MPLS basics on Router OS 3.x

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MPLS

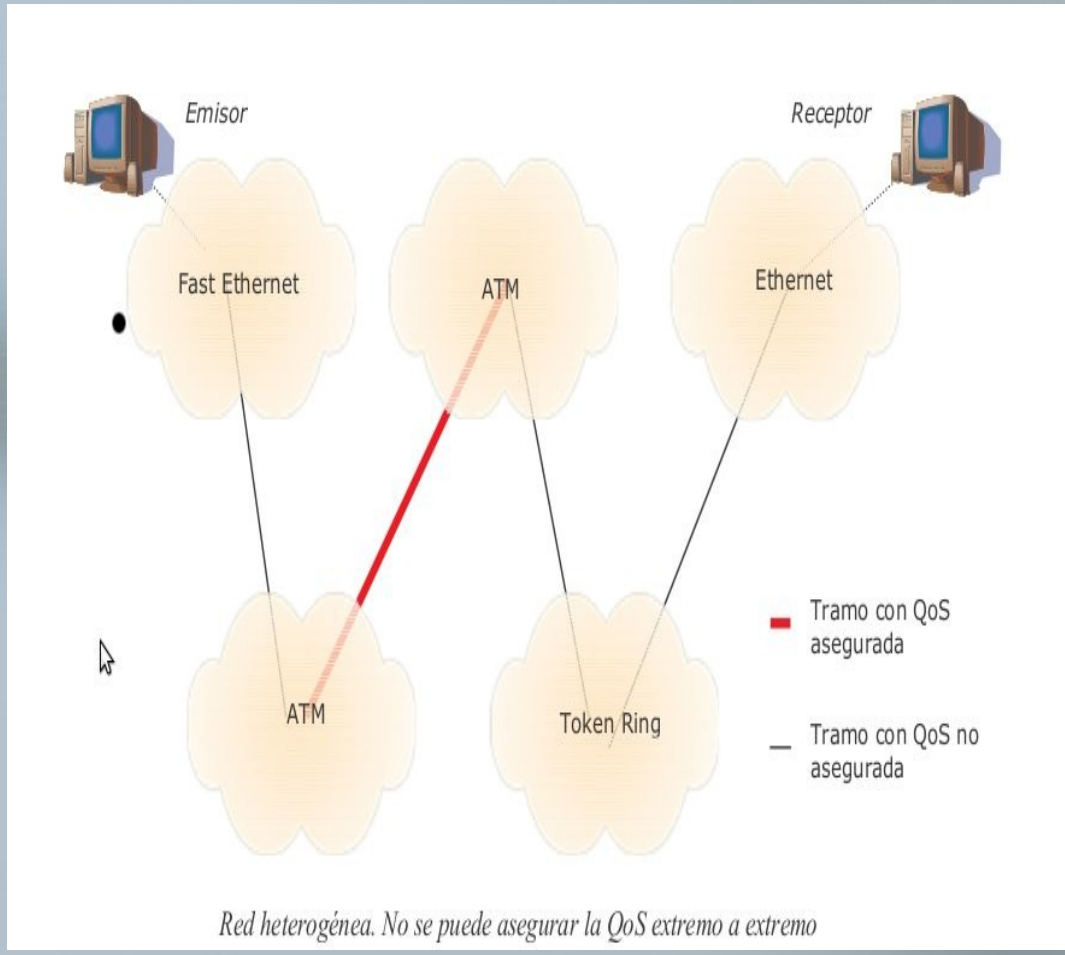
- Introduction
- MPLS Objectives
- Characteristics
- Operation
- MPLS on Router Os 3.x
  - Implementing of MPLS
  - Tools for examine MPLS

Introduction

- The unstoppable growth of the Internet and also the increasing demand of new and more sophisticated services, call for fundamental technological changes regarding common practices developed during the mid 90`s.
- One of the success factors of today’s Internet is the adoption of the TCP/IP protocols as a de-facto standard for all kinds of services and applications.
- Internet has replaced the traditional data networks; it is now the model of the public network.

Introduction

- Internet is much more appreciated for access services and distribution of contents than for data transport services (known as “best-effort”).
- Current applications requires a more expedite and deterministic response, not randomized.
- The increase in services, users and volumes of information demand new technologies for the transport of data.



Red heterogénea. No se puede asegurar la QoS extremo a extremo

Introduction

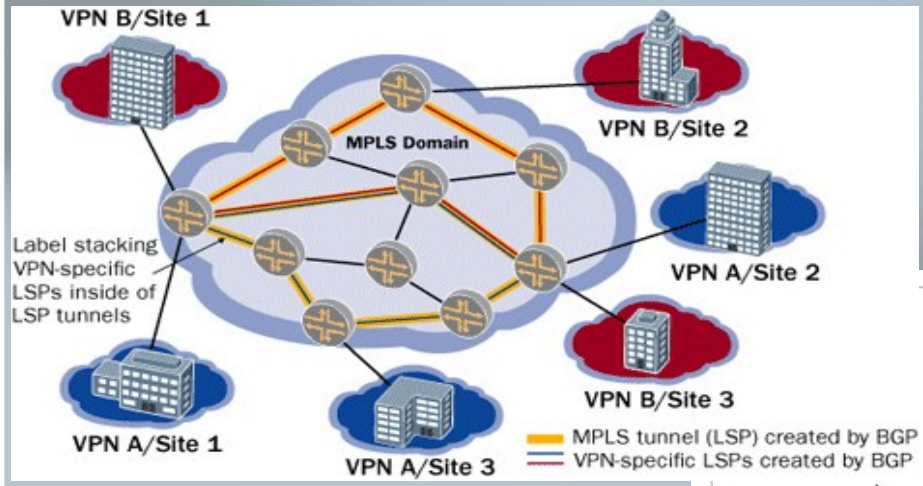
- IP is the only protocol recognized as a global standard for internet data transport.
- IP facts
  - There are no differentiated services available
  - Each router bases the transport decisions on layer 3, depending on ip address and routing table.
  - There is large IP header
  - Packets are variable size

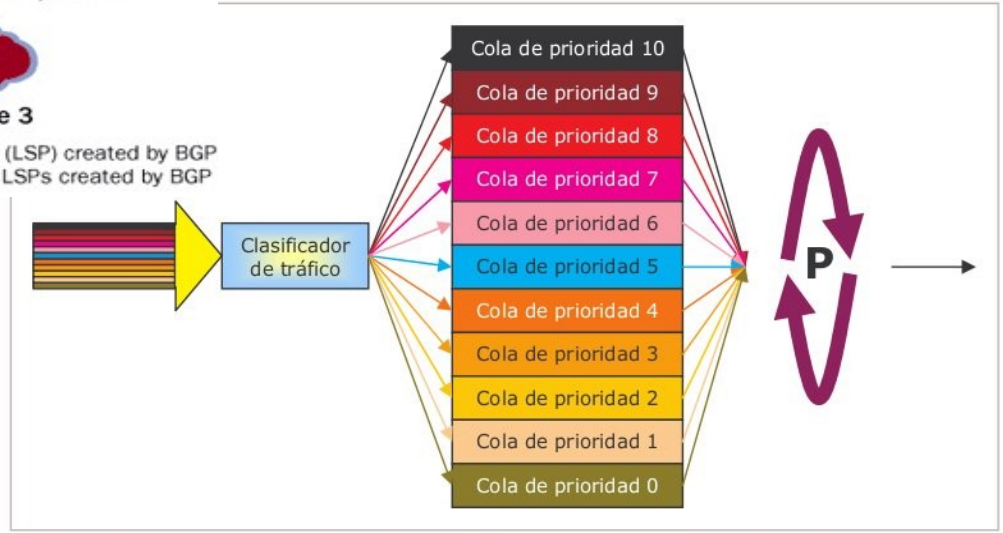
Introduction

- ATM is a technology that resolves these problems, but it is expensive, complex and not accepted for the market.
- MPLS combines the forwarding algorithm used in ATM with IP, between circuit switching (ATM) and packet forwarding (IP)

MPLS Objectives

- The main objective is to create flexible and scalable networks with an increase in performance and stability. This includes traffic engineering and support of Virtual Private Networks (VPN), Quality of Service (QoS)





MPLS Requirements

MPLS must be able to:

- operate on any transport technology, not only ATM
- support packet delivery both ways: unicast & multicast
- be compatible with the Model of Integrated Services of Internet Engineering Task Force (IETF), including the RSVP protocol allow for constant growth of the Internet.
- be compatible with operation-, administrative- and maintenance procedures of current IP networks

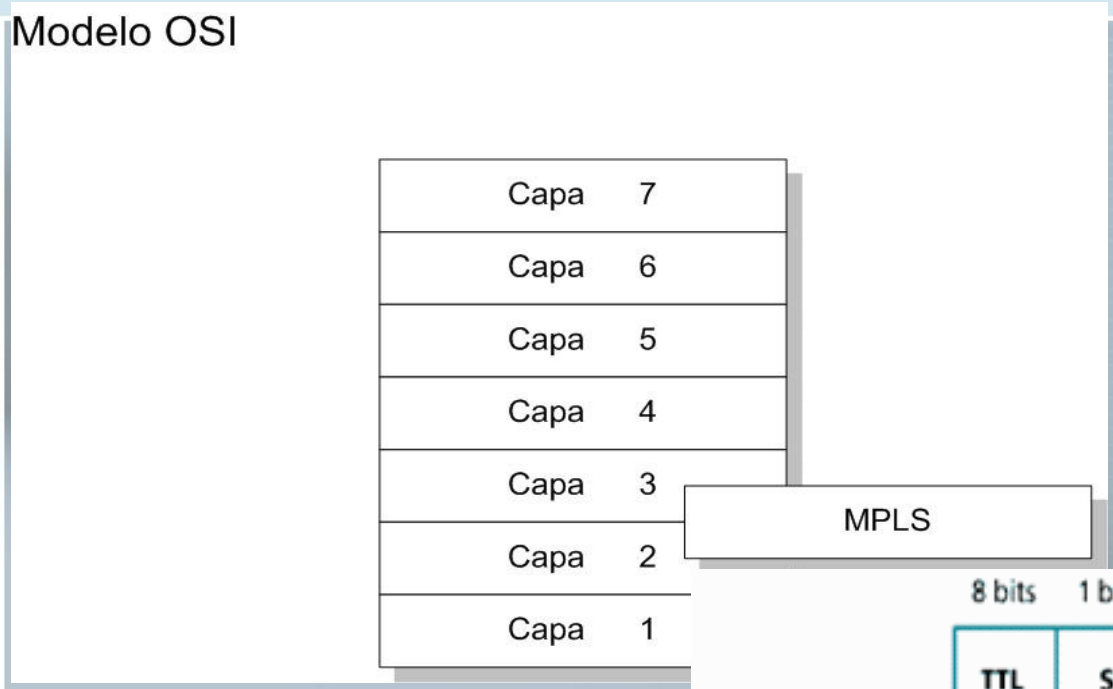
Characteristics

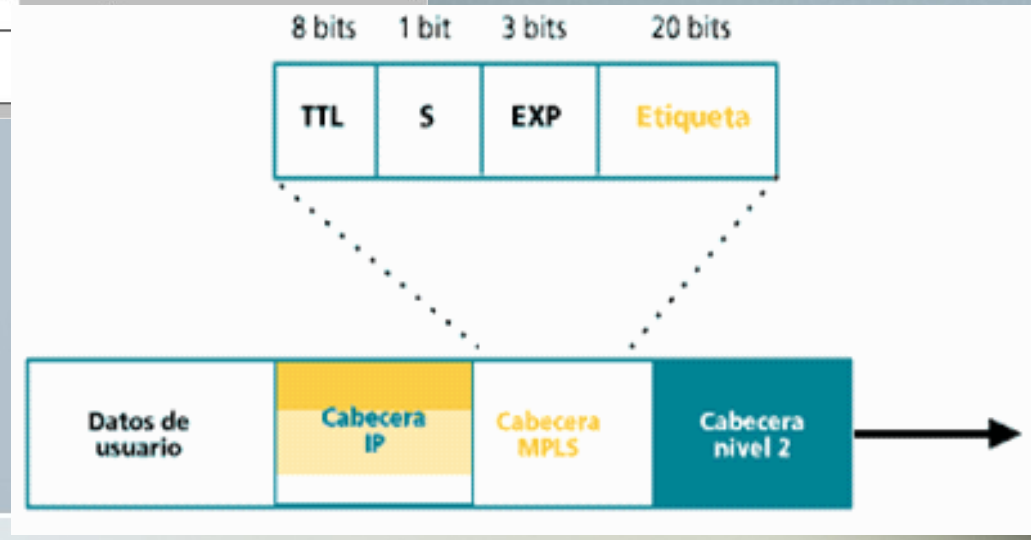
- Multi Protocol Label Switching, is a method to route packets across a network using information contained in labels that are attached to IP packets
- MPLS is meant to improve packet forwarding across the network.
- MPLS is based on inserting labels into packets that are transported through a network, these labels are placed between layer 2 and 3 of the OSI model
- The labels are fixed length (32 bits) and contain MPLS information to indicate each router how to forward each packet to its destination. This information only representative per router.

Characteristics

- The label is modified at each node, with the appropriate label and routed to the next node
- Each data packet encapsulates and carries the labels during its path from source to destination.
- MPLS is much faster than IP transport because processing is performed at layer 2 and the exchange of labels at layer 3, combining the best of both worlds.

Operation


Modelo OSI
Capa 7
Capa 6
Capa 5
Capa 4
Capa 3
Capa 2
Capa 1
MPLS


8 bits
1 bit
3 bits
20 bits
TTL
S
EXP
Etiqueta
Datos de usuario
Cabecera IP
Cabecera MPLS
Cabecera nivel 2

Operation

IP packet forwarding on traditional networks

- The routing protocols are used for the distribution of the router information
- The forwarding of IP packets is based only on its IP address. When the packet is received by the router, the next hop is determined by the destination IP address. This process is repeated for each node until reaching the destiny.

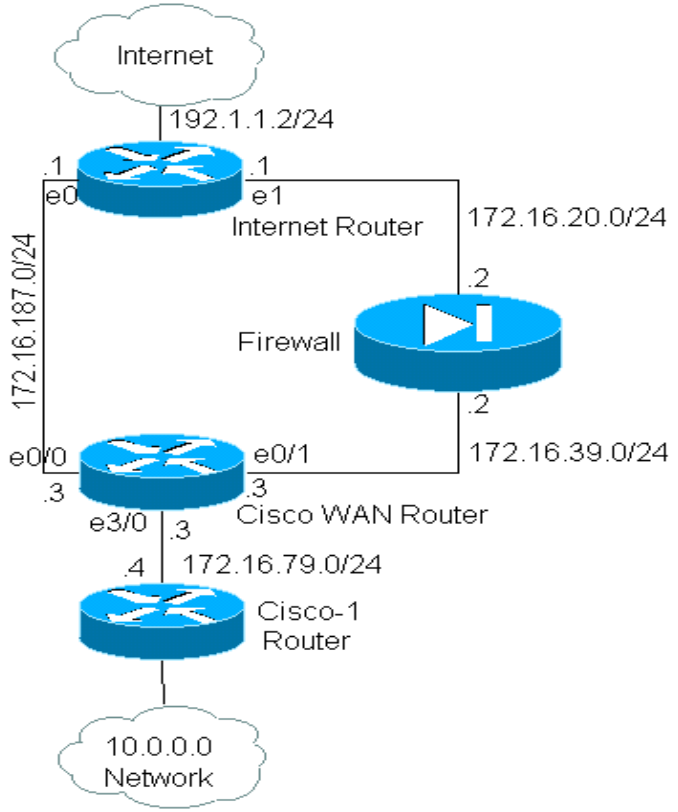
Operation

- **IP packet forwarding on traditional networks**

Route List

Routes | Rules

	Destination	Gateway	Gateway...	Interface	Distance	Routing Mark	Pref. Source
AS	0.0.0.0/0	192.168.253.2		Internet	1		
DA	9.9.9.1			LoBridge	0		9.9.9.1
DA	9.9.9.2	192.168.100.2		Wan	110		
DA	9.9.9.3	192.168.100.2		Wan	110		
DA	9.9.9.4	192.168.100.2		Wan	110		
DA	172.103.0.0/16	192.168.100.2		Wan	110		
DA	192.168.0.0/24			Dmz	0		192.168.0.1
DA	192.168.1.0/24			bridge1	0		192.168.1.1
AS	192.168.40.0...	192.168.1.111		bridge1	1		
AS	192.168.45.0...	192.168.1.111		bridge1	1		
DA	192.168.90.0...	192.168.100.2		Wan	110		
DA	192.168.100....			Wan	0		192.168.100.1
DA	192.168.251....	192.168.253.2		Internet	110		
DA	192.168.252....	192.168.253.2		Internet	110		
DA	192.168.253....			Internet	0		192.168.253.1
DA	192.168.254....	192.168.253.2		Internet	110		
DA	200.200.1.8/29	192.168.100.2		Wan	110		
DA	200.200.1.16...	192.168.100.2		Wan	110		
DA	200.200.1.16...	192.168.100.2		Wan	110		



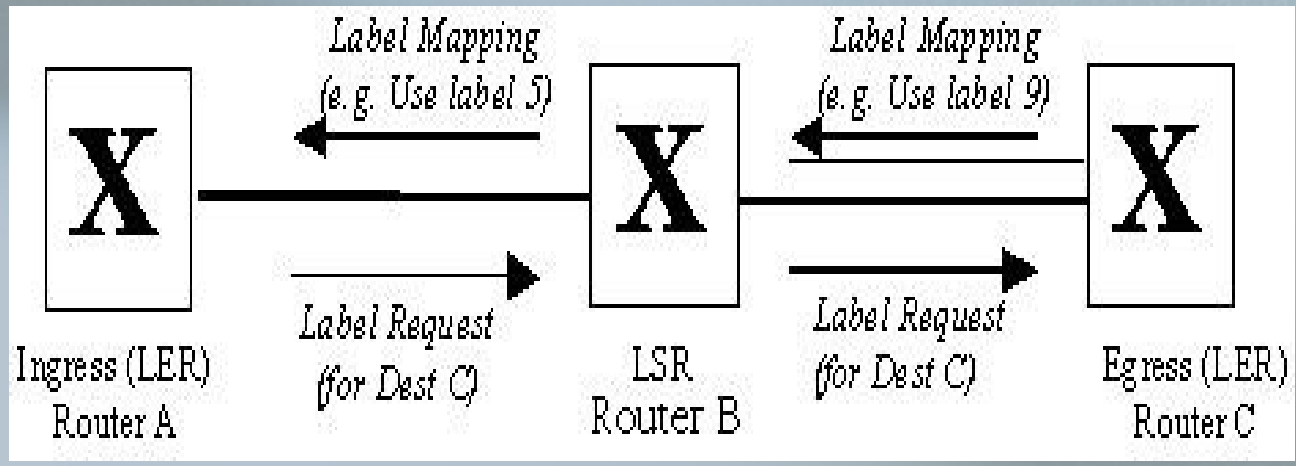
Operation

IP packet forwarding on MPLS networks

- Packet forwarding is done through labels, based on the destination IP and other parameters like QoS and source address.
- Labels are created for each router and in some cases for each interface and have only local meaning.
- Routers assign labels to define paths called Label Switched Paths (LSP) between end points. Therefore only routers at the edge of the MPLS network perform routing lookups.
- The Edge Label Switch Routers (LER) assign or remove labels at packet ingress or egress, depending on the case, in order to converge with traditional IP networks

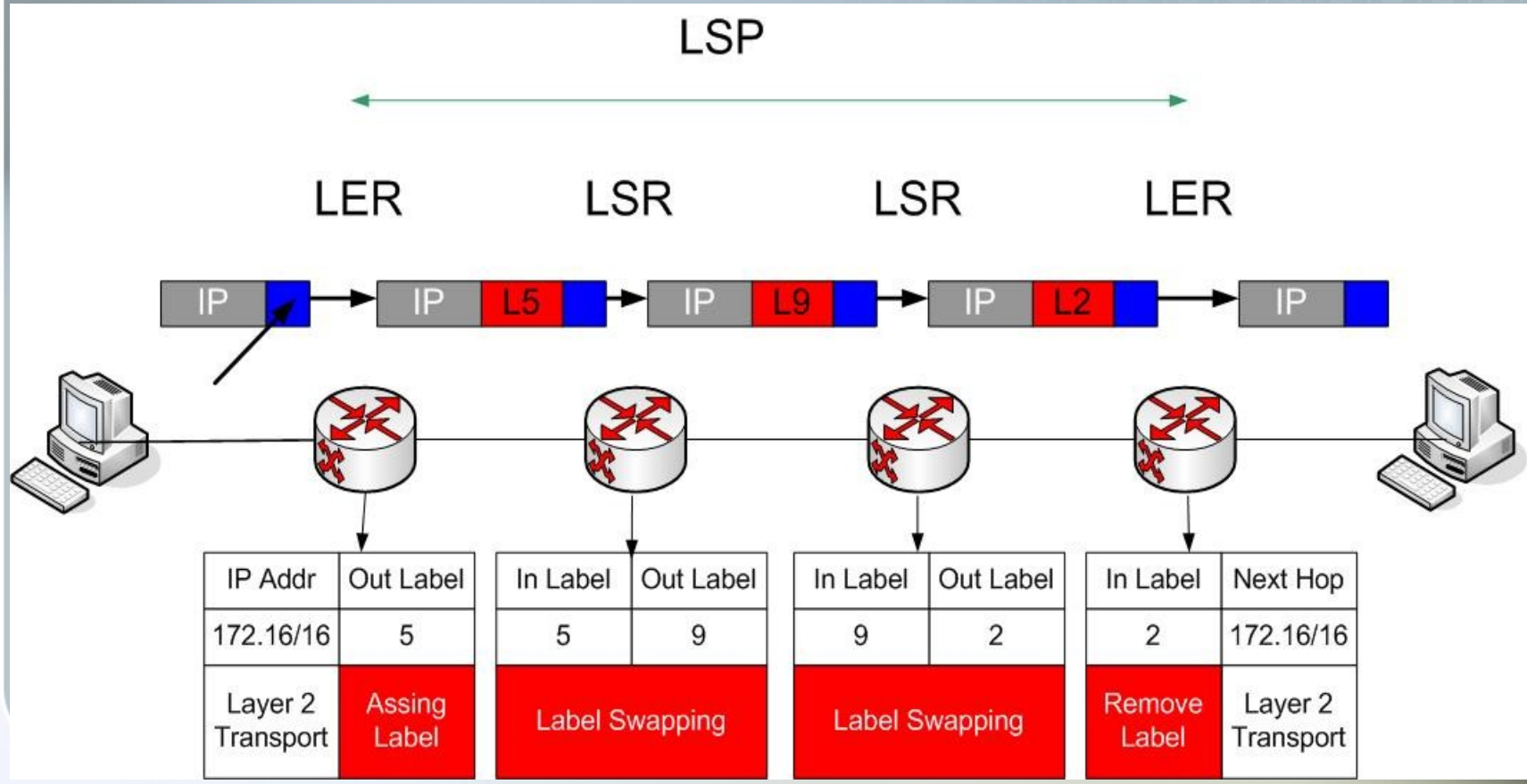
Operation

- **IP packet forwarding on MPLS networks**



Operation

- **IP packet forwarding on MPLS networks**



Operation

Plane of a MPLS network

- Control plane: Performs all the functions related to identification and accessibility of destinations, containing all the required information for layer 3. Examples of these routing protocols are OSPF and BGP, which handle the operations related to label exchange between neighbouring routers
- Data plane: Carries out the packet forwarding.
  These can be either IP layer 3 or labelled packets. The information exchange between neighbouring routers create mappings of IP destination prefixes translated to labels in the control plane, used to forward data plane labelled packets.

Operation

- Forwarding equivalence class (FEC)
  This is a group of packets treated the same way, over the same path and with the same forwarding

- MPLS Label Switch Router (LSR):
  Refers to equipment that performs label switching. The LSR receives a labelled packet, replaces the ingress label to the corresponding egress label and sends the packet via the appropriate interface.

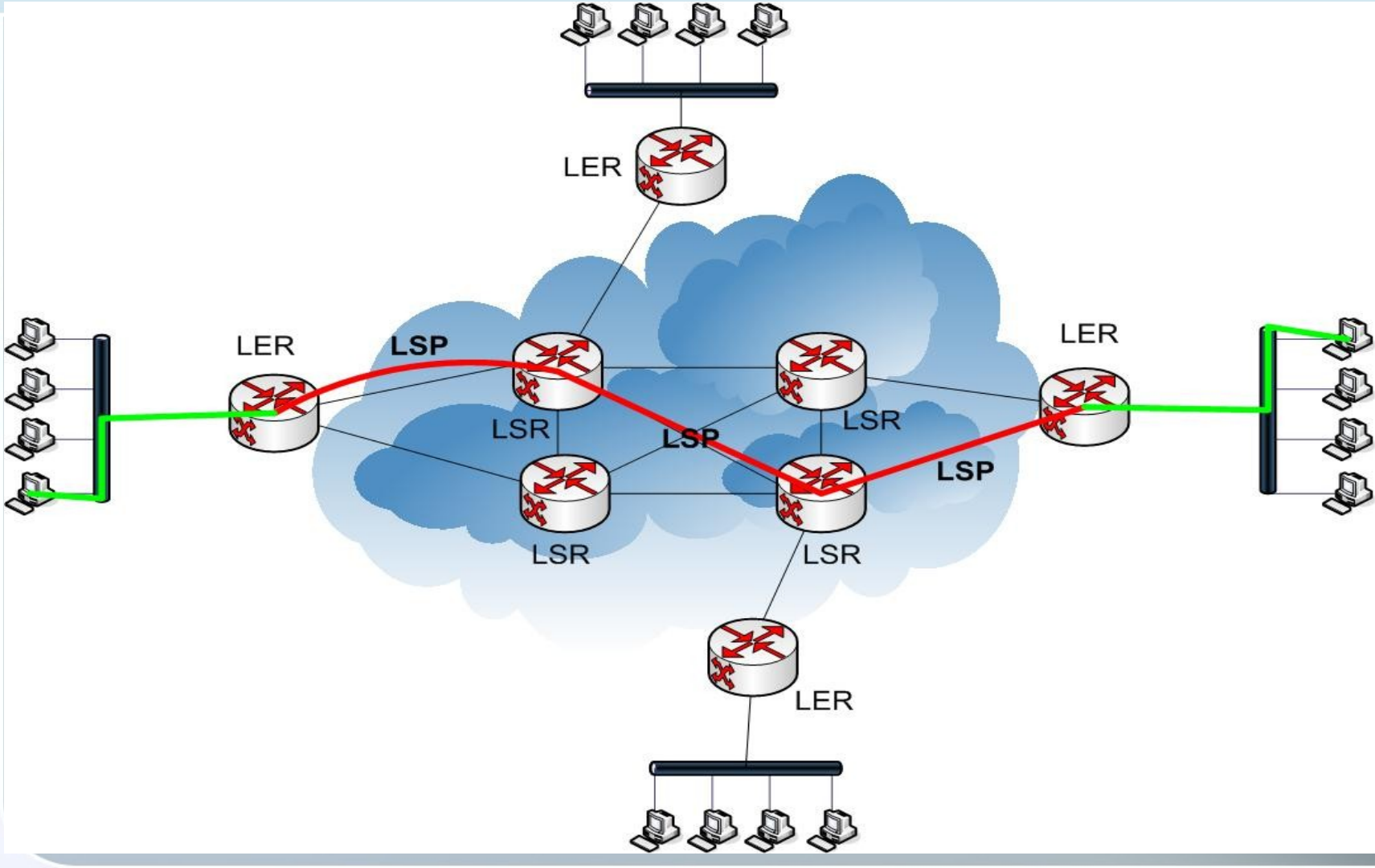
Operation

- MPLS Label Edge Switch Router (LER): This is a LSR at the border of the MPLS domain to assign or remove labels from packets in the MPLS domain.
  - In the case of domain ingress packet it receives the IP packet, inserts the label (push) and forwards it to destination through the MPLS domain
  - In the case of domain egress packets it removes the label of the MPLS packet and forwards it to the IP network

Operation

- MPLS Label Switched Path (LSP)
  This refers to the path, from source to destination through the MPLS network. LSP are unidirectional by nature.

Operation



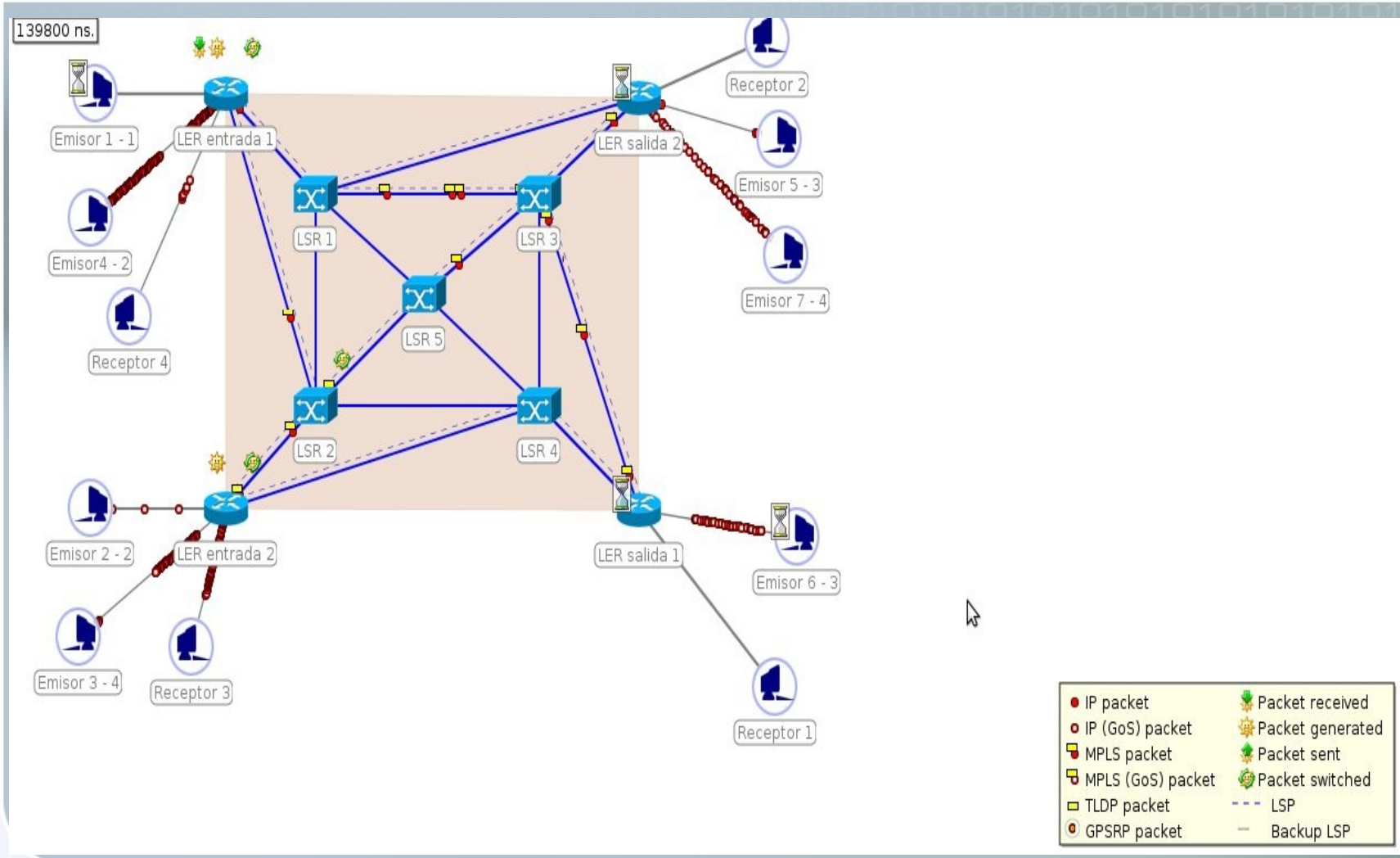
Operation

- The forwarded egress packet leaves the node as an ordinary IP packet until reaching a MPLS label edge router (LER)
- Within the LER the packet parameters like source, destination, QoS, etc. are analysed and label based on a forwarding equivalence class (FEC) is assigned. The label that will be added to the IP packet is determined by these values.
- Each LSR exchanges the labels giving the same treatment to each FEC.
- On arrival at the egress LER the MPLS label is removed from the packet and is forwarded to the IP network.
- LSP is the path to be followed by the packet within a MPLS network

Operation

- MPLS works on a variety of switching technologies of layer 2.
- The MPLS label is placed between layer 3 and layer 2
- Labels may be nested, forming a LIFO stack (last in, first out). This allow to add (or remove) flows. The mechanism is scalable.
- The packets are forwarded depending on the labels
  - There is no need to examine the complete header
  - Switching (addressing) is much faster
- Each packet is classified into traffic classes called FEC
- Therefore, LSPs define FEC-label associations.

Operation


139800 ns.
Emisor 1 - 1
LER entrada 1
Receptor 2
LER salida 2
Emisor 5 - 3
Emisor4 - 2
LSR 1
LSR 3
Emisor 7 - 4
Receptor 4
LSR 5
LSR 2
LSR 4
Emisor 2 - 2
LER entrada 2
LER salida 1
Emisor 6 - 3
Emisor 3 - 4
Receptor 3
Receptor 1
IP packet
IP (GoS) packet
MPLS packet
MPLS (GoS) packet
TLDP packet
GPSRP packet
Packet received
Packet generated
Packet sent
Packet switched
LSP
Backup LSP

MPLS on Router OS 3.x

- Mikrotik says in the wiki page, RouterOS at the moment not supports the following MPLS features:
  - IPv6 support
  - LDP features:
  - downstream on demand label advertisement
  - ordered label distribution control
  - conservative label retention
  - * MPLS IP VPN features
  - proper CE-PE IGP protocol support
  - * TE features
  - fast reroute
  - link/node protection

Implementation of MPLS on Router OS 3.x

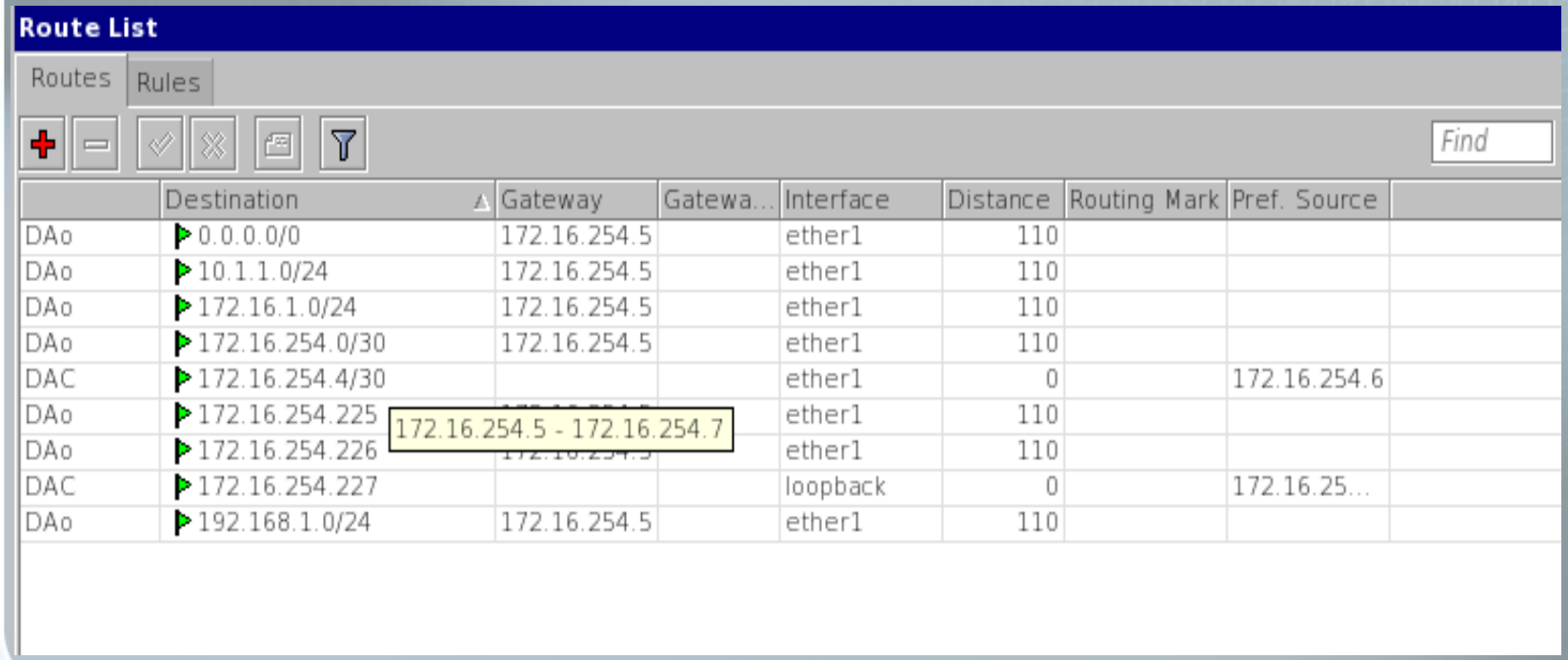
- Steps for implementation of MPLS on Router OS 3.x
- Configure IP addressing
  - Establish configuration of loopback address for stablish LDP sessions
    - /interface bridge add name=loopback
    - /ip address add address=172.16.254.225/32 interface=loopback
  - Establish interface address on MPLS router
    - /ip address add address=172.16.1.1/24 interface=ether3
    - /ip address add address=172.16.254.1/30 interface=ether1
    - /ip address add address=172.16.254.5/30 interface=ether2
  - Configure protocol for distribution of labels in layer 3 (in this case OSPF)
    - /routing ospf set redistribute-connected=as-type-1
    - /routing ospf network add area=backbone network=172.16.254.0/30
    - /routing ospf network add area=backbone network=172.16.254.4/30

Implementation of MPLS on Router OS 3.x

- LDP get enabled, for label distribution for routes
  - /mpls ldp set enabled=yes transport-address=172.16.254.225 lsr-id=172.16.254.225
  - /mpls ldp set enabled=yes transport-address=172.16.254.225 lsr-id=172.16.254.225
  - /mpls ldp interface add interface=ether1
  - /mpls ldp interface add interface=ether2
- Not all label bindings are necesary, Label filtering can be used to distribute only specified sets of labels. This reduce network load.
  - /mpls ldp advertise-filter add prefix=172.16.254.225/27 advertise=yes
  - /mpls ldp advertise-filter add prefix=0.0.0.0/0 advertise=no

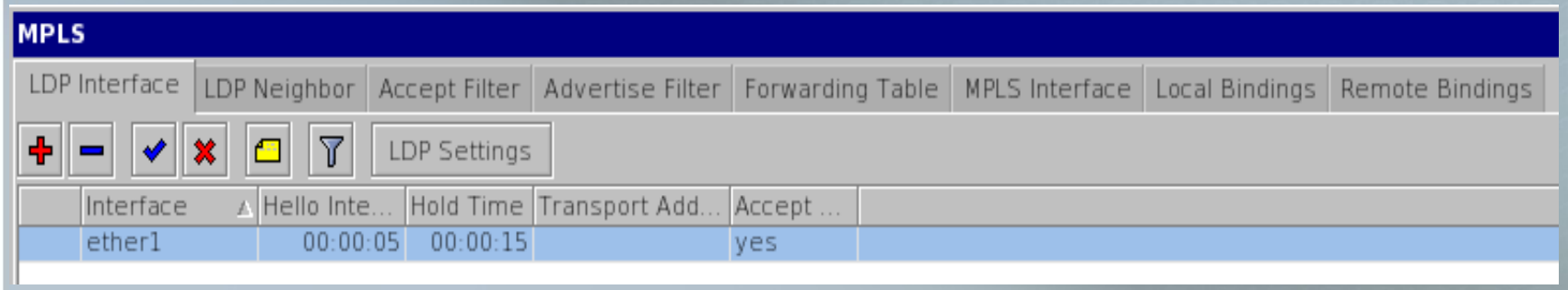
Tools for examine MPLS on Router OS 3.x

- MPLS network use IP routing for distribution labels in the network
  - /ip route print
-



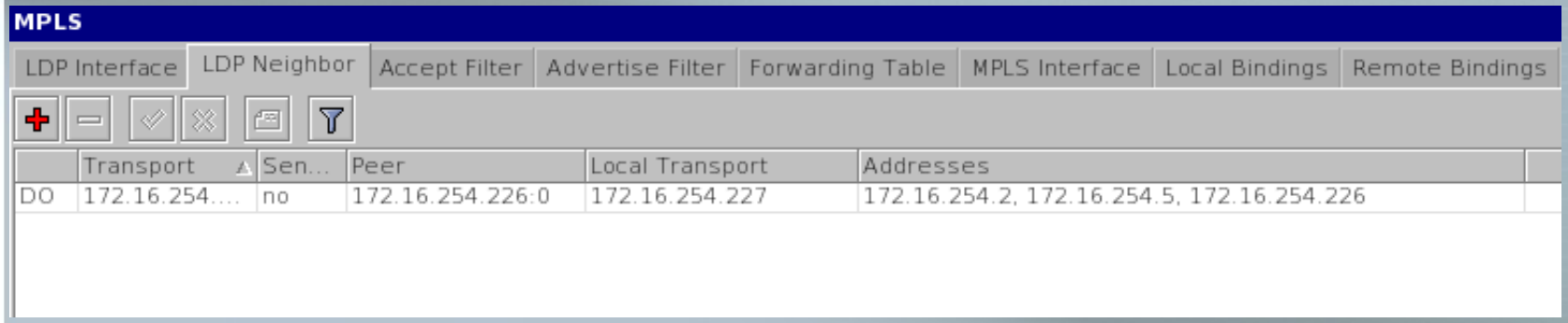
Tools for examine MPLS on Router OS 3.x

- LDP interface is enabled
  - /mpls ldp interface print



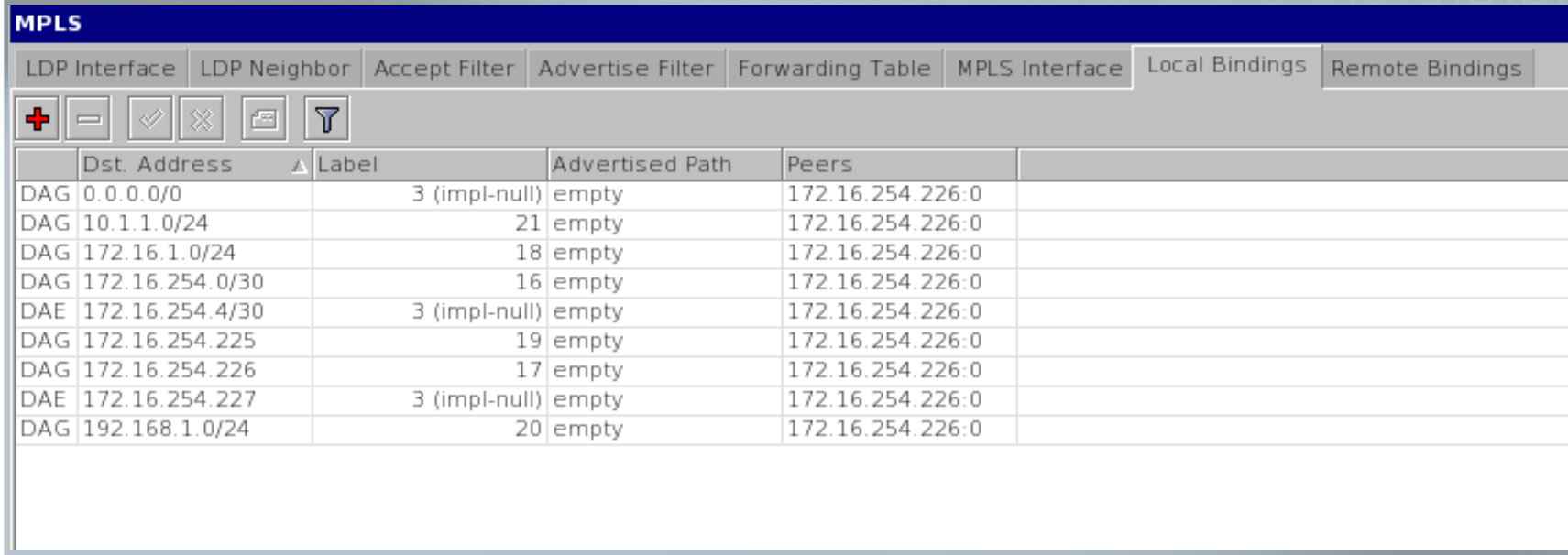
Tools for examine MPLS on Router OS 3.x

- Neighbors in MPLS router
  - /mpls ldp neighbor print



Tools for examine MPLS on Router OS 3.x

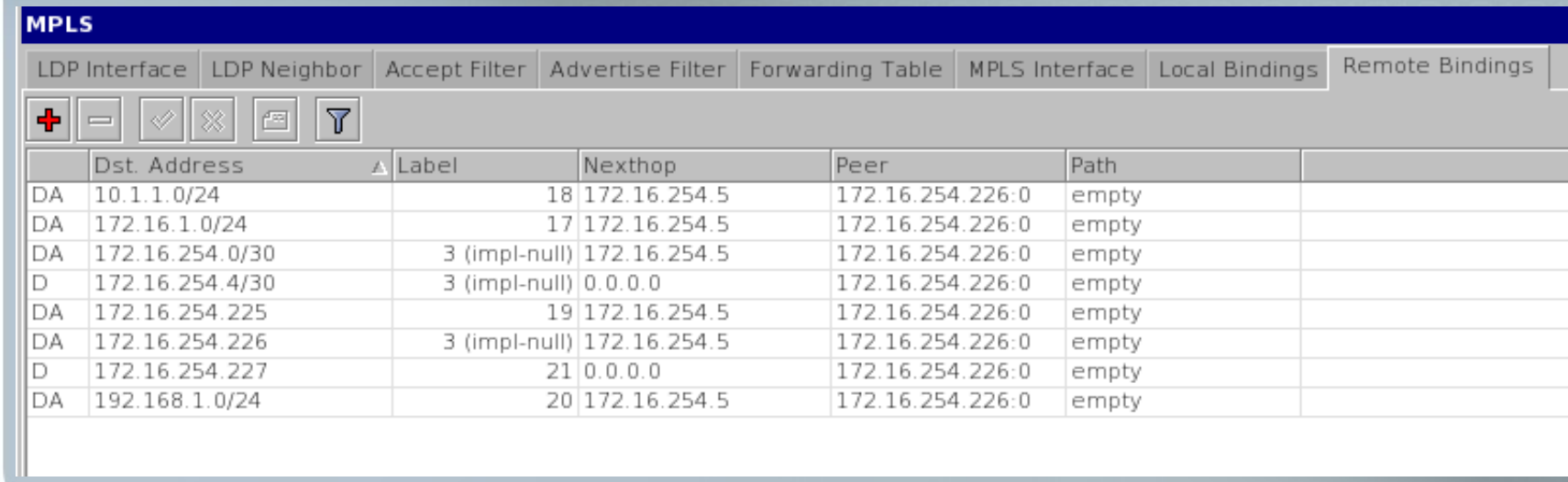
- Show local labels that this router assigned and peers.
  - /mpls local-bindings print



	Dst. Address	Label	Advertised Path	Peers
DAG	0.0.0.0/0	3 (impl-null)	empty	172.16.254.226:0
DAG	10.1.1.0/24	21	empty	172.16.254.226:0
DAG	172.16.1.0/24	18	empty	172.16.254.226:0
DAG	172.16.254.0/30	16	empty	172.16.254.226:0
DAE	172.16.254.4/30	3 (impl-null)	empty	172.16.254.226:0
DAG	172.16.254.225	19	empty	172.16.254.226:0
DAG	172.16.254.226	17	empty	172.16.254.226:0
DAE	172.16.254.227	3 (impl-null)	empty	172.16.254.226:0
DAG	192.168.1.0/24	20	empty	172.16.254.226:0

Tools for examine MPLS on Router OS 3.x

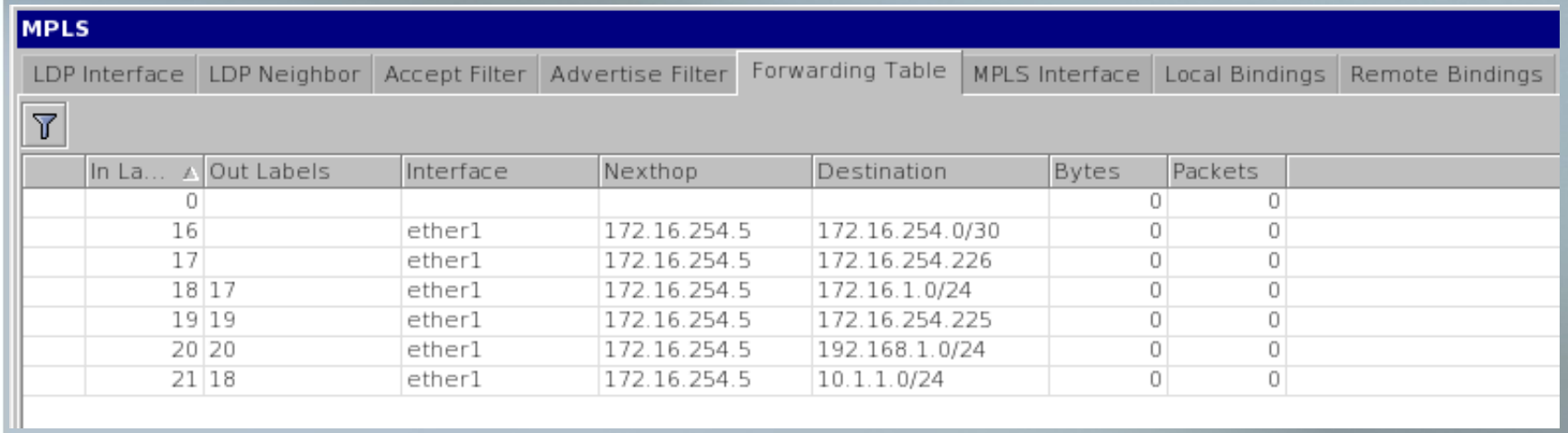
- shows labels that are allocated for routes by neighboring routers and advertised to this router
  - /mpls remote-bindings print



	Dst. Address	Label	Nexthop	Peer	Path
DA	10.1.1.0/24	18	172.16.254.5	172.16.254.226:0	empty
DA	172.16.1.0/24	17	172.16.254.5	172.16.254.226:0	empty
DA	172.16.254.0/30	3 (impl-null)	172.16.254.5	172.16.254.226:0	empty
D	172.16.254.4/30	3 (impl-null)	0.0.0.0	172.16.254.226:0	empty
DA	172.16.254.225	19	172.16.254.5	172.16.254.226:0	empty
DA	172.16.254.226	3 (impl-null)	172.16.254.5	172.16.254.226:0	empty
D	172.16.254.227	21	0.0.0.0	172.16.254.226:0	empty
DA	192.168.1.0/24	20	172.16.254.5	172.16.254.226:0	empty

Tools for examine MPLS on Router OS 3.x

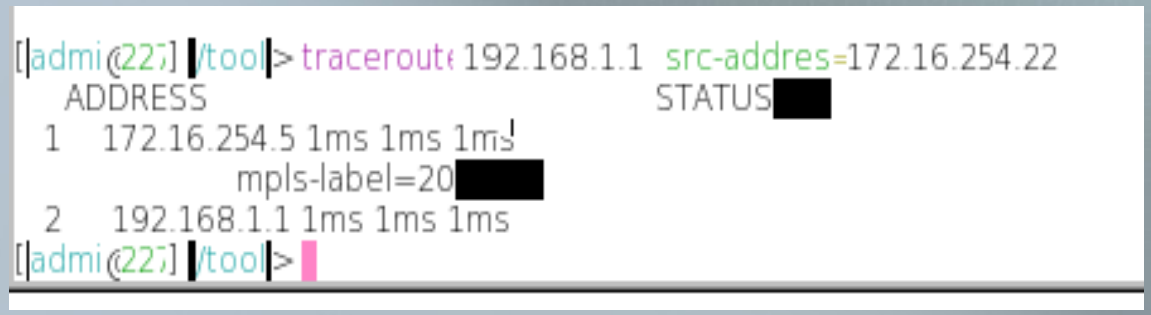
- Shows forwarding table
  - /mpls forwarding-table print



In La...	Out Labels	Interface	Nexthop	Destination	Bytes	Packets
0					0	0
16		ether1	172.16.254.5	172.16.254.0/30	0	0
17		ether1	172.16.254.5	172.16.254.226	0	0
18	17	ether1	172.16.254.5	172.16.1.0/24	0	0
19	19	ether1	172.16.254.5	172.16.254.225	0	0
20	20	ether1	172.16.254.5	192.168.1.0/24	0	0
21	18	ether1	172.16.254.5	10.1.1.0/24	0	0

Tools for examine MPLS on Router OS 3.x

- Special observations:
  - In MPLS network traceroute can not be used the same way as IP networks, because MPLS handles produced ICMP errors (example asymetric LSP)
  - You must use src-addrees in traceroute
    - /tool traceroute 172.16.2.1 src-address=172.16.254.225



Thanks, Thats all

- http://www.ietf.org/html.charters/mpls-charter.html
- http://wiki.mikrotik.com/wiki/MPLSVPLS
- http://www.cisco.com/warp/public/cc/cisco/mkt/wan/ipatm/tech/mpls_wp.htm
- http://www.cisco.com/warp/public/cc/cisco/mkt/servprod/dial/tech/mpls_wi.htm
- http://www.rediris.es/rediris/boletin153/enfoque1.html
- http://www.mplsforum.org
- http://www.ietf.org/html.charters/mpls-charter.html
- http://www.internet2.uanl.mx/mpls
- http://www.mpls.unam.mx
- http://www.invdes.reduno.com.mx/mpls

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