



MPLS VPLS Implementation

By
Antonius Duty Susilo
Indonesia

**MUM Cambodia
2019**

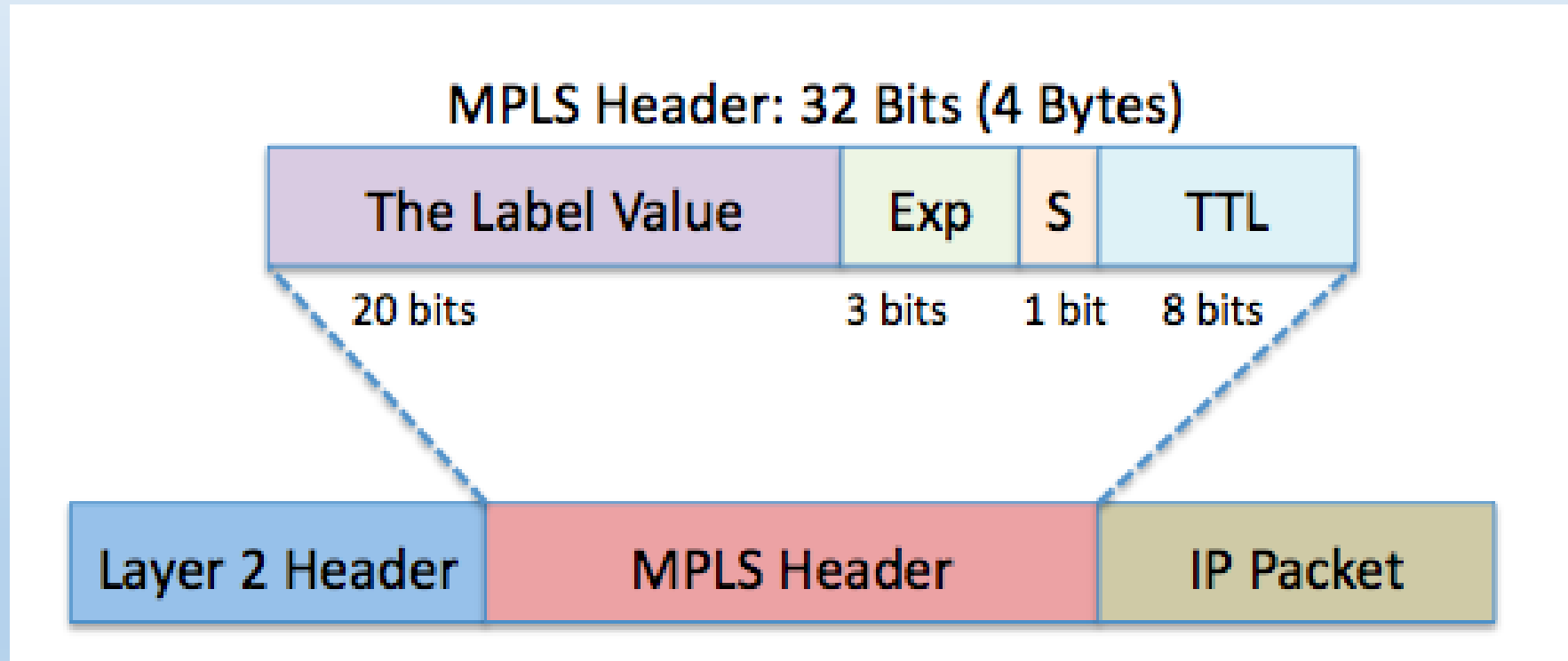


- Antonius Duty Susilo
- Email : dutymlg@gmail.com
- Mikrotik Trainer And Consultant
- Instructor Cisco Academy, Oracle Academy (Oracle WDP (Oracle Workspace Development Program))
- Ph.D Student In UTEM Malaysia (Universiti Teknikal Malaysia Melaka)
- Guest Lecturer in POLINEMA (Politeknik Negeri Malang), STIMATA (STMIK PPKIA Pradnya Paramita Malang, STIKI (Sekolah Tinggi Informatika dan Komputer Indonesia Malang)

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

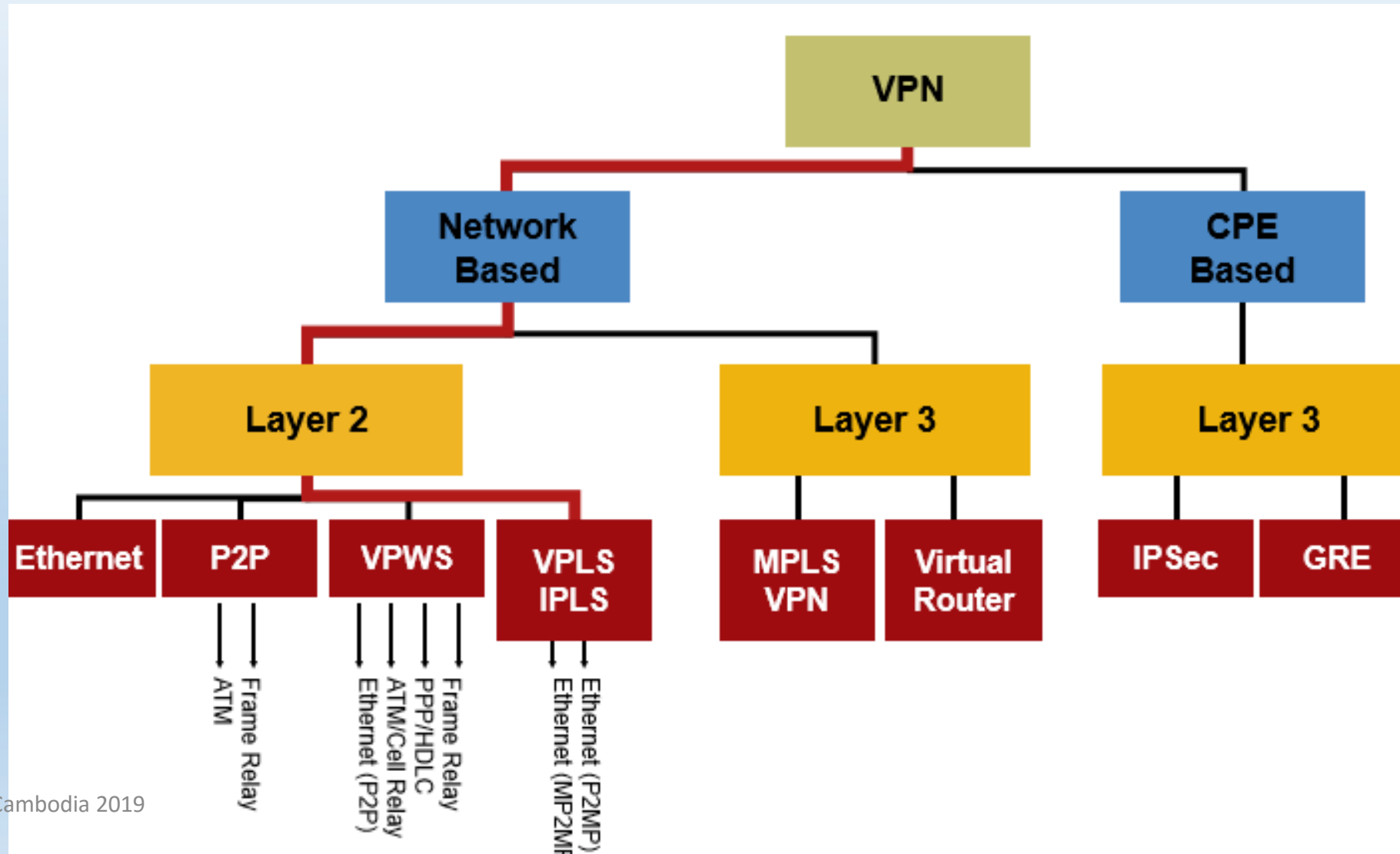
At the final destination router the label is removed.

And the packet is delivered via normal IP routing.

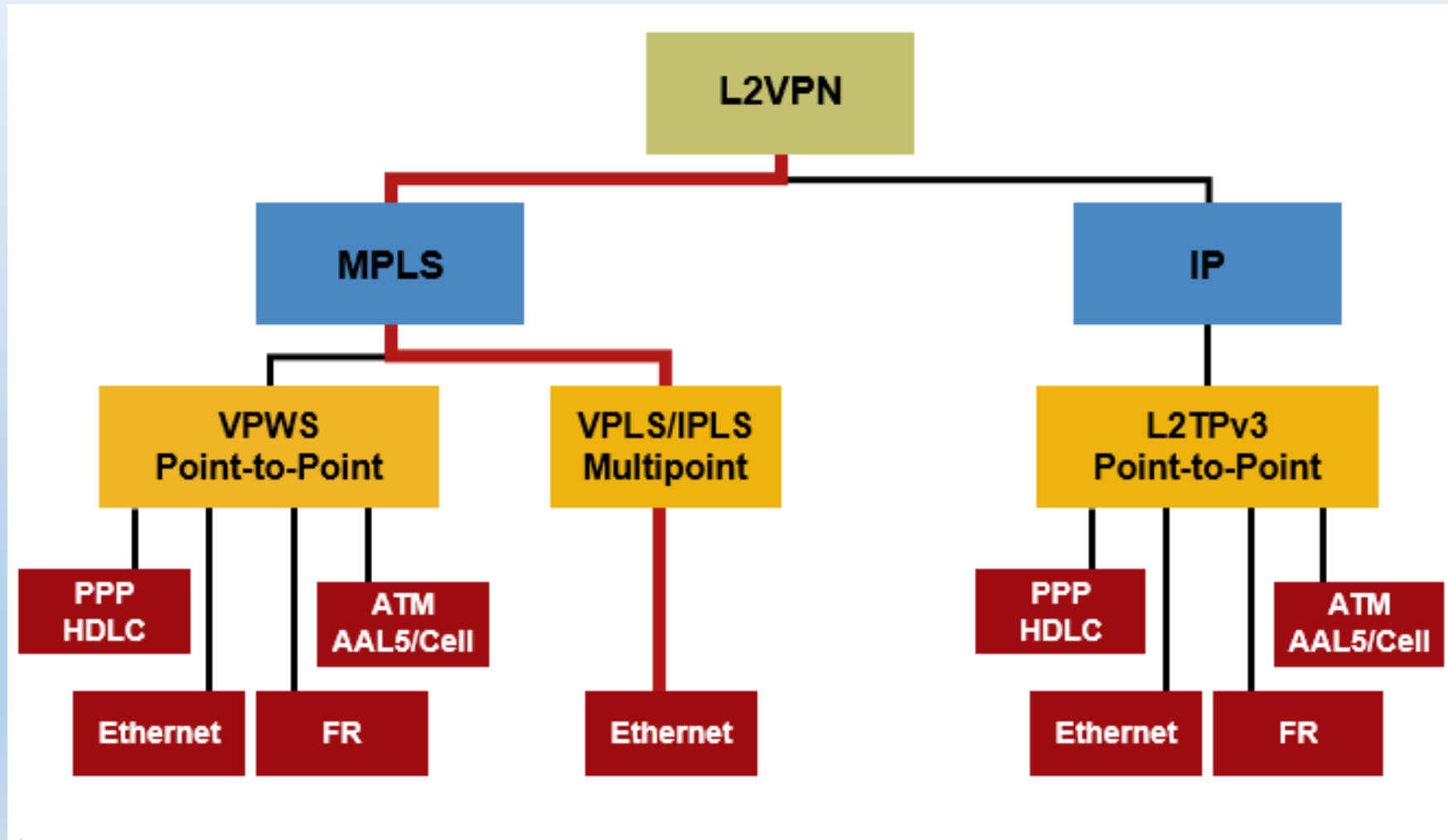
MPLS Operation

- 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

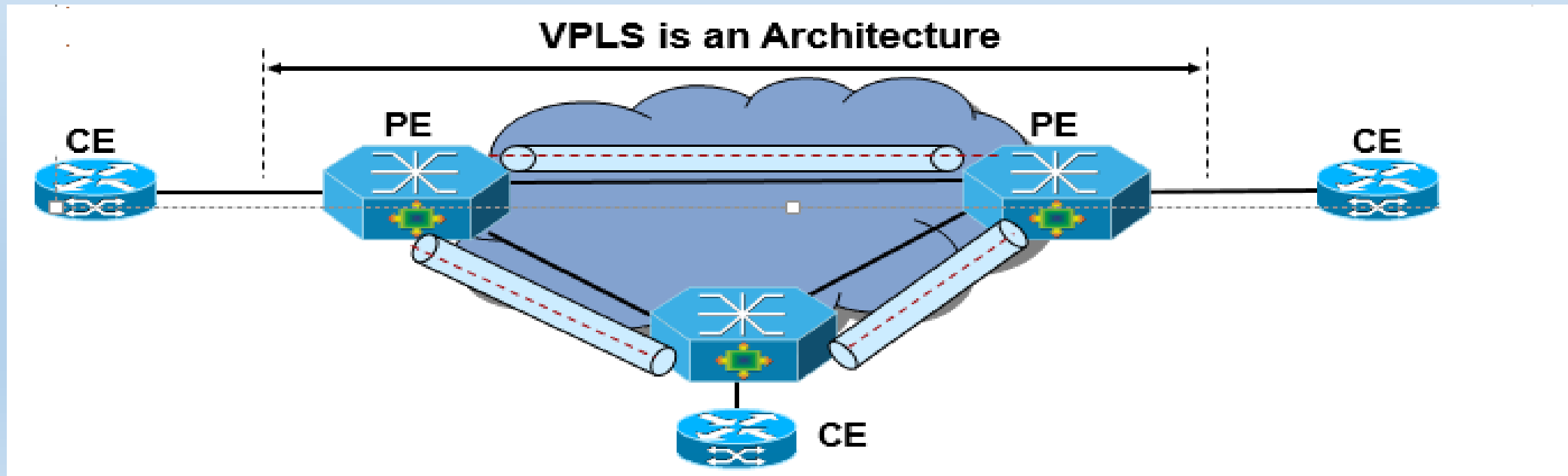


L2VPN Model



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

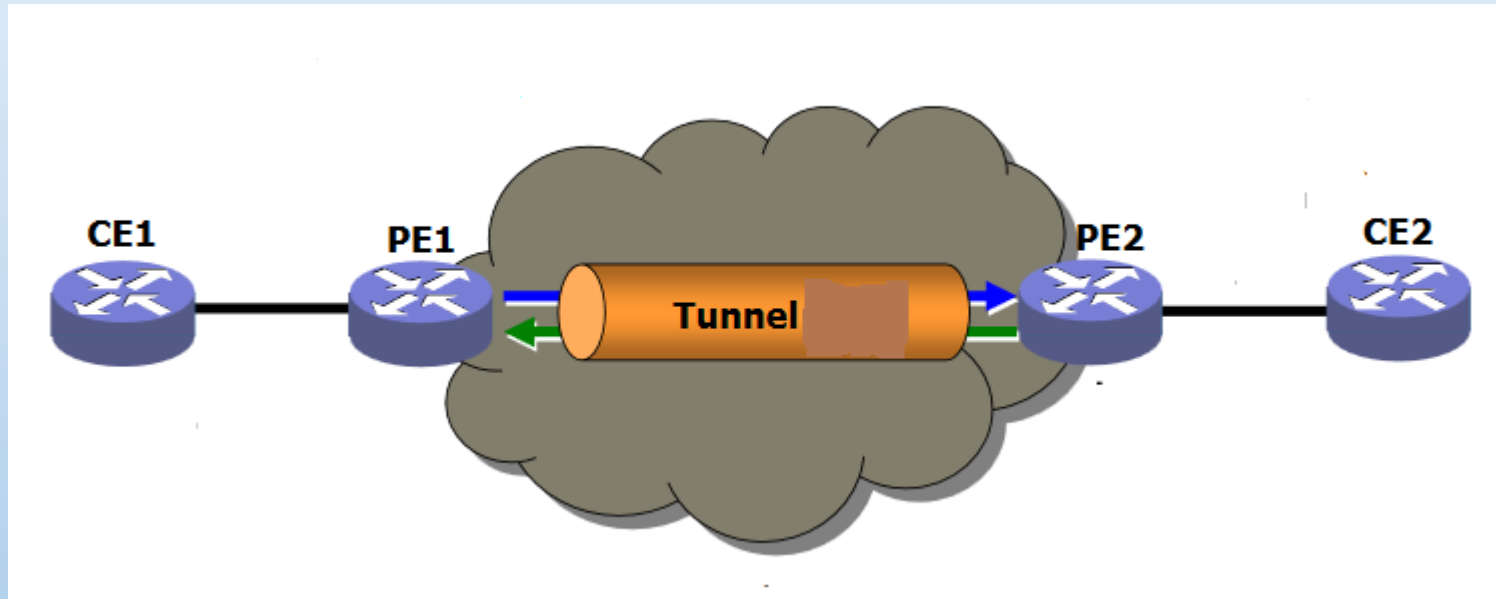
LDP messages sent in the form of TLVs (Type, Length, Value)

Label Space Of LDP

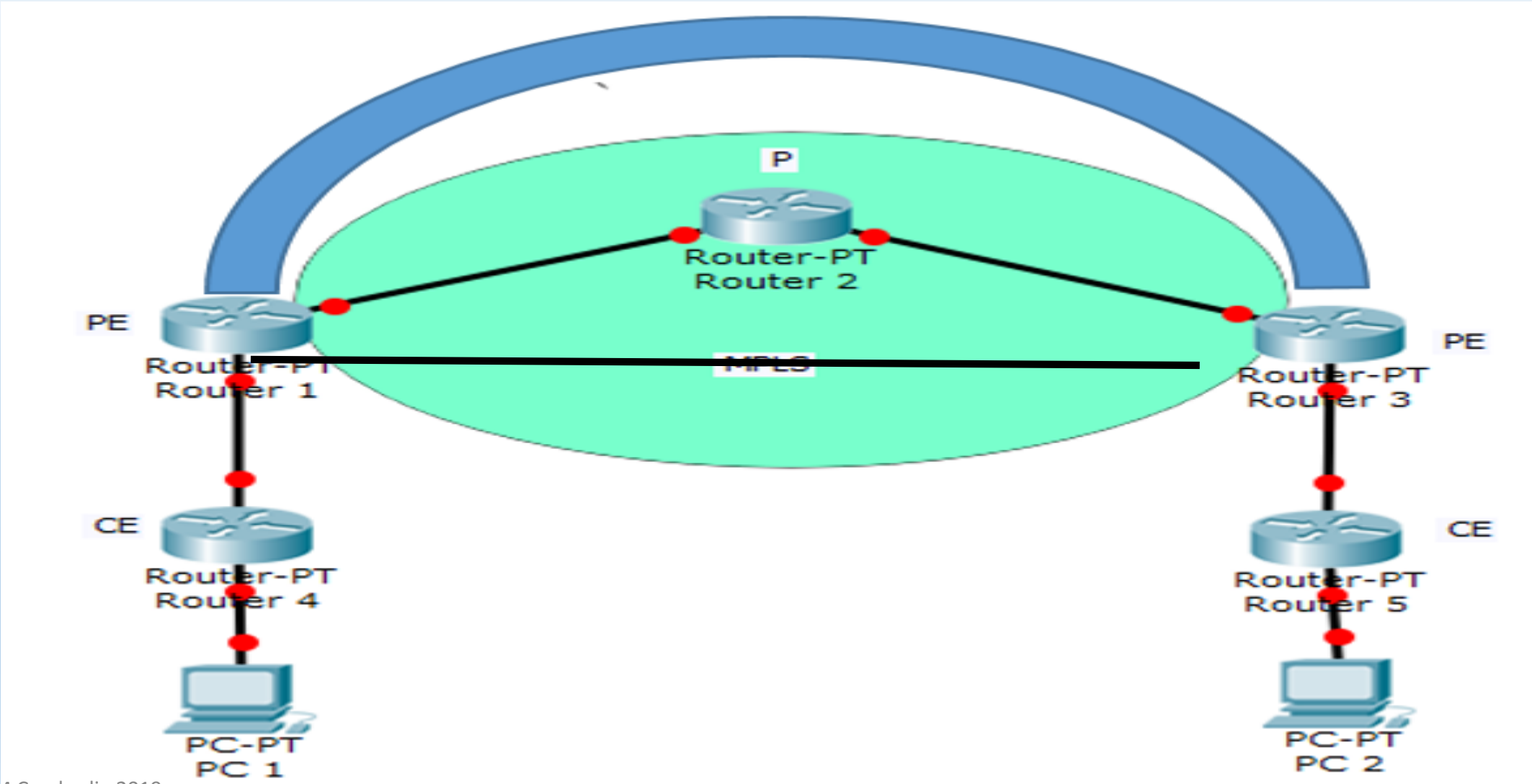
LSRs establish one LDP session per label space. Per-platform label space requires only one LDP session, even if there are multiple parallel links between a pair of LSRs.

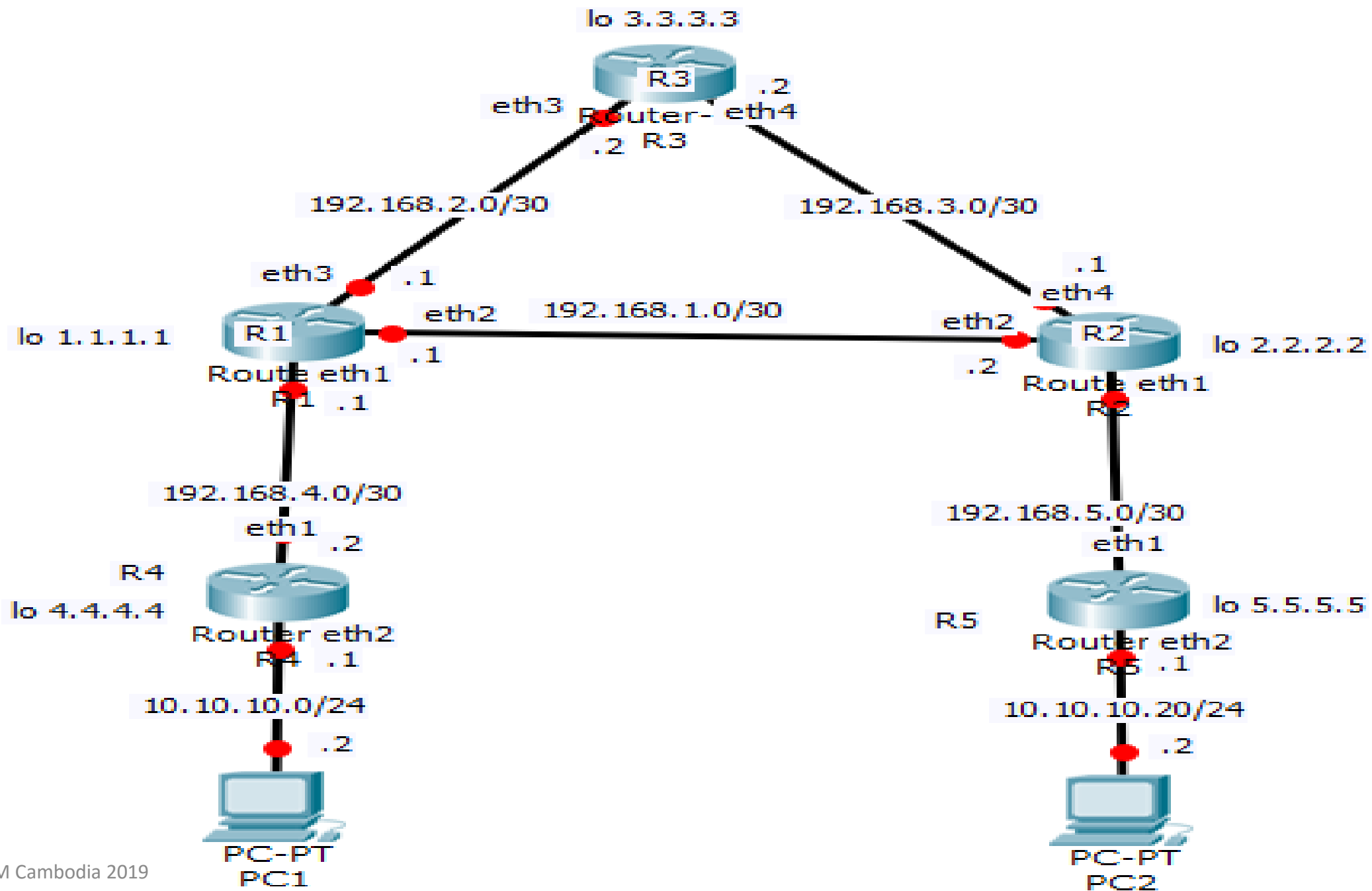
Per-platform label space is announced by setting the label space ID

Tunnel VPN



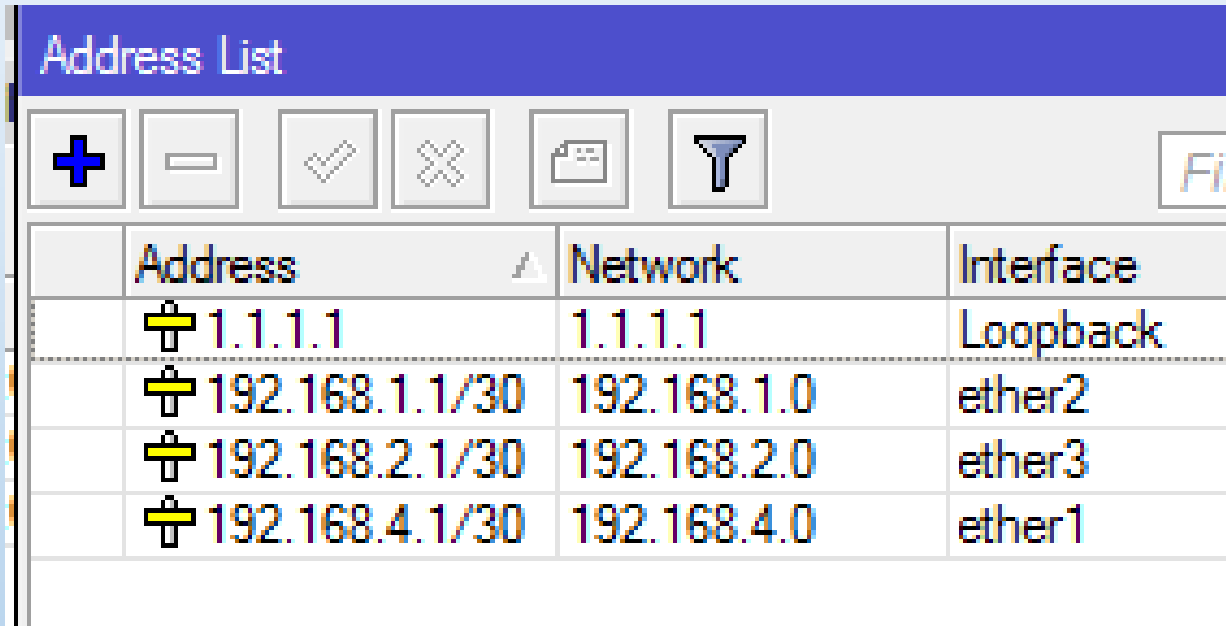
LAB





R1

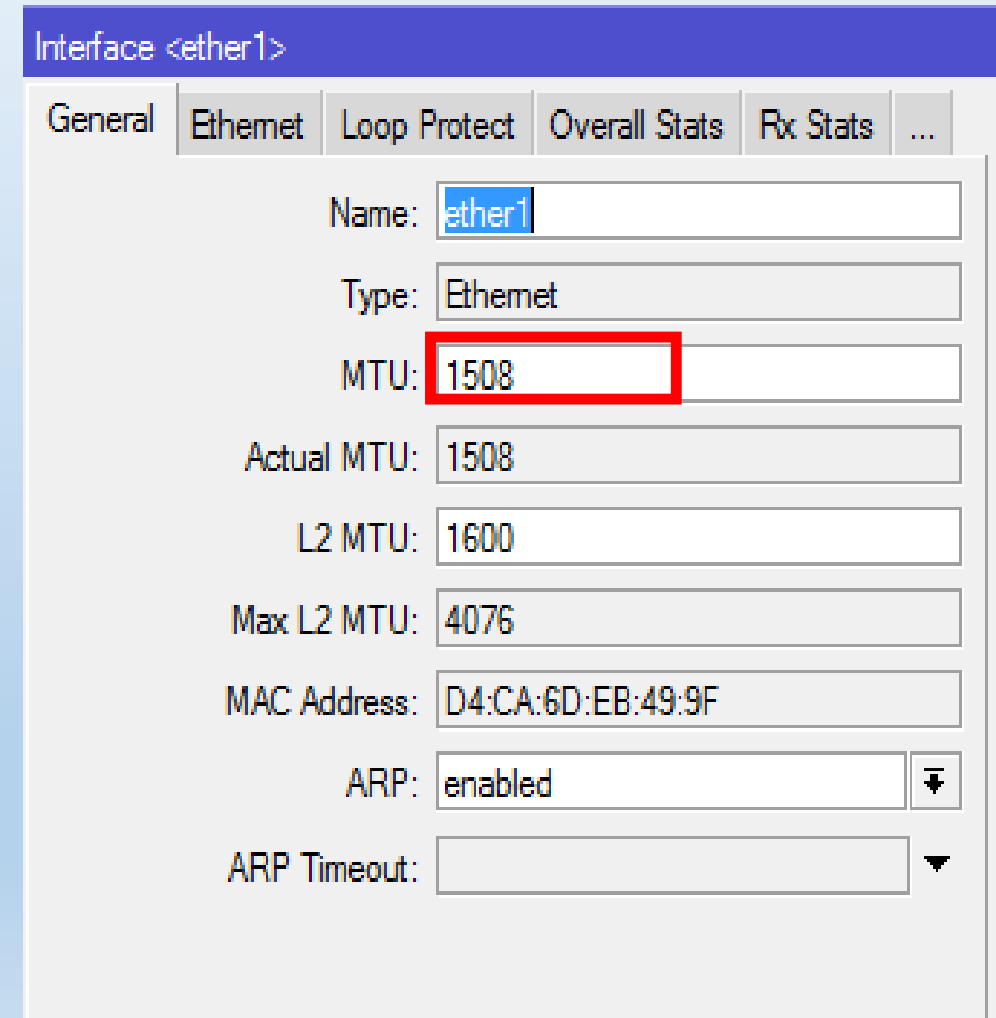
IP Address



The screenshot shows the 'Address List' configuration window. It features a toolbar with icons for adding (+), removing (-), checking (✓), unchecking (✗), saving (floppy disk), and filtering (funnel). Below the toolbar is a table with the following data:

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



The screenshot shows the 'Interface <ether1>' configuration window. The 'General' tab is selected. The 'MTU' field is highlighted with a red box and contains the value '1508'. Other fields include Name (ether1), Type (Ethernet), Actual MTU (1508), L2 MTU (1600), Max L2 MTU (4076), MAC Address (D4:CA:6D:EB:49:9F), ARP (enabled), and 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

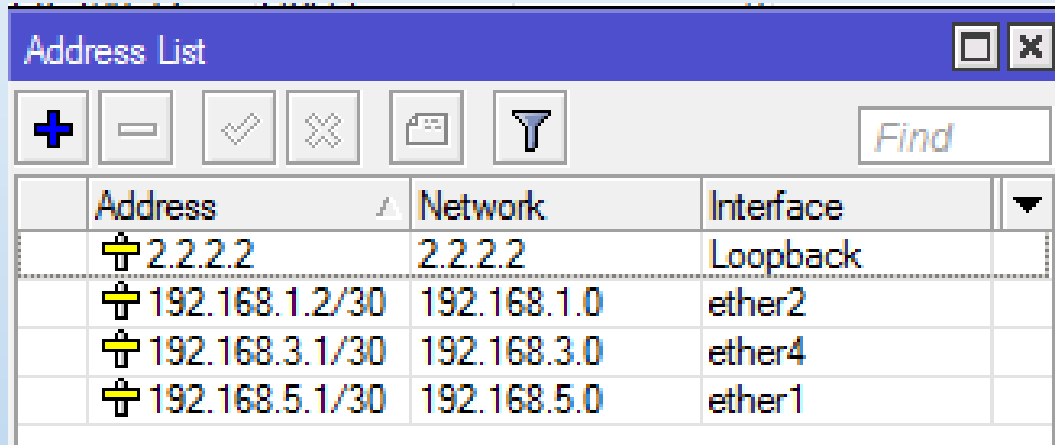
LDP Interface | LDP Neighbor | Accept Filter | Advertise Filter | Forwarding

+ - ✓ ✗ 📁 🏠 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

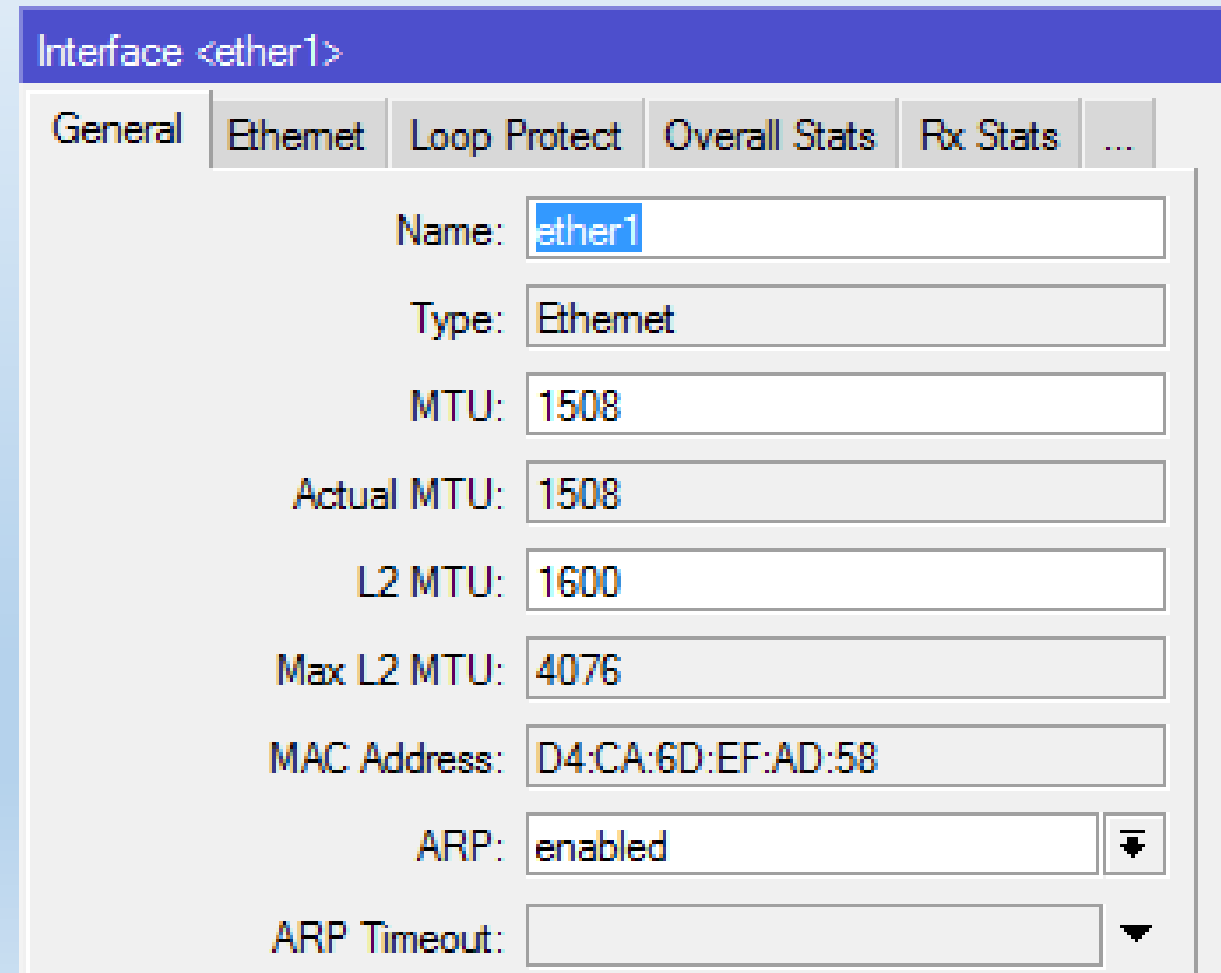
Ether1,2 and 4



The Address List window displays a table of IP addresses and their associated interfaces. The table has columns for Address, Network, and Interface. The entries are:

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



The Interface configuration window for ether1 shows the following settings:

- 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: (empty)

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

+ - ✓ ✕ 📄 🔍

	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 Networks' configuration page. It features a blue header with the text 'OSPF'. Below the header are four tabs: 'Instances', 'Networks', 'Areas', and 'Area Ranges'. The 'Networks' tab is selected. Below the tabs is a toolbar with icons for adding (+), removing (-), checking (✓), deleting (✗), saving (floppy disk), and filtering (funnel). Below the toolbar is a table with two columns: 'Network' and 'Area'. The table contains two entries, both with a network icon on the left.

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. It features a blue header with the text 'OSPF Instance <default>'. Below the header are four tabs: 'General', 'Metrics', 'MPLS', and 'Status'. The 'General' tab is selected. Below the tabs are several configuration fields, each with a label and a dropdown menu.

Name:

Router ID:

Redistribute Default Route:

Redistribute Connected Routes:

Redistribute Static Routes:

Redistribute RIP Routes:

Redistribute BGP Routes:

Redistribute Other OSPF Routes:

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

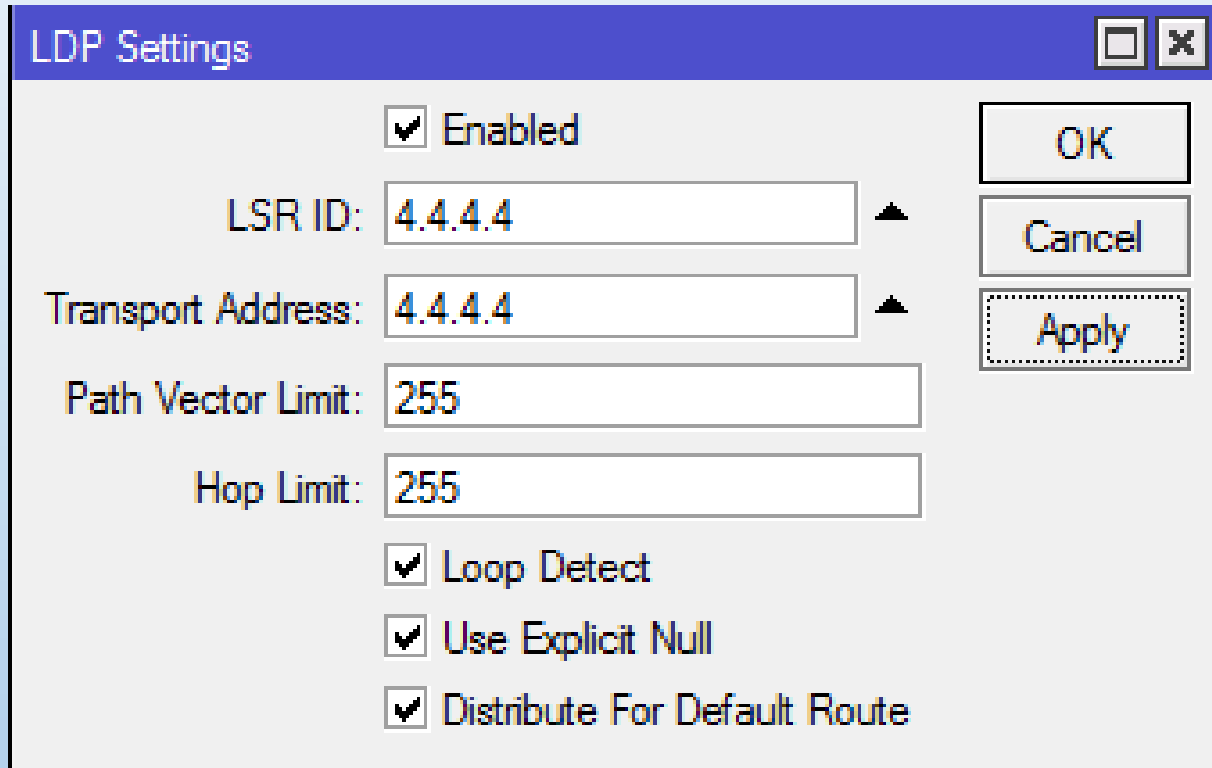
Instances Networks Areas Area Ranges

+ - ✓ ✗ [icon] [icon]

Network	Area
 192.168.4.0/30	backbone

R4

LDP Settings

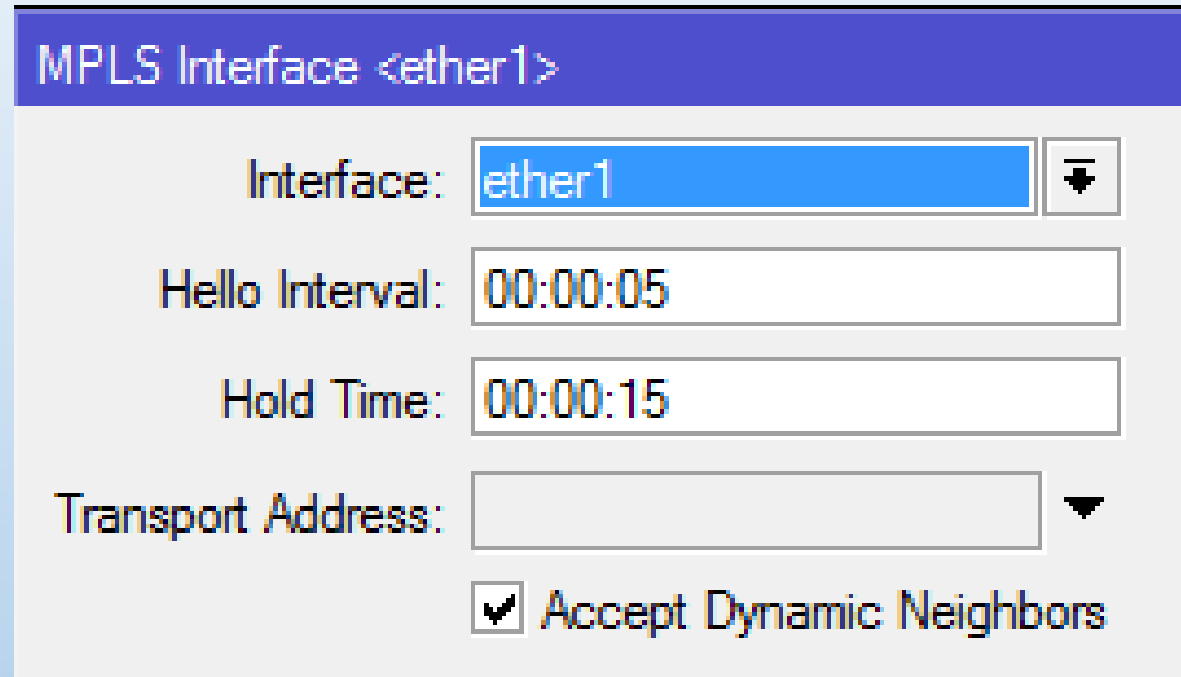


The screenshot shows the 'LDP Settings' dialog box with the following configuration:

- 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

+ - ✓ ✗ [Folder Icon] [Filter 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	...
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
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	...
						     			
	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

dutymlg@gmail.com

+62 85102077829