

MPLS

Multi Protocol Label Switching



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Biodata

- S2 Magister Teknologi Informasi ITB Bandung
- Pengajar di SMK Telkom Malang
- Pengajar di STMIK Pradnya Paramita Malang
- Pengajar di Universitas Ma Chung Malang
- Trainer dan Konsultan Mikrotik
- Trainer di Belajarmikrotik.com
- Trainer Cisco Networking Academy Program (CNAP), Oracle Academy, Oracle WDP, Mikrotik Academy



SMK Telkom Malang

- Didirikan tahun 1992
- Dahulu bernama SMK Telkom Sandhy Putra Malang sekarang menjadi bagian dari Telkom Schools
- Terdiri dari 2 jurusan RPL dan TKJ
- Sekarang ada 9 kelas paralel kelas 10,11 dan 12
- Milik Yayasan Sandhykara Putra Telkom Bandung

Belajarmikrotik.com

- Didirikan tahun 2013
- Fokus ke dunia pendidikan melalui pelatihan Mikrotik dan Mikrotik Academy

Proses Jaringan Komputer

- Ada 3 proses dalam jaringan computer
 1. Bridging
Protokol : STP, RSTP
 2. Routing
Protokol : Static, RIP, OSPF, BGP
 3. Switching
Protokol : MPLS, ATM (Asynchronous Transfer Mode), Frame relay

Konsep Routing

- Menggunakan layer 3
- Forwarding menggunakan alamat IP yang dituju
- Routing lookup dilakukan di tiap hop sehingga proses routing harus diaktifkan di semua device
- Setiap router menentukan policy routing
- Terjadi beban routing yang tidak seimbang pada router

Konsep Switching

- Menggunakan pengiriman paket data dalam bentuk kelompok-kelompok atau Label
- Setiap label yang ditransmisikan tidak terkait dengan kelompok label lainnya

Teori Dasar MPLS

- MPLS adalah teknologi packet-forwarding (melewatkan paket data sesuai dengan pilihan jalur terbaik) yang menggunakan label untuk forwarding data
- Dengan MPLS keputusan forwarding tidak lagi berdasarkan IP Header dan table routing sehingga beban proses menjadi minimal yang mengakibatkan terjadinya efisiensi proses forwarding
- MPLS tidak membutuhkan tambahkan packet header layer 3

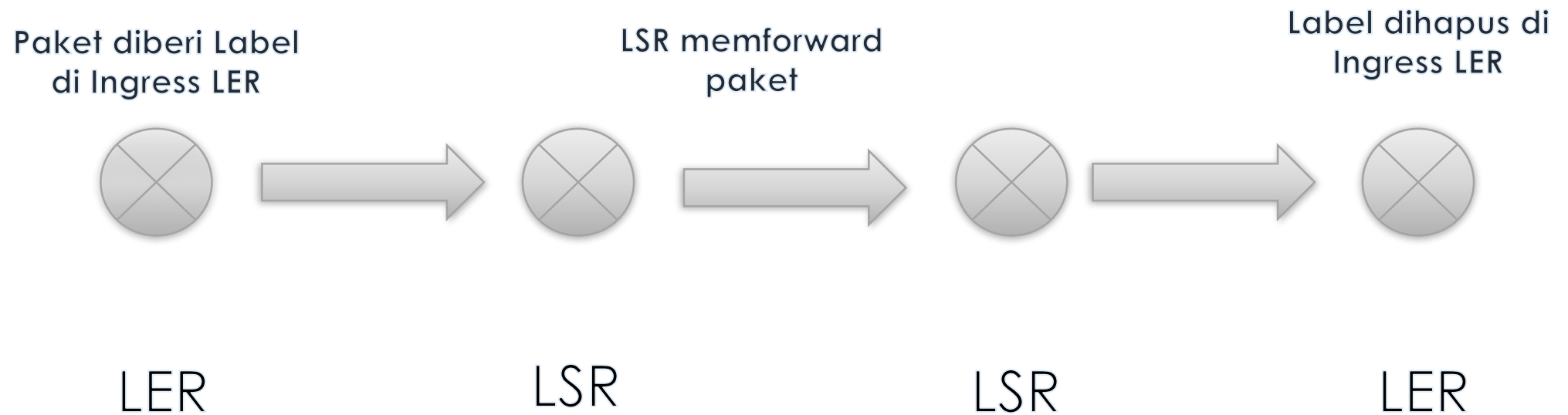
Keuntungan MPLS

- Beban routing lookup dapat secara maksimal di distribusikan secara merata di setiap edge Router
- Mengurangi beban routing lookup di core network router
- Redundancy dan load balancing

Cara kerja MPLS

- Perlu diberikan Header Label pada paket data pada jaringan MPLS. Label dihilangkan atau ditambahkan oleh router **LER (Label Edge Router)**
- Router **LSP (Label Switched Path)** menyiapkan jalur aliran data ke semua kombinasi node (Diumpamakan LSP sebagai unidirectional tunnel ke semua router)
- Selanjutnya paket data dikirimkan ke setiap router **LSR (Label Switching Router)** yang sudah ditentukan sebelumnya oleh LSR

Cara kerja Label MPLS



■ **Fungsi LER**

- Menambah Label ketika traffic datang (Ingress)
- Menambah Label lagi (Stack) jika ada service lagi
- Menghilangkan semua Label (POP) ketika keluar dari MPLS (Egress).

■ **Fungsi LSR**

- Forwarding paket (SWAP) berdasarkan label LSP yang sudah dibuat
- Menghilangkan paket terluar (POP) jika terjadi Label Stack

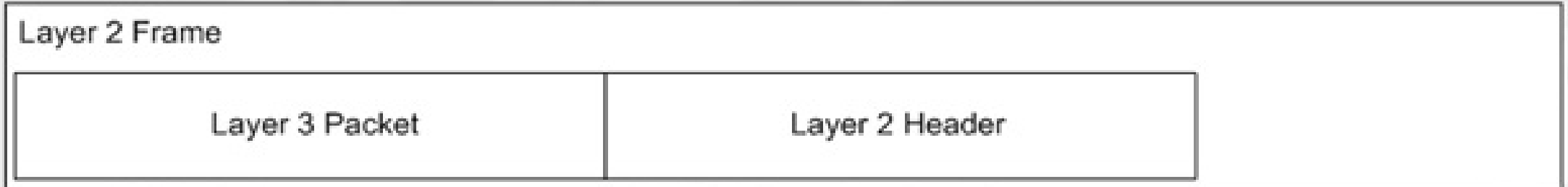
Header MPLS

- Berisi satu atau beberapa label (shims) yang masing-masing berukuran 32 bit yaitu Label (20 bits), EXP (3bits), End of stack flag (1 bit), TTL (8 bits)

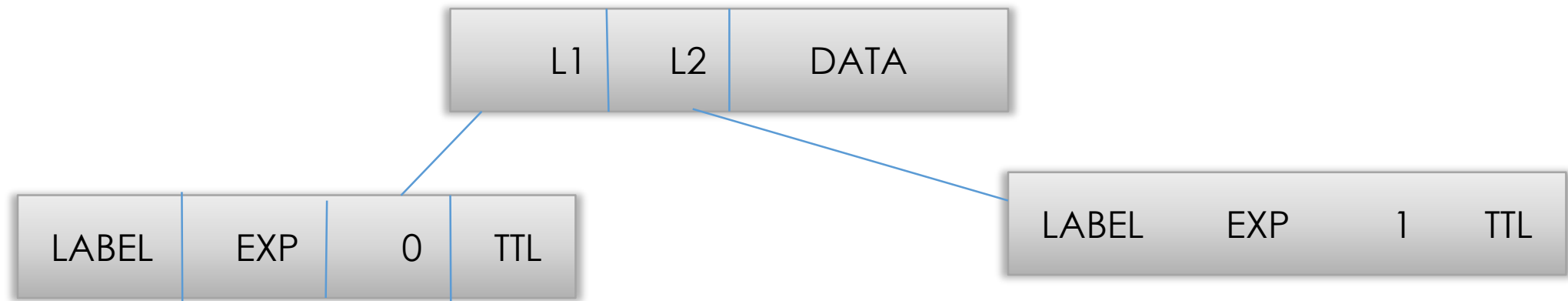
Label MPLS

- Dapat Multiple Label dalam satu paket Label Stack
- Top label atau label terluar digunakan untuk mengatur paket sampai ke tujuan kemudian dihapus
- Label selanjutnya untuk proses berikutnya contoh pointing VPN, menunjuk interface
- Contoh :
 - VPN
 - VPLS
 - Traffic Engineering

Header MPLS



Label MPLS



- MPLS L3VPN biasanya membutuhkan 2 Label
- MPLS L2VPN (VPLS) dan Traffic membutuhkan 2 label atau lebih
- Traffic Engineering dapat menggunakan lebih dari 2 label

Posisi Router MPLS

- **P (Provider Router)**
Router Backbone yang melakukan label Switching (LSR)
- **PE (Provider Edge Router)**
Melakukan label (LER) yang terhubung ke Internet, L3VPN, L2VPN, Traffic Engineering
- **CE (Customer Edge Router)**
Perangkat yang ada di client yang akan berkomunikasi dengan PE

MPLS LSP (Label Switched Path)

Setiap router berfungsi sebagai LSP

Ada 2 proses LSP yaitu :

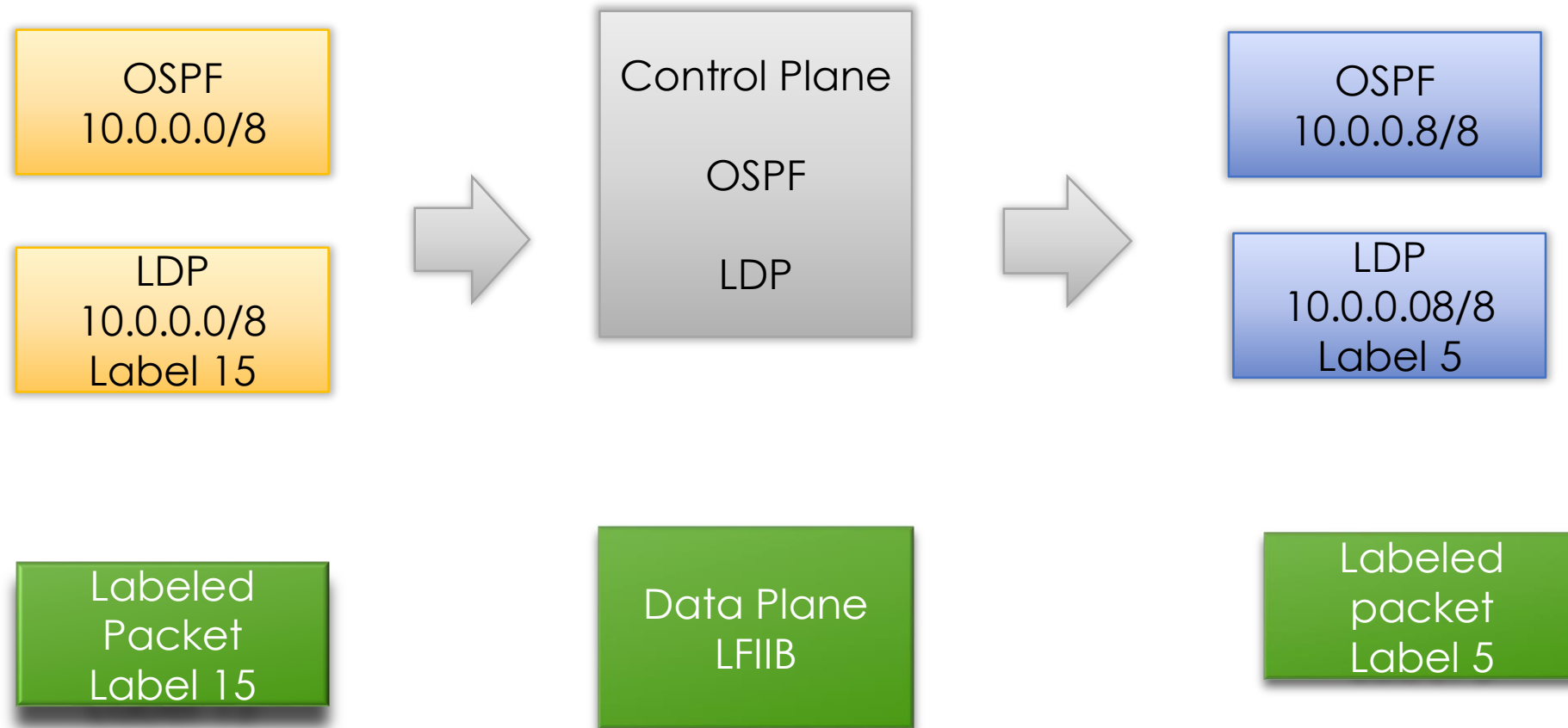
a. **Control Plane**

Proses pertukaran informasi routing layer 3 dan pertukaran informasi Label

b. **Data Plane**

Proses forwarding berdasarkan label dan IP address tujuan

Fungsi LSR (Label Switching Router)



MPLS Control Plane

- Masih dibutuhkan routing layer 3 untuk menyebarkan informasi routing dan informasi Label ke setiap router
- Metode Distribusi Label (Label Exchange Protocol) yang digunakan adalah static Label Mapping, LDP, TDP, BGP(VPN), RSVP (MPLS-TE)

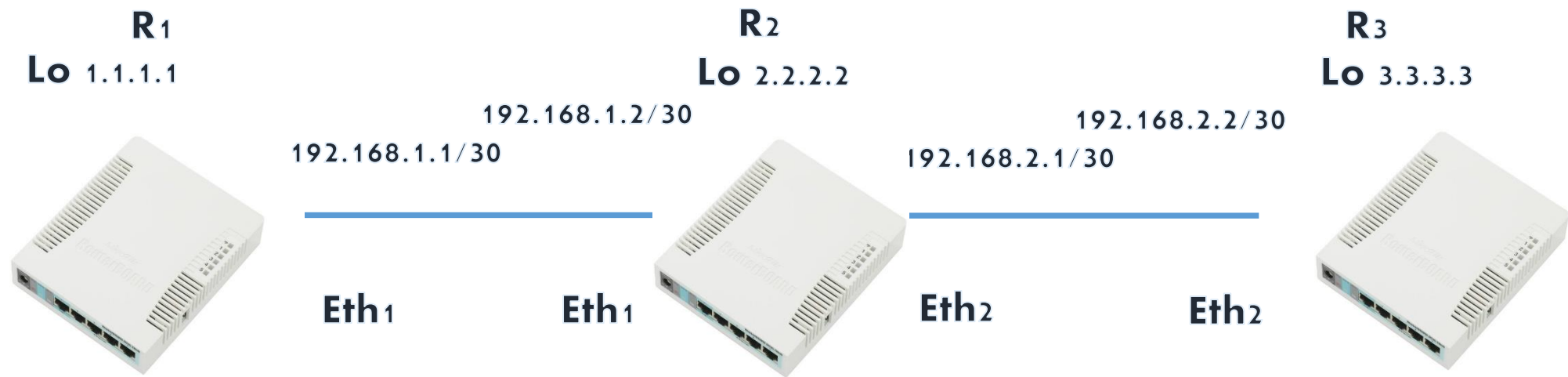
MPLS Data Plane

- Data Plane
 - = Proses forwarding sederhana berisi pertukaran data
- Label Forwarding Information Base (LFIB) menentukan forwarding paket data sesuai label yang sudah ada

Penerapan MPLS

- ✓ Virtual Private Networking (VPN)
- ✓ Traffic Engineering (TE)
- ✓ Quality of Service (QoS)
- ✓ Any Transport over MPLS (AToM)

Lab Static Label



Langkah Awal

- Membuat Loopback pada interface Bridge
- Membuat IP loopback di interface bridge loopback
- Membuat Ip Point to Point
- Mengaktifkan OSPF
- Membuat static label

Konfigurasi loopback di Router 1

Bridge

Bridge Ports Filters NAT Hosts

+ - ✓ ✗ 📁 🔍 Settings

	Name	Type	L2 MTU	Tx	Rx
R	loopback	Bridge	65535		0 bps

Interface <loopback>

General STP Status Traffic

Name: loopback

Type: Bridge

MTU: 1500

L2 MTU: 65535

MAC Address:

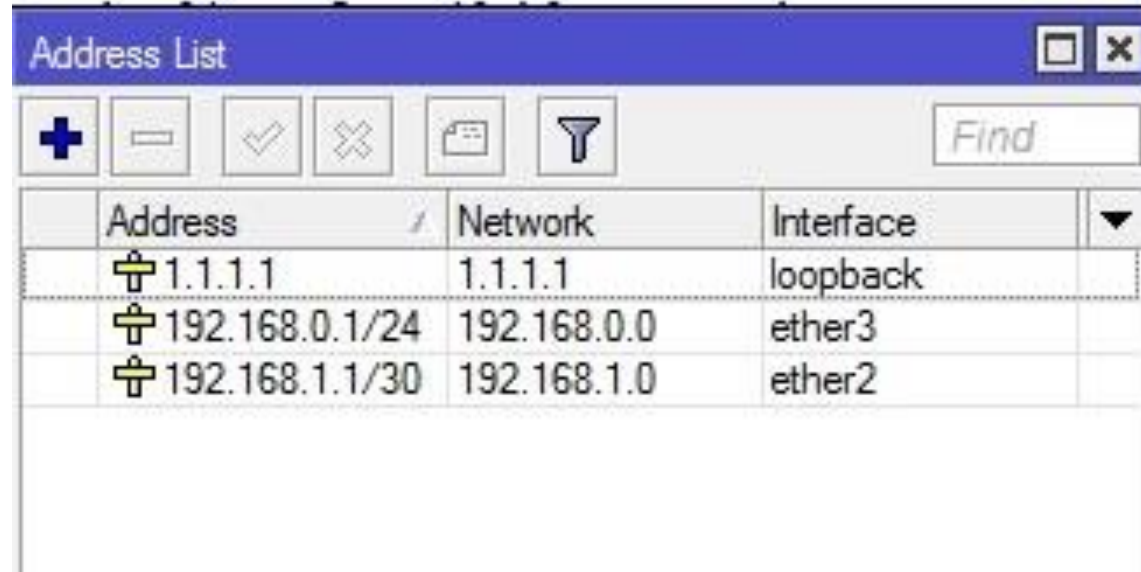
ARP: enabled

Admin. MAC Address:

OK Cancel Apply Disable Comment Copy Remove Torch

1 item

Konfigurasi IP Address di R1



The screenshot shows the 'Address List' window in Mikrotik WinBox. The window has a blue title bar and a toolbar with icons for adding, deleting, saving, and filtering. A 'Find' search box is also present. The main area contains a table with three columns: 'Address', 'Network', and 'Interface'. Each row in the table has a small icon to its left. The table lists three entries: a loopback address 1.1.1.1, and two Ethernet addresses on ether3 and ether2.

	Address	Network	Interface	
	1.1.1.1	1.1.1.1	loopback	
	192.168.0.1/24	192.168.0.0	ether3	
	192.168.1.1/30	192.168.1.0	ether2	

Konfigurasi Network OSPF Di R1

OSPF			
Instances		Networks	Areas
		Area Ranges	Virtual Links
		Neighbors	NBMA
			
			
Network		/	Area
 1.1.1.1			backbone
 192.168.0.0/24			backbone
 192.168.1.0/30			backbone

Tampilan Interface OSPF di R1

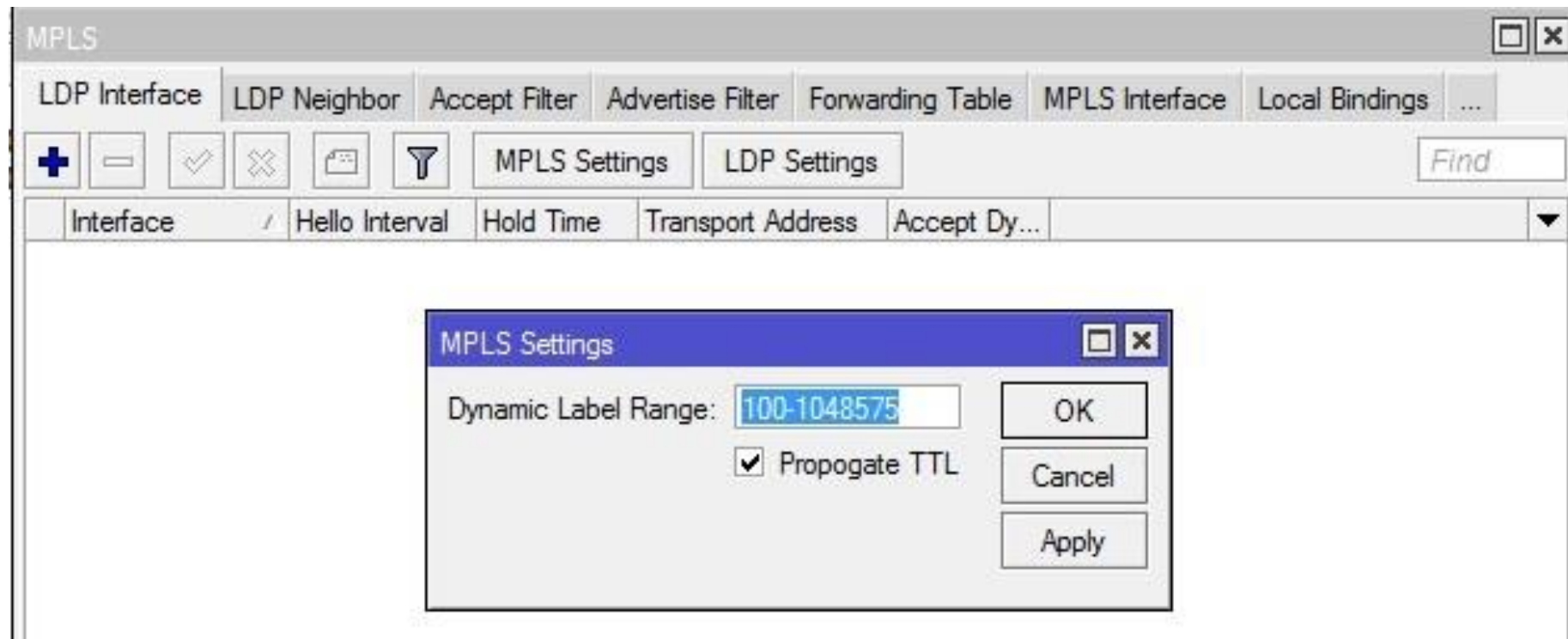
	Interface	Cost	Priority	Authentic...	Authenticatio...	Network Type	Instance	Area
	all	10	1	none	*****	broadcast	default	unknown
D	ether2	10	1	none	*****	broadcast	default	backbone
D	ether3	10	1	none	*****	broadcast	default	backbone
DP	loopback	10	1	none	*****	broadcast	default	backbone

Konfigurasi Static label di R1

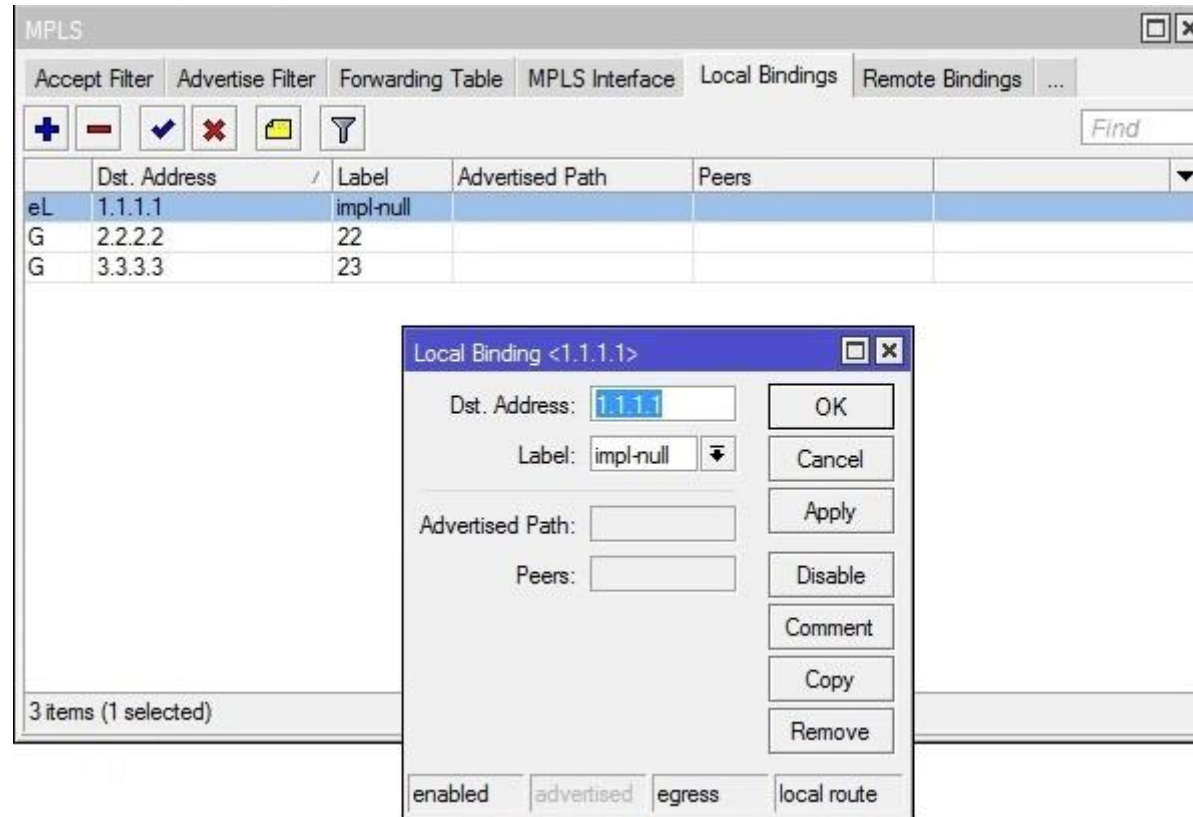
	Dst	Label
Local	1.1.1.1	Impl-null
	2.2.2.2	22
	3.3.3.3	23

	Dst	Label	Hop
Remote	2.2.2.2	Impl-null	192.168.1.2
	3.3.3.3	23	192.168.1.2

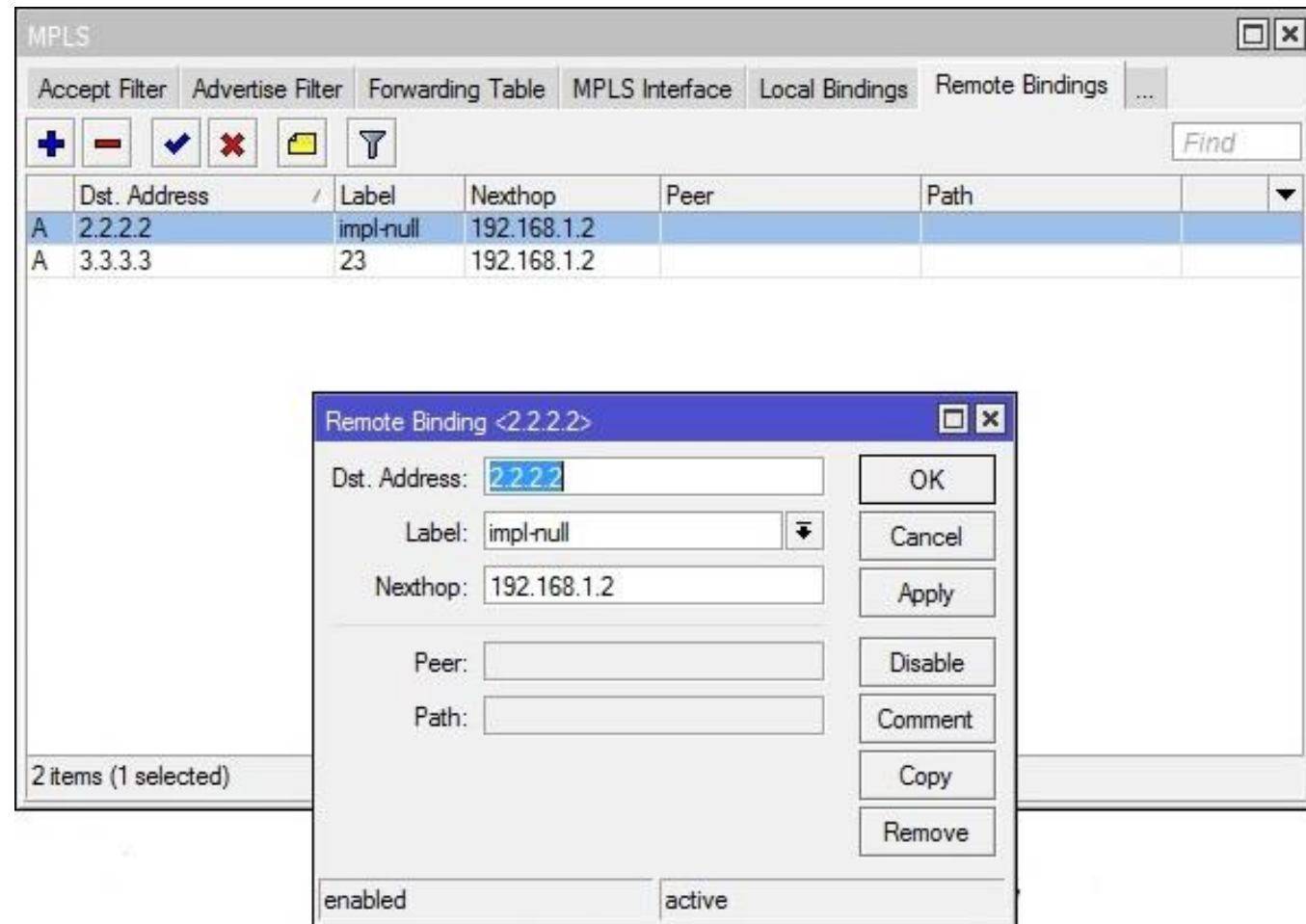
Mendefinisikan Range Statik Label di R1



Konfigurasi Local Bindings di R1



Konfigurasi Remote Bindings di R1



Hasil Trace route di R1

Traceroute (Running)

Traceroute To: 3.3.3.3

Packet Size: 56

Timeout: 1000 ms

Protocol: icmp

Port: 33434

☐ Use DNS

Count:

Max Hops:

Src. Address: 1.1.1.1

Interface:

DSCP:

Routing Table:

Start

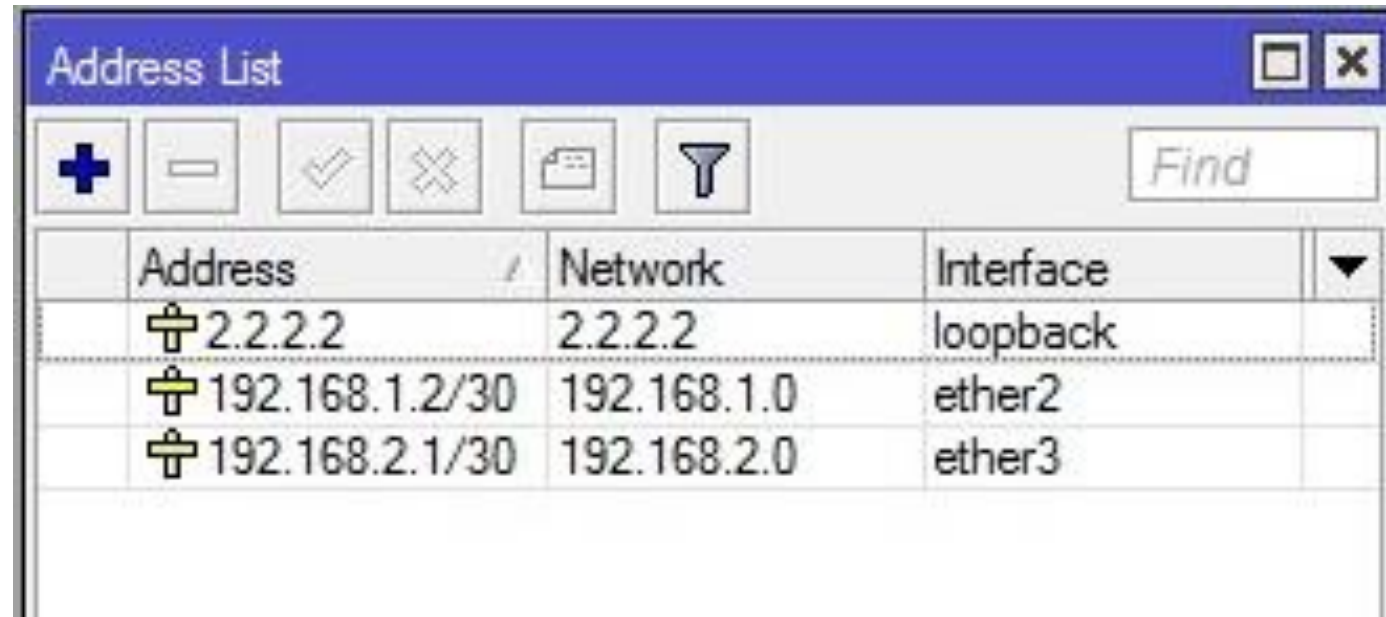
Stop

Close

New Window

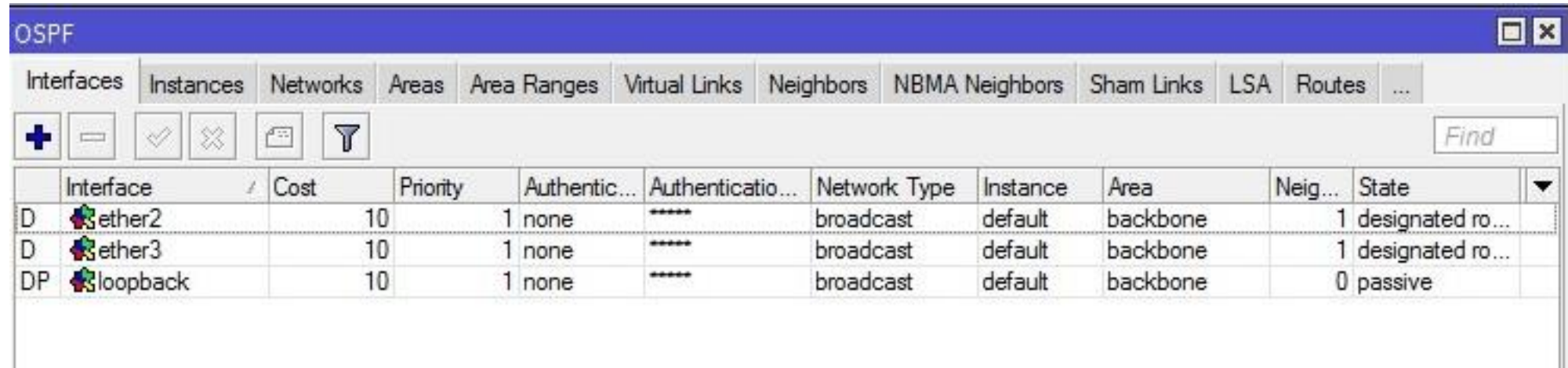
Hop	/	Host	Loss	Sent	Last	Avg.	Best	Worst	Std. Dev.	History	Status	
1		192.168.1.2	0.0%	17	0.3ms	0.3	0.3	0.7	0.1		<MPLS:L=23,E=0>	
2		3.3.3.3	0.0%	17	0.2ms	0.2	0.2	0.3	0.0			

Konfigurasi IP di R2



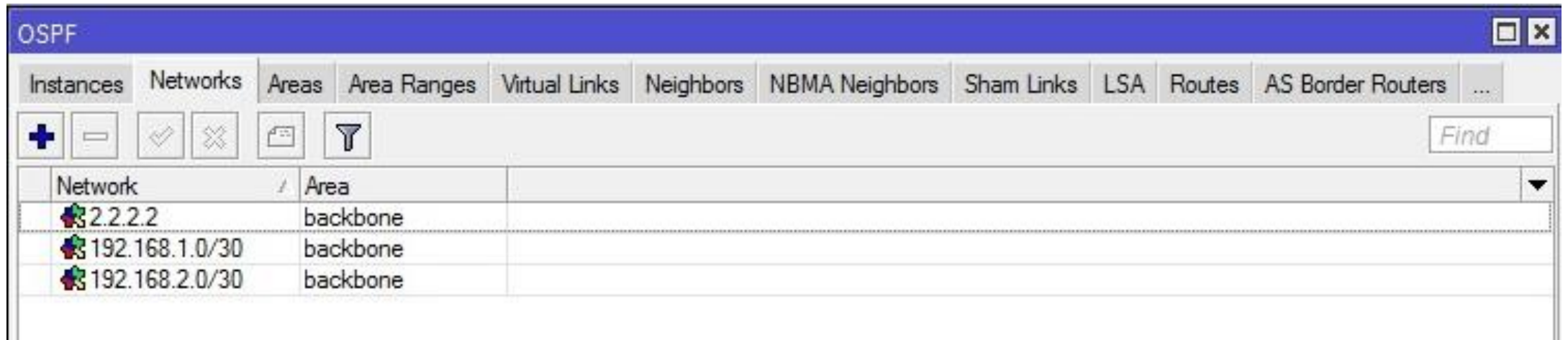
	Address	Network	Interface	
+	2.2.2.2	2.2.2.2	loopback	
+	192.168.1.2/30	192.168.1.0	ether2	
+	192.168.2.1/30	192.168.2.0	ether3	

Konfigurasi OSPF di R2



	Interface	Cost	Priority	Authentic...	Authenticatio...	Network Type	Instance	Area	Neig...	State
D	ether2	10	1	none	*****	broadcast	default	backbone	1	designated ro...
D	ether3	10	1	none	*****	broadcast	default	backbone	1	designated ro...
DP	loopback	10	1	none	*****	broadcast	default	backbone	0	passive

Konfigurasi OSPF di R2



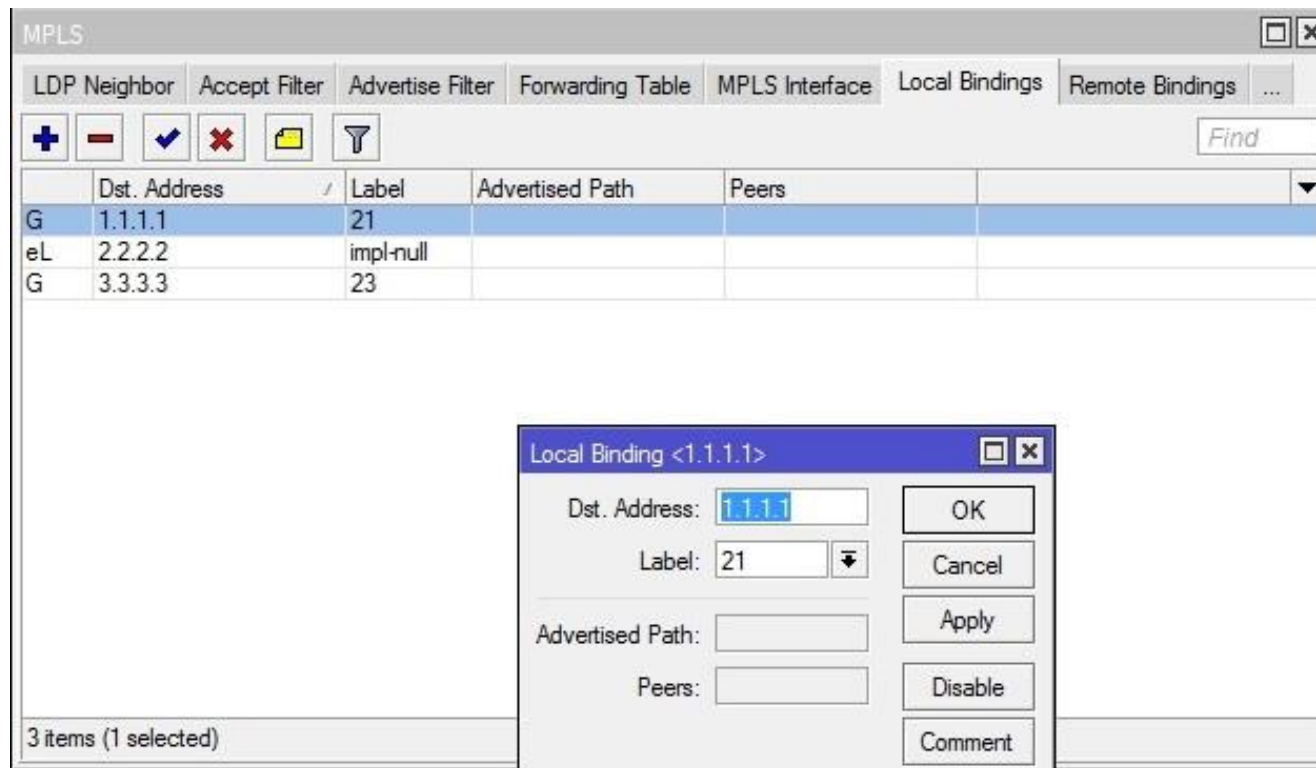
OSPF	
Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LSA Routes AS Border Routers ...	
+ - [check] [X] [icon] [funnel] Find	
Network	Area
2.2.2.2	backbone
192.168.1.0/30	backbone
192.168.2.0/30	backbone

Konfigurasi Static label di R2

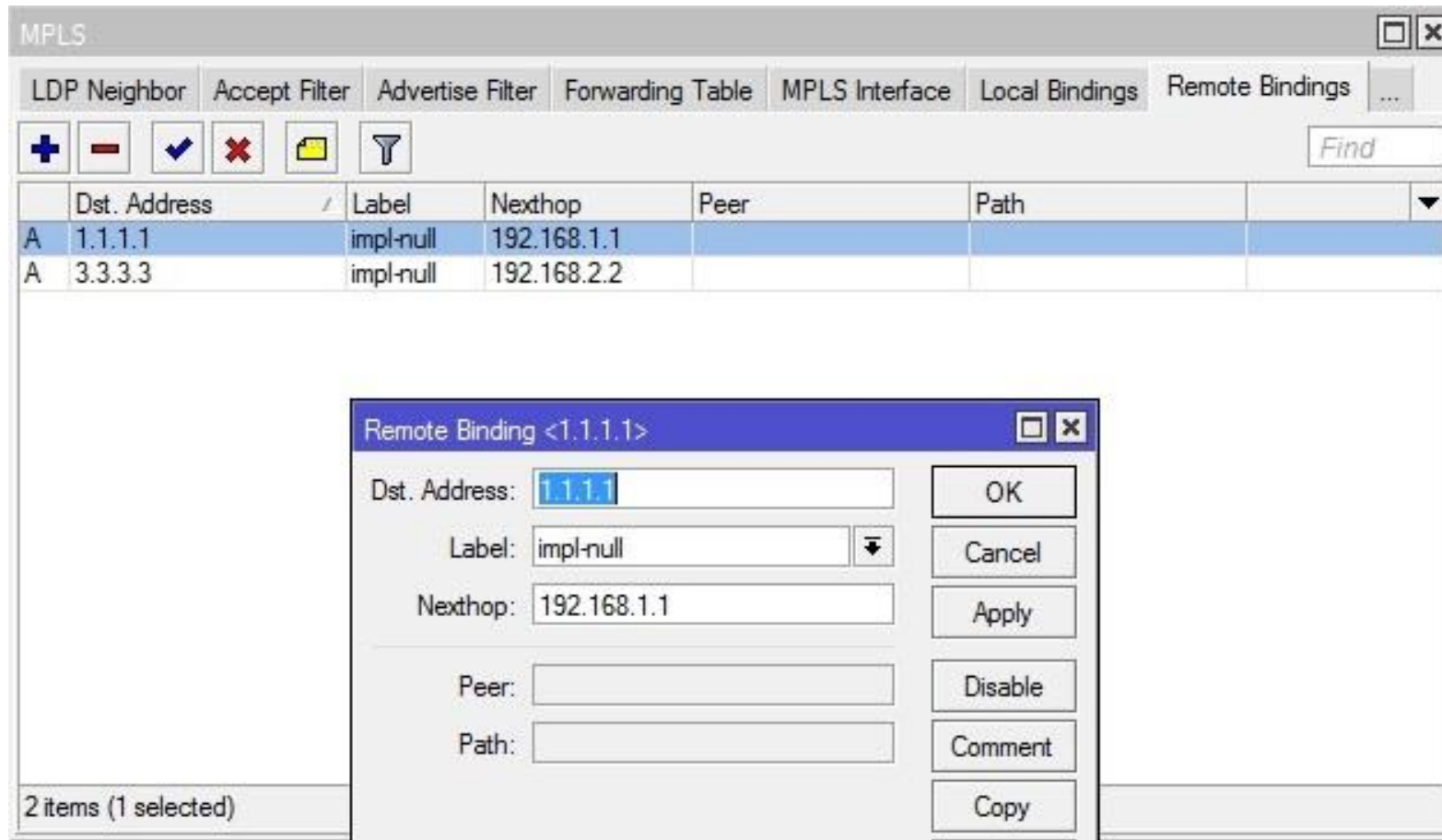
	Dst	Label
Local	1.1.1.1	21
	2.2.2.2	Impl-null
	3.3.3.3	23

	Dst	Label	Hop
Remote	1.1.1.1	Impl-null	192.168.1.1
	3.3.3.3	Impl-null	192.168.2.2

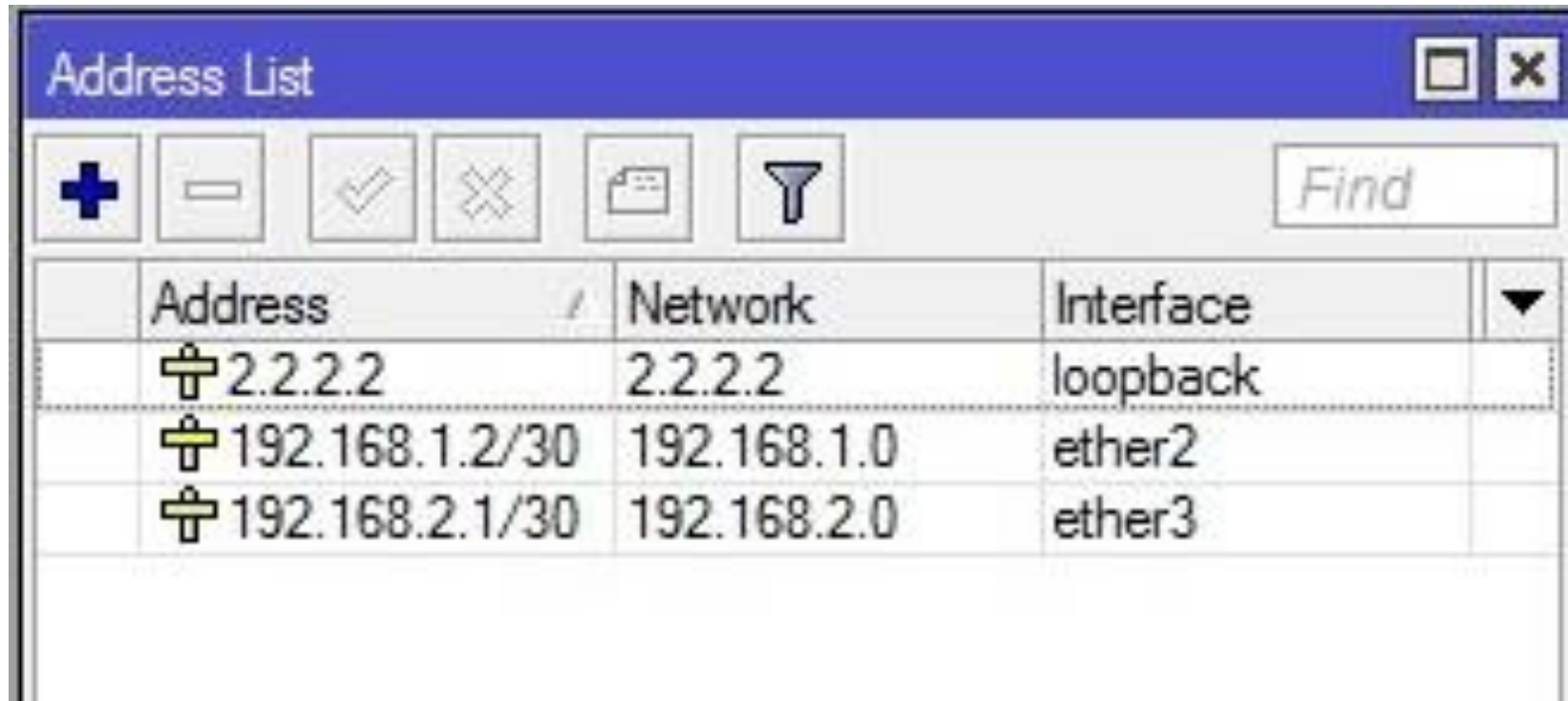
Konfigurasi Local Bindings di R2



Konfigurasi Remote Bindings di R2



Konfigurasi IP di R3



	Address	Network	Interface	
	2.2.2.2	2.2.2.2	loopback	
	192.168.1.2/30	192.168.1.0	ether2	
	192.168.2.1/30	192.168.2.0	ether3	

Konfigurasi Interface OSPF di R3

OSPF											
Interfaces Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LSA Routes ...											
Find											
	Interface	Cost	Priority	Authentic...	Authenticatio...	Network Type	Instance	Area	Neig...	State	
X	 all	10	1	none	-----	broadcast	default	unknown	0	down	
D	 ether3	10	1	none	-----	broadcast	default	backbone	1	backup	
DP	 loopback	10	1	none	-----	broadcast	default	backbone	0	passive	

Konfigurasi Network OSPF di R3

OSPF			
Instances		Networks	Areas
		Area Ranges	Virtual Links
		Neighbors	N
     			
	Network	/	Area
	 3.3.3.0/24		backbone
	 192.168.2.0/30		backbone
	 192.168.3.0/24		backbone

Membuat Static label di R3

	Dst	Label
Local	1.1.1.1	21
	2.2.2.2	22
	3.3.3.3	Impl-null

	Dst	Label	Hop
Remote	2.2.2.2	Impl-null	192.168.2.1
	1.1.1.1	21	192.168.2.1

Konfigurasi Local Bindings di R3

MPLS					
LDP Interface	LDP Neighbor	Accept Filter	Advertise Filter	Forwarding Table	MPLS Interface
Local Bindings					
+ - ✓ ✗ 📁 🔍					
	Dst. Address	/	Label	Advertised Path	Peers
G	1.1.1.1		21		
G	2.2.2.2		22		
eL	3.3.3.3		impl-null		

Local Binding <3.3.3.3>

Dst. Address: 3.3.3.3

Label: impl-null

Advertised Path:

Peers:

OK

Cancel

Apply

Disable

Comment

Copy

Remove

enabled

advertised

egress

local route

Konfigurasi Remote Bindings Di R3

MPLS

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

+ - ✓ ✗ 📁 🔍

	Dst. Address	Label	Nexthop	Peer	Path
A	1.1.1.1	21	192.168.2.1		
A	2.2.2.2	impl-null	192.168.2.1		

Remote Binding <2.2.2.2>

Dst. Address: 2.2.2.2

Label: impl-null

Nexthop: 192.168.2.1

Peer:

Path:

OK Cancel Apply Disable Comment Copy Remove

enabled active

Hasil Traceroute di R3

Traceroute (Running)

Traceroute To: 1.1.1.1

Packet Size: 56

Timeout: 1000 ms

Protocol: icmp

Port: 33434

☐ Use DNS

Count:

Max Hops:

Src. Address: 3.3.3.3

Interface:

DSCP:

Routing Table:

Start

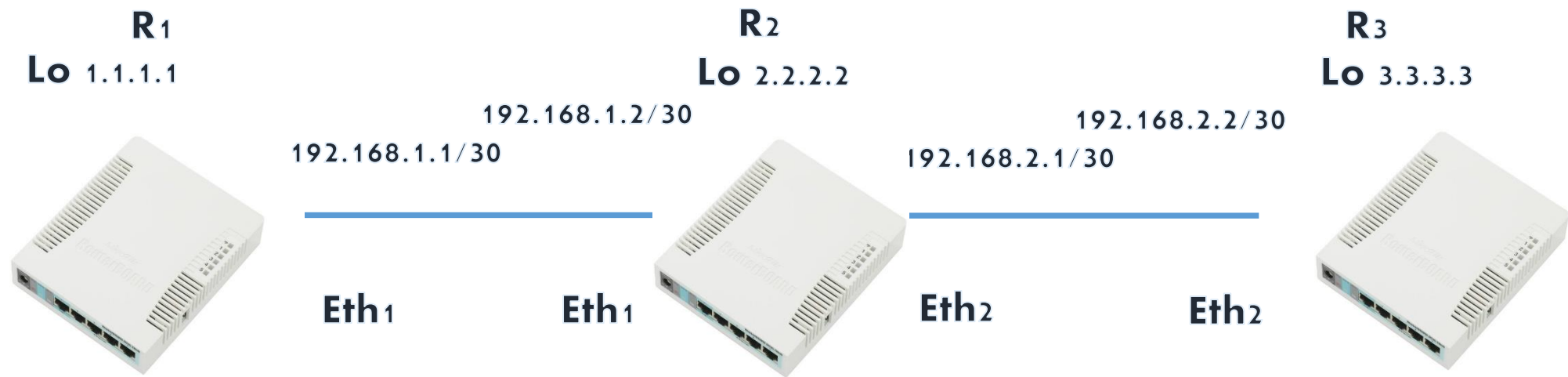
Stop

Close

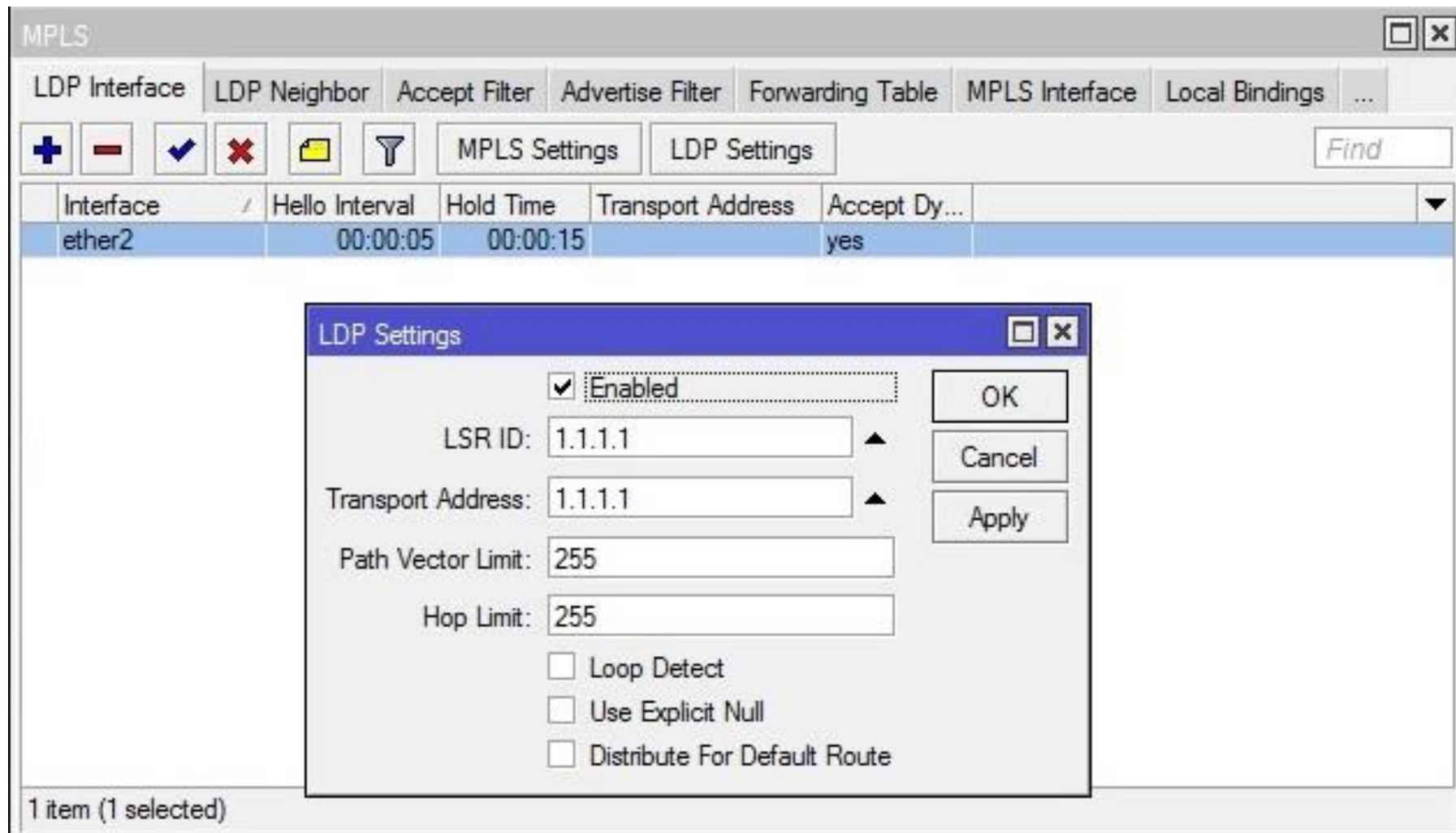
New Window

Hop	/	Host	Loss	Sent	Last	Avg.	Best	Worst	Std. Dev.	History	Status
1		192.168.2.1	0.0%	10	0.3ms	0.4	0.3	1.0	0.2		<MPLS:L=21,E=0>
2		1.1.1.1	0.0%	10	0.2ms	0.2	0.2	0.3	0.0		

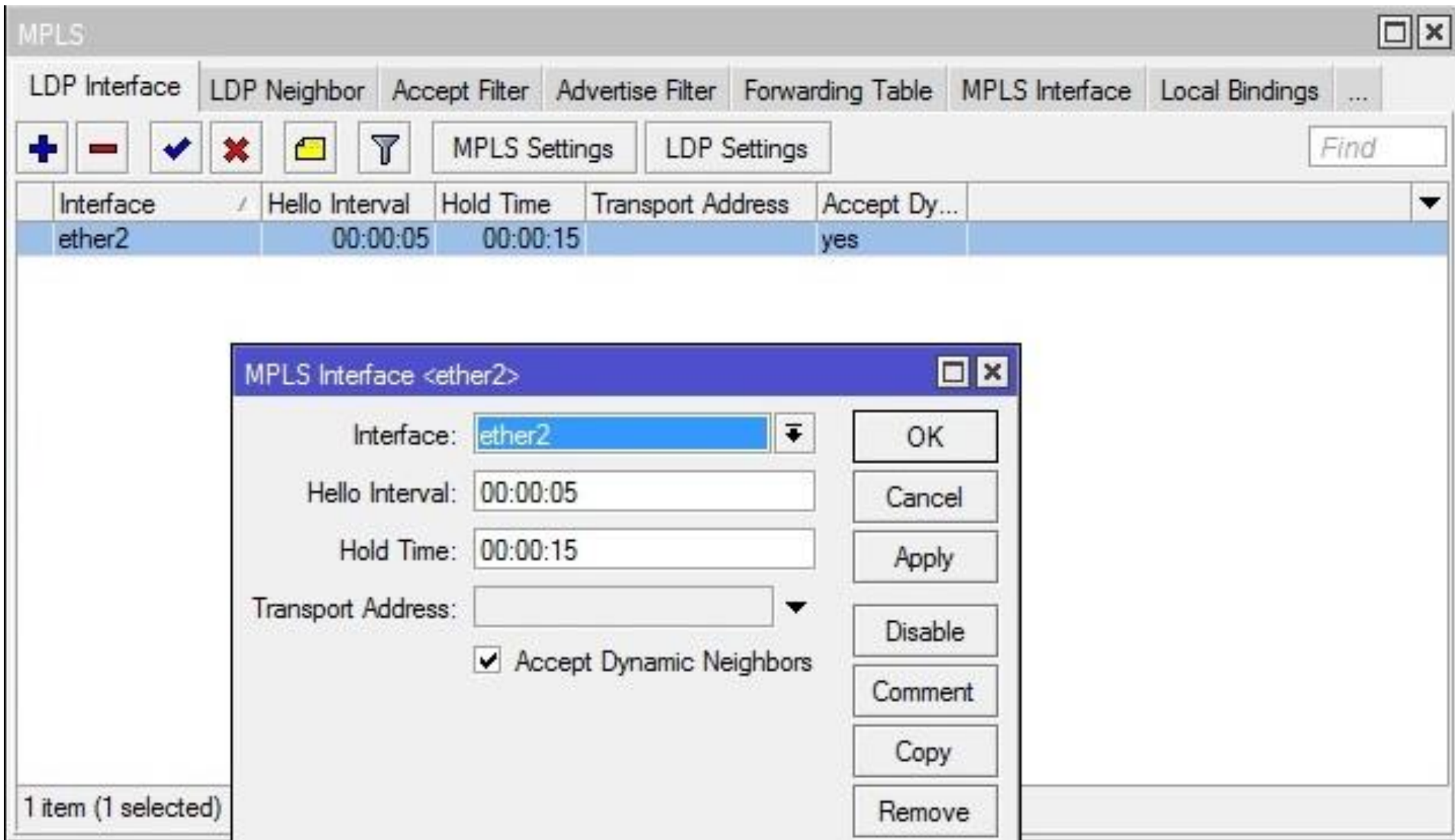
Lab LDP (Label Distribution Protocol)



Konfigurasi LDP di R1



Konfigurasi LDP Interface di R1

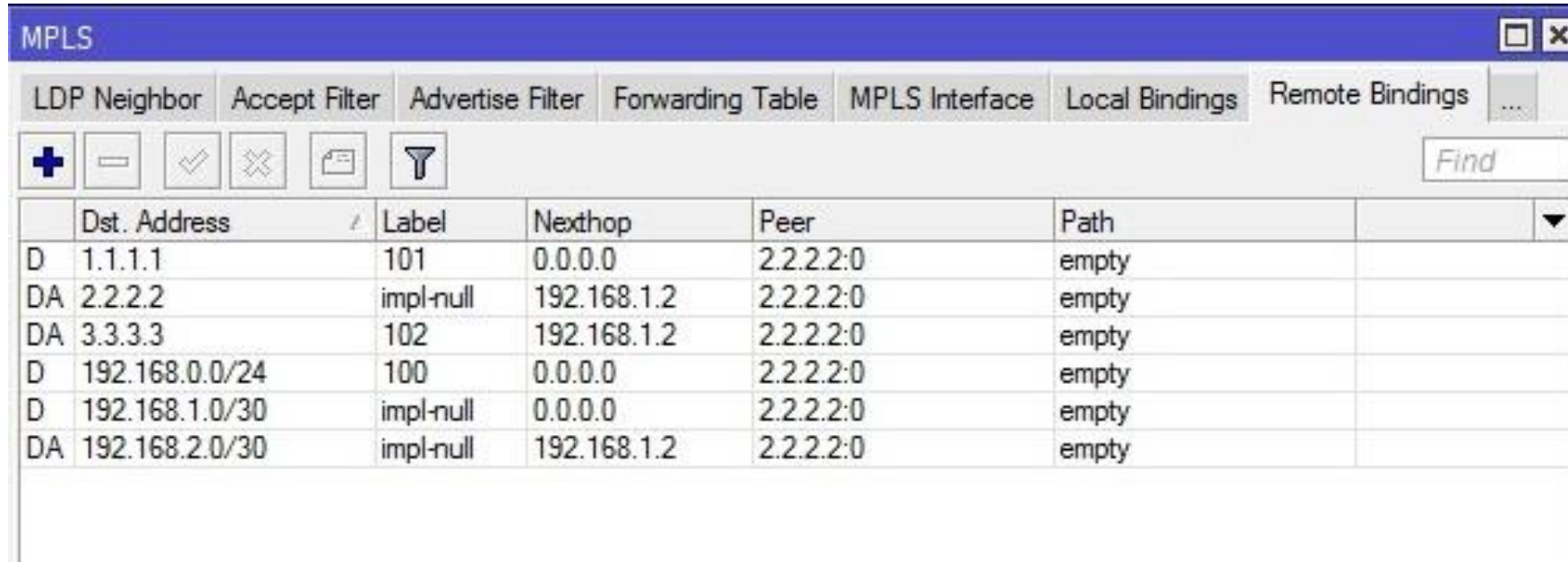


Hasil Local Bindings

The screenshot shows the MPLS configuration window with the 'Forwarding Table' tab selected. The table displays the following data:

	Dst. Address	Label	Advertised Path	Peers
DAeL	1.1.1.1	impl-null	empty	2.2.2.2:0
DAG	2.2.2.2	106	empty	2.2.2.2:0
DAG	3.3.3.3	107	empty	2.2.2.2:0
DAeL	192.168.0.0/24	impl-null	empty	2.2.2.2:0
DAeL	192.168.1.0/30	impl-null	empty	2.2.2.2:0
DAG	192.168.2.0/30	108	empty	2.2.2.2:0

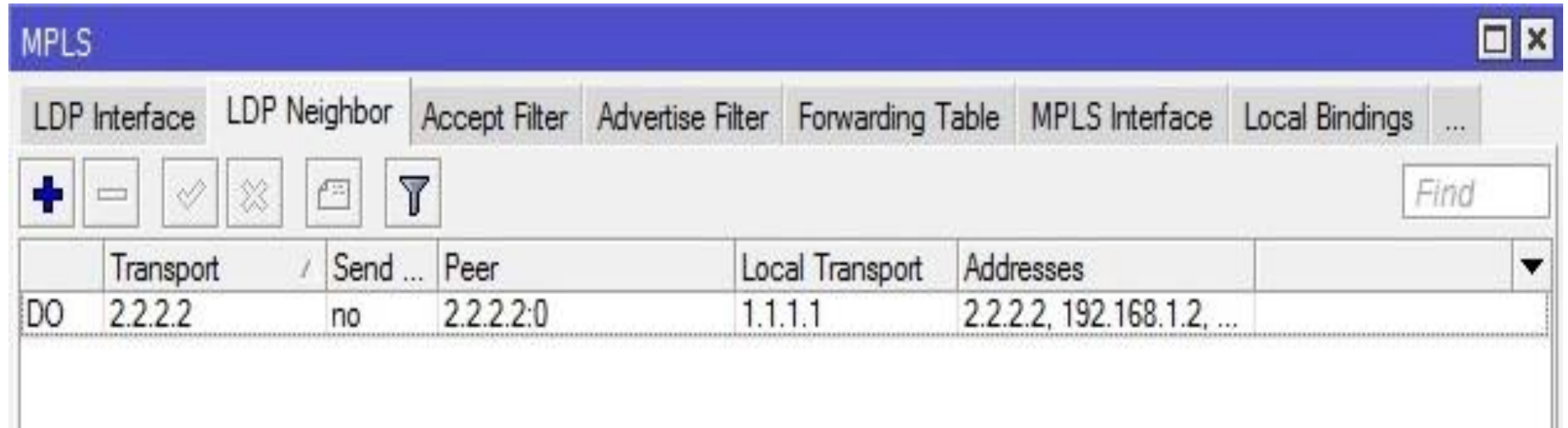
Hasil Remote Bindings



The screenshot shows the 'MPLS' configuration window in Mikrotik WinBox, specifically the 'Remote Bindings' tab. The window has a blue title bar and a menu bar with options: LDP Neighbor, Accept Filter, Advertise Filter, Forwarding Table, MPLS Interface, Local Bindings, and Remote Bindings. Below the menu bar is a toolbar with icons for adding (+), removing (-), saving (floppy disk), deleting (X), and filtering (funnel), along with a 'Find' search box. The main area contains a table with 7 columns: an action column, 'Dst. Address', 'Label', 'Nexthop', 'Peer', 'Path', and a dropdown arrow. The table lists six entries with their respective actions, destination addresses, labels, next hops, peers, and paths.

	Dst. Address	Label	Nexthop	Peer	Path	
D	1.1.1.1	101	0.0.0.0	2.2.2.2:0	empty	
DA	2.2.2.2	impl-null	192.168.1.2	2.2.2.2:0	empty	
DA	3.3.3.3	102	192.168.1.2	2.2.2.2:0	empty	
D	192.168.0.0/24	100	0.0.0.0	2.2.2.2:0	empty	
D	192.168.1.0/30	impl-null	0.0.0.0	2.2.2.2:0	empty	
DA	192.168.2.0/30	impl-null	192.168.1.2	2.2.2.2:0	empty	

Hasil LDP Neighbor



The screenshot shows the Mikrotik WinBox interface for the MPLS configuration. The 'LDP Neighbor' tab is selected. The table below displays the LDP neighbor information for the DO interface.

	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, ...	▼

Konfigurasi LDP Interface di R2

MPLS Interface <ether2>

Interface: ether2

Hello Interval: 00:00:05

Hold Time: 00:00:15

Transport Address:

☒ Accept Dynamic Neighbors

OK

Cancel

Apply

Disable

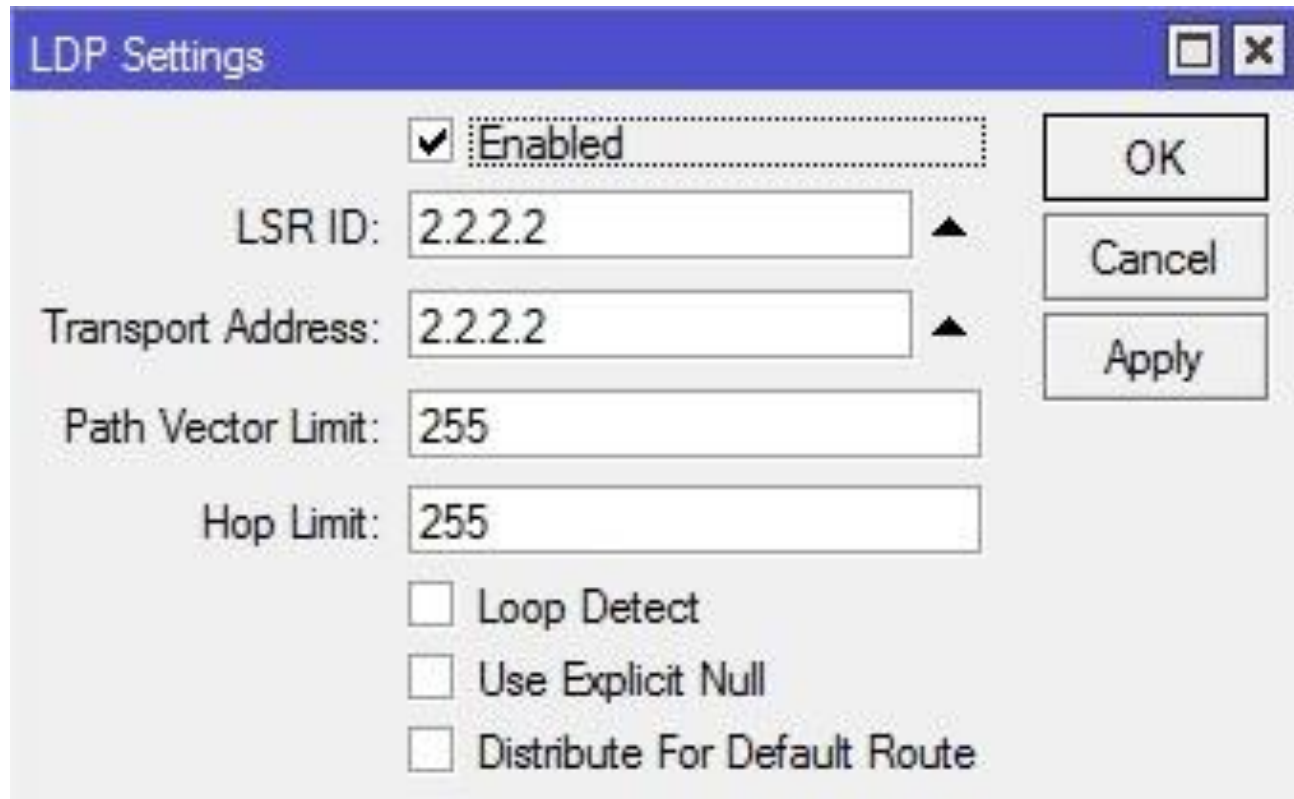
Comment

Copy

Remove

enabled

Konfigurasi LDP di R2



LDP Settings

☒ Enabled

LSR ID: 2.2.2.2 ▲

Transport Address: 2.2.2.2 ▲

Path Vector Limit: 255

Hop Limit: 255

☐ Loop Detect

☐ Use Explicit Null

☐ Distribute For Default Route

OK

Cancel

Apply

Tampilan Local Bindings di R2

MPLS

LDP InterfaceLDP NeighborAccept FilterAdvertise FilterForwarding TableMPLS InterfaceLocal BindingsRemote Bindings

	Dst. Address	/	Label	Advertised Path	Peers	
DAG	1.1.1.1		110	empty	1.1.1.1:0, 3.3.3.3:0	
DAeL	2.2.2.2		impl-null	empty	1.1.1.1:0, 3.3.3.3:0	
DAG	3.3.3.3		111	empty	1.1.1.1:0, 3.3.3.3:0	
DAG	192.168.0.0/24		109	empty	1.1.1.1:0, 3.3.3.3:0	
DAeL	192.168.1.0/30		impl-null	empty	1.1.1.1:0, 3.3.3.3:0	
DAeL	192.168.2.0/30		impl-null	empty	1.1.1.1:0, 3.3.3.3:0	

Tampilan Remote Bindings di R2

MPLS

LDP InterfaceLDP NeighborAccept FilterAdvertise FilterForwarding TableMPLS InterfaceLocal BindingsRemote Bindings

	Dst. Address	Label	Nexthop	Peer	Path	
DA	1.1.1.1	impl-null	192.168.1.1	1.1.1.1:0	empty	
D	1.1.1.1	106	0.0.0.0	3.3.3.3:0	empty	
D	2.2.2.2	115	0.0.0.0	1.1.1.1:0	empty	
D	2.2.2.2	105	0.0.0.0	3.3.3.3:0	empty	
D	3.3.3.3	116	0.0.0.0	1.1.1.1:0	empty	
DA	3.3.3.3	impl-null	192.168.2.2	3.3.3.3:0	empty	
DA	192.168.0.0/24	impl-null	192.168.1.1	1.1.1.1:0	empty	
D	192.168.0.0/24	107	0.0.0.0	3.3.3.3:0	empty	
D	192.168.1.0/30	impl-null	0.0.0.0	1.1.1.1:0	empty	
D	192.168.1.0/30	104	0.0.0.0	3.3.3.3:0	empty	
D	192.168.2.0/30	117	0.0.0.0	1.1.1.1:0	empty	
D	192.168.2.0/30	impl-null	0.0.0.0	3.3.3.3:0	empty	

Tampilan LDP Neighbor

MPLS

LDP InterfaceLDP NeighborAccept FilterAdvertise FilterForwarding TableMPLS InterfaceLocal BindingsRemote 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, 192.168.0.1, 192.168.1.1	
DO	3.3.3.3	no	3.3.3.3:0	2.2.2.2	3.3.3.3, 192.168.2.2, 192.168.3.1	

Konfigurasi LDP Interface di R 3

MPLS Interface <ether3>

Interface: ether3

Hello Interval: 00:00:05

Hold Time: 00:00:15

Transport Address:

☒ Accept Dynamic Neighbors

OK

Cancel

Apply

Disable

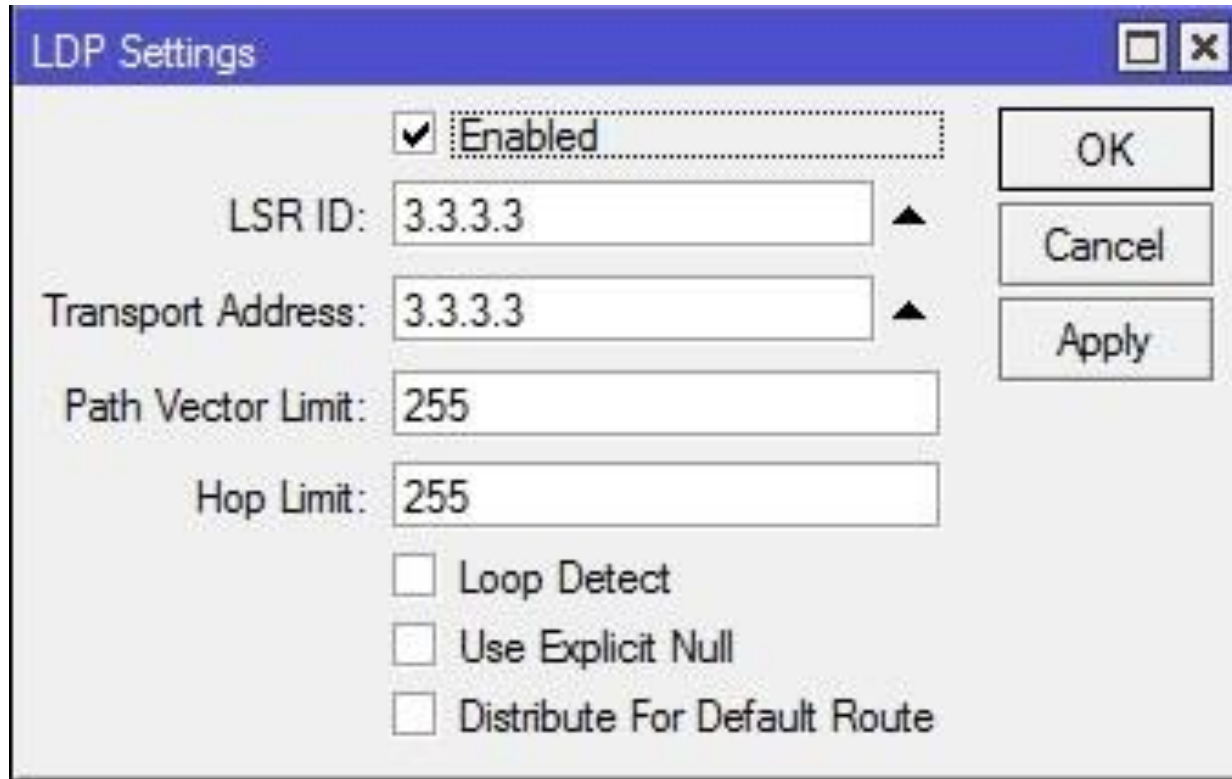
Comment

Copy

Remove

enabled

Konfigurasi LDP di R3



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

Tampilan Local Bindings di R3

MPLS

LDP InterfaceLDP NeighborAccept FilterAdvertise FilterForwarding TableMPLS InterfaceLocal BindingsRemote Bindings

	Dst. Address	/	Label	Advertised Path	Peers	
DAG	1.1.1.1		118	empty	2.2.2.2:0	
DAG	2.2.2.2		117	empty	2.2.2.2:0	
DAeL	3.3.3.3		impl-null	empty	2.2.2.2:0	
DAG	192.168.0.0/24		119	empty	2.2.2.2:0	
DAG	192.168.1.0/30		116	empty	2.2.2.2:0	
DAeL	192.168.2.0/30		impl-null	empty	2.2.2.2:0	

Tampilan Remote Bindings di R3

MPLS

LDP InterfaceLDP NeighborAccept FilterAdvertise FilterForwarding TableMPLS InterfaceLocal BindingsRemote Bindings

	Dst. Address	Label	Nexthop	Peer	Path	
DA	1.1.1.1	110	192.168.2.1	2.2.2.2:0	empty	
DA	2.2.2.2	impl-null	192.168.2.1	2.2.2.2:0	empty	
D	3.3.3.3	111	0.0.0.0	2.2.2.2:0	empty	
DA	192.168.0.0/24	109	192.168.2.1	2.2.2.2:0	empty	
DA	192.168.1.0/30	impl-null	192.168.2.1	2.2.2.2:0	empty	
D	192.168.2.0/30	impl-null	0.0.0.0	2.2.2.2:0	empty	

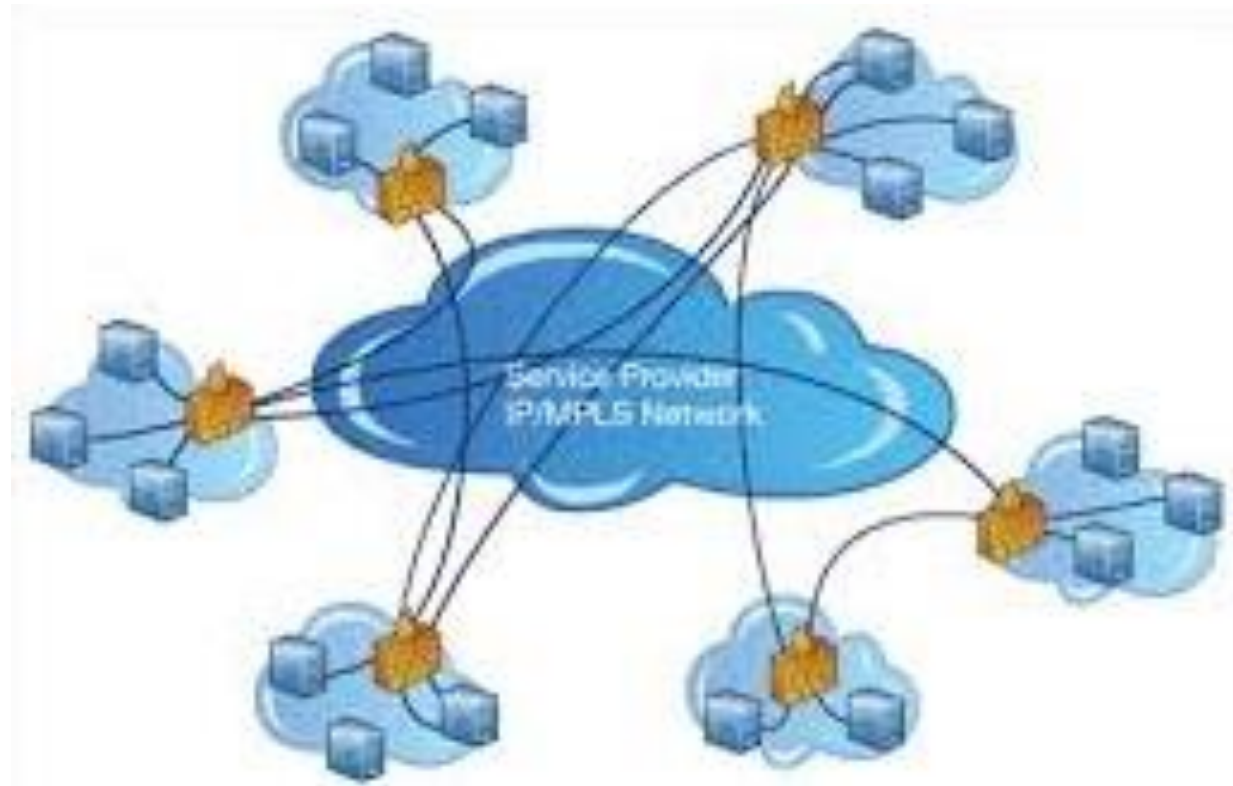
Tampilan LDP Neighbor di R3

MPLS

LDP InterfaceLDP NeighborAccept FilterAdvertise FilterForwarding TableMPLS InterfaceLocal BindingsRemote Bindings

	Transport	/	Send ...	Peer	Local Transport	Addresses	
DO	2.2.2.2		no	2.2.2.2:0	3.3.3.3	2.2.2.2, 192.168.1.2, ...	

Lab Lanjutan



- Penerapan yang lebih advanced dapat menggunakan **L3VPN** atau **L2VPN (VPLS)**



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