MIKROTIK LOAD BALANCING WITH PCC AND COMMON PROBLEMS

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About me

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About URANUS

- URANUS has been focusing on wireless networking market since 2015.
- Became MikroTik distributor since 2016.
- Website: http://uranus.com.vn
- Support website: http://forum.uranus.com.vn

Objective

- Using PCC (Per Connection Classifier) to load balancing multiple Internet links *correctly*.
- Solving common problems beside PCC load balancing.

What is load balancing & why do we want it?

- Load Balancing is a technique to distribute the workload across two or more network links in order to maximize throughput, minimize response time, and avoid overload.
- Distribution may be **symmetrical** or **asymmetrical** depending on rate of network links.
- Useful when the downstream bandwidth requirement to a single routing device exceeds the capabilities of a single network link.
- Using multiple network links with load balancing, instead of single network links, may increase reliability through redundancy

How does it work?

- PCC **divides** the traffic into streams and then uses **routing rules** to sort the traffic **evenly** (**or not**) across multiple network links.
- This is done by:
  - Using a hashing algorithm to first sort the traffic based on source address, source port, destination address, destination port or various combinations thereof.
  - Using **packet marking** and **marking route** and several **routing tables** to ensure traffic follows a specified route out the specified WAN interface.

Understand the Solution

- MikroTik RouterOS is extremely powerful and configurable, so this can be a double edged sword, several possible solutions to the same problem.
- Each has multiple moving pieces
- Greatest success with any solution by understanding the pieces and what they do.

Understanding the PCC Load Balancing Solution

Terms must to understand

- **Packet**: The container for our data, header and payload.
- **Connection:** "Conduit" through which host to host communication occurs, based on Src/Dst addresses and ports
- **Mangle Facility:** is a kind of 'marker' that marks packets for future processing with special marks. They identify a packet based on its mark and process it accordingly. Mangle marks *exist only within the router*, they are not transmitted across the network.

Understanding the PCC Load Balancing Solution

Terms must to understand

- **PCC**: PCC matcher will allow to divide traffic into equal streams with ability to keep packets with specific set of options in one particular stream (we can specify this set of options from src-address, src-port, dst-address, dst-port)

Understanding the PCC Load Balancing Solution

- PCC (cont.) – How does this work?

PCC takes selected **fields from IP header**, and with the help of a hashing algorithm converts selected fields into 32-bit value. This value then is divided by a specified **Denominator** and the remainder then is compared to a specified **Remainder**, if **equal** then packet will be **captured**. You can choose from src-address, dst-address, src-port, dst-port from the header to use in this operation.

Understanding the PCC Load Balancing Solution

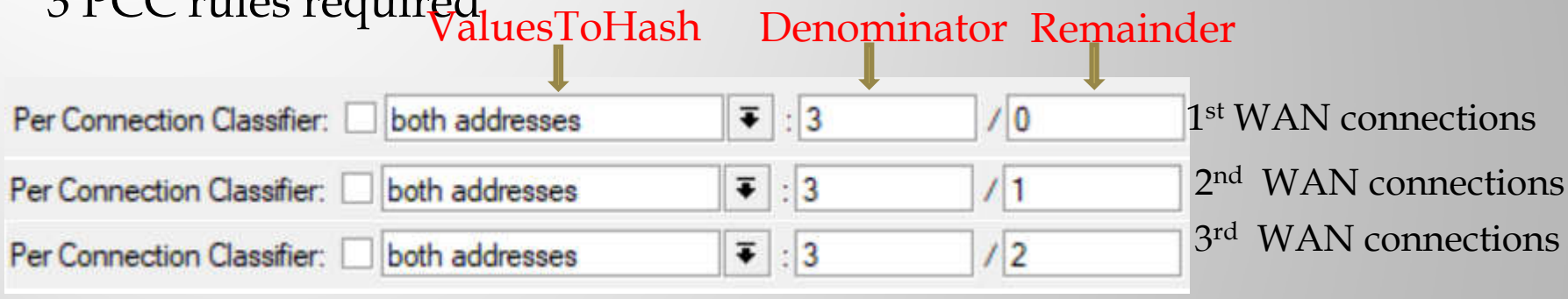
- PCC (cont.) How does this work (cont.)

```
per-connection-classifier=
PerConnectionClassifier ::= [!]ValuesToHash:Denominator/Remainder
  Remainder ::= 0..4294967295    (integer number)
  Denominator ::= 1..4294967295    (integer number)
  ValuesToHash ::= both-addresses|both-ports|dst-address-and-port|
  src-address|src-port|both-addresses-and-ports|dst-address|dst-
port|src-address-and-port
```

Understanding the PCC Load Balancing Solution

- PCC (cont.) – Example: 3 WAN Connections

3 PCC rules required



- The 1st line means "produce the output of the hash function given the packet's both IP addresses, divide it by 3 and if the remainder is 0, perform the action of marking the connection as WAN1"
- The 2nd rule means "produce the output of the hash function given the packet's both IP addresses, divide it by 3 and if the remainder is 1, perform the action of marking the connection as WAN2"
- The 3rd rule means "produce the output of the hash function given the packet's both IP addresses, divide it by 3 and if the remainder is 2, perform the action of marking the connection as WAN3"

Understanding the PCC Load Balancing Solution

- PCC (cont.) - How to set PCC, Remember?

2 WAN connections:

2 / 0 First WAN

2 / 1 Second WAN

3 WAN connections:

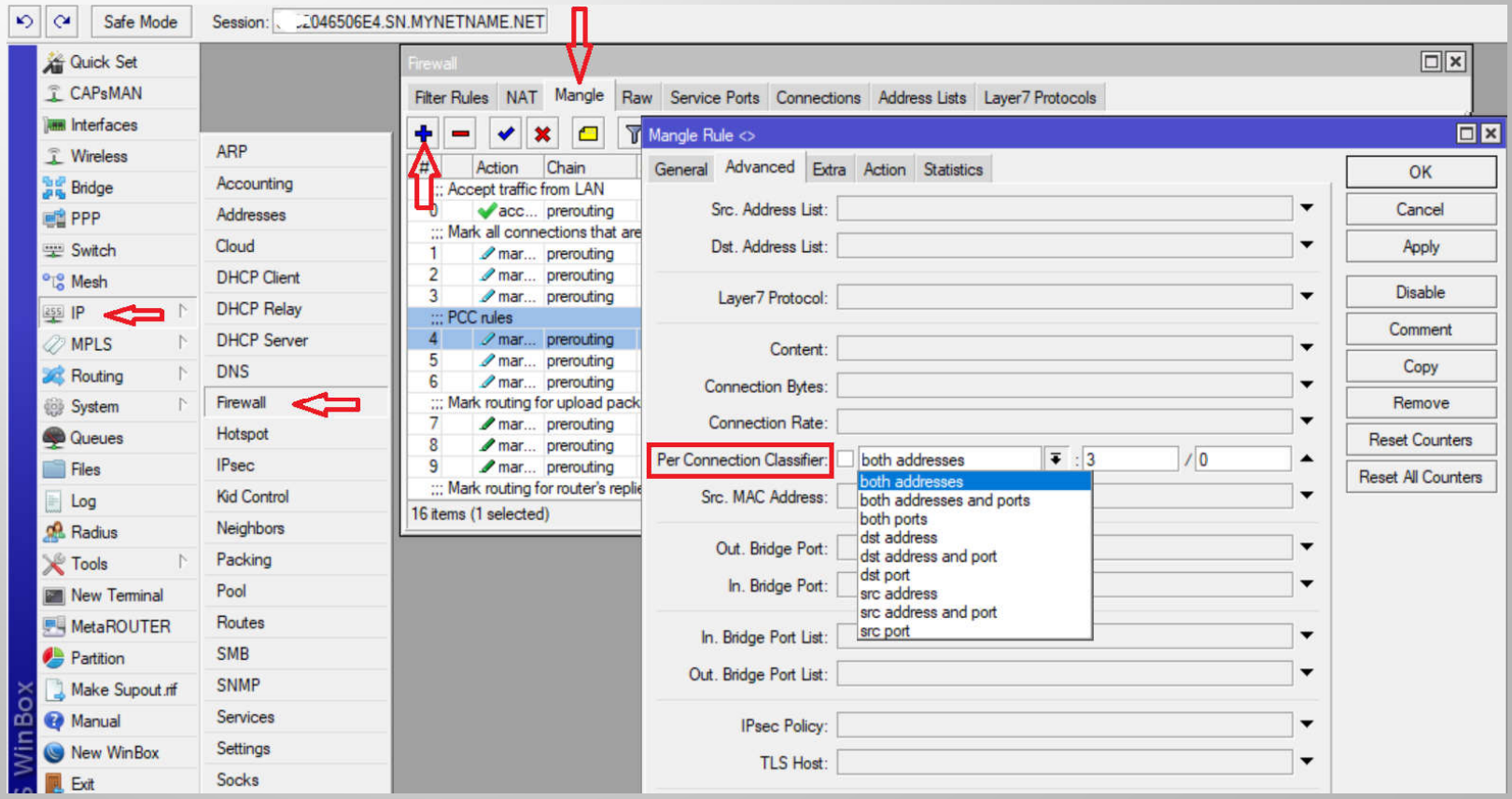
3 / 0 First WAN

3 / 1 Second WAN

3 / 2 Third WAN and so on...

Understanding the PCC Load Balancing Solution

- PCC (cont.): Where does it found?



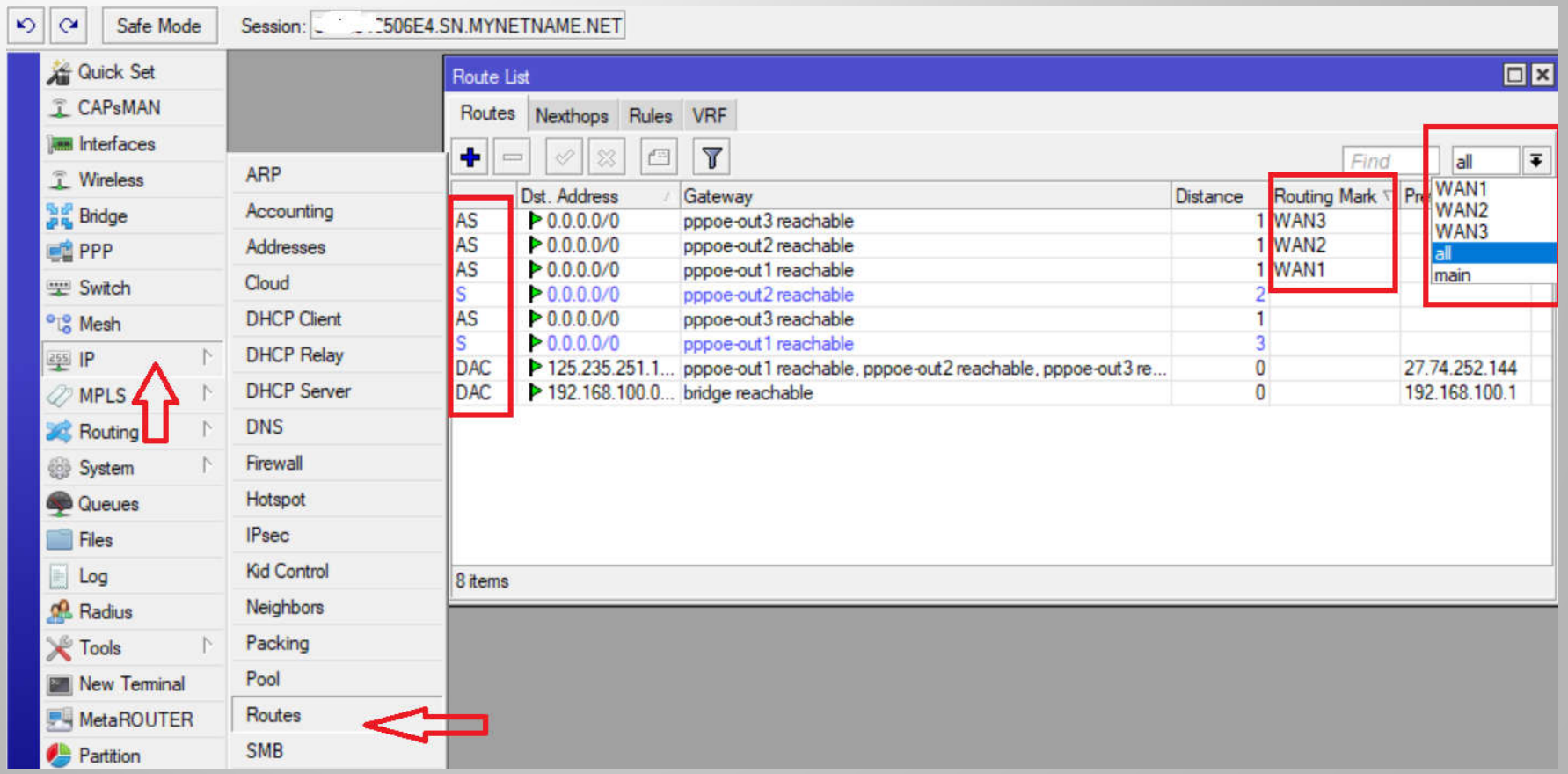
Understanding the PCC Load Balancing Solution

Terms must to understand

- **Routing Table:** Route rules, the rules the router uses to determine what to do with a packet. By comparing the **destination address** in the packet to **the list of routes**, the router decides which interface to send the packet out. By adding a **routing mark** with mangle, we can have **multiple routing tables**!

Understanding the PCC Load Balancing Solution

- Routing Table (cont.)



Understanding the PCC Load Balancing Solution

Terms must to understand

- **Routing-mark**:
  - RouterOS attribute assigned to each packet
  - Routing-mark can be changed in firewall mangle facility just before any routing decision:
    - chain Prerouting – for all incoming traffic
    - chain Output – for outgoing traffic **from** router
  - Every new routing mark has its own routing table with the same name
  - By default all packets have the "main" routing mark

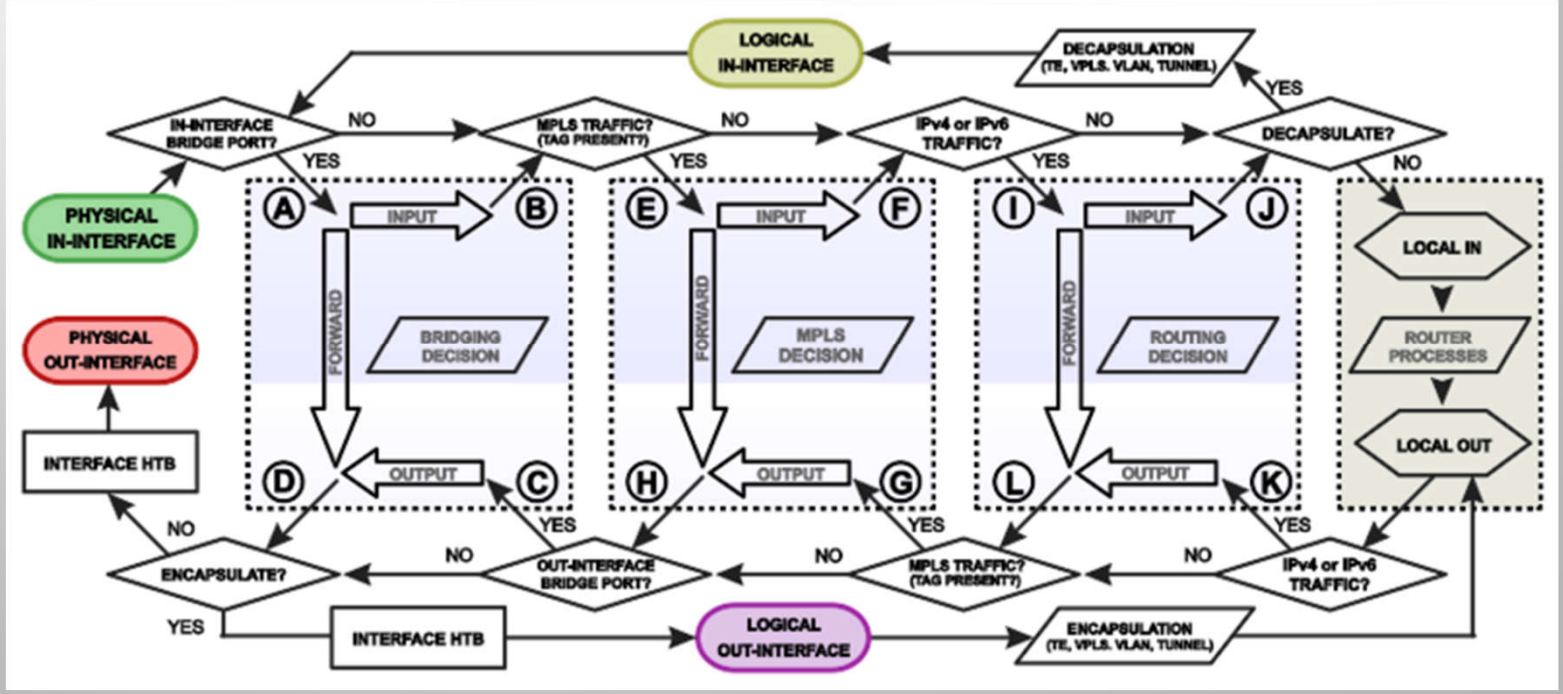
Understanding the PCC Load Balancing Solution

Terms must to understand

- **MikroTik packet low**: This manual describes the order in which an IP packet traverses various internal facilities of the router and some general information regarding packet handling, common IP protocols and protocol options.

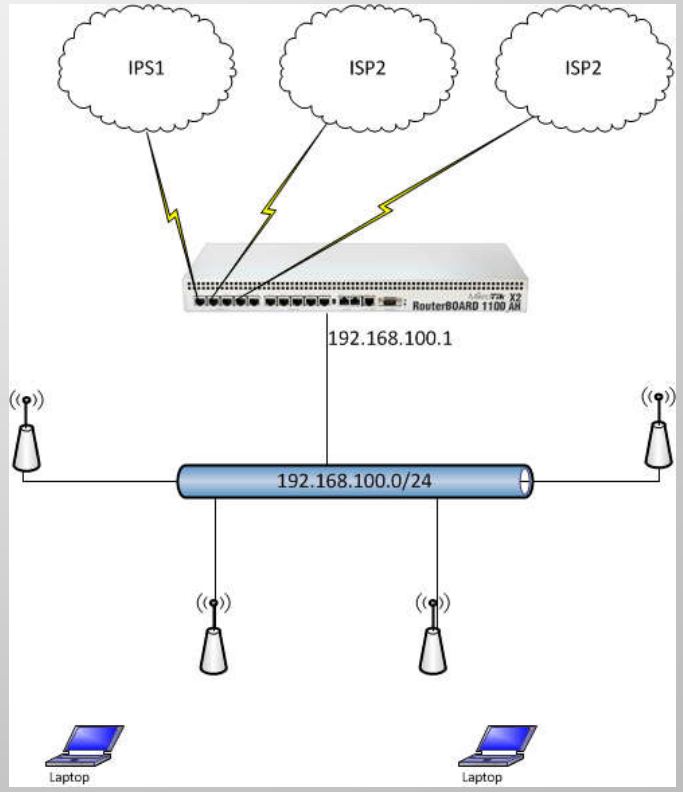
Understanding the PCC Load Balancing Solution

- MikroTik packet low (cont.)
  - Overall Packet flow Diagram (RouterOS v6): https://wiki.mikrotik.com/wiki/Manual:Packet_Flow



How to setup

Scenario: One router MikroTik RB1100AHx2, many clients, 3 FTTH links



Step by Step Configuration

- Set up the basic portion of the network
  - Private IP address on Bridge interface, Bridge interface is logical bridge or CPU bridge, included ether4 – ether13.
  - DHCP Server on Bridge interface
  - DNS server
  - Configure PPPoE clients for 3 WAN links, in this case on ether1, ether2, ether3
  - Masquerade for 3 PPPoE clients
  - Defines default route for 3 WAN links
  - Firewall if required
- Create load balancing part of the configuration:
  - Mangle rules
  - Routing tables

Bassic configuration

- Assigns an IP address and ports for Bridged interface

/ip address
add address=192.168.100.1/24 interface=bridge network=192.168.100.0
/interface bridge port
add bridge=bridge hw=no interface=ether6
add bridge=bridge hw=no interface=ether9
add bridge=bridge hw=no interface=ether8
add bridge=bridge hw=no interface=ether10
add bridge=bridge hw=no interface=ether11
add bridge=bridge hw=no interface=ether12
add bridge=bridge hw=no interface=ether13
add bridge=bridge hw=no interface=ether7
add bridge=bridge hw=no interface=ether4
add bridge=bridge hw=no interface=ether5

Basic configuration

- Configure PPPoE clients for 3 WAN links

```
/interface pppoe-client
add disabled=no interface=ether1 keepalive-timeout=60 max-
mru=1480 max-mtu=\
    1480 mrru=1600 name=pppoe-out1 password=T9a799
user=t008_ftth_abc
add disabled=no interface=ether2 keepalive-timeout=60 max-
mru=1480 max-mtu=\
    1480 mrru=1600 name=pppoe-out2 password=r23hnV
user=t008_ftth_xyz
add disabled=no interface=ether3 keepalive-timeout=60
name=pppoe-out3 \
    password=hT2t5g user=t008_ftth_123
```

Basic configuration

- Masquerade for 3 WAN links

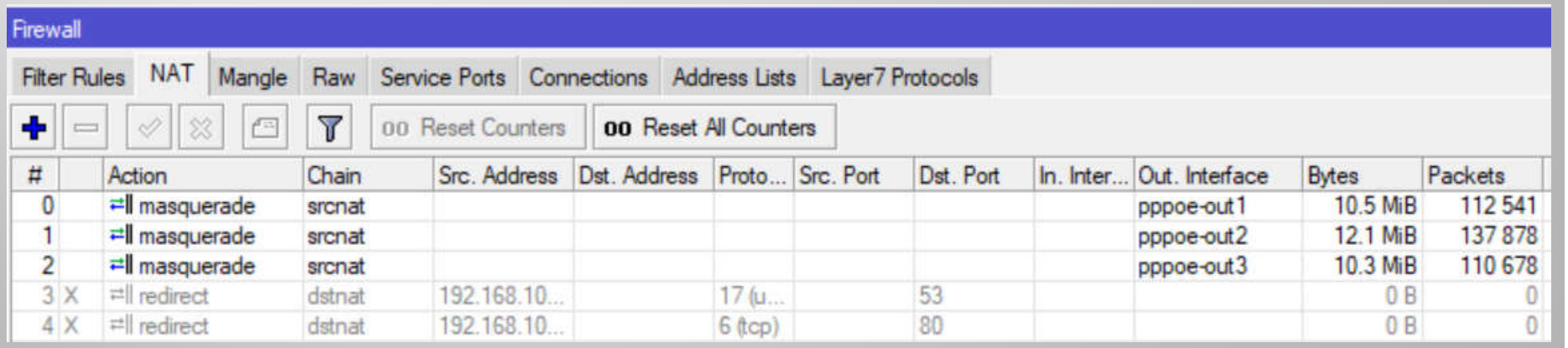
/ip firewall nat

add action=masquerade chain=srcnat out-interface=pppoe-out1

add action=masquerade chain=srcnat out-interface=pppoe-out2

add action=masquerade chain=srcnat out-interface=pppoe-out3

Where can we configure on Winbox?



#		Action	Chain	Src. Address	Dst. Address	Proto...	Src. Port	Dst. Port	In. Inter...	Out. Interface	Bytes	Packets
0		masquerade	srcnat							pppoe-out1	10.5 MiB	112 541
1		masquerade	srcnat							pppoe-out2	12.1 MiB	137 878
2		masquerade	srcnat							pppoe-out3	10.3 MiB	110 678
3	X	redirect	dstnat	192.168.10...		17 (u...		53			0 B	0
4	X	redirect	dstnat	192.168.10...		6 (tcp)		80			0 B	0

Basic configuration

- Define default routes for 3 WAN links

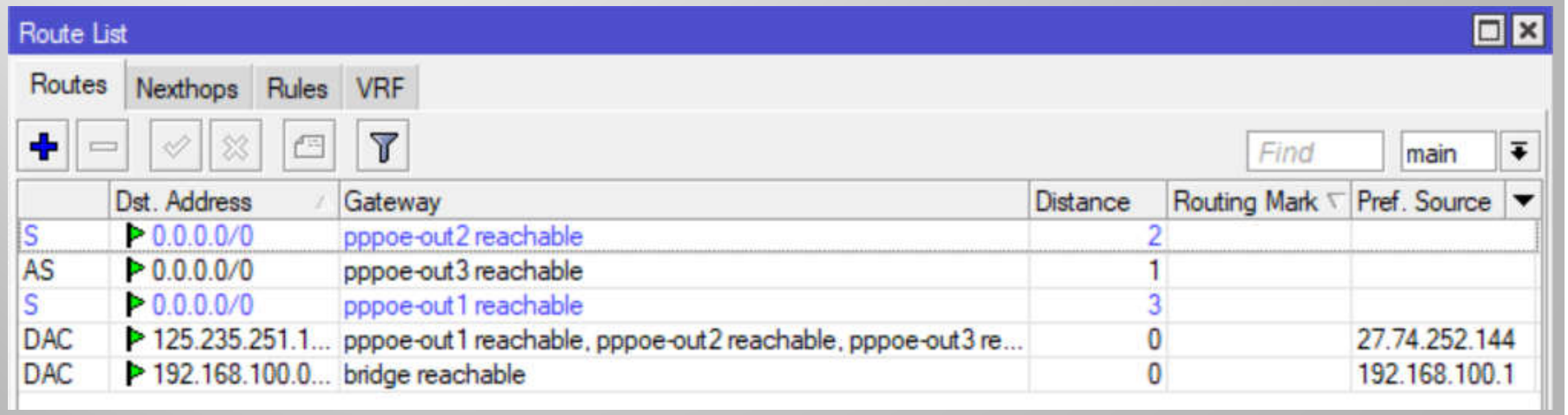
/ip route

add check-gateway=ping distance=1 gateway=pppoe-out3

add check-gateway=ping distance=2 gateway=pppoe-out2

add check-gateway=ping distance=3 gateway=pppoe-out1

What does look like on **main** routing tables



	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
S	0.0.0.0/0	pppoe-out2 reachable	2		
AS	0.0.0.0/0	pppoe-out3 reachable	1		
S	0.0.0.0/0	pppoe-out1 reachable	3		
DAC	125.235.251.1...	pppoe-out1 reachable, pppoe-out2 reachable, pppoe-out3 re...	0		27.74.252.144
DAC	192.168.100.0...	bridge reachable	0		192.168.100.1

PCC Load balancing configuration

- Create load balancing part of the configuration:
  - Define address list for Local Address Network (LAN)
  - Mangle rules

PCC Load balancing configuration

- Define LAN address list

/ip firewall address-list

add address=192.168.100.0/24 list=LAN

PCC Load balancing configuration

- Bypass mangle rules for local traffic

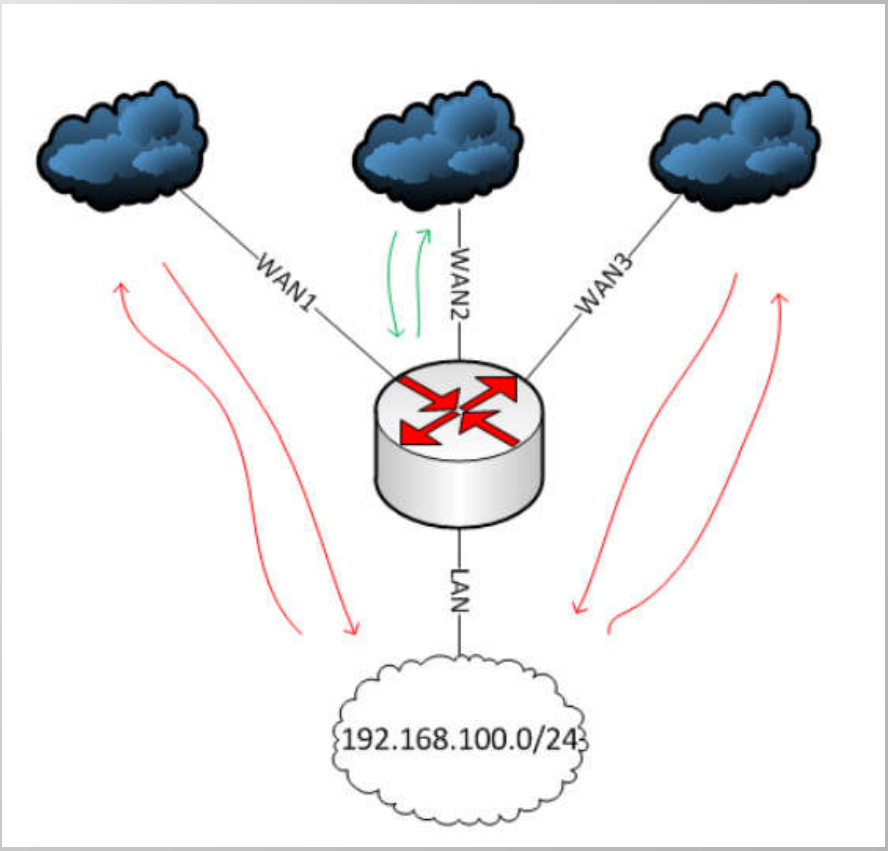
We need to ensure that any traffic going to our local bypasses all the 'line balancing' rules.

We do this with an action of 'accept'. In this case, internal traffic is on LAN address list.

```
/ip firewall mangle
add action=accept chain=prerouting
comment="Accept traffic from LAN"  \
    dst-address-list=LAN src-address-list=LAN
```

PCC Load balancing configuration

- Topology:
  - In this topology, there possible traffic flows
  - WAN -> Router
  - Router ->WAN
  - WAN -> LAN
  - LAN -> WAN



PCC Load balancing configuration

Taking care of incoming connections

- When a connection is initiated from the internet through one of the ISPs we need to ensure that this connections is replied through the same ISP (from the same public IP)
- We need to mark these connections, and then put them in the proper routing table.

PCC Load balancing configuration

Router marking – WAN -> Router

- Catch the connection from internet to the router, and mark them

add action=mark-connection chain=input comment="Mark all connections that are initiated from outsite" connection-mark=no-mark in-interface=pppoe-out1 new-connection-mark=WAN1-to-ROS passthrough=no

add action=mark-connection chain=input connection-mark=no-mark in-interface=pppoe-out2 new-connection-mark=WAN2-to-ROS passthrough=no

add action=mark-connection chain=input connection-mark=no-mark in-interface=pppoe-out3 new-connection-mark=WAN3-to-ROS passthrough=no

PCC Load balancing configuration

Router marking – WAN -> Router (cont.)

- Then put these connections into the proper routing tables.

add action=mark-routing chain=output comment="Mark routing for router's replies" connection-mark=WAN1-to-ROS new-routing-mark=WAN1 passthrough=no

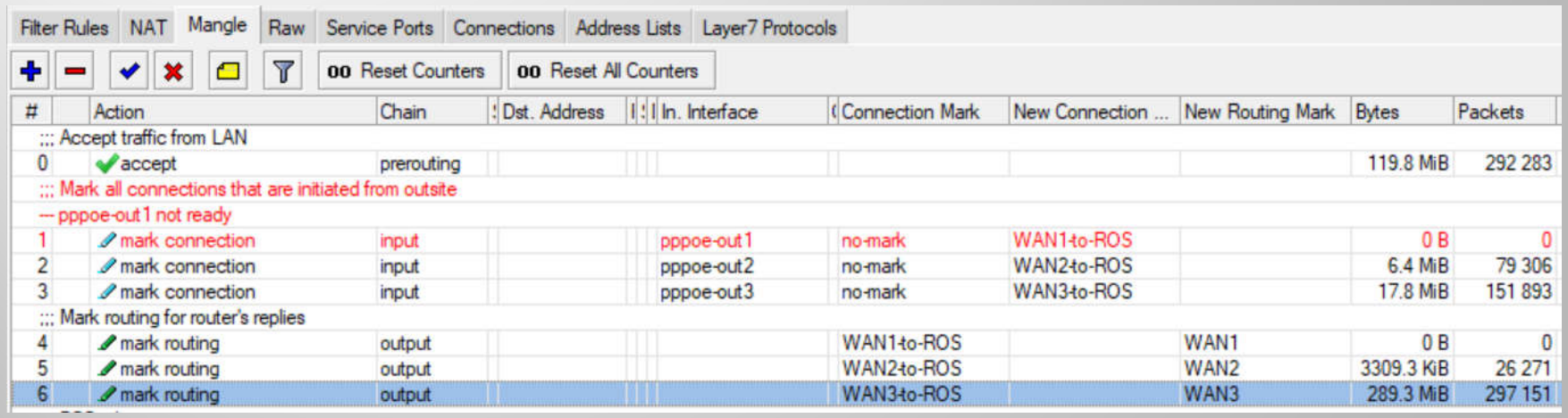
add action=mark-routing chain=output connection-mark=WAN2-to-ROS new-routing-mark=WAN2 passthrough=no

add action=mark-routing chain=output connection-mark=WAN3-to-ROS new-routing-mark=WAN3 passthrough=no

PCC Load balancing configuration

Router marking – WAN -> Router (cont.)

- What does look like on Winbox



#	Action	Chain	Dst. Address	In. Interface	Connection Mark	New Connection ...	New Routing Mark	Bytes	Packets
;;; Accept traffic from LAN									
0	accept	prerouting						119.8 MiB	292 283
;;; Mark all connections that are initiated from outsite									
--- pppoe-out1 not ready									
1	mark connection	input		pppoe-out1	no-mark	WAN1-to-ROS		0 B	0
2	mark connection	input		pppoe-out2	no-mark	WAN2-to-ROS		6.4 MiB	79 306
3	mark connection	input		pppoe-out3	no-mark	WAN3-to-ROS		17.8 MiB	151 893
;;; Mark routing for router's replies									
4	mark routing	output			WAN1-to-ROS		WAN1	0 B	0
5	mark routing	output			WAN2-to-ROS		WAN2	3309.3 KiB	26 271
6	mark routing	output			WAN3-to-ROS		WAN3	289.3 MiB	297 151

PCC Load balancing configuration

Taking care of the LAN

- Same principle applies to the LAN
- Connections initiated from the internet through one ISP, should be replied to through the same ISP

PCC Load balancing configuration

LAN marking

add action=mark-connection chain=forward comment="Mark all connections for NAT inbound" connection-mark=no-mark in-interface=pppoe-out1 new-connection-mark=WAN1-to-LAN passthrough=no

add action=mark-connection chain=forward connection-mark=no-mark in-interface=pppoe-out2 new-connection-mark=WAN2-to-LAN passthrough=no

add action=mark-connection chain=forward connection-mark=no-mark in-interface=pppoe-out3 new-connection-mark=WAN3-to-LAN passthrough=no

PCC Load balancing configuration

LAN marking (cont.)

add action=mark-routing chain=prerouting connection-mark=WAN1-to-LAN new-routing-mark=WAN1 passthrough=no src-address-list=LAN

add action=mark-routing chain=prerouting connection-mark=WAN2-to-LAN new-routing-mark=WAN2 passthrough=no src-address-list=LAN

add action=mark-routing chain=prerouting connection-mark=WAN3-to-LAN new-routing-mark=WAN3 passthrough=no src-address-list=LAN

PCC Load balancing configuration

Incoming connections - done

- We have ensured that when a connection from the internet to our router, or services inside of our network is established, it works.

LAN – partially done

- So what about connections outgoing from our LAN to the internet?
- These we actually want to load-balance

PCC Load balancing configuration

LAN -> WAN mangle

add action=mark-connection chain=prerouting comment="PCC rules“ connection-mark=no-mark dst-address-list=!LAN dst-address-type=!local new-connection-mark=LAN-to-WAN1 passthrough=yes per-connection-classifier=both-addresses:3/0 src-address-list=LAN

add action=mark-connection chain=prerouting connection-mark=no-mark dst-address-list=!LAN dst-address-type=!local new-connection-mark= LAN-to-WAN2 passthrough=yes per-connection-classifier=both-addresses:3/1 src-address-list=LAN

add action=mark-connection chain=prerouting connection-mark=no-mark dst-address-list=!LAN dst-address-type=!local new-connection-mark=LAN-to-WAN3 passthrough=yes per-connection-classifier=both-addresses:3/2 src-address-list=LAN

PCC Load balancing configuration

- LAN -> WAN mangle (cont.)

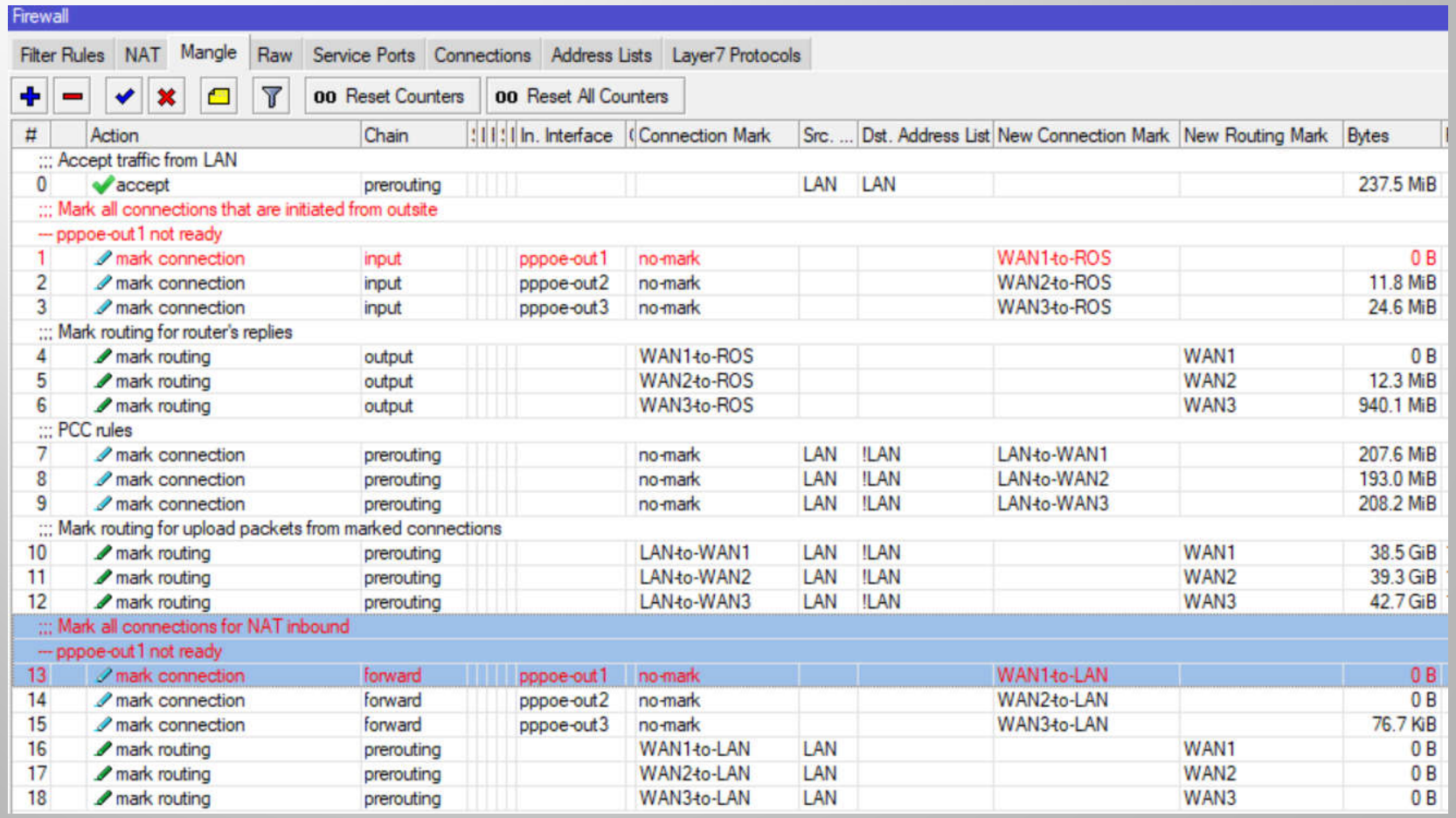
add action=mark-routing chain=prerouting comment="Mark routing for upload packets from marked connections“ connection-mark=LAN-to-WAN1 dst-address-list=!LAN new-routing-mark=WAN1 passthrough=no src-address-list=LAN

add action=mark-routing chain=prerouting connection-mark=LAN-to-WAN2 dst-address-list=!LAN new-routing-mark=WAN2 passthrough=no src-address-list=LAN

add action=mark-routing chain=prerouting connection-mark=LAN-to-WAN3 dst-address-list=!LAN new-routing-mark=WAN3 passthrough=no src-address-list=LAN

PCC Load balancing configuration

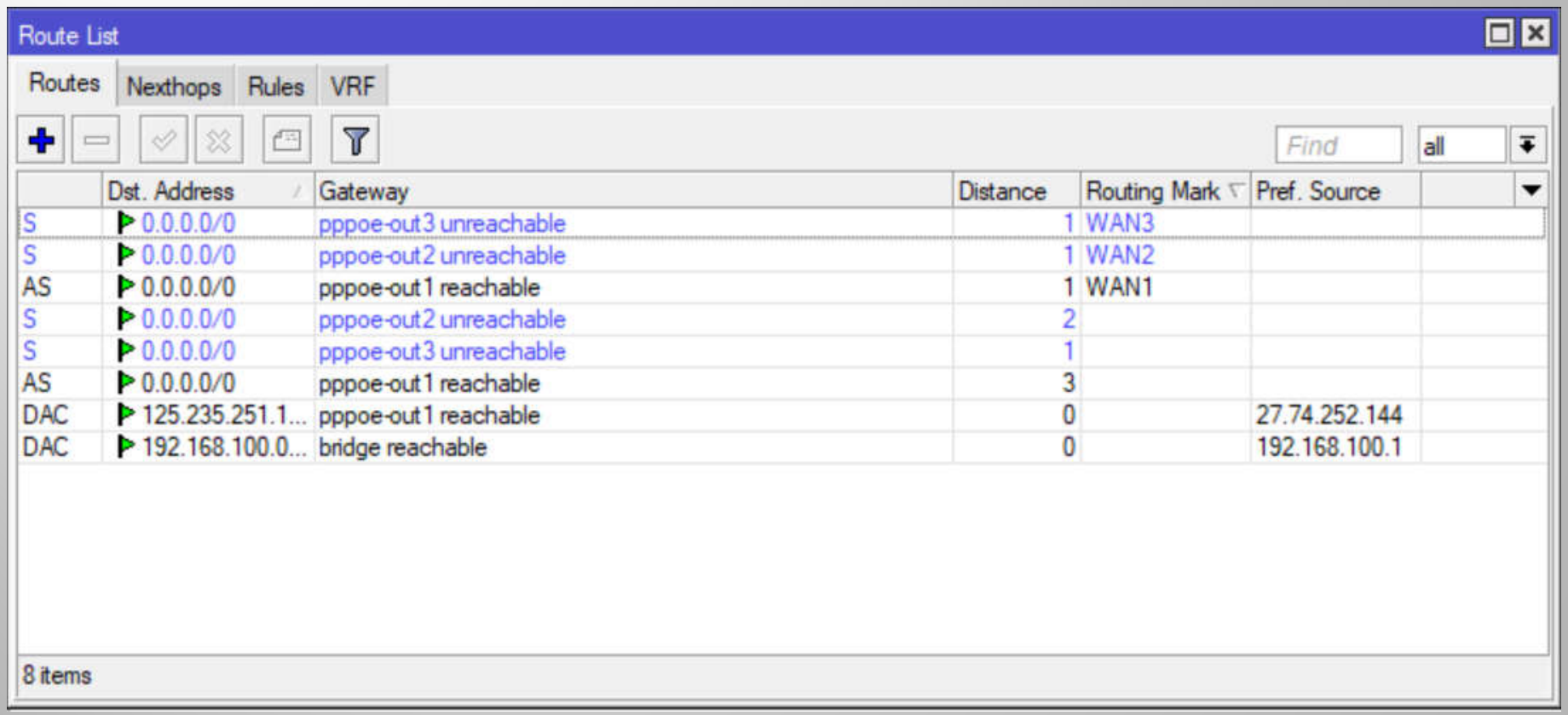
- Mangle in GUI



#	Action	Chain	In. Interface	Connection Mark	Src. ...	Dst. Address List	New Connection Mark	New Routing Mark	Bytes
;;; Accept traffic from LAN									
0	accept	prerouting			LAN	LAN			237.5 MiB
;;; Mark all connections that are initiated from outsite									
--- pppoe-out1 not ready									
1	mark connection	input	pppoe-out1	no-mark			WAN1-to-ROS		0 B
2	mark connection	input	pppoe-out2	no-mark			WAN2-to-ROS		11.8 MiB
3	mark connection	input	pppoe-out3	no-mark			WAN3-to-ROS		24.6 MiB
;;; Mark routing for router's replies									
4	mark routing	output		WAN1-to-ROS				WAN1	0 B
5	mark routing	output		WAN2-to-ROS				WAN2	12.3 MiB
6	mark routing	output		WAN3-to-ROS				WAN3	940.1 MiB
;;; PCC rules									
7	mark connection	prerouting		no-mark	LAN	!LAN	LAN-to-WAN1		207.6 MiB
8	mark connection	prerouting		no-mark	LAN	!LAN	LAN-to-WAN2		193.0 MiB
9	mark connection	prerouting		no-mark	LAN	!LAN	LAN-to-WAN3		208.2 MiB
;;; Mark routing for upload packets from marked connections									
10	mark routing	prerouting		LAN-to-WAN1	LAN	!LAN		WAN1	38.5 GiB
11	mark routing	prerouting		LAN-to-WAN2	LAN	!LAN		WAN2	39.3 GiB
12	mark routing	prerouting		LAN-to-WAN3	LAN	!LAN		WAN3	42.7 GiB
;;; Mark all connections for NAT inbound									
--- pppoe-out1 not ready									
13	mark connection	forward	pppoe-out1	no-mark			WAN1-to-LAN		0 B
14	mark connection	forward	pppoe-out2	no-mark			WAN2-to-LAN		0 B
15	mark connection	forward	pppoe-out3	no-mark			WAN3-to-LAN		76.7 KiB
16	mark routing	prerouting		WAN1-to-LAN	LAN			WAN1	0 B
17	mark routing	prerouting		WAN2-to-LAN	LAN			WAN2	0 B
18	mark routing	prerouting		WAN3-to-LAN	LAN			WAN3	0 B

PCC Load balancing configuration

- Routing tables



Common problems

- I can access just 1 WAN interface from Internet.
- I can not access LAN services from Internet via inbound NAT.
- How to load balance for different rate WAN links.

References documents

- https://wiki.mikrotik.com/wiki/Manual:PCC
- https://blog.linitx.com/load-balancing-multiple-internet-connections/
- MikroTik RouterOS Workshop Load Balancing Best Practice by Warsaw, MUM Europe 2012.
- Bandwidth-based load-balancing with failover. The easy way by Tomas Kirnak.
- Load Balancing Using by Steve Discher.

Questions?

THANK YOU!