MikroTik RouterOS Workshop
Load Balancing
Best Practice

Warsaw

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About Me

- Jānis Meģis, MikroTik
- Jānis (Tehnical, Trainer, NOT Sales)
  - Support & Training Engineer for almost 8 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

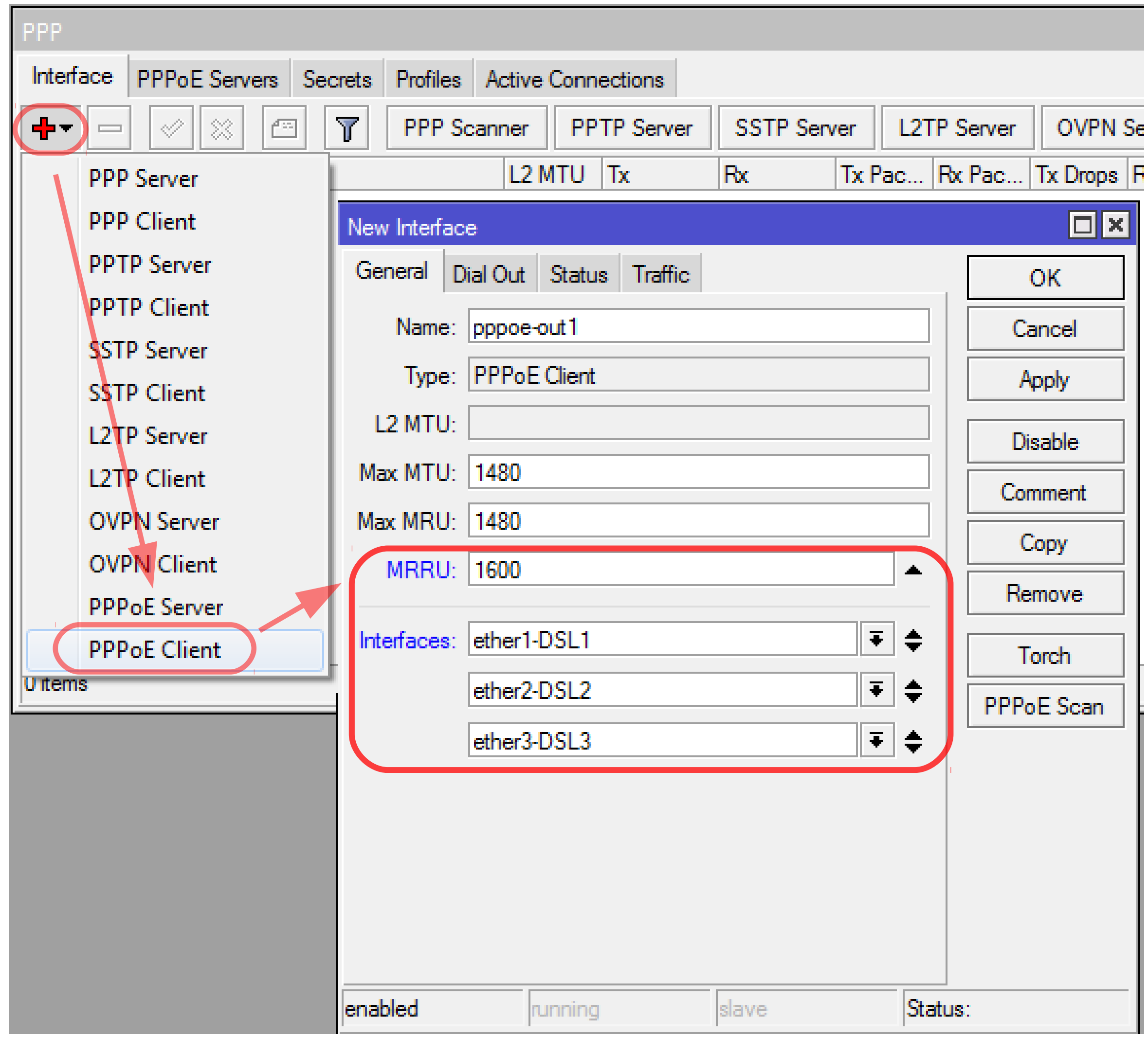
- Sub-Packet Load Balancing (MLPPP)
- Per Packet Load Balancing (Bonding)
- Per Connection Load Balancing (nth)
- Per address-pair Load Balancing (ECMP, PCC, Bonding)
- Custom Load Balancing (Policy Routing)
- Bandwidth based Load Balancing (MPLS RSVP-TE Tunnels)

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

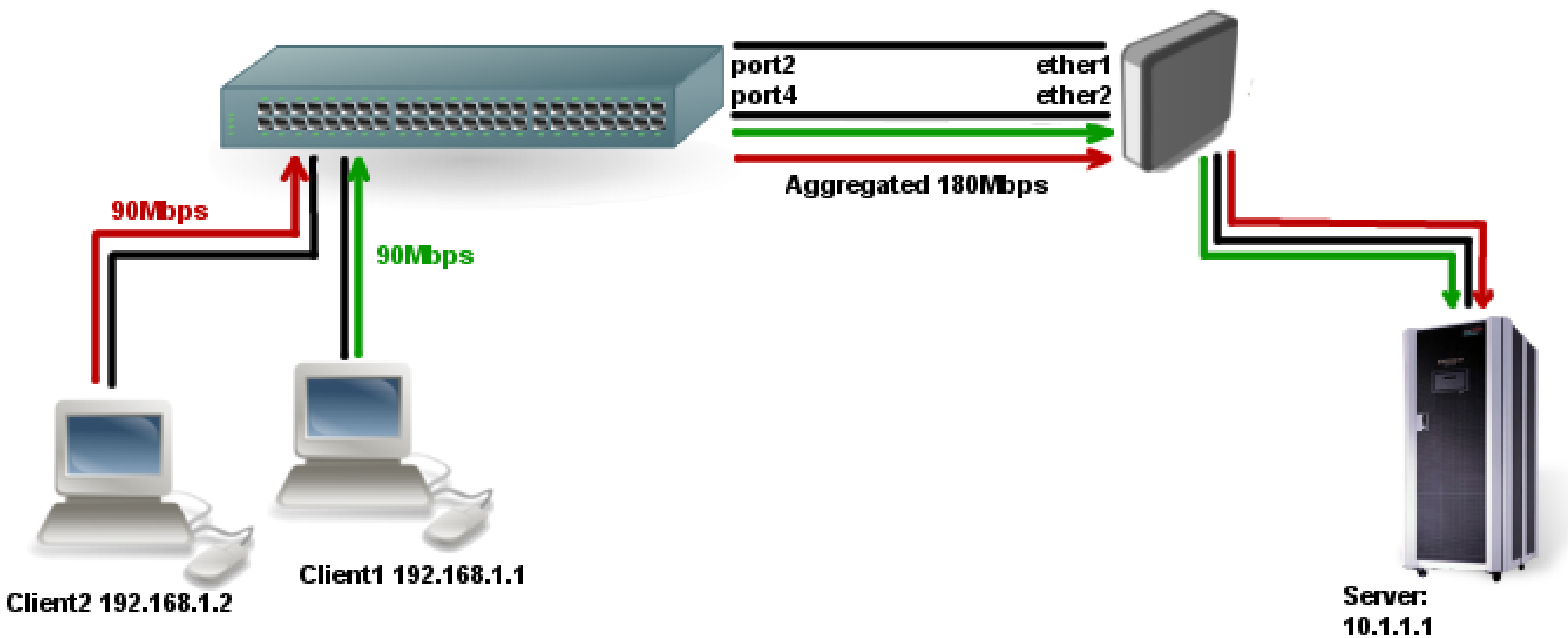


Bonding

- 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

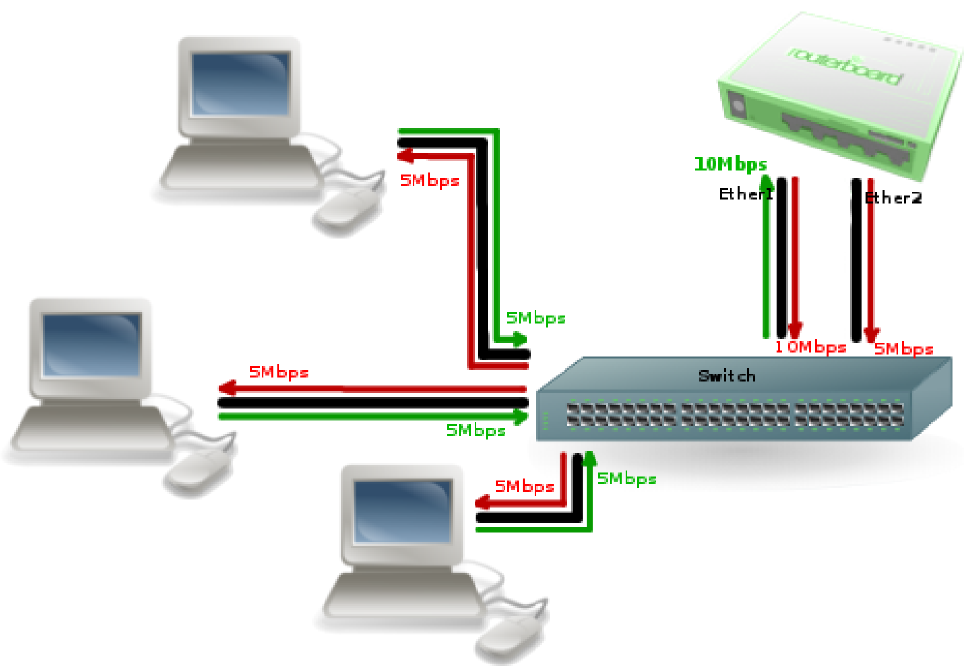
• 802.3ad mode is an IEEE standard also called LACP (Link Aggregation Control Protocol).



Balance-rr and balance-xor

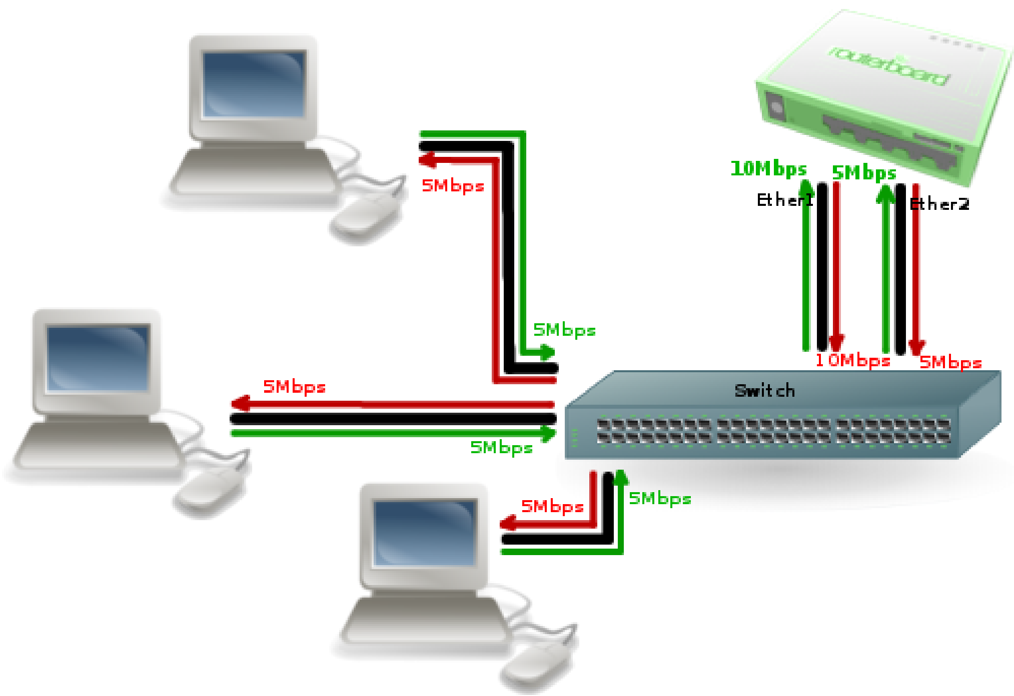
- Balance-rr mode uses Round Robin algorithm - packets are transmitted in sequential order from the first available slave to the last.
- When utilizing multiple sending and multiple receiving links, packets often are received out of order (problem for TCP)
- Balance-xor balances outgoing traffic across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

Balance-tlb



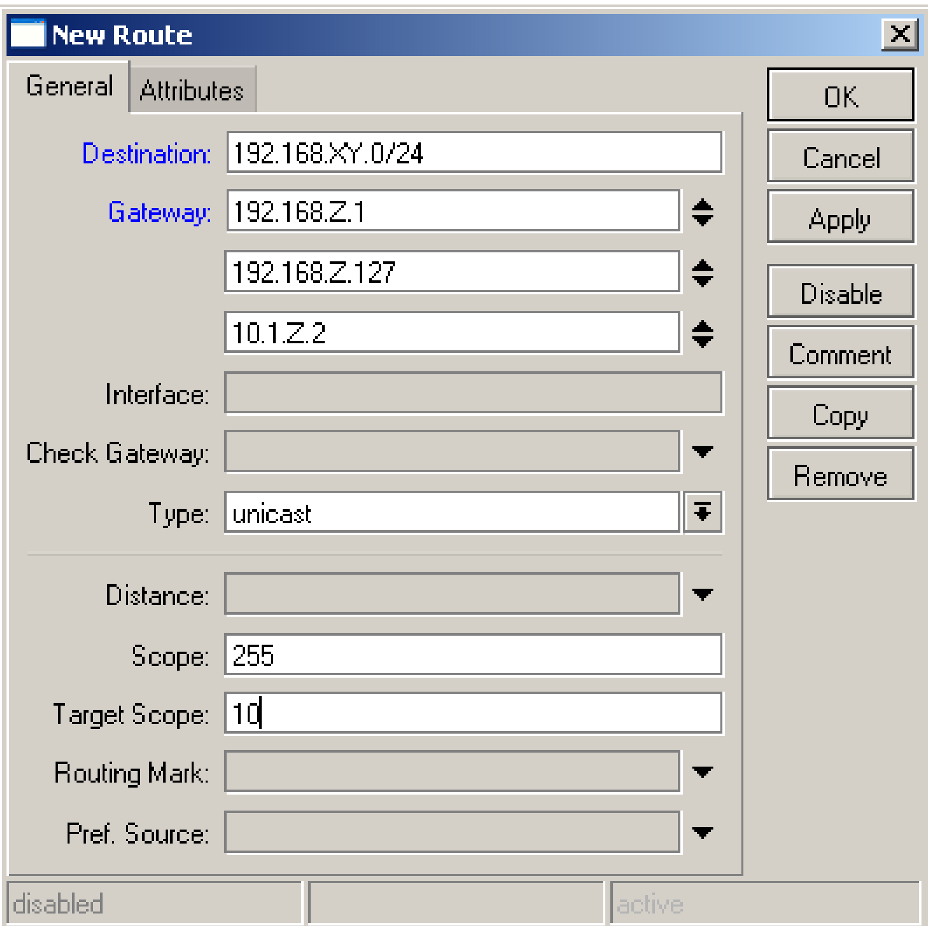
- The outgoing traffic is distributed according to the current load
- Incoming traffic is not balanced
- This mode is address-pair load balancing
- No additional configuration is required for the switch

Balance-alb



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

ECMP Routes



- 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.

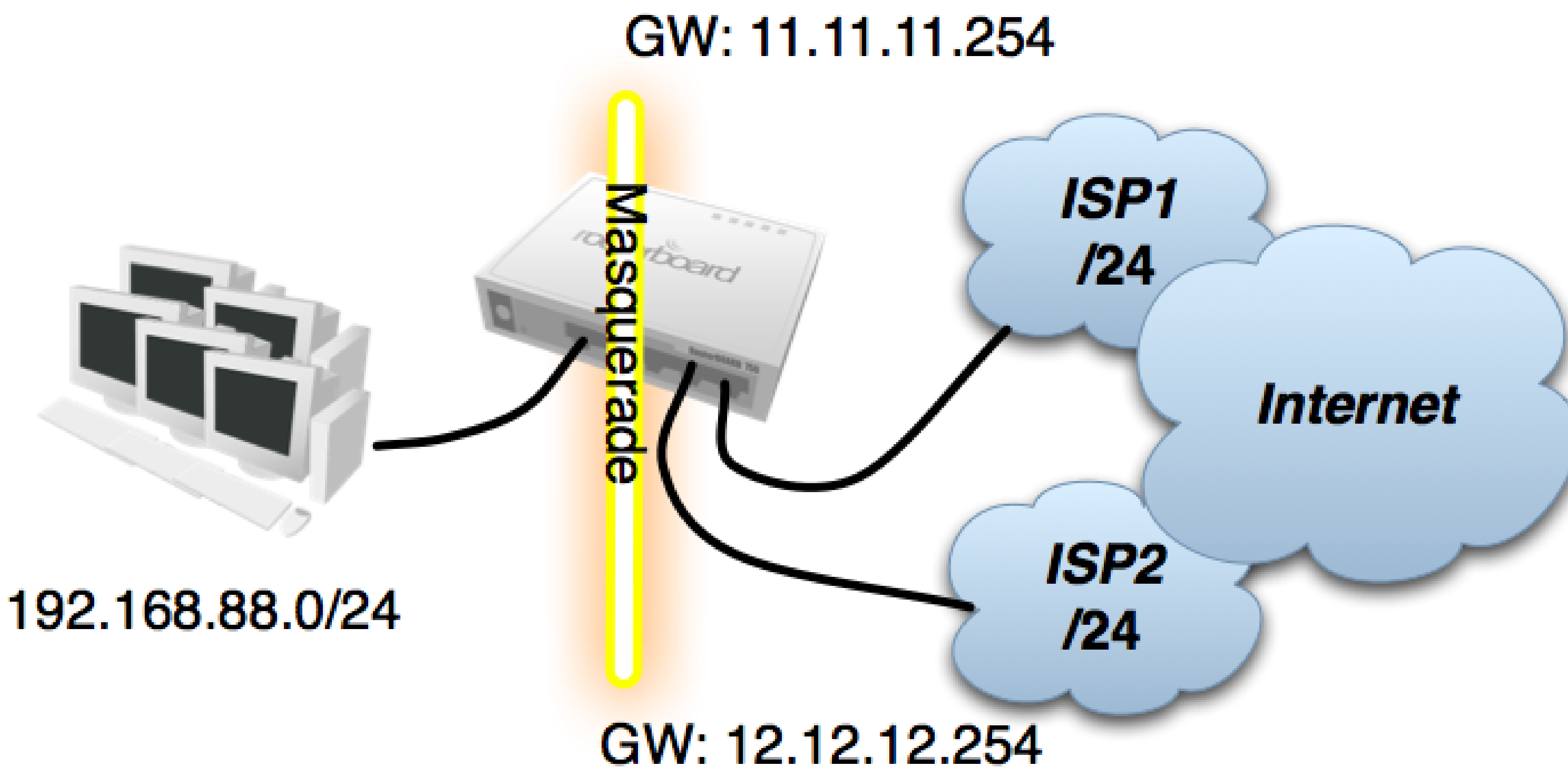
Interface ECMP Routing

- In case you have more that 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 for 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 polices 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 ether 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

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?

Traffic 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 <u>**bandwidth**</u> 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 current routing path (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

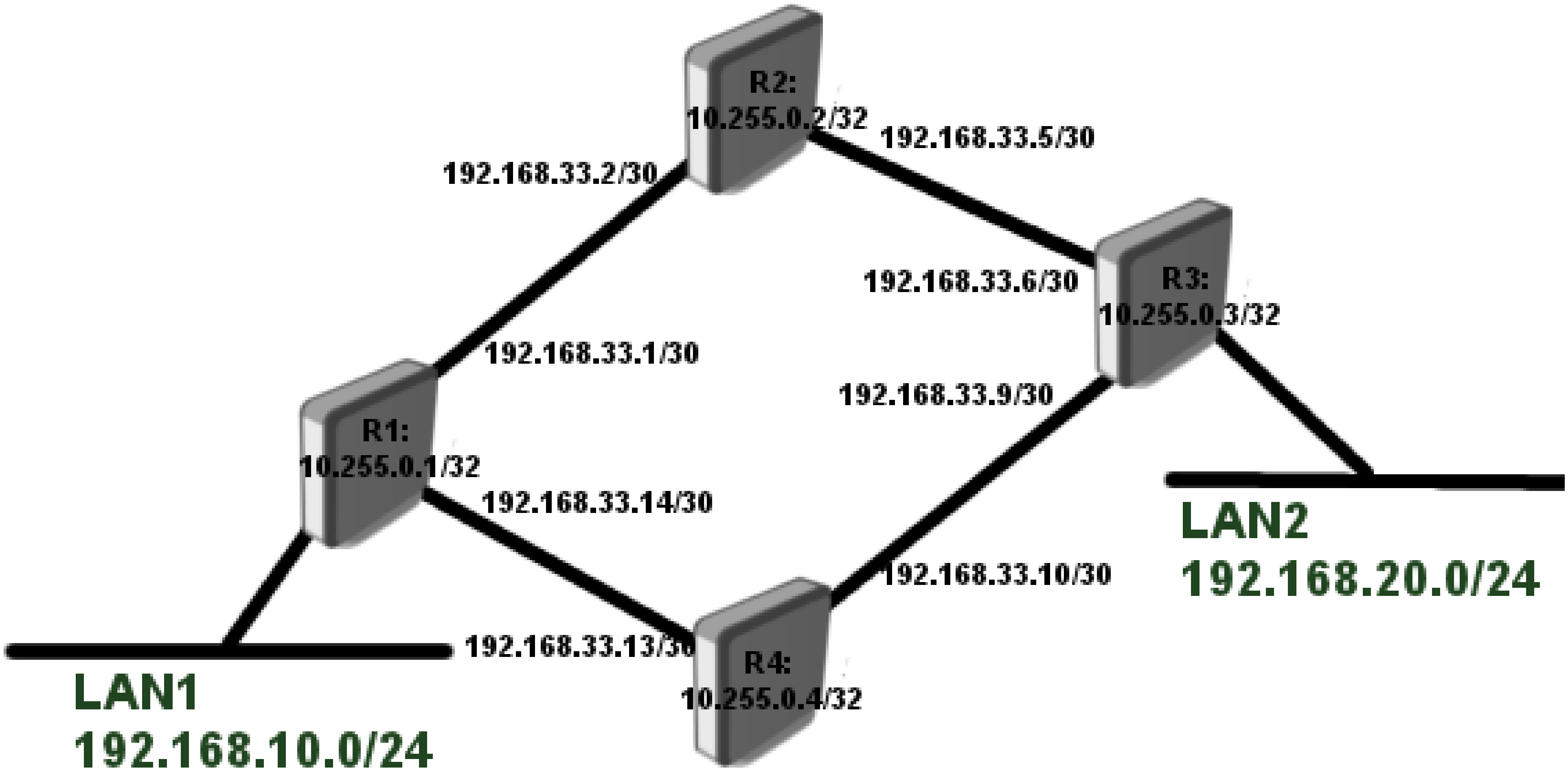
- Each router is connected to a neighbouring router using /30 network and each of them have unique Loopback address form 10.255.0.x network. Loopback addresses will be used as tunnel source and destination.

```
/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
```

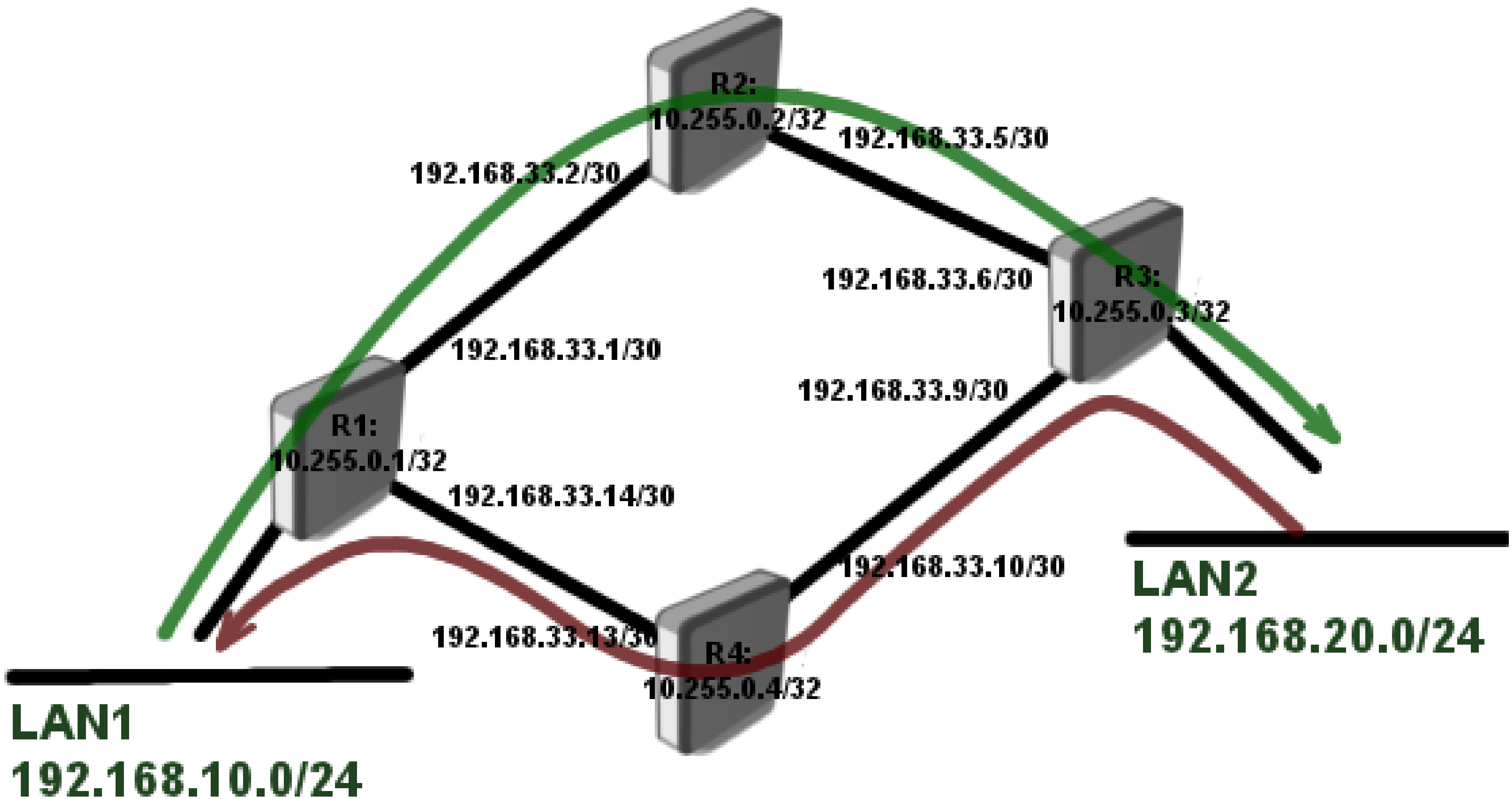
Resource Reservation

- 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


R2:
10.255.0.2/32
192.168.33.5/30
192.168.33.2/30
192.168.33.6/30
R3:
10.255.0.3/32
192.168.33.1/30
192.168.33.9/30
R1:
10.255.0.1/32
192.168.33.14/30
192.168.33.10/30
LAN2
192.168.20.0/24
192.168.33.13/30
R4:
10.255.0.4/32
LAN1
192.168.10.0/24

TE tunnel setup

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

R1

```
/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
```

R3

```
/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
```

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                 5.0Mbps
 1   ether2                                        10Mbps          1     10.0Mbp
```

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

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

R1

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

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

R3

```
[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.

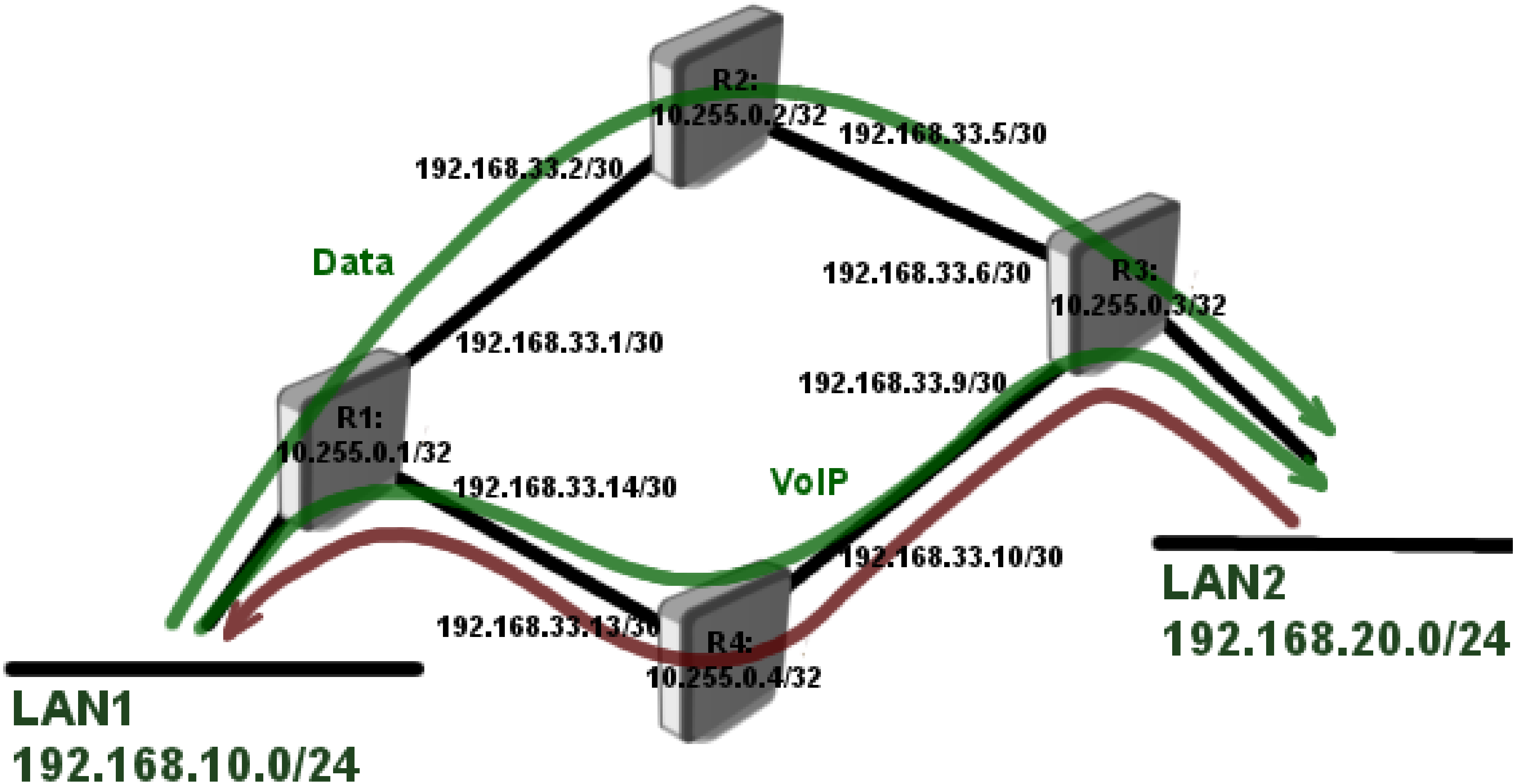
Automatic Failover

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

```
/interface trafic-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
```

R1

```
/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
```

```
/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:TE_Tunnels
- http://wiki.mikrotik.com/wiki/Manual:MPLS/Traffic-eng
- http://wiki.mikrotik.com/wiki/Manual:MPLS/Overview