



MPLS VPLS Implementation

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**MUM Cambodia
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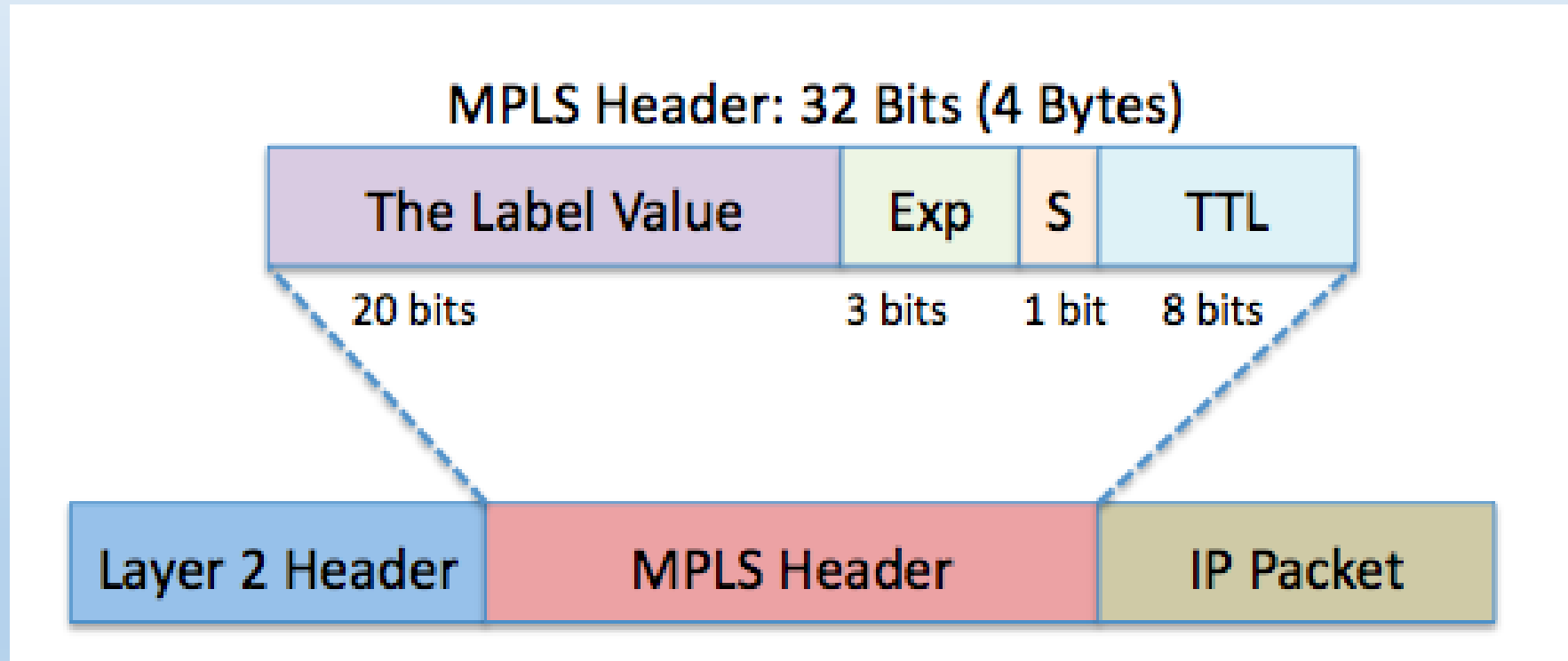


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What is MPLS

- MPLS stands for “Multi-Protocol Label Switching”.
- MPLS is best summarized as a “Layer 2.5 networking protocol”.
- MPLS combines layer 2 switching technology and layer 3 routing technology so that it becomes the best network solution in solving speed, scalability, QOS (Quality of Service), and traffic engineering problems.

MPLS LABEL FORMAT



Label Switching

MPLS does “label switching” instead:

The router applies a “label” based on this information.

Future routers use the label to route the traffic

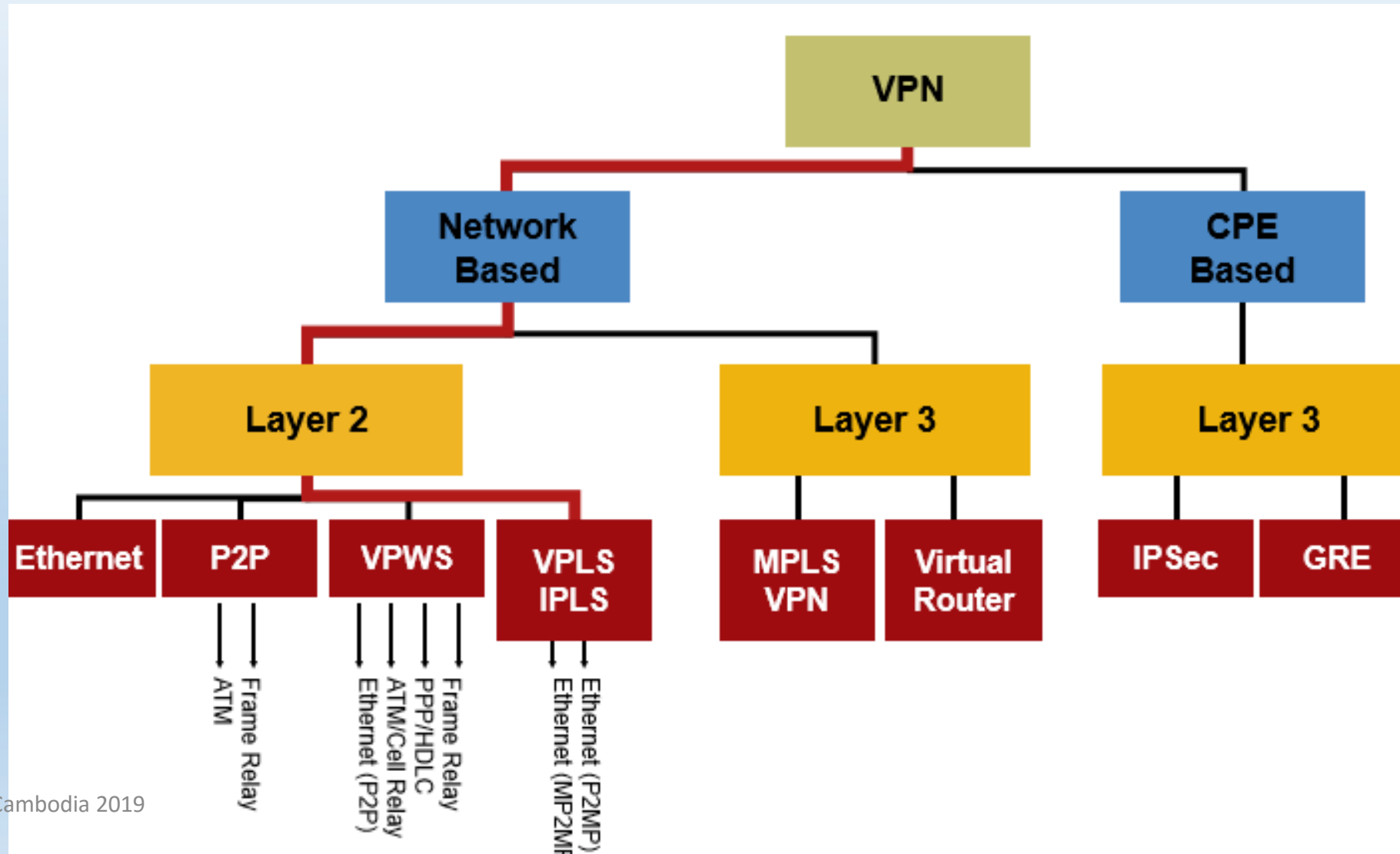
At the final destination router the label is removed.

And the packet is delivered via normal IP routing.

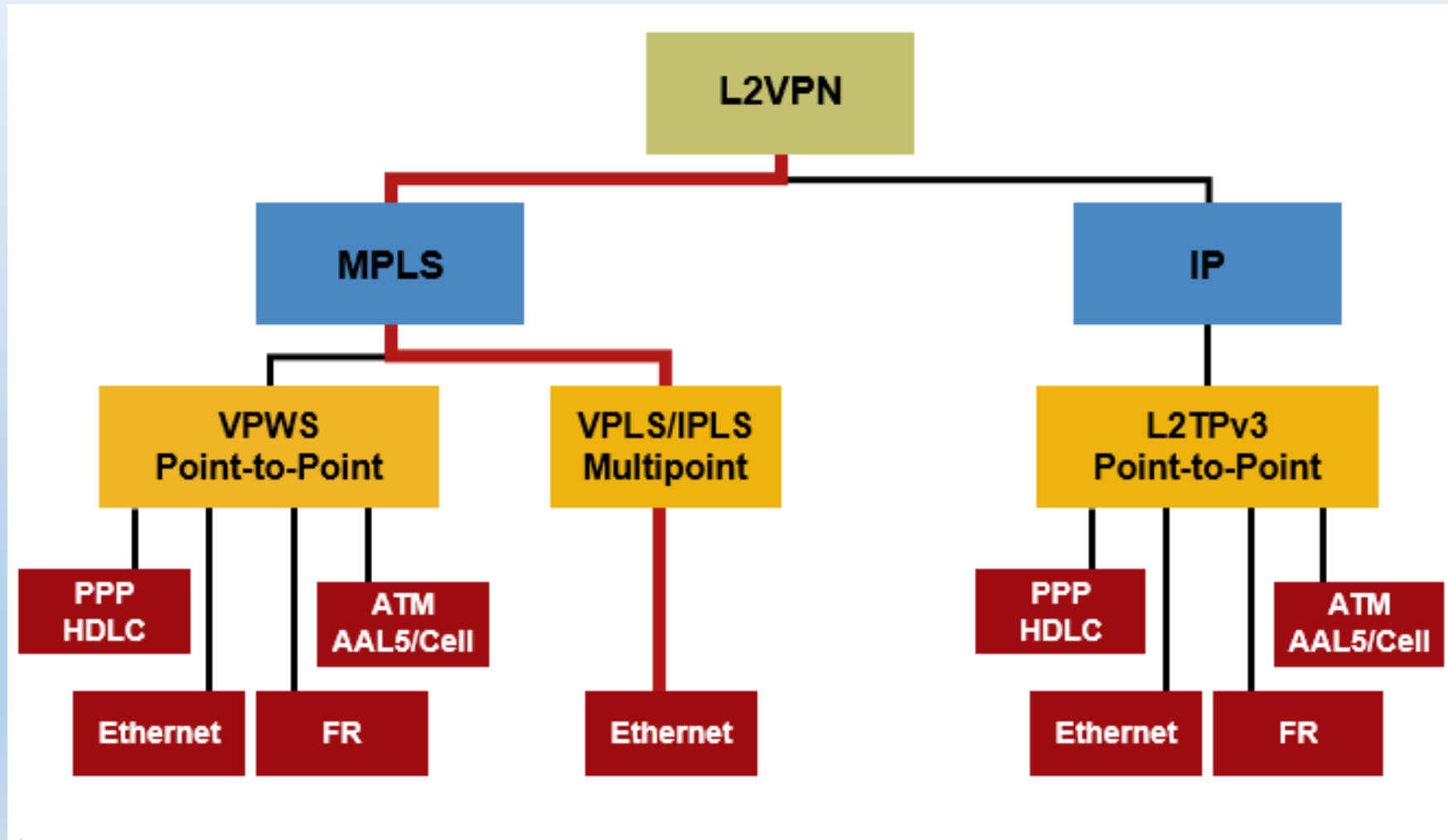
MPLS Operation

- At ingress LSR (Label Switch Router) of an MPLS domain, an MPLS header is inserted to a packet before the packet is forwarded
- At subsequent LSRs
 - The label is used as an index into a forwarding table that specifies the next hop and a new label.
 - The old label is replaced with the new label, and the packet is forwarded to the next hop.
- Egress LSR strips the label and forwards the packet to final destination based on the IP packet header

Classification Of VPNs

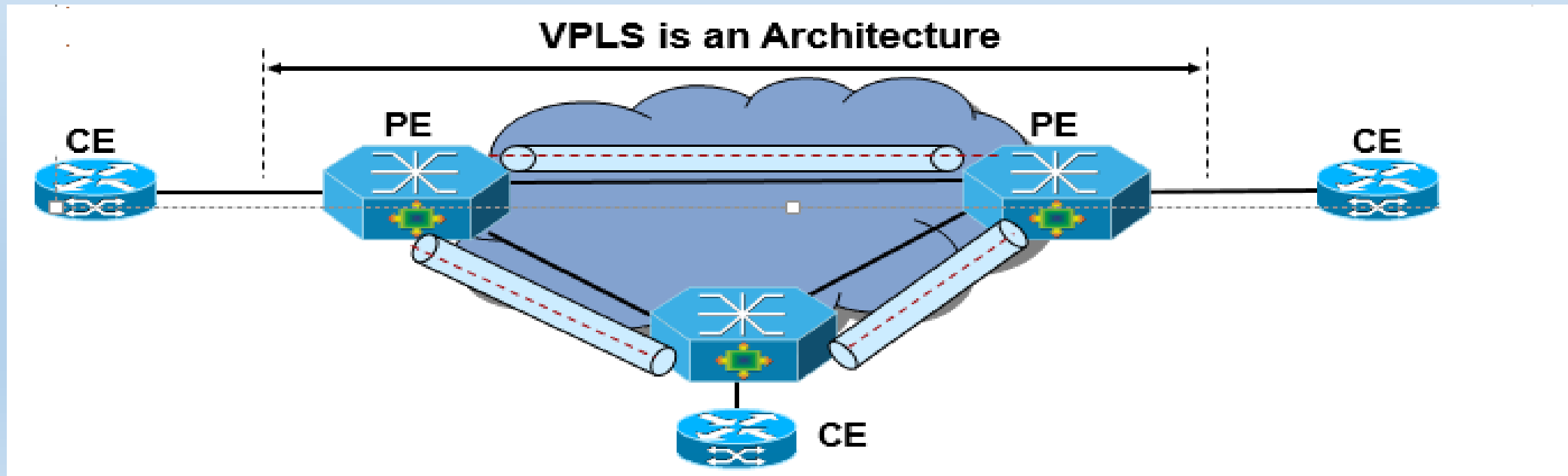


L2VPN Model



VPLS

- VPLS defines an architecture allows MPLS networks offer Layer 2 multipoint Ethernet Services
- SP emulates an IEEE Ethernet bridge network (virtual)



LDP (Label Distribution Protocol)

Label Distribution Protocol – LDP works between adjacent/non-adjacent peers

LDP sessions are established between peers

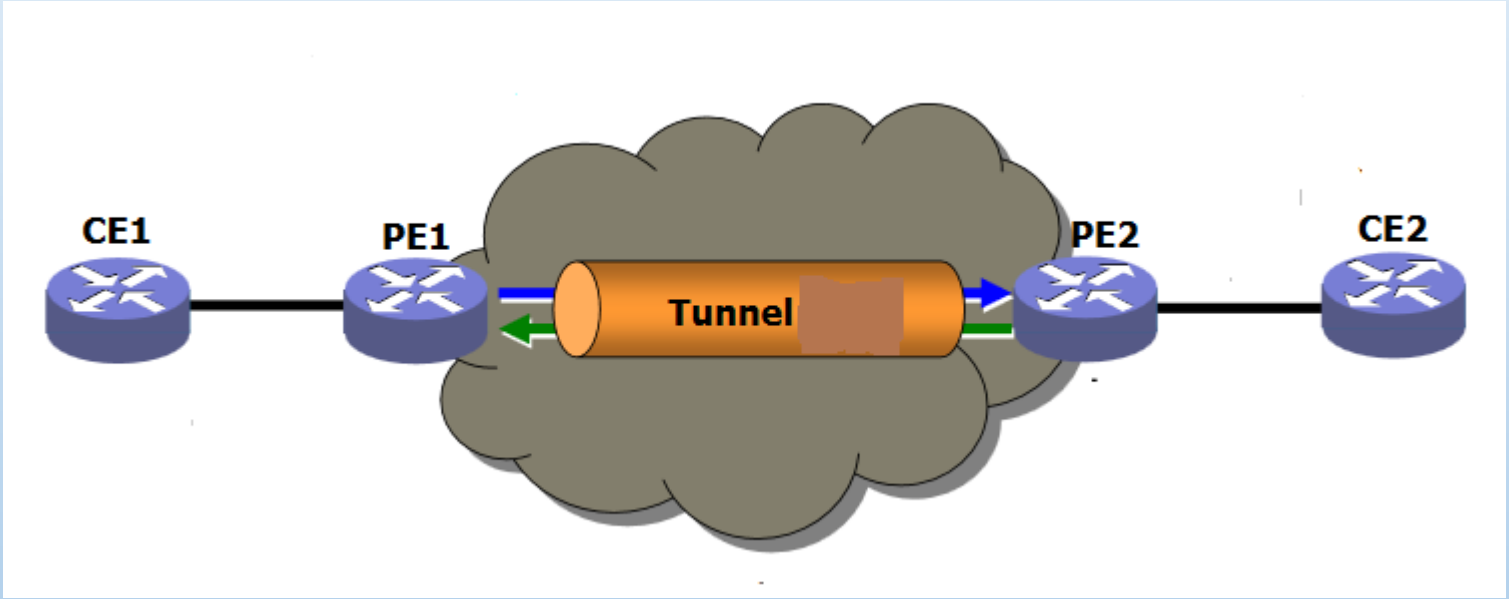
LDP messages sent in the form of TLVs (Type, Length, Value)

Label Space Of LDP

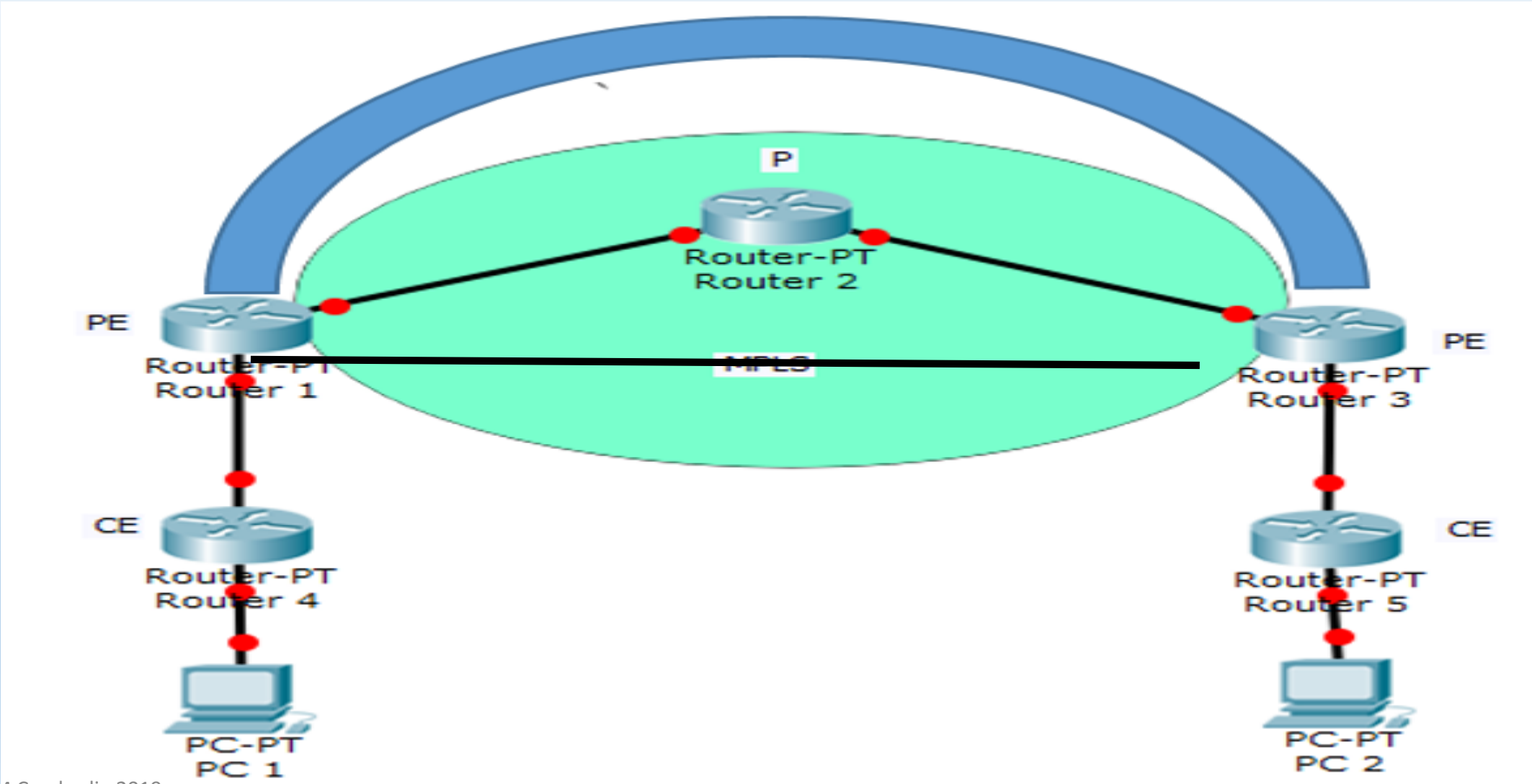
LSRs establish one LDP session per label space. Per-platform label space requires only one LDP session, even if there are multiple parallel links between a pair of LSRs.

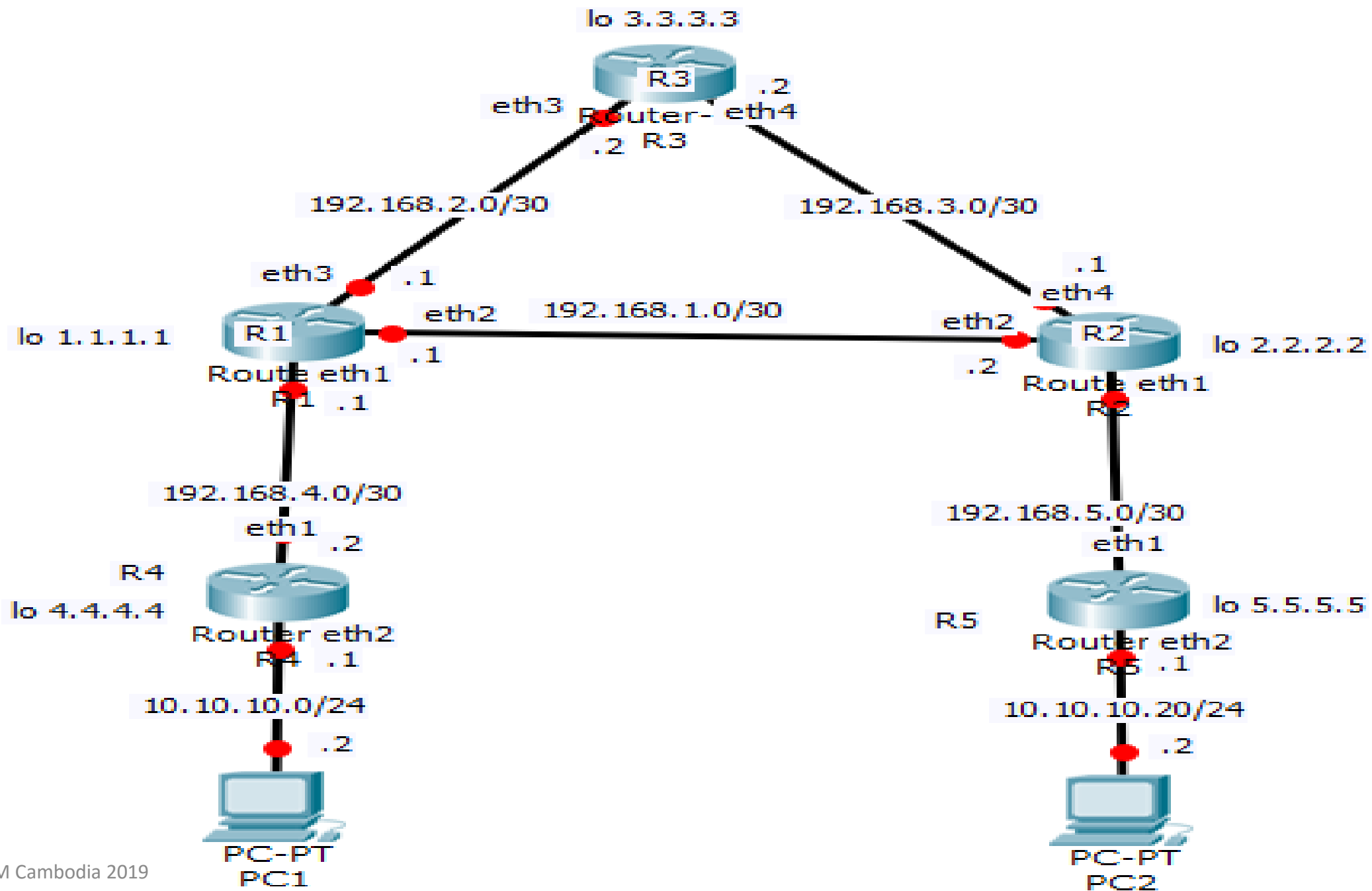
Per-platform label space is announced by setting the label space ID

Tunnel VPN



LAB





R1

IP Address

| Address | Network | Interface |
|----------------|-------------|-----------|
| 1.1.1.1 | 1.1.1.1 | Loopback |
| 192.168.1.1/30 | 192.168.1.0 | ether2 |
| 192.168.2.1/30 | 192.168.2.0 | ether3 |
| 192.168.4.1/30 | 192.168.4.0 | ether1 |

MTU 1508 in eth1, eth2,eth3

Interface <ether1>

General Ethernet Loop Protect Overall Stats Rx Stats ...

Name: ether1

Type: Ethernet

MTU: 1508

Actual MTU: 1508

L2 MTU: 1600

Max L2 MTU: 4076

MAC Address: D4:CA:6D:EB:49:9F

ARP: enabled

ARP Timeout:

R1

OSPF Instance

OSPF Instance <default>

General Metrics MPLS Status

Name:

Router ID:

Redistribute Default Route: ▾

Redistribute Connected Routes: ▾

Redistribute Static Routes: ▾

Redistribute RIP Routes: ▾







Redistribute BGP Routes: ▾




Redistribute Other OSPF Routes: ▾

OSPF Networks

OSPF

Instances Networks Areas Area Ranges

| | Network | Area |
|--|----------------|----------|
|  | 192.168.1.0/30 | backbone |
|  | 192.168.2.0/30 | backbone |
|  | 192.168.4.0/30 | backbone |

R1

LDP Settings

LDP Settings

Enabled

LSR ID: 1.1.1.1

Transport Address: 1.1.1.1

Path Vector Limit: 255

Hop Limit: 255

Loop Detect

Use Explicit Null

Distribute For Default Route

OK

Cancel

Apply

LDP Interface

MPLS

LDP Interface | LDP Neighbor | Accept Filter | Advertise Filter | Forwarding

+ - ✓ ✗ 📁 🏠 MPLS Settings LDP Settings

| Interface | Hello Interval | Hold Time | Transport Address | Advertisement |
|-----------|----------------|-----------|-------------------|---------------|
| ether1 | 00:00:05 | 00:00:15 | | yes |
| ether2 | 00:00:05 | 00:00:15 | | yes |
| ether3 | 00:00:05 | 00:00:15 | | yes |

R2

Ether1,2 and 4

| Address | Network | Interface |
|----------------|-------------|-----------|
| 2.2.2.2 | 2.2.2.2 | Loopback |
| 192.168.1.2/30 | 192.168.1.0 | ether2 |
| 192.168.3.1/30 | 192.168.3.0 | ether4 |
| 192.168.5.1/30 | 192.168.5.0 | ether1 |

MTU ether1,ether2,ether4

Interface <ether1>

General Ethernet Loop Protect Overall Stats Rx Stats ...

Name: ether1

Type: Ethernet

MTU: 1508

Actual MTU: 1508

L2 MTU: 1600

Max L2 MTU: 4076

MAC Address: D4:CA:6D:EF:AD:58

ARP: enabled

ARP Timeout:

R2

OSPF Instance

OSPF Instance <default>

General Metrics MPLS Status

Name:

Router ID:

Redistribute Default Route: ▾

Redistribute Connected Routes: ▾

Redistribute Static Routes: ▾

Redistribute RIP Routes: ▾

Redistribute BGP Routes: ▾




Redistribute Other OSPF Routes: ▾

OSPF Networks

OSPF

Instances Networks Areas Area Ranges

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| | Network | Area |
|--|--|----------|
| |  192.168.1.0/30 | backbone |
| |  192.168.3.0/30 | backbone |
| |  192.168.5.0/30 | backbone |

R2

LDP Settings

LDP Settings

Enabled

LSR ID: 2.2.2

Transport Address: 2.2.2

Path Vector Limit: 255

Hop Limit: 255

Loop Detect

Use Explicit Null

Distribute For Default Route

OK

Cancel

Apply

LDP Interface

MPLS

LDP Interface LDP Neighbor Accept Filter Advertise Filter Forwarding Table

+ - ✓ ✕ 📄 🗑️ MPLS Settings LDP Settings

| Interface | Hello Interval | Hold Time | Transport Address | Accept Dy.. |
|-----------|----------------|-----------|-------------------|-------------|
| ether1 | 00:00:05 | 00:00:15 | | yes |
| ether2 | 00:00:05 | 00:00:15 | | yes |
| ether4 | 00:00:05 | 00:00:15 | | yes |

R3

IP Address Interface

| Address | Network | Interface |
|----------------|-------------|-----------|
| 3.3.3.3 | 3.3.3.3 | Loopback |
| 192.168.2.2/30 | 192.168.2.0 | ether3 |
| 192.168.3.2/30 | 192.168.3.0 | ether4 |

MTU ether 3,ether4

Interface <ether3>

General | Ethernet | Loop Protect | Overall Stats | Rx Stats | ...

Name: ether3

Type: Ethernet

MTU: 1508

Actual MTU: 1508

L2 MTU: 1598

Max L2 MTU: 2028

MAC Address: D4:CA:6D:F2:10:12

ARP: enabled

ARP Timeout:

R3

OSPF Networks

The screenshot shows the 'OSPF' configuration page with the 'Networks' tab selected. Below the tabs are several control icons: a plus sign, a minus sign, a checkmark, an 'X' mark, a document icon, and a funnel icon. A table lists the configured networks and their associated areas.

| Network | Area |
|----------------|----------|
| 192.168.2.0/30 | backbone |
| 192.168.3.0/30 | backbone |

OSPF Instance

The screenshot shows the 'OSPF Instance <default>' configuration page with the 'General' tab selected. The configuration includes fields for Name, Router ID, and several redistribution options.

Name: default

Router ID: 3.3.3.3

Redistribute Default Route: always (as type 1)

Redistribute Connected Routes: as type 1

Redistribute Static Routes: no

Redistribute RIP Routes: no

Redistribute BGP Routes: no

Redistribute Other OSPF Routes: as type 1

R3

LDP Settings

LDP Settings

Enabled

LSR ID: 3.3.3.3

Transport Address: 3.3.3.3

Path Vector Limit: 255

Hop Limit: 255

Loop Detect

Use Explicit Null

Distribute For Default Route

OK

Cancel

Apply

LDP Interface

MPLS

LDP Interface | LDP Neighbor | Accept Filter | Advertise Filter | Forwarding Table

+ - ✓ ✗ 📁 📏

MPLS Settings | LDP Settings

| Interface | Hello Interval | Hold Time | Transport Address | Accept Dy... |
|-----------|----------------|-----------|-------------------|--------------|
| ether3 | 00:00:05 | 00:00:15 | | yes |
| ether4 | 00:00:05 | 00:00:15 | | yes |

R4

IP Address

| Address | Network | Interface |
|----------------|-------------|-----------|
| 4.4.4.4 | 4.4.4.4 | Loopback |
| 10.10.10.1/24 | 10.10.10.0 | ether2 |
| 192.168.4.2/30 | 192.168.4.0 | ether1 |

MTU ether1 , ether2

Interface <ether1>

General | Ethernet | Loop Protect | Overall Stats | Rx Stats | ...

Name: ether1

Type: Ethernet

MTU: 1508

Actual MTU: 1508

L2 MTU: 1600

Max L2 MTU: 4076

MAC Address: D4:CA:6D:F2:11:F0

ARP: enabled

ARP Timeout:

VPLS Interface

Interface <VPLS-LAN1>

General Status Traffic

Name: VPLS-LAN1

Type: VPLS

MTU: 1508

Actual MTU: 1508

L2 MTU: 1508

MAC Address: 02:A7:06:7C:77:B8

ARP: enabled

ARP Timeout:

Remote Peer: 5.5.5.5

VPLS ID: 2:2

Cisco Style

Cisco Style ID: 0

Advertised L2MTU: 1508

R4

Bridge Interface

Interface <VPLS>

General STP VLAN Status Traffic

Name: VPLS

Type: Bridge

MTU:

Actual MTU: 1500

L2 MTU: 1508

MAC Address: 02:A7:06:7C:77:B8

ARP: enabled

ARP Timeout:

Admin. MAC Address:

R4

Port Bridge

| # | Interface | Bridge | Horizon | Priority (h... | Path Cost | Role |
|-----|-----------|--------|---------|----------------|-----------|-----------------|
| 0 H | ether2 | VPLS | | 80 | 10 | designated port |
| 1 | VPLS-LAN1 | VPLS | | 80 | 10 | designated port |

Name of Bridge

| | Name | Type | L2 MTU | Tx | Rx | Tx Pac |
|---|----------|--------|--------|-------|-------|--------|
| R | Loopback | Bridge | 65535 | 0 bps | 0 bps | |
| R | VPLS | Bridge | 1508 | 0 bps | 0 bps | |

R4

OSPF Instance

OSPF Network

OSPF Instance <default>

General Metrics MPLS Status

Name: default

Router ID: 4.4.4.4

Redistribute Default Route: always (as type 1) ▾

Redistribute Connected Routes: as type 1 ▾

Redistribute Static Routes: no ▾

Redistribute RIP Routes: no ▾


Redistribute BGP Routes: no ▾

Redistribute Other OSPF Routes: as type 1 ▾

OSPF

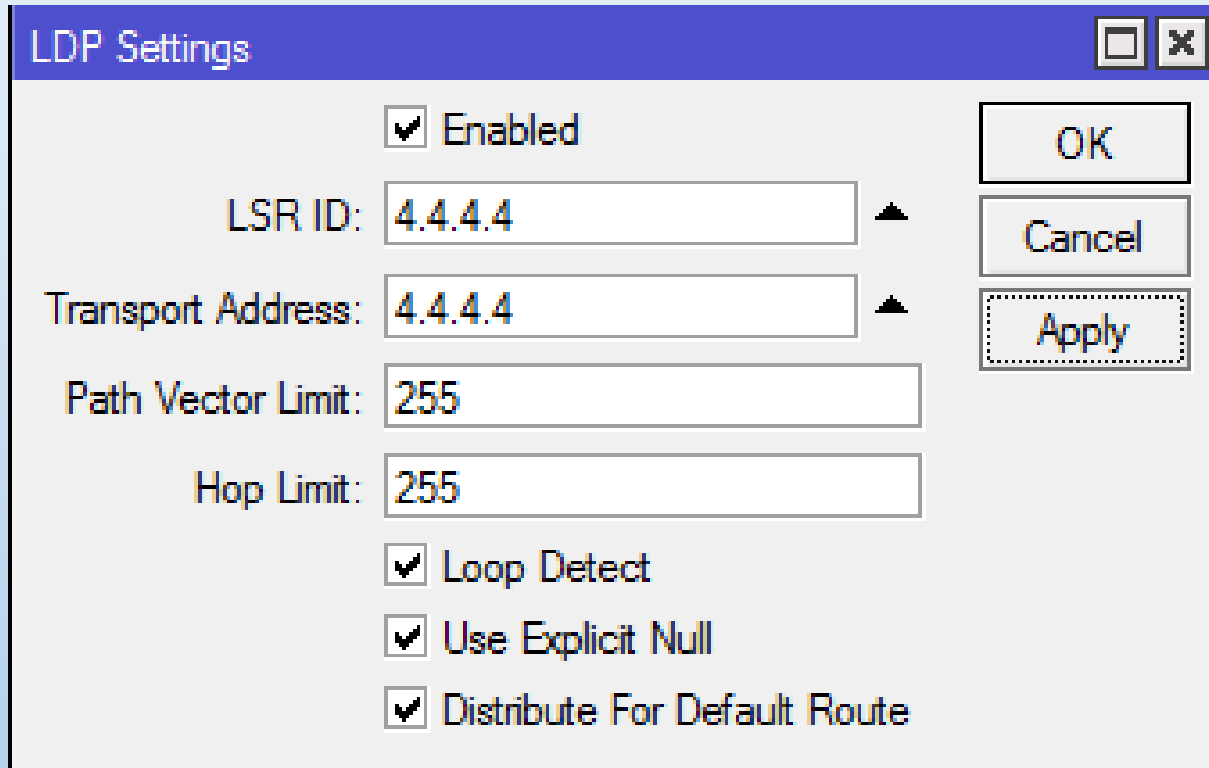
Instances Networks Areas Area Ranges

+ - ✓ ✗ [icon] [icon]

| Network | Area |
|--|----------|
|  192.168.4.0/30 | backbone |

R4

LDP Settings

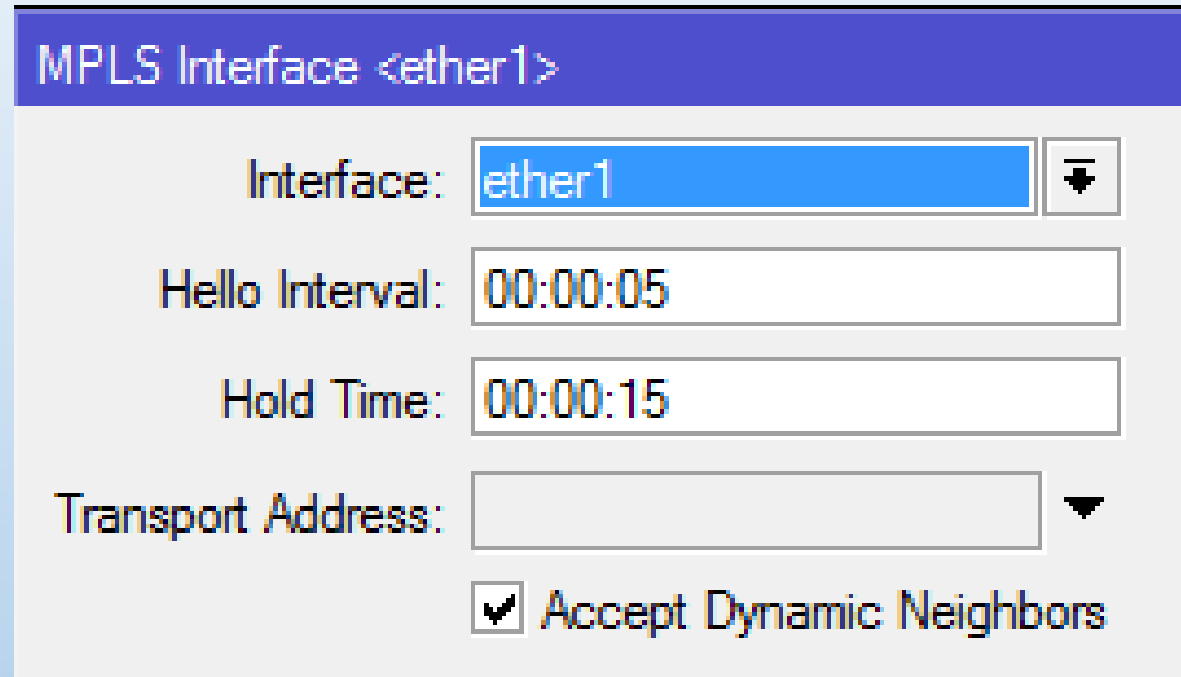


The screenshot shows the 'LDP Settings' dialog box with the following configuration:

- Enabled
- LSR ID: 4.4.4.4
- Transport Address: 4.4.4.4
- Path Vector Limit: 255
- Hop Limit: 255
- Loop Detect
- Use Explicit Null
- Distribute For Default Route

Buttons: OK, Cancel, Apply

MPLS Interface



The screenshot shows the 'MPLS Interface <ether1>' configuration window with the following settings:

- Interface: ether1
- Hello Interval: 00:00:05
- Hold Time: 00:00:15
- Transport Address: (empty)
- Accept Dynamic Neighbors

R5

IP Address

| Address | Network | Interface |
|----------------|-------------|-----------|
| 5.5.5.5 | 5.5.5.5 | loopback |
| 10.10.20.1/24 | 10.10.20.0 | ether2 |
| 192.168.5.2/30 | 192.168.5.0 | ether1 |

MTU ether1

Interface <ether1>

General | Ethernet | Loop Protect | Overall Stats | Rx Stats | ...

Name: ether1

Type: Ethernet

MTU: 1508

Actual MTU: 1508

L2 MTU: 1598

Max L2 MTU: 2028

MAC Address: B8:69:F4:82:C2:EF

ARP: enabled

ARP Timeout:

Name of Bridge

R5

VPLS-LAN2 Interface

Interface <VPLS>

General | STP | VLAN | Status | Traffic

Name:

Type:

MTU:

Actual MTU:

L2 MTU:

MAC Address:

ARP:

ARP Timeout:

Admin. MAC Address:

Interface <VPLS-LAN2>

General | Status | Traffic

Name:

Type:

MTU:

Actual MTU:

L2 MTU:

MAC Address:

ARP:

ARP Timeout:

Remote Peer:

VPLS ID:

Cisco Style

Cisco Style ID:

Advertised L2MTU:

PW Type: tagged ethernet raw ethernet

R5

Bridge

Bridge

Bridge Ports VLANs MSTIs Port MST Overrides Filters NAT Hosts MDB

+ - ✓ ✗ 📁 🏠 Settings

| | Name | Type | L2 MTU | Tx | Rx |
|---|----------|--------|--------|----|-------|
| R | VPLS | Bridge | 1508 | | 0 bps |
| R | Hoopback | Bridge | 65535 | | 0 bps |

Bridge Ports

Bridge

Bridge Ports VLANs MSTIs Port MST Overrides Filters NAT Hosts MDB

+ - ✓ ✗ 📄 🏠

| # | | Interface | Bridge | Horizon | Priority (h... | Path Cost | Role |
|---|---|-----------|--------|---------|----------------|-----------|-----------------|
| 0 | | VPLS-LAN2 | VPLS | | 80 | 10 | root port |
| 1 | H | ether2 | VPLS | | 80 | 10 | designated port |

OSPF Instance

R5

OSPF Network

OSPF Instance <default>

General Metrics MPLS Status

Name: default

Router ID: 5.5.5.5

Redistribute Default Route: always (as type 1) ▾

Redistribute Connected Routes: as type 1 ▾

Redistribute Static Routes: no ▾

Redistribute RIP Routes: no ▾


Redistribute BGP Routes: no ▾

Redistribute Other OSPF Routes: as type 1 ▾

OSPF

Instances Networks Areas Area Ranges

+ - ✓ ✗ [icon] [icon]

| | Network | Area |
|--|--|----------|
| |  192.168.5.0/30 | backbone |

R5

VPLS Interface

MPLS Interface <ether1>

Interface: ether1

Hello Interval: 00:00:05

Hold Time: 00:00:15

Transport Address:

Accept Dynamic Neighbors

LDP Settings

LDP Settings

Enabled

LSR ID: 5.5.5.5

Transport Address: 5.5.5.5

Path Vector Limit: 255

Hop Limit: 255

Loop Detect

Use Explicit Null

Distribute For Default Route

OK

Cancel

Apply

R1

MPLS

LDP Interface LDP Neighbor Accept Filter Advertise Filter Forwarding Table MPLS Interface Local Bindings ...

+ - ✓ ✗ 🗨️ 🔍 Find

| | Transport | Send ... | Peer | Local Transport | Addresses |
|----|-----------|----------|-----------|-----------------|--|
| DO | 2.2.2.2 | no | 2.2.2.2:0 | 1.1.1.1 | 2.2.2.2, 192.168.1.2, 192.168.3.1, 192.168.5.1 |
| DO | 3.3.3.3 | no | 3.3.3.3:0 | 1.1.1.1 | 3.3.3.3, 192.168.2.2, 192.168.3.2 |
| DO | 4.4.4.4 | no | 4.4.4.4:0 | 1.1.1.1 | 4.4.4.4, 10.10.10.1, 192.168.4.2 |

R2

MPLS

LDP Interface LDP Neighbor Accept Filter Advertise Filter Forwarding Table MPLS Interface Local Bindings Remote Bindings

+ - ✓ ✗ 🗨️ 🔍

| | Transport | Send ... | Peer | Local Transport | Addresses |
|----|-----------|----------|-----------|-----------------|--|
| DO | 1.1.1.1 | no | 1.1.1.1:0 | 2.2.2.2 | 1.1.1.1, 192.168.1.1, 192.168.2.1, 192.168.4.1 |
| DO | 3.3.3.3 | no | 3.3.3.3:0 | 2.2.2.2 | 3.3.3.3, 192.168.2.2, 192.168.3.2 |
| DO | 5.5.5.5 | no | 5.5.5.5:0 | 2.2.2.2 | 5.5.5.5, 10.10.20.2, 192.168.5.2 |

R3







MPLS

LDP Interface LDP Neighbor Accept Filter Advertise Filter Forwarding Table MPLS Interface Local Bindings Remote Bindings







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| | Transport | Send ... | Peer | Local Transport | Addresses |
|----|-----------|----------|-----------|-----------------|--|
| DO | 1.1.1.1 | no | 1.1.1.1:0 | 3.3.3.3 | 1.1.1.1, 192.168.1.1, 192.168.2.1, 192.168.4.1 |
| DO | 2.2.2.2 | no | 2.2.2.2:0 | 3.3.3.3 | 2.2.2.2, 192.168.1.2, 192.168.3.1, 192.168.5.1 |

R4

| MPLS | | | | | | | | | | | | | |
|---|-----------|--------------|-----------|-----------------|--|------------------|----------------|----------------|-----------------|--|--|--|--|
| LDP Interface | | LDP Neighbor | | Accept Filter | Advertise Filter | Forwarding Table | MPLS Interface | Local Bindings | Remote Bindings | | | | |
|       | | | | | | | | | | | | | |
| | Transport | Send ... | Peer | Local Transport | Addresses | | | | | | | | |
| DO | 1.1.1.1 | no | 1.1.1.1:0 | 4.4.4.4 | 1.1.1.1, 192.168.1.1, 192.168.2.1, 192.168.4.1 | | | | | | | | |
| DOT | 5.5.5.5 | yes | 5.5.5.5:0 | 4.4.4.4 | 5.5.5.5, 10.10.20.2, 192.168.5.2 | | | | | | | | |

R5

| MPLS | | | | | | | | | | | |
|---|-----------|--------------|-----------|-----------------|--|------------------|----------------|----------------|-----|------|--|
| LDP Interface | | LDP Neighbor | | Accept Filter | Advertise Filter | Forwarding Table | MPLS Interface | Local Bindings | ... | | |
|       | | | | | | | | | | Find | |
| | Transport | Send ... | Peer | Local Transport | Addresses | | | | | | |
| DO | 2.2.2.2 | no | 2.2.2.2:0 | 5.5.5.5 | 2.2.2.2, 192.168.1.2, 192.168.3.1, 192.168.5.1 | | | | | | |
| DOT | 4.4.4.4 | yes | 4.4.4.4:0 | 5.5.5.5 | 4.4.4.4, 10.10.10.2, 192.168.4.2 | | | | | | |

Ping Test From PC 1

```
C:\Users\Duty>ping 10.10.10.1

Pinging 10.10.10.1 with 32 bytes of data:
Reply from 10.10.10.1: bytes=32 time<1ms TTL=64
Reply from 10.10.10.1: bytes=32 time<1ms TTL=64
Reply from 10.10.10.1: bytes=32 time<1ms TTL=64
Reply from 10.10.10.1: bytes=32 time<1ms TTL=64

Ping statistics for 10.10.10.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\Duty>ping 10.10.10.2

Pinging 10.10.10.2 with 32 bytes of data:
Reply from 10.10.10.2: bytes=32 time<1ms TTL=128
Reply from 10.10.10.2: bytes=32 time<1ms TTL=128

Ping statistics for 10.10.10.2:
    Packets: Sent = 2, Received = 2, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
Control-C
^C
C:\Users\Duty>ping 10.10.20.1

Pinging 10.10.20.1 with 32 bytes of data:
Reply from 10.10.20.1: bytes=32 time=1ms TTL=61
Reply from 10.10.20.1: bytes=32 time<1ms TTL=61
Reply from 10.10.20.1: bytes=32 time<1ms TTL=61
Reply from 10.10.20.1: bytes=32 time<1ms TTL=61
```

Trace Route From PC1 to PC2 (Normal and Ether2 (R1) is Down)

```
C:\Users\Duty>tracert 10.10.20.1

Tracing route to 10.10.20.1 over a maximum of 30 hops

  1    <1 ms    <1 ms    <1 ms    10.10.10.1
  2    <1 ms    <1 ms    <1 ms    192.168.4.1
  3    <1 ms    <1 ms    <1 ms    192.168.1.2
  4    <1 ms    <1 ms    <1 ms    10.10.20.1

Trace complete.

C:\Users\Duty>tracert 10.10.20.1

Tracing route to 10.10.20.1 over a maximum of 30 hops

  1    <1 ms    <1 ms    <1 ms    10.10.10.1
  2     1 ms    <1 ms     5 ms    192.168.4.1
  3     1 ms    <1 ms    <1 ms    192.168.2.2
  4    <1 ms    <1 ms    <1 ms    192.168.3.1
  5     5 ms    <1 ms    <1 ms    10.10.20.1

Trace complete.
```

Thank You

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