

# **MikroTik RouterOS Workshop**

## **Load Balancing**

### **Best Practice**

Las Vegas  
MUM USA 2011

# About Me

- Jānis Meģis, MikroTik
- Jānis (Technical, Trainer, NOT Sales)
  - ◆ Support & Training Engineer for almost 7 years
  - ◆ Specialization: QoS, PPP, Firewall, Routing
  - ◆ Teaching MikroTik RouterOS classes since 2005

# Load Balancing

- Load Balancing is a technique to distribute the workload across two or more network links in order to maximize throughput, minimise response time, and avoid overload
- Using multiple network links with load balancing, instead of single network links, may increase reliability through redundancy

# Types of Load Balancing

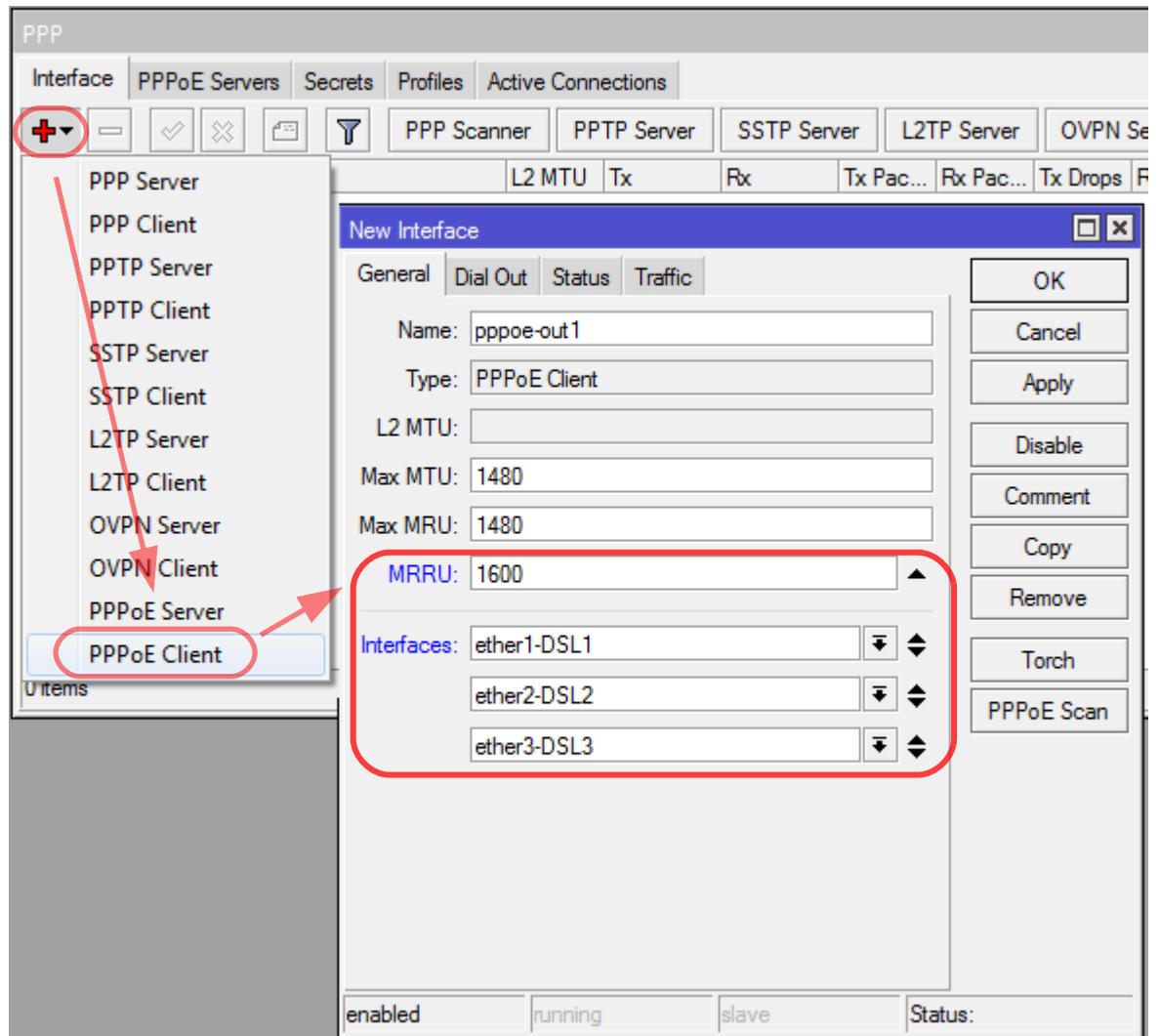
- Sub-Packet Load Balancing (MLPPP)
- Per Packet Load Balancing (Bonding)
- Per Connection Load Balancing (nth)
- Per address-pair Load Balancing (ECMP, PCC, Bonding)
  
- Custom Load Balancing (Policy Routing)
  
- Bandwidth based Load Balancing  
(MPLS RSTV Traffic Engineering Tunnels)

# Multi-Link PPP

- PPP Multi-link Protocol allows to divide packet equally and send each part into multiple channels
- MLPPP can be created:
  - ◆ over single physical link – where multiple channels run on the same link (anti-fragmentation)
  - ◆ over multiple physical links - where multiple channels run on the multiple link (load balancing)
- MLPPP must be supported by both ends
- (MLPPP is legacy stuff from modem era)

# MLPPP configuration

- Server must have MLPPP support
- All lines must have same user name and password
- RouterOS has only the MLPPP client implementation

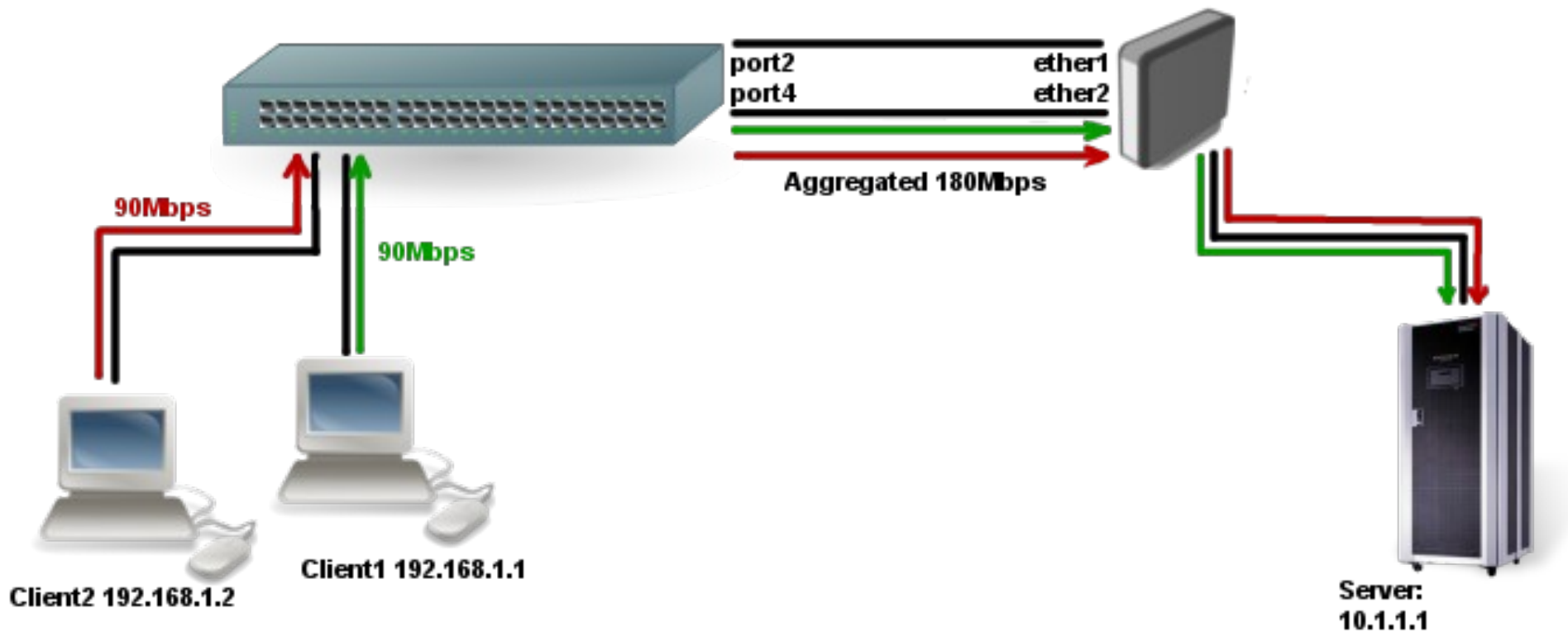


# Bonding

- Bonding is a technology that allows you to aggregate multiple Ethernet-like interfaces into a single virtual link, thus getting higher data rates and providing fail-over
- Bonding (load balancing) modes:
  - ➔802.3ad
  - ➔Balance-rr
  - ➔Balance-xor
  - ➔Balance-tlb
  - ➔Balance-alb

# 802.3ad

- 802.3ad mode is an IEEE standard also called LACP (Link Aggregation Control Protocol).

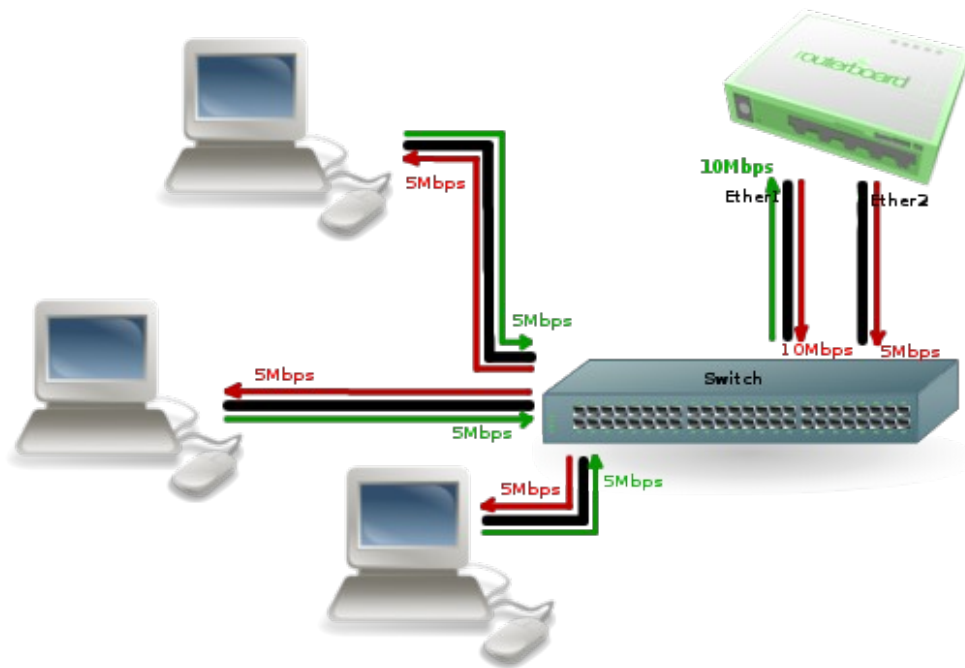




# Balance-rr and balance-xor

- Balance-rr mode uses Round Robin algorithm - packets are transmitted in sequential order from the first available slave to the last.
- When utilizing multiple sending and multiple receiving links, packets often are received out of order (problem for TCP)
- Balance-xor balances outgoing traffic across the active ports based on a hash from specific protocol header fields and accepts incoming traffic from any active port

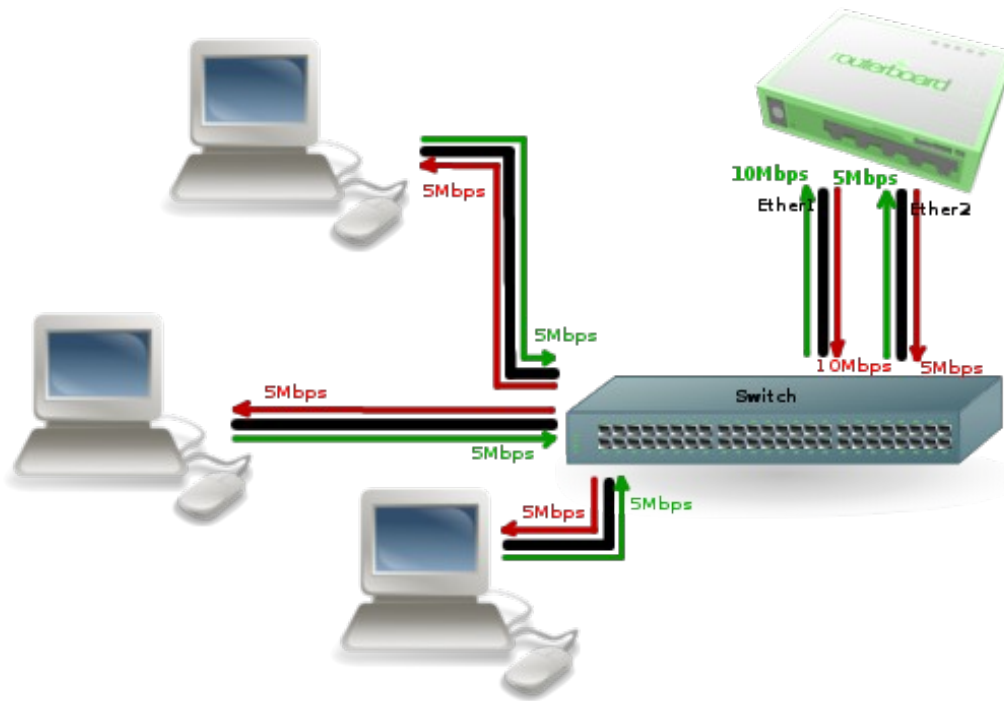
# Balance-tlb



- The outgoing traffic is distributed according to the current load
- Incoming traffic is not balanced
- This mode is address-pair load balancing
- No additional configuration is required for the switch

# Balance-alb

- In short alb = tlb + receive load balancing
- This mode requires a device driver capability to change the MAC address



# ECMP Routes

**New Route**

General | Attributes

Destination: 192.168.XY.0/24

Gateway: 192.168.Z.1

192.168.Z.127

10.1.Z.2

Interface:

Check Gateway:

Type: unicast

Distance:

Scope: 255

Target Scope: 10

Routing Mark:

Pref. Source:

disabled | active

OK  
Cancel  
Apply  
Disable  
Comment  
Copy  
Remove

- ECMP (Equal Cost Multi Path) routes have more than one gateway to the same remote network
- Gateways will be used in Round Robin per SRC/DST address combination
- Same gateway can be written several times!!

# “Check-gateway” Option

- You can set the router to check gateway reachability using ICMP (ping) or ARP protocols
- If the gateway is unreachable in a simple route – the route will become inactive
- If one gateway is unreachable in an ECMP route, only the reachable gateways will be used in the Round Robin algorithm
- If Check-gateway option is enabled on one route it will affect all routes with that gateway.

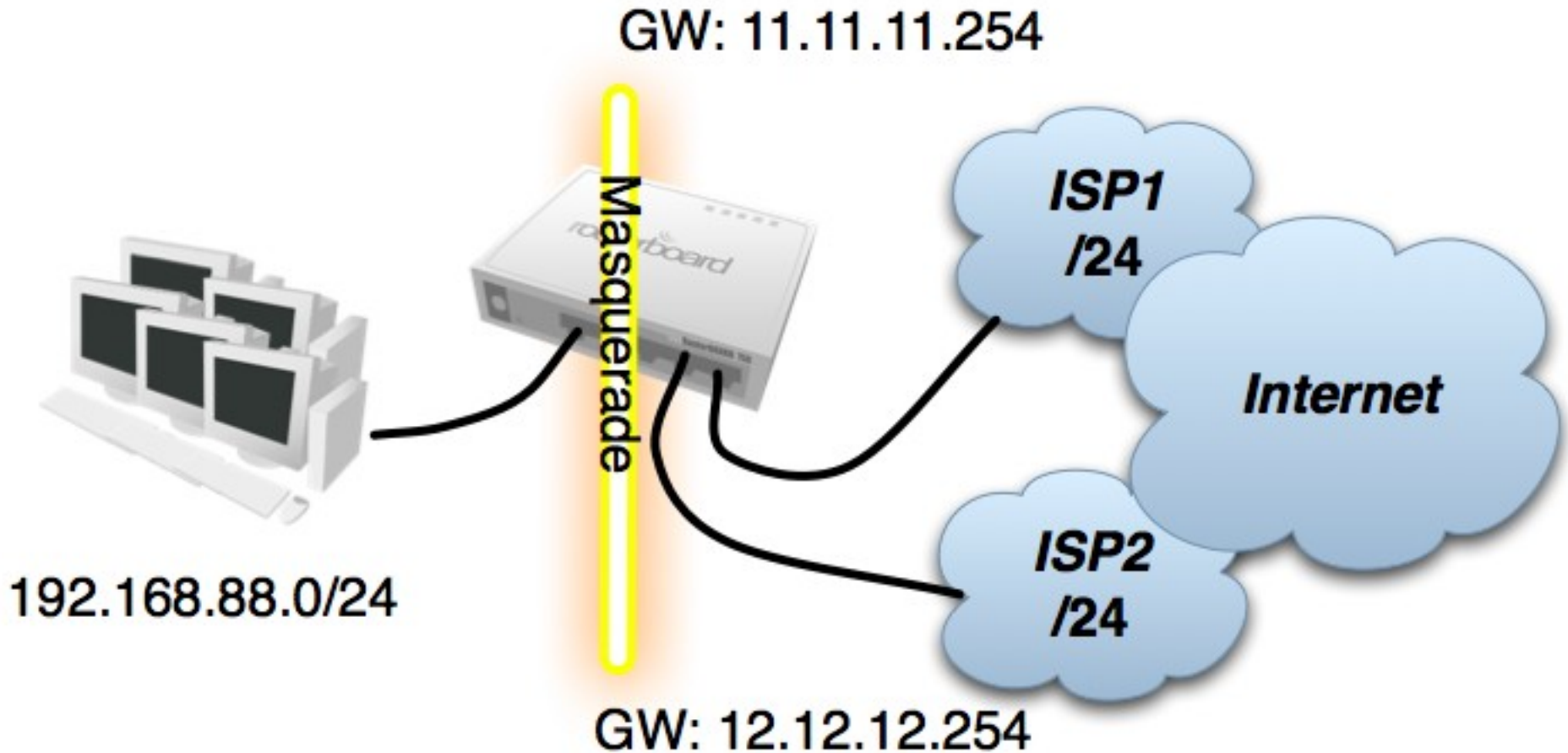
# Interface ECMP Routing

- In case you have more than one PPP connection from the same server, but MLPPP is impossible (different user names, server support missing) it is possible to use Interface routing
- Simple IP address routing is impossible all PPP connections that have the same gateway IP address
- To enable interface routing just specify all PPP interfaces as route gateway-interfaces
- Works only on PPP interfaces.

# ECMP and Masquerade

- As forwarding database is rebuilt every 10min in Linux Kernel, there is a chance that connection will jump to the other gateway
- In the case of masquerading this jump results in a change of source address and in eventual disconnect
- More info at:
  - ◆ <http://www.enyo.de/fw/security/notes/linux-dst-cache-dos.html>
  - ◆ <http://marc.info/?m=105217616607144>
  - ◆ <http://lkml.indiana.edu/hypermail/linux/net/0305.2/index.html#19>

# Configuration Setup





# Basic Configuration

```
[admin@MikroTik] > /interface set 1 name=to_ISP1  
[admin@MikroTik] > /interface set 2 name=to_ISP2  
[admin@MikroTik] > /interface set 3 name=Local
```

```
[admin@MikroTik] /ip address> add address=192.168.88.254/24 interface=Local  
[admin@MikroTik] /ip address> add address=11.11.11.1/24 interface=to_ISP1  
[admin@MikroTik] /ip address> add address=12.12.12.1/24 interface=to_ISP2
```

```
[admin@MikroTik] /ip route> add gateway=11.11.11.254 distance=2  
[admin@MikroTik] /ip route> add gateway=12.12.12.254 distance=3
```

```
[admin@MikroTik] /ip firewall nat> add chain=srcnat out-interface=to_ISP1 action=masquerade  
[admin@MikroTik] /ip firewall nat> add chain=srcnat out-interface=to_ISP2 action=masquerade
```

# Policy Routing

- Policy routing is a method that allows you to create separate routing policies for different traffic by creating custom routing tables
- In RouterOS these routing tables are created:
  - ◆ For every table specified in /ip route rule
  - ◆ For every routing-mark in mangle facility
- Marked traffic is automatically assigned to the proper routing table (no need for lookup rules)

# 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

# Traffic to Connected Networks

- As connected routes are available only in “main” routing table, it is necessary that traffic to connected networks stay in “main” routing table
- This will also allow proper communication between locally and remotely connected clients

```
/ip firewall mangle> add chain=prerouting src-address=192.168.88.0/24  
dst-address=11.11.11.0/24 action=accept
```

```
/ip firewall mangle> add chain=prerouting src-address=192.168.88.0/24  
dst-address=12.12.12.0/24 action=accept
```

```
/ip firewall mangle> add chain=prerouting src-address=192.168.88.0/24  
dst-address=192.168.88.0/24 action=accept
```

# Remote Connections

- In the case when a connection is initiated from a public interface it is necessary to ensure that these connections will be replied via the same interface (from the same public IP)
- First we need to capture these connections (you can either use default connection mark “no-mark” or connection state “new” here)

```
/ip firewall mangle> add chain=prerouting connection-mark=no-mark in-interface=to ISP1  
                        action=mark-connection new-connection-mark=ISP1_conn  
  
/ip firewall mangle> add chain=prerouting connection-mark=no-mark in-interface=to_ISP2  
                        action=mark-connection new-connection-mark=ISP2_conn
```

# Custom Policy Routing

- Now we need to create a default route for every routing table (or else it will be resolved by main routing table)

```
/ip route> add gateway=11.11.11.254 routing-mark=ISP1_traffic  
/ip route> add gateway=12.12.12.254 routing-mark=ISP2_traffic
```

- Let's create a jump rule to your custom policy routing here

```
/ip firewall mangle> add chain=prerouting in-interface=Local connection-mark=no-mark  
                        action=jump jump-target=policy_routing
```

# Mark Routing

- Mark routing rules in mangle chain “output” will ensure that router itself is reachable via both public IP addresses
- Mark routing rules in mangle chain “prerouting” will ensure your desired load balancing

```
/ip firewall mangle> add chain=prerouting connection-mark=ISP1_conn src-address=192.168.88.0/24
                        action=mark-routing new-routing-mark=ISP1_traffic
/ip firewall mangle> add chain=prerouting connection-mark=ISP2_conn src-address=192.168.88.0/24
                        action=mark-routing new-routing-mark=ISP2_traffic
/ip firewall mangle> add chain=output connection-mark=ISP1_conn
                        action=mark-routing new-routing-mark=ISP1_traffic
/ip firewall mangle> add chain=output connection-mark=ISP2_conn
                        action=mark-routing new-routing-mark=ISP2_traffic
```

# Mangle configuration

Firewall

Filter Rules NAT Mangle Service Ports Connections Address Lists Layer7 Protocols

+ - ✓ ✗ [icon] [icon] Reset Counters 00 Reset All Counters

#	Action	Chain	Src. Address	Dst. Address	In. Interface	Connection Mark
::: Accept all traffic to connected networks						
0	✓ accept	prerouting	192.168.88.0/24	11.11.11.0/24		
1	✓ accept	prerouting	192.168.88.0/24	12.12.12.0/24		
2	✓ accept	prerouting	192.168.88.0/24	192.168.88.0/24		
::: Mark all connections that are initiated from outside						
3	✎ mark connection	prerouting			to_ISP1	no-mark
4	✎ mark connection	prerouting			to_ISP2	no-mark
::: Jump to your custom policy routing chain						
5	🔗 jump	prerouting			Local	no-mark
::: Mark routing for upload packets from marked connections						
6	✎ mark routing	prerouting	192.168.88.0/24			ISP1_conn
7	✎ mark routing	prerouting	192.168.88.0/24			ISP2_conn
::: Mark routing for router's replies						
8	✎ mark routing	output				ISP1_conn
9	✎ mark routing	output				ISP2_conn



# Custom Policy Routing

- There is no best way that we can suggest for load balancing, you can either:
  - ◆ Balance based on client IP address (address list)
  - ◆ Balance based on traffic type (p2p, layer-7, protocol, port)
  - ◆ Use automatic balancing (PCC)
- We do not suggest to use “nth” for policy routing of typical user traffic.

# Per-address-pair Load Balancing

- In many situations communication between two hosts consist of more than one simultaneous connection.
- If those connections are taking different routing paths they might have different latency, drop rate, fragmentation or source address (NAT) – this way making multi-connection communications impossible.
- That is why instead of per-connection load balancing we should think about per-address-pair load balancing

# Per Connection Classifier

- PCC is a firewall matcher that allows you to divide traffic into equal streams with ability to keep packets with specific set of options in one particular stream
- You can specify set of options from src-address, src-port, dst-address, dst-port
- More info at:  
<http://wiki.mikrotik.com/wiki/PCC>

# PCC Configuration

- We just need to add 2 rules to our “policy\_routing” chain to ensure automatic per-address-pair load balancing

```
/ip firewall mangle> add chain=policy_routing dst-address-type=!local  
per-connection-classifier=both-addresses:2/0  
action=mark-connection new-connection-mark=ISP1_conn
```

```
/ip firewall mangle> add chain=policy_routing dst-address-type=!local  
per-connection-classifier=both-addresses:2/1  
action=mark-connection new-connection-mark=ISP2_conn
```

# Usual Problems

- Be careful about using “no-mark” connection mark if you have other mangle configuration in a different chain
- ISP specified DNS servers might block requests from non-ISP public IPs, so we suggest you use public (ISP independent) DNS servers.
- If you would like to ensure fail-over – enable “check-gateway” option in all default routes.

# What about bandwidth based Load-Balancing?

# Transport Engineering

- TE is one of MPLS features that allow to establish unidirectional label switching paths
- TE is based on RSVP (Resource ReSerVation Protocol) + RFC 3209 that adds support for explicit route and label exchange
- TE tunnels are similar to LDP, but with additional features:
  - ◆ Usage of either full or partial explicit routes
  - ◆ Constraint (such as **bandwidth** and link properties) based LSP (Label Switched Path) establishment

# How Does Constraints Work?

- Constraints are set by user and does not necessarily reflect actual bandwidth
- Constraints can be set for:
  - ◆ bandwidth of link participating in a RSVP TE network
  - ◆ bandwidth reserved for tunnel
- So, at any moment in time, the bandwidth available on TE link is bandwidth configured for link minus sum of all reservations made on the link (not physically available bandwidth)



# TE Tunnel Establishment

- TE tunnels can be established:
  - ◆ along the path that data from the head-end of a tunnel is routed to the tail-end (no additional configuration required)
  - ◆ along a statically configured explicit path (it is necessary to manually input path)
  - ◆ CSPF (Constrained Shortest Path First) - This option needs assistance from IGP routing protocol (such as OSPF) to distribute bandwidth information throughout the network.

# Network Layout

- Each router is connected to a neighbouring router using /30 network and each of them have unique Loopback address form 10.255.0.x network. Loopback addresses will be used as tunnel source and destination.

```
/system identity set name=Rx
```

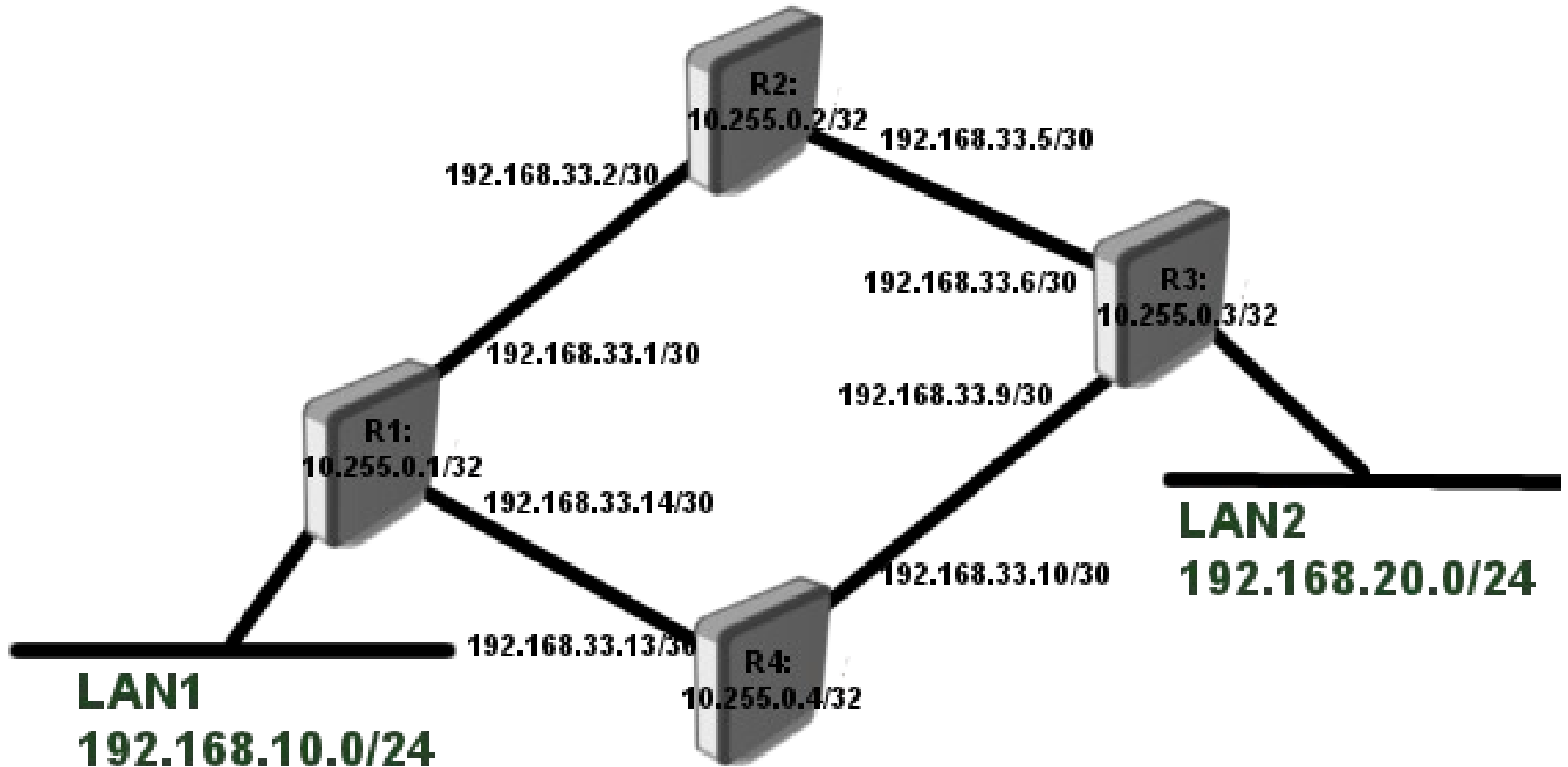
```
/interface bridge add name=Loopback
```

```
/ip add add address=10.255.0.x/24 interface=Loopback
```

```
/ip add add address=192.168.33.x/30 interface=ether1
```

```
/ip add add address=192.168.33.y/30 interface=ether2
```

# Network Layout



# Loopback and CSPF

- Loopback addresses need to be reachable from whole network – we will use OSPF to distribute that information
- Also OSPF can help us to distribute TE reservations for CSPF

```
/routing ospf instance
    set default mpls-te-area=backbone
        mpls-te-router-id=Loopback router-id=10.255.0.x

/routing ospf network
    add network=192.168.33.0/24 area=backbone
    add network=10.255.0.x/32 area=backbone
```

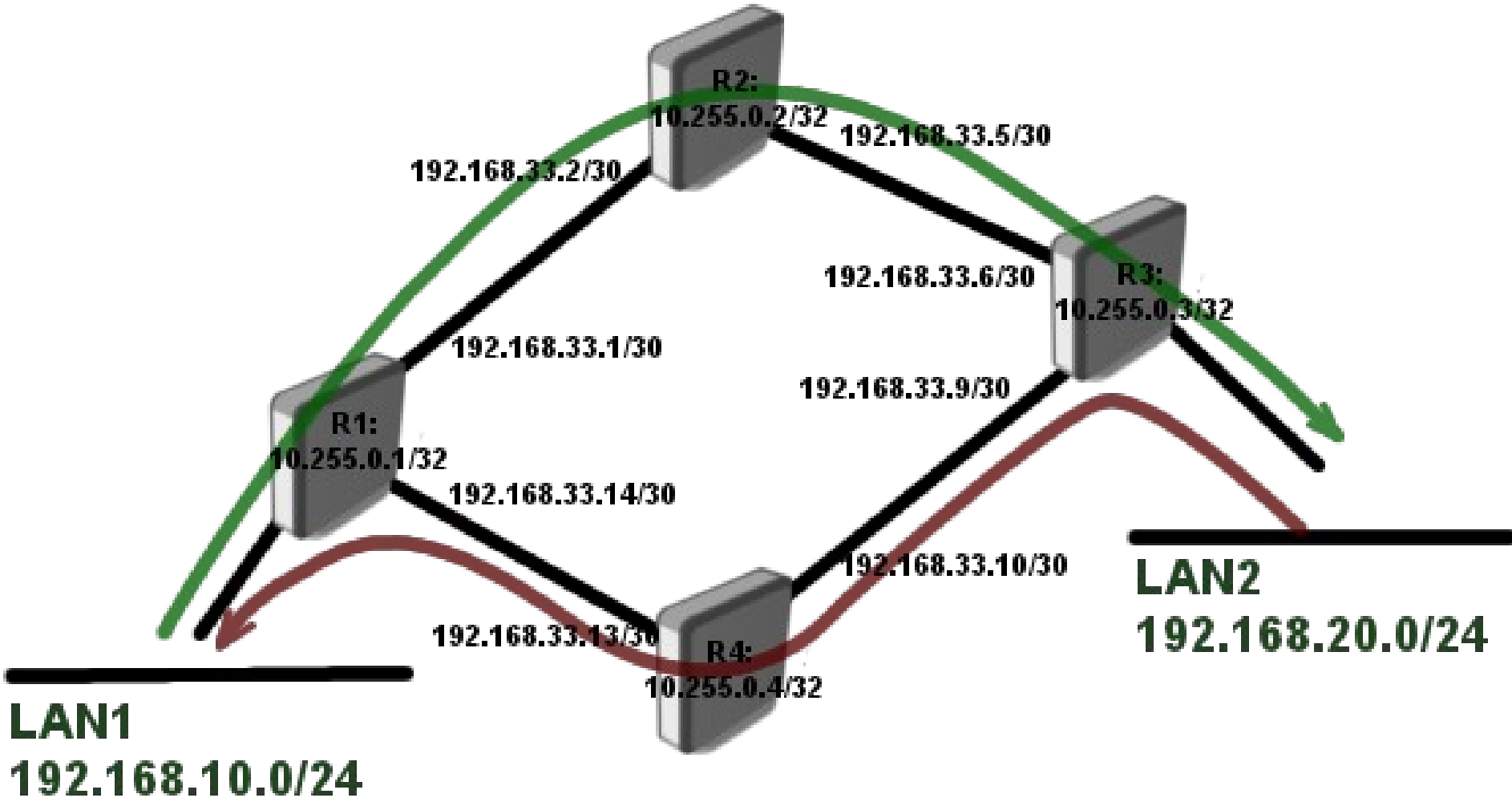
# Resource Reservation

- Lets set up TE resource for every interface on which we might want to run TE tunnel.
- Configuration on all the routers are the same:

```
/mpls traffic-eng interface  
  add interface=ether1 bandwidth=10Mbps  
  add interface=ether2 bandwidth=10Mbps
```

- Note that at this point this does not represent how much bandwidth will actually flow through the interface

# First Task



# TE tunnel setup

- We will use static path configuration as primary, and dynamic (CSPF) as secondary path if primary fails

```
/mpls traffic-eng tunnel-path
add name=dyn use-cspf=yes
add name=tun-first-link use-cspf=no
    hops=192.168.33.2:strict,192.168.33.5:strict,192.168.33.6:strict

/interface traffic-eng
add bandwidth=5Mbps name=TE-to-R3 to-address=10.255.0.3 primary-path=tun-first-link
    secondary-paths=dyn record-route=yes from-address=10.255.0.1
```

R1

```
/mpls traffic-eng tunnel-path
add name=dyn use-cspf=yes
add name=tun-second-link use-cspf=no
    hops=192.168.33.10:strict,192.168.33.13:strict,192.168.33.14:strict

/interface traffic-eng
add bandwidth=5Mbps name=TE-to-R1 to-address=10.255.0.1 primary-path=tun-second-link
    secondary-paths=dyn record-route=yes from-address=10.255.0.3
```

R3

# TE Tunnel Monitoring

```
[admin@R1] /mpls traffic-eng> path-state print
Flags: L - locally-originated, E - egress, F - forwarding, P - sending-path,
R - sending-resv
#      SRC          DST          BANDWIDTH OUT.. OUT-NEXT-HOP
0 LFP  10.255.0.1:1    10.255.0.3:15  5.0Mbps eth.. 192.168.33.2
1 E R  10.255.0.3:1    10.255.0.1:8   5.0Mbps
[admin@R1] /mpls traffic-eng> resv-state print
Flags: E - egress, A - active, N - non-output, S - shared
#      SRC          DST          BANDWIDTH LABEL          INT...
0 AS  10.255.0.1:1    10.255.0.3:15  5.0Mbps 41          ether1
[admin@R1] /mpls traffic-eng>
[admin@R1] /mpls traffic-eng> interface print
Flags: X - disabled, I - invalid
#      INTERFACE          BANDWIDTH  TE-METRIC  REMAINING-BW
0      ether1              10Mbps    1          5.0Mbps
1      ether2              10Mbps    1          10.0Mbps
```



# TE Tunnel Monitoring

- If multiple tunnels are created and all the bandwidth on that particular interface is used, then the tunnel will try to look for different path.

```
[admin@R1] /interface traffic-eng> monitor 0
      tunnel-id: 14
primary-path-state: established
      primary-path: tun-first-link
secondary-path-state: not-necessary
      active-path: tun-first-link
      active-lspid: 1
      active-label: 39
      explicit-route: S:192.168.33.2/32,S:192.168.33.5/32,S:192.168.33.6/32
reserved-bandwidth: 5.0Mbps
```

# Route traffic over TE

```
/ip address add address=10.99.99.1/30 interface=TE-to-R3
```

**R1**

```
/ip route add dst-address=192.168.20.0/24 gateway=10.99.99.2
```

```
/ip address add address=10.99.99.2/30 interface=TE-to-R1
```

**R3**

```
/ip route add dst-address=192.168.10.0/24 gateway=10.99.99.1
```

```
[admin@R1] /ip address> /tool traceroute 10.99.99.1
```

#	ADDRESS	RT1	RT2	RT3	STATUS
1	192.168.33.2	2ms	1ms	1ms	<MPLS:L=41,E=0>
2	10.99.99.1	3ms	1ms	1ms	

- To route LAN traffic over a TE tunnel we will assign address 10.99.99.1/30 and 10.99.99.2/30 to each tunnel end.

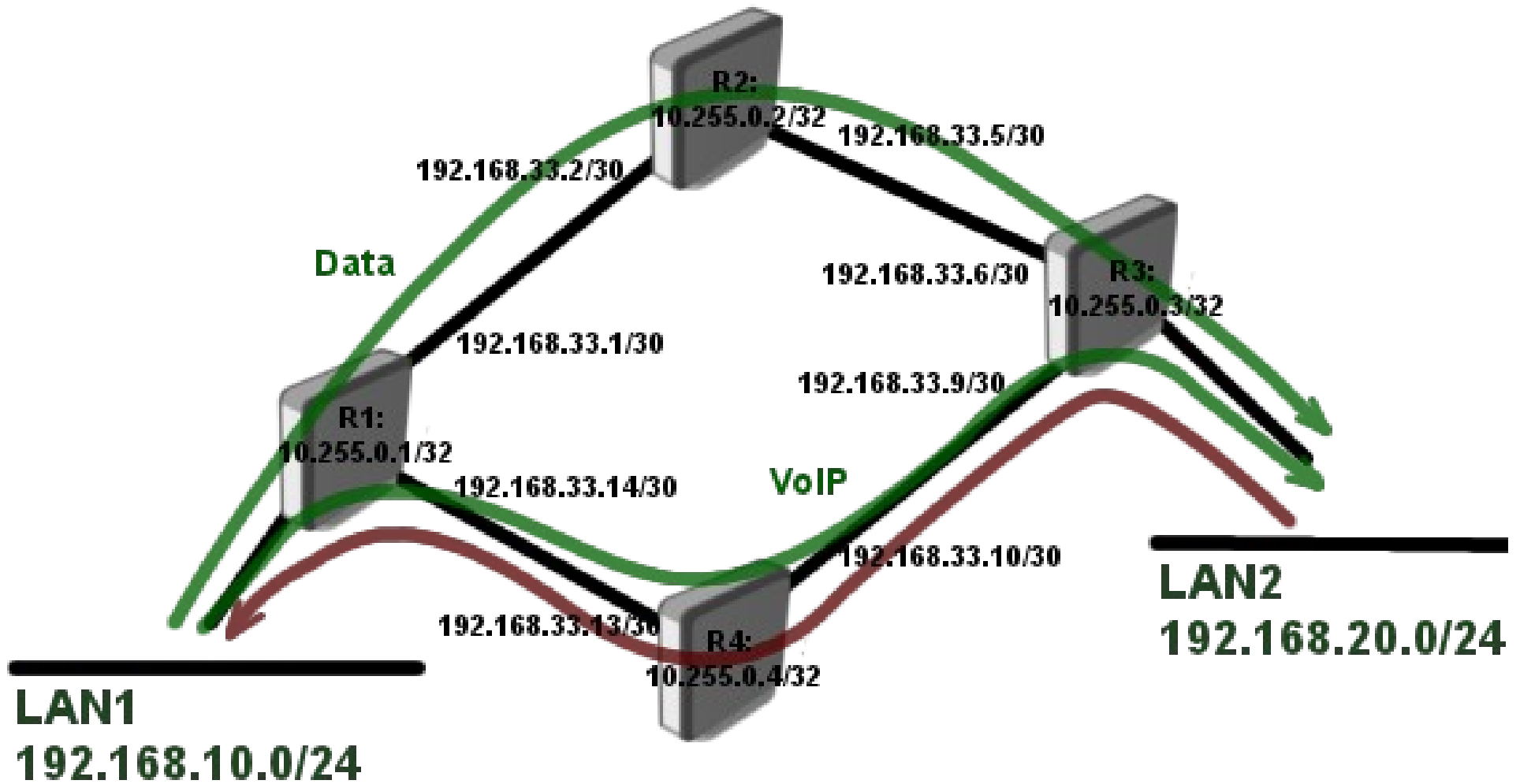
# Automatic Failover

```
/interface traffic-eng set TE-to-R3 reoptimize-interval=5s R1
```

```
/interface traffic-eng set TE-to-R1 reoptimize-interval=5s R3
```

- By default the tunnel will try to switch back to the primary path every minute. This setting can be changed with **primary-retry-interval** parameter.

# Additional Tunnels



# Additional Tunnels

```
/mpls traffic-eng tunnel-path
add name=tun-second-link use-cspf=no \
    hops=192.168.33.13:strict,192.168.33.10:strict,192.168.33.9:strict
/interface traffic-eng
add name=TE-to-R3-VOIP to-address=10.255.0.3 bandwidth=5Mbps record-route=yes \
    primary-path=tun-second-link secondary-paths=dyn reoptimize-interval=5s
```

**R1**

```
/ip address add address=10.100.100.1/30 interface=TE-to-R3-VOIP
/ip route add dst-address=192.168.20.250/32 gateway=10.100.100.2
```

**R1**

```
/ip address add address=10.100.100.2/30 interface=TE-to-R1
```

**R3**

# Good luck!

- [http://wiki.mikrotik.com/wiki/Manual:Simple\\_TE](http://wiki.mikrotik.com/wiki/Manual:Simple_TE)
- [http://wiki.mikrotik.com/wiki/Manual:TE\\_Tunnels](http://wiki.mikrotik.com/wiki/Manual:TE_Tunnels)
- <http://wiki.mikrotik.com/wiki/Manual:MPLS/Traffic-eng>
- <http://wiki.mikrotik.com/wiki/Manual:MPLS/Overview>