Cisco ME3600X/ME3600-24CX/ME3800X

Design Guide

Last Updated: September 2013

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

Text Part Number: OL-30517-01

THE SPECIFICATIONS AND INFORMATION REGARDING THE PRODUCTS IN THIS MANUAL ARE SUBJECT TO CHANGE WITHOUT NOTICE. ALL STATEMENTS, INFORMATION, AND RECOMMENDATIONS IN THIS MANUAL ARE BELIEVED TO BE ACCURATE BUT ARE PRESENTED WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. USERS MUST TAKE FULL RESPONSIBILITY FOR THEIR APPLICATION OF ANY PRODUCTS.

THE SOFTWARE LICENSE AND LIMITED WARRANTY FOR THE ACCOMPANYING PRODUCT ARE SET FORTH IN THE INFORMATION PACKET THAT SHIPPED WITH THE PRODUCT AND ARE INCORPORATED HEREIN BY THIS REFERENCE. IF YOU ARE UNABLE TO LOCATE THE SOFTWARE LICENSE OR LIMITED WARRANTY, CONTACT YOUR CISCO REPRESENTATIVE FOR A COPY.

The Cisco implementation of TCP header compression is an adaptation of a program developed by the University of California, Berkeley (UCB) as part of UCB's public domain version of the UNIX operating system. All rights reserved. Copyright © 1981, Regents of the University of California.

NOTWITHSTANDING ANY OTHER WARRANTY HEREIN, ALL DOCUMENT FILES AND SOFTWARE OF THESE SUPPLIERS ARE PROVIDED "AS IS" WITH ALL FAULTS. CISCO AND THE ABOVE-NAMED SUPPLIERS DISCLAIM ALL WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, THOSE OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT OR ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE.

IN NO EVENT SHALL CISCO OR ITS SUPPLIERS BE LIABLE FOR ANY INDIRECT, SPECIAL, CONSEQUENTIAL, OR INCIDENTAL DAMAGES, INCLUDING, WITHOUT LIMITATION, LOST PROFITS OR LOSS OR DAMAGE TO DATA ARISING OUT OF THE USE OR INABILITY TO USE THIS MANUAL, EVEN IF CISCO OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Cisco and the Cisco Logo are trademarks of Cisco Systems, Inc. and/or its affiliates in the U.S. and other countries. A listing of Cisco's trademarks can be found at www.cisco.com/go/trademarks. Third party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company.

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.

Cisco ME3600X/ME3600-24CX/ME3800X Design Guide

© 2013 Cisco Systems, Inc. All rights reserved.

CONTENTS

Preface

Introduction

This document provides design guidance, best practice procedures, and detailed configurations for deployment of ME3600X/ME3800X product in a Service Provider Carrier Ethernet network. The contained information is expected to help explain the ME3600X/ME3800X series product design in the context of a Service Provider environment and provide guidance on deployment in a Service Provider's access networks.

Audience

This document is intended for all technical person who are involved in the design/deployment of ME3600X/ME3800X Carrier Ethernet product.

The Solution

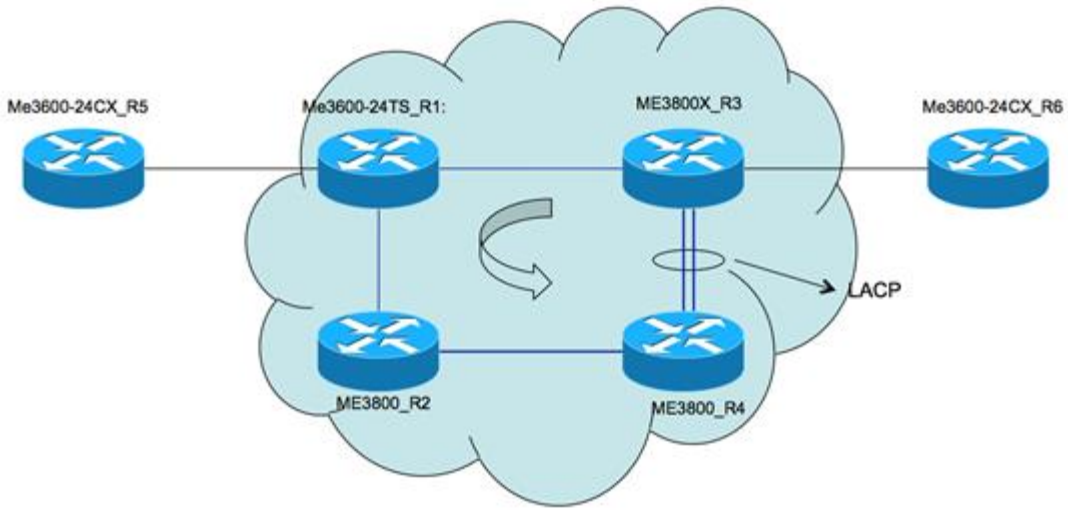
The solution is a Layer 2-based design. The benefit of layer 2 solution is simple network topology, easy for operation, fast convergence (with the help of REP/G.8032 feature).

Chapter 1
Layer 2-based Design

In the layer 2 based solution design section, the following features will be covered:

- Ethernet Virtual Connection (EVC)
- Multiple Spanning Tree (MST)
- Link Aggregation Control Protocol (LACP)
- Operations, Administration, and Maintenance (OAM)
- Quality of Service (QoS)
- G.8032 (Ethernet Ring Protection Switching)
- Resilient Ethernet Protocol (REP)

The following topology will be used for the layer 2 solution design:



R1, R2, R3, and R4 are the access devices; these are the Cisco ME3600X/ME3800X series product.

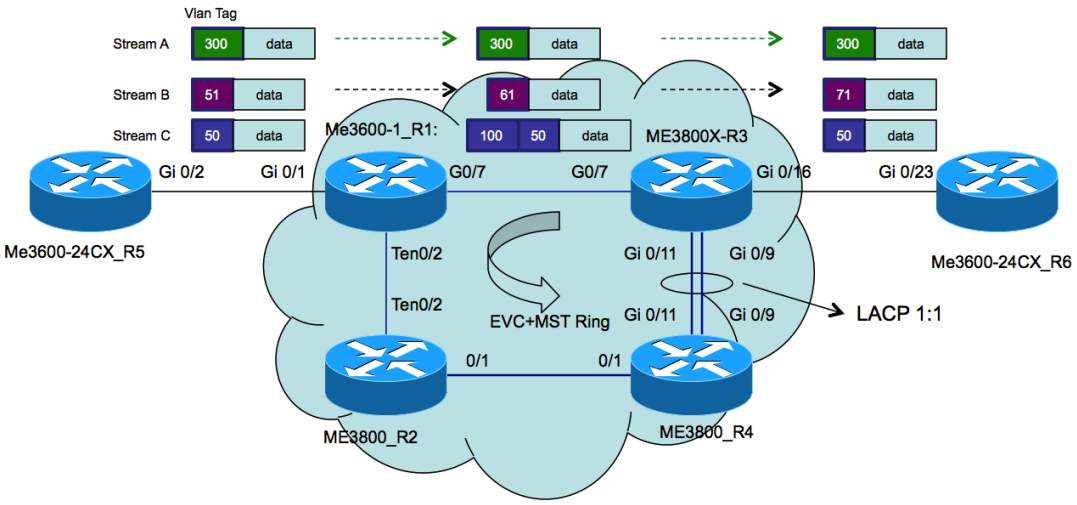
R5 and R6 are the Cisco ME3600X-24CX devices.

Design Example (A)—EVC+MST+LACP+Qos+OAM

Ethernet Virtual Connection (EVC)

Ethernet Virtual Connection (EVC) is defined by the Metro-Ethernet Forum (MEF), An EVC is a conceptual service pipe within the service provider network.EVC feature provides the vlan translation in a very flexible way.

EVC Technology



In this example, there are three streams – A, B, and C that come from R5, across the access ring.

The vlan tag of streamA (Vlan300) will be kept unchanged.

The vlan tag of streamB (Vlan51) will be changed to vlan61.

The vlan tag of streamC (Vlan50) will be added one more outer tag (QinQ).

EVC Sample configuration on R1:

```
interface GigabitEthernet0/1
 switchport trunk allowed vlan none    //EVC mode CLI
 switchport mode trunk
 service instance 50 ethernet
  encapsulation dot1q 50
  rewrite ingress tag pop 1 symmetric
  bridge-domain 100
 !
 service instance 51 ethernet
  encapsulation dot1q 51
  rewrite ingress tag pop 1 symmetric
  bridge-domain 61
 !
 service instance 300 ethernet
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  bridge-domain 300

interface GigabitEthernet0/7
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 61 ethernet
  encapsulation dot1q 61
  rewrite ingress tag pop 1 symmetric
  bridge-domain 61
 !
 service instance 100 ethernet
  encapsulation dot1q 100 second-dot1q 50
  rewrite ingress tag pop 2 symmetric
  bridge-domain 100
 !
 service instance 300 ethernet
  encapsulation dot1q 300
rewrite ingress tag pop 1 symmetric
  bridge-domain 300
 !
```

EVC Sample configuration on R3:

```
interface GigabitEthernet0/7
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 61 ethernet
  encapsulation dot1q 61
  rewrite ingress tag pop 1 symmetric
  bridge-domain 61
 !
 service instance 100 ethernet
  encapsulation dot1q 100 second-dot1q 50
  rewrite ingress tag pop 2 symmetric
  bridge-domain 100
 !
 service instance 300 ethernet
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  bridge-domain 300

interface GigabitEthernet0/16
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 71 ethernet
  encapsulation dot1q 71
  rewrite ingress tag pop 1 symmetric
  bridge-domain 61
 !
 service instance 100 ethernet
  encapsulation dot1q 50
  rewrite ingress tag pop 1 symmetric
  bridge-domain 100
```

```
 !
 service instance 300 ethernet
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  bridge-domain 300
!
```

Configuration on R5:

```
interface GigabitEthernet0/2
 switchport trunk allowed vlan 50,51,300
 switchport mode trunk
 media-type rj45

interface Vlan50
 ip address 9.9.0.5 255.255.255.0
!
interface Vlan51
 ip address 8.8.0.5 255.255.255.0
!
interface Vlan300
 ip address 7.7.0.5 255.255.255.0

ME3600X-24CX-R5#ping 7.7.0.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 7.7.0.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
ME3600X-24CX-R5#ping 8.8.0.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.8.0.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/200/1000 ms
ME3600X-24CX-R5#ping 9.9.0.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 9.9.0.6, timeout is 2 seconds:
!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/200/1000 ms
```

Configuration on R6:

```
interface GigabitEthernet0/23
 switchport trunk allowed vlan 50,71,300
 switchport mode trunk

interface Vlan50
 ip address 9.9.0.6 255.255.255.0
!
interface Vlan71
 ip address 8.8.0.6 255.255.255.0
!
interface Vlan300
 ip address 7.7.0.6 255.255.255.0

ME3600X-24CX-R6#ping 9.9.0.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 9.9.0.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R6#ping 8.8.0.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.8.0.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R6#ping 7.7.0.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 7.7.0.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
```

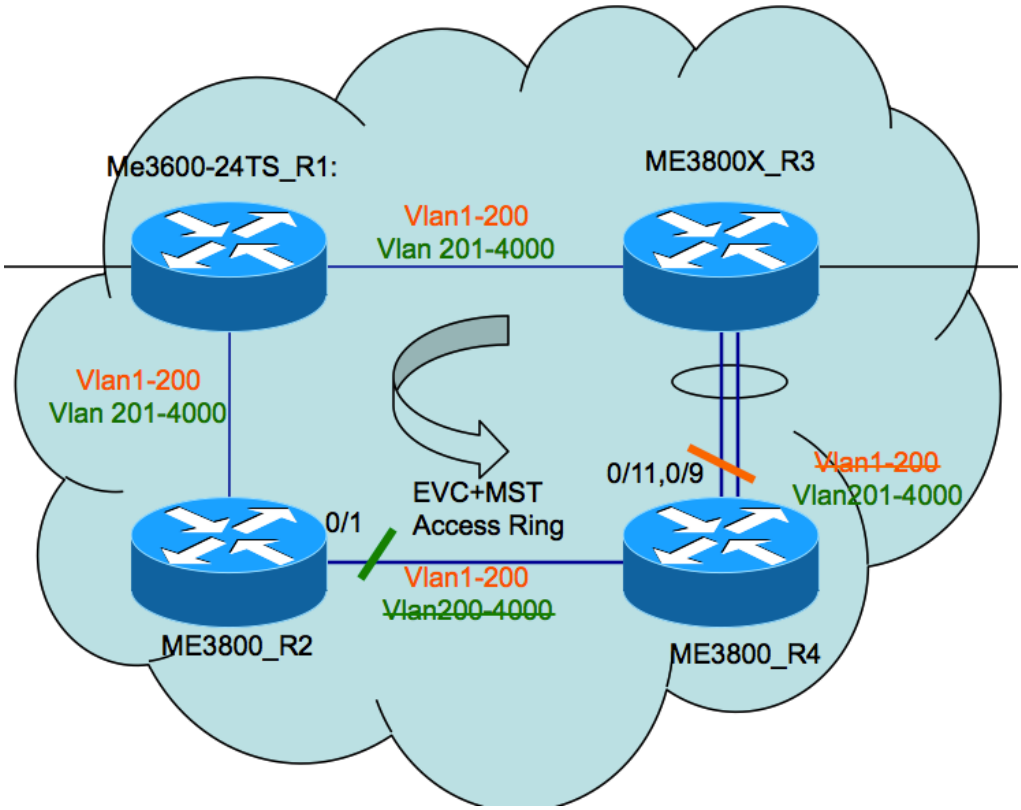
Multiple Spanning Tree (MST)

MSTs (IEEE 802.1s) combine the best aspects from both the PVST+ and the 802.1q. The idea is that several VLANs can be mapped to a reduced number of spanning tree instances.

See the following table for the MST design example:

MST Design example	MST Instance 1	MST Instance 2	MST Design example
Vlan range	Vlan1-200	Vlan 201-4000	Vlan range
Block port	R2 gigabitEthernet0/1	R4:port-channel(0/11,0/9)	Block port
Root Bridge	R1	R3	Root Bridge

MST Sample Topology



MST Sample Configuration at R1

```
spanning-tree mode mst
spanning-tree extend system-id
!
spanning-tree mst configuration
 instance 1 vlan 1-200
 instance 2 vlan 201-4000
!
spanning-tree mst 1 priority 24576 //configuration CLI:spanning-tree mst
1 root primary


interface GigabitEthernet0/7
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer // layer 2 protocol peer is needed for the MST message
  bridge-domain 1

interface TenGigabitEthernet0/2
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
```

MST Sample Configuration at R2

```
spanning-tree mode mst
spanning-tree extend system-id
!
spanning-tree mst configuration
 instance 1 vlan 1-200
 instance 2 vlan 201-4000

interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer  //layer 2 protocol peer is needed for the MST message
  bridge-domain 1

interface TenGigabitEthernet0/2
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
```

MST Sample Configuration at R3

```
       spanning-tree mode mst
       spanning-tree extend system-id
       !
       spanning-tree mst configuration
        instance 1 vlan 1-200
        instance 2 vlan 201-4000
       !
       spanning-tree mst 2 priority 24576

       interface Port-channel20
        switchport trunk allowed vlan none
        switchport mode trunk
        lacp fast-switchover
        lacp max-bundle 1
        service instance 1 ethernet
         encapsulation untagged
         l2protocol peer
         bridge-domain 1

       interface GigabitEthernet0/7
        switchport trunk allowed vlan none
        switchport mode trunk
        service instance 1 ethernet
         encapsulation untagged
         l2protocol peer
         bridge-domain 1
!
```

MST Sample Configuration at R4

```
spanning-tree mode mst
spanning-tree extend system-id
!
spanning-tree mst configuration
 instance 1 vlan 1-200
 instance 2 vlan 201-4000


interface Port-channel20
 switchport trunk allowed vlan none
 switchport mode trunk
 lacp fast-switchover
 lacp max-bundle 1
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1

interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
```

MST Status Verification

```
ME3600X-R1#sh spanning-tree
MST0
  Spanning tree enabled protocol mstp
  Root ID    Priority    32768
             Address     0027.0cab.2f80
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768  (priority 32768 sys-id-ext 0)
             Address     0027.0cab.2f80
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------
Gi0/1               Desg FWD 20000     128.1    P2p
Gi0/7               Desg FWD 20000     128.7    P2p
Te0/2               Desg FWD 20000     128.26   P2p

MST1
  Spanning tree enabled protocol mstp
  Root ID    Priority    24577
             Address     0027.0cab.2f80
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    24577  (priority 24576 sys-id-ext 1)
             Address     0027.0cab.2f80
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------
Gi0/1               Desg FWD 20000     128.1    P2p
Gi0/7               Desg FWD 20000     128.7    P2p
Te0/2               Desg FWD 20000     128.26   P2p
```

```
      MST2
        Spanning tree enabled protocol mstp
        Root ID    Priority    24578
            Address     f4ac.c1b8.ea80

                    Cost        20000
                    Port        7 (GigabitEthernet0/7)
                    Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

        Bridge ID  Priority    32770  (priority 32768 sys-id-ext 2)
                    Address     0027.0cab.2f80
                    Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

      Interface           Role Sts Cost      Prio.Nbr Type
      ------------------- ---- --- --------- -------- --------------------------
      Gi0/1               Desg FWD 20000     128.1    P2p
      Gi0/7               Root FWD 20000     128.7    P2p
      Te0/2               Desg FWD 20000     128.26   P2p

ME3600X-R1#
```

```
ME3800X-R2#sh spanning-tree

MST0
  Spanning tree enabled protocol mstp
  Root ID    Priority    32768
             Address     0027.0cab.2f80
             Cost        0
             Port        26 (TenGigabitEthernet0/2)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768  (priority 32768 sys-id-ext 0)
             Address     0027.0cab.4680
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- ------------------------------
---
Gi0/1               Desg FWD 20000     128.1    P2p
Te0/2               Root FWD 20000     128.26   P2p


MST1
```

```
  Spanning tree enabled protocol mstp
  Root ID    Priority    24577
             Address     0027.0cab.2f80
             Cost        20000
             Port        26 (TenGigabitEthernet0/2)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     0027.0cab.4680
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
---
Gi0/1               Desg FWD 20000     128.1    P2p
Te0/2               Root FWD 20000     128.26   P2p


MST2
  Spanning tree enabled protocol mstp
  Root ID    Priority    24578
             Address     f4ac.c1b8.ea80
             Cost        40000
             Port        26 (TenGigabitEthernet0/2)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32770  (priority 32768 sys-id-ext 2)
             Address     0027.0cab.4680
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
---
Gi0/1               Altn BLK 20000     128.1    P2p
Te0/2               Root FWD 20000     128.26   P2p

ME3800X-R2#
```

```
ME3800X-R3#sh spanning-tree

MST0
  Spanning tree enabled protocol mstp
  Root ID    Priority    32768
             Address     0027.0cab.2f80
             Cost        0
             Port        7 (GigabitEthernet0/7)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768  (priority 32768 sys-id-ext 0)
             Address     f4ac.c1b8.ea80
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
---
Gi0/7               Root FWD 20000     128.7    P2p
Gi0/16              Desg FWD 20000     128.16   P2p
Po20                Desg FWD 20000     128.47   P2p
```

```
MST1
  Spanning tree enabled protocol mstp
  Root ID    Priority    24577
             Address     0027.0cab.2f80
             Cost        20000
             Port        7 (GigabitEthernet0/7)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     f4ac.c1b8.ea80
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
---
Gi0/7               Root FWD 20000     128.7    P2p
Gi0/16              Desg FWD 20000     128.16   P2p
Po20                Desg FWD 20000     128.47   P2p


MST2
  Spanning tree enabled protocol mstp
  Root ID    Priority    24578
             Address     f4ac.c1b8.ea80
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    24578  (priority 24576 sys-id-ext 2)
             Address     f4ac.c1b8.ea80
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
---
Gi0/7               Desg FWD 20000     128.7    P2p
Gi0/16              Desg FWD 20000     128.16   P2p
Po20                Desg FWD 20000     128.47   P2p

ME3800X-R3#
```

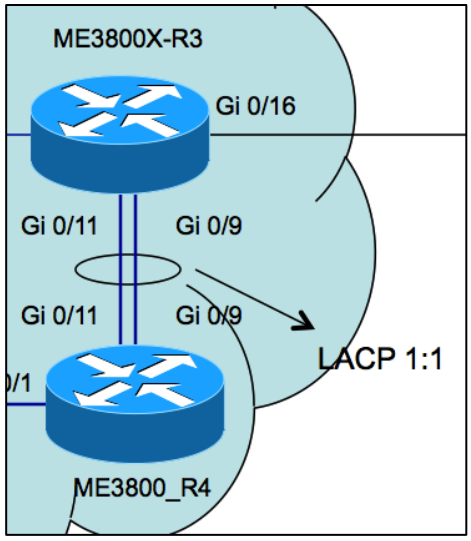
```
ME3800X-R4#show spanning-tree

MST0
  Spanning tree enabled protocol mstp
  Root ID    Priority    32768
             Address     0027.0cab.2f80
             Cost        0
             Port        1 (GigabitEthernet0/1)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768  (priority 32768 sys-id-ext 0)
             Address     0027.0cab.a680
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
```

```
---
Gi0/1               Root FWD 20000     128.1    P2p
Po20                Altn BLK 20000     128.47   P2p


MST1
  Spanning tree enabled protocol mstp
  Root ID    Priority    24577
             Address     0027.0cab.2f80
             Cost        40000
             Port        1 (GigabitEthernet0/1)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     0027.0cab.a680
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
---
Gi0/1               Root FWD 20000     128.1    P2p
Po20                Altn BLK 20000     128.47   P2p


MST2
  Spanning tree enabled protocol mstp
  Root ID    Priority    24578
             Address     f4ac.c1b8.ea80
             Cost        20000
             Port        47 (Port-channel20)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32770  (priority 32768 sys-id-ext 2)
             Address     0027.0cab.a680
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
---
Gi0/1               Desg FWD 20000     128.1    P2p
Po20                Root FWD 20000     128.47   P2p

ME3800X-R4#
```

Link Aggregate Control Protocol (LACP)

Link Aggregation Control Protocol (LACP) is part of an IEEE specification (802.3ad) that allows you to bundle several physical ports together to form a single logical channel.

In this example,two links between R3 and R4 will be combined together, LACP fast rate and LACP 1:1 feature will be enabled.



LACP Configuration on R3

```
interface GigabitEthernet0/9
 switchport trunk allowed vlan none
 switchport mode trunk
 channel-group 20 mode active
 lacp rate fast
!
interface GigabitEthernet0/11
 switchport trunk allowed vlan none
 switchport mode trunk
 channel-group 20 mode active
 lacp rate fast

interface Port-channel20
 switchport trunk allowed vlan none
 switchport mode trunk
 lacp fast-switchover
 lacp max-bundle 1
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 61 ethernet
  encapsulation dot1q 61
  rewrite ingress tag pop 1 symmetric
  bridge-domain 61
```

```
 !
 service instance 100 ethernet
  encapsulation dot1q 100 second-dot1q 50
  rewrite ingress tag pop 2 symmetric
  bridge-domain 100
 !
 service instance 300 ethernet
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  bridge-domain 300
 !
```

LACP Configuration on R4

```
interface GigabitEthernet0/9
 switchport trunk allowed vlan none
 switchport mode trunk
 channel-group 20 mode active
 lacp rate fast
!
interface GigabitEthernet0/11
 switchport trunk allowed vlan none
 switchport mode trunk
 channel-group 20 mode active
 lacp rate fast


interface Port-channel20
 switchport trunk allowed vlan none
 switchport mode trunk
 lacp fast-switchover
 lacp max-bundle 1
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 61 ethernet
  encapsulation dot1q 61
  rewrite ingress tag pop 1 symmetric
  bridge-domain 61
 !
 service instance 100 ethernet
  encapsulation dot1q 100 second-dot1q 50
  rewrite ingress tag pop 2 symmetric
  bridge-domain 100
 !
 service instance 300 ethernet
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  bridge-domain 300
 !
```

Verify the LACP Status

```
ME3800X-R3#show etherchannel port-channel
      Channel-group listing:
      ----------------------

Group: 20
----------
      Port-channels in the group:
      ---------------------

Port-channel: Po20    (Primary Aggregator)

------------

Age of the Port-channel   = 6d:14h:17m:27s
Logical slot/port   = 2/20          Number of ports = 1
HotStandBy port = Gi0/11
Port state          = Port-channel Ag-Inuse
Protocol            =   LACP
Fast-switchover     = enabled
Direct Load Swap    = disabled

Ports in the Port-channel:

Index   Load    Port      EC state        No of bits
------+------+--------+------------------+-----------
  0     00     Gi0/9      Active             0

Time since last port bundled:    0d:00h:09m:51s    Gi0/9
Time since last port Un-bundled: 0d:00h:09m:51s    Gi0/11

ME3800X-R3#show lacp internal
Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 20
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi0/9     FA      bndl      32768         0x14      0x14    0x10A       0x3F
Gi0/11    FA      hot-sby   32768         0x14      0x14    0x10C       0x7
```

```
ME3800X-R4#show etherchannel port-channel
      Channel-group listing:
      ----------------------

Group: 20
----------
      Port-channels in the group:
      ---------------------

Port-channel: Po20    (Primary Aggregator)

------------

Age of the Port-channel   = 6d:14h:24m:31s
Logical slot/port   = 2/20          Number of ports = 1
```

```
HotStandBy port = Gi0/11
Port state          = Port-channel Ag-Inuse
Protocol            =   LACP
Fast-switchover     = enabled
Direct Load Swap    = disabled

Ports in the Port-channel:

Index   Load    Port      EC state        No of bits
------+------+--------+------------------+-----------
  0     00     Gi0/9      Active             0

Time since last port bundled:    0d:00h:14m:02s    Gi0/9
Time since last port Un-bundled: 0d:00h:14m:02s    Gi0/9

ME3800X-R4#show lacp internal
Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 20
                            LACP port     Admin     Oper    Port        Port
Port      Flags   State     Priority      Key       Key     Number      State
Gi0/9     FA      bndl      32768         0x14      0x14    0x10A       0x3F
Gi0/11    FA      hot-sby   32768         0x14      0x14    0x10C       0x7
ME3800X-R4#
```

Quality of Service (QoS)

All QoS configuration on the ME 3800X and 3600X switches is Modular QoS CLI (MQC) compliant.Quality of service (QoS) on the ME 3800X and ME 3600X switches includes :

- Traffic classification
- Marking
- Policing
- Queuing, and Scheduling

For Ingress Service Policies, below items can be configured:

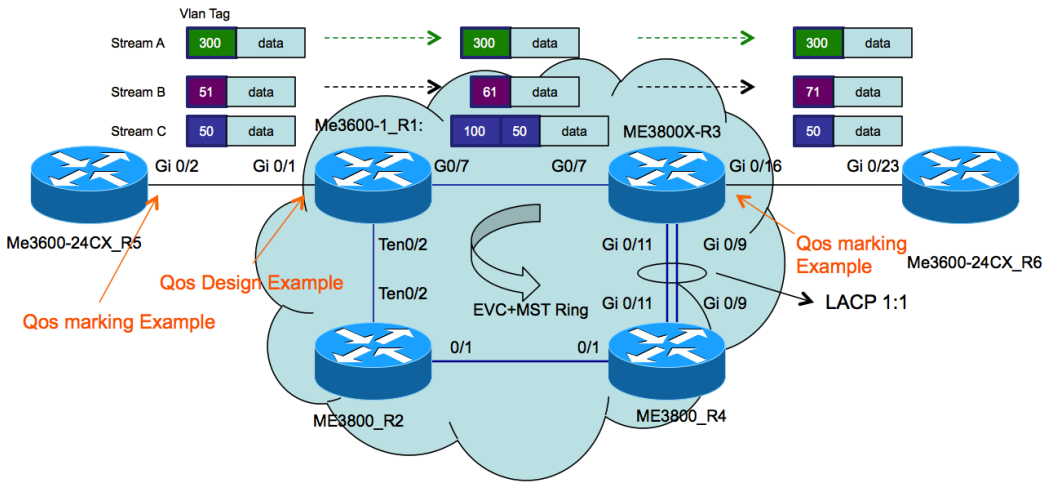
- Traffic Classification
- Marking
- Policing

For egress service policy, below items can be configured:

- Traffic Classification
- Marking
- Policing on the PQ
- Queuing
- Scheduling

Service policies can be attached to Routed ports,Regular Ethernet Flow Points (EFPs), Switchport Trunk mode , Switchport Access mode. Note: Service Polices can’t be attached to SVI interface.

In the Qos design example below, The Qos design example will focus on the Gi0/1 of R1. Meanwhile, Qos marking examples will be configured on R5(gi0/2) and R3 (gi0/16).



Traffic from R5 to R1 will include three streams , they are voice/video/data. Below table lists the COS value and vlan Tag for each steams.

streams	Vlan Tag	COS value
Voice stream	Vlan 50	5
Video stream	Vlan 51	4
Data stream	Vlan 300	1

To make the traffic from R5 includes the correct COS value, below Configuration are applied on R5 for the COS marking:

```
class-map match-all data
 match vlan  300
class-map match-all video
 match vlan  51
class-map match-all voice
 match vlan  50
!
policy-map vlan_video
 class class-default
  set cos 4
policy-map vlan_voice
 class class-default
```

```
  set cos 5
policy-map vlan_data
 class class-default
  set cos 1
policy-map vlan_port
 class voice
   service-policy vlan_voice
 class video
   service-policy vlan_video
 class data
   service-policy vlan_data


interface GigabitEthernet0/2
 switchport trunk allowed vlan 50,51,300
 switchport mode trunk
 media-type rj45
 service-policy output vlan_port
```

For the traffic stream from R6 to R3, similar configuration can be applied on R6 in order to make sure the COS value is set. Or another alternative way is to set the COS value on R3 gi0/16 for the incoming traffic. Below is the example for set the COS value on R3:

```
policy-map voice
 class class-default
  set cos 5
policy-map data
 class class-default
  set cos 1
policy-map video
 class class-default
  set cos 4

interface GigabitEthernet0/16
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 71 ethernet
  encapsulation dot1q 71
  rewrite ingress tag pop 1 symmetric
  service-policy input video
  bridge-domain 61
 !
 service instance 100 ethernet
  encapsulation dot1q 50
  rewrite ingress tag pop 1 symmetric
  service-policy input voice
  bridge-domain 100
 !
 service instance 300 ethernet
```

```
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  service-policy input data
  bridge-domain 300
ME3800X-R3#
```

For the R1 Giga 0/1 Qos egress design,

	Egress Queuing
Voice stream	25Mbps(priority Queue)
Video Stream	30Mbps
Data stream	25Mbps
Class Default	20Mbps

For ingress policing,

	Ingress policing
Voice stream	25Mbps
Video Stream	100Mbps
Data stream	100Mbps

Qos design example configuration on R1:

```
class-map match-any data
 match cos  1
class-map match-any video
 match cos  4
class-map match-any voice
 match cos  5
!
policy-map ingress_video
 class video
  police cir 100000000
policy-map ingress_voice
 class voice
  police cir 25000000
policy-map child
 class voice
  police cir 25000000
  priority
 class video
  bandwidth 30000
```

```
 class data
  bandwidth 25000
 class class-default
  bandwidth 20000
policy-map ingress_data
 class data
  police 100000000
policy-map parent
 class class-default
  shape average 100000000   //Shaping 100Mbps
   service-policy child

interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 service-policy output parent
 service instance 50 ethernet
  encapsulation dot1q 50
  rewrite ingress tag pop 1 symmetric
  service-policy input ingress_voice
  bridge-domain 100
 !
 service instance 51 ethernet
  encapsulation dot1q 51
  rewrite ingress tag pop 1 symmetric
  service-policy input ingress_video
  bridge-domain 61
 !
 service instance 300 ethernet
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  service-policy input ingress_data
  bridge-domain 300
```

Verification of QoS classification on R1:

```
Ping from the R5:

ME3600X-24CX-R5#ping 9.9.0.6 repeat 1000 // simulate voice stream
Type escape sequence to abort.
Sending 1000, 100-byte ICMP Echos to 9.9.0.6, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!(Skiped)
Success rate is 100 percent (1000/1000), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R5#ping 8.8.0.6 repeat 2000// simulate video stream
Type escape sequence to abort.
Sending 2000, 100-byte ICMP Echos to 8.8.0.6, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!(skiped)
Success rate is 100 percent (2000/2000), round-trip min/avg/max = 1/1/20 ms
ME3600X-24CX-R5#ping 7.7.0.6 repeat 3000 // simulate data stream
Type escape sequence to abort.
Sending 3000, 100-byte ICMP Echos to 7.7.0.6, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Success rate is 100 percent (3000/3000), round-trip min/avg/max = 1/1/36 ms
ME3600X-24CX-R5#


Verify on the R1:

ME3600X-R1#show policy-map interface gigabitEthernet 0/1
 GigabitEthernet0/1

  Service-policy output: parent

    Class-map: class-default (match-any)
      6000 packets, 736000 bytes
      5 minute offered rate 13000 bps, drop rate 0000 bps
      Match: any
  Traffic Shaping
    Average Rate Traffic Shaping
    Shape 100000 (kbps)
      Output Queue:
        Default Queue-limit 49152 bytes
        Tail Packets Drop: 0
        Tail Bytes Drop: 0

      Service-policy : child

        Class-map: voice (match-any)
          1000 packets, 126000 bytes  //classification works
          5 minute offered rate 0000 bps, drop rate 0000 bps
          Match: cos  5
          police:
            cir 25000000 bps, bc 781250 bytes
            conform-action transmit
            exceed-action drop
          conform: 1000 (packets) 122000 (bytes)
          exceed: 0 (packets) 0 (bytes)
          conform: 0 bps, exceed: 0 bps
          Strict Priority
          Queue-limit current-queue-depth 0 bytes
              Output Queue:
                Default Queue-limit 49152 bytes
```

```
                Tail Packets Drop: 0
                Tail Bytes Drop: 0

        Class-map: video (match-any)
          2000 packets, 244000 bytes  // classification works
          5 minute offered rate 0000 bps, drop rate 0000 bps
          Match: cos  4
          Bandwidth 30000 (kbps)
          Bandwidth Remaining 164108433 (percent)
          Queue-limit current-queue-depth 0 bytes
              Output Queue:
                Default Queue-limit 49152 bytes
                Tail Packets Drop: 0
                Tail Bytes Drop: 0

        Class-map: data (match-any)
          3000 packets, 366000 bytes  // classification works
          5 minute offered rate 3000 bps, drop rate 0000 bps
          Match: cos  1
          Bandwidth 25000 (kbps)
          Bandwidth Remaining 164108433 (percent)
          Queue-limit current-queue-depth 0 bytes
              Output Queue:
                Default Queue-limit 49152 bytes
                Tail Packets Drop: 0
                Tail Bytes Drop: 0

        Class-map: class-default (match-any)
          0 packets, 0 bytes
          5 minute offered rate 0000 bps, drop rate 0000 bps
          Match: any
          Bandwidth 20000 (kbps)
          Bandwidth Remaining 164108433 (percent)
          Queue-limit current-queue-depth 0 bytes
              Output Queue:
                Default Queue-limit 49152 bytes
                Tail Packets Drop: 0
                Tail Bytes Drop: 0
ME3600X-R1#
```

E-OAM (Operations Administration Maintenance)

Ethernet Operations, Administration, and Maintenance (OAM) is a protocol for installing, monitoring, and troubleshooting Ethernet networks to increase management capability within the context of the overall Ethernet infrastructure. The Cisco ME 3800X and ME 3600X switch supports

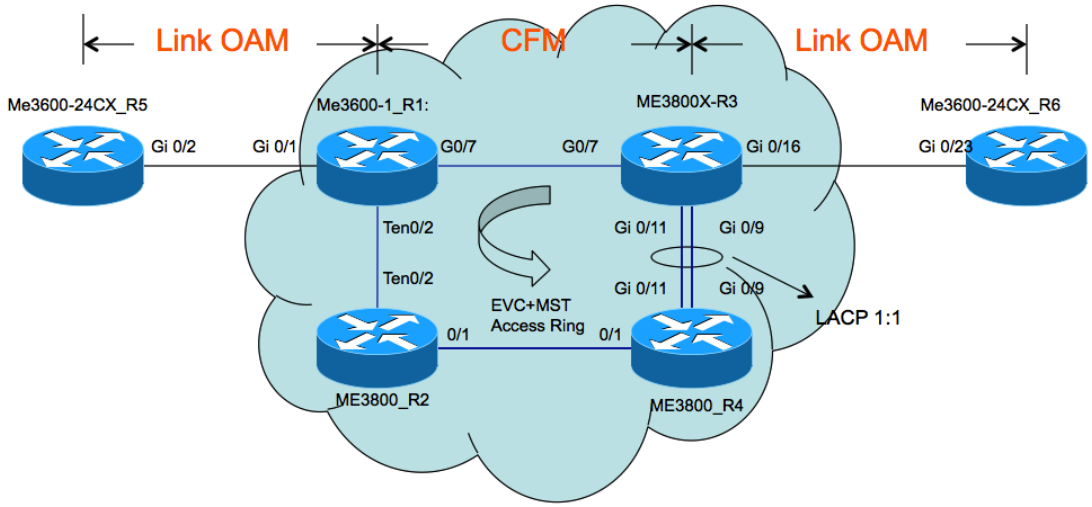
- IEEE 802.1ag Connectivity Fault Management (CFM),
- Ethernet Local Management Interface (E-LMI),
- IEEE 802.3ah Ethernet(link OAM)

In this example, Link OAM and CFM will be covered. E-LMI will be covered in other example.

Link OAM will be configured between R5 and R1; R3 and R6

CFM will be configured between R1 and R3.

Below is the topology for Link OAM and CFM.



Configuration on R5:

```
interface GigabitEthernet0/2
 switchport trunk allowed vlan 50,51,300
 switchport mode trunk
 media-type rj45
 ethernet oam remote-loopback supported //remote loopback is enabled for
LinkOAM
 ethernet oam    //Link OAM 802.3ah
 service-policy output vlan_port
```

Configuration on R1:

```
ethernet cfm ieee   // enable CFM
ethernet cfm global
ethernet cfm domain DOMAIN_LEVEL6 level 6
 service service_id_level6 evc EVC_Test300 vlan 300
  continuity-check
!
ethernet evc EVC_Test300
 oam protocol cfm svlan 300 domain DOMAIN_LEVEL6

interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 ethernet oam remote-loopback supported  // enable link OAM
 ethernet oam
 service-policy output parent
```

```
 service instance 50 ethernet
  encapsulation dot1q 50
  rewrite ingress tag pop 1 symmetric
  service-policy input ingress_voice
  bridge-domain 100
 !
 service instance 51 ethernet
  encapsulation dot1q 51
  rewrite ingress tag pop 1 symmetric
  service-policy input ingress_video
  bridge-domain 61
 !
 service instance 300 ethernet EVC_Test300
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  service-policy input ingress_data
  bridge-domain 300
   cfm mep domain DOMAIN_LEVEL6 mpid 1015  //Config Mpid point
```

Configuration on R3:

```
ethernet cfm ieee
ethernet cfm global
ethernet cfm domain DOMAIN_LEVEL6 level 6
 service service_id_level6 evc EVC_Test300 vlan 300
  continuity-check
!
ethernet evc EVC_Test300
 oam protocol cfm svlan 300 domain DOMAIN_LEVEL6

interface GigabitEthernet0/16
 switchport trunk allowed vlan none
 switchport mode trunk
 ethernet oam remote-loopback supported  //enable remote loopback
 ethernet oam    //enable link OAM
 service instance 71 ethernet
  encapsulation dot1q 71
  rewrite ingress tag pop 1 symmetric
  service-policy input video
  bridge-domain 61
 !
 service instance 100 ethernet
  encapsulation dot1q 50
  rewrite ingress tag pop 1 symmetric
  service-policy input voice
  bridge-domain 100
 !
 service instance 300 ethernet EVC_Test300
  encapsulation dot1q 300
  rewrite ingress tag pop 1 symmetric
  service-policy input data
  bridge-domain 300
   cfm mep domain DOMAIN_LEVEL6 mpid 1036  //Config mpid
```

Configuration on R6:

```
interface GigabitEthernet0/23
 switchport trunk allowed vlan 50,71,300
 switchport mode trunk
 ethernet oam remote-loopback supported
 ethernet oam
```

Verify Link OAM on R1:

```
    ME3600X-R1#show ethernet oam summary
Symbols:          * - Master Loopback State,  # - Slave Loopback
State
                  & - Error Block State
Capability codes: L - Link Monitor,  R - Remote Loopback
                  U - Unidirection,  V - Variable Retrieval

  Local                         Remote
Interface       MAC Address     OUI     Mode    Capability

  Gi0/1         6073.5ce3.4902 00000C active   L R

ME3600X-R1#show ethernet oam status
GigabitEthernet0/1
General
-------
  Admin state:           enabled
  Mode:                  active
  PDU max rate:          10 packets per second
  PDU min rate:          1 packet per 1000 ms
  Link timeout:          5000 ms
  High threshold action: no action
  Link fault action:     no action
  Dying gasp action:     no action
  Critical event action: no action

Link Monitoring
---------------
  Status: supported (on)

  Symbol Period Error
    Window:              100 x 1048576 symbols
    Low threshold:       1 error symbol(s)
    High threshold:      none

  Frame Error
    Window:              10 x 100 milliseconds
    Low threshold:       1 error frame(s)
    High threshold:      none

  Frame Period Error
    Window:              1000 x 10000 frames
    Low threshold:       1 error frame(s)
    High threshold:      none

  Frame Seconds Error
```

```
    Window:               100 x 100 milliseconds
    Low threshold:        1 error second(s)
    High threshold:       none

  Receive-Frame CRC Error
    Window:               10 x 100 milliseconds
    Low threshold:        10 error frame(s)
    High threshold:       none

  Transmit-Frame CRC Error: Not Supported

ME3600X-R1#
```

Verify CFM on R1:

```
ME3600X-R1#show ethernet cfm maintenance-points local
Local MEPs:
--------------------------------------------------------------------------------
MPID Domain Name                                    Lvl   MacAddress     Type  CC
Ofld Domain Id                                      Dir   Port           Id
     MA Name                                              SrvcInst       Source
     EVC name
--------------------------------------------------------------------------------
1015 DOMAIN_LEVEL6                                  6     0027.0cab.2f80 BD-V  Y
No   DOMAIN_LEVEL6                                  Up    Gi0/1          300
     service_id_level6                                    300            Static
     EVC_Test300

Total Local MEPs: 1

Local MIPs: None
ME3600X-R1#show ethernet cfm maintenance-points remote
--------------------------------------------------------------------------------
MPID  Domain Name                                    MacAddress          IfSt  PtSt
 Lvl  Domain ID                                      Ingress
 RDI  MA Name                                        Type Id             SrvcInst
      EVC Name                                                           Age
      Local MEP Info
--------------------------------------------------------------------------------
1036  DOMAIN_LEVEL6                                  f4ac.c1b8.ea80      Up    Up
 6    DOMAIN_LEVEL6                                  Gi0/7
 -    service_id_level6                              BD-V 300            300
      EVC_Test300                                                        9s
      MPID: 1015 Domain: DOMAIN_LEVEL6 MA: service_id_level6

Total Remote MEPs: 1
ME3600X-R1#

ME3600X-R1#show ethernet oam summary
Symbols:          * - Master Loopback State,  # - Slave Loopback State
                  & - Error Block State
Capability codes: L - Link Monitor,  R - Remote Loopback
                  U - Unidirection,  V - Variable Retrieval

  Local                          Remote
Interface       MAC Address     OUI    Mode    Capability
```

```
  Gi0/1          6073.5ce3.4902 00000C active   L R

ME3600X-R1#ping ethernet mpid 1036 domain DOMAIN_LEVEL6 vlan 300
Type escape sequence to abort.
Sending 5 Ethernet CFM loopback messages to f4ac.c1b8.ea80, timeout is 5
seconds:!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

ME3600X-R1#ping ethernet mpid 1036 domain DOMAIN_LEVEL6 service
service_id_level6
Type escape sequence to abort.
Sending 5 Ethernet CFM loopback messages to f4ac.c1b8.ea80, timeout is 5
seconds:!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Verify CFM on R3:

```
ME3800X-R3#show ethernet cfm maintenance-points local
Local MEPs:
--------------------------------------------------------------------------------
MPID Domain Name                                Lvl   MacAddress     Type  CC
Ofld Domain Id                                  Dir   Port           Id
     MA Name                                          SrvcInst       Source
     EVC name
--------------------------------------------------------------------------------
1036 DOMAIN_LEVEL6                              6     f4ac.c1b8.ea80 BD-V  Y
No   DOMAIN_LEVEL6                              Up    Gi0/16         300
     service_id_level6                                300            Static
     EVC_Test300

Total Local MEPs: 1

Local MIPs: None
ME3800X-R3#show ethernet cfm maintenance-points remote
--------------------------------------------------------------------------------
MPID  Domain Name                                MacAddress          IfSt  PtSt
 Lvl  Domain ID                                  Ingress
 RDI  MA Name                                    Type Id             SrvcInst
      EVC Name                                                       Age
      Local MEP Info
--------------------------------------------------------------------------------
1015  DOMAIN_LEVEL6                              0027.0cab.2f80      Up    Up
 6    DOMAIN_LEVEL6                              Gi0/7
 -    service_id_level6                          BD-V 300            300
      EVC_Test300                                                    5s
      MPID: 1036 Domain: DOMAIN_LEVEL6 MA: service_id_level6

Total Remote MEPs: 1
ME3800X-R3#

ME3800X-R3#show ethernet oam summary
Symbols:          * - Master Loopback State,  # - Slave Loopback State
                  & - Error Block State
Capability codes: L - Link Monitor,  R - Remote Loopback
                  U - Unidirection,  V - Variable Retrieval
```

```
  Local                          Remote
Interface       MAC Address    OUI    Mode    Capability

  Gi0/16        e4d3.f12b.f717 00000C active   L R

ME3800X-R3#show ethernet oam status
GigabitEthernet0/16
General
-------
  Admin state:           enabled
  Mode:                  active
  PDU max rate:          10 packets per second
  PDU min rate:          1 packet per 1000 ms
  Link timeout:          5000 ms
  High threshold action: no action
  Link fault action:     no action
  Dying gasp action:     no action
  Critical event action: no action

Link Monitoring
---------------
  Status: supported (on)

  Symbol Period Error
    Window:              100 x 1048576 symbols
    Low threshold:       1 error symbol(s)
    High threshold:      none

  Frame Error
    Window:              10 x 100 milliseconds
    Low threshold:       1 error frame(s)
    High threshold:      none

  Frame Period Error
    Window:              1000 x 10000 frames
    Low threshold:       1 error frame(s)
    High threshold:      none

  Frame Seconds Error
    Window:              100 x 100 milliseconds
    Low threshold:       1 error second(s)
    High threshold:      none

  Receive-Frame CRC Error
    Window:              10 x 100 milliseconds
    Low threshold:       10 error frame(s)
    High threshold:      none

  Transmit-Frame CRC Error: Not Supported

ME3800X-R3#
```

Verify CFM on R6:

```
ME3600X-24CX-R6#show ethernet oam discovery
GigabitEthernet0/23
Local client
------------
  Administrative configurations:
    Mode:               active
    Unidirection:       not supported
    Link monitor:       supported (on)
    Remote loopback:    supported
    MIB retrieval:      not supported
    Mtu size:           1500

  Operational status:
    Port status:        operational
    Loopback status:    no loopback
    PDU revision:       0

Remote client
-------------
  MAC address: f4ac.c1b8.ea90
  Vendor(oui): 00000C(cisco)

  Administrative configurations:
    PDU revision:       7
    Mode:               active
    Unidirection:       not supported
    Link monitor:       supported
    Remote loopback:    supported
    MIB retrieval:      not supported
    Mtu size:           1500

ME3600X-24CX-R6#show ethernet oam summary
Symbols:          * - Master Loopback State,  # - Slave Loopback
State
                  & - Error Block State
Capability codes: L - Link Monitor,  R - Remote Loopback
                  U - Unidirection,  V - Variable Retrieval

  Local                         Remote
Interface       MAC Address     OUI     Mode    Capability

  Gi0/23        f4ac.c1b8.ea90 00000C active   L R

ME3600X-24CX-R6#
```

Shutdown the interface on R6 , Verify the CFM status on R1

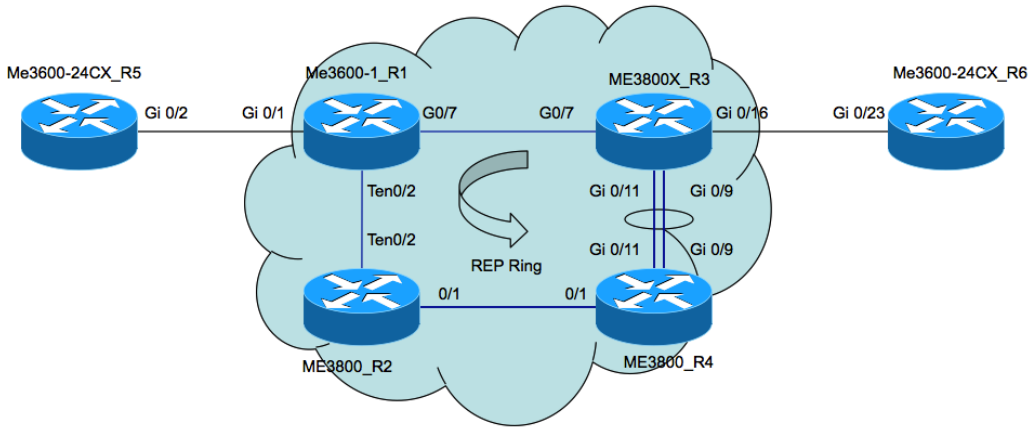
```
ME3600X-24CX-R6(config)#interface gigabitEthernet 0/23
ME3600X-24CX-R6(config-if)#shutdown

ME3600X-R1#
ME3600X-R1#
*Jun  8 21:25:50.064: %ETHER_SERVICE-6-EVC_STATUS_CHANGED: status of EVC_Test300
changed to InActive
ME3600X-R1#
ME3600X-R1#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
MPID  Domain Name                                   MacAddress          IfSt  PtSt
 Lvl  Domain ID                                     Ingress
 RDI  MA Name                                       Type Id             SrvcInst
      EVC Name                                                         Age
      Local MEP Info
-------------------------------------------------------------------------------
1036  DOMAIN_LEVEL6                                 f4ac.c1b8.ea80      Down  Up
 6    DOMAIN_LEVEL6                                 Gi0/7
 -    service_id_level6                             BD-V 300            300
      EVC_Test300                                                       2s
      MPID: 1015 Domain: DOMAIN_LEVEL6 MA: service_id_level6

Total Remote MEPs: 1
ME3600X-R1#

// no shutdown the interface of R6
ME3600X-24CX-R6(config)#interface gigabitEthernet 0/23
ME3600X-24CX-R6(config-if)#no shutdown

ME3600X-R1#
*Jun  8 21:27:52.828: %ETHER_SERVICE-6-EVC_STATUS_CHANGED: status of EVC_Test300
changed to Active
ME3600X-R1#

ME3600X-R1#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
MPID  Domain Name                                   MacAddress          IfSt  PtSt
 Lvl  Domain ID                                     Ingress
 RDI  MA Name                                       Type Id             SrvcInst
      EVC Name                                                         Age
      Local MEP Info
-------------------------------------------------------------------------------
1036  DOMAIN_LEVEL6                                 f4ac.c1b8.ea80      Up    Up
 6    DOMAIN_LEVEL6                                 Gi0/7
 -    service_id_level6                             BD-V 300            300
      EVC_Test300                                                       5s
      MPID: 1015 Domain: DOMAIN_LEVEL6 MA: service_id_level6

Total Remote MEPs: 1
ME3600X-R1#
```

Verify the Remote Loopback function:

```
(1) on R6 ,start the OAM Loopback
ME3600X-24CX-R6#ethernet oam remote-loopback start interface gigabitEthernet
0/23
ME3600X-24CX-R6#

(2) On R1 router, the interface status become "Test"
ME3600X-R1#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
MPID  Domain Name                                MacAddress          IfSt  PtSt
 Lvl  Domain ID                                  Ingress
 RDI  MA Name                                    Type Id             SrvcInst
      EVC Name                                                       Age
      Local MEP Info
-------------------------------------------------------------------------------
1036  DOMAIN_LEVEL6                              f4ac.c1b8.ea80      Test  Up
 6    DOMAIN_LEVEL6                              Gi0/7
 -    service_id_level6                          BD-V 300            300
      EVC_Test300                                                    3s
      MPID: 1015 Domain: DOMAIN_LEVEL6 MA: service_id_level6

Total Remote MEPs: 1
ME3600X-R1#
```

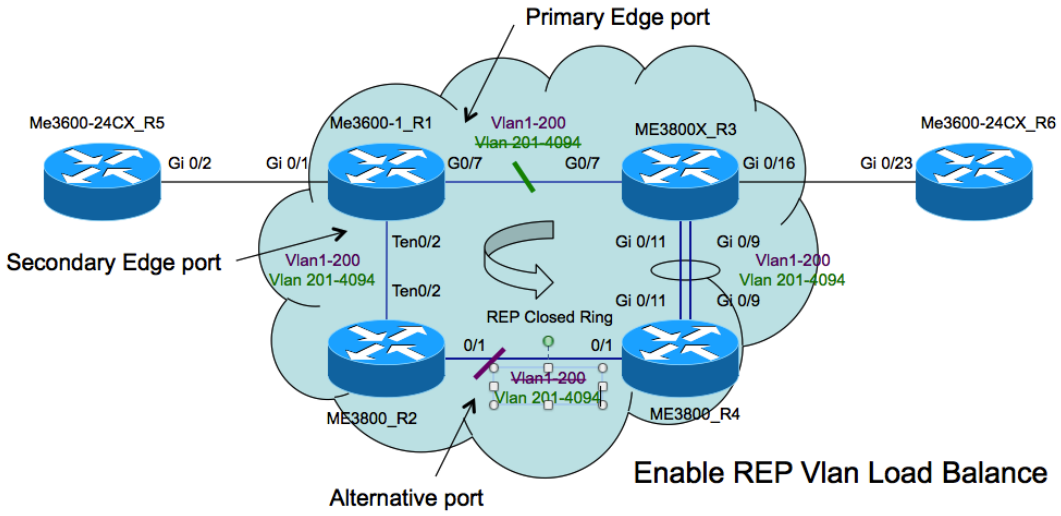
Design Example(B)—REP+Etherchannel + VPLS+ IGMP Snooping

In this example , R1, R2, R3, AND R4 will be in one REP ring. Below is the topology.



Resilient Ethernet Protocol (REP)

The Resilient Ethernet Protocol (REP) is a Cisco proprietary protocol that provides an alternative to the Spanning Tree Protocol (STP). REP provides a way to control network loops, handle link failures, and improve convergence time.



R1, R2, R3, and R4 will be a closed REP ring, see the following table for the REP design requirement.

REP	Routers

REP Primary Edge port	R1 gi0/7
REP Secondary Edge port	R1 Ten 0/2
REP Preferred Alternate Port	R2 Gi 0/1
REP Vlan load balance	Vlan 1-200 blocked at Alt port vlan 201-4094 blocked at primary Edge port

R1 configuration :

```
interface GigabitEthernet0/7
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10 edge primary  //primary edge port
 rep preempt delay 15              // delay 15 second for the preempt.
 rep block port preferred vlan 1-200  //preferred port block vlan 1-
200

interface TenGigabitEthernet0/2
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10 edge
```

Important: You cannot configure REP on interfaces that are configured with EVC service instances.

R2 configuration :

```
R2 configuration:

interface TenGigabitEthernet0/2
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10

interface GigabitEthernet0/1
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10 preferred   //alternate port
```

R3 configuration :

```
interface GigabitEthernet0/7
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10

interface GigabitEthernet0/9
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 channel-group 20 mode on
!
interface GigabitEthernet0/10
!
interface GigabitEthernet0/11
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
```

```
 channel-group 20 mode on

interface Port-channel20
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10
```

R4 configuration :

```
interface GigabitEthernet0/1
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10

interface GigabitEthernet0/9
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 channel-group 20 mode on
!
interface GigabitEthernet0/11
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 channel-group 20 mode on
interface Port-channel20
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10
```

Verify REP topology status:

```
ME3600X-R1#show rep topology
REP Segment 10
BridgeName       PortName   Edge Role
---------------- ---------- ---- ----
ME3600X-R1       Gi0/7      Pri  Alt
ME3800X-R3       Gi0/7           Open
ME3800X-R3       Po20            Open
ME3800X-R4       Po20            Open
ME3800X-R4       Gi0/1           Open
ME3800X-R2       Gi0/1           Alt
ME3800X-R2       Te0/2           Open
ME3600X-R1       Te0/2      Sec  Open

ME3600X-R1#sh interfaces gigabitEthernet 0/7 rep  detail
GigabitEthernet0/7   REP enabled
Segment-id: 10 (Primary Edge)
PortID: 000700270CAB2F80
Preferred flag: No
Operational Link Status: TWO_WAY
Current Key: 000100270CAB46809BD3
Port Role: Alternate
Blocked VLAN: 201-4094
Admin-vlan: 1
Preempt Delay Timer: 15 sec
```

```
LSL Ageout Timer: 5000 ms
LSL Ageout Retries: 5
Configured Load-balancing Block Port: prefer
Configured Load-balancing Block VLAN: 1-200
STCN Propagate to: none
LSL PDU rx: 25561, tx: 22931
HFL PDU rx: 3, tx: 3
BPA TLV rx: 13909, tx: 13508
BPA (STCN, LSL) TLV rx: 0, tx: 0
BPA (STCN, HFL) TLV rx: 0, tx: 0
EPA-ELECTION TLV rx: 34, tx: 31
EPA-COMMAND TLV rx: 2, tx: 2
EPA-INFO TLV rx: 3289, tx: 3489

ME3600X-R1#

ME3800X-R2#sh interfaces gigabitEthernet 0/1 rep  detail
GigabitEthernet0/1   REP enabled
Segment-id: 10 (Preferred)
PortID: 000100270CAB4680
Preferred flag: Yes
Operational Link Status: TWO_WAY
Current Key: 000100270CAB46809BD3
Port Role: Alternate
Blocked VLAN: 1-200
Admin-vlan: 1
Preempt Delay Timer: disabled
LSL Ageout Timer: 5000 ms
LSL Ageout Retries: 5
Configured Load-balancing Block Port: none
Configured Load-balancing Block VLAN: none
STCN Propagate to: none
LSL PDU rx: 14683, tx: 12497
HFL PDU rx: 2, tx: 2
BPA TLV rx: 12790, tx: 6545
BPA (STCN, LSL) TLV rx: 0, tx: 0
BPA (STCN, HFL) TLV rx: 0, tx: 0
EPA-ELECTION TLV rx: 6, tx: 7
EPA-COMMAND TLV rx: 2, tx: 2
EPA-INFO TLV rx: 1641, tx: 1641

ME3800X-R2#
```

EtherChannel (Ethernet Channel)

EtherChannels have automatic configuration with either Port Aggregation Protocol (PAgP) or Link Aggregation Control Protocol (LACP). PAgP is a Cisco-proprietary protocol that you can only run on Cisco switches and on those switches that licensed vendors license to support PAgP. IEEE 802.3ad defines LACP. LACP allows Cisco switches to manage Ethernet channels between switches that conform to the 802.3ad protocol.

In this example, The EtherChannel “on” mode will be used.

EtherChannel on mode can be used to manually configure an EtherChannel. The on mode forces a port to join an EtherChannel without negotiations

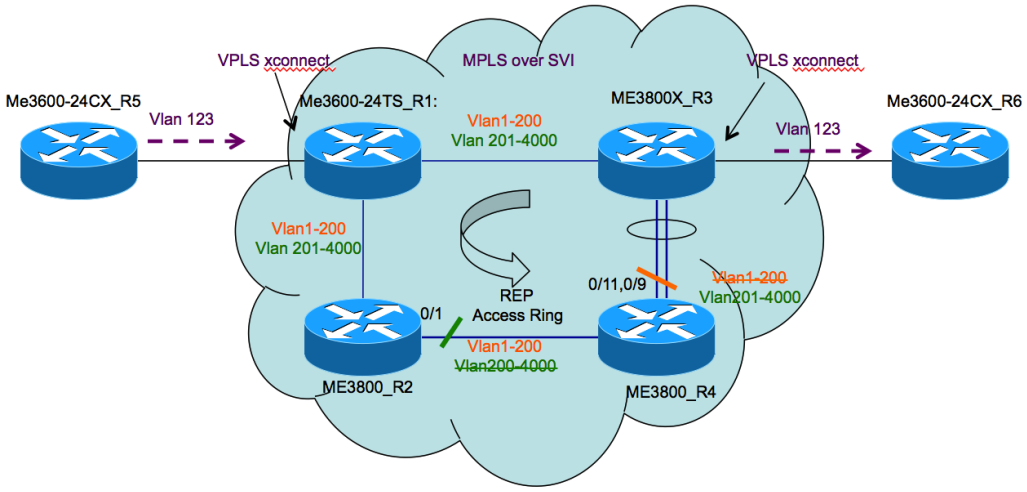
Configuration example on R3 and R4:

```
R3:

interface GigabitEthernet0/9
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 channel-group 20 mode on
interface GigabitEthernet0/11
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 channel-group 20 mode on
interface Port-channel20
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10

R4:
interface GigabitEthernet0/9
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 channel-group 20 mode on
!
interface GigabitEthernet0/11
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 channel-group 20 mode on

interface Port-channel20
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10

Verify on R3:

ME3800X-R4#show etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
```

```
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------
-----------
20     Po20(SU)         -        Gi0/9(P)    Gi0/11(P)
```

Virtual Private LAN Services (VPLS)

Virtual Private LAN Services (VPLS) is a class of VPN that supports the connection of multiple sites in a single bridged domain over a managed IP/MPLS network. In this example, MPLS will be enabled on SVI interface of R1 and R3, VPLS will be setup between R1 and R3. R5 can ping R6 via the VPLS network (R1, R2, R3, and R4).



Configuration R1:

```
Configuration R1:

interface GigabitEthernet0/7
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10 edge primary
 rep preempt delay 15
 rep block port preferred vlan 1-200

interface Vlan300
 ip address 13.13.13.1 255.255.255.0
 mpls ip
!
router ospf 1234
 router-id 1.1.1.1
```

```
 network 1.1.1.1 0.0.0.0 area 0
 network 13.13.13.0 0.0.0.255 area 0
!

l2 vfi vpls manual
 vpn id 123
 neighbor 3.3.3.3 encapsulation mpls

interface GigabitEthernet0/1
 switchport trunk allowed vlan 123
 switchport mode trunk

interface Vlan123
 no ip address
 xconnect vfi vpls

ME3600X-R1#show mpls ldp neighbor
    Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 1.1.1.1:0
   TCP connection: 3.3.3.3.45140 - 1.1.1.1.646
   State: Oper; Msgs sent/rcvd: 62/60; Downstream
   Up time: 00:44:19
   LDP discovery sources:
     Vlan300, Src IP addr: 13.13.13.3
     Targeted Hello 1.1.1.1 -> 3.3.3.3, active, passive
        Addresses bound to peer LDP Ident:
          10.74.13.163    13.13.13.3      3.3.3.3
ME3600X-R1#

ME3600X-R1#show mpls l2transport vc

Local intf     Local circuit              Dest address    VC ID
Status
-------------  -------------------------- --------------- ----------
----------
VFI vpls       vfi                        3.3.3.3         123
UP
```

Configuration R3:

```
Configuration R3:


interface GigabitEthernet0/7
 switchport trunk allowed vlan 50,100,300
 switchport mode trunk
 rep segment 10

interface GigabitEthernet0/16
 switchport trunk allowed vlan 123
 switchport mode trunk

l2 vfi vpls manual
 vpn id 123
 neighbor 1.1.1.1 encapsulation mpls
```

```
interface Vlan123
 no ip address
 xconnect vfi vpls
!
interface Vlan300
 ip address 13.13.13.3 255.255.255.0
 mpls ip
!
router ospf 1234
 router-id 3.3.3.3
 network 3.3.3.3 0.0.0.0 area 0
 network 13.13.13.0 0.0.0.255 area 0

ME3800X-R3#show mpls l2transport vc

Local intf     Local circuit              Dest address    VC ID
Status
-------------  -------------------------- --------------- ----------
----------
VFI vpls       vfi                        1.1.1.1         123
UP

ME3800X-R3#show mpls ldp neighbor
    Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 3.3.3.3:0
   TCP connection: 1.1.1.1.646 - 3.3.3.3.45140
   State: Oper; Msgs sent/rcvd: 63/64; Downstream
   Up time: 00:46:26
   LDP discovery sources:
     Vlan300, Src IP addr: 13.13.13.1
     Targeted Hello 3.3.3.3 -> 1.1.1.1, active, passive
        Addresses bound to peer LDP Ident:
          10.74.13.161    13.13.13.1      1.1.1.1
ME3800X-R3#
```

Configuration on R5 and R6

```
Configuraiton on R5:

interface GigabitEthernet0/2
 switchport trunk allowed vlan 123
 switchport mode trunk
 media-type rj45

interface Vlan123
 ip address 9.9.0.5 255.255.255.0

ME3600X-24CX-R5#PING 9.9.0.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 9.9.0.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R5#

Configuraiton on R6:
```

```
interface GigabitEthernet0/23
 switchport trunk allowed vlan 123
 switchport mode trunk

interface Vlan123
 ip address 9.9.0.6 255.255.255.0

ME3600X-24CX-R6#ping 9.9.0.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 9.9.0.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R6#
```

IGMP Snooping

Cisco ME3600X can use IGMP snooping to constrain the flooding of multicast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast devices

Configuration on R1:

```
ME3600X-R1(config)#ip igmp snooping vlan 50  //enable vlan 50 for
igmp snooping
ME3600X-R1(config)#no ip igmp snooping vlan 100 //disable vlan 100
for igmp snooping
ME3600X-R1(config)#
ME3600X-R1(config)#
ME3600X-R1(config)#end
ME3600X-R1#show ip igmp snooping
Global IGMP Snooping configuration:
-------------------------------------------
IGMP snooping Oper State     : Enabled
IGMPv3 snooping (minimal)    : Enabled
Report suppression           : Enabled
TCN solicit query            : Disabled
TCN flood query count        : 2
Robustness variable          : 2
Last member query count      : 2
Last member query interval   : 1000
Check TTL=1                  : No
Check Router-Alert-Option    : No

Vlan 1:
--------
IGMP snooping Admin State          : Enabled
IGMP snooping Oper State           : Enabled
IGMPv2 immediate leave             : Disabled
Report suppression                 : Enabled
Robustness variable                : 2
Last member query count            : 2
Last member query interval         : 1000
```

```
Check TTL=1                          : Yes
Check Router-Alert-Option            : Yes

Vlan 50:
--------
IGMP snooping Admin State            : Enabled
IGMP snooping Oper State             : Enabled
IGMPv2 immediate leave               : Disabled
Report suppression                   : Enabled
Robustness variable                  : 2
Last member query count              : 2
Last member query interval           : 1000
Check TTL=1                          : Yes
Check Router-Alert-Option            : Yes


Vlan 100:
--------
IGMP snooping Admin State            : Disabled
IGMP snooping Oper State             : Disabled
IGMPv2 immediate leave               : Disabled
Report suppression                   : Enabled
Robustness variable                  : 2
Last member query count              : 2
Last member query interval           : 1000
Check TTL=1                          : Yes
Check Router-Alert-Option            : Yes

ME3600X-R1#
```

Design Example(C)—G.8032+OAM

G.8032 (Ethernet Ring Protection Switching)

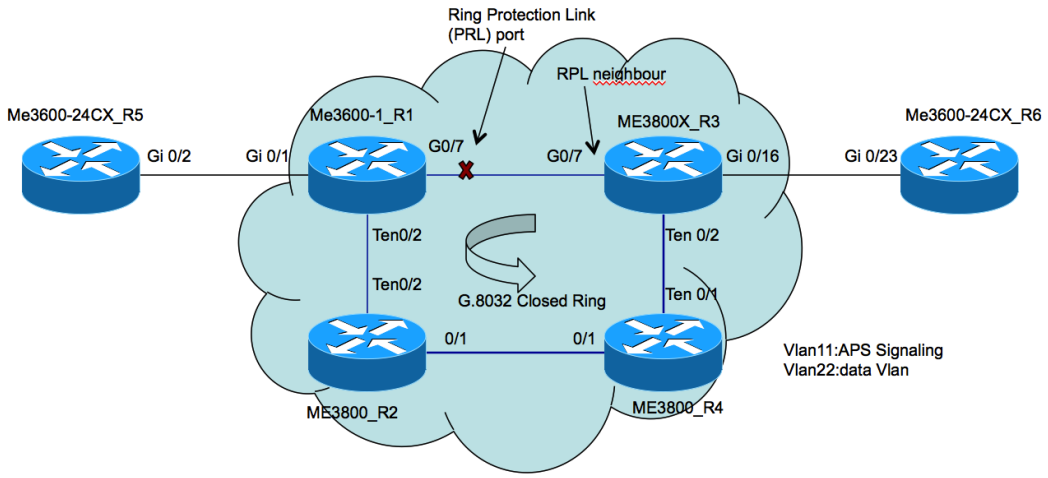
The ITU-T G.8032 Ethernet Ring Protection Switching feature implements protection switching mechanisms for Ethernet layer ring topologies. This feature uses the G.8032 Ethernet Ring Protection (ERP) protocol, defined in ITU-T G.8032, to provide protection for Ethernet traffic in a ring topology, while ensuring that no loops are within the ring at the Ethernet layer.

G.8032 provide fast convergence.

In this example, R1, R2, R3, AND R4 will be in a G.8032 closed ring. R1 g0/7 will be the Ring protection Link port. The G0/7 of R3 will be the RPL neighbor port.

Vlan 11 will be used for the APS signaling

Vlan 22 is the customer's data vlan.



Configuration on R1:

```
Configuration on R1:
vlan 11,22
ethernet cfm ieee
ethernet cfm global
ethernet cfm domain domain1 level 5
 service service1 evc evc1 vlan 11 direction down
  continuity-check
  continuity-check interval 1s  // currently  this interval can't
less than 1s.
  efd notify g8032    //notify the G.8032 module
!
```

```
!
ethernet ring g8032 profile profile1
 timer wtr 1       //wait to restore timer
 timer guard 10
!
ethernet ring g8032 test1
 port0 interface GigabitEthernet0/7
  monitor service instance 1
 port1 interface TenGigabitEthernet0/2
  monitor service instance 1
 instance 1
  profile profile1
  rpl port0 owner
  inclusion-list vlan-ids 11,22  // vlan 11 is for APS Signaling,vlan
22 is the customer's data
  aps-channel
   port0 service instance 1
   port1 service instance 1
  !
 !
ethernet evc evc1

! interface GigabitEthernet0/7
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet evc1
  encapsulation dot1q 11
  bridge-domain 11
  cfm mep domain domain1 mpid 1
 !
 service instance 2 ethernet
  encapsulation dot1q 22
  rewrite ingress tag pop 1 symmetric
  bridge-domain 22
 !
interface TenGigabitEthernet0/2
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet evc1
  encapsulation dot1q 11
  bridge-domain 11
  cfm mep domain domain1 mpid 2
 !
 service instance 2 ethernet
  encapsulation dot1q 22
  rewrite ingress tag pop 1 symmetric
  bridge-domain 22
 !
!

interface Vlan22
 ip address 9.9.0.1 255.255.255.0
```

Configuration on R2:

```
ethernet cfm ieee
ethernet cfm global
ethernet cfm domain domain1 level 5
 service service1 evc evc1 vlan 11 direction down
   continuity-check
   continuity-check interval 1s
   efd notify g8032
!
!
ethernet ring g8032 profile profile1
 timer wtr 1
 timer guard 10
!
ethernet ring g8032 test1
 port0 interface GigabitEthernet0/1
  monitor service instance 1
 port1 interface TenGigabitEthernet0/2
  monitor service instance 1
 instance 1
  profile profile1
  inclusion-list vlan-ids 11,22
  aps-channel
   port0 service instance 1
   port1 service instance 1

ethernet evc evc1

vlan 11,22

interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet evc1
  encapsulation dot1q 11
  bridge-domain 11
  cfm mep domain domain1 mpid 3
 !
 service instance 2 ethernet
  encapsulation dot1q 22
  rewrite ingress tag pop 1 symmetric
  bridge-domain 22
 !
interface TenGigabitEthernet0/2
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet evc1
  encapsulation dot1q 11
  bridge-domain 11
  cfm mep domain domain1 mpid 4
 !
 service instance 2 ethernet
  encapsulation dot1q 22
  rewrite ingress tag pop 1 symmetric
  bridge-domain 22
 !
!
```

```
interface Vlan22
 ip address 9.9.0.2 255.255.255.0
```

Configuration on R3:

```
ethernet cfm ieee
ethernet cfm global
ethernet cfm domain domain1 level 5
 service service1 evc evc1 vlan 11 direction down
  continuity-check
  continuity-check interval 1s
  efd notify g8032
!
!
ethernet ring g8032 profile profile1
 timer wtr 1
 timer guard 10
!
ethernet ring g8032 test1
 port0 interface GigabitEthernet0/7
  monitor service instance 1
 port1 interface TenGigabitEthernet0/2
  monitor service instance 1
 instance 1
  profile profile1
  rpl port0 neighbor
  inclusion-list vlan-ids 11,22
  aps-channel
   port0 service instance 1
   port1 service instance 1
  !
 !
!
ethernet evc evc1
!
vlan 11,22

interface GigabitEthernet0/7
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet evc1
  encapsulation dot1q 11
  bridge-domain 11
  cfm mep domain domain1 mpid 5
 !
 service instance 2 ethernet
  encapsulation dot1q 22
  rewrite ingress tag pop 1 symmetric
  bridge-domain 22
 !
interface TenGigabitEthernet0/2
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet evc1
  encapsulation dot1q 11
```

```
  bridge-domain 11
  cfm mep domain domain1 mpid 6
 !
 service instance 2 ethernet
  encapsulation dot1q 22
  rewrite ingress tag pop 1 symmetric
  bridge-domain 22
 !
interface Vlan22
 ip address 9.9.0.3 255.255.255.0
```

Configuration on R4:

```
ethernet cfm ieee
ethernet cfm global
ethernet cfm domain domain1 level 5
 service service1 evc evc1 vlan 11 direction down
  continuity-check
  continuity-check interval 1s
  efd notify g8032
!
!
ethernet ring g8032 profile profile1
 timer wtr 1
 timer guard 10
!
ethernet ring g8032 test1
 port0 interface GigabitEthernet0/1
  monitor service instance 1
 port1 interface TenGigabitEthernet0/1
  monitor service instance 1
 instance 1
  profile profile1
  inclusion-list vlan-ids 11,22
  aps-channel
   port0 service instance 1
   port1 service instance 1
  !
 !
!
ethernet evc evc1
vlan 11,22


interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet evc1
  encapsulation dot1q 11
  bridge-domain 11
  cfm mep domain domain1 mpid 7
 !
 service instance 2 ethernet
  encapsulation dot1q 22
  rewrite ingress tag pop 1 symmetric
  bridge-domain 22
```

```
 !
interface TenGigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet evc1
  encapsulation dot1q 11
  bridge-domain 11
  cfm mep domain domain1 mpid 8
 !
 service instance 2 ethernet
  encapsulation dot1q 22
  rewrite ingress tag pop 1 symmetric
  bridge-domain 22

interface Vlan22
 ip address 9.9.0.4 255.255.255.0
```

Verifying the G.8032 Ring status:

```
ME3600X-R1#show ethernet ring g8032 brief
R: Interface is the RPL-link
F: Interface is faulty
B: Interface is blocked
FS: Local forced switch
MS: Local manual switch

RingName                          Inst NodeType  NodeState     Port0     Port1
-------------------------------------------------------------------------------
--
test1                             1    Owner     Idle          R,B
ME3600X-R1#

ME3600X-R1#show ethernet ring g8032 status
Ethernet ring test1 instance 1 is RPL Owner node in Idle State
 Port0: GigabitEthernet0/7 (Monitor: Service Instance 1)
  APS-Channel: GigabitEthernet0/7
  Status: RPL, blocked
  Remote R-APS NodeId: 0000.0000.0000, BPR: 0
 Port1: TenGigabitEthernet0/2 (Monitor: Service Instance 1)
  APS-Channel: TenGigabitEthernet0/2
  Status: Non-RPL
  Remote R-APS NodeId: 0000.0000.0000, BPR: 0
 APS Level: 7
 Profile: profile1
  WTR interval: 1 minutes
  Guard interval: 10 milliseconds
  HoldOffTimer: 0 seconds
  Revertive mode

ME3600X-R1#show ethernet ring g8032 port status
 Port: GigabitEthernet0/7
 Ring: test1
    Block vlan list: 11,22
    Unblock vlan list:
    REQ/ACK: 5/5
    Instance 1 is in Blocked state
```

```
 Port: TenGigabitEthernet0/2
 Ring: test1
    Block vlan list:
    Unblock vlan list: 11,22
    REQ/ACK: 1/1
    Instance 1 is in Unblocked state



ME3800X-R2#show ethernet ring g8032 brief
R: Interface is the RPL-link
F: Interface is faulty
B: Interface is blocked
FS: Local forced switch
MS: Local manual switch

RingName                          Inst NodeType  NodeState     Port0    Port1
--------------------------------------------------------------------------------
--
test1                             1    Normal    Idle
ME3800X-R2#

ME3800X-R2#show ethernet ring g8032 status
Ethernet ring test1 instance 1 is Normal Node node in Idle State
 Port0: GigabitEthernet0/1 (Monitor: Service Instance 1)
  APS-Channel: GigabitEthernet0/1
  Status: Non-RPL
  Remote R-APS NodeId: 0000.0000.0000, BPR: 0
 Port1: TenGigabitEthernet0/2 (Monitor: Service Instance 1)
  APS-Channel: TenGigabitEthernet0/2
  Status: Non-RPL
  Remote R-APS NodeId: 0027.0cab.2f80, BPR: 0
 APS Level: 7
 Profile: profile1
  WTR interval: 1 minutes
  Guard interval: 10 milliseconds
  HoldOffTimer: 0 seconds
  Revertive mode

ME3800X-R2#
ME3800X-R2#show ethernet ring g8032 port status
 Port: GigabitEthernet0/1
 Ring: test1
    Block vlan list:
    Unblock vlan list: 11,22
    REQ/ACK: 4/4
    Instance 1 is in Unblocked state

 Port: TenGigabitEthernet0/2
 Ring: test1
    Block vlan list:
    Unblock vlan list: 11,22
    REQ/ACK: 1/1
    Instance 1 is in Unblocked state



ME3800X-R3#show ethernet ring g8032 brief
R: Interface is the RPL-link
```

```
F: Interface is faulty
B: Interface is blocked
FS: Local forced switch
MS: Local manual switch

RingName                          Inst NodeType  NodeState     Port0    Port1
-------------------------------------------------------------------------------
--
test1                             1    Neighbor  Idle          R,B

ME3800X-R3#show ethernet ring g8032 status
Ethernet ring test1 instance 1 is RPL Neighbor node in Idle State
 Port0: GigabitEthernet0/7 (Monitor: Service Instance 1)
  APS-Channel: GigabitEthernet0/7
  Status: RPL, blocked
  Remote R-APS NodeId: 0027.0cab.2f80, BPR: 0
 Port1: TenGigabitEthernet0/2 (Monitor: Service Instance 1)
  APS-Channel: TenGigabitEthernet0/2
  Status: Non-RPL
  Remote R-APS NodeId: 0027.0cab.2f80, BPR: 0
 APS Level: 7
 Profile: profile1
  WTR interval: 1 minutes
  Guard interval: 10 milliseconds
  HoldOffTimer: 0 seconds
  Revertive mode

ME3800X-R3#show ethernet ring g8032 port status
 Port: GigabitEthernet0/7
 Ring: test1
    Block vlan list: 11,22
    Unblock vlan list:
    REQ/ACK: 1/1
    Instance 1 is in Blocked state

 Port: TenGigabitEthernet0/2
 Ring: test1
    Block vlan list:
    Unblock vlan list: 11,22
    REQ/ACK: 3/3
    Instance 1 is in Unblocked state

ME3800X-R3#

ME3800X-R4#show ethernet ring g8032 status
Ethernet ring test1 instance 1 is Normal Node node in Idle State
 Port0: GigabitEthernet0/1 (Monitor: Service Instance 1)
  APS-Channel: GigabitEthernet0/1
  Status: Non-RPL
  Remote R-APS NodeId: 0027.0cab.2f80, BPR: 0
 Port1: TenGigabitEthernet0/1 (Monitor: Service Instance 1)
  APS-Channel: TenGigabitEthernet0/1
  Status: Non-RPL
  Remote R-APS NodeId: 0000.0000.0000, BPR: 0
 APS Level: 7
 Profile: profile1
  WTR interval: 1 minutes
  Guard interval: 10 milliseconds
  HoldOffTimer: 0 seconds
```

```
  Revertive mode

ME3800X-R4#show ethernet ring g8032 b
ME3800X-R4#show ethernet ring g8032 brief
R: Interface is the RPL-link
F: Interface is faulty
B: Interface is blocked
FS: Local forced switch
MS: Local manual switch

RingName                          Inst NodeType  NodeState     Port0    Port1
-------------------------------------------------------------------------------
--
test1                             1    Normal    Idle
ME3800X-R4#

ME3800X-R4#show ethernet ring g8032 port status
 Port: GigabitEthernet0/1
 Ring: test1
    Block vlan list:
    Unblock vlan list: 11,22
    REQ/ACK: 2/2
    Instance 1 is in Unblocked state

 Port: TenGigabitEthernet0/1
 Ring: test1
    Block vlan list:
    Unblock vlan list: 11,22
    REQ/ACK: 3/3
    Instance 1 is in Unblocked state

ME3800X-R4#


ME3600X-R1#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
--
MPID  Domain Name                                 MacAddress          IfSt
PtSt
 Lvl  Domain ID                                   Ingress
 RDI  MA Name                                     Type Id             SrvcInst
      EVC Name                                                       Age
      Local MEP Info
-------------------------------------------------------------------------------
--
5     domain1                                     f4ac.c1b8.ea87      Up
Unkn
 5    domain1                                     Gi0/7
 -    service1                                    BD-V 11             1
      evc1                                                           0s
      MPID: 1 Domain: domain1 MA: service1
4     domain1                                     0027.0cab.469a      Up    Up
 5    domain1                                     Te0/2
 -    service1                                    BD-V 11             1
      evc1                                                           0s
      MPID: 2 Domain: domain1 MA: service1

Total Remote MEPs: 2
ME3600X-R1#
```

```
ME3800X-R2#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
--
MPID  Domain Name                                    MacAddress          IfSt
PtSt
 Lvl  Domain ID                                      Ingress
 RDI  MA Name                                        Type Id             SrvcInst
      EVC Name                                                           Age
      Local MEP Info
-------------------------------------------------------------------------------
--
7     domain1                                        0027.0cab.a681      Up    Up
 5    domain1                                        Gi0/1
 -    service1                                       BD-V 11             1
      evc1                                                               0s
      MPID: 3 Domain: domain1 MA: service1
2     domain1                                        0027.0cab.2f9a      Up    Up
 5    domain1                                        Te0/2
 -    service1                                       BD-V 11             1
      evc1                                                               0s
      MPID: 4 Domain: domain1 MA: service1

Total Remote MEPs: 2
ME3800X-R2#


ME3800X-R3#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
--
MPID  Domain Name                                    MacAddress          IfSt
PtSt
 Lvl  Domain ID                                      Ingress
 RDI  MA Name                                        Type Id             SrvcInst
      EVC Name                                                           Age
      Local MEP Info
-------------------------------------------------------------------------------
--
1     domain1                                        0027.0cab.2f87      Up
Unkn
 5    domain1                                        Gi0/7
 -    service1                                       BD-V 11             1
      evc1                                                               0s
      MPID: 5 Domain: domain1 MA: service1
8     domain1                                        0027.0cab.a699      Up    Up
 5    domain1                                        Te0/2
 -    service1                                       BD-V 11             1
      evc1                                                               0s
      MPID: 6 Domain: domain1 MA: service1

Total Remote MEPs: 2
ME3800X-R3#

ME3800X-R4#show ethernet cfm maintenance-points remote
-------------------------------------------------------------------------------
--
MPID  Domain Name                                    MacAddress          IfSt
PtSt
```

```
 Lvl  Domain ID                                    Ingress
 RDI  MA Name                                      Type Id             SrvcInst
      EVC Name                                                       Age
      Local MEP Info
------------------------------------------------------------------------------
--
3     domain1                                     0027.0cab.4681      Up    Up
 5    domain1                                     Gi0/1
 -    service1                                    BD-V 11             1
      evc1                                                           0s
      MPID: 7 Domain: domain1 MA: service1
6     domain1                                     f4ac.c1b8.ea9a      Up    Up
 5    domain1                                     Te0/1
 -    service1                                    BD-V 11             1
      evc1                                                           0s
      MPID: 8 Domain: domain1 MA: service1

Total Remote MEPs: 2
ME3800X-R4#
```

The cli **show vlan counters** displays the Traffic Stats for SVI as below:

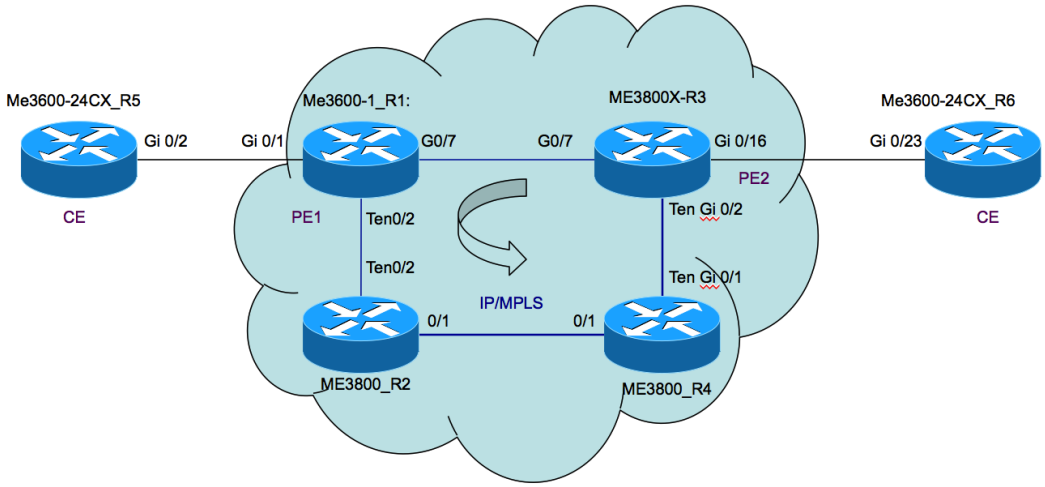
```
       Vlan Id                                  : 50
       L2 Unicast Packets                       : 0
       L2 Unicast Octets                        : 0
       L3 Input Unicast Packets                 : 3813937687
       L3 Input Unicast Octets                  : 274603513742
       L3 Output Unicast Packets                : 350581947
       L3 Output Unicast Octets                 : 25241907698
       L3 Output Multicast Packets              : 7284
       L3 Output Multicast Octets               : 783016
       L3 Input Multicast Packets               : 641
       L3 Input Multicast Octets                : 86870
       L2 Multicast Packets                     : 0
       L2 Multicast Octets                      : 0
```

Chapter 2
Layer 3-based Solution

In the layer 3 based solution design section, The following features will be covered:

- Layer 3 Virtual Private Network (L3VPN)
- Virtual Private LAN Service (VPLS)
- Bidirectional Forwarding Detection (BFD)
- Ethernet Operation Administration Maintenance (E-OAM)
- Quality of Service (QoS)
- Remote loop free Alternate (Remote-LFA)
- Y.1731 Performance Monitoring (Y.1731PM)
- MPLS Operation Administration Maintenance (MPLS OAM)

Layer 3 based Solution Design Topology:



R1, R2, R3, AND R4 are the PE device.

R5,R6 are the CE device.

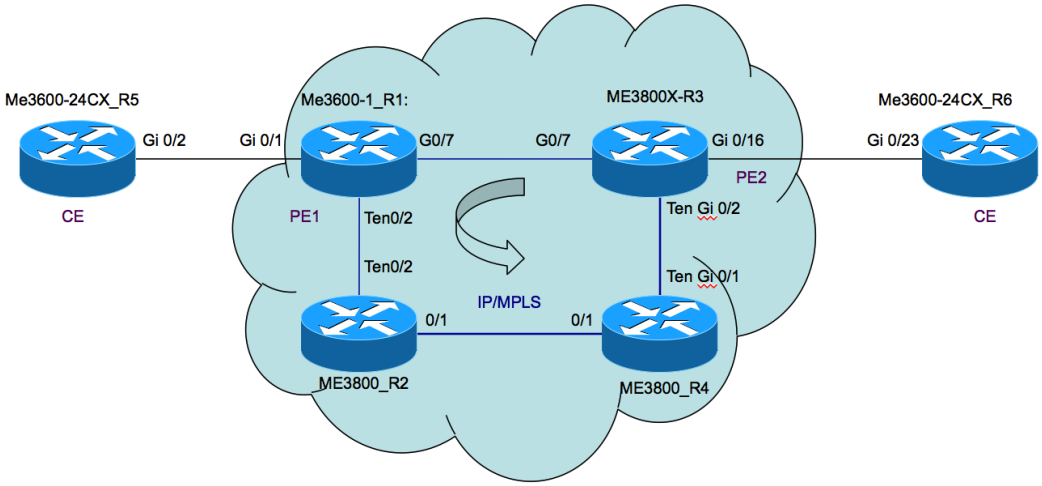
In the ring of R1, R2, R3, and R4, MPLS is enabled.

Design Example(D)—OSPF+BFD+ Remote LFA+L3VPN+MPLS OAM

OSPF and BFD

OSPF(Open Shortest Path first) is a link-state routing protocol.BFD(Bidirectional Forwarding Detection) is a detection protocol which is designed to provide fast forwarding path failure detection time.

In this example, BFD support for OSPF is configured.



R1, R2, R3, and R4 is in a OSPF ring , BFD for OSPF is enabled on each router.

Configuration at R1:

```
ME3600X-R1#sh run interface gigabitEthernet 0/7
Building configuration...

Current configuration : 182 bytes
!
interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.1 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3   //BFD timer and
configuration
 no bfd echo            //BFD mode, no echo mode is configured here.

interface TenGigabitEthernet0/2
 no switchport
 ip address 12.12.12.1 255.255.255.0
```

```
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3  //BFD timer and
configuration
no bfd echo                 //BFD mode, no echo mode is configured
here.


end


router ospf 1234
 router-id 1.1.1.1
 fast-reroute per-prefix enable prefix-priority low
 fast-reroute per-prefix remote-lfa tunnel mpls-ldp
 network 1.1.1.1 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 13.13.13.0 0.0.0.255 area 0
 bfd all-interfaces

ME3600X-R1#show bfd neighbors  //verify the BFD neighbour

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS      State
Int
12.12.12.2                              2/2          Up         Up
Te0/2
13.13.13.3                              3/1          Up         Up
Gi0/7
ME3600X-R1#
```

Configuration at R2:

```
ME3800X-R2#sh run interface tenGigabitEthernet 0/2
interface TenGigabitEthernet0/2
 no switchport
 ip address 12.12.12.2 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3  //BFD timer and
configuration
 no bfd echo
end

ME3800X-R2#sh run interface gigabitEthernet 0/1
interface GigabitEthernet0/1
 no switchport
 ip address 24.24.24.2 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3  //BFD timer and
configuration
 no bfd echo
end
```

```
router ospf 1234
 router-id 2.2.2.2
 fast-reroute per-prefix enable prefix-priority low
 fast-reroute per-prefix remote-lfa tunnel mpls-ldp
 network 2.2.2.2 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 24.24.24.0 0.0.0.255 area 0
 bfd all-interfaces       //BFD enable under OSPF
!
ME3800X-R2#show bfd neighbors

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS      State
Int
12.12.12.1                              2/2          Up         Up
Te0/2
24.24.24.4                              1/1          Up         Up
Gi0/1
```

Configuration at R3:

```
ME3800X-R3#sh run interface gigabitEthernet 0/7

!
interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.3 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
end

ME3800X-R3#sh run interface tenGigabitEthernet 0/2
interface TenGigabitEthernet0/2
 no switchport
 ip address 34.34.34.3 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
end


ME3800X-R3#show bfd  neighbors

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS      State
Int
13.13.13.1                              1/3          Up         Up
Gi0/7
34.34.34.4                              2/3          Up         Up
Te0/2
```

Configuration at R4:

```
ME3800X-R4#sh run interface gigabitEthernet 0/1
!
interface GigabitEthernet0/1
 no switchport
 ip address 24.24.24.4 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
end

ME3800X-R4#sh run interface tenGigabitEthernet 0/1
interface TenGigabitEthernet0/1
 no switchport
 ip address 34.34.34.4 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
end

ME3800X-R4#sh run | b r o
router ospf 1234
 router-id 4.4.4.4
 fast-reroute per-prefix enable prefix-priority low
 fast-reroute per-prefix remote-lfa tunnel mpls-ldp
 network 4.4.4.4 0.0.0.0 area 0
 network 24.24.24.0 0.0.0.255 area 0
 network 34.34.34.0 0.0.0.255 area 0
 network 99.1.1.0 0.0.0.255 area 0
 bfd all-interfaces

ME3800X-R4#show bfd neighbors

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS     State
Int
24.24.24.2                              1/1          Up        Up
Gi0/1
34.34.34.3                              3/2          Up        Up
Te0/1
ME3800X-R4#
```

Remote LFA (Loop free alternative)

IP-FRR/LFA and Remote IP LFA feature is supported on ME3600X/ME3800X/ME3600X-24CX since 15.3(2)S release. This feature helps to archive the fast convergence of the network.

In this example,Remote LFA is configured on both R1, R2, R3, and R4.

Configuration at R1:

```
router ospf 1234
 router-id 1.1.1.1
 fast-reroute per-prefix enable prefix-priority low // IP-FRR
configuration
 fast-reroute per-prefix remote-lfa tunnel mpls-ldp //Remote LFA
Configuration
 network 1.1.1.1 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 13.13.13.0 0.0.0.255 area 0
 bfd all-interfaces
```

Configuration at R2:

```
router ospf 1234
 router-id 2.2.2.2
 fast-reroute per-prefix enable prefix-priority low
 fast-reroute per-prefix remote-lfa tunnel mpls-ldp
 network 2.2.2.2 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 24.24.24.0 0.0.0.255 area 0
 bfd all-interfaces
```

Configuration at R3:

```
router ospf 1234
 router-id 3.3.3.3
 fast-reroute per-prefix enable prefix-priority low
 fast-reroute per-prefix remote-lfa tunnel mpls-ldp
 network 3.3.3.3 0.0.0.0 area 0
 network 13.13.13.0 0.0.0.255 area 0
 network 34.34.34.0 0.0.0.255 area 0
 bfd all-interfaces
```

Configuration at R4:

```
router ospf 1234
 router-id 4.4.4.4
 fast-reroute per-prefix enable prefix-priority low
 fast-reroute per-prefix remote-lfa tunnel mpls-ldp
 network 4.4.4.4 0.0.0.0 area 0
 network 24.24.24.0 0.0.0.255 area 0
 network 34.34.34.0 0.0.0.255 area 0
 network 99.1.1.0 0.0.0.255 area 0
 bfd all-interfaces
```

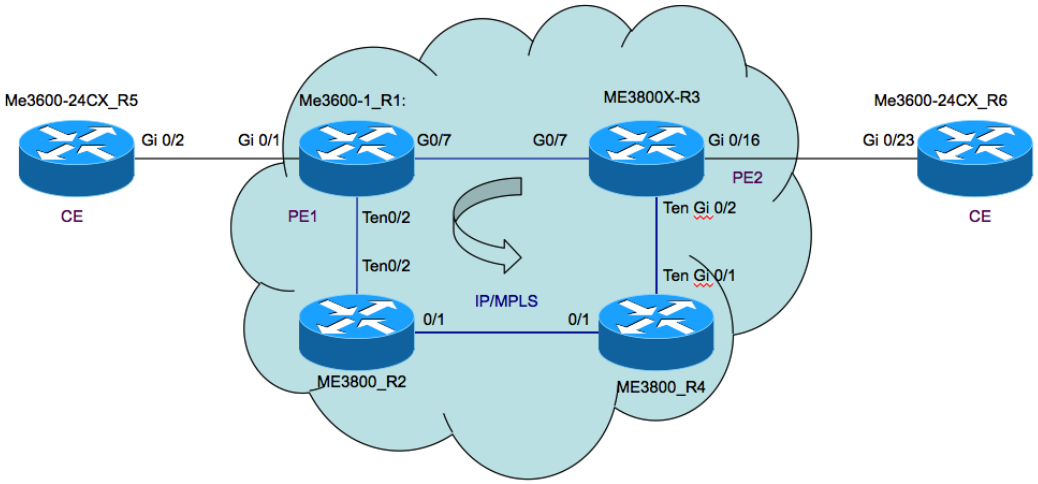
Verification on Remote FLA:

```
ME3600X-R1#show ip route 3.3.3.3
Routing entry for 3.3.3.3/32
  Known via "ospf 1234", distance 110, metric 2, type intra area
  Last update from 13.13.13.3 on GigabitEthernet0/7, 04:41:41 ago
  Routing Descriptor Blocks:
  * 13.13.13.3, from 3.3.3.3, 04:41:41 ago, via GigabitEthernet0/7
      Route metric is 2, traffic share count is 1
      Repair Path: 4.4.4.4, via MPLS-Remote-Lfa2  //From R1 to R3
,there is a pre-computer repair path
ME3600X-R1#

ME3600X-R1#show ip route 4.4.4.4
Routing entry for 4.4.4.4/32
  Known via "ospf 1234", distance 110, metric 3, type intra area
  Last update from 12.12.12.2 on TenGigabitEthernet0/2, 3d00h ago
  Routing Descriptor Blocks:
    13.13.13.3, from 4.4.4.4, 3d00h ago, via GigabitEthernet0/7
      Route metric is 3, traffic share count is 1
      Repair Path: 12.12.12.2, via TenGigabitEthernet0/2
  * 12.12.12.2, from 4.4.4.4, 3d00h ago, via TenGigabitEthernet0/2
      Route metric is 3, traffic share count is 1
      Repair Path: 13.13.13.3, via GigabitEthernet0/7
ME3600X-R1#
```

Layer 3 Virtual Private Network (L3VPN)

MPLS Layer 3 VPNs use a peer-to-peer model that uses Border Gateway Protocol (BGP) to distribute VPN-related information.

In this example, see the topology below:



R5,R6 will be CE device

R1,R4 will be the PE device.

BGP will be enabled on R1 and R4.

Configuration at R5:

```
interface GigabitEthernet0/2
 no switchport
 ip address 15.15.15.5 255.255.255.0
 media-type rj45

router ospf 15
 router-id 5.5.5.5
 network 5.5.5.5 0.0.0.0 area 0
 network 15.15.15.0 0.0.0.255 area 0


ME3600X-24CX-R5#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 10.74.13.1 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 10.74.13.1
      1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.100 [110/2] via 15.15.15.1, 1w0d, GigabitEthernet0/2
      3.0.0.0/32 is subnetted, 1 subnets
O E2     3.3.3.100 [110/1] via 15.15.15.1, 3d00h, GigabitEthernet0/2
      5.0.0.0/32 is subnetted, 1 subnets
C        5.5.5.5 is directly connected, Loopback0
      6.0.0.0/32 is subnetted, 1 subnets
O E2     6.6.6.6 [110/2] via 15.15.15.1, 3d00h, GigabitEthernet0/2
      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.74.13.0/24 is directly connected, GigabitEthernet0
L        10.74.13.167/32 is directly connected, GigabitEthernet0
      15.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        15.15.15.0/24 is directly connected, GigabitEthernet0/2
L        15.15.15.5/32 is directly connected, GigabitEthernet0/2
      36.0.0.0/24 is subnetted, 1 subnets
O E2     36.36.36.0 [110/1] via 15.15.15.1, 3d00h, GigabitEthernet0/2
ME3600X-24CX-R5#
ME3600X-24CX-R5#ping 6.6.6.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 6.6.6.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
```

Configuration at R1

```
vrf definition ABC
 rd 123:123
 !
 address-family ipv4
  route-target export 123:123
  route-target import 123:123
 exit-address-family
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface Loopback1
 vrf forwarding ABC
 ip address 1.1.1.100 255.255.255.255

interface GigabitEthernet0/1
 no switchport
 vrf forwarding ABC
 ip address 15.15.15.1 255.255.255.0

interface GigabitEthernet0/7
```

```
 no switchport
 ip address 13.13.13.1 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo

router bgp 100
 bgp log-neighbor-changes
 no bgp default ipv4-unicast
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 !
 address-family ipv4
 exit-address-family
 !
 address-family vpnv4
  neighbor 3.3.3.3 activate
  neighbor 3.3.3.3 send-community extended
 exit-address-family
 !
 address-family ipv4 vrf ABC
  redistribute ospf 15
 exit-address-family

router ospf 15 vrf ABC
 redistribute bgp 100 subnets
 network 1.1.1.0 0.0.0.255 area 0
 network 15.15.15.0 0.0.0.255 area 0


ME3600X-R1#show ip bgp all
For address family: IPv4 Unicast


For address family: VPNv4 Unicast

BGP table version is 19, 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: 123:123 (default for vrf ABC)
 *>  1.1.1.100/32     0.0.0.0                  0         32768 ?
 *>i 3.3.3.100/32     3.3.3.3                  0    100      0 ?
 *>  5.5.5.5/32       15.15.15.5               2         32768 ?
 *>i 6.6.6.6/32       3.3.3.3                  2    100      0 ?
 *>  15.15.15.0/24    0.0.0.0                  0         32768 ?
 *>i 36.36.36.0/24    3.3.3.3                  0    100      0 ?

For address family: IPv4 Multicast

For address family: MVPNv4 Unicast
```

```
ME3600X-R1#
```

Configuration at R3

```
vrf definition ABC
 rd 123:123
 !
 address-family ipv4
  route-target export 123:123
  route-target import 123:123
 exit-address-family

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.3 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo

interface GigabitEthernet0/16
 no switchport
 vrf forwarding ABC
 ip address 36.36.36.3 255.255.255.0

router ospf 36 vrf ABC
 redistribute bgp 100 subnets
 network 3.3.3.100 0.0.0.0 area 0
 network 36.36.36.0 0.0.0.255 area 0

router bgp 100
 bgp log-neighbor-changes
 no bgp default ipv4-unicast
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 !
 address-family ipv4
 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 ABC
  redistribute ospf 36
 exit-address-family

ME3800X-R3#show ip bgp all
For address family: IPv4 Unicast


For address family: VPNv4 Unicast

BGP table version is 10, local router ID is 3.3.3.3
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: 123:123 (default for vrf ABC)
 *>i 1.1.1.100/32     1.1.1.1                  0    100      0 ?
 *>  3.3.3.100/32     0.0.0.0                  0         32768 ?
 *>i 5.5.5.5/32       1.1.1.1                  2    100      0 ?
 *>  6.6.6.6/32       36.36.36.6               2         32768 ?
 *>i 15.15.15.0/24    1.1.1.1                  0    100      0 ?
 *>  36.36.36.0/24    0.0.0.0                  0         32768 ?

For address family: IPv4 Multicast


For address family: MVPNv4 Unicast

ME3800X-R3#
```

Configuration at R6

```
interface Loopback0
 ip address 6.6.6.6 255.255.255.255

interface GigabitEthernet0/23
 no switchport
 ip address 36.36.36.6 255.255.255.0

router ospf 36
 network 6.6.6.6 0.0.0.0 area 0
 network 36.36.36.0 0.0.0.255 area 0


ME3600X-24CX-R6#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 10.74.13.1 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 10.74.13.1
      1.0.0.0/32 is subnetted, 1 subnets
```

```
O E2     1.1.1.100 [110/1] via 36.36.36.3, 3d00h, GigabitEthernet0/23
      3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.100 [110/2] via 36.36.36.3, 3d00h, GigabitEthernet0/23
      5.0.0.0/32 is subnetted, 1 subnets
O E2     5.5.5.5 [110/2] via 36.36.36.3, 3d00h, GigabitEthernet0/23
      6.0.0.0/32 is subnetted, 1 subnets
C        6.6.6.6 is directly connected, Loopback0
      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.74.13.0/24 is directly connected, GigabitEthernet0
L        10.74.13.168/32 is directly connected, GigabitEthernet0
      15.0.0.0/24 is subnetted, 1 subnets
O E2     15.15.15.0 [110/1] via 36.36.36.3, 3d00h,
GigabitEthernet0/23
      36.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        36.36.36.0/24 is directly connected, GigabitEthernet0/23
L        36.36.36.6/32 is directly connected, GigabitEthernet0/23
```

MPLS OAM

MPLS OAM helps service providers monitor label-switched paths (LSPs) and quickly isolate MPLS forwarding problems to assist with fault detection and troubleshooting in an MPLS network.

```
ME3600X-R1#ping mpls ipv4 4.4.4.4/32
Sending 5, 100-byte MPLS Echos to Target FEC Stack TLV descriptor,
     timeout is 2 seconds, send interval is 0 msec:

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no label
entry,
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'l' - Label switched with FEC change, 'd' - see DDMAP for return
code,
  'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
 Total Time Elapsed 8 ms

ME3600X-R1#traceroute MPLs ipv4 4.4.4.4/32
more work needed here to demux the tfs subtlv and to display the
right output

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no label
entry,
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'l' - Label switched with FEC change, 'd' - see DDMAP for return
code,
  'X' - unknown return code, 'x' - return code 0
```

```
Type escape sequence to abort.
  0 12.12.12.1 MRU 1500 [Labels: 20 Exp: 0]
L 1 12.12.12.2 MRU 1504 [Labels: implicit-null Exp: 0] 0 ms
! 2 24.24.24.4 4 ms
ME3600X-R1#


E3600X-R1#show mpls ldp neighbor
    Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 1.1.1.1:0
   TCP connection: 2.2.2.2.27182 - 1.1.1.1.646
   State: Oper; Msgs sent/rcvd: 55968/55918; Downstream
   Up time: 4w5d
   LDP discovery sources:
     TenGigabitEthernet0/2, Src IP addr: 12.12.12.2
        Addresses bound to peer LDP Ident:
          10.74.13.162    12.12.12.2      2.2.2.2         24.24.24.2
    Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 1.1.1.1:0
   TCP connection: 3.3.3.3.51987 - 1.1.1.1.646
   State: Oper; Msgs sent/rcvd: 5001/4988; Downstream
   Up time: 3d00h
   LDP discovery sources:
     GigabitEthernet0/7, Src IP addr: 13.13.13.3
        Addresses bound to peer LDP Ident:
          10.74.13.163    3.3.3.3         13.13.13.3      34.34.34.3
    Peer LDP Ident: 4.4.4.4:0; Local LDP Ident 1.1.1.1:0
   TCP connection: 4.4.4.4.14257 - 1.1.1.1.646
   State: Oper; Msgs sent/rcvd: 428/429; Downstream
   Up time: 06:03:57
   LDP discovery sources:
     Targeted Hello 1.1.1.1 -> 4.4.4.4, active, passive
        Addresses bound to peer LDP Ident:
          10.74.13.164    24.24.24.4      4.4.4.4         34.34.34.4
ME3600X-R1#
```

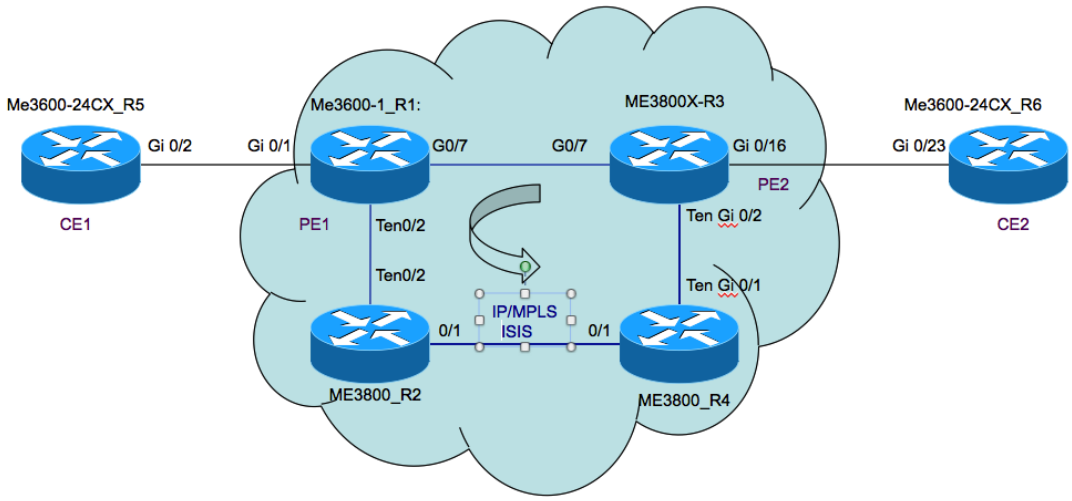
Design Example(E1)—ISIS+BFD+Remote LFA+EoMPLS+E-LMI+MPLS OAM

ISIS+BFD

The Intermediate System-to-Intermediate System (IS-IS) routing protocol is an Interior Gateway Protocol (IGP) standardized by the Internet Engineering Task Force (IETF) and commonly used in large Service Provider networks.

Bi-directional Forwarding Detection (BFD) provides rapid failure detection times between forwarding engines.

BFD for ISIS configuration example is listed below.



Configuration at R1

```
interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.1 255.255.255.0
 ip router isis  //ISIS configuration under the interface
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point

interface TenGigabitEthernet0/2
 no switchport
 ip address 12.12.12.1 255.255.255.0
 ip router isis //ISIS configuration under the interface
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3  //BFD configuration
 no bfd echo
```

```
 isis network point-to-point
!

router isis
 net 47.0000.0000.0001.00
 is-type level-2-only  //ISIS level 2 is used
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces  //BFD configuration
!

ME3600X-R1#show isis neighbors

System Id      Type Interface   IP Address      State Holdtime
Circuit Id
ME3800X-R2     L2   Te0/2       12.12.12.2      UP    29        00
ME3800X-R3     L2   Gi0/7       13.13.13.3      UP    28        00
ME3600X-R1#show bfd  neighbors

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS     State
Int
12.12.12.2                              1/2          Up        Up
Te0/2
13.13.13.3                              2/2          Up        Up
Gi0/7
ME3600X-R1#

ME3600X-R1#show ip route  isis
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 10.74.13.1 to network 0.0.0.0

      2.0.0.0/32 is subnetted, 1 subnets
i L2     2.2.2.2 [115/10] via 12.12.12.2, 00:42:01,
TenGigabitEthernet0/2
      3.0.0.0/32 is subnetted, 1 subnets
i L2     3.3.3.3 [115/10] via 13.13.13.3, 00:42:01,
GigabitEthernet0/7
      4.0.0.0/32 is subnetted, 1 subnets
i L2     4.4.4.4 [115/20] via 13.13.13.3, 00:42:01,
GigabitEthernet0/7
                 [115/20] via 12.12.12.2, 00:42:01,
TenGigabitEthernet0/2
      24.0.0.0/24 is subnetted, 1 subnets
i L2     24.24.24.0 [115/20] via 12.12.12.2, 00:42:01,
```

```
TenGigabitEthernet0/2
      34.0.0.0/24 is subnetted, 1 subnets
i L2     34.34.34.0 [115/20] via 13.13.13.3, 00:42:01,
GigabitEthernet0/7
```

Configuration at R2

```
interface GigabitEthernet0/1
 no switchport
 ip address 24.24.24.2 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point

interface TenGigabitEthernet0/2
 no switchport
 ip address 12.12.12.2 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point

router isis
 net 47.0000.0000.0002.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces

ME3800X-R2#show bfd neighbors

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS     State
Int
12.12.12.1                              2/1          Up        Up
Te0/2
24.24.24.4                              1/4          Up        Up
Gi0/1
ME3800X-R2#show isis  neighbors

System Id      Type Interface   IP Address      State Holdtime
Circuit Id
ME3600X-R1     L2   Te0/2       12.12.12.1      UP    27        01
ME3800X-R4     L2   Gi0/1       24.24.24.4      UP    28        01
ME3800X-R2#
```

Configuration At R3

```
interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.3 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point

interface TenGigabitEthernet0/2
 no switchport
 ip address 34.34.34.3 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point

router isis
 net 47.0000.0000.0003.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces
!


ME3800X-R3#show isis  neighbors

System Id      Type Interface   IP Address      State Holdtime
Circuit Id
ME3600X-R1     L2   Gi0/7       13.13.13.1      UP    22        00
ME3800X-R4     L2   Te0/2       34.34.34.4      UP    22        00
ME3800X-R3#show bfd neighbors

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS     State
Int
13.13.13.1                              2/2          Up        Up
Gi0/7
34.34.34.4                              1/2          Up        Up
Te0/2
ME3800X-R3#
```

Configuration at R4:

```
interface GigabitEthernet0/1
 no switchport
 ip address 24.24.24.4 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
```

```
 no bfd echo
 isis network point-to-point

interface TenGigabitEthernet0/1
 no switchport
 ip address 34.34.34.4 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point

router isis
 net 47.0000.0000.0004.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces
!

ME3800X-R4#show bfd neighbors

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS     State
Int
24.24.24.2                              4/1          Up        Up
Gi0/1
34.34.34.3                              2/1          Up        Up
Te0/1
ME3800X-R4#show isis neighbors

System Id      Type Interface   IP Address      State Holdtime
Circuit Id
ME3800X-R2     L2   Gi0/1       24.24.24.2      UP    23        01
ME3800X-R3     L2   Te0/1       34.34.34.3      UP    22        01
ME3800X-R4#


ME3800X-R4#show isis neighbors

System Id      Type Interface   IP Address      State Holdtime
Circuit Id
ME3800X-R2     L2   Gi0/1       24.24.24.2      UP    23        01
ME3800X-R3     L2   Te0/1       34.34.34.3      UP    29        01
ME3800X-R4#show bfd neighbors

IPv4 Sessions
NeighAddr                              LD/RD         RH/RS     State
Int
24.24.24.2                              4/1          Up        Up
Gi0/1
34.34.34.3                              2/1          Up        Up
Te0/1
ME3800X-R4#
```

Remote LFA

Configuration at R1

```
router isis
 net 47.0000.0000.0001.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all   //IP -FRR enable under ISIS
 fast-reroute remote-lfa level-2 mpls-ldp  //Remote LFA configuration
 passive-interface Loopback0
 bfd all-interfaces


ME3600X-R1#show ip route 3.3.3.3
Routing entry for 3.3.3.3/32
  Known via "isis", distance 115, metric 10, type level-2
  Redistributing via isis
  Last update from 13.13.13.3 on GigabitEthernet0/7, 00:58:01 ago
  Routing Descriptor Blocks:
  * 13.13.13.3, from 3.3.3.3, 00:58:01 ago, via GigabitEthernet0/7
      Route metric is 10, traffic share count is 1
      Repair Path: 4.4.4.4, via MPLS-Remote-Lfa2

ME3600X-R1#show ip route 4.4.4.4
Routing entry for 4.4.4.4/32
  Known via "isis", distance 115, metric 20, type level-2
  Redistributing via isis
  Last update from 13.13.13.3 on GigabitEthernet0/7, 00:58:07 ago
  Routing Descriptor Blocks:
    13.13.13.3, from 4.4.4.4, 00:58:07 ago, via GigabitEthernet0/7
      Route metric is 20, traffic share count is 1
      Repair Path: 12.12.12.2, via TenGigabitEthernet0/2
  * 12.12.12.2, from 4.4.4.4, 00:58:07 ago, via TenGigabitEthernet0/2
      Route metric is 20, traffic share count is 1
      Repair Path: 13.13.13.3, via GigabitEthernet0/7
ME3600X-R1#
```

Configuration at R2

```
router isis
 net 47.0000.0000.0002.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces

ME3800X-R2#show ip route 3.3.3.3
Routing entry for 3.3.3.3/32
  Known via "isis", distance 115, metric 20, type level-2
  Redistributing via isis
  Last update from 12.12.12.1 on TenGigabitEthernet0/2, 00:59:11 ago
  Routing Descriptor Blocks:
```

```
  * 24.24.24.4, from 3.3.3.3, 00:59:11 ago, via GigabitEthernet0/1
      Route metric is 20, traffic share count is 1
      Repair Path: 12.12.12.1, via TenGigabitEthernet0/2
    12.12.12.1, from 3.3.3.3, 00:59:11 ago, via TenGigabitEthernet0/2
      Route metric is 20, traffic share count is 1
      Repair Path: 24.24.24.4, via GigabitEthernet0/1
ME3800X-R2#
```

Configuation at R3

```
router isis
 net 47.0000.0000.0003.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces

ME3800X-R3#show ip route  1.1.1.1
Routing entry for 1.1.1.1/32
  Known via "isis", distance 115, metric 10, type level-2
  Redistributing via isis
  Last update from 13.13.13.1 on GigabitEthernet0/7, 01:00:10 ago
  Routing Descriptor Blocks:
  * 13.13.13.1, from 1.1.1.1, 01:00:10 ago, via GigabitEthernet0/7
      Route metric is 10, traffic share count is 1
      Repair Path: 2.2.2.2, via MPLS-Remote-Lfa1

ME3800X-R3#show ip route  2.2.2.2
Routing entry for 2.2.2.2/32
  Known via "isis", distance 115, metric 20, type level-2
  Redistributing via isis
  Last update from 13.13.13.1 on GigabitEthernet0/7, 01:00:20 ago
  Routing Descriptor Blocks:
  * 34.34.34.4, from 2.2.2.2, 01:00:20 ago, via TenGigabitEthernet0/2
      Route metric is 20, traffic share count is 1
      Repair Path: 13.13.13.1, via GigabitEthernet0/7
    13.13.13.1, from 2.2.2.2, 01:00:20 ago, via GigabitEthernet0/7
      Route metric is 20, traffic share count is 1
      Repair Path: 34.34.34.4, via TenGigabitEthernet0/2
ME3800X-R3#
```

Configuation at R4

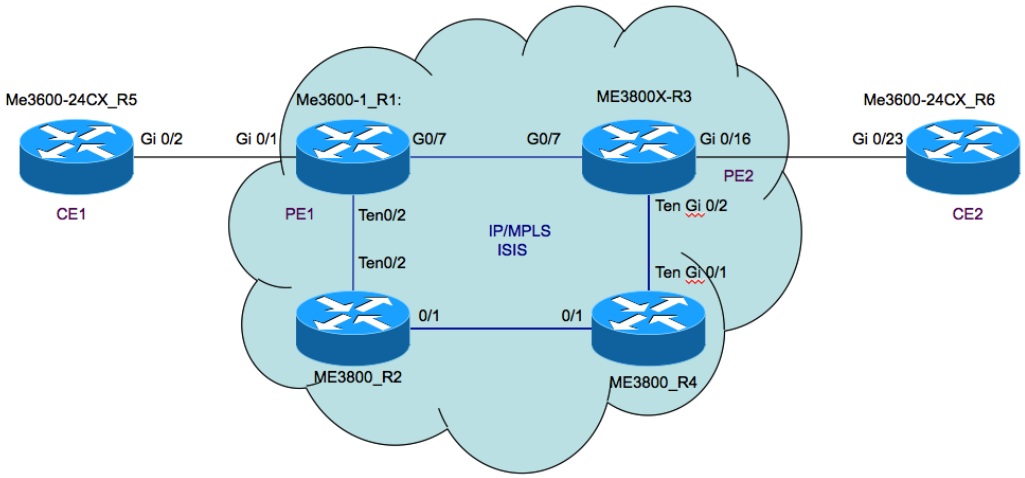
```
router isis
 net 47.0000.0000.0004.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces

ME3800X-R4#show ip route 1.1.1.1
Routing entry for 1.1.1.1/32
  Known via "isis", distance 115, metric 20, type level-2
```

```
  Redistributing via isis
  Last update from 34.34.34.3 on TenGigabitEthernet0/1, 01:01:14 ago
  Routing Descriptor Blocks:
    34.34.34.3, from 1.1.1.1, 01:01:14 ago, via TenGigabitEthernet0/1
      Route metric is 20, traffic share count is 1
      Repair Path: 24.24.24.2, via GigabitEthernet0/1
  * 24.24.24.2, from 1.1.1.1, 01:01:14 ago, via GigabitEthernet0/1
      Route metric is 20, traffic share count is 1
      Repair Path: 34.34.34.3, via TenGigabitEthernet0/1
```

Ethernet over MPLS (EoMPLS)

Ethernet over MPLS (EoMPLS) is part of Cisco's Any Transport over MPLS to provide L2 connectivity (pseudo-wire) over MPLS cloud.

In this example, see the topology below,



R5 is the CE1,

R6 is the CE2;

R1 and R3 are the PE device.

R1, R2, R3, AND R4 are in the MPLS cloud. EoMPLS is configured on R1 and R3 port.

Configuration at R1

```
interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 ethernet uni id PE1_CE1
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
```

```
 service instance 2 ethernet e234
  encapsulation dot1q 234
  ethernet lmi ce-vlan map 234
  xconnect 3.3.3.3 100 encapsulation mpls  //EoMPLS configuration
  cfm mep domain l5 mpid 11
 !

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.1 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point
end

interface Loopback0
 ip address 1.1.1.1 255.255.255.255

router isis
 net 47.0000.0000.0001.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces

ME3600X-R1#show mpls l2transport vc

Local intf     Local circuit              Dest address    VC ID
Status
-------------  -------------------------- --------------- ----------
----------
Gi0/1          Eth VLAN 234               3.3.3.3         100
UP
```

Configuration at R3

```
ME3800X-R3#sh run interface gigabitEthernet 0/7
Building configuration...

Current configuration : 197 bytes
!
interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.3 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point
end

interface GigabitEthernet0/16
 switchport trunk allowed vlan none
```

```
 switchport mode trunk
 ethernet uni id PE2_CE2
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 2 ethernet e234
  encapsulation dot1q 234
  ethernet lmi ce-vlan map 234
  xconnect 1.1.1.1 100 encapsulation mpls //EoMPLS configuration
  cfm mep domain l5 mpid 22
 !
interface Loopback0
 ip address 3.3.3.3 255.255.255.255

router isis
 net 47.0000.0000.0003.00
 is-type level-2-only
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-2 mpls-ldp
 passive-interface Loopback0
 bfd all-interfaces

ME3800X-R3#show mpls l2transport vc

Local intf     Local circuit              Dest address    VC ID
Status
-------------  -------------------------- --------------- ----------
----------
Gi0/16         Eth VLAN 234               1.1.1.1         100
UP
```

Configuration at R5

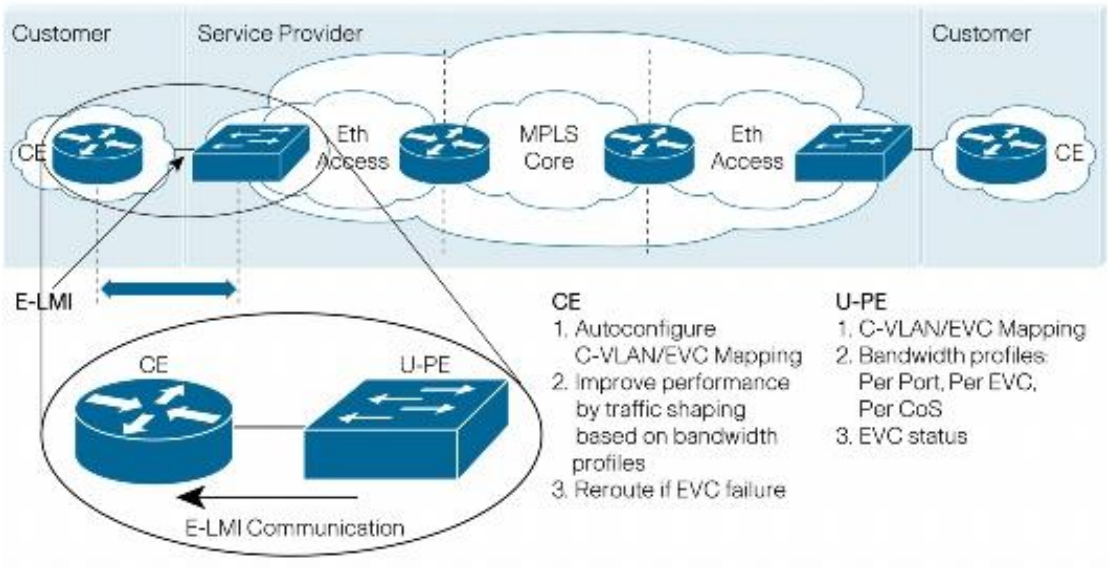
```
interface GigabitEthernet0/2
 switchport trunk allowed vlan 234
 switchport mode trunk
 media-type rj45

interface Vlan234
 ip address 99.1.1.5 255.255.255.0

ME3600X-24CX-R5#ping 99.1.1.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 99.1.1.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R5#
```

Configuration a R6

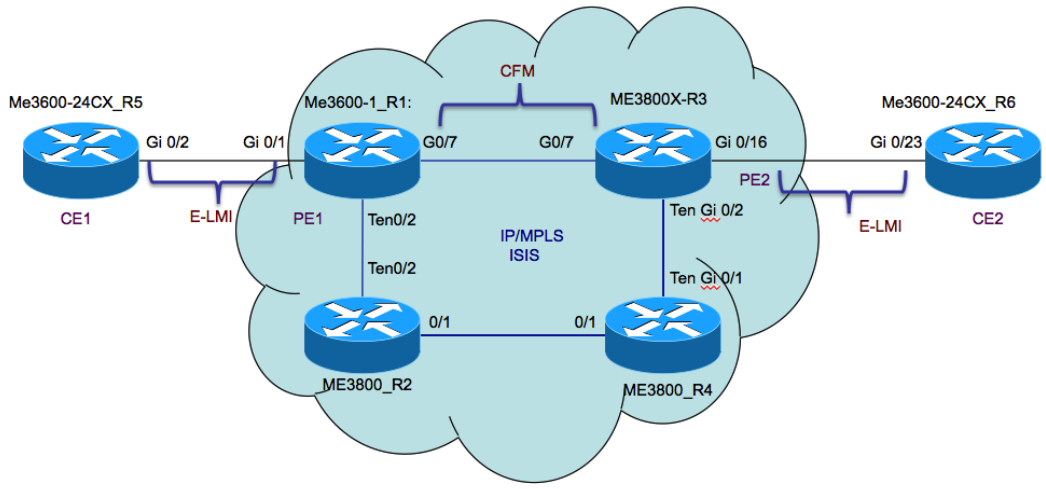
```
interface GigabitEthernet0/23
 switchport trunk allowed vlan 234
 switchport mode trunk

ME3600X-24CX-R6#sh run interface vl234
Building configuration...

Current configuration : 60 bytes
!
interface Vlan234
 ip address 99.1.1.6 255.255.255.0
end

ME3600X-24CX-R6#ping 99.1.1.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 99.1.1.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R6#
```

Ethernet Local Management Interface (PW E-LMI)

E-LMI(Ethernet Local Management Interface) defines the protocol and procedures that convey the information that allows auto-configuration of the CE device by the service provider's user-facing provider edge (U-PE) device. The E-LMI protocol also provides the means for notification of the status of an EVC.



In the example,



CE1 and PE1 are the E-LMI interface.

CE2 and PE2 are the E-LMI interface.

PE1 and PE2 will have the CFM

Configuration at R5

```
ethernet lmi global
ethernet lmi ce

interface GigabitEthernet0/2
 switchport trunk allowed vlan 234
 switchport mode trunk
 media-type rj45


ME3600X-24CX-R5#show ethernet lmi evc
St  EVC Id                                                      Port
--- ----------------------------------------------------------- ----
----------
 A  e234
Gi0/2

Key: St=Status, A=Active, P=Partially Active, I=Inactive, ?=Link Down
```

Configuration at R1

```
ethernet cfm ieee
ethernet cfm global
ethernet cfm domain l5 level 5
 service s1 evc e234
  continuity-check
  continuity-check interval 1s
```

```
!
ethernet lmi global
ethernet evc e234
 oam protocol cfm domain l5

interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 ethernet uni id PE1_CE1
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 2 ethernet e234
  encapsulation dot1q 234
  ethernet lmi ce-vlan map 234
  xconnect 3.3.3.3 100 encapsulation mpls
  cfm mep domain l5 mpid 11
 !

ME3600X-R1#show ethernet lmi evc detail e234
EVC Id: e234
interface GigabitEthernet0/1
  Time since Last Full Report: 00:06:38
  Ether LMI Link Status: Up
  UNI Status: Up
  UNI Id: PE1_CE1
  CE-VLAN/EVC Map Type: Bundling
  VLAN: 234

  EVC Status: Active
  EVC Type: Point-to-Point
  Remote UNI Count: Configured = 1, Active = 1

  UNI Id                                   UNI Status     Port
  ------                                   ----------     ----
  PE2_CE2                                  Up             Remote

ME3600X-R1#
```

Configuraiton at R3

```
ethernet cfm ieee
ethernet cfm global
ethernet cfm domain l5 level 5
 service s1 evc e234
  continuity-check
  continuity-check interval 1s
!
ethernet lmi global
ethernet evc e234
 oam protocol cfm domain l5


interface GigabitEthernet0/16
```

```
 switchport trunk allowed vlan none
 switchport mode trunk
 ethernet uni id PE2_CE2
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 2 ethernet e234
  encapsulation dot1q 234
  ethernet lmi ce-vlan map 234
  xconnect 1.1.1.1 100 encapsulation mpls
  cfm mep domain l5 mpid 22

ME3800X-R3#show ethernet lmi evc detail e234
EVC Id: e234
interface GigabitEthernet0/16
  Time since Last Full Report: 00:09:04
  Ether LMI Link Status: Up
  UNI Status: Up
  UNI Id: PE2_CE2
  CE-VLAN/EVC Map Type: Bundling
  VLAN: 234

  EVC Status: Active
  EVC Type: Point-to-Point
  Remote UNI Count: Configured = 1, Active = 1

  UNI Id                                    UNI Status    Port
  ------                                    ----------    ----
  PE1_CE1                                   Up            Remote

ME3800X-R3#
```

Configuration at R6

```
ethernet lmi global
ethernet lmi ce

interface GigabitEthernet0/23
 switchport trunk allowed vlan 234
 switchport mode trunk

ME3600X-24CX-R6#show ethernet lmi evc
St  EVC Id                                                          Port
--- ------------------------------------------------------------ ----
----------
 A  e234
Gi0/23

Key: St=Status, A=Active, P=Partially Active, I=Inactive, ?=Link Down
```

MPLS OAM

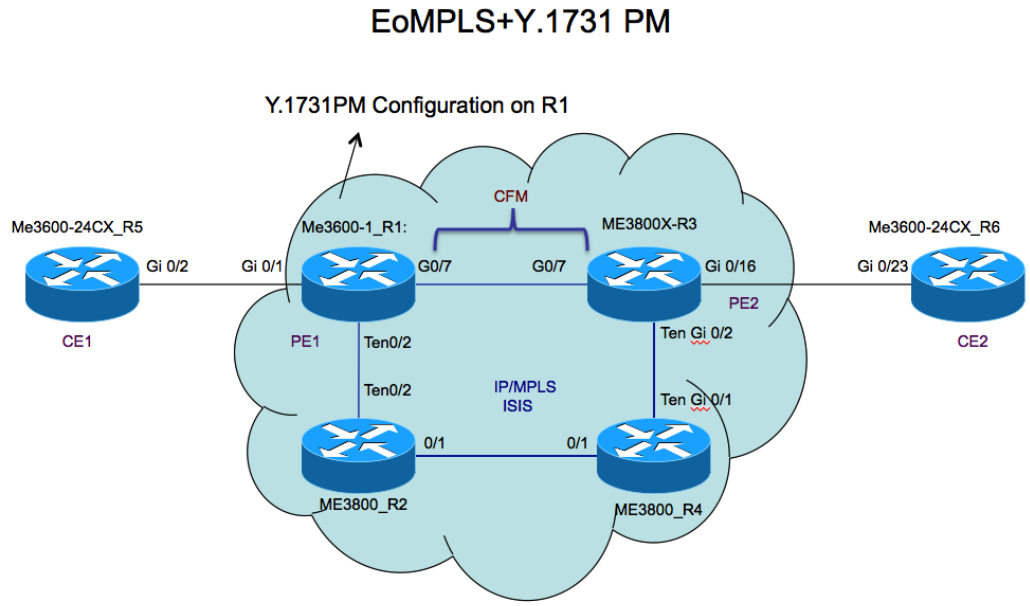
```
ME3600X-R1#ping mpls pseudowire 3.3.3.3 100
Sending 5, 100-byte MPLS Echos to 3.3.3.3,
     timeout is 2 seconds, send interval is 0 msec:

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no label
entry,
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'l' - Label switched with FEC change, 'd' - see DDMAP for return
code,
  'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
 Total Time Elapsed 8 ms

ME3600X-R1#
ME3600X-R1#traceroute mpls ipv4 3.3.3.3/32
more work needed here to demux the tfs subtlv and to display the
right output

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no label
entry,
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'l' - Label switched with FEC change, 'd' - see DDMAP for return
code,
  'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.
  0 13.13.13.1 MRU 1500 [Labels: implicit-null Exp: 0]
! 1 13.13.13.3 1 ms
ME3600X-R1#

ME3600X-R1#ping mpls ipv4 4.4.4.4/32
Sending 5, 100-byte MPLS Echos to Target FEC Stack TLV descriptor,
     timeout is 2 seconds, send interval is 0 msec:

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
  'L' - labeled output interface, 'B' - unlabeled output interface,
  'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
  'M' - malformed request, 'm' - unsupported tlvs, 'N' - no label
entry,
```

```
  'P' - no rx intf label prot, 'p' - premature termination of LSP,
  'R' - transit router, 'I' - unknown upstream index,
  'l' - Label switched with FEC change, 'd' - see DDMAP for return
code,
  'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
 Total Time Elapsed 8 ms
```

Design Example(E2)—Y.1731PM+EoMPLS

Y.1731 Performance Monitoring

Y.1731 Performance Monitoring (PM) provides a standard ethernet PM function that includes measurement of ethernet frame delay, frame delay variation, frame loss, and frame throughput measurements specified by the ITU-T Y-1731 standard and interpreted by the Metro Ethernet Forum (MEF) standards group.



Configuration at R1

```
ethernet cfm ieee  //CFM configuration
ethernet cfm global
ethernet cfm domain l5 level 5
 service s1 evc e234
  continuity-check
  continuity-check interval 1s
!
ethernet evc e234
 oam protocol cfm domain l5
!
interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 ethernet uni id PE1_CE1
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 2 ethernet e234
```

```
  encapsulation dot1q 234
  xconnect 3.3.3.3 100 encapsulation mpls
  cfm mep domain l5 mpid 11

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.1 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point

ip sla 10
 ethernet y1731 delay DMM domain l5 evc e234 mpid 22 cos 2 source
mpid 11
  history interval 1
  aggregate interval 30
ip sla schedule 10 start-time now  //start it now
```

Configuration at R3

```
ethernet cfm ieee
ethernet cfm global
ethernet cfm domain l5 level 5
 service s1 evc e234
  continuity-check
  continuity-check interval 1s
!
ethernet evc e234
 oam protocol cfm domain l5

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.3 255.255.255.0
 ip router isis
 mpls ip
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 isis network point-to-point
!
interface GigabitEthernet0/16
 switchport trunk allowed vlan none
 switchport mode trunk
 ethernet uni id PE2_CE2
 service instance 1 ethernet
  encapsulation untagged
  l2protocol peer
  bridge-domain 1
 !
 service instance 2 ethernet e234
  encapsulation dot1q 234
  xconnect 1.1.1.1 100 encapsulation mpls
  cfm mep domain l5 mpid 22
 !
```

R1 Y.1731PM Verification

```
1):start the testing:
 ip sla schedule 10 start-time now

ME3600X-R1#show ethernet cfm pm session summary
Number of Configured Session : 1
Number of Active Session: 1
Number of Inactive Session: 0

ME3600X-R1#show ethernet cfm pm session active
Display of Active Session
-------------------------------------------------------------------------------
EPM-ID   SLA-ID    Lvl/Type/ID/Cos/Dir Src-Mac-address Dst-Mac-address
-------------------------------------------------------------------------------
 0     10           5/XCON/N/A/2/Up     0027.0cab.2f80  f4ac.c1b8.ea80
Total number of Active Session: 1
ME3600X-R1#

ME3600X-R1#show ethernet cfm pm sess db 0
-------------------------------------------------------------------------------
      TX Time FWD                   RX Time FWD
      TX Time BWD                   RX Time BWD               Frame Delay
      Sec:nSec                      Sec:nSec                   Sec:nSec
-------------------------------------------------------------------------------
Session ID: 0
*******************************************************************************
1374180023:351165979           1374207627:148140980
1374207627:148201980           1374180023:351622979             0:396000
*******************************************************************************
1374180024:357429979           1374207628:154643980
1374207628:155117980           1374180024:358524979             0:621000
*******************************************************************************
1374180025:367539979           1374207629:164510980
1374207629:165693980           1374180025:369092979             0:370000
*******************************************************************************
1374180026:377649979           1374207630:174617980
1374207630:175020980           1374180026:378419979             0:367000
*******************************************************************************
1374180027:387757979           1374207631:184734980
1374207631:185365980           1374180027:388761979             0:373000
*******************************************************************************
1374180028:397970979           1374207632:195075980
1374207632:239736980           1374180028:443135979             0:504000
*******************************************************************************
1374180029:407983979           1374207633:204983980
1374207633:205410980           1374180029:408803979             0:393000
*******************************************************************************
1374180030:418092979           1374207634:215090980
1374207634:215538980           1374180030:418923979             0:383000
*******************************************************************************
1374180031:428199979           1374207635:225193980
1374207635:227379980           1374180031:430761979             0:376000
*******************************************************************************
1374180032:438310979           1374207636:235309980
1374207636:235727980           1374180032:439107979             0:379000
*******************************************************************************
1374180033:448568979           1374207637:245565980
```

```
1374207637:245886980          1374180033:449266979          0:377000
********************************************************************************
1374180034:458529979          1374207638:255533980
1374207638:255925980          1374180034:459299979          0:378000
********************************************************************************
1374180035:468650979          1374207639:265642980
1374207639:266013980          1374180035:469387979          0:366000
********************************************************************************
1374180036:478748979          1374207640:275746980
1374207640:276127980          1374180036:479497979          0:368000
********************************************************************************
1374180037:488859979          1374207641:285866980
1374207641:286271980          1374180037:489641979          0:377000
********************************************************************************
1374180038:498977979          1374207642:295990980
1374207642:296362980          1374180038:499727979          0:378000
********************************************************************************
1374180039:509084979          1374207643:306090980
1374207643:306444980          1374180039:509806979          0:368000
********************************************************************************
1374180040:519195979          1374207644:316200980
1374207644:316551980          1374180040:519911979          0:365000
********************************************************************************
1374180041:529299979          1374207645:326311980
1374207645:326698980          1374180041:530056979          0:370000
********************************************************************************
1374180042:539409979          1374207646:336425980
1374207646:336799980          1374180042:540153979          0:370000
********************************************************************************
1374180043:549705979          1374207647:346717980
1374207647:347039980          1374180043:550392979          0:365000
********************************************************************************
1374180044:559626979          1374207648:356643980
1374207648:357021980          1374180044:560386979          0:382000
********************************************************************************
1374180045:569735979          1374207649:366754980
1374207649:367144980          1374180045:570503979          0:378000
********************************************************************************
1374180046:579846979          1374207650:376867980
1374207650:377248980          1374180046:580603979          0:376000
********************************************************************************
1374180047:589968979          1374207651:386992980
1374207651:387354980          1374180047:590711979          0:381000
********************************************************************************
1374180048:600076979          1374207652:397110980
1374207652:397458980          1374180048:600811979          0:387000
********************************************************************************
1374180049:610203979          1374207653:407232980
1374207653:407584980          1374180049:610934979          0:379000
********************************************************************************
1374180050:620285979          1374207654:417314980
1374207654:417680980          1374180050:621030979          0:379000
********************************************************************************
1374180051:630398979          1374207655:427432980
1374207655:427792980          1374180051:631143979          0:385000
********************************************************************************
1374180052:640503979          1374207656:437555980
1374207656:437926980          1374180052:641267979          0:393000
********************************************************************************
```

```
1374180053:650765979           1374207657:447800980
1374207657:448118980           1374180053:651471979           0:388000
********************************************************************************
1374180054:660725979           1374207658:457755980
1374207658:459700980           1374180054:663039979           0:369000
********************************************************************************
1374180055:670833979           1374207659:467870980
1374207659:468224980           1374180055:671557979           0:370000
********************************************************************************
1374180056:680945979           1374207660:477984980
1374207660:478339980           1374180056:681673979           0:373000
********************************************************************************
1374180057:691055979           1374207661:488101980
1374207661:488477980           1374180057:691811979           0:380000
********************************************************************************
1374180058:701172979           1374207662:498222980
1374207662:498544980           1374180058:701874979           0:380000
********************************************************************************
1374180059:711273979           1374207663:508314980
1374207663:508642980           1374180059:711966979           0:365000
********************************************************************************
1374180060:721383979           1374207664:518426980
1374207664:518815980           1374180060:722136979           0:364000
********************************************************************************
1374180061:731493979           1374207665:528539980
1374207665:528895980           1374180061:732215979           0:366000
********************************************************************************
1374180062:741604979           1374207666:538658980
1374207666:539001980           1374180062:742321979           0:374000
********************************************************************************
1374180063:751865979           1374207667:548920980
1374207667:549104980           1374180063:752426979           0:377000
********************************************************************************
1374180064:761823979           1374207668:558870980
1374207668:559202980           1374180064:762519979           0:364000
********************************************************************************
1374180065:771932979           1374207669:568982980
1374207669:569322980           1374180065:772632979           0:360000
********************************************************************************
1374180066:782058979           1374207670:579112980
1374207670:580057980           1374180066:783386979           0:383000
********************************************************************************
1374180067:792152979           1374207671:589207980
1374207671:589963980           1374180067:793270979           0:362000
********************************************************************************
1374180068:802266979           1374207672:599346980
1374207672:599659980           1374180068:802967979           0:388000
********************************************************************************
1374180069:812374979           1374207673:609447980
1374207673:609768980           1374180069:813068979           0:373000
********************************************************************************
1374180070:822486979           1374207674:619561980
1374207674:619879980           1374180070:823180979           0:376000
********************************************************************************
1374180071:832595979           1374207675:629670980
1374207675:629979980           1374180071:833276979           0:372000
********************************************************************************
1374180072:842704979           1374207676:639787980
1374207676:640116980           1374180072:843414979           0:381000
```

```
********************************************************************************
1374180073:852962979           1374207677:650045980
1374207677:650368980           1374180073:853663979           0:378000
********************************************************************************
1374180074:862926979           1374207678:660019980
1374207678:660330980           1374180074:863620979           0:383000
********************************************************************************
1374180075:873037979           1374207679:670128980
1374207679:670429980           1374180075:873721979           0:383000
********************************************************************************
1374180076:883144979           1374207680:680236980
1374207680:680544980           1374180076:883834979           0:382000
********************************************************************************
1374180077:893291979           1374207681:690382980
1374207681:690667980           1374180077:893948979           0:372000
********************************************************************************
1374180078:903361979           1374207682:700460980
1374207682:700747980           1374180078:904026979           0:378000
********************************************************************************
1374180079:913472979           1374207683:710557980
1374207683:710829980           1374180079:914109979           0:365000
********************************************************************************
1374180080:923581979           1374207684:720668980
1374207684:721010980           1374180080:924284979           0:361000
********************************************************************************
1374180081:933691979           1374207685:730785980
1374207685:731111980           1374180081:934385979           0:368000
********************************************************************************
1374180082:943803979           1374207686:740903980
1374207686:741200980           1374180082:944471979           0:371000
********************************************************************************
1374180083:954062979           1374207687:751161980
1374207687:751555980           1374180083:954826979           0:370000
********************************************************************************
1374180084:964030979           1374207688:761134980
1374207688:761421980           1374180084:964706979           0:389000
********************************************************************************
1374180085:974129979           1374207689:771229980
1374207689:812989980           1374180086:16270979            0:381000
********************************************************************************
1374180086:984240979           1374207690:781346980
1374207690:781638980           1374180086:984914979           0:382000
********************************************************************************
1374180087:994348979           1374207691:791454980
1374207691:791750980           1374180087:995025979           0:381000
********************************************************************************
1374180089:4461979             1374207692:801581980
1374207692:801853980           1374180089:5127979             0:394000
********************************************************************************
1374180090:14569979            1374207693:811674980
1374207693:812083980           1374180090:16124979            0:1146000
********************************************************************************
1374180091:24681979            1374207694:821792980
1374207694:822058980           1374180091:25322979            0:375000
********************************************************************************
1374180092:34790979            1374207695:831901980
1374207695:832329980           1374180092:35590979            0:372000
********************************************************************************
1374180093:44902979            1374207696:842030980
```

```
1374207696:842416980          1374180093:45681979           0:393000
********************************************************************************
1374180094:55172979           1374207697:852304980
1374207697:860371980          1374180094:63639979           0:400000
********************************************************************************
1374180095:65117979           1374207698:862234980
1374207698:862498980          1374180095:65750979           0:369000
********************************************************************************
1374180096:75230979           1374207699:872350980
1374207699:872630980          1374180096:75884979           0:374000
********************************************************************************
1374180097:85338979           1374207700:882458980
1374207700:882723980          1374180097:85973979           0:370000
********************************************************************************
1374180098:95446979           1374207701:892572980
1374207701:892949980          1374180098:96196979           0:373000
********************************************************************************
1374180099:105557979          1374207702:902685980
1374207702:902930980          1374180099:106172979          0:370000
********************************************************************************
1374180100:115669979          1374207703:912793980
1374207703:913045980          1374180100:116303979          0:382000
********************************************************************************
1374180101:125778979          1374207704:922900980
1374207704:923151980          1374180101:126389979          0:360000
********************************************************************************
1374180102:135884979          1374207705:933011980
1374207705:933259980          1374180102:136493979          0:361000
********************************************************************************
1374180103:145995979          1374207706:943126980
1374207706:943393980          1374180103:146626979          0:364000
********************************************************************************
1374180104:156256979          1374207707:953388980
1374207707:953618980          1374180104:156868979          0:382000
********************************************************************************
1374180105:166219979          1374207708:963367980
1374207708:963618980          1374180105:166849979          0:379000
********************************************************************************
1374180106:176330979          1374207709:973475980
1374207709:973719980          1374180106:176944979          0:370000
********************************************************************************
1374180107:186439979          1374207710:983588980
1374207710:983819980          1374180107:187041979          0:371000
********************************************************************************
1374180108:196706979          1374207711:993861980
1374207711:994029980          1374180108:197250979          0:376000
********************************************************************************
1374180109:206665979          1374207713:3829980
1374207713:4051980            1374180109:207271979          0:384000
********************************************************************************
1374180110:216768979          1374207714:13928980
1374207714:14176980           1374180110:217397979          0:381000
********************************************************************************
1374180111:226878979          1374207715:24037980
1374207715:24596980           1374180111:227815979          0:378000
********************************************************************************
1374180112:236987979          1374207716:34149980
1374207716:34386980           1374180112:237603979          0:379000
********************************************************************************
```

```
1374180113:247096979           1374207717:44272980
1374207717:44491980            1374180113:247700979           0:385000
********************************************************************************
1374180114:257359979           1374207718:54524980
1374207718:54756980            1374180114:257970979           0:379000
********************************************************************************
1374180115:267316979           1374207719:64484980
1374207719:64708980            1374180115:267913979           0:373000
********************************************************************************
1374180116:277425979           1374207720:74593980
1374207720:74811980            1374180116:278012979           0:369000
********************************************************************************
1374180117:287535979           1374207721:84705980
1374207721:84918980            1374180117:288119979           0:371000
********************************************************************************
1374180118:297646979           1374207722:94827980
1374207722:95053980            1374180118:298249979           0:377000
********************************************************************************
1374180119:307757979           1374207723:104942980
1374207723:105142980           1374180119:308339979           0:382000
********************************************************************************
1374180120:317864979           1374207724:115049980
1374207724:115242980           1374180120:318436979           0:379000
********************************************************************************
1374180121:327975979           1374207725:125158980
1374207725:125344980           1374180121:328533979           0:372000
********************************************************************************
1374180122:338084979           1374207726:135266980
1374207726:135443980           1374180122:338631979           0:370000
********************************************************************************
1374180123:348193979           1374207727:145386980
1374207727:145597980           1374180123:348786979           0:382000
ME3600X-R1#

ME3600X-R1#  show ip sla history 10 interval-statistics
Delay Statistics for Y1731 Operation 10
Type of operation: Y1731 Delay Measurement
Latest operation start time: *22:40:48.275 UTC Thu Jul 18 2013
Latest operation return code: OK
Distribution Statistics:


Interval 1
 Start time:  *22:40:48.275 UTC Thu Jul 18 2013
 End time:  *22:41:18.275 UTC Thu Jul 18 2013
 Number of measurements initiated: 30
 Number of measurements completed: 30
 Flag: OK


Delay:
  Number of TwoWay observations: 30
    Min/Avg/Max TwoWay: 357/377/397 (microsec)
  Time of occurrence TwoWay:
    Min - *22:41:14.315 UTC Thu Jul 18 2013
    Max - *22:40:59.311 UTC Thu Jul 18 2013

 Bin TwoWay:
   Bin Range (microsec)    Total observations
```

```
            0 - < 5000           30
         5000 - < 10000          0
        10000 - < 15000          0
             15000 - < 20000           0
        20000 - < 25000          0
        25000 - < 30000          0
        30000 - < 35000          0
        35000 - < 40000          0
        40000 - < 45000          0
        45000 - < 4294967295     0

Delay Variance:
  Number of TwoWay positive observations: 14
    Min/Avg/Max TwoWay positive: 0/5/15 (microsec)
  Time of occurrence TwoWay positive:
    Min - *22:40:54.307 UTC Thu Jul 18 2013
    Max - *22:40:59.311 UTC Thu Jul 18 2013
  Number of TwoWay negative observations: 15
    Min/Avg/Max TwoWay negative: 1/6/15 (microsec)
  Time of occurrence TwoWay negative:
    Min - *22:40:54.307 UTC Thu Jul 18 2013
    Max - *22:40:59.311 UTC Thu Jul 18 2013

 Bin TwoWay positive:
   Bin Range (microsec)    Total observations
            0 - < 5000           14
         5000 - < 10000          0
        10000 - < 15000          0
        15000 - < 20000          0
        20000 - < 25000          0
             25000 - < 30000           0
        30000 - < 35000          0
        35000 - < 40000          0
        40000 - < 45000          0
        45000 - < 4294967295     0

 Bin TwoWay negative:
   Bin Range (microsec)    Total observations
            0 - < 5000           15
         5000 - < 10000          0
        10000 - < 15000          0
        15000 - < 20000          0
        20000 - < 25000          0
        25000 - < 30000          0
        30000 - < 35000          0
        35000 - < 40000          0
        40000 - < 45000          0
        45000 - < 4294967295     0

ME3600X-R1#
```

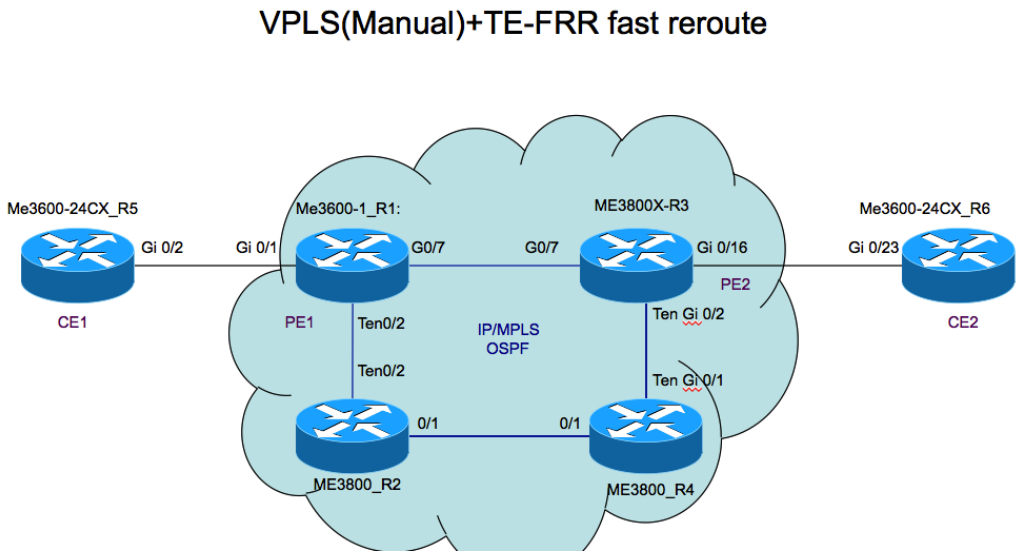
Design Example (F1)—VPLS (manual)+TE-FRR

Virtual Private LAN Service (VPLS)

Virtual Private LAN Services (VPLS) is a class of VPN that supports the connection of multiple sites in a single bridged domain over a managed IP/MPLS network.

In this example, Multipoint manual configuration mode will be used for VPLS.

A sample topology is as shown below:



Configuration at R1

```
l2 vfi vlan234 manual   //VPLS Configuraiton
 vpn id 234
 bridge-domain 234
 neighbor 2.2.2.2 encapsulation mpls
 neighbor 3.3.3.3 encapsulation mpls
 neighbor 4.4.4.4 encapsulation mpls

interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation dot1q 234
  rewrite ingress tag pop 1 symmetric
  bridge-domain 234

interface GigabitEthernet0/7
 no switchport
```

```
 ip address 13.13.13.1 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 mpls traffic-eng backup-path Tunnel13
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

interface TenGigabitEthernet0/2
 no switchport
 ip address 12.12.12.1 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

interface Loopback0
 ip address 1.1.1.1 255.255.255.255

interface Vlan234
 ip address 99.1.1.1 255.255.255.0
 xconnect vfi vlan234

router ospf 1234
 router-id 1.1.1.1
 network 1.1.1.1 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 13.13.13.0 0.0.0.255 area 0
 bfd all-interfaces
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0

ME3600X-R1#show mpls l2transport vc

Local intf     Local circuit              Dest address    VC ID
Status
-------------  -------------------------- --------------- ----------
----------
VFI vlan234    vfi                        2.2.2.2         234
UP
VFI vlan234    vfi                        3.3.3.3         234
UP
VFI vlan234    vfi                        4.4.4.4         234
UP
```

Configuration at R2

```
l2 vfi vlan234 manual
 vpn id 234
 bridge-domain 234
 neighbor 1.1.1.1 encapsulation mpls
 neighbor 3.3.3.3 encapsulation mpls
 neighbor 4.4.4.4 encapsulation mpls
```

```
interface Loopback0
 ip address 2.2.2.2 255.255.255.255

interface TenGigabitEthernet0/2
 no switchport
 ip address 12.12.12.2 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

router ospf 1234
 router-id 2.2.2.2
 network 2.2.2.2 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 24.24.24.0 0.0.0.255 area 0
 bfd all-interfaces
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0

interface Vlan234
 no ip address
 xconnect vfi vlan234
```

Configuration at R3

```
l2 vfi vlan234 manual
 vpn id 234
 bridge-domain 234
 neighbor 1.1.1.1 encapsulation mpls
 neighbor 2.2.2.2 encapsulation mpls
 neighbor 4.4.4.4 encapsulation mpls

interface Loopback0
 ip address 3.3.3.3 255.255.255.255

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.3 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

interface TenGigabitEthernet0/2
 no switchport
 ip address 34.34.34.3 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000
```

```
interface GigabitEthernet0/16
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation dot1q 234
  rewrite ingress tag pop 1 symmetric
  bridge-domain 234

interface Vlan234
 ip address 99.1.1.3 255.255.255.0
 xconnect vfi vlan234

ME3800X-R3#show mpls l2transport vc

Local intf     Local circuit               Dest address    VC ID
Status
-------------  --------------------------- --------------- ----------
----------
VFI vlan234    vfi                         1.1.1.1         234
UP
VFI vlan234    vfi                         2.2.2.2         234
UP
VFI vlan234    vfi                         4.4.4.4         234
UP

ME3800X-R3#
```

Configuration at R4

```
l2 vfi vlan234 manual
 vpn id 234
 bridge-domain 234
 neighbor 1.1.1.1 encapsulation mpls
 neighbor 2.2.2.2 encapsulation mpls
 neighbor 3.3.3.3 encapsulation mpls

interface GigabitEthernet0/1
 no switchport
 ip address 24.24.24.4 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

interface TenGigabitEthernet0/1
 no switchport
 ip address 34.34.34.4 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000
```

```
router ospf 1234
 router-id 4.4.4.4
 network 4.4.4.4 0.0.0.0 area 0
 network 24.24.24.0 0.0.0.255 area 0
 network 34.34.34.0 0.0.0.255 area 0
 network 99.1.1.0 0.0.0.255 area 0
 bfd all-interfaces
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0

interface Vlan234
 no ip address
 xconnect vfi vlan234

ME3800X-R4#show mpls l2transport vc

Local intf     Local circuit               Dest address    VC ID
Status
-------------  --------------------------- --------------- ----------
----------
VFI vlan234    vfi                         1.1.1.1         234
UP
VFI vlan234    vfi                         2.2.2.2         234
UP
VFI vlan234    vfi                         3.3.3.3         234
UP
```

Configuration at R5

```
interface GigabitEthernet0/2
 switchport trunk allowed vlan 234
 switchport mode trunk
 media-type rj45
interface Vlan234
 ip address 99.1.1.5 255.255.255.0

ME3600X-24CX-R5# ping 99.1.1.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 99.1.1.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R5# ping 99.1.1.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 99.1.1.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1/1/1 ms
ME3600X-24CX-R5#
```

Configuration at R6

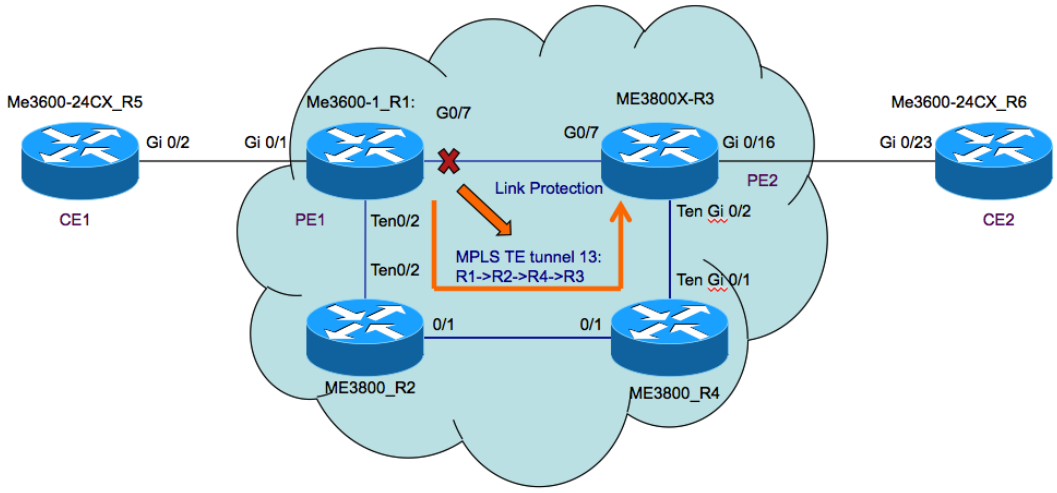
```
interface GigabitEthernet0/23
 switchport trunk allowed vlan 234
```

```
 switchport mode trunk
interface Vlan234
 ip address 99.1.1.6 255.255.255.0

ME3600X-24CX-R6#ping 99.1.1.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 99.1.1.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R6#ping 99.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 99.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R6#
```

MPLS Traffic Engineering and Fast Reroute (TE-FRR)

Below is the Topology for MPLS-TE FRR.

The Link protection will be configured.



Configuation at R1

```
mpls label protocol ldp
mpls ldp discovery quick-start
mpls traffic-eng tunnels


interface Tunnel13
 ip unnumbered Loopback0
 tunnel mode mpls traffic-eng
 tunnel destination 3.3.3.3
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 1000
```

```
 tunnel mpls traffic-eng path-option 1 explicit name frr_13
//explicit path
 tunnel mpls traffic-eng fast-reroute
!
interface Tunnel31
 ip unnumbered Loopback0
 tunnel mode mpls traffic-eng
 tunnel destination 3.3.3.3
 tunnel mpls traffic-eng path-option 1 dynamic //dynamic path
 tunnel mpls traffic-eng fast-reroute

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.1 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 mpls traffic-eng backup-path Tunnel13
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000


interface TenGigabitEthernet0/2
 no switchport
 ip address 12.12.12.1 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

router ospf 1234
 router-id 1.1.1.1
 network 1.1.1.1 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 13.13.13.0 0.0.0.255 area 0
 bfd all-interfaces
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

Configuation at R2

```
mpls label protocol ldp
mpls ldp discovery quick-start
mpls traffic-eng tunnels

interface TenGigabitEthernet0/2
 no switchport
 ip address 12.12.12.2 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
```

```
 ip rsvp bandwidth 25000

interface GigabitEthernet0/1
 no switchport
 ip address 24.24.24.2 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

router ospf 1234
 router-id 2.2.2.2
 network 2.2.2.2 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 24.24.24.0 0.0.0.255 area 0
 bfd all-interfaces
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

Configuration at R3

```
mpls label protocol ldp
mpls ldp discovery quick-start
mpls traffic-eng tunnels

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.3 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

interface TenGigabitEthernet0/2
 no switchport
 ip address 34.34.34.3 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

router ospf 1234
 router-id 3.3.3.3
 network 3.3.3.3 0.0.0.0 area 0
 network 13.13.13.0 0.0.0.255 area 0
 network 34.34.34.0 0.0.0.255 area 0
 bfd all-interfaces
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

Configuration at R4

```
mpls label protocol ldp
mpls ldp discovery quick-start
mpls traffic-eng tunnels

interface GigabitEthernet0/1
 no switchport
 ip address 24.24.24.4 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

interface TenGigabitEthernet0/1
 no switchport
 ip address 34.34.34.4 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

router ospf 1234
 router-id 4.4.4.4
 network 4.4.4.4 0.0.0.0 area 0
 network 24.24.24.0 0.0.0.255 area 0
 network 34.34.34.0 0.0.0.255 area 0
 network 99.1.1.0 0.0.0.255 area 0
 bfd all-interfaces
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

Verification on R1

```
ME3600X-R1#show interfaces tunnel 13
Tunnel13 is up, line protocol is up
  Hardware is Tunnel
  Interface is unnumbered. Using address of Loopback0 (1.1.1.1)
  MTU 17936 bytes, BW 100 Kbit/sec, DLY 50000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive not set
  Tunnel source 1.1.1.1, destination 3.3.3.3
  Tunnel protocol/transport Label Switching
  Tunnel transmit bandwidth 8000 (kbps)
  Tunnel receive bandwidth 8000 (kbps)
  Last input never, output never, output hang never
  Last clearing of "show interface" counters 03:47:50
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops:
0
  Queueing strategy: fifo
  Output queue: 0/0 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
```

```
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
ME3600X-R1#


ME3600X-R1#show interfaces tunnel 31
Tunnel31 is up, line protocol is up
  Hardware is Tunnel
  Interface is unnumbered. Using address of Loopback0 (1.1.1.1)
  MTU 17940 bytes, BW 100 Kbit/sec, DLY 50000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive not set
  Tunnel source 1.1.1.1, destination 3.3.3.3
  Tunnel protocol/transport Label Switching
  Tunnel transmit bandwidth 8000 (kbps)
  Tunnel receive bandwidth 8000 (kbps)
  Last input never, output never, output hang never
  Last clearing of "show interface" counters 03:16:55
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops:
0
  Queueing strategy: fifo
  Output queue: 0/0 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
ME3600X-R1#

ME3600X-R1#show mpls traffic-eng fast-reroute database  detail
FRR Database Summary:
  Protected interfaces     : 1
  Protected LSPs/Sub-LSPs  : 1
  Backup tunnels           : 1
  Active interfaces        : 0
  FRR Active tunnels       : 0

P2P LSPs:

 Tun ID: 31, LSP ID: 2, Source: 1.1.1.1
 Destination: 3.3.3.3
  State         : ready
  InLabel       : Tunnel Head
  OutLabel      : Gi0/7:implicit-null
  FRR OutLabel  : Tu13:implicit-null
```

```
ME3600X-R1#show mpls traffic-eng tunnels protection

P2P TUNNELS:
ME3600X-R1_t13
  LSP Head, Tunnel13, Admin: up, Oper: up
  Src 1.1.1.1, Dest 3.3.3.3, Instance 7
  Fast Reroute Protection: Requested
    Outbound: Unprotected: no backup tunnel assigned
      LSP signalling info:
        Original: out i/f: Te0/2, label: 25, nhop: 12.12.12.2
                  nnhop: 4.4.4.4; nnhop rtr id: 4.4.4.4
  Path Protection: None
ME3600X-R1_t31
  LSP Head, Tunnel31, Admin: up, Oper: up
  Src 1.1.1.1, Dest 3.3.3.3, Instance 2
  Fast Reroute Protection: Requested
    Outbound: FRR Ready
      Backup Tu13 to LSP nhop
        Tu13: out i/f: Te0/2, label: 25
      LSP signalling info:
        Original: out i/f: Gi0/7, label: implicit-null, nhop:
13.13.13.3
        With FRR: out i/f: Tu13, label: implicit-null
      LSP bw: 0 kbps, Backup level: any-unlim, type: any pool
  Path Protection: None

P2MP TUNNELS:
ME3600X-R1#
```

Design Example (F2)—VPLS (BGP Auto Discovery-BGP Signlaing)

VPLS –BGP Auto Discovery BGP Singaling

Configuration at R1

```
l2vpn vfi context vlan234
 vpn id 234
 autodiscovery bgp signaling bgp // Use BGP Signaling for the BGP
Autodiscovery
  ve id 12
  ve range 12

bridge-domain 234
 member GigabitEthernet0/1 service-instance 1 //New CLI for L2VPN

interface GigabitEthernet0/1
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation dot1q 234
  rewrite ingress tag pop 1 symmetric

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.1 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 mpls traffic-eng backup-path Tunnel13
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

interface Vlan234
 no ip address
 member vfi vlan234

router bgp 1234
 bgp log-neighbor-changes
 neighbor 3.3.3.3 remote-as 1234
 neighbor 3.3.3.3 update-source Loopback0
 !
 address-family l2vpn vpls
  neighbor 3.3.3.3 activate
  neighbor 3.3.3.3 send-community extended
  neighbor 3.3.3.3 suppress-signaling-protocol ldp
 exit-address-family

router ospf 1234
```

```
 router-id 1.1.1.1
 network 1.1.1.1 0.0.0.0 area 0
 network 12.12.12.0 0.0.0.255 area 0
 network 13.13.13.0 0.0.0.255 area 0
 bfd all-interfaces
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0


ME3600X-R1#show l2vpn atom vc detail
pseudowire100006 is up, VC status is up PW type: Ethernet
  Create time: 00:06:32, last status change time: 00:06:32
    Last label FSM state change time: 00:06:32
  Destination address: 3.3.3.3 VC ID: 234
    Output interface: Gi0/7, imposed label stack {47}
    Preferred path: not configured
    Default path: active
    Next hop: 13.13.13.3
  Member of vfi service vlan234
    Bridge-Domain id: 234
    Service id: 0x24000002
  Signaling protocol: BGP
    Local VE ID: 12, Remote VE ID: 14
    Status TLV support (local/remote)          : Not Applicable
      LDP route watch                          : Not Applicable
      Label/status state machine               : established, LruRru
      Local dataplane status received          : No fault
      BFD dataplane status received            : Not Applicable
      BFD peer monitor status received         : Not Applicable
      Status received from access circuit      : No fault
      Status sent to access circuit            : No fault
      Status received from pseudowire i/f      : No fault
      Status sent to network peer              : Not Applicable
      Status received from network peer        : Not Applicable
      Adjacency status of remote peer          : Not Applicable
  Bindings
    Parameter    Local                          Remote
    ------------ ------------------------------ ----------------------
---------
    Label        37                             47
    Group ID     0                              0
    Interface
    MTU          1500                           1500
    Control word off                            off
    PW type      Ethernet                       Ethernet
    VCCV CV type 0x32                           0x32
                   LSPV [2], BFD/Raw [5]          LSPV [2], BFD/Raw
[5]
                   BFD/Raw + sig [6]              BFD/Raw + sig [6]
    VCCV CC type 0x03                           0x03
                   CW [1], RA [2]                 CW [1], RA [2]
    Status TLV   disabled                       N/A
  Dataplane:
    SSM segment/switch IDs: 16407/4113 (used), PWID: 17
  Rx Counters
    5 input transit packets, 680 bytes
    0 drops, 0 seq err
  Tx Counters
    5 output transit packets, 610 bytes
```

```
    0 drops
```

Configuration at R2

```
l2vpn vfi context vlan234
 vpn id 234
 autodiscovery bgp signaling bgp
  ve id 14
  ve range 12

bridge-domain 234
 member GigabitEthernet0/16 service-instance 1


interface GigabitEthernet0/16
 switchport trunk allowed vlan none
 switchport mode trunk
 service instance 1 ethernet
  encapsulation dot1q 234
  rewrite ingress tag pop 1 symmetric

interface GigabitEthernet0/7
 no switchport
 ip address 13.13.13.3 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls traffic-eng tunnels
 bfd interval 50 min_rx 50 multiplier 3
 no bfd echo
 ip rsvp bandwidth 25000

interface Vlan234
 no ip address
 member vfi vlan234


router bgp 1234
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 1234
 neighbor 1.1.1.1 update-source Loopback0
 !
 address-family l2vpn vpls
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 send-community extended
  neighbor 1.1.1.1 suppress-signaling-protocol ldp
 exit-address-family


ME3800X-R3# show mpls l2transport vc

Local intf     Local circuit              Dest address    VC ID
Status
-------------  -------------------------- --------------- ----------
----------
VFI vlan234    vfi                        1.1.1.1         234
UP

ME3800X-R3# show mpls l2transport vc detail
```

```
Local interface: VFI vlan234 vfi up
  Interworking type is Ethernet
  Destination address: 1.1.1.1, VC ID: 234, VC status: up
    Output interface: Gi0/7, imposed label stack {37}
    Preferred path: not configured
    Default path: active
    Next hop: 13.13.13.1
  Create time: 00:11:20, last status change time: 00:11:20
    Last label FSM state change time: 00:11:20
  Signaling protocol: BGP
    Status TLV support (local/remote)   : Not Applicable
      LDP route watch                   : Not Applicable
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not Applicable
      Last BFD peer monitor  status rcvd: Not Applicable
      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: Not Applicable
      Last remote LDP TLV    status rcvd: Not Applicable
      Last remote LDP ADJ    status rcvd: Not Applicable
    MPLS VC labels: local 47, remote 37
    Group ID: local 0, remote 0
    MTU: local 1500, remote 1500
  Control Word: Off
  Dataplane:
    SSM segment/switch IDs: 16412/4118 (used), PWID: 26
  VC statistics:
    transit packet totals: receive 5, send 5
    transit byte totals:   receive 680, send 610
    transit packet drops:  receive 0, seq error 0, send 0


ME3800X-R3#
```

Configuration at R5

```
interface GigabitEthernet0/2
 switchport trunk allowed vlan 234
 switchport mode trunk
 media-type rj45
end

interface Vlan234
 ip address 99.1.1.5 255.255.255.0

ME3600X-24CX-R5#ping 99.1.1.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 99.1.1.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R5#
```

Configuration at R6

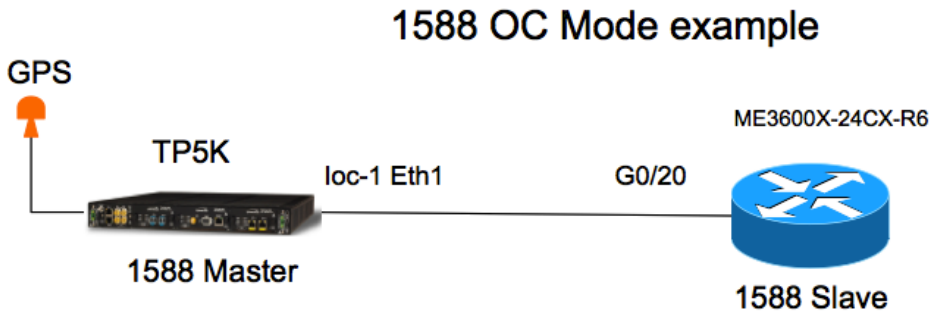
```
interface GigabitEthernet0/23
 switchport trunk allowed vlan 234
 switchport mode trunk
interface Vlan234
 ip address 99.1.1.6 255.255.255.0

ME3600X-24CX-R6#ping 99.1.1.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 99.1.1.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
ME3600X-24CX-R6#
```

Chapter 3
Cisco ME3600X-24CX-TDM/Clocking Solution

Important: 1588 is only supported on Cisco ME3600X-24CX. It is not supported on Cisco ME3600X-24TS/24FS/ME3800X.

1588 Ordinary Clocking

Topology:



Important: The TP5K didn't connect to the GPS.This example just show how to configure the 1588 OC on the ME3600X-24CX.

TP5K Configuration:

```
tp5000> show ip config ioc1

   ETH1 PORT PARAMETERS
 IP address:     20.1.1.1
 IP mask    :    255.255.255.0
 IP gateway:     20.1.1.2
 IP state   :    enable


   ETH2 PORT PARAMETERS
 IP address:     192.168.2.11
 IP mask    :    255.255.255.0
 IP gateway:     192.168.2.1
 IP state   :    enable

tp5000>

tp5000> show ip status ioc
ETH1       Link encap:Ethernet  HWaddr 00:B0:AE:02:8F:00
           inet addr:20.1.1.1  Bcast:20.1.1.255  Mask:255.255.255.0
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
```

```
           RX packets:86401 errors:0 dropped:0 overruns:0 frame:0
           TX packets:80154 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:8071577 (7.6 MiB)  TX bytes:7509248 (7.1 MiB)

ETH2       Link encap:Ethernet  HWaddr 00:B0:AE:02:8E:FF
           inet addr:192.168.2.11  Bcast:192.168.2.255
Mask:255.255.255.0
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:94659 errors:0 dropped:0 overruns:0 frame:0
           TX packets:115524 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:5689494 (5.4 MiB)  TX bytes:4867640 (4.6 MiB)

tp5000>
tp5000> show ptp-client ioc-1 all

Index IP Address       VLAN  PRI Clock Id                 Mode Ann
Sync Delay
1     6.6.6.6          0     0   13:1A:53:FF:FE:BC:00:00  D    1    -
5   -4
```

Cisco ME3600X-24CX-R6 Configuration:

```
interface Loopback0
 ip address 6.6.6.6 255.255.255.255

interface GigabitEthernet0/20
 no switchport
 ip address 20.1.1.2 255.255.255.0

ptp clock ordinary domain 0
 clock-port slave slave
  transport ipv4 unicast interface Lo0 negotiation
  clock source 20.1.1.1

ME3600X-24CX-R6#ping 20.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 20.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
ME3600X-24CX-R6#

ME3600X-24CX-R6#ping 20.1.1.1 source 6.6.6.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 20.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 6.6.6.6
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
ME3600X-24CX-R6#

ME3600X-24CX-R6#show ptp clock running

                      PTP Ordinary Clock [Domain 0]

         State          Ports          Pkts sent      Pkts rcvd
```

```
Redundancy Mode

         PHASE_ALIGNED  1               1151693        3396000
Track one
                                PORT SUMMARY

PTP Master
Name                Tx Mode      Role         Transport    State
Sessions     Port Addr

slave               unicast      slave        Lo0          Slave
1            20.1.1.1
ME3600X-24CX-R6#

ME3600X-24CX-R6#show ptp clock dataset current

CLOCK [Ordinary Clock, domain 0]

  Steps Removed: 1
  Offset From Master: -4ns
  Mean Path Delay: 68ns
ME3600X-24CX-R6#


ME3600X-24CX-R6#show platform ptp all
Slave info  : [Loopback0][0x13C22020]
---------------------------------
clock role          : SLAVE
Slave Port hdl      : 788529158
Tx Mode             : Unicast-Negotiation
Slave IP            : 6.6.6.6
Max Clk Srcs        : 1
Boundary Clock      : FALSE
Lock status         : PHASE ALIGNED
Refcnt              : 1
Configured-Flags    : 0x7F - Clock Port Stream
Config-Ready-Flags  : Port Stream
-----------
PTP Engine Handle   : 0
Master IP           : 20.1.1.1
Local Priority      : 0
Set Master IP       : 20.1.1.1

ME3600X-24CX-R6#
ME3600X-24CX-R6#show ptp  port dataset port

PORT [slave]

  Clock Identity: 0x13:1A:53:FF:FE:BC:0:0
  Port Number: 1
  Port State: Slave
  Min Delay Req Interval (log base 2): 0
  Peer Mean Path Delay: 0
  Announce interval (log base 2): 1
  Announce Receipt Timeout: 3
  Sync Interval (log base 2): -5
  Delay Mechanism: End to End
  Peer Delay Request Interval (log base 2): -4
  PTP version: 2
```

```
ME3600X-24CX-R6#
```

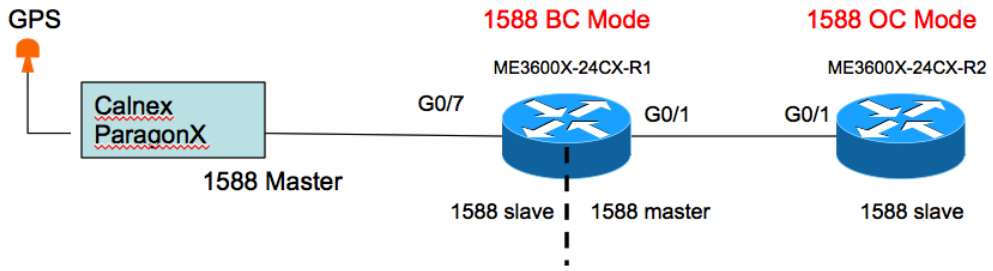
1588 Boundary Clocking (1588 BC)

Important: 1588 BC feature need the 1588 BC license.

Installing the 1588 BC license:

```
ME3600X-24CX-R6#license install
flash:FOC1638N1E2_201307252252552840.lic
Installing licenses from "flash:FOC1638N1E2_201307252252552840.lic"
Installing...Feature:1588BC...Successful:Supported
1/1 licenses were successfully installed
0/1 licenses were existing licenses
0/1 licenses were failed to install

Note:
Need a restart to active the 1588 BC license

After restart: 1588 BC configuration is available.

ME3600X-24CX-R6(config)#ptp clock ?
  boundary          Configure PTP Boundary clock
  e2e-transparent   Configure PTP End-to-End Transparent Clock
  ordinary          Configure PTP Ordinary clock
```

Topology:



Configuration on R1:

```
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
 ip ospf 1 area 0
!
interface Loopback1
 ip address 1.1.1.11 255.255.255.255
```

```
 ip ospf 1 area 0

interface GigabitEthernet0/1
 no switchport
 ip address 1.2.1.1 255.255.255.0
 ip ospf 1 area 0
 media-type rj45

interface GigabitEthernet0/7
 no switchport
 ip address 10.1.1.2 255.255.255.0
 ip ospf 1 area 0

router ospf 1

ptp clock boundary domain 0
 output 1pps 0/0
 clock-port slave slave
  transport ipv4 unicast interface Lo1 negotiation
  clock source 10.1.1.1
 clock-port master master
  transport ipv4 unicast interface Lo0 negotiation
!
!


R1#show ptp clock running



                      PTP Boundary Clock [Domain 0]

          State           Ports           Pkts sent      Pkts rcvd
Redundancy Mode

          PHASE_ALIGNED   2               529959         548746
Track one

                                PORT SUMMARY

PTP Master
Name                 Tx Mode      Role         Transport    State
Sessions     Port Addr

slave                unicast      slave        Lo1          Slave
1            10.1.1.1
master               unicast      master       Lo0          Master
1            -
R1#


R1#show ptp clock running domain 0



                      PTP Boundary Clock [Domain 0]

          State           Ports           Pkts sent      Pkts rcvd
Redundancy Mode
```

```
         PHASE_ALIGNED  2               4536525        4475470
Track one

                                PORT SUMMARY

PTP Master
Name                 Tx Mode      Role         Transport    State
Sessions     Port Addr

slave                unicast      slave        Lo1          Slave
1            10.1.1.1
master               unicast      master       Lo0          Master
1            -


                              SESSION INFORMATION

slave [Lo1] [Sessions 1]

 Peer addr           Pkts in    Pkts out    In Errs    Out Errs

 10.1.1.1            3353226    1137107     0          0

master [Lo0] [Sessions 1]

 Peer addr           Pkts in    Pkts out    In Errs    Out Errs

 2.2.2.2             1122244    3399418     0          0
R1#


R1#show platform ptp all
Slave info  : [Loopback1][0x1307BD08]
--------------------------------
clock role           : SLAVE
Slave Port hdl       : 452984836
Tx Mode              : Unicast-Negotiation
Slave IP             : 1.1.1.11
Max Clk Srcs         : 1
Boundary Clock       : TRUE
Lock status          : PHASE ALIGNED
Refcnt               : 1
Configured-Flags     : 0x7F - Clock Port Stream
Config-Ready-Flags   : Port Stream

----------------------------
Master info : [Loopback0][0x1307BE88]
----------------------------
Clock-role          : MASTER
Master Port Hdl     : 2432696325
Master Engine Hdl   : -1
Master tx mode      : Unicast-Negotiation
No. of Slaves       : 1
No. of 'UP' Slaves  : 0
Master IP           : 1.1.1.1
Master State        : 0x81F
Boundary Clock      : TRUE
```

```
QL-info:
-------
clockClass          : 13
clockQuality        : 47
Scaled Log Var      : 52592

List of slaves under this master
--------------------------------
Slave info (master's) : [Loopback0][0x1307BC40]
--------------------------------
clock role          : MASTER/SLAVE
Slave Port hdl      : 0
Slave IP            : 2.2.2.2
Max Clk Srcs        : 1
Refcnt              : 1
Configured-Flags    : 0x0 -
Config-Ready-Flags  :
-----------
PTP Engine Handle   : 0
Local Priority      : 0

R1#

R1#show ptp  port dataset port

PORT [slave]

  Clock Identity: 0xA:94:4D:FF:FE:60:0:0
  Port Number: 1
  Port State: Slave
  Min Delay Req Interval (log base 2): 0
  Peer Mean Path Delay: 0
  Announce interval (log base 2): 1
  Announce Receipt Timeout: 3
  Sync Interval (log base 2): -5
  Delay Mechanism: End to End
  Peer Delay Request Interval (log base 2): -4
  PTP version: 2

PORT [master]

  Clock Identity: 0xA:94:4D:FF:FE:60:0:0
  Port Number: 2
  Port State: Master
  Min Delay Req Interval (log base 2): 0
  Peer Mean Path Delay: 0
  Announce interval (log base 2): 1
  Announce Receipt Timeout: 3
  Sync Interval (log base 2): -5
  Delay Mechanism: End to End
  Peer Delay Request Interval (log base 2): -4
  PTP version: 2
R1#

1#show ptp port running detail

PORT [slave] CURRENT PTP MASTER PORT
  Protocol Address: 10.1.1.1
  Clock Identity: 0x0:0:0:0:0:0:0:0
```

```
PORT [slave] PREVIOUS PTP MASTER PORT

PORT [slave] LIST OF PTP MASTER PORTS

LOCAL PRIORITY 0
  Protocol Address: 10.1.1.1
  Clock Identity:  0x0:0:0:0:0:0:0:1
  PTSF Status:
  Alarm In Stream:
  Clock Stream Id: 0
  Priority1: 0
  Priority2: 0
  Class: 7
  Accuracy: Within 25ns
  Offset (log variance): 0
  Steps Removed: 0

R1#
```

Configuration on R2

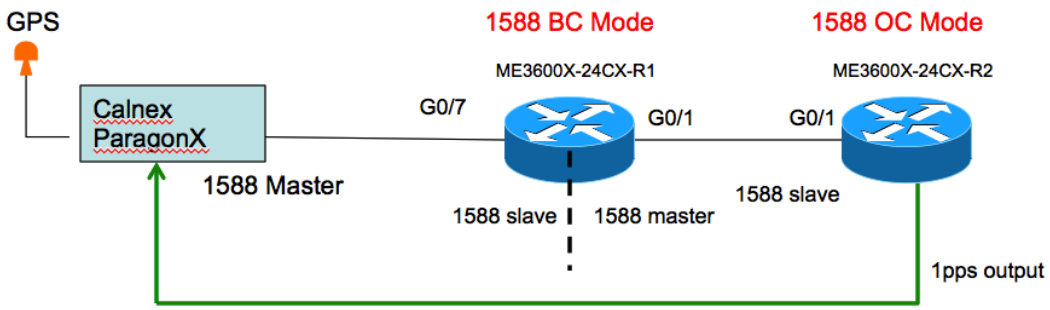
```
router ospf 1

interface Loopback0
 ip address 2.2.2.2 255.255.255.255
 ip ospf 1 area 0
!
interface Loopback1
 ip address 2.2.2.22 255.255.255.255
 ip ospf 1 area 0

interface GigabitEthernet0/1
 no switchport
 ip address 1.2.1.2 255.255.255.0
 ip ospf 1 area 0
 media-type rj45


ptp clock ordinary domain 0
 tod 0/0 ntp
 output 1pps 0/0
 clock-port slave slave
  transport ipv4 unicast interface Lo0 negotiation
  clock source 1.1.1.1


R2#     show ptp clock running domain 0



                      PTP Ordinary Clock [Domain 0]

         State           Ports          Pkts sent      Pkts rcvd
Redundancy Mode
```

```
         PHASE_ALIGNED  1               1141086        3455773
Track one

                                PORT SUMMARY

PTP Master
Name                Tx Mode      Role         Transport    State
Sessions     Port Addr

slave               unicast      slave        Lo0          Slave
1            1.1.1.1


                              SESSION INFORMATION

slave [Lo0] [Sessions 1]

 Peer addr          Pkts in    Pkts out   In Errs    Out Errs

 1.1.1.1            3455773    1141086    0          0
R2#

R2#show platform ptp  all
Slave info  : [Loopback0][0x131AFE10]
--------------------------------
clock role          : SLAVE
Slave Port hdl      : 3942645762
Tx Mode             : Unicast-Negotiation
Slave IP            : 2.2.2.2
Max Clk Srcs        : 1
Boundary Clock      : FALSE
Lock status         : PHASE ALIGNED
Refcnt              : 1
Configured-Flags    : 0x7F - Clock Port Stream
Config-Ready-Flags  : Port Stream
-----------
PTP Engine Handle   : 0
Master IP           : 1.1.1.1
Local Priority      : 0
Set Master IP       : 1.1.1.1

R2#
R2# show ptp port dataset port

PORT [slave]

  Clock Identity: 0xA:92:8B:FF:FE:28:0:0
  Port Number: 1
  Port State: Slave
  Min Delay Req Interval (log base 2): 0
  Peer Mean Path Delay: 0
  Announce interval (log base 2): 1
  Announce Receipt Timeout: 3
  Sync Interval (log base 2): -5
  Delay Mechanism: End to End
  Peer Delay Request Interval (log base 2): -4
  PTP version: 2
R2#
```

```
R2#show ptp port running detail

PORT [slave] CURRENT PTP MASTER PORT
  Protocol Address: 1.1.1.1
  Clock Identity: 0x0:0:0:0:0:0:0:0

PORT [slave] PREVIOUS PTP MASTER PORT

PORT [slave] LIST OF PTP MASTER PORTS

LOCAL PRIORITY 0
  Protocol Address: 1.1.1.1
  Clock Identity:  0xA:94:4D:FF:FE:60:0:0
  PTSF Status:
  Alarm In Stream:
  Clock Stream Id: 0
  Priority1: 0
  Priority2: 0
  Class: 7
  Accuracy: Within 25ns
  Offset (log variance): 0
  Steps Removed: 0

R2#
```

1PPS Configuration

Topology:

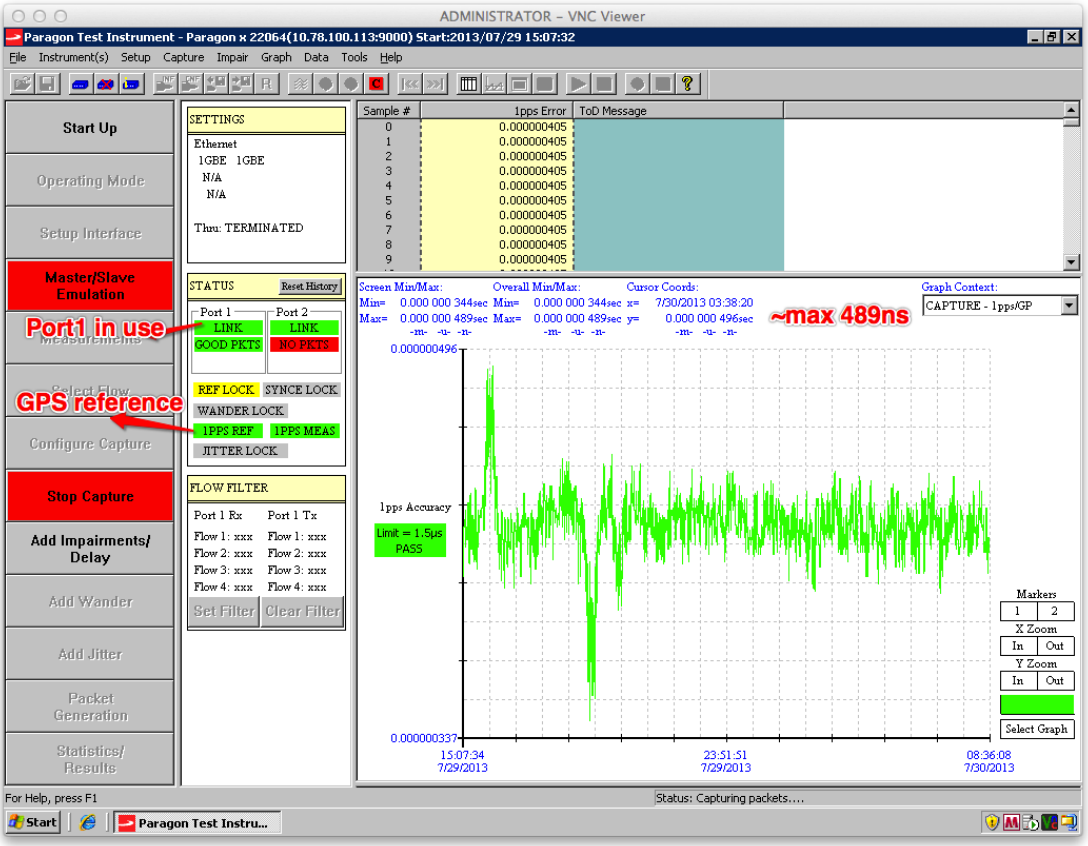


Output 1pps signal on the R2, see the green line, connect the 1pps signal to the Testing equipment(Calnex ParagonX),compare the 1pps signal with the stardarnd 1pps signal.

Configuration at R2

```
ptp clock ordinary domain 0
 tod 0/0 ntp
 output 1pps 0/0  // output 1pps Signal
 clock-port slave slave
  transport ipv4 unicast interface Lo0 negotiation
  clock source 1.1.1.1
```

Testing Result on the Calnex:



BITS Port Configuration

Configuring the BITS port :

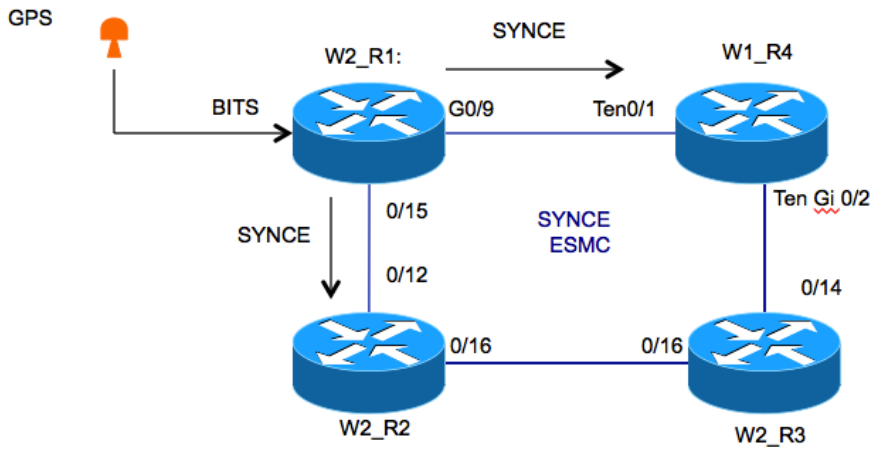
```
R1#sh runn | i network-clock
network-clock synchronization automatic
network-clock synchronization mode QL-enabled
network-clock input-source 1 External 1/0/0 e1 crc4 linecode hdb3
network-clock wait-to-restore 0 global
esmc process
controller BITS input applique E1 framing fas_crc4 linecode
hdb3//this line is automatically generated due to the old code. It
will be removed in the future
```

Verifying the BITS port selection

```
R1#              show network-clocks synchronization
Symbols:      En - Enable, Dis - Disable, Adis - Admin Disable
              NA - Not Applicable
              *  - Synchronization source selected
              #  - Synchronization source force selected
              &  - Synchronization source manually switched

Automatic selection process : Enable
Equipment Clock : 2048 (EEC-Option1)
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
T0 : External 1/0/0 e1 crc4
Hold-off (global) : 300 ms
Wait-to-restore (global) : 0 sec
Tsm Delay : 180 ms
Revertive : No

Nominated Interfaces

 Interface            SigType      Mode/QL       Prio  QL_IN  ESMC Tx
ESMC Rx
 Internal             NA           NA/Dis        251   QL-SEC    NA
NA
*External 1/0/0       E1 CRC4      NA/En         1     QL-PRC    NA
NA
R1#
```

SYNCE ESMC

Toplogy



R1,R2,R3 are the ME3600X-24CX

R4 is the ME3800X.

Configuration at R1

```
interface GigabitEthernet0/15
 no switchport
 ip address 1.2.1.1 255.255.255.0
 ip ospf 1 area 0
 synchronous mode  //Enable SYNCE

interface GigabitEthernet0/9
 no switchport
 ip address 1.4.1.1 255.255.255.0
 ip ospf 1 area 0
 synchronous mode



network-clock synchronization automatic
network-clock synchronization mode QL-enabled
network-clock input-source 1 External 1/0/0 e1 crc4 linecode
hdb3//Configure BITS
network-clock wait-to-restore 0 global
```

```
esmc process // enable the ESMC process
controller BITS input applique E1 framing fas_crc4 linecode hdb3

R1#              show network-clocks synchronization
Symbols:      En - Enable, Dis - Disable, Adis - Admin Disable
              NA - Not Applicable
              *  - Synchronization source selected
              #  - Synchronization source force selected
              &  - Synchronization source manually switched

Automatic selection process : Enable
Equipment Clock : 2048 (EEC-Option1)
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
T0 : External 1/0/0 e1 crc4
Hold-off (global) : 300 ms
Wait-to-restore (global) : 0 sec
Tsm Delay : 180 ms
Revertive : No

Nominated Interfaces

 Interface             SigType      Mode/QL       Prio   QL_IN   ESMC Tx
ESMC Rx
 Internal              NA           NA/Dis        251    QL-SEC     NA
NA
*External 1/0/0        E1 CRC4      NA/En         1      QL-PRC     NA
NA
R1#                        //Get the clocking via BITS port
```

Configuration at R2

```
interface GigabitEthernet0/12
 no switchport
 ip address 1.2.1.2 255.255.255.0
 ip ospf 1 area 0
 synchronous mode

interface GigabitEthernet0/16
 no switchport
 ip address 2.3.1.1 255.255.255.0
 ip ospf 1 area 0
 synchronous mode

network-clock synchronization automatic
network-clock synchronization mode QL-enabled
network-clock input-source 1 interface GigabitEthernet0/12
network-clock input-source 2 interface GigabitEthernet0/16
esmc process


R2#show network-clocks synchronization
Symbols:      En - Enable, Dis - Disable, Adis - Admin Disable
              NA - Not Applicable
              *  - Synchronization source selected
```

```
             #  - Synchronization source force selected
             &  - Synchronization source manually switched

Automatic selection process : Enable
Equipment Clock : 2048 (EEC-Option1)
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
T0 : GigabitEthernet0/12
Hold-off (global) : 300 ms
Wait-to-restore (global) : 300 sec
Tsm Delay : 180 ms
Revertive : No

Nominated Interfaces

 Interface            SigType     Mode/QL      Prio  QL_IN  ESMC Tx
ESMC Rx
 Internal             NA          NA/Dis       251   QL-SEC    NA
NA
*Gi0/12               NA          Sync/En      1     QL-PRC    -
-
 Gi0/16               NA          Sync/En      2     QL-DNU    -
-
R2#
```

Configuration at R3

```
interface GigabitEthernet0/14
 no switchport
 ip address 3.4.1.1 255.255.255.0
 ip ospf 1 area 0
 synchronous mode
!
interface GigabitEthernet0/15
!
interface GigabitEthernet0/16
 no switchport
 ip address 2.3.1.2 255.255.255.0
 ip ospf 1 area 0
 synchronous mode

network-clock synchronization automatic
network-clock synchronization mode QL-enabled
network-clock input-source 2 interface GigabitEthernet0/14
network-clock input-source 1 interface GigabitEthernet0/16
network-clock wait-to-restore 0 global
esmc process

R3#               SH NETWOrk-clocks  SYnchronization
Symbols:     En - Enable, Dis - Disable, Adis - Admin Disable
             NA - Not Applicable
             *  - Synchronization source selected
             #  - Synchronization source force selected
             &  - Synchronization source manually switched

Automatic selection process : Enable
```

```
Equipment Clock : 2048 (EEC-Option1)
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
T0 : GigabitEthernet0/16
Hold-off (global) : 300 ms
Wait-to-restore (global) : 0 sec
Tsm Delay : 180 ms
Revertive : No

Nominated Interfaces

 Interface            SigType      Mode/QL      Prio  QL_IN  ESMC Tx
ESMC Rx
 Internal             NA           NA/Dis       251   QL-SEC    NA
NA
 Gi0/14               NA           Sync/En      2     QL-PRC    -
-
*Gi0/16               NA           Sync/En      1     QL-PRC    -
-
R3#
```

Configuration at R4

```
interface TenGigabitEthernet0/1
 no switchport
 ip address 1.4.1.2 255.255.255.0
 ip ospf 1 area 0
 synchronous mode  //For Whale1 platform ,only Ten Giga port can be
used to get the SYNCE clocking
!
interface TenGigabitEthernet0/2
 no switchport
 ip address 3.4.1.2 255.255.255.0
 ip ospf 1 area 0
 synchronous mode

network-clock synchronization automatic
network-clock synchronization mode QL-enabled
network-clock input-source 1 interface TenGigabitEthernet0/1
network-clock input-source 2 interface TenGigabitEthernet0/2
network-clock wait-to-restore 0 global
esmc process


R4#SH network-clocks  synchronization
Symbols:     En - Enable, Dis - Disable, Adis - Admin Disable
             NA - Not Applicable
             *  - Synchronization source selected
             #  - Synchronization source force selected
             &  - Synchronization source manually switched

Automatic selection process : Enable
Equipment Clock : 2048 (EEC-Option1)
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
```

```
T0 : TenGigabitEthernet0/1
Hold-off (global) : 300 ms
Wait-to-restore (global) : 0 sec
Tsm Delay : 180 ms
Revertive : No

Nominated Interfaces

 Interface            SigType     Mode/QL      Prio  QL_IN  ESMC Tx
ESMC Rx
 Internal             NA          NA/Dis       251   QL-SEC    NA
NA
*Te0/1                NA          Sync/En      1     QL-PRC    -
-
 Te0/2                NA          Sync/En      2     QL-PRC    -
-
R4#
```