.2.2/32
set interfaces lo0 unit 2 family mpls
set protocols rsvp interface all
set protocols mpls traffic-engineering mpls-forwarding
set protocols mpls label-switched-path to-pe1 to 1.1.1.1
set protocols mpls label-switched-path to-pe1 fast-reroute
set protocols mpls interface all
set protocols ospf traffic-engineering
set protocols ospf export EXPORTCE
```

set protocols ospf area 0.0.0.0 interface all
set policy-options policy-statement EXPORTCE term 1 from protocol static
set policy-options policy-statement EXPORTCE term 1 then accept
set routing-options static route 102.102.102.102/32 next-hop 11.0.0.100

CE1

set system root-authentication encrypted-password
"1Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-3/2/7 vlan-tagging
set interfaces ge-3/2/7 unit 101 vlan-id 101
set interfaces ge-3/2/7 unit 101 family inet address 10.0.0.100/24
set interfaces lo0 unit 101 family inet address 101.101.101.101/32
set routing-options static route 0.0.0.0/0 next-hop 10.0.0.1

CE2

set system root-authentication encrypted-password
"1Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-3/2/7 vlan-tagging
set interfaces ge-3/2/7 unit 102 vlan-id 102
set interfaces ge-3/2/7 unit 102 family inet address 11.0.0.100/24
set interfaces lo0 unit 102 family inet address 102.102.102.102/32
set routing-options static route 0.0.0.0/0 next-hop 11.0.0.1

Lab 10

Juniper VPLS

Introduction :

Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint to multipoint communication over IP or MPLS networks. It allows geographically dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudo-wires.
BGP can autonomously signal pseudowires between the PE routers participating in the same virtual private LAN service (VPLS) network. As PE routers are added to and removed from the VPLS network, BGP can signal pseudowires to new PE routers and tear down old pseudowires to old PE routers. Each PE router only needs to be configured with the identity of the VPLS routing instance. Each PE router does not need to be configured with the identities of all of the PE routers that are or might become a part of the VPLS network.
When you configure BGP for signaling in a VPLS network, customer sites can be either single-homed to a single PE router or multihomed to two or more PE routers. Multihoming provides redundancy for the connection between the customer site and the service provider's network.
Option to configure all of the PE routers in the VPLS network as a full mesh or you can use BGP route reflectors. For full mesh configurations, each PE router needs to be able to create a bidirectional pseudowire to each of the other PE routers participating in the VPLS network.
You can configure BGP signaling for the VPLS routing instance. BGP is used to signal the pseudowires linking each of the PE routers participating in the VPLS routing instance. The pseudowires carry VPLS traffic across the service provider's network between the VPLS sites.
You cannot configure both BGP signaling and LDP signaling for the same VPLS routing instance. If you attempt to configure the statements that enable BGP signaling for the VPLS routing instance (the site, site-identifier, and site-range statements) and the statements that enable LDP signaling for the same instance (the neighbor and vpls-id statements), the commit operation fails.

Configuring the VPLS Site Name and Site Identifier
When you configure BGP signaling for the VPLS routing instance, on each PE router you must configure each VPLS site that has a connection to the PE router. All the Layer 2 circuits provisioned for a VPLS site are listed as the set of logical interfaces (using the interface statement) within the site statement.

Configuring Automatic Site Identifiers for VPLS
When you enable automatic site identifiers, the Junos OS automatically assigns site identifiers to VPLS sites. To configure automatic site identifiers for a VPLS routing instance, include the automatic-site-id statement:

Configuring the Site Range
When you enable BGP signaling for each VPLS routing instance, you can optionally configure the site range. The site range specifies an upper limit on the maximum site identifier that can be

accepted to allow a pseudowire to be brought up. You must specify a value from 1 through 65,534. The default value is 65,534. We recommend using the default. Pseudowires cannot be established to sites with site identifiers greater than the configured site range. If you issue the show vpls connections command, such sites are displayed as OR (out of range).

Configuring the VPLS Site Preference

You can specify the local preference value advertised for a particular VPLS site. The site preference value is specified using the site-preference statement configured at the [edit routing-instances routing-instance-name protocols vpls site site-name] hierarchy level. By configuring the site-preference statement, a value configured for the local-preference statement at the [edit protocols bgp] hierarchy level is ignored by the VPLS routing instance. However, you can change the site preference value for VPLS routes exported to other routers by configuring an export policy. When a PE router receives multiple advertisements with the same VPLS edge (VE) device identifier, the advertisement with the highest local preference value is preferred.

Configuring the VPLS MAC Table Timeout Interval

You can modify the timeout interval for the VPLS table. We recommend you that configure longer values for small, stable VPLS networks and shorter values for large, dynamic VPLS networks. If the VPLS table does not receive any updates during the timeout interval, the router waits one additional interval before automatically clearing the MAC address entries from the VPLS table.

Configuring the Size of the VPLS MAC Address Table

You can modify the size of the VPLS media access control (MAC) address table. The default table size is 512 MAC addresses, the minimum is 16 addresses, and the maximum is 65,536 addresses.

Limiting the Number of MAC Addresses Learned from an Interface

You can configure a limit on the number of MAC addresses learned by a VPLS routing instance using the mac-table-size statement. If the MAC table limit is reached, new MAC addresses can no longer be added to the table. Eventually the oldest MAC addresses are removed from the MAC address table automatically. This frees space in the table, allowing new entries to be added. However, as long as the table is full, new MAC addresses are dropped.

Because this limit applies to each VPLS routing instance, the MAC addresses of a single interface can consume all the available space in the table, preventing the routing instance from acquiring addresses from other interfaces.

You can limit the number of MAC addresses learned from each interface configured for a VPLS routing instance. To do so, include the interface-mac-limit statement:

Pre-lab:

1. Which protocol can you for signaling the control plane of VPLS? LDP or BGP?

   Both. There is a BGP signaled VPLS variant and LDP Signaled VPLS variant.

2. What is the instance type that you will use?

   VPLS

3. What is the default size of Mac-Address-Table in VPLS Implementation? What is Minimum and What is the Maximum?

   Default is 512, Minimum is 16 and Maximum is 65536

4. How many Encapsulations are available for a VPLS Interface?

   Ethernet and Ethernet-Vlan.

5. What are two essential parameters for VPLS Implementation?

   Site-Name and Site-Identifier.

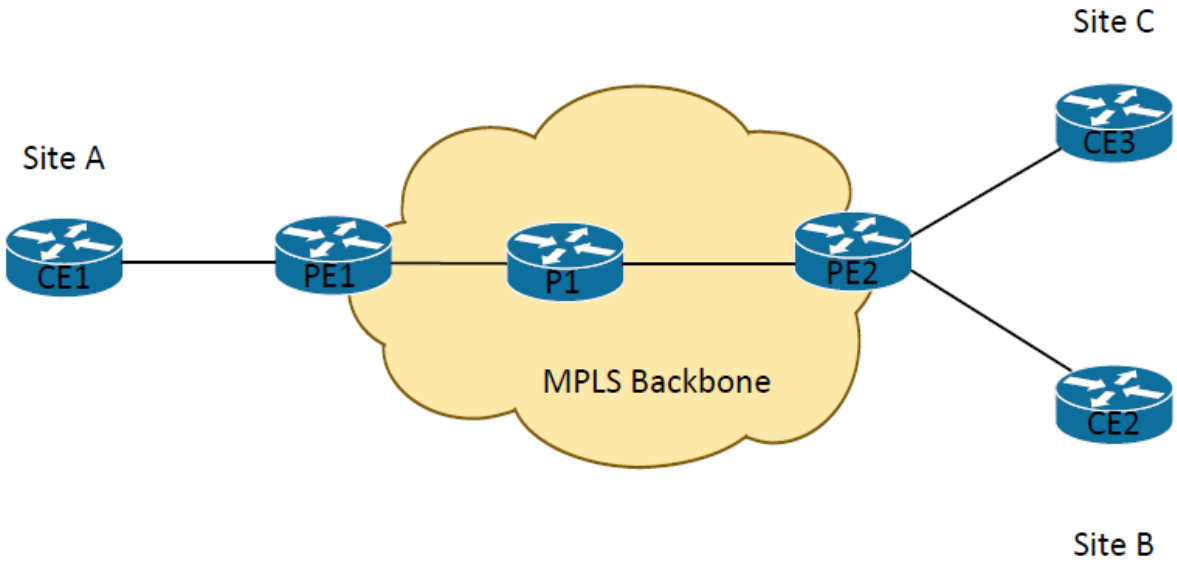
6. What Encapsulation you will use at interface level if you are willing to assign a vlan-id / interface?

   Encapsulation vlan-vpls

Lab Scenario:

In this lab, you will enable the core routers with MPLS/OSPF A0 RSVP, Configure a Bi-Directional LSP. Configure MP-iBGP between PE1 and PE2 to enable VPLS and Finally configure OSPF between CE1, CE2 & CE3 over VPLS and advertise Loopback interfaces.

Lab Diagram:



Lab IP Addressing:

Node	IP
CE1 to PE1	100.0.0.100/24
PE2 to CE2	100.0.0.200/24
PE2 to CE3	100.0.0.30/24
PE1 to P1	192.168.X.0/30
P1 to PE2	192.168.X.4/30
PE1 Loopback	1.1.1.1
P1 Loopback	3.3.3.3
PE2 Loopback	2.2.2.2
CE1 Loopback	100.100.100.100

CE2 Loopback	200.200.200.200
CE3 Loopback	30.30.30.30

Procedure:

1. Configure OSPF in Area 0 for Routers PE1/PE2/P1.

2. Configure RSVP to include all the Core Interfaces on PE1/PE2/P. what is the default reservation parameters?

3. Configure MPLS to all the core Interfaces on PE1/PE2/P.

4. Configure an LSP from PE1(1.1.1.1) to PE2 (2.2.2.2) and PE2(2.2.2.2) to PE1(1.1.1.1). Confirm both LSPs are up ?

5. Configure BGP between PE1 and PE2 and enable the peering for L2VPN Signaling.

6. Configure Routing Instance for VPLS. Name the instance as VPLS1. Configure a RD of 1:1 and Route-Target of target:1:1 for PE1 and RD of 1:2 and Route-target of target:1:1 for PE2 respectively.

7. Configure protocol VPLS for Routing-instance. Configure Site-Identifier value of 1 for PE1 and site-identifier value of 2 for PE2. Configure site-name as vpls. Configure site-range of 20 for both the instances

8. Once VPLS is converged, Configure OSPF between CE1, CE2 and CE3 and see if CE1, CE2 and CE3 can establish OSPF over VPLS to exchange their Loopback Networks.

Detailed Lab Guide

1. Configure OSPF in Area 0 for Routers PE1/PE2/P. Enable Traffic Engineering for OSPF.

   set protocols ospf area 0.0.0.0 interface all

   set protocols ospf traffic-engineering

2. Configure RSVP to include all the Core Interfaces on PE1/PE2/P.

   set protocols rsvp interface all

   Default Reservation Parameters. The output is from PE1.

   lab@R:pe1> show rsvp interface brief

   RSVP interface: 3 active

   ge-1/1/2.0 Up 1 100% 1000Mbps 1000Mbps 0bps 0bps

   lo0.0 Up 0 100% 0bps 0bps 0bps 0bps

3. Configure MPLS to all the core Interfaces on PE1/PE2/P.

   On PE1/PE2/P, Configure MPLS as follows

   set protocols mpls interface all

   lab@R:p> show mpls interface brief

   Interface State Administrative groups (x: extended)

   ge-1/1/3.0 Up <none>

   ge-1/1/4.0 Up <none>

4. Configure an LSP from PE1(1.1.1.1) to PE2 (2.2.2.2) and PE2(2.2.2.2) to PE1(1.1.1.1).

   On PE1

   set protocols mpls label-switched-path to-pe2 to 2.2.2.2

   set protocols mpls interface all

   lab@R:pe1> show mpls lsp ingress

   Ingress LSP: 1 sessions

   To From State Rt P ActivePath LSPname

   2.2.2.2 1.1.1.1 Up 0 * to-pe2

   Total 1 displayed, Up 1, Down 0

   On PE2

   set protocols mpls label-switched-path to-pe1 to 1.1.1.1

   set protocols mpls interface all

   lab@R:pe2> show mpls lsp ingress

   Ingress LSP: 1 sessions

   To From State Rt P ActivePath LSPname

   1.1.1.1 2.2.2.2 Up 0 * to-pe1

   Total 1 displayed, Up 1, Down 0

5. Configure BGP between PE1 and PE2 and enable the peering for L2VPN Signaling.

```
lab@R:pe1> show configuration protocols bgp
group ibgp {
    neighbor 2.2.2.2 {
        local-address 1.1.1.1;
        family l2vpn {
            signaling;
        }
        peer-as 100;
    }
}

lab@R:pe1> show configuration routing-options
autonomous-system 100;

lab@R:pe1> show bgp summary
Groups: 1 Peers: 1 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
bgp.l2vpn.0
                       1          1          0          0          0          0
Peer                     AS      InPkt     OutPkt    OutQ   Flaps Last Up/Dwn State|#Active/Received/A
ccepted/Damped...
2.2.2.2                 100      11967      11962       0       0 3d 17:36:18 Establ
  bgp.l2vpn.0: 1/1/1/0
  vpls1.l2vpn.0: 1/1/1/0

lab@R:pe1>


lab@R:pe1> set cli logical-system pe2
Logical system: pe2

lab@R:pe2> show configuration protocols bgp
group ibgp {
    neighbor 1.1.1.1 {
        local-address 2.2.2.2;
        family l2vpn {
            signaling;
        }
        peer-as 100;
    }
}

lab@R:pe2> show configuration routing-options
autonomous-system 100;

lab@R:pe2> show bgp summary
Groups: 1 Peers: 1 Down peers: 0
Table          Tot Paths  Act Paths Suppressed    History Damp State    Pending
bgp.l2vpn.0
                       1          1          0          0          0          0
Peer                     AS      InPkt     OutPkt    OutQ   Flaps Last Up/Dwn State|#Active/Received/
ccepted/Damped...
1.1.1.1                 100      11964      11971       0       0 3d 17:37:20 Establ
  bgp.l2vpn.0: 1/1/1/0
  vpls1.l2vpn.0: 1/1/1/0
```

6. Configure Routing Instance for VPLS. Name the instance as VPLS1. Configure a RD of 1:1 and Route-Target of target:1:1 for PE1 and RD of 1:2 and Route-target of target:1:1 for PE2 respectively.

```
lab@R:pe1> show configuration routing-instances
vpls1 {
    instance-type vpls;
    interface ge-1/1/1.0;
    route-distinguisher 1:1;
    vrf-target target:1:1;
```

```
lab@R:pe2> show configuration routing-instances
vpls1 {
    instance-type vpls;
    interface ge-1/0/6.0;
    interface ge-1/1/6.0;
    route-distinguisher 1:2;
    vrf-target target:1:1;
    protocols {
        vpls {
            site-range 20;
            interface ge-1/1/6.0;
            interface ge-1/0/6.0;
```

7. Configure protocol VPLS for Routing-instance. Configure Site-Identifier value of 1 for PE1 and site-identifier value of 2 for PE2. Configure site-name as vpls. Configure site-range of 20 for both the instances. What are the site id assigned for Site B and site C? On PE1 and PE2 what are the incoming labels and outgoing labels all sites?

```
lab@R:pe1> show configuration routing-instances
vpls1 {
    instance-type vpls;
    interface ge-1/1/1.0;
    route-distinguisher 1:1;
    vrf-target target:1:1;
    protocols {
        vpls {
            site-range 20;
            no-tunnel-services;
            site vpls1 {
                site-identifier 1;
                interface ge-1/1/1.0;
            }
        }
    }
}
```

```
lab@R:pe2> show configuration routing-instances
vpls1 {
    instance-type vpls;
    interface ge-1/0/6.0;
    interface ge-1/1/6.0;
    route-distinguisher 1:2;
    vrf-target target:1:1;
    protocols {
        vpls {
            site-range 20;
            interface ge-1/1/6.0;
            interface ge-1/0/6.0;
            no-tunnel-services;
            site vpls1 {
                site-identifier 2;
            }
        }
    }
}
```

```
lab@R:pe1> show vpls connections
Layer-2 VPN connections:

Legend for connection status (St)
EI -- encapsulation invalid      NC -- interface encapsulation not CCC/TCC/VPLS
EM -- encapsulation mismatch     WE -- interface and instance encaps not same
VC-Dn -- Virtual circuit down    NP -- interface hardware not present
CM -- control-word mismatch      -> -- only outbound connection is up
CN -- circuit not provisioned    <- -- only inbound connection is up
OR -- out of range               Up -- operational
OL -- no outgoing label          Dn -- down
LD -- local site signaled down   CF -- call admission control failure
RD -- remote site signaled down  SC -- local and remote site ID collision
LN -- local site not designated  LM -- local site ID not minimum designated
RN -- remote site not designated RM -- remote site ID not minimum designated
XX -- unknown connection status  IL -- no incoming label
MM -- MTU mismatch               MI -- Mesh-Group ID not available
BK -- Backup connection          ST -- Standby connection
PF -- Profile parse failure      PB -- Profile busy
RS -- remote site standby        SN -- Static Neighbor
LB -- Local site not best-site   RB -- Remote site not best-site
VM -- VLAN ID mismatch

Legend for interface status
Up -- operational
Dn -- down

Instance: vpls1
  Local site: vpls1 (1)
    connection-site           Type  St     Time last up          # Up trans
    2                         rmt   Up     Dec 14 10:24:09 2016           1
      Remote PE: 2.2.2.2, Negotiated control-word: No
      Incoming label: 262146, Outgoing label: 262145
      Local interface: lsi.17825792, Status: Up, Encapsulation: VPLS
        Description: Intf - vpls vpls1 local site 1 remote site 2

lab@R:pe1>
```

```
lab@R:pe2> show vpls connections
Layer-2 VPN connections:

Legend for connection status (St)
EI -- encapsulation invalid      NC -- interface encapsulation not CCC/TCC/VPLS
EM -- encapsulation mismatch     WE -- interface and instance encaps not same
VC-Dn -- Virtual circuit down    NP -- interface hardware not present
CM -- control-word mismatch      -> -- only outbound connection is up
CN -- circuit not provisioned    <- -- only inbound connection is up
OR -- out of range               Up -- operational
OL -- no outgoing label          Dn -- down
LD -- local site signaled down   CF -- call admission control failure
RD -- remote site signaled down  SC -- local and remote site ID collision
LN -- local site not designated  LM -- local site ID not minimum designated
RN -- remote site not designated RM -- remote site ID not minimum designated
XX -- unknown connection status  IL -- no incoming label
MM -- MTU mismatch               MI -- Mesh-Group ID not available
BK -- Backup connection          ST -- Standby connection
PF -- Profile parse failure      PB -- Profile busy
RS -- remote site standby        SN -- Static Neighbor
LB -- Local site not best-site   RB -- Remote site not best-site
VM -- VLAN ID mismatch

Legend for interface status
Up -- operational
Dn -- down

Instance: vpls1
  Local site: vpls1 (2)
    connection-site           Type  St     Time last up          # Up trans
    1                         rmt   Up     Dec 14 10:24:09 2016           1
      Remote PE: 1.1.1.1, Negotiated control-word: No
      Incoming label: 262145, Outgoing label: 262146
      Local interface: lsi.84934658, Status: Up, Encapsulation: VPLS
        Description: Intf - vpls vpls1 local site 2 remote site 1

lab@R:pe2>
```

```
lab@R:pe1> show vpls statistics
VPLS statistics:

Instance: vpls1
   Local interface: ge-1/1/1.0, Index: 372
     Broadcast packets:                    37
     Broadcast bytes  :                  2220
     Multicast packets:                  3082
     Multicast bytes  :                304264
     Flooded packets  :                     0
     Flooded bytes    :                     0
     Unicast packets  :                    71
     Unicast bytes    :                  6828
     Current MAC count:                     1 (Limit 1024)
   Local interface: lsi.17825792, Index: 373
   Remote PE: 2.2.2.2
     Broadcast packets:                    19
     Broadcast bytes  :                  1140
     Multicast packets:                  3719
     Multicast bytes  :                369230
     Flooded packets  :                     0
     Flooded bytes    :                     0
     Unicast packets  :                    76
     Unicast bytes    :                  6866
     Current MAC count:                     2
```

```
lab@R:pe2> show vpls statistics
VPLS statistics:

Instance: vpls1
   Local interface: ge-1/1/6.0, Index: 369
     Broadcast packets:                    13
     Broadcast bytes  :                   780
     Multicast packets:                  2612
     Multicast bytes  :                256544
     Flooded packets  :                     0
     Flooded bytes    :                     0
     Unicast packets  :                    58
     Unicast bytes    :                  5278
     Current MAC count:                     1 (Limit 1024)
   Local interface: lsi.84934658, Index: 377
   Remote PE: 1.1.1.1
     Broadcast packets:                    34
     Broadcast bytes  :                  2040
     Multicast packets:                  2596
     Multicast bytes  :                254832
     Flooded packets  :                     0
     Flooded bytes    :                     0
     Unicast packets  :                    58
     Unicast bytes    :                  5682
     Current MAC count:                     1
   Local interface: ge-1/0/6.0, Index: 381
     Broadcast packets:                     0
     Broadcast bytes  :                     0
     Multicast packets:                   122
     Multicast bytes  :                 12420
     Flooded packets  :                     0
     Flooded bytes    :                     0
     Unicast packets  :                    37
     Unicast bytes    :                  3670
     Current MAC count:                     1 (Limit 1024)
```

```
lab@R:pe2> show vpls mac-table

MAC flags (S -static MAC, D -dynamic MAC, L -locally learned, C -Control MAC
           SE -Statistics enabled, NM -Non configured MAC, R -Remote PE MAC)

Logical system    : pe2
Routing instance : vpls1
 Bridging domain : __vpls1__, VLAN : NA
   MAC                 MAC      Logical          NH     RTR
   address             flags    interface        Index  ID
   40:b4:f0:e6:79:4f   D        ge-1/0/6.0
   40:b4:f0:e6:79:9c   D        lsi.84934658
   40:b4:f0:e6:79:a3   D        ge-1/1/6.0

lab@R:pe2>



lab@R:pe1> show vpls mac-table

MAC flags (S -static MAC, D -dynamic MAC, L -locally learned, C -Control MAC
           SE -Statistics enabled, NM -Non configured MAC, R -Remote PE MAC)

Logical system    : pe1
Routing instance : vpls1
 Bridging domain : __vpls1__, VLAN : NA
   MAC                 MAC      Logical          NH     RTR
   address             flags    interface        Index  ID
   40:b4:f0:e6:79:9c   D        ge-1/1/1.0
   40:b4:f0:e6:79:a3   D        lsi.17825792

lab@R:pe1>
```

8. Once VPLS is converged, Configure OSPF between CE1 and CE2 and see if CE1 and CE2 can establish OSPF over VPLS to exchange their Loopback Networks.

```
lab@R:ce1> show route protocol ospf

inet.0: 6 destinations, 6 routes (6 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

30.30.30.30/32     *[OSPF/10] 00:12:33, metric 1
                    > to 100.0.0.30 via ge-1/1/0.0
200.200.200.200/32 *[OSPF/10] 05:48:37, metric 1
                    > to 100.0.0.200 via ge-1/1/0.0
224.0.0.5/32       *[OSPF/10] 3d 12:10:18, metric 1
                      MultiRecv

lab@R:ce1> show ospf neighbor
Address          Interface              State     ID               Pri  Dead
100.0.0.30       ge-1/1/0.0             Full      30.30.30.30      128    33
100.0.0.200      ge-1/1/0.0             Full      200.200.200.200  128    31

lab@R:ce1> ping 30.30.30.30 rapid
PING 30.30.30.30 (30.30.30.30): 56 data bytes
!!!!!
--- 30.30.30.30 ping statistics ---
5 packets transmitted, 5 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.678/2.599/7.171/2.577 ms

lab@R:ce1> ping 200.200.200.200 rapid
PING 200.200.200.200 (200.200.200.200): 56 data bytes
!!!!!
--- 200.200.200.200 ping statistics ---
5 packets transmitted, 5 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.691/0.711/0.778/0.034 ms

lab@R:ce1>
```

```
lab@R:ce2> show ospf neighbor
Address          Interface              State     ID               Pri  Dead
100.0.0.30       ge-1/1/7.0             Full      30.30.30.30      128    34
100.0.0.100      ge-1/1/7.0             Full      100.100.100.100  128    34

lab@R:ce2> show route protocol ospf

inet.0: 6 destinations, 6 routes (6 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

30.30.30.30/32     *[OSPF/10] 00:13:32, metric 1
                    > to 100.0.0.30 via ge-1/1/7.0
100.100.100.100/32 *[OSPF/10] 3d 12:10:10, metric 1
                    > to 100.0.0.100 via ge-1/1/7.0
224.0.0.5/32       *[OSPF/10] 3d 12:10:59, metric 1
                      MultiRecv

lab@R:ce2> ping 30.30.30.30 rapid
PING 30.30.30.30 (30.30.30.30): 56 data bytes
!!!!!
--- 30.30.30.30 ping statistics ---
5 packets transmitted, 5 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.636/0.661/0.735/0.037 ms

lab@R:ce2> ping 100.100.100.100 rapid
PING 100.100.100.100 (100.100.100.100): 56 data bytes
!!!!!
--- 100.100.100.100 ping statistics ---
5 packets transmitted, 5 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.686/0.702/0.745/0.022 ms

lab@R:ce2>
```

```
lab@R:ce3> show ospf neighbor
Address          Interface              State     ID               Pri  Dead
100.0.0.200      ge-1/0/5.0             Full      200.200.200.200  128    31
100.0.0.100      ge-1/0/5.0             Full      100.100.100.100  128    33

lab@R:ce3> show route protocol ospf

inet.0: 6 destinations, 6 routes (6 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

100.100.100.100/32 *[OSPF/10] 00:14:29, metric 1
                    > to 100.0.0.100 via ge-1/0/5.0
200.200.200.200/32 *[OSPF/10] 00:14:29, metric 1
                    > to 100.0.0.200 via ge-1/0/5.0
224.0.0.5/32       *[OSPF/10] 00:17:16, metric 1
                       MultiRecv

lab@R:ce3> ping 100.100.100.100 rapid
PING 100.100.100.100 (100.100.100.100): 56 data bytes
!!!!!
--- 100.100.100.100 ping statistics ---
5 packets transmitted, 5 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.686/0.706/0.753/0.024 ms

lab@R:ce3> ping 200.200.200.200 rapid
PING 200.200.200.200 (200.200.200.200): 56 data bytes
!!!!!
--- 200.200.200.200 ping statistics ---
5 packets transmitted, 5 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.636/0.657/0.703/0.023 ms

lab@R:ce3>
```

Deliverables:

37. Diagram of the lab with IP addresses and Autonomous system numbers.
38. Running configuration of all the routers.
39. The output of all the command stated in each step
40. Traceroute from CE1 to CE2

Instructions to follow at the end of each lab

41. Make sure you erase your configuration from NVRAM of the devices used.
42. Do not save any of the configurations in flash memory.
43. All cables must be unplugged and secured in the box.
44. There must not be any kind of garbage around the desk or racks after you are done with lab.

PE1

```
set system root-authentication encrypted-password
"$1$Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-1/1/1 encapsulation vlan-vpls
set interfaces ge-1/1/1 unit 0 encapsulation vlan-vpls
set interfaces ge-1/1/1 unit 0 vlan-id 513
set interfaces ge-1/1/1 unit 0 family vpls
set interfaces ge-1/1/2 unit 0 family inet address 192.168.1.1/30
set interfaces ge-1/1/2 unit 0 family mpls
set interfaces lo0 unit 0 family inet address 1.1.1.1/32
set routing-options autonomous-system 100
set protocols rsvp interface all
set protocols mpls label-switched-path to-pe2 to 2.2.2.2
set protocols mpls label-switched-path to-pe2 no-cspf
set protocols mpls interface all
set protocols bgp group ibgp neighbor 2.2.2.2 local-address 1.1.1.1
set protocols bgp group ibgp neighbor 2.2.2.2 family l2vpn signaling
set protocols bgp group ibgp neighbor 2.2.2.2 peer-as 100
set protocols ospf area 0.0.0.0 interface all
set routing-instances vpls1 instance-type vpls
set routing-instances vpls1 interface ge-1/1/1.0
set routing-instances vpls1 route-distinguisher 1:1
set routing-instances vpls1 vrf-target target:1:1
set routing-instances vpls1 protocols vpls site-range 20
set routing-instances vpls1 protocols vpls no-tunnel-services
set routing-instances vpls1 protocols vpls site vpls1 site-identifier 1
set routing-instances vpls1 protocols vpls site vpls1 interface ge-1/1/1.0
```

PE2

```
set system root-authentication encrypted-password
"$1$Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-1/0/6 encapsulation vlan-vpls
set interfaces ge-1/0/6 unit 0 encapsulation vlan-vpls
set interfaces ge-1/0/6 unit 0 vlan-id 513
set interfaces ge-1/0/6 unit 0 family vpls
set interfaces ge-1/1/5 unit 0 family inet address 192.168.1.6/30
set interfaces ge-1/1/5 unit 0 family mpls
set interfaces ge-1/1/6 encapsulation vlan-vpls
set interfaces ge-1/1/6 unit 0 encapsulation vlan-vpls
set interfaces ge-1/1/6 unit 0 vlan-id 513
set interfaces ge-1/1/6 unit 0 family vpls
set interfaces lo0 unit 0 family inet address 2.2.2.2/32
set routing-options autonomous-system 100
set protocols rsvp interface all
set protocols mpls label-switched-path to-pe1 to 1.1.1.1
set protocols mpls label-switched-path to-pe1 no-cspf
set protocols mpls interface all
set protocols bgp group ibgp neighbor 1.1.1.1 local-address 2.2.2.2
set protocols bgp group ibgp neighbor 1.1.1.1 family l2vpn signaling
set protocols bgp group ibgp neighbor 1.1.1.1 peer-as 100
set protocols ospf area 0.0.0.0 interface all
set routing-instances vpls1 instance-type vpls
set routing-instances vpls1 interface ge-1/0/6.0
set routing-instances vpls1 interface ge-1/1/6.0
set routing-instances vpls1 route-distinguisher 1:2
set routing-instances vpls1 vrf-target target:1:1
set routing-instances vpls1 protocols vpls site-range 20
set routing-instances vpls1 protocols vpls interface ge-1/1/6.0
set routing-instances vpls1 protocols vpls interface ge-1/0/6.0
set routing-instances vpls1 protocols vpls no-tunnel-services
set routing-instances vpls1 protocols vpls site vpls1 site-identifier 2
```

P

```
set system root-authentication encrypted-password
"$1$Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-1/1/3 unit 0 family inet address 192.168.1.2/30
set interfaces ge-1/1/3 unit 0 family mpls
set interfaces ge-1/1/4 unit 0 family inet address 192.168.1.5/30
set interfaces ge-1/1/4 unit 0 family mpls
set interfaces lo0 unit 0 family inet address 3.3.3.3/32
set protocols rsvp interface all
set protocols mpls interface all
set protocols ospf area 0.0.0.0 interface all
```

CE1

```
set system root-authentication encrypted-password
"$1$Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-1/1/0 vlan-tagging
set interfaces ge-1/1/0 unit 0 vlan-id 513
set interfaces ge-1/1/0 unit 0 family inet address 100.0.0.100/24
set interfaces lo0 unit 0 family inet address 100.100.100.100/32
set protocols ospf area 0.0.0.0 interface all
```

CE2

```
set system root-authentication encrypted-password
"$1$Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-1/1/7 vlan-tagging
set interfaces ge-1/1/7 unit 0 vlan-id 513
set interfaces ge-1/1/7 unit 0 family inet address 100.0.0.200/24
set interfaces lo0 unit 0 family inet address 200.200.200.200/32
set protocols ospf area 0.0.0.0 interface all
```

CE3

```
set system root-authentication encrypted-password
"$1$Xqg9sJ9c$8HWXB1bAiqCp5jJtBgOL.1"
set system login user lab uid 2003
set system login user lab class super-user
set system login user lab authentication encrypted-password
"$1$4R4gh6Av$ZF.GI7r.tecWmzO8uFnmE0"
set security forwarding-options family inet6 mode packet-based
set security forwarding-options family mpls mode packet-based
set security forwarding-options family iso mode packet-based
set interfaces ge-1/0/5 vlan-tagging
set interfaces ge-1/0/5 unit 0 vlan-id 513
set interfaces ge-1/0/5 unit 0 family inet address 100.0.0.30/24
set interfaces lo0 unit 0 family inet address 30.30.30.30/32
set protocols ospf area 0.0.0.0 interface all
```