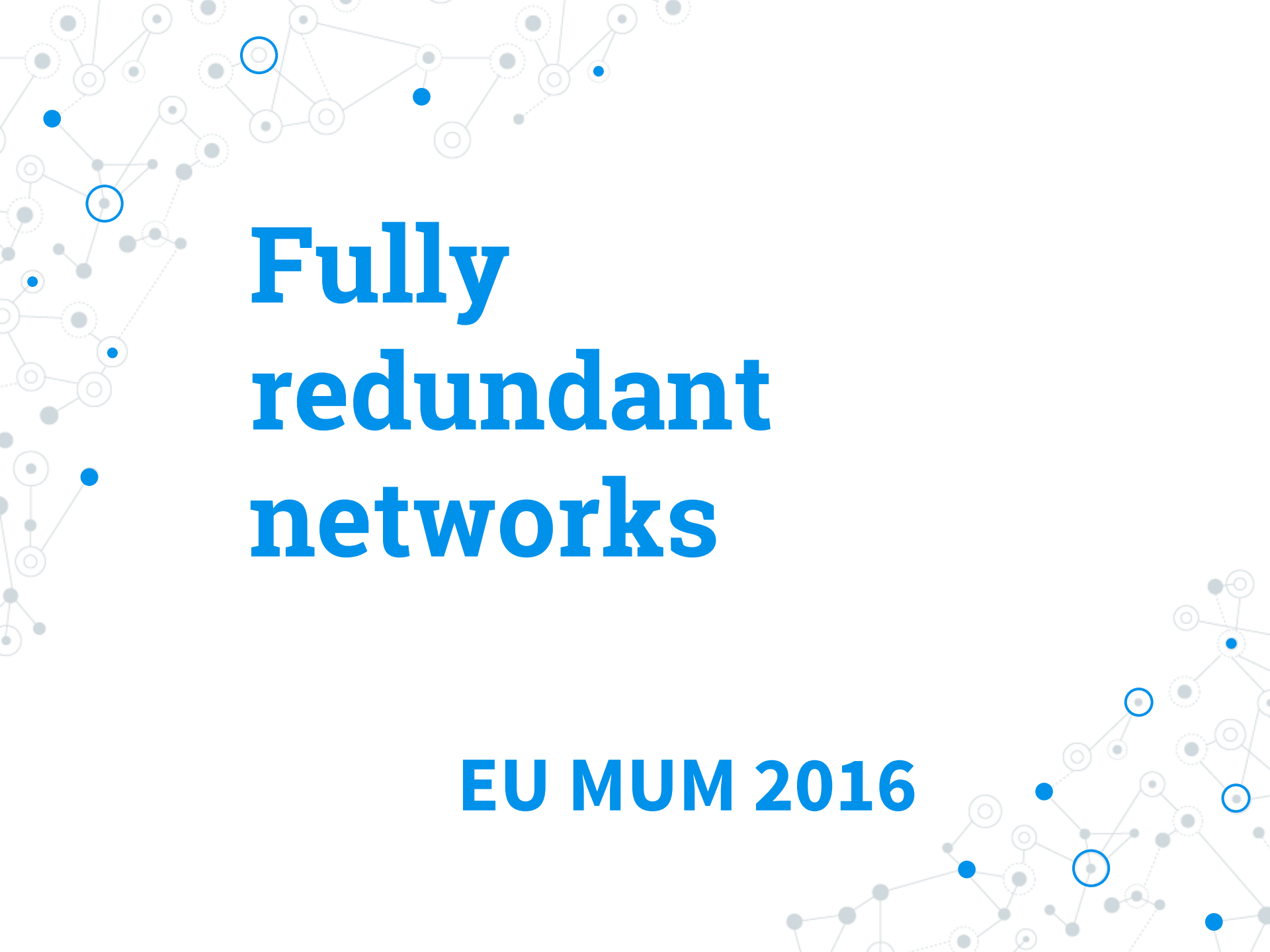


A decorative background featuring a network diagram with nodes and edges. The nodes are represented by circles of varying sizes and colors (blue, grey, white), connected by thin lines. Some nodes are highlighted with blue outlines. The network is distributed across the top-left and bottom-right corners of the slide.

Fully redundant networks

EU MUM 2016



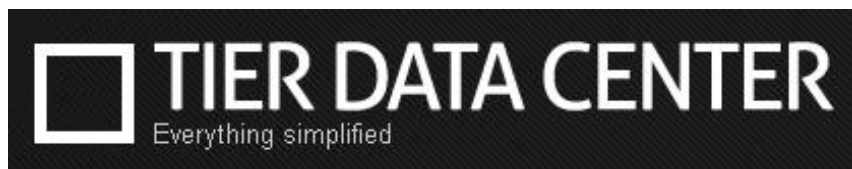
Hello!

I am Mihai Săftoiu

MTCNA, MTCTCE, MTCWE,
MTCUME, MTCRE, MTCINE
MikroTik Trainer



Consulting & Training



**A long time ago in a galaxy far,
far away....**



X-Wing Fighter



How can we make it work?

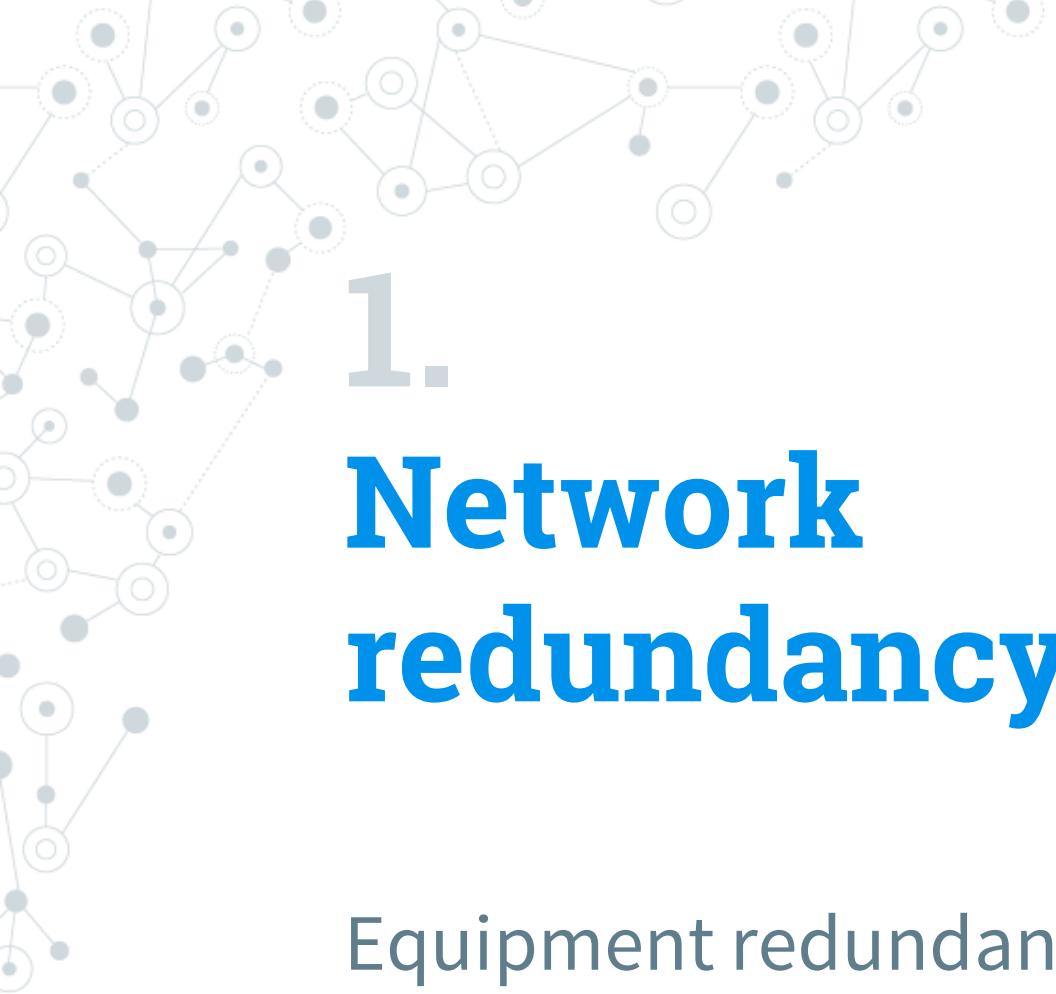




“

What is network redundancy?

*Is redundant network redundancy
redundant?*



1.

Network redundancy

Equipment redundancy

Path redundancy



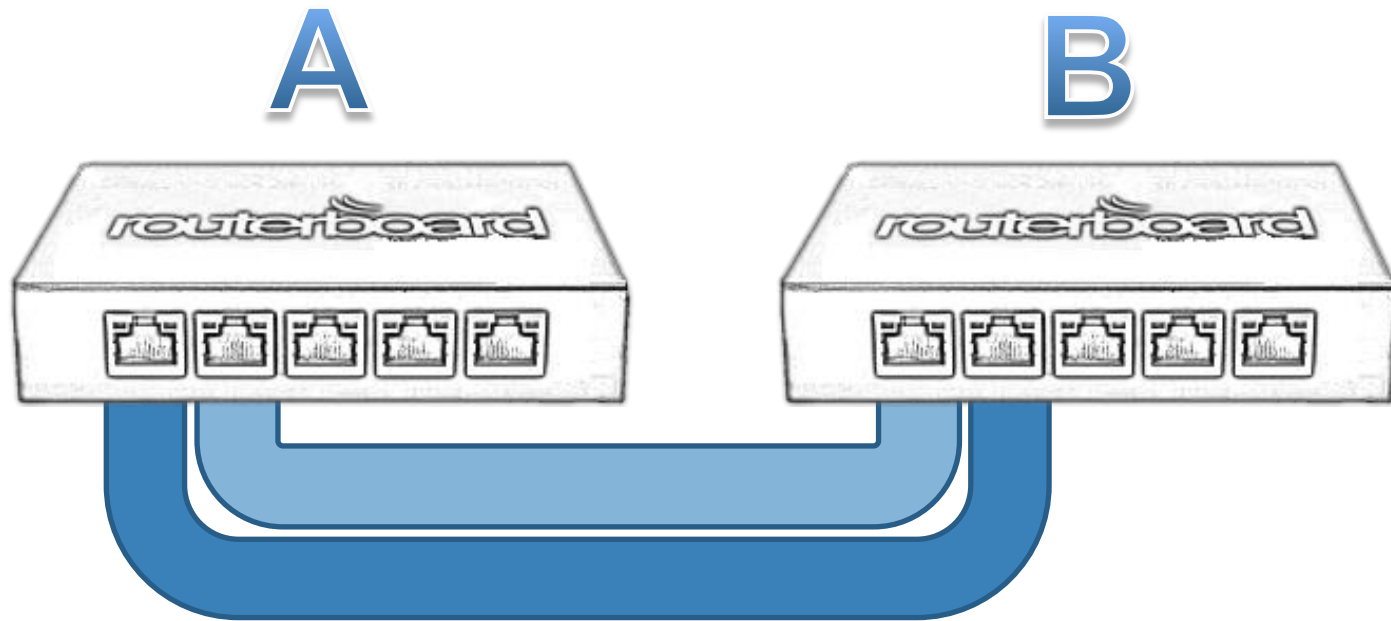
Equipment redundancy



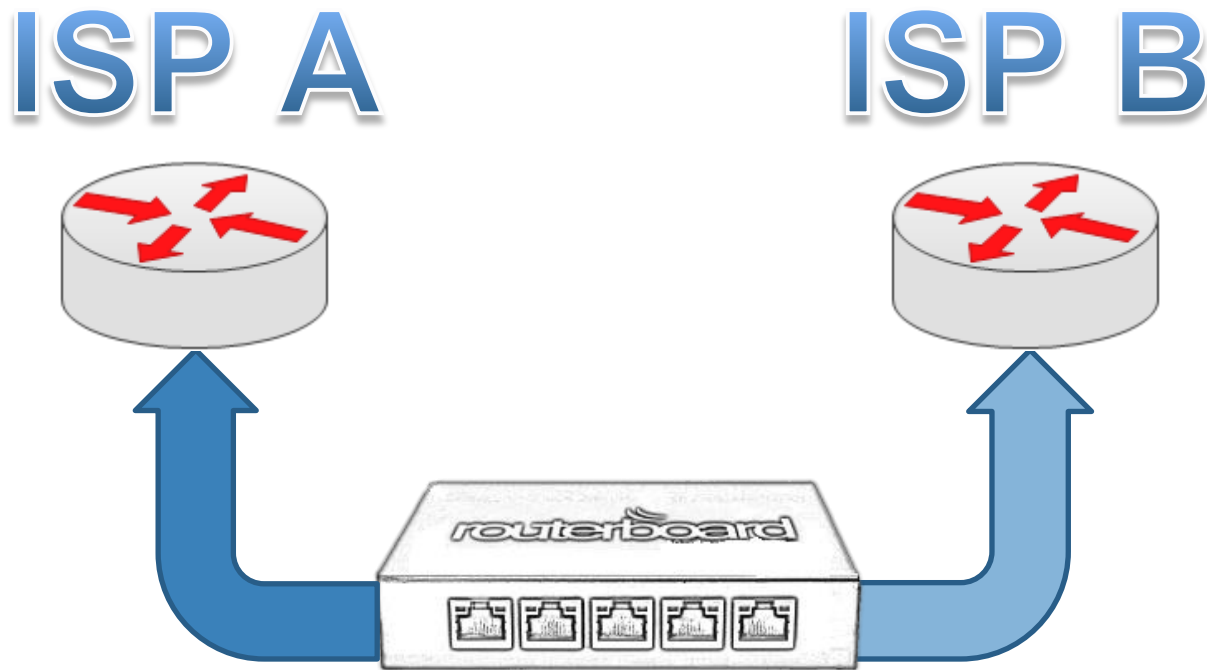
Path redundancy



Path redundancy



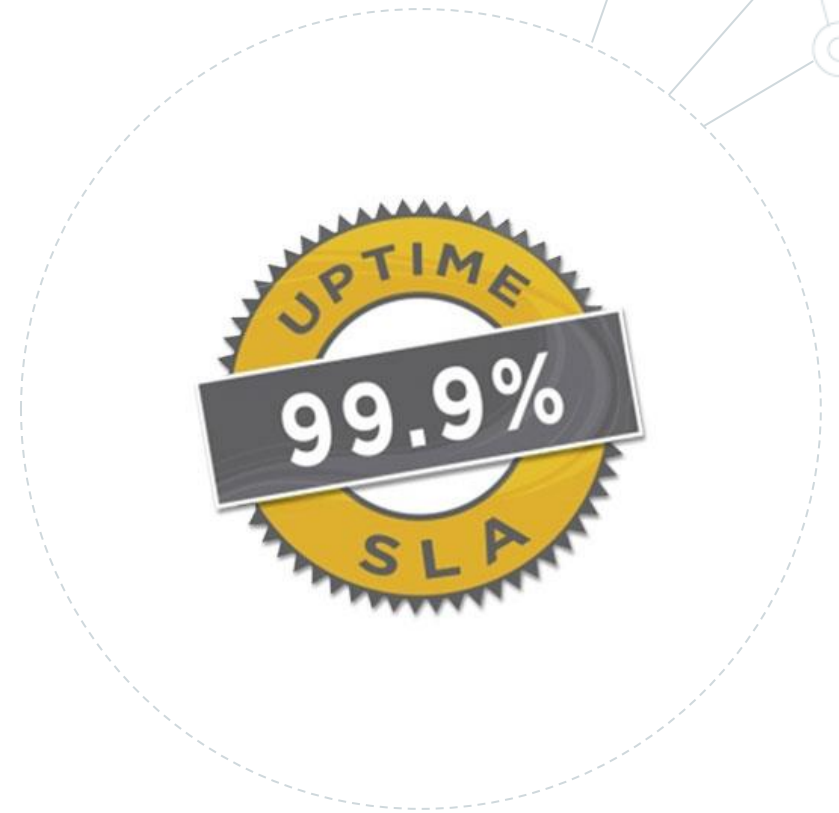
Upstream path redundancy



SLAs are based on calculations

Network uptime SLA:

This is not TIER based, as in case of data centers, but mathematically calculated.



Calculation based on 1%



For every single point of failure
in the network we take 1%
(thumb rule) of monthly
downtime into account

A decorative network diagram in the top-left corner, featuring a complex web of interconnected nodes and lines. The nodes are represented by circles of varying sizes, some with concentric rings, and the lines are thin and grey. The diagram is partially cut off by the left edge of the slide.

2.

Non redundant networks

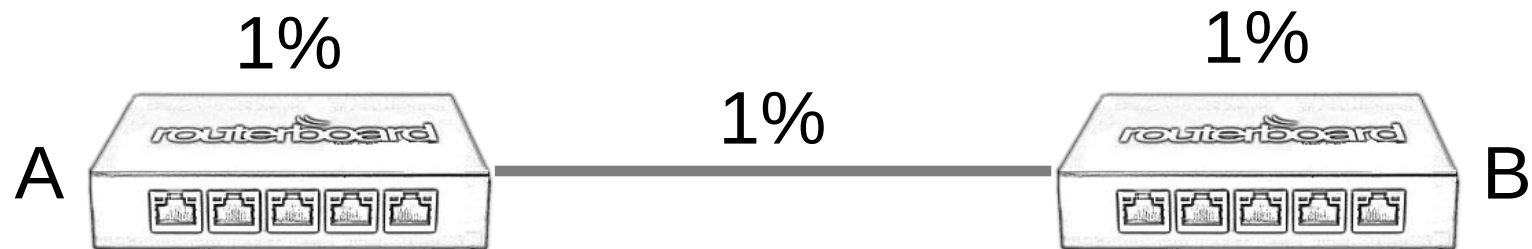
No equipment redundancy

No path redundancy

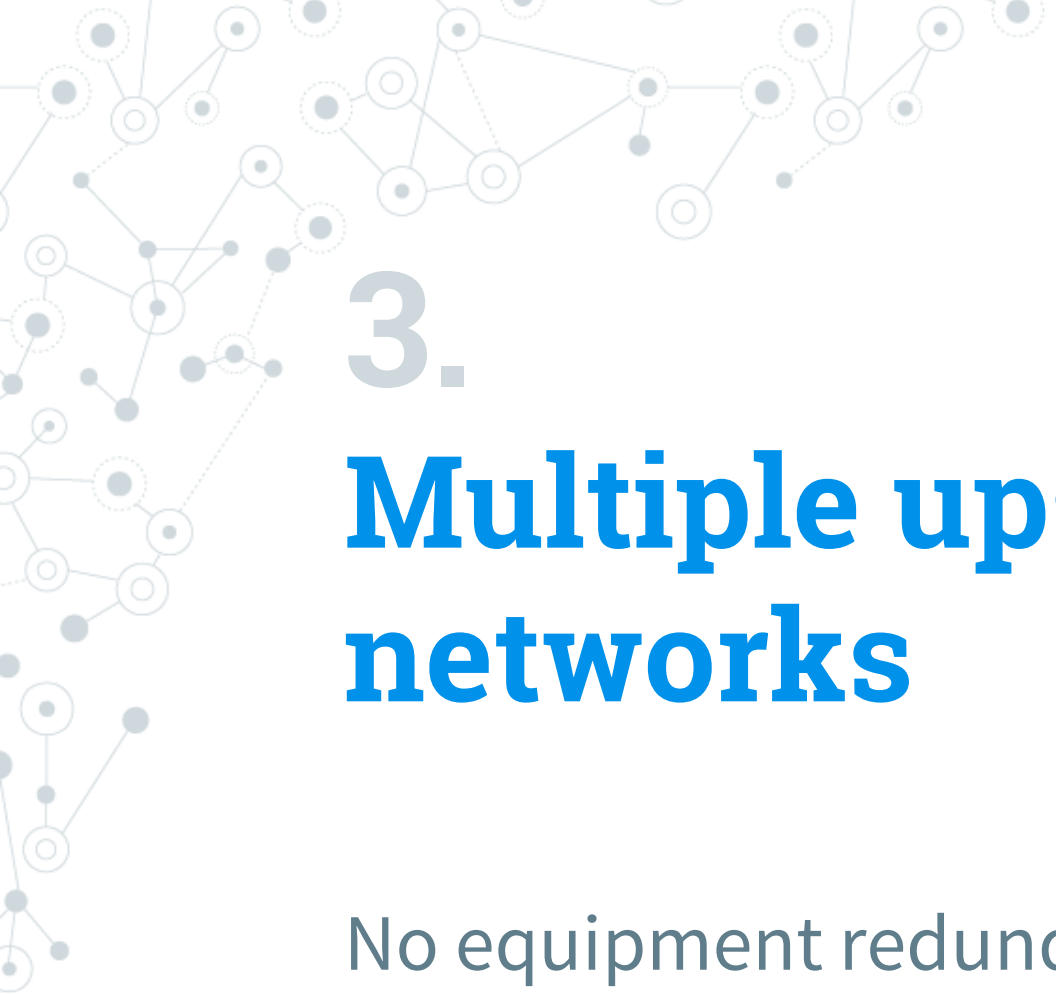
A decorative network diagram in the bottom-right corner, similar to the one in the top-left. It shows a complex web of interconnected nodes and lines, with nodes represented by circles of varying sizes and lines as thin grey connections. The diagram is partially cut off by the right edge of the slide.

EXAMPLE

- ◎ 1% means: $30,5 \text{ days} \times 24\text{h} / 100 = \mathbf{7,32\text{h}}$
- ◎ 1% of downtime for device A
- ◎ 1% of downtime for device B
- ◎ 1% of downtime for the link



Max network downtime = 3%
(SLA = 97% guaranteed uptime)



3.

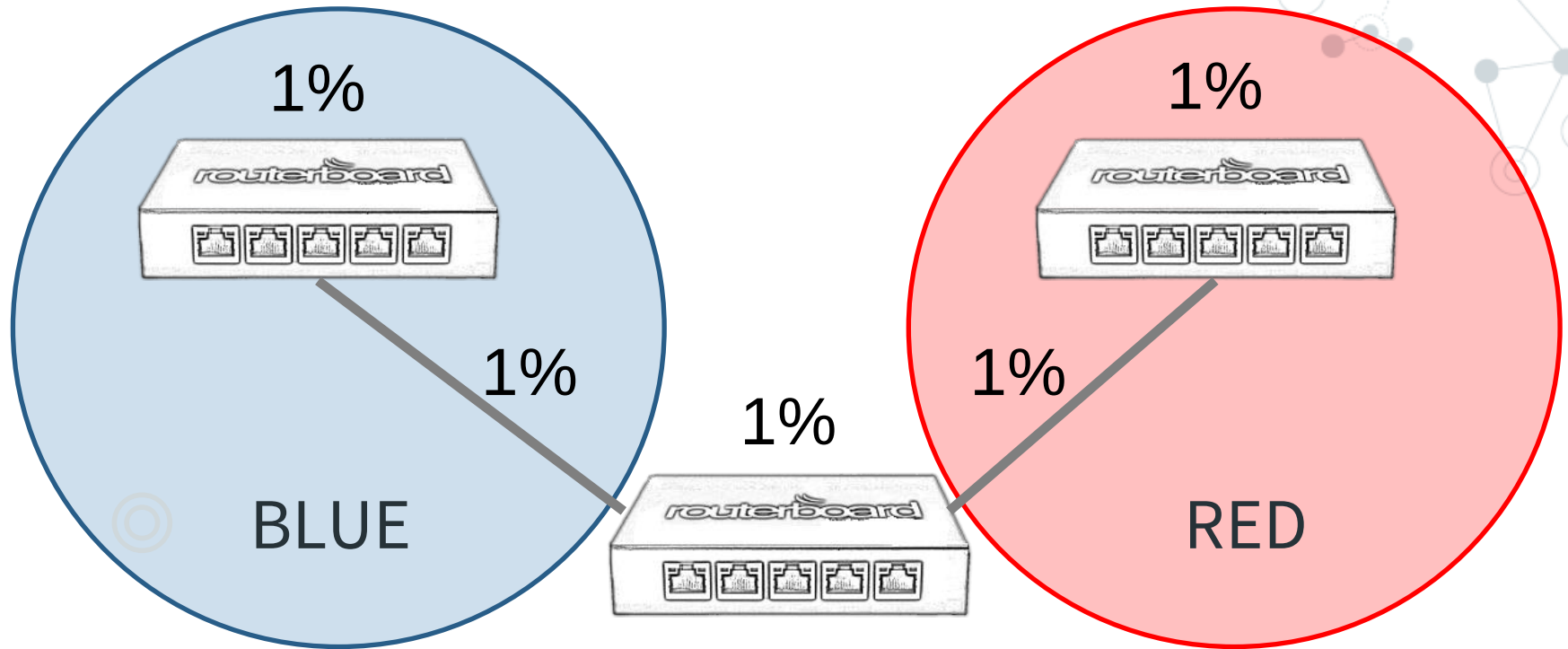
Multiple upstream networks

No equipment redundancy

Partial upstream path redundancy



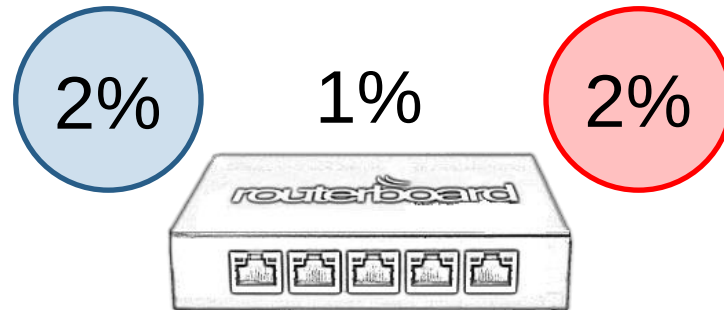
WHAT IF WE DO IT LIKE THIS?



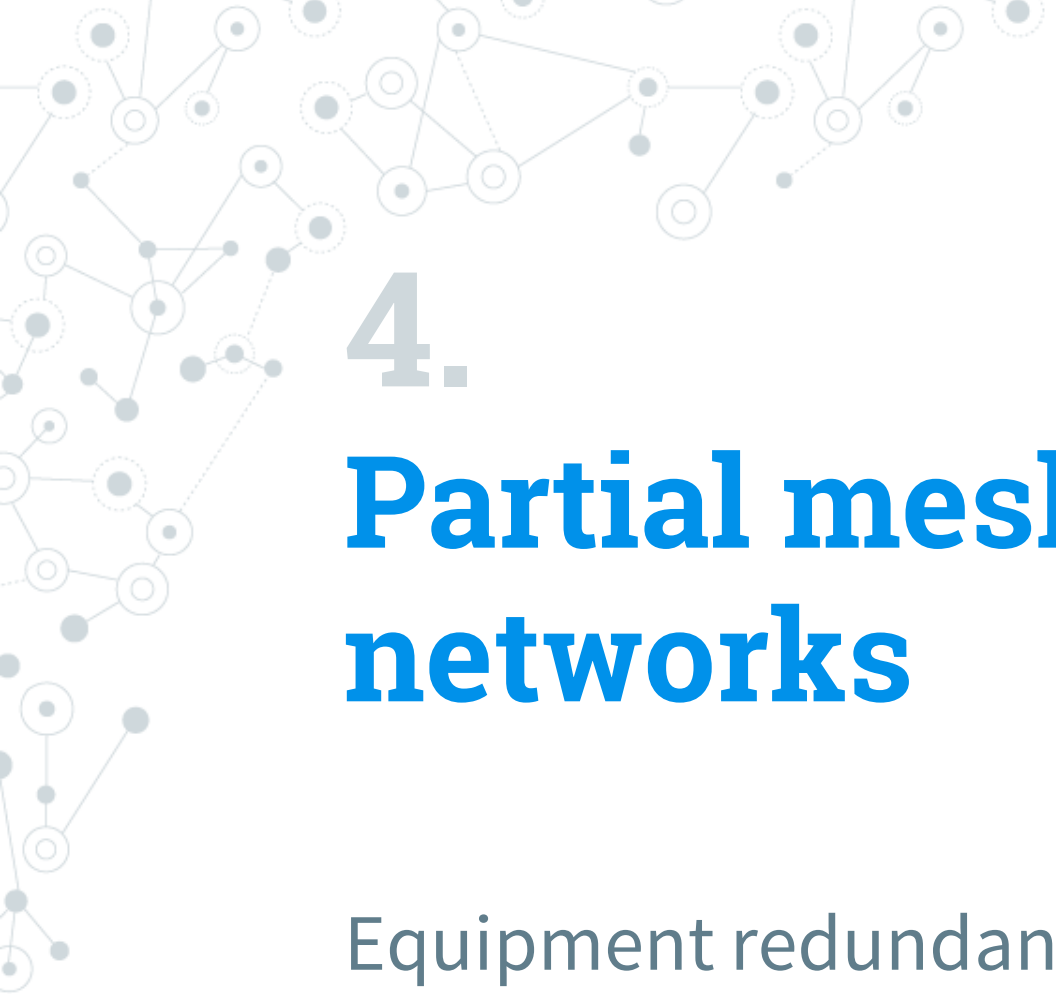
◎ BLUE max downtime = 2%

◎ RED max downtime = 2%

CALCULATION



- ◎ The chance BLUE and RED will both be down is: $2\% \times 2\% = 0,04\%$
- ◎ The worst case that RB and both ISPs will be down is: $1\% + 0,04\% = 1,04\%$
- ◎ SLA for the current network: 98,96%



4.

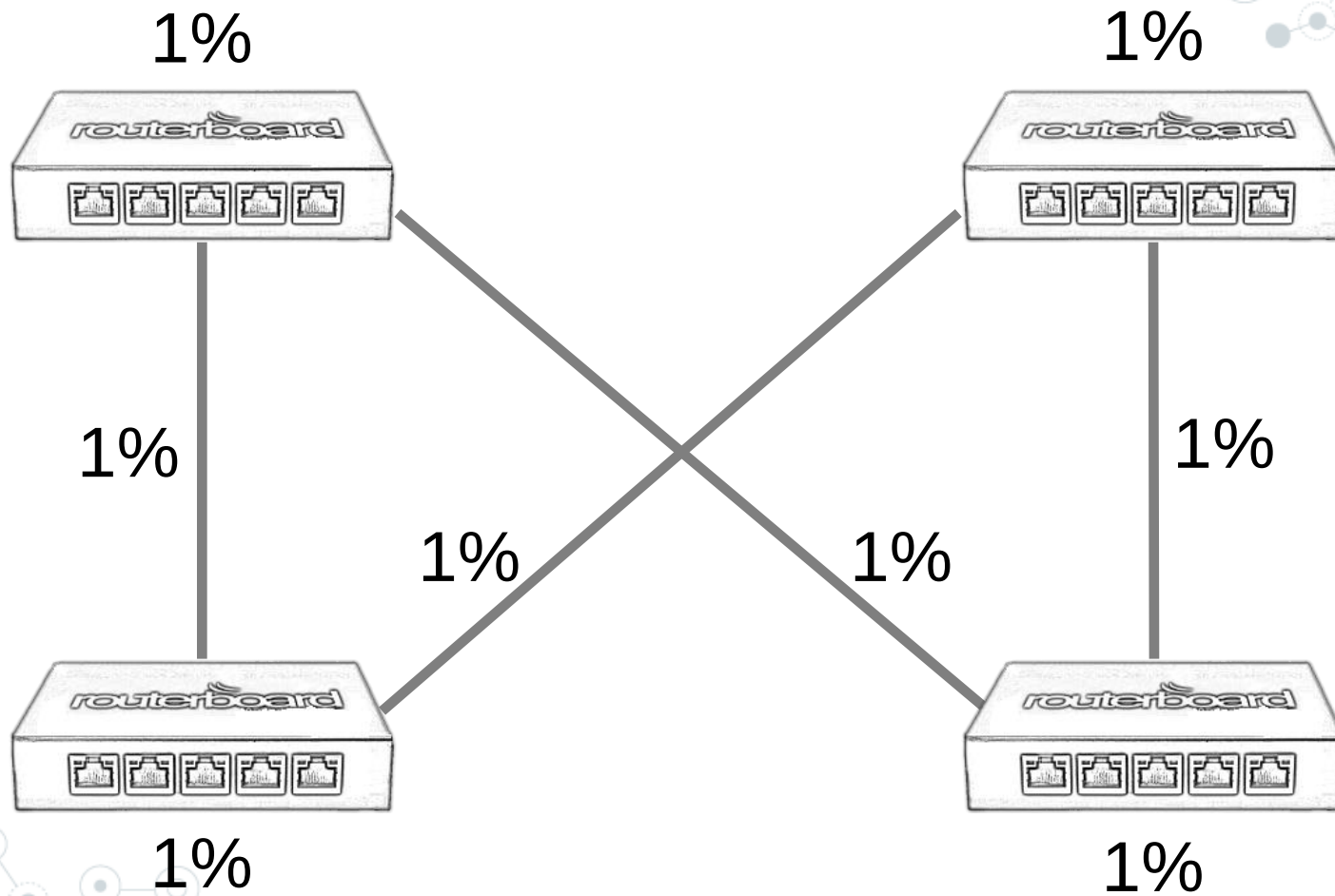
Partial mesh networks

Equipment redundancy

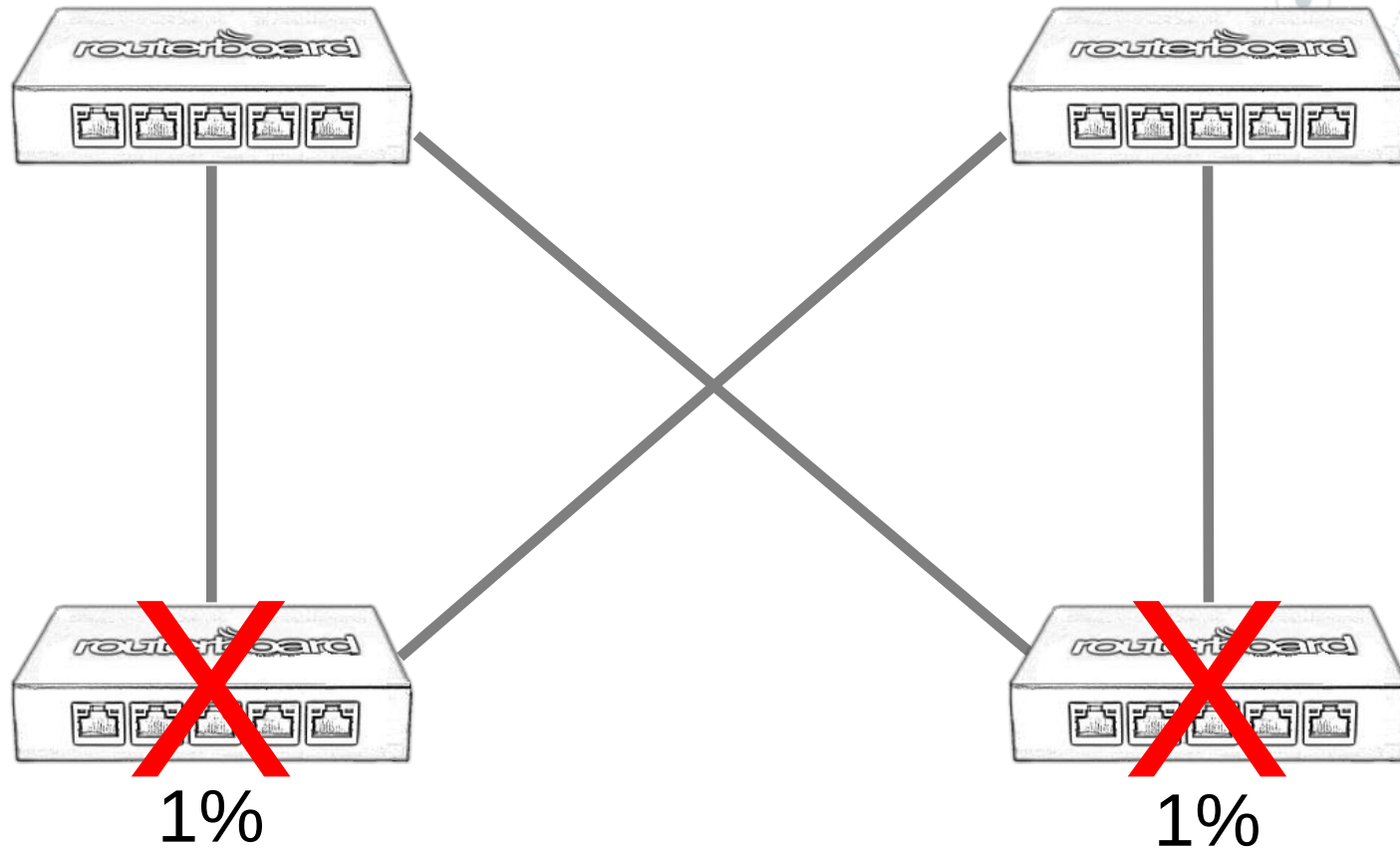
Multiple upstream path
redundancy



WITH UP TO 3 POINTS OF FAILURE THIS NETWORK CAN FAIL IN 6 WAYS



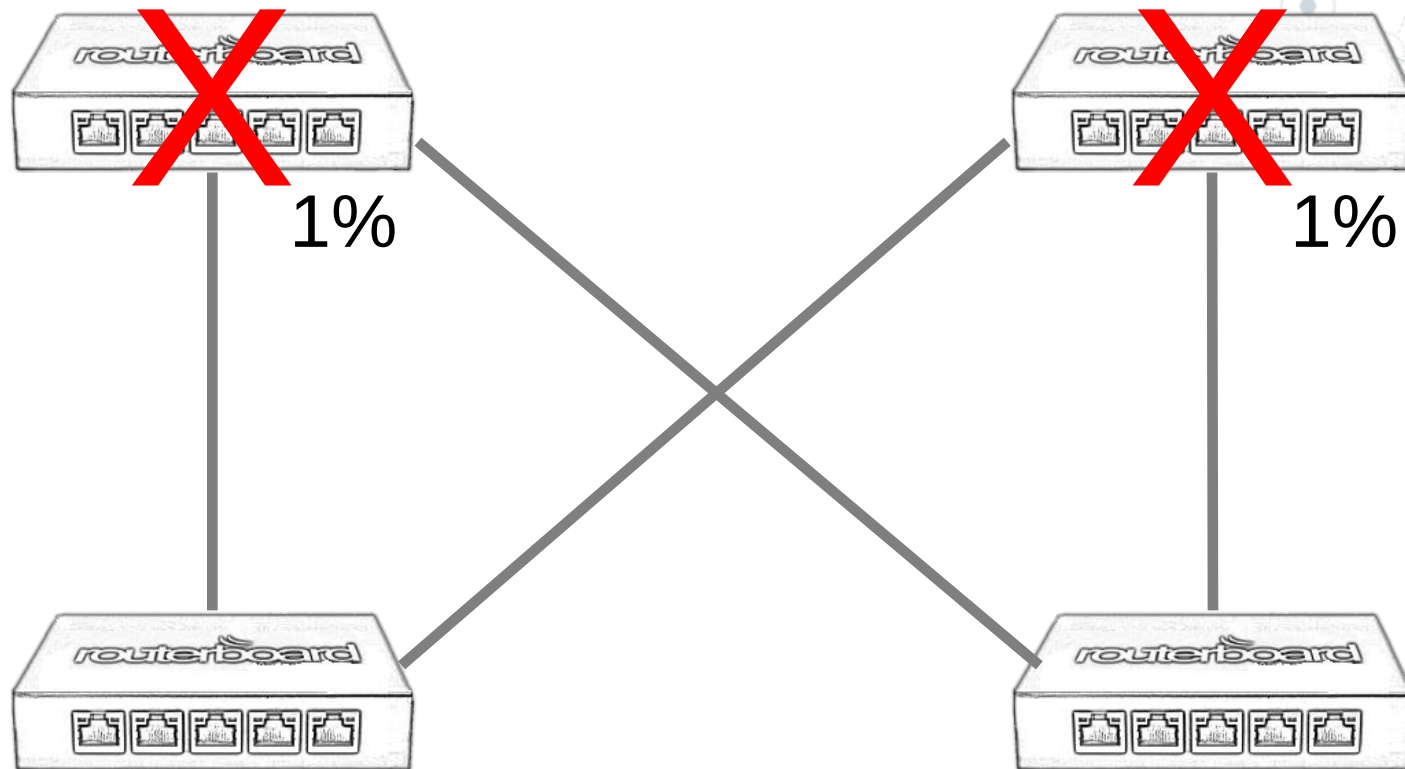
FAIL NO. 1



The chance for this to happen:

$$1\% \times 1\% = 0,01\%$$

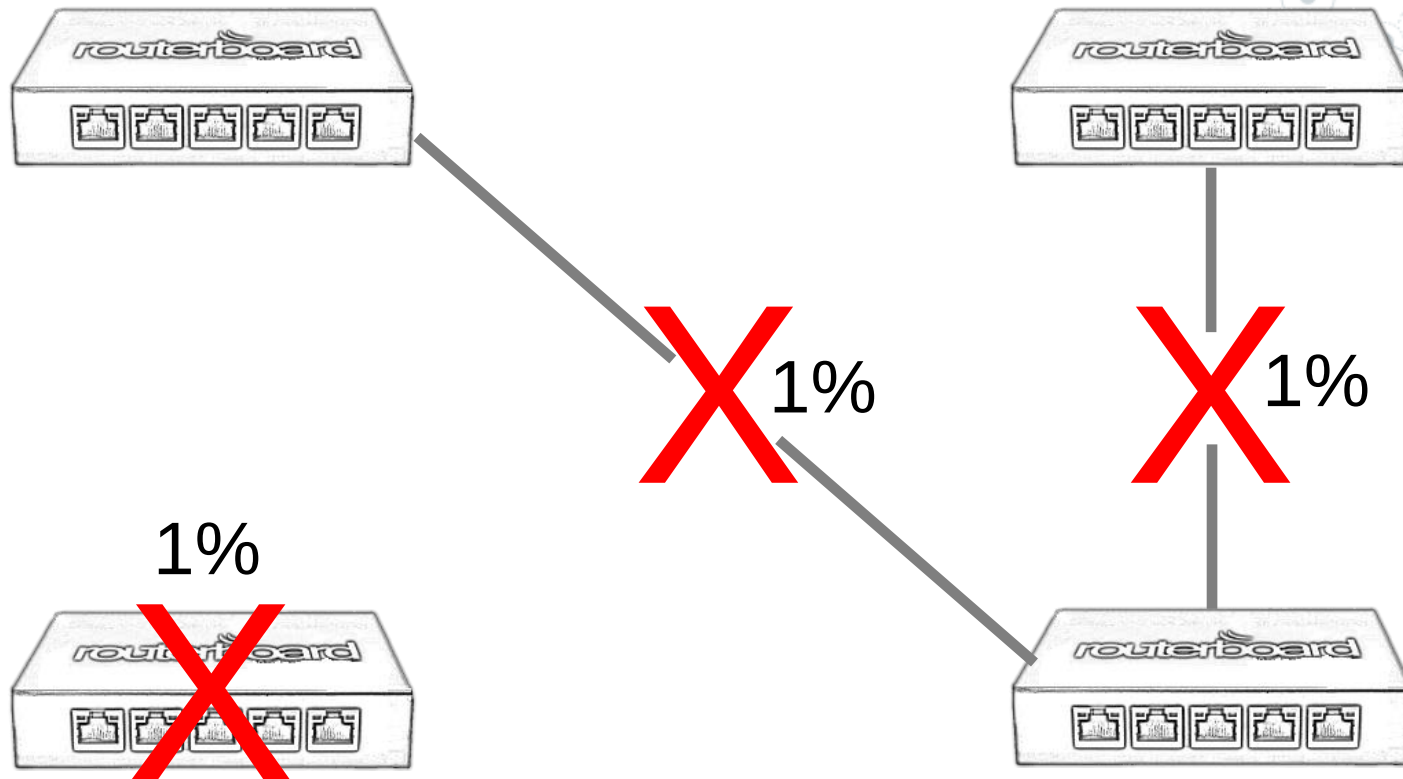
FAIL NO. 2



The chance for this to happen:

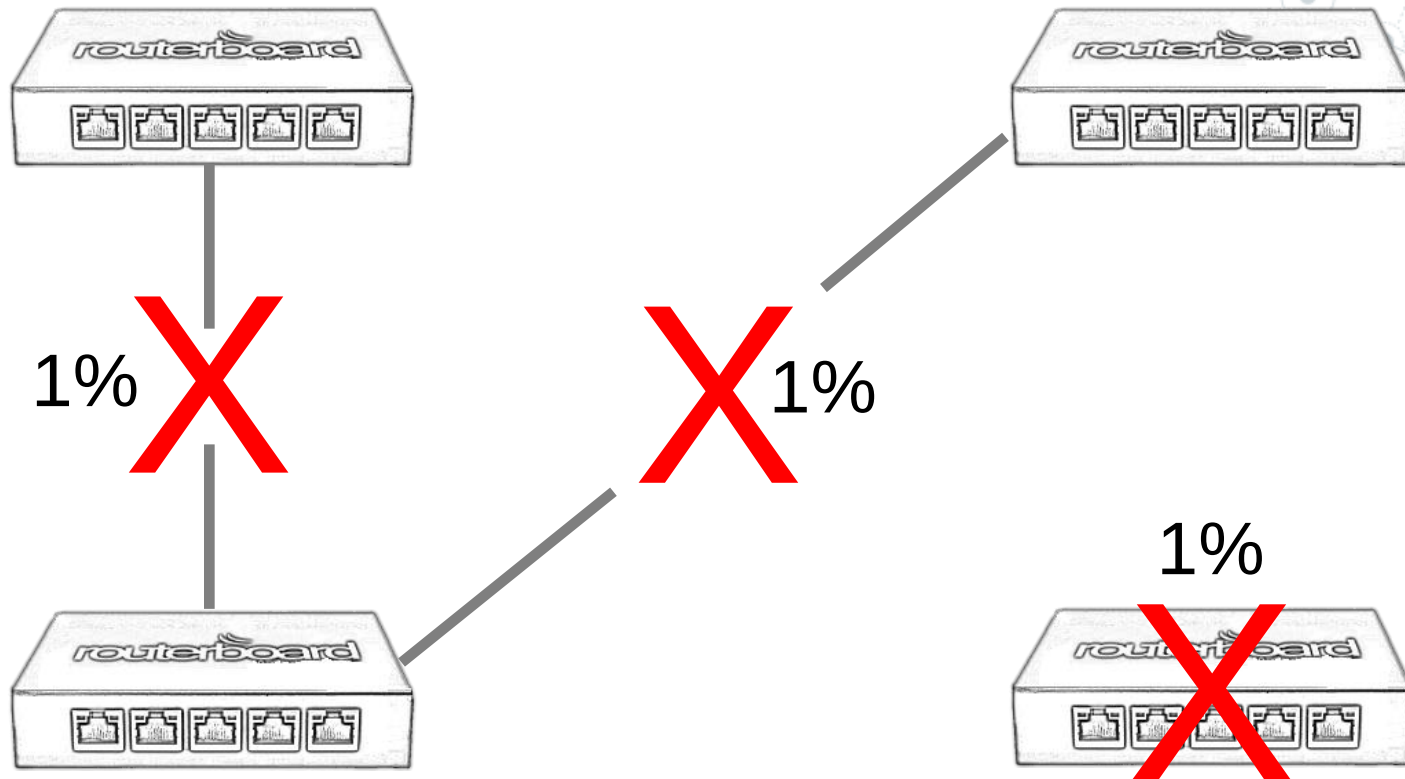
$$1\% \times 1\% = 0,01\%$$

FAIL NO. 3



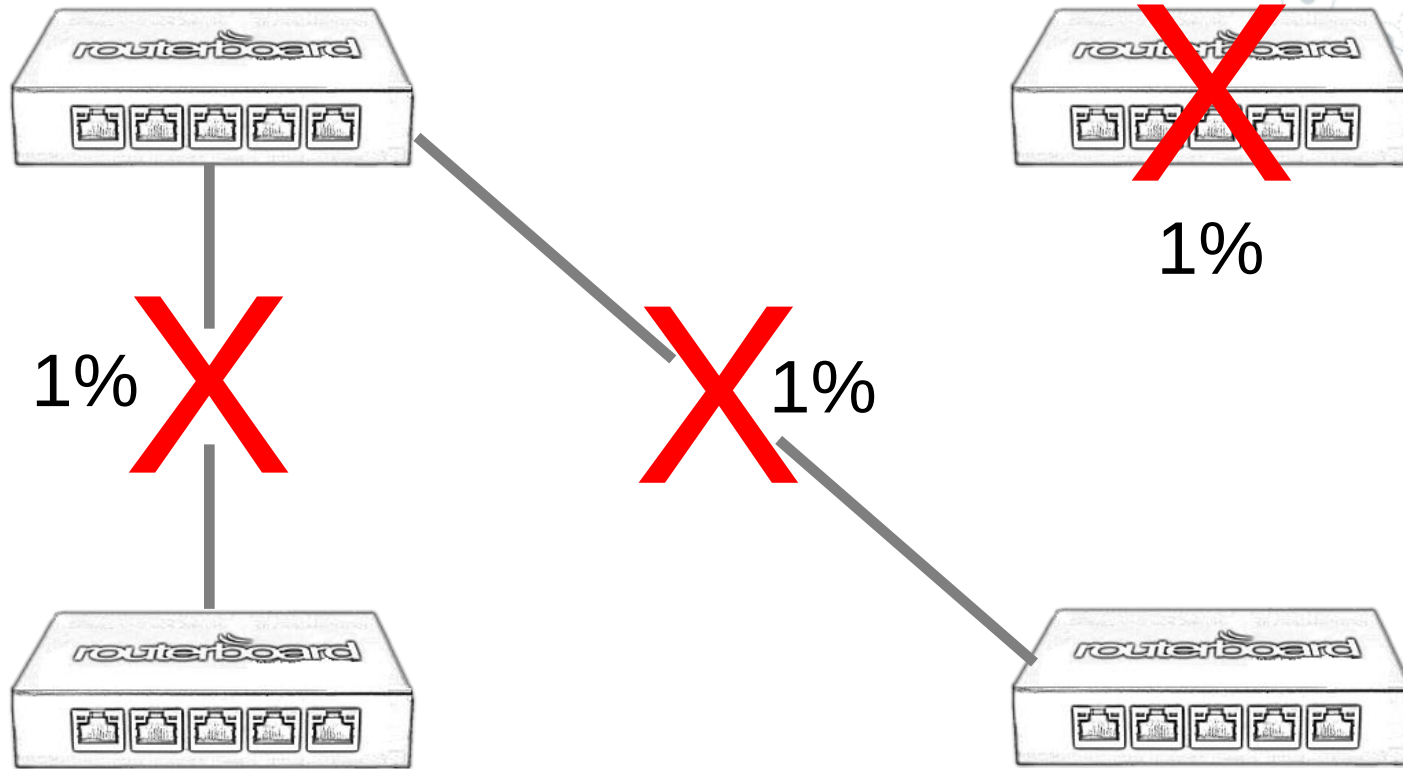
🎯 The chance for this to happen:
 $1\% \times 1\% \times 1\% = 0,0001\%$

FAIL NO. 4



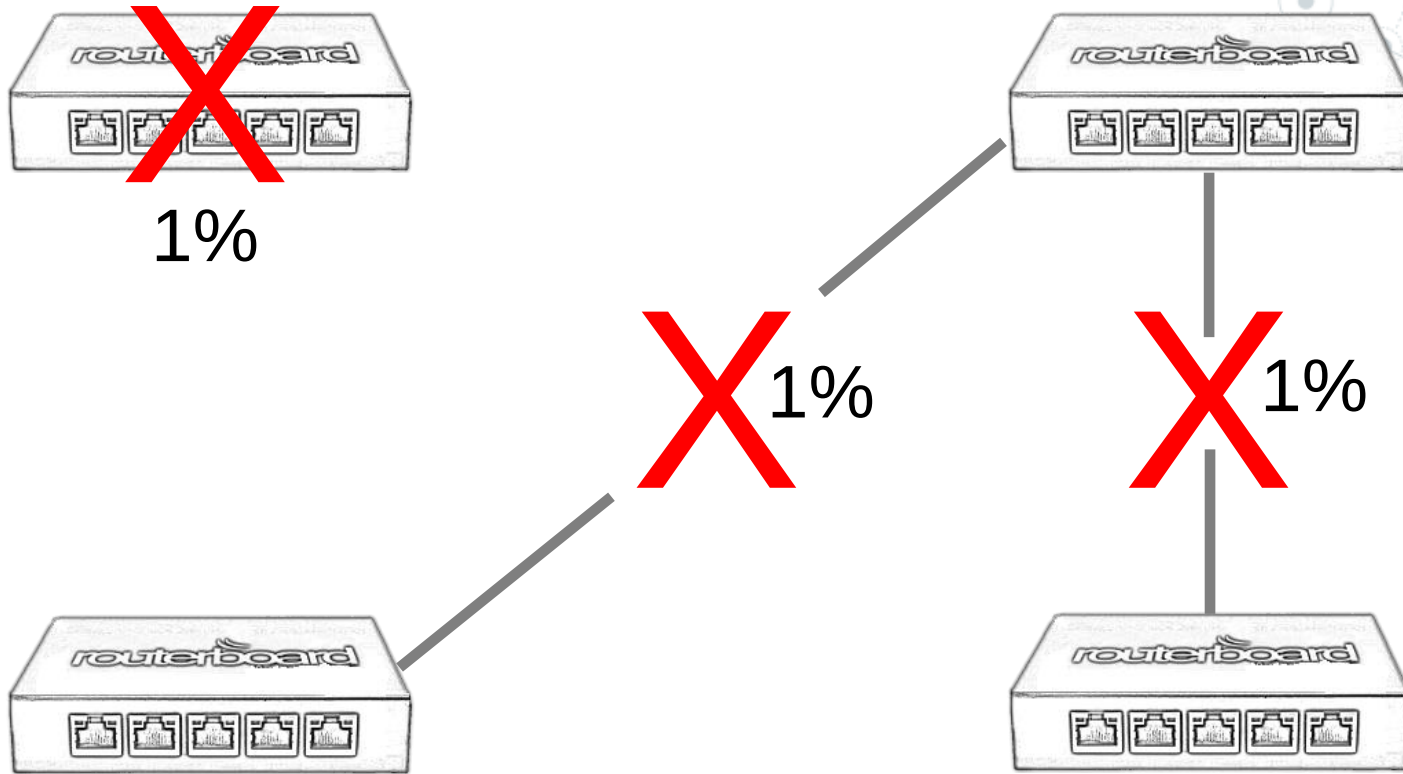
🎯 The chance for this to happen:
 $1\% \times 1\% \times 1\% = 0,0001\%$

FAIL NO. 5



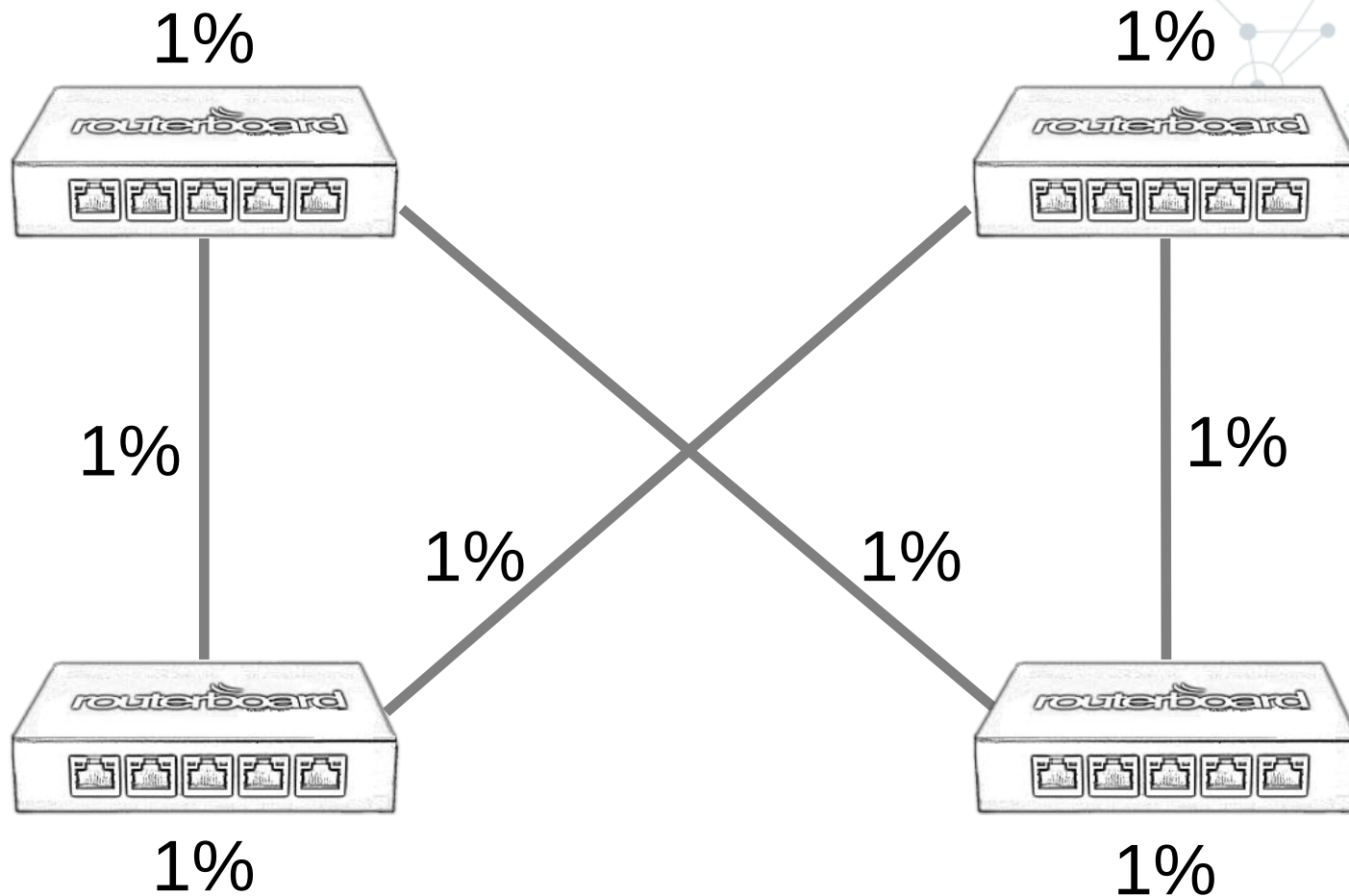
🎯 The chance for this to happen:
 $1\% \times 1\% \times 1\% = 0,0001\%$

FAIL NO. 6



🎯 The chance for this to happen:
 $1\% \times 1\% \times 1\% = 0,0001\%$

TOTAL FAILURE RATE



$$4 \times 0,0001\% + 2 \times 0,01\% = 0,0204\%$$

SLA: 99,9796% (**99,9%**)

A decorative network diagram in the top-left corner, featuring a complex web of interconnected nodes and lines. The nodes are represented by circles of varying sizes, some with concentric rings, and the lines are thin and grey. The diagram is partially cut off by the left edge of the slide.

5.

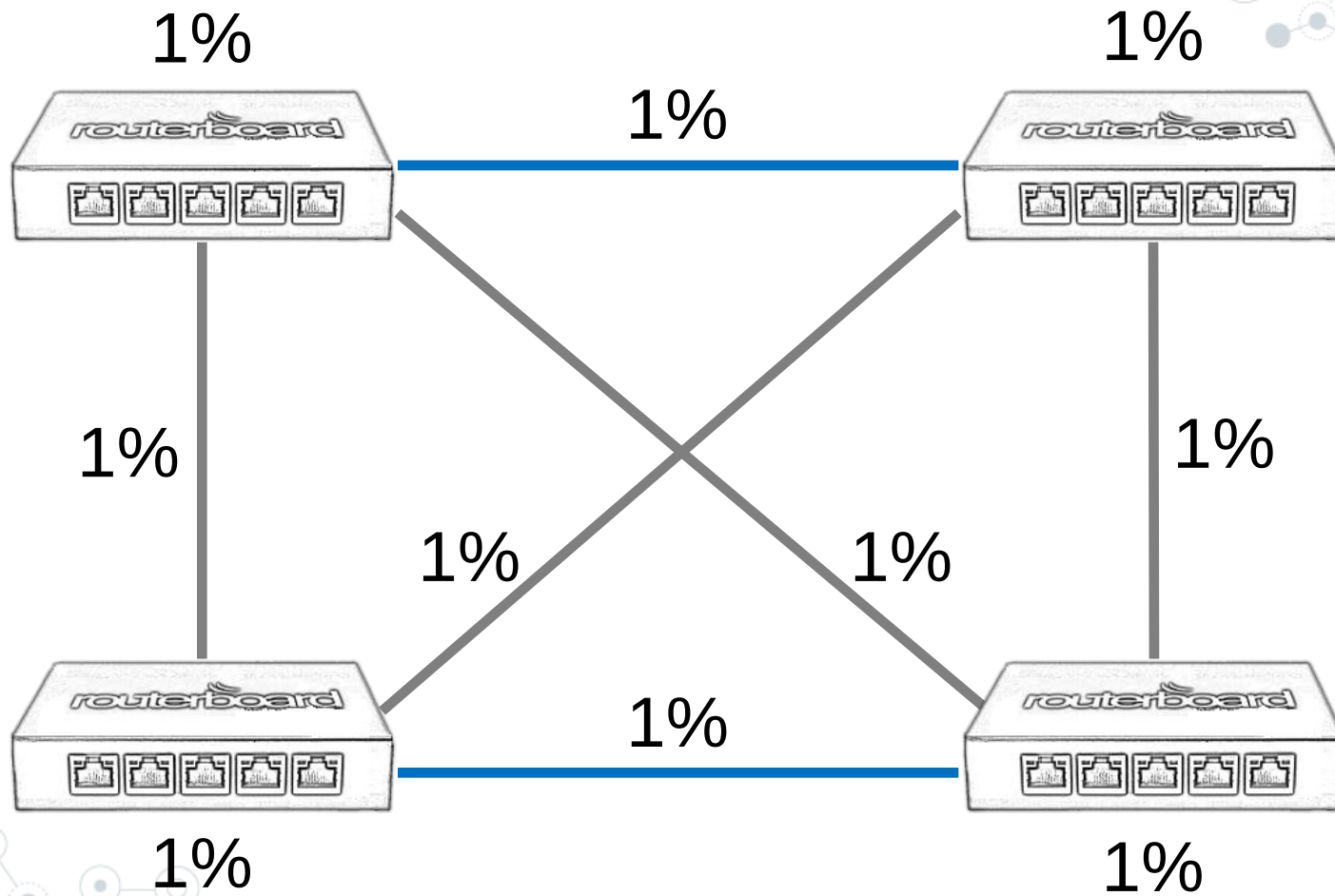
Mesh networks

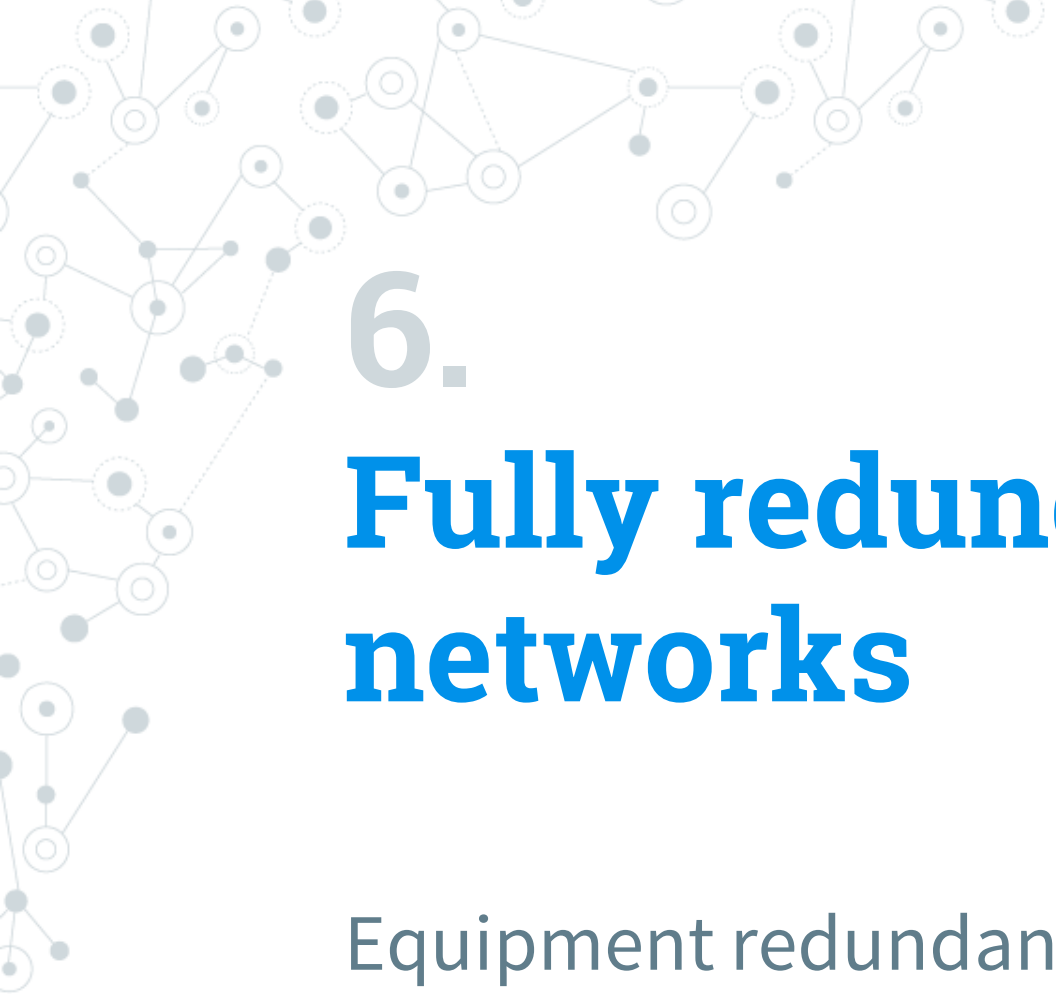
Equipment redundancy

Multiple path redundancy and
upstream path redundancy

A decorative network diagram in the bottom-right corner, similar to the one in the top-left. It shows a complex web of interconnected nodes and lines, with nodes represented by circles of varying sizes and lines by thin grey lines. The diagram is partially cut off by the right edge of the slide.

99,9% MESH NETWORK





6.

Fully redundant networks

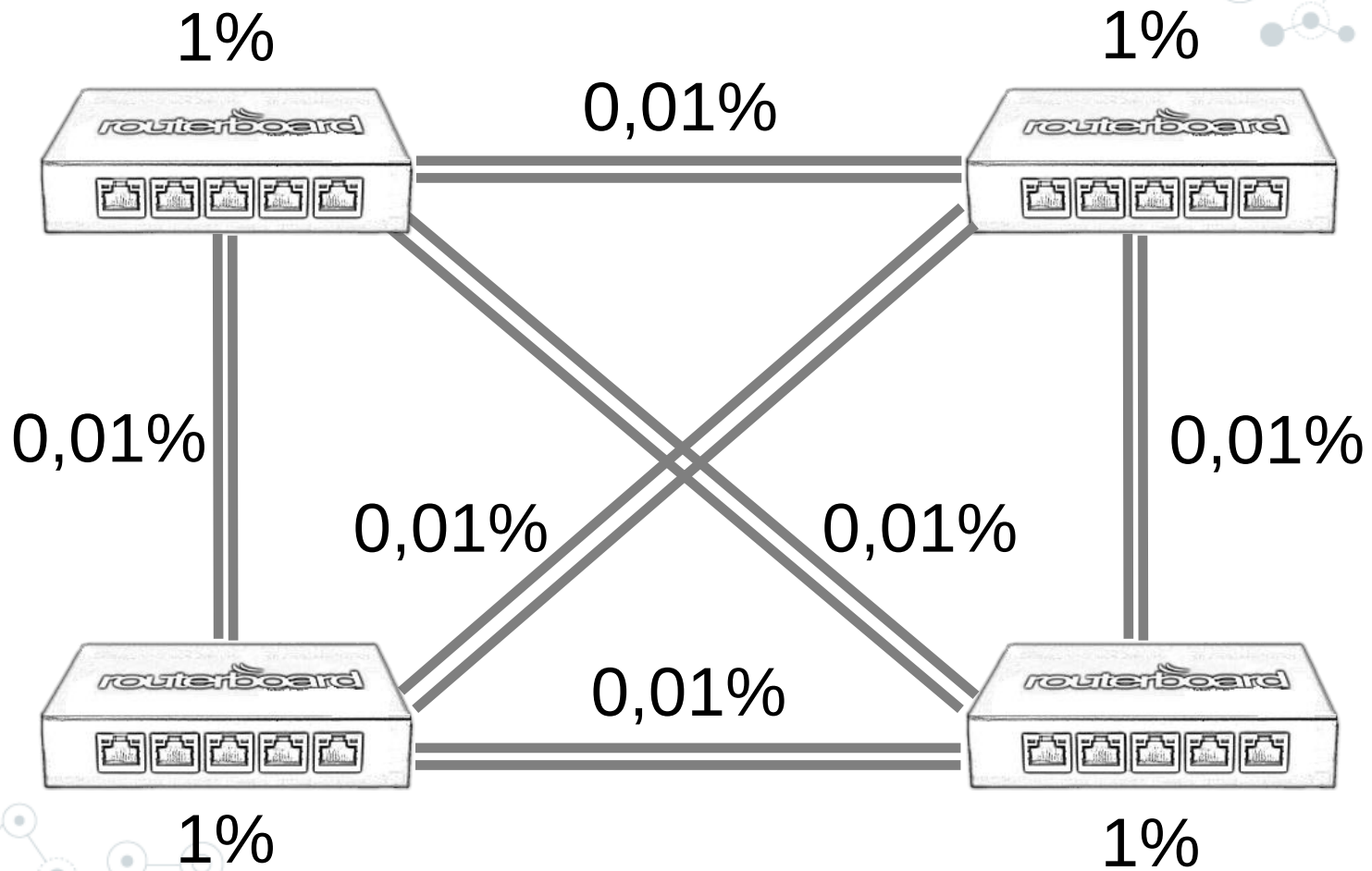
Equipment redundancy

Double path redundancy with
double upstream path redundancy



99,98%

FULLY REDUNDANT NETWORK



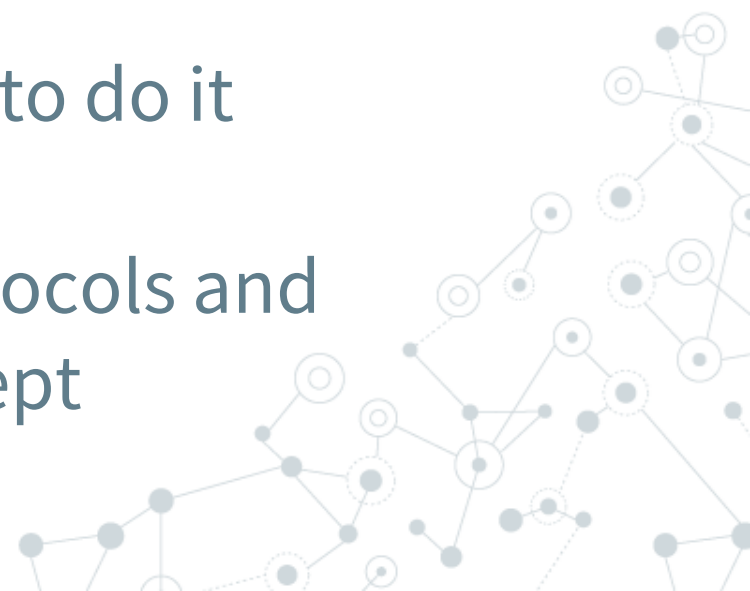


7.

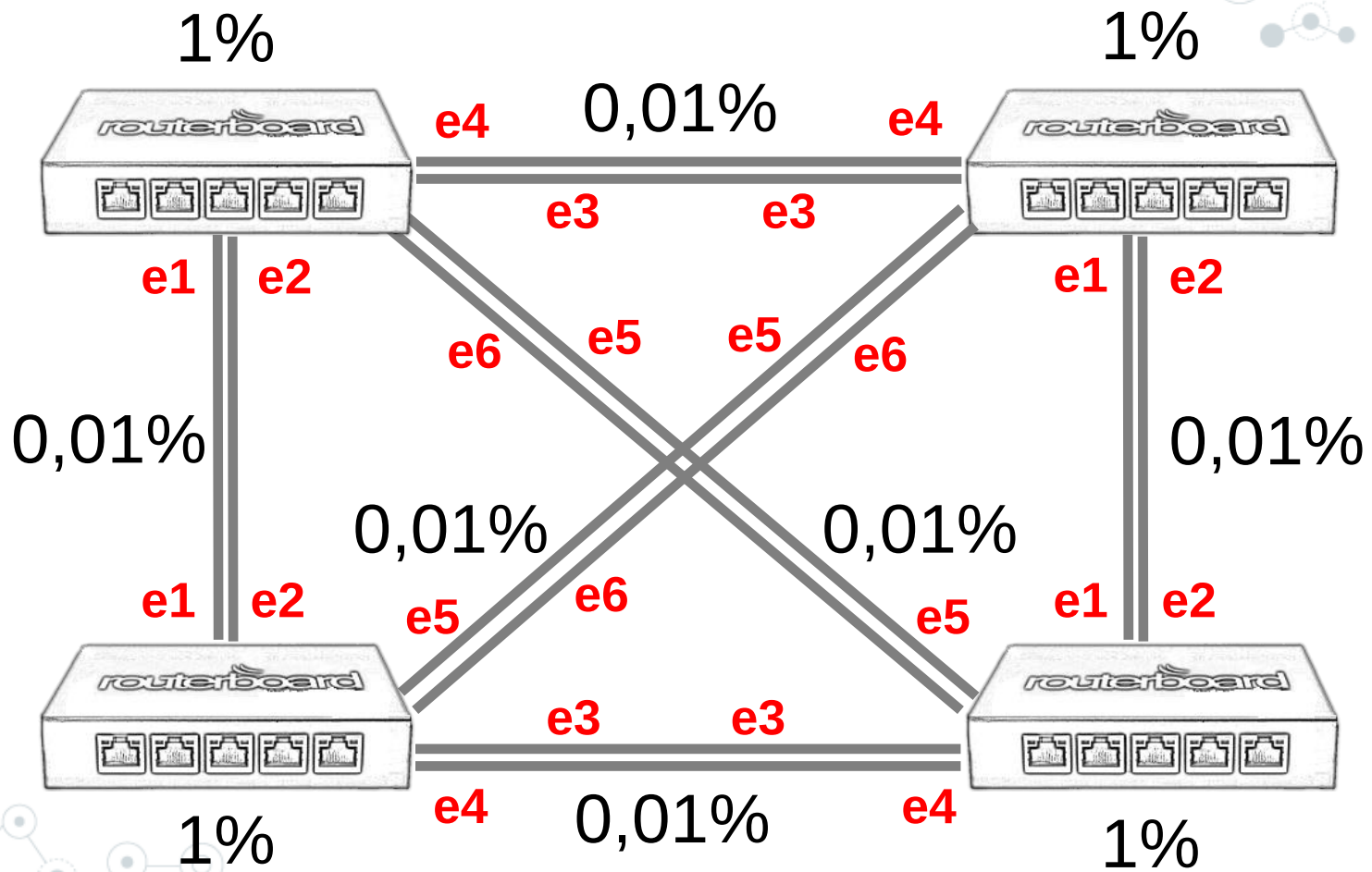
Let's do it on MikroTik

There are different ways to do it

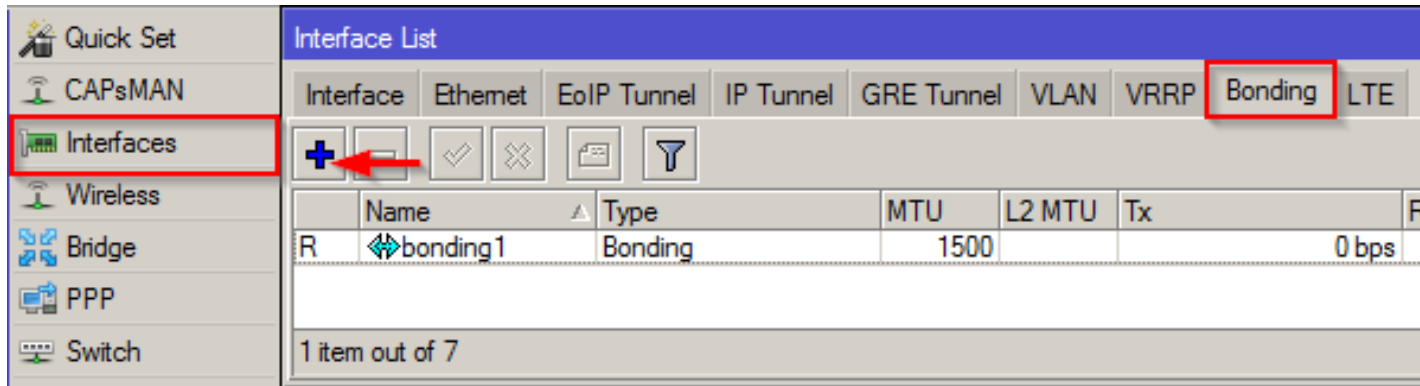
We will use multiple protocols and
layers to prove the concept



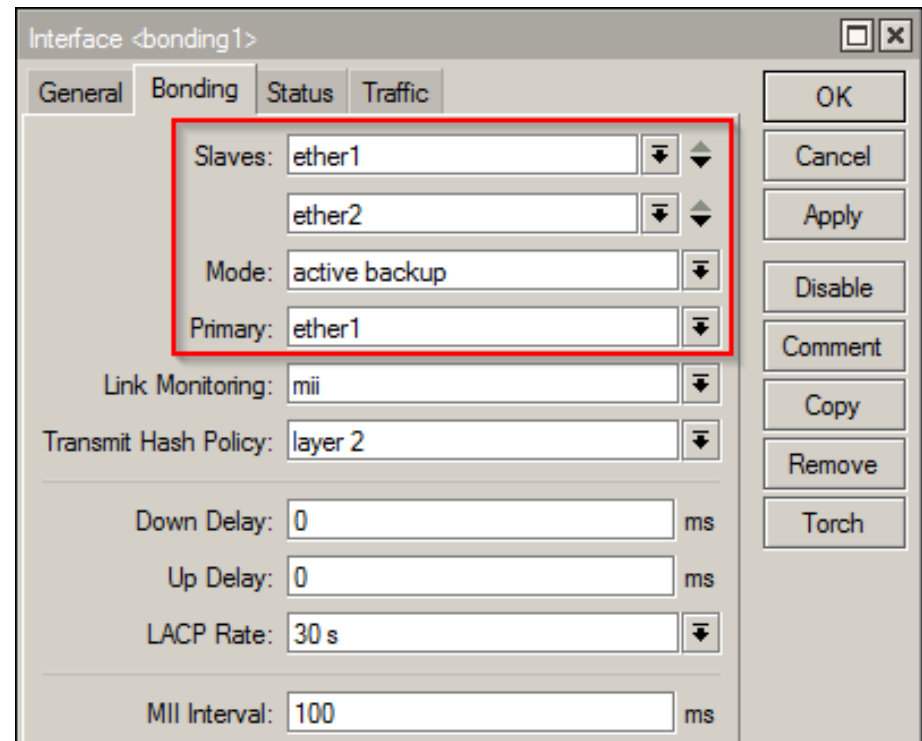
Use bonding active-backup



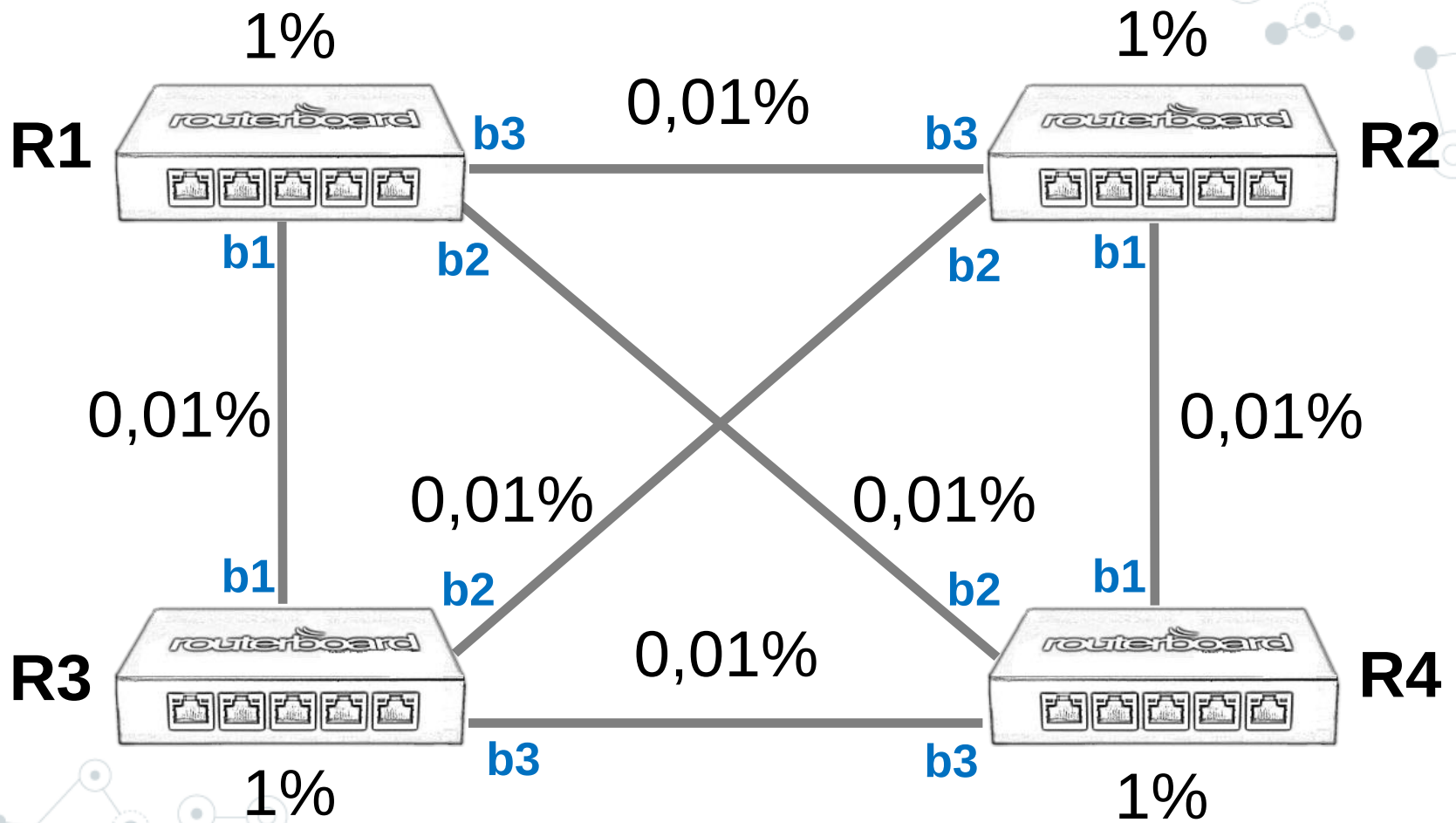
Create the bonding interfaces



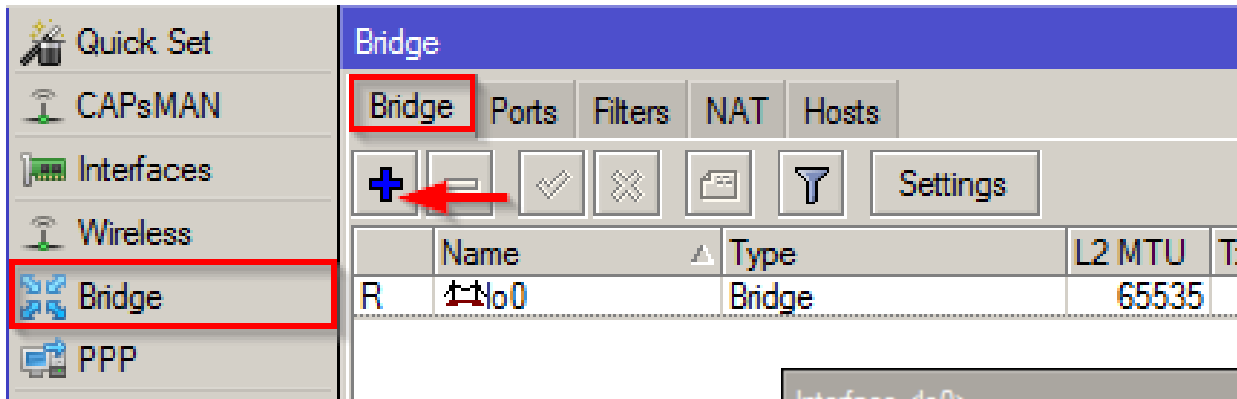
Repeat this process for every bonding link on every router until you get all 3 bonding interfaces on each router



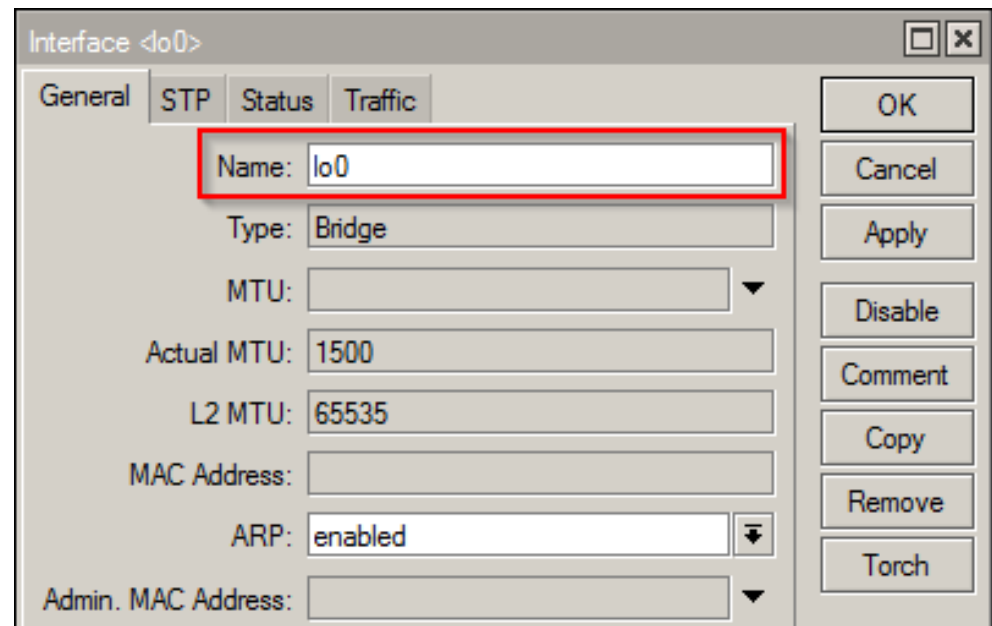
Resulting network



Loopback setup



On every router add
a loopback device
(a bridge with no
ports attached)



Adding loopback IPs

The screenshot shows the Mikrotik WinBox interface. On the left, the 'IP' menu item is highlighted with a red box. In the center, the 'Addresses' sub-menu is also highlighted with a red box. On the right, the 'Address List' window is open, displaying a table with one entry: 192.168.1.1 on the lo0 interface. A red arrow points to the '+' icon in the Address List toolbar. Below this, the 'Address <192.168.1.1>' configuration window is shown, with its input fields (Address, Network, Interface) highlighted by a red box.

On every router add
a loopback IP
(/32 netmask)

Address	Network	Interface
192.168.1.1	192.168.1.1	lo0

Address <192.168.1.1>

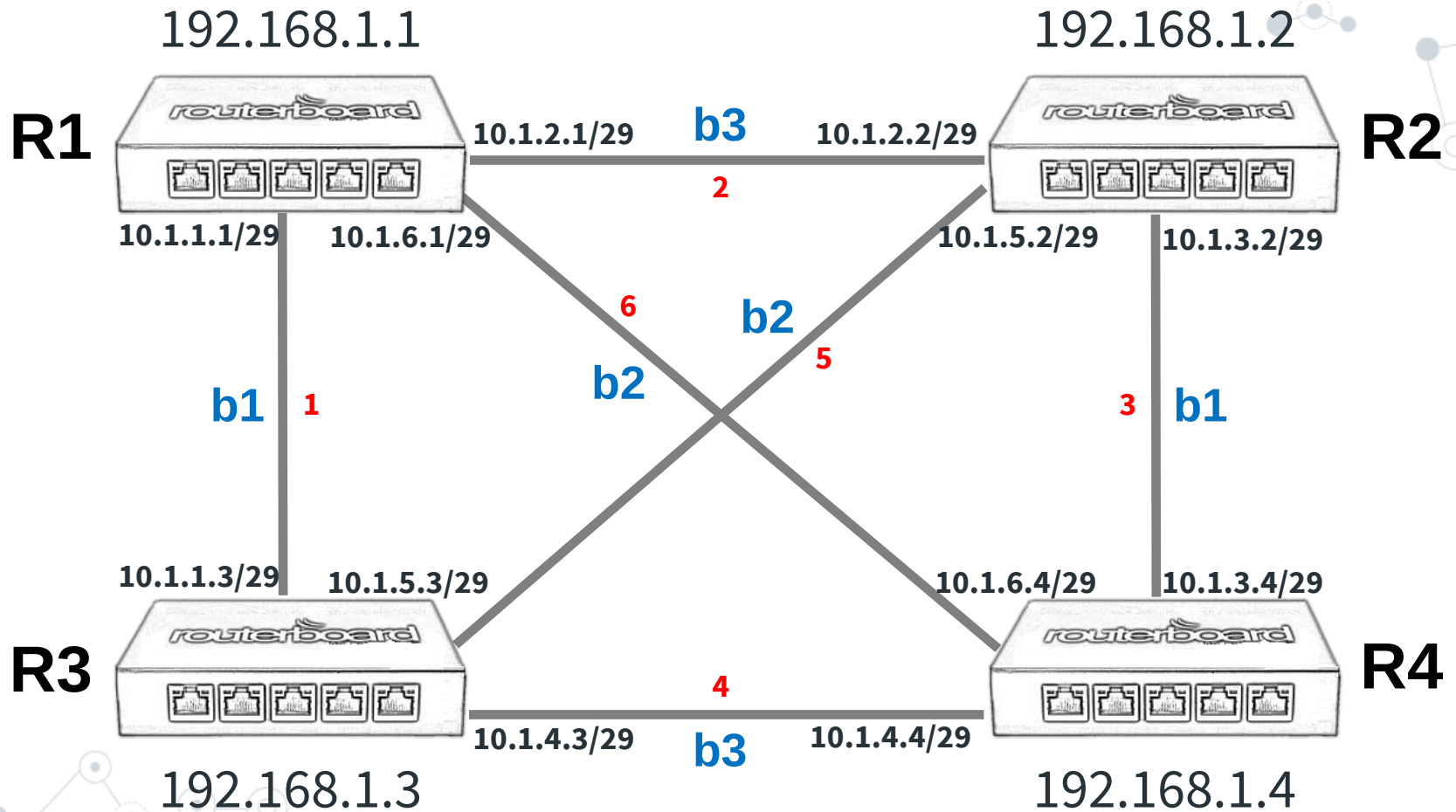
Address: 192.168.1.1

Network: 192.168.1.1

Interface: lo0

Buttons: OK, Cancel, Apply, Disable, Comment

Interconnections

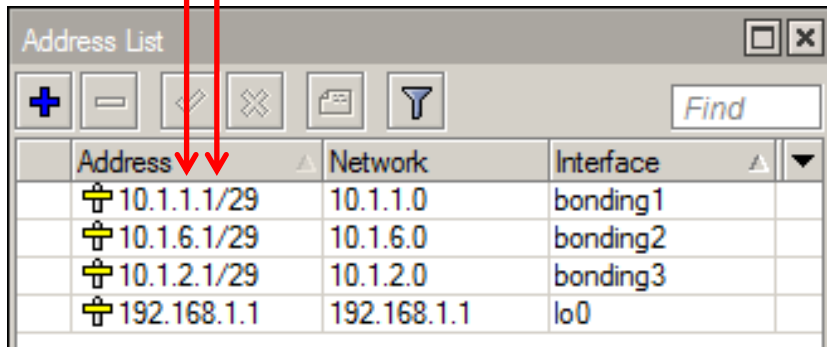


Adding the interconnect networks

Link number

Router number

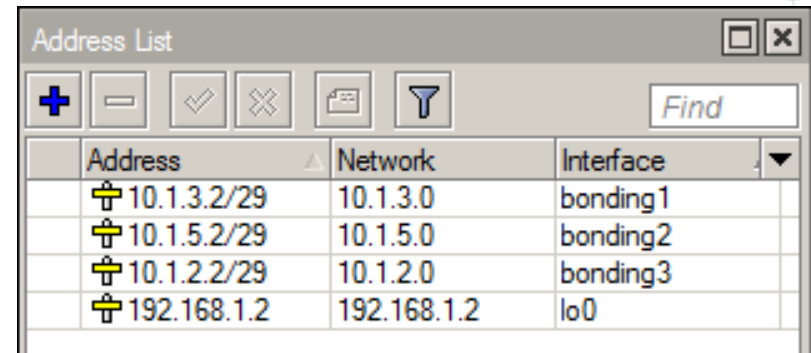
R1



Address List

Address	Network	Interface
10.1.1.1/29	10.1.1.0	bonding1
10.1.6.1/29	10.1.6.0	bonding2
10.1.2.1/29	10.1.2.0	bonding3
192.168.1.1	192.168.1.1	lo0

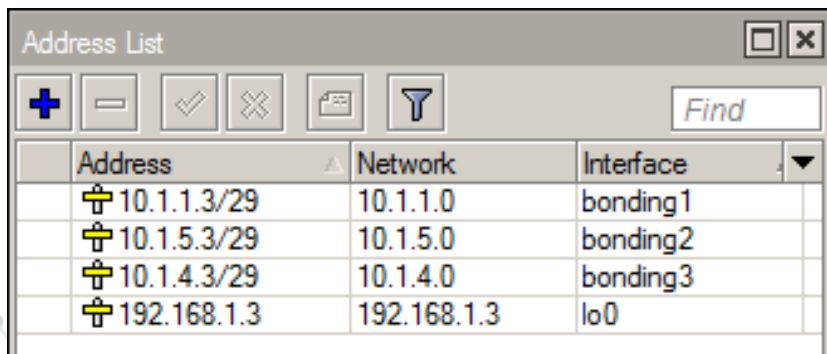
R2



Address List

Address	Network	Interface
10.1.3.2/29	10.1.3.0	bonding1
10.1.5.2/29	10.1.5.0	bonding2
10.1.2.2/29	10.1.2.0	bonding3
192.168.1.2	192.168.1.2	lo0

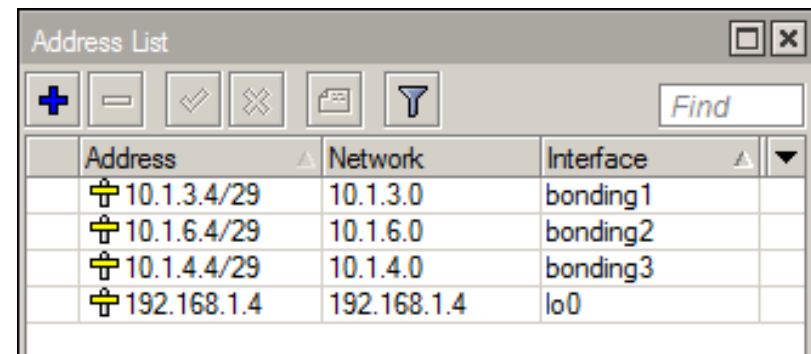
R3



Address List

Address	Network	Interface
10.1.1.3/29	10.1.1.0	bonding1
10.1.5.3/29	10.1.5.0	bonding2
10.1.4.3/29	10.1.4.0	bonding3
192.168.1.3	192.168.1.3	lo0

R4



Address List

Address	Network	Interface
10.1.3.4/29	10.1.3.0	bonding1
10.1.6.4/29	10.1.6.0	bonding2
10.1.4.4/29	10.1.4.0	bonding3
192.168.1.4	192.168.1.4	lo0

OSPF setup

The screenshot shows the OSPF configuration interface. On the left, the 'Routing' menu is expanded, and 'OSPF' is selected. The main window displays the 'Instances' tab, which contains a table with the following data:

Name	Router ID	Running
* default	192.168.1.1	no

A dialog box titled 'OSPF Instance <default>' is open, showing the 'General' tab. The 'Router ID' field is highlighted with a red box and contains the value '192.168.1.1'. Other fields in the dialog include 'Name' (default), 'Redistribute Default Route' (never), 'Redistribute Connected Routes' (no), 'Redistribute Static Routes' (no), and 'Redistribute RIP Routes' (no). Buttons for 'OK', 'Cancel', 'Apply', 'Disable', 'Comment', 'Copy', and 'Remove' are visible on the right side of the dialog.

Set the OSPF router ID to the loopback address

OSPF setup

The screenshot displays the OSPF configuration interface. The 'Networks' tab is selected, showing a list of networks to be advertised. A red box highlights the '+', '-', and filter icons, with a red arrow pointing to the '+' icon. An 'Address List' window is open, showing a list of IP addresses and their corresponding interfaces.

Network	Area
10.1.1.0/29	backbone
10.1.2.0/29	backbone
10.1.6.0/29	backbone
192.168.1.1	backbone

Address	Network	Interface
10.1.1.1/29	10.1.1.0	bonding1
10.1.2.1/29	10.1.2.0	bonding3
10.1.6.1/29	10.1.6.0	bonding2
192.168.1.1	192.168.1.1	lo0

Add all connected networks to OSPF

Adding the interconnect networks

R1

OSPF

Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LS

Address List

Network	Area
10.1.1.0/29	backbone
10.1.2.0/29	backbone
10.1.6.0/29	backbone
192.168.1.1	backbone

Address	Network	Interface
10.1.1.1/29	10.1.1.0	bonding1
10.1.2.1/29	10.1.2.0	bonding3
10.1.6.1/29	10.1.6.0	bonding2
192.168.1.1	192.168.1.1	lo0

R2

OSPF

Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LS

Address List

Network	Area
10.1.2.0/29	backbone
10.1.3.0/29	backbone
10.1.5.0/29	backbone
192.168.1.2	backbone

Address	Network	Interface
10.1.2.2/29	10.1.2.0	bonding3
10.1.3.2/29	10.1.3.0	bonding1
10.1.5.2/29	10.1.5.0	bonding2
192.168.1.2	192.168.1.2	lo0

R3

OSPF

Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LS

Address List

Network	Area
10.1.1.0/29	backbone
10.1.4.0/29	backbone
10.1.5.0/29	backbone
192.168.1.3	backbone

Address	Network	Interface
10.1.1.3/29	10.1.1.0	bonding1
10.1.4.3/29	10.1.4.0	bonding3
10.1.5.3/29	10.1.5.0	bonding2
192.168.1.3	192.168.1.3	lo0

R4

OSPF

Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LS

Address List

Network	Area
10.1.3.0/24	backbone
10.1.4.0/29	backbone
10.1.6.0/29	backbone
192.168.1.4	backbone

Address	Network	Interface
10.1.3.4/29	10.1.3.0	bonding1
10.1.4.4/29	10.1.4.0	bonding3
10.1.6.4/29	10.1.6.0	bonding2
192.168.1.4	192.168.1.4	lo0



R4 - Routing table result

OSPF

Instances

Networks

Areas

Area Ranges

Virtual Links

Neighbors

NBMA Neighbors

Sham Links

LSA

Routes

	Network	Area
	10.1.3.0/24	backbone
	10.1.4.0/29	backbone
	10.1.6.0/29	backbone
	192.168.1.4	backbone

Route List

Routes

Nexthops

Rules

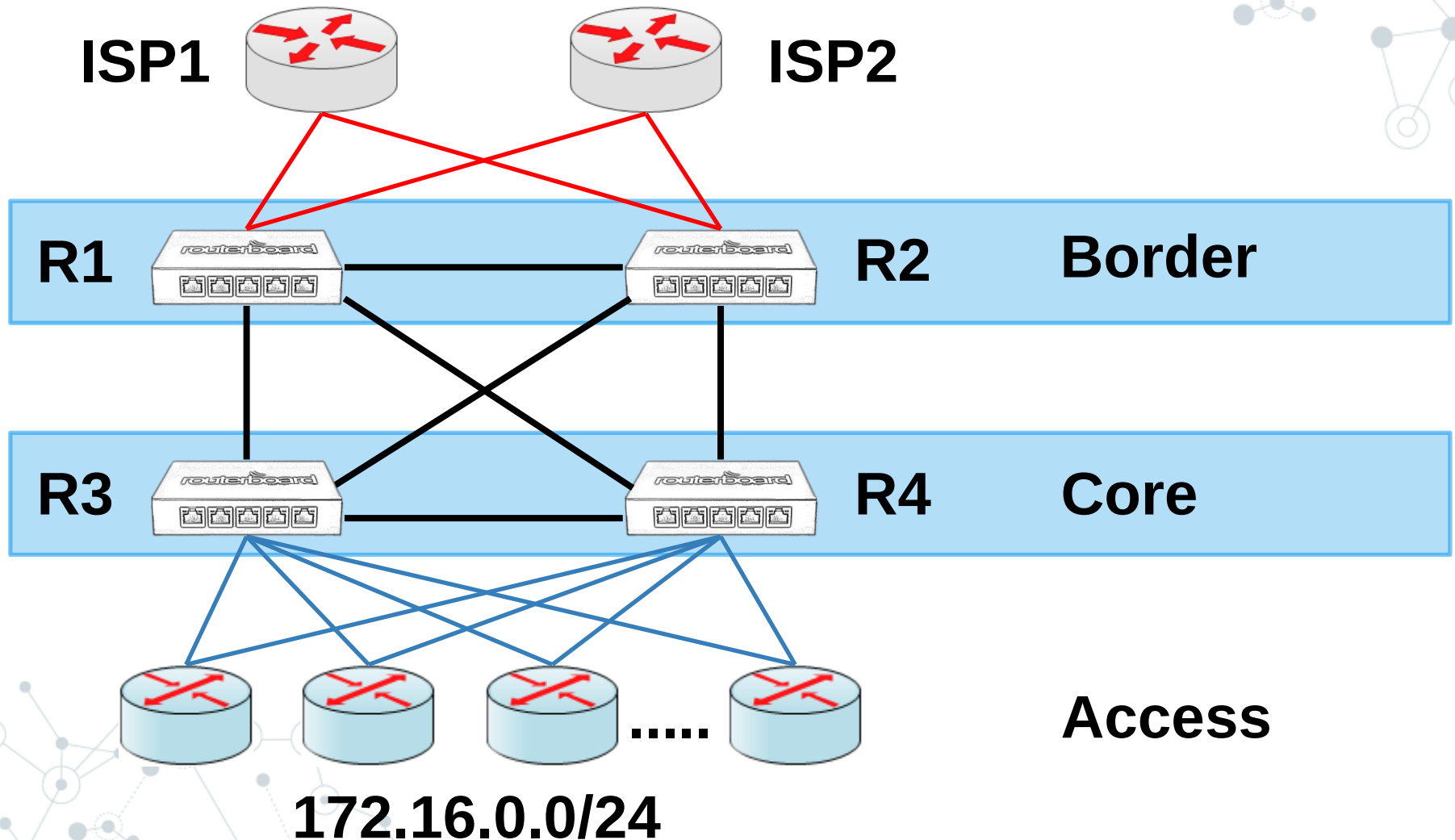
VRF

Find

all

	Dst. Address	Gateway	Distance	Pref. Source
DAo	10.1.1.0/29	10.1.4.3 reachable bonding3, 10.1.6.1 reachable bonding2	110	
DAo	10.1.2.0/29	10.1.3.2 reachable bonding1, 10.1.6.1 reachable bonding2	110	
DAC	10.1.3.0/29	bonding1 reachable	0	10.1.3.4
DAC	10.1.4.0/29	bonding3 reachable	0	10.1.4.4
DAo	10.1.5.0/29	10.1.3.2 reachable bonding1, 10.1.4.3 reachable bonding3	110	
DAC	10.1.6.0/29	bonding2 reachable	0	10.1.6.4
DAo	192.168.1.1	10.1.6.1 reachable bonding2	110	
DAo	192.168.1.2	10.1.3.2 reachable bonding1	110	
DAo	192.168.1.3	10.1.4.3 reachable bonding3	110	
DAC	192.168.1.4	lo0 reachable	0	192.168.1.4

Providers and customers



OSPF specifics

The network is now
fully redundant but it
depends on OSPF for
path selection and
convergence

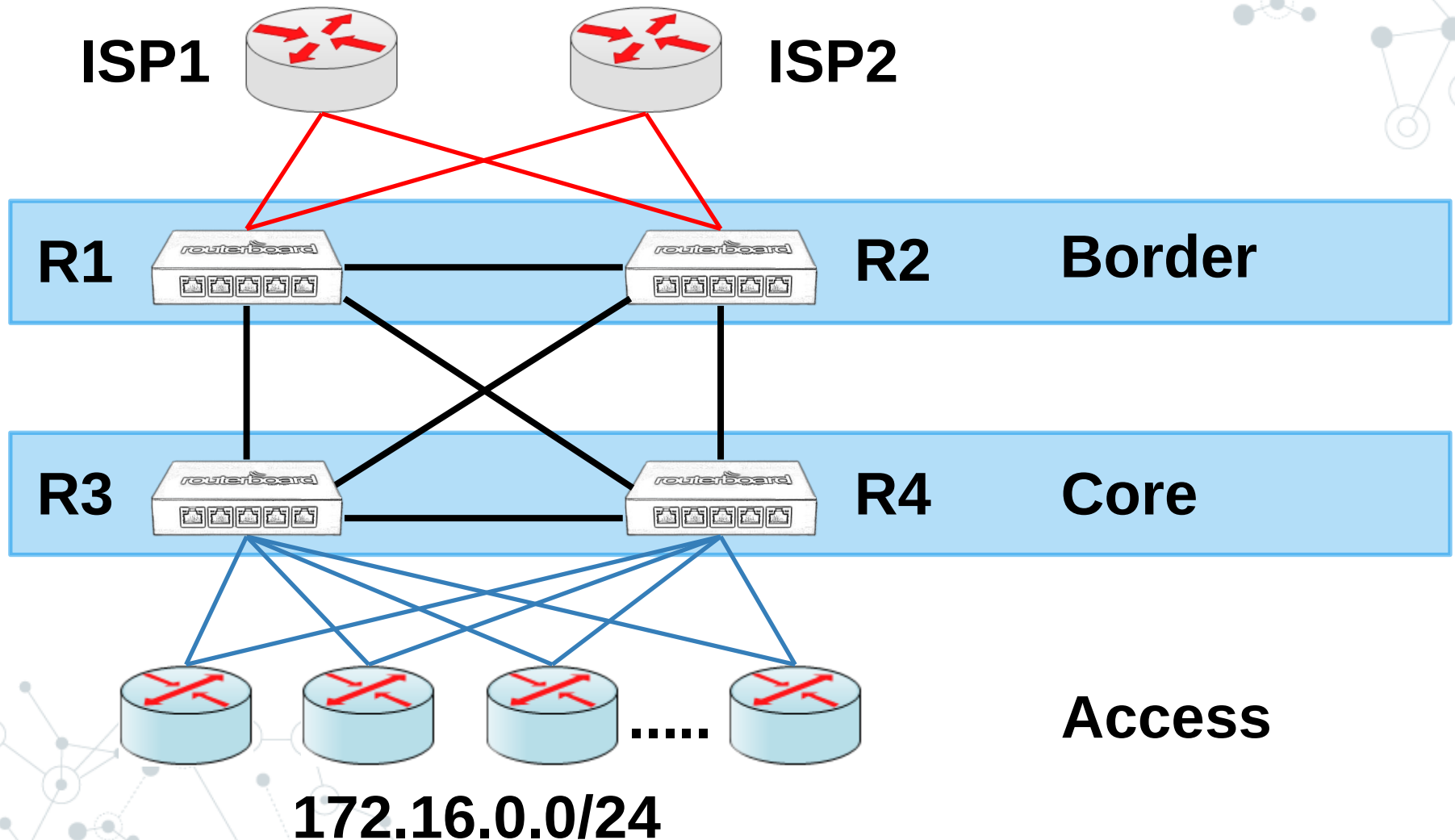


MPLS TE to the rescue

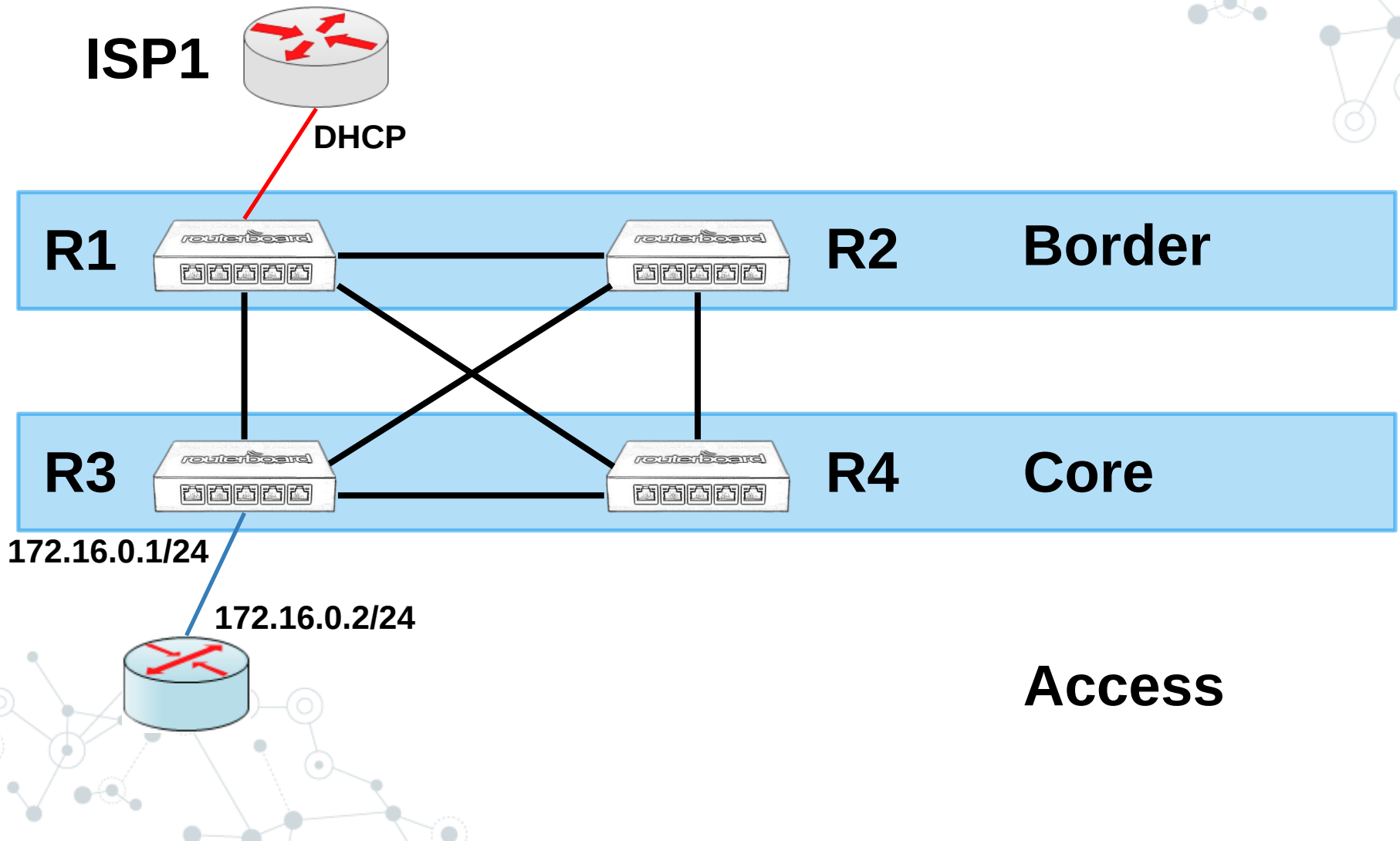
Deploy MPLS TE for
faster and better
path control



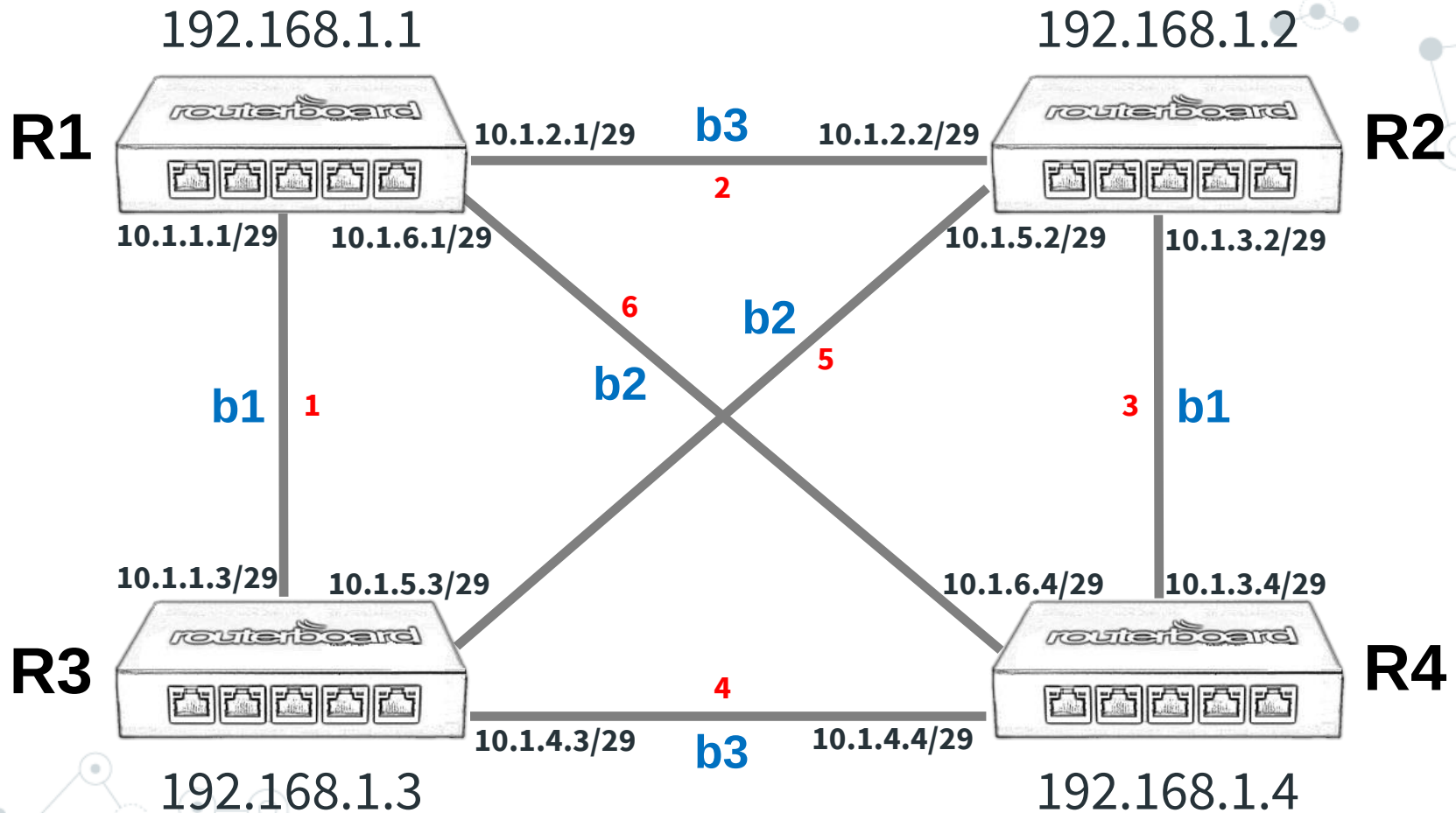
For demo purposes we will turn this network...



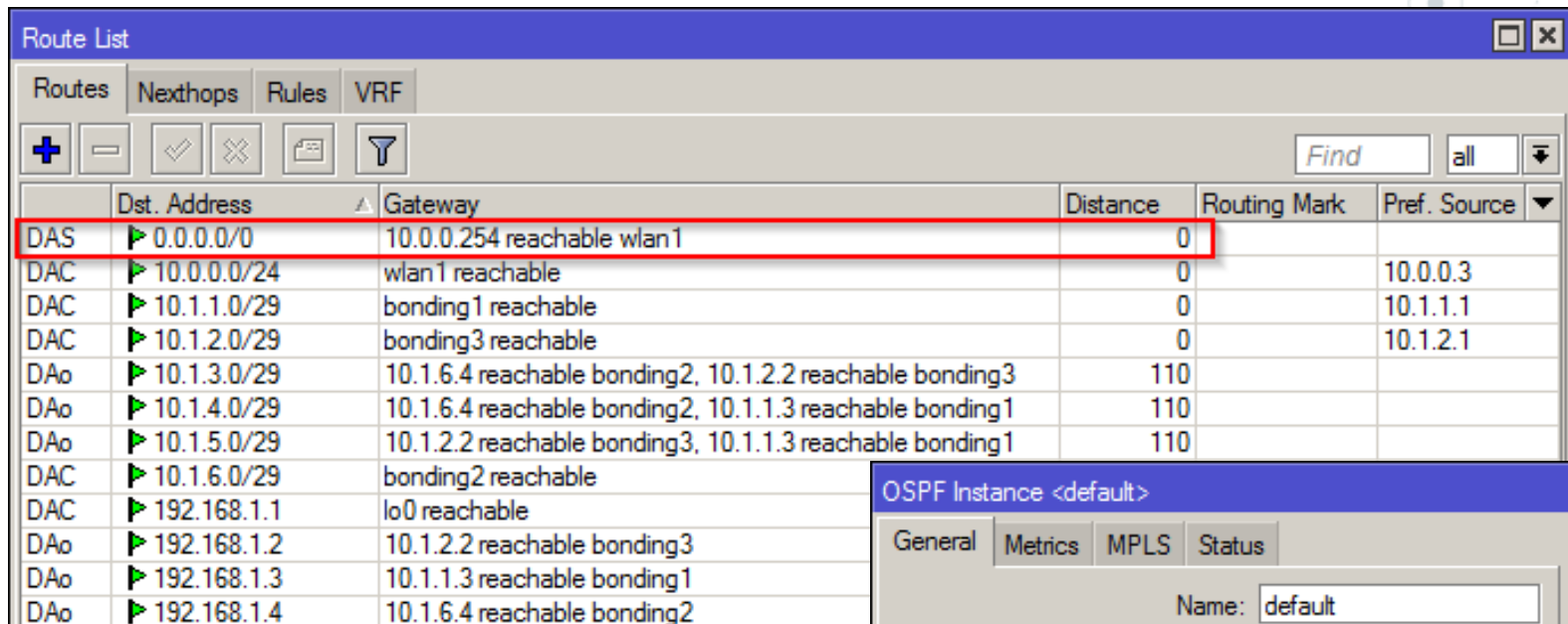
Into this simplified network



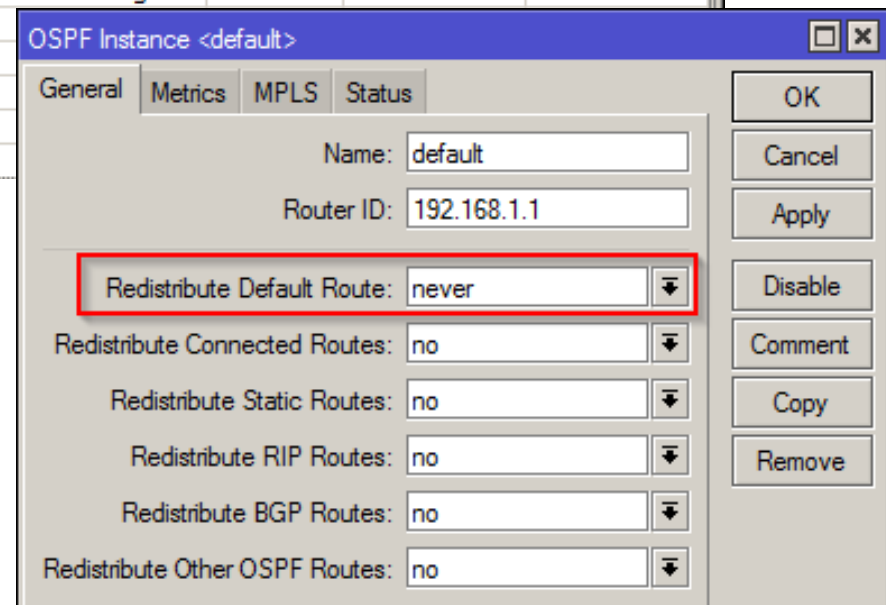
The rest remains the same



First things first (R1 default route)



	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
DAS	0.0.0.0/0	10.0.0.254 reachable wlan 1	0		
DAC	10.0.0.0/24	wlan 1 reachable	0		10.0.0.3
DAC	10.1.1.0/29	bonding1 reachable	0		10.1.1.1
DAC	10.1.2.0/29	bonding3 reachable	0		10.1.2.1
DAo	10.1.3.0/29	10.1.6.4 reachable bonding2, 10.1.2.2 reachable bonding3	110		
DAo	10.1.4.0/29	10.1.6.4 reachable bonding2, 10.1.1.3 reachable bonding1	110		
DAo	10.1.5.0/29	10.1.2.2 reachable bonding3, 10.1.1.3 reachable bonding1	110		
DAC	10.1.6.0/29	bonding2 reachable			
DAC	192.168.1.1	lo0 reachable			
DAo	192.168.1.2	10.1.2.2 reachable bonding3			
DAo	192.168.1.3	10.1.1.3 reachable bonding1			
DAo	192.168.1.4	10.1.6.4 reachable bonding2			



OSPF Instance <default>

General Metrics MPLS Status

Name: default

Router ID: 192.168.1.1

Redistribute Default Route: never

Redistribute Connected Routes: no

Redistribute Static Routes: no

Redistribute RIP Routes: no

Redistribute BGP Routes: no

Redistribute Other OSPF Routes: no

OK Cancel Apply Disable Comment Copy Remove

Do the same for **R2**
on non-simplified
setups

R3 & Customer setup

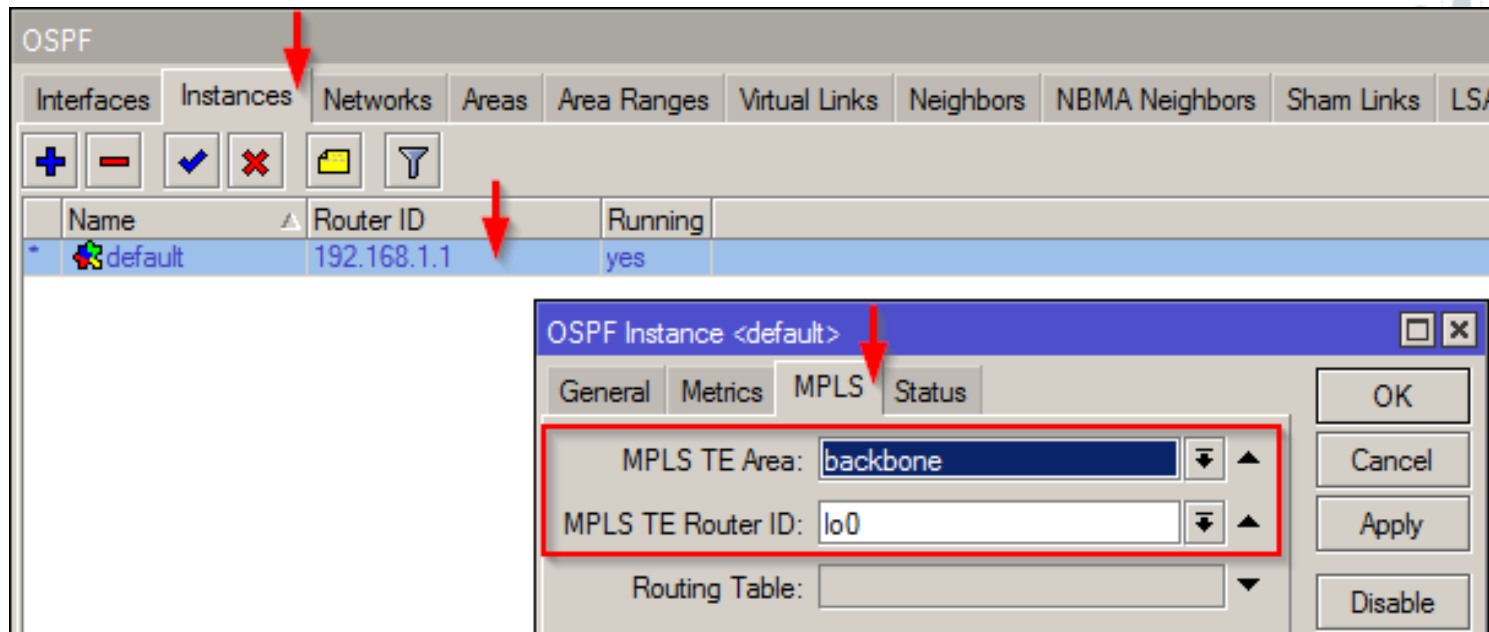
Route List			Address List		
Routes			Address List		
+ - [check] [x] [icon] [filter]			+ - [check] [x] [icon] [filter] [Find]		
	Dst. Address	Gateway	Address	Network	Interface
DAo	▶ 192.168.1.4	10.1.4.4 reachable bonding3	✚ 10.1.1.3/29	10.1.1.0	bonding1
DAC	▶ 192.168.1.3	lo0 reachable	✚ 10.1.5.3/29	10.1.5.0	bonding2
DAo	▶ 192.168.1.2	10.1.5.2 reachable bonding2	✚ 10.1.4.3/29	10.1.4.0	bonding3
DAo	▶ 192.168.1.1	10.1.1.1 reachable bonding1	✚ 172.16.0.1/24	172.16.0.0	ether5
DAC	▶ 172.16.0.0/24	ether5 reachable	✚ 192.168.1.3	192.168.1.3	lo0
DAo	▶ 10.1.6.0/29	10.1.4.4 reachable bonding3, 10.1.1.1			
DAC	▶ 10.1.5.0/29	bonding2 reachable			
DAC	▶ 10.1.4.0/29	bonding3 reachable			
DAo	▶ 10.1.3.0/29	10.1.5.2 reachable bonding2, 10.1.4.4			
DAo	▶ 10.1.2.0/29	10.1.5.2 reachable bonding2, 10.1.1.1			
DAC	▶ 10.1.1.0/29	bonding1 reachable			

R3

Customer equipment towards R3

Route List			Address List		
Routes			Address List		
+ - [check] [x] [icon] [filter]			+ - [check] [x] [icon] [filter] [Find]		
	Dst. Address	Gateway	Address	Network	Interface
AS	▶ 0.0.0.0/0	172.16.0.1 reachable ether1			
DAC	▶ 172.16.0.0/24	ether1 reachable	✚ 172.16.0.2/24	172.16.0.0	ether1
DAC	▶ 192.168.90.0/24	ether2 reachable	✚ 192.168.90.1/24	192.168.90.0	ether2

Preliminary MPLS TE over OSPF



Do this for all 4 routers

Setting up MPLS TE interfaces

The screenshot displays the MPLS configuration interface. On the left is a sidebar with various configuration categories: MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, LCD, MetaROUTER, Partition, Make Supout.rif, and Manual. The main panel is divided into two sections: 'MPLS' and 'Traffic Eng'. The 'Traffic Eng' section is highlighted with a red box. Below this, a table lists the configured TE interfaces:

Interface	Bandwidth (bps)	TE Metric	Remaining Bw.
bonding1	1G	1	1000.0 Mbps
bonding2	1G	1	1000.0 Mbps
bonding3	1G	1	1000.0 Mbps

Below the table, a dialog box titled 'TE Interface <bonding1>' is open. It contains the following fields:

- Interface: bonding1
- Bandwidth: 1G bps
- K Factor: 3
- Resource Class: 0 Hex
- Refresh Time: 30.000
- ☐ Use UDP

Buttons for OK, Cancel, Apply, Disable, and Copy are visible on the right side of the dialog.

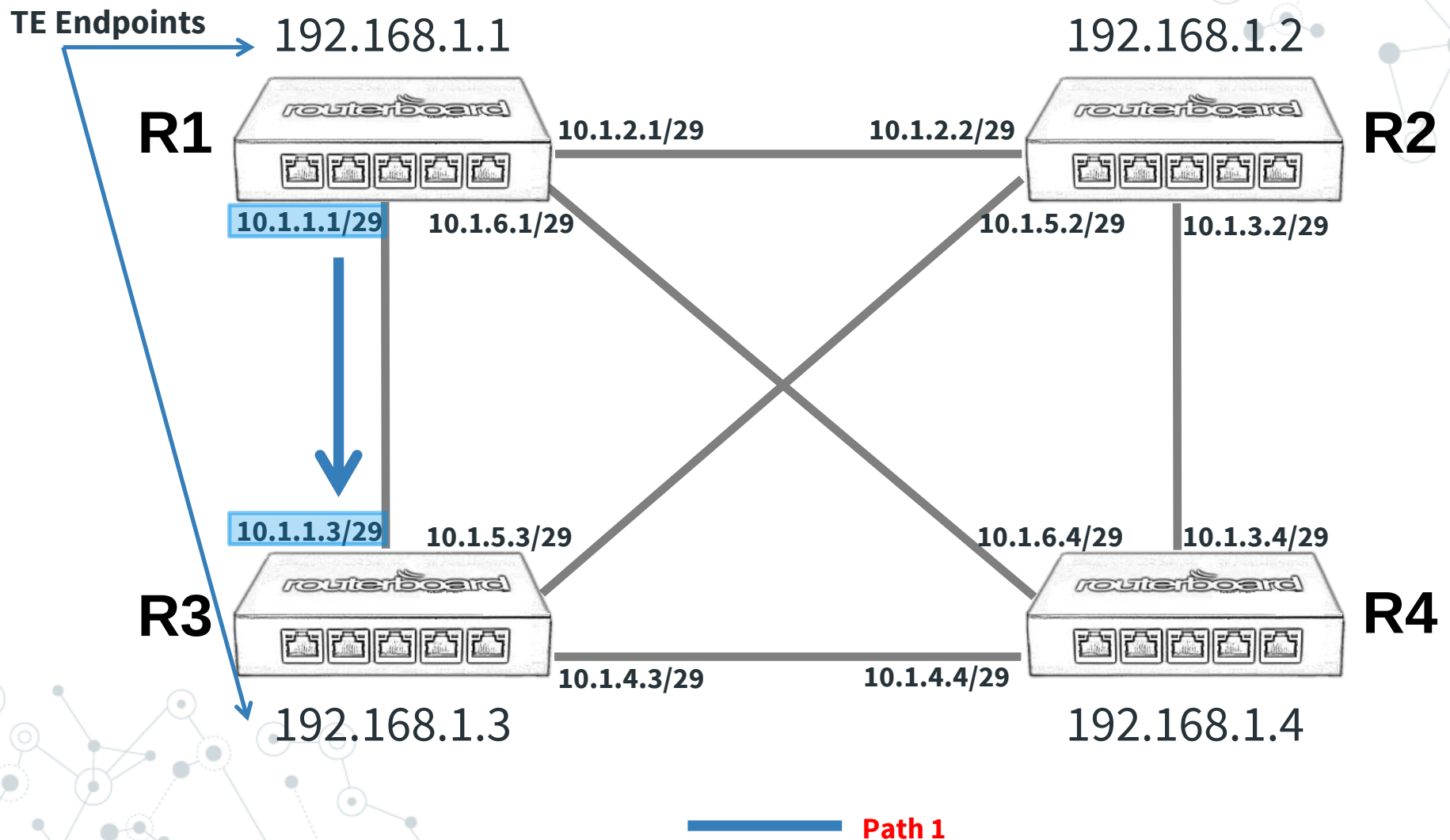
Add each bonding interface to TE
on all 4 routers

TE tunnels are unidirectional

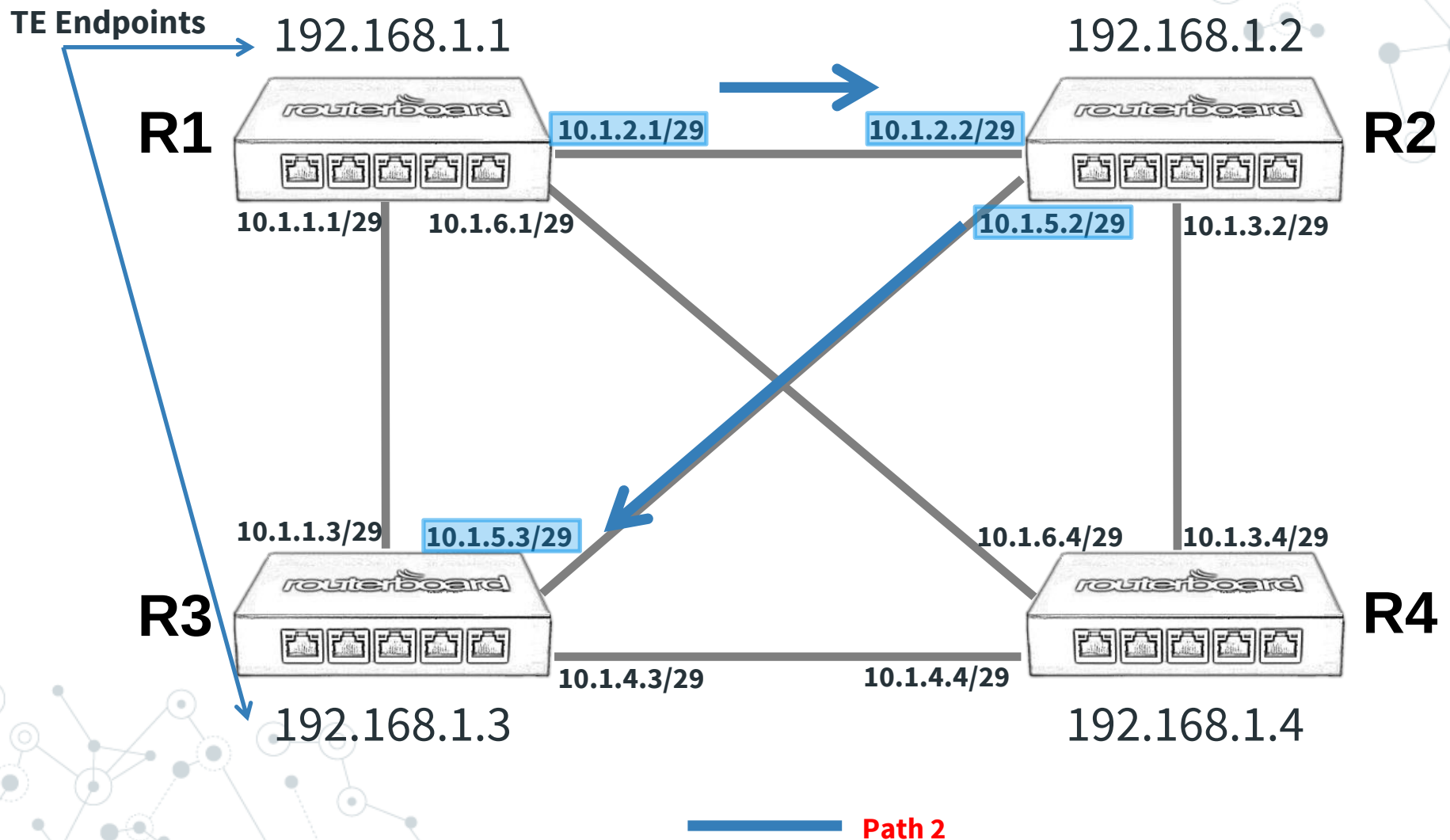
We need to set up paths
in both directions



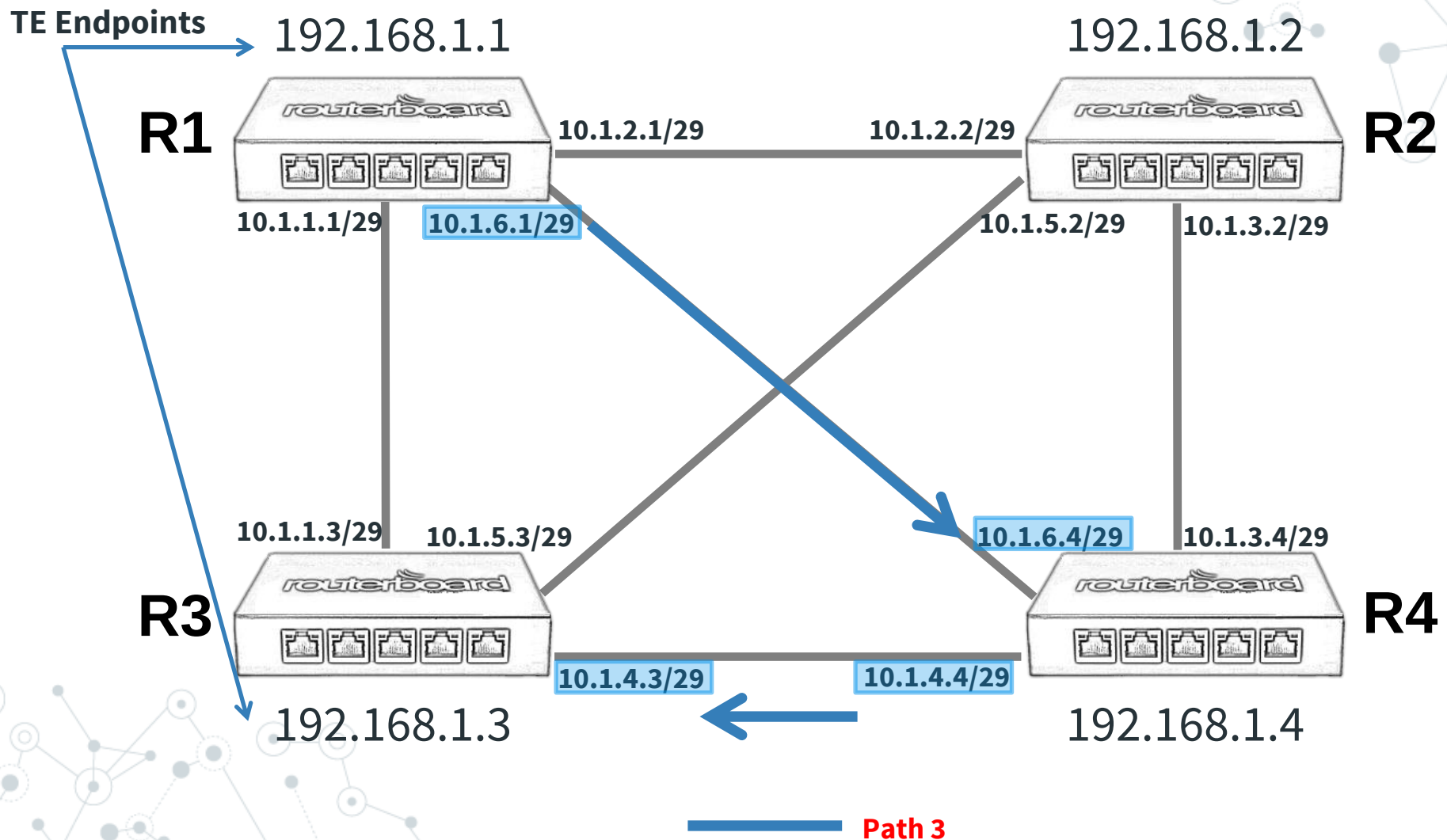
Possible paths from R1 to R3



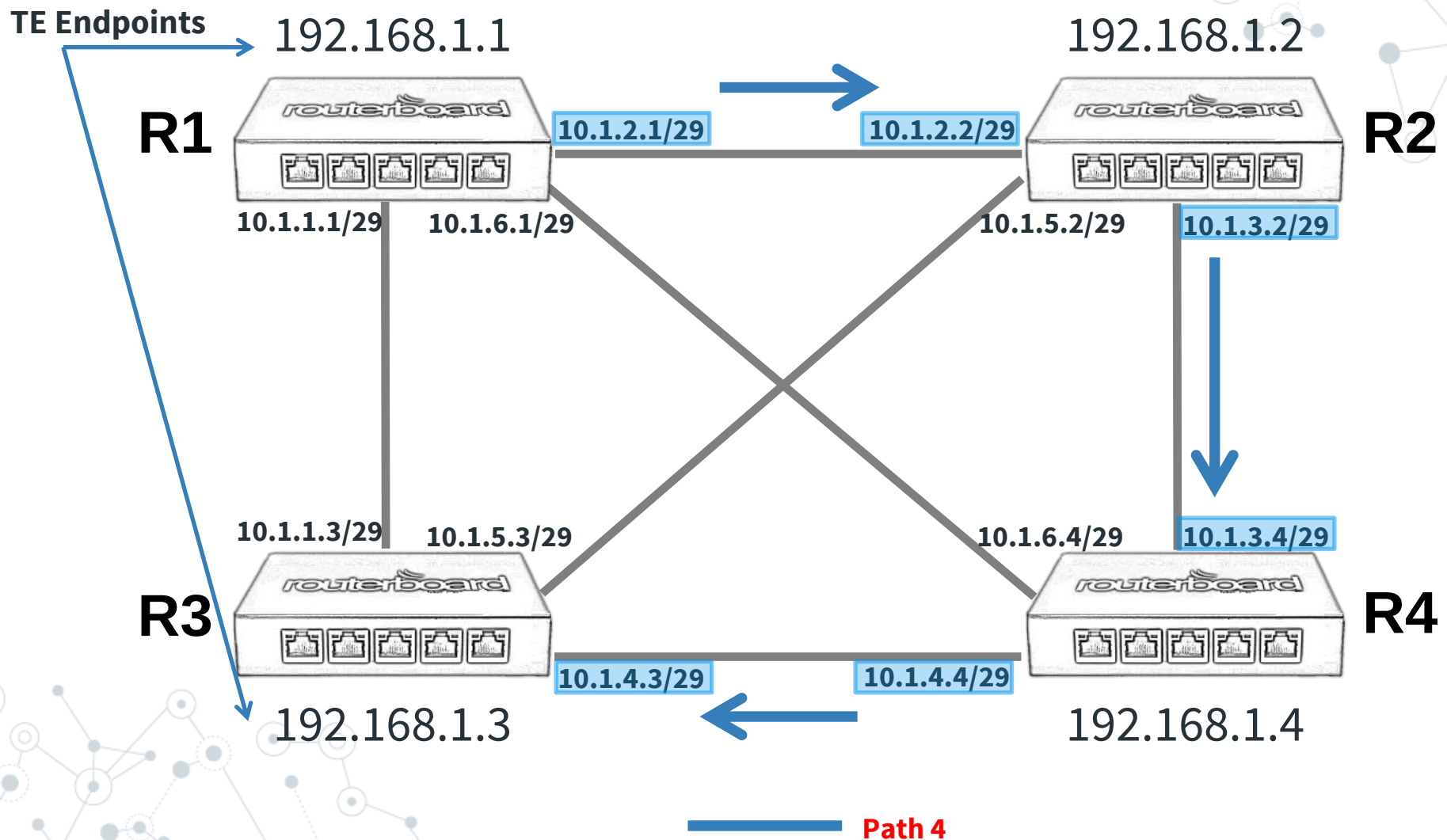
Possible paths from R1 to R3



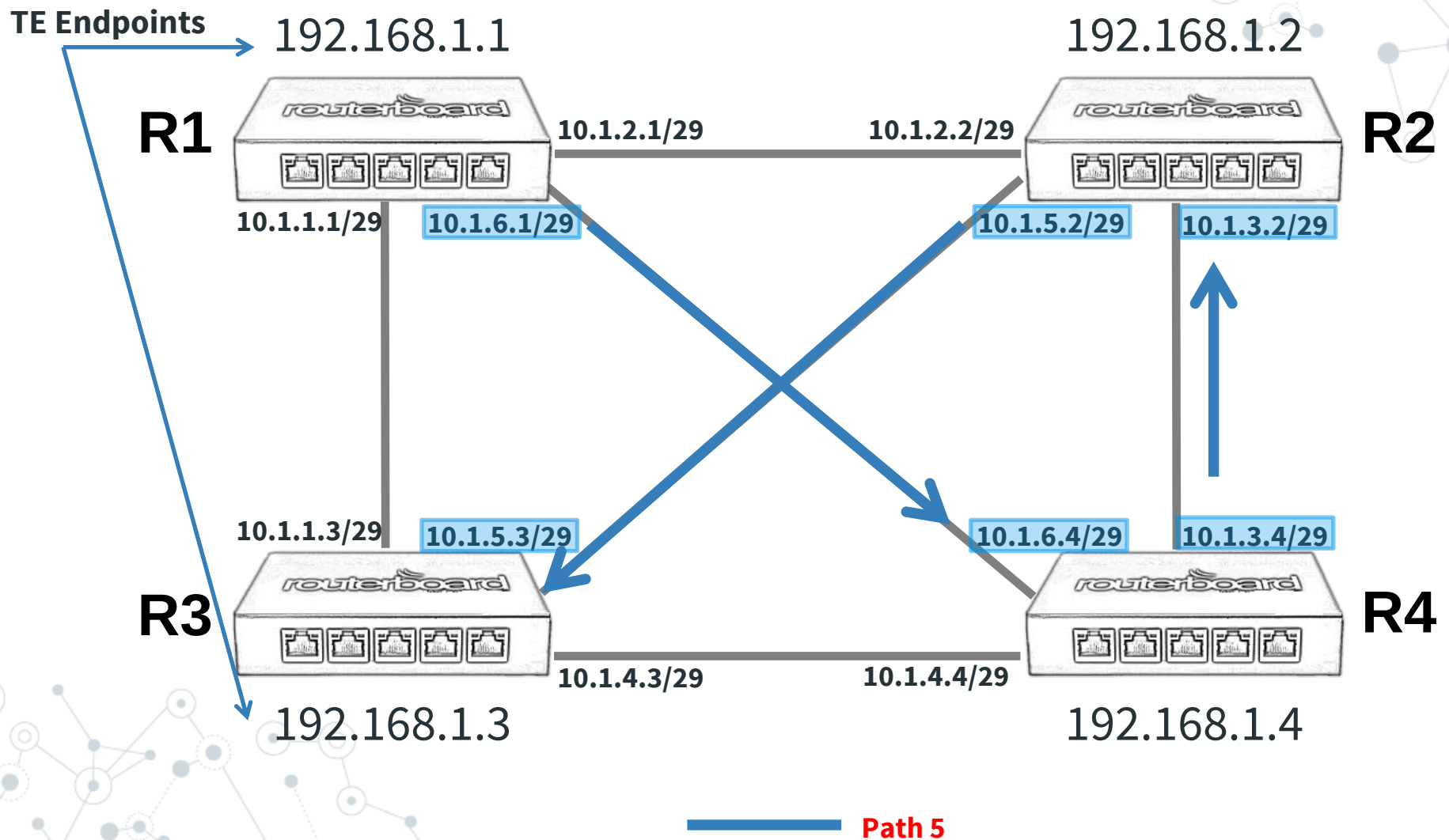
Possible paths from R1 to R3



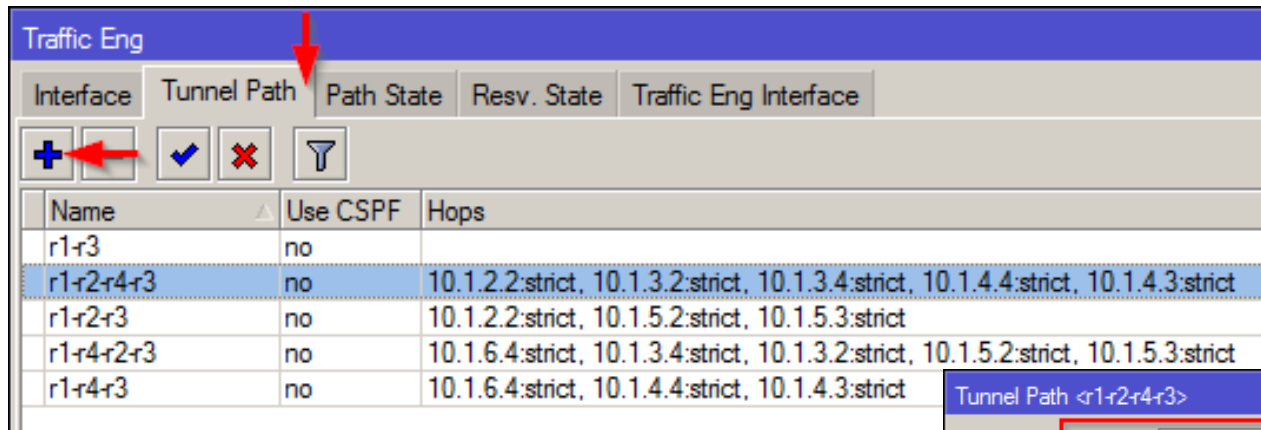
Possible paths from R1 to R3

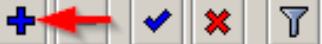


Possible paths from R1 to R3



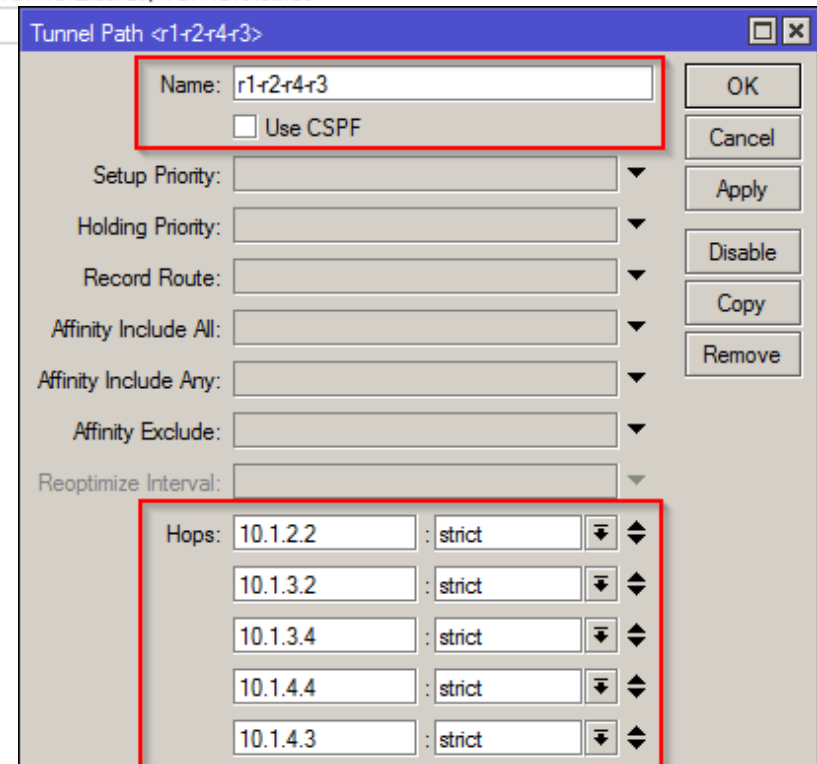
Set up TE unidirectional paths on R1



Interface	Tunnel Path	Path State	Resv. State	Traffic Eng Interface
				
Name	Use CSPF	Hops		
r1-r3	no			
r1-r2-r4-r3	no	10.1.2.2:strict, 10.1.3.2:strict, 10.1.3.4:strict, 10.1.4.4:strict, 10.1.4.3:strict		
r1-r2-r3	no	10.1.2.2:strict, 10.1.5.2:strict, 10.1.5.3:strict		
r1-r4-r2-r3	no	10.1.6.4:strict, 10.1.3.4:strict, 10.1.3.2:strict, 10.1.5.2:strict, 10.1.5.3:strict		
r1-r4-r3	no	10.1.6.4:strict, 10.1.4.4:strict, 10.1.4.3:strict		

Add all possible paths

Add *strict next-hops* as well as the *strict* local Pref-src towards the next *next-hop*



Tunnel Path <r1-r2-r4-r3>

Name: ☐ Use CSPF

Setup Priority:

Holding Priority:

Record Route:

Affinity Include All:

Affinity Include Any:

Affinity Exclude:

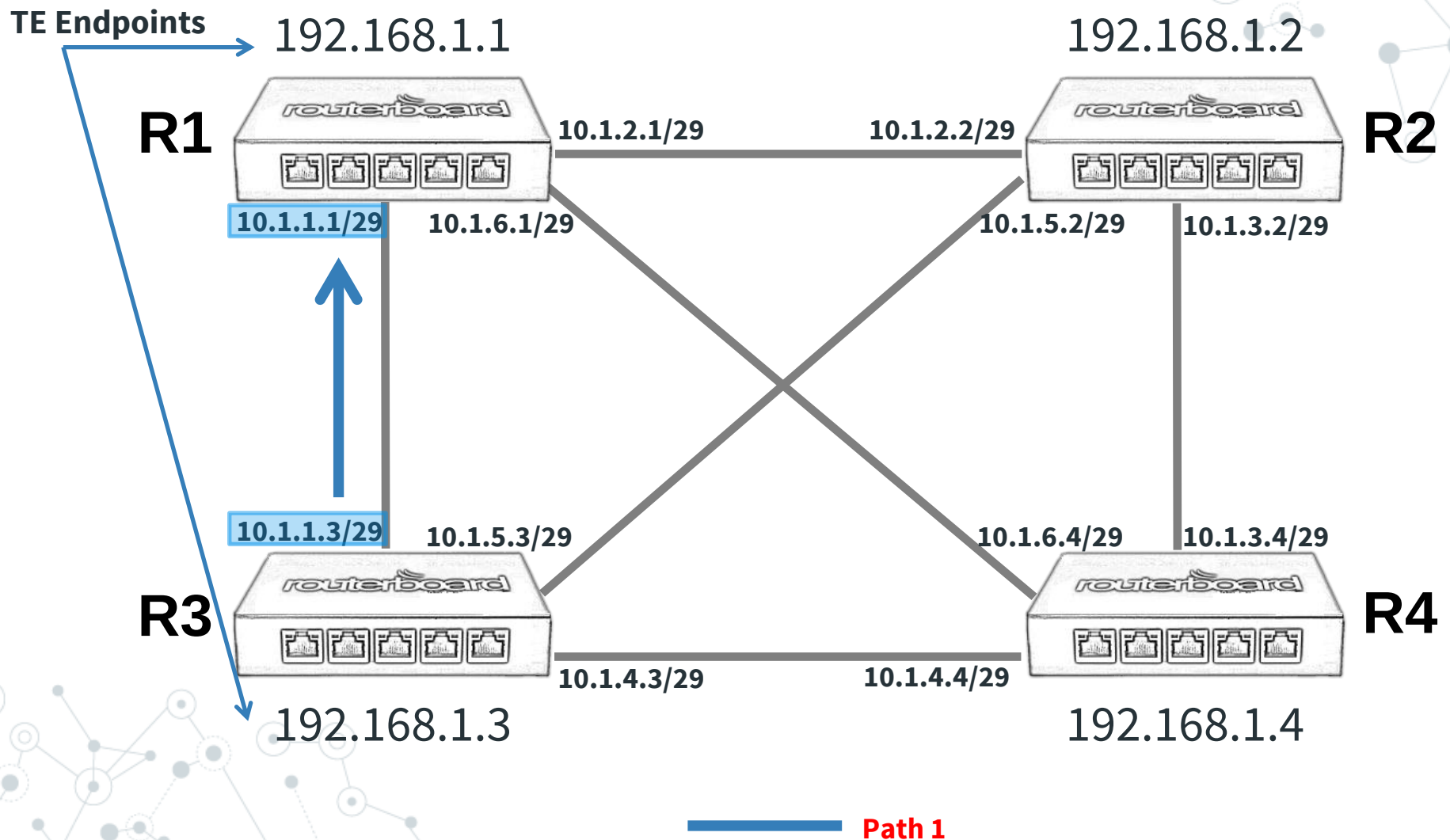
Reoptimize Interval:

Hops:

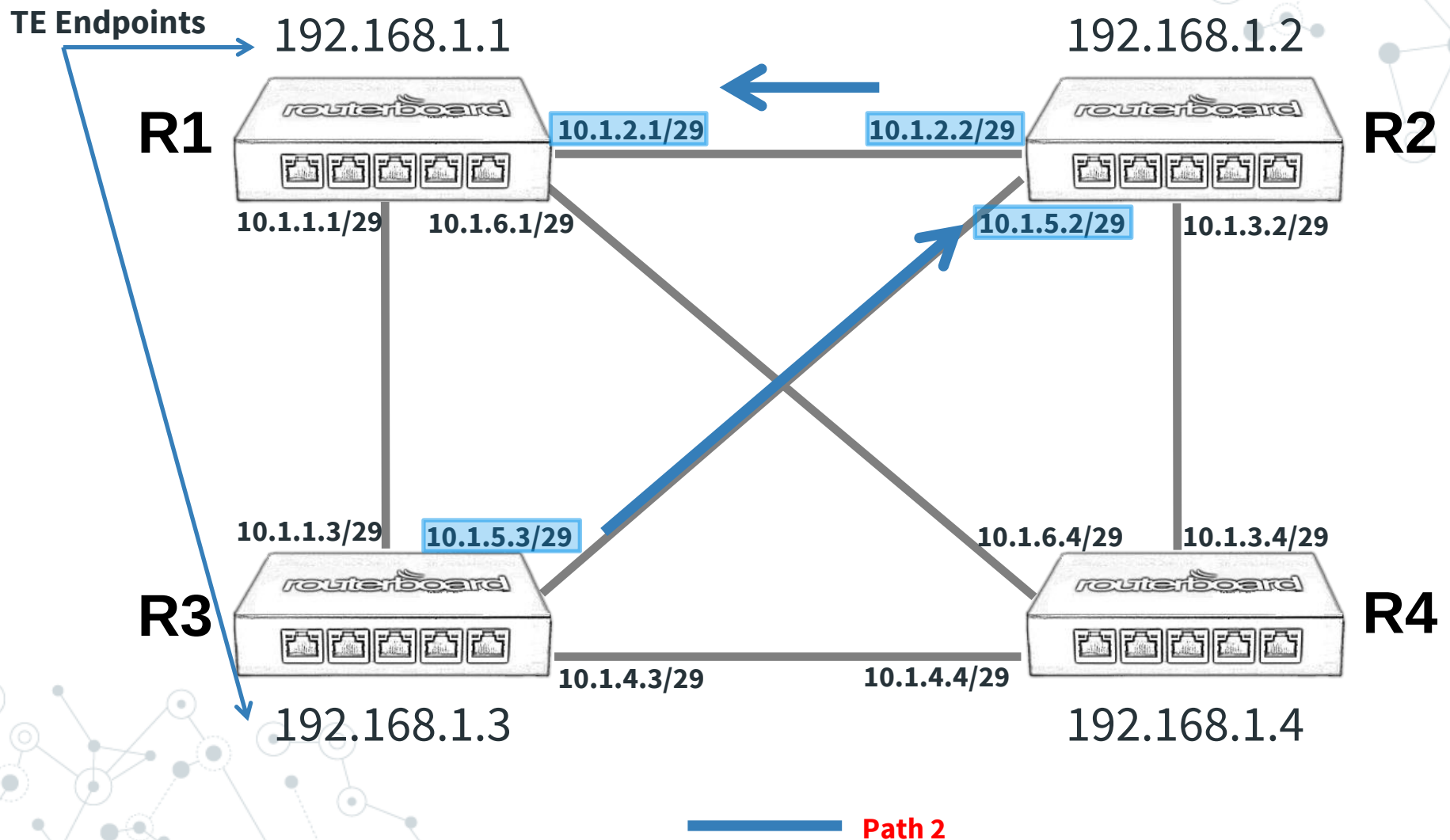
10.1.2.2	: strict	⬇ ⬆ ⬇
10.1.3.2	: strict	⬇ ⬆ ⬇
10.1.3.4	: strict	⬇ ⬆ ⬇
10.1.4.4	: strict	⬇ ⬆ ⬇
10.1.4.3	: strict	⬇ ⬆ ⬇

OK Cancel Apply Disable Copy Remove

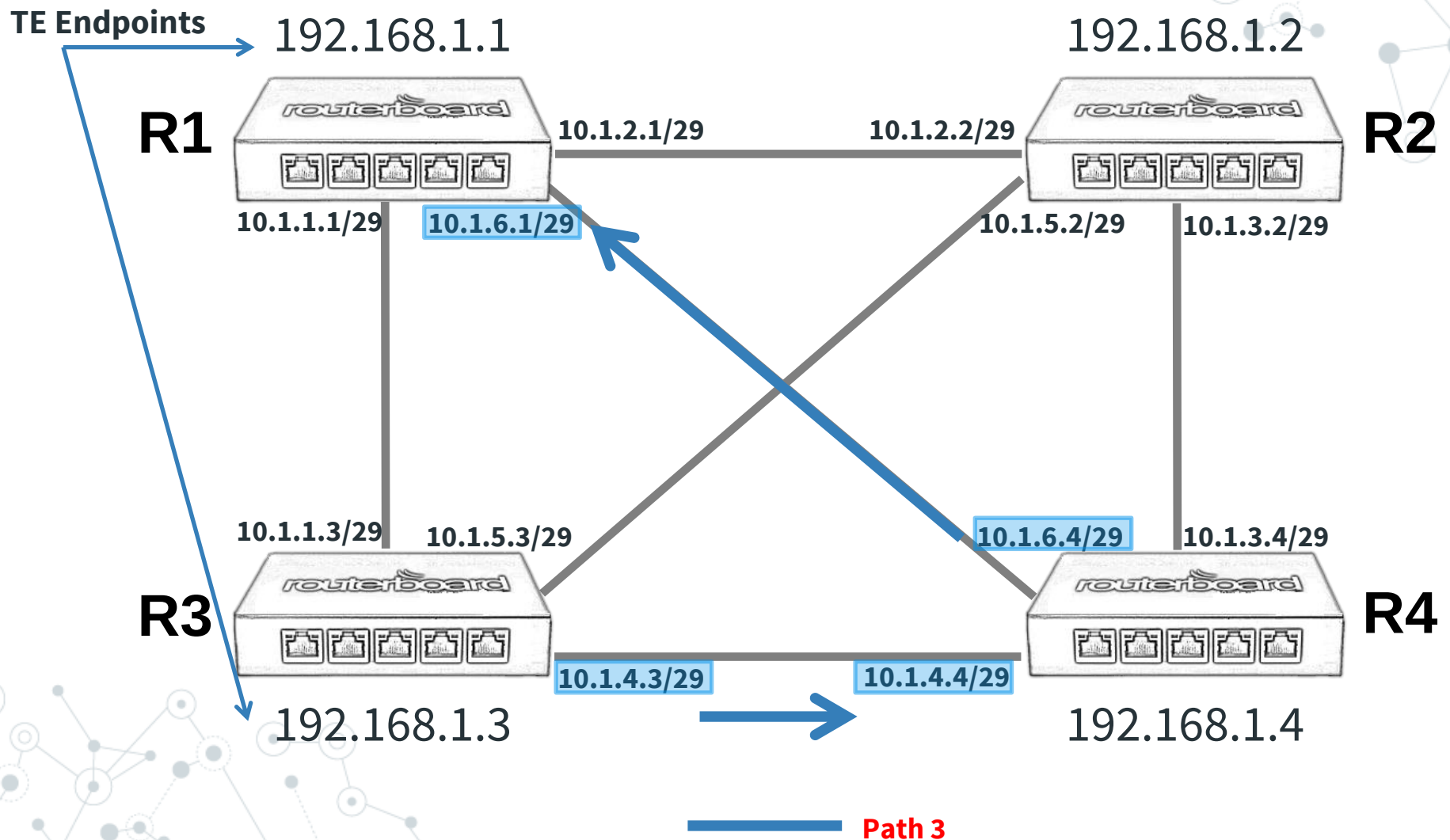
Possible paths from R3 to R1



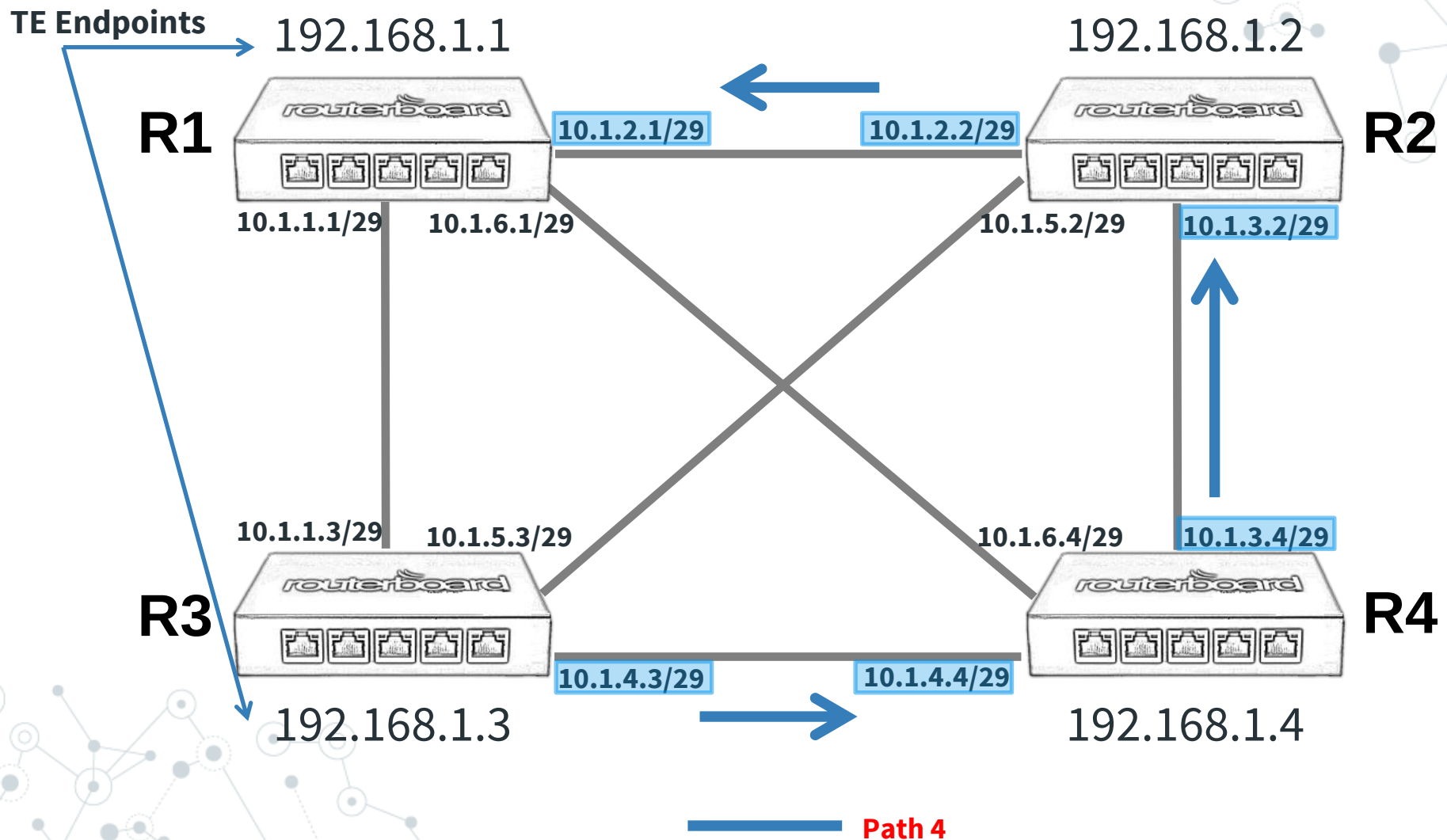
Possible paths from R3 to R1



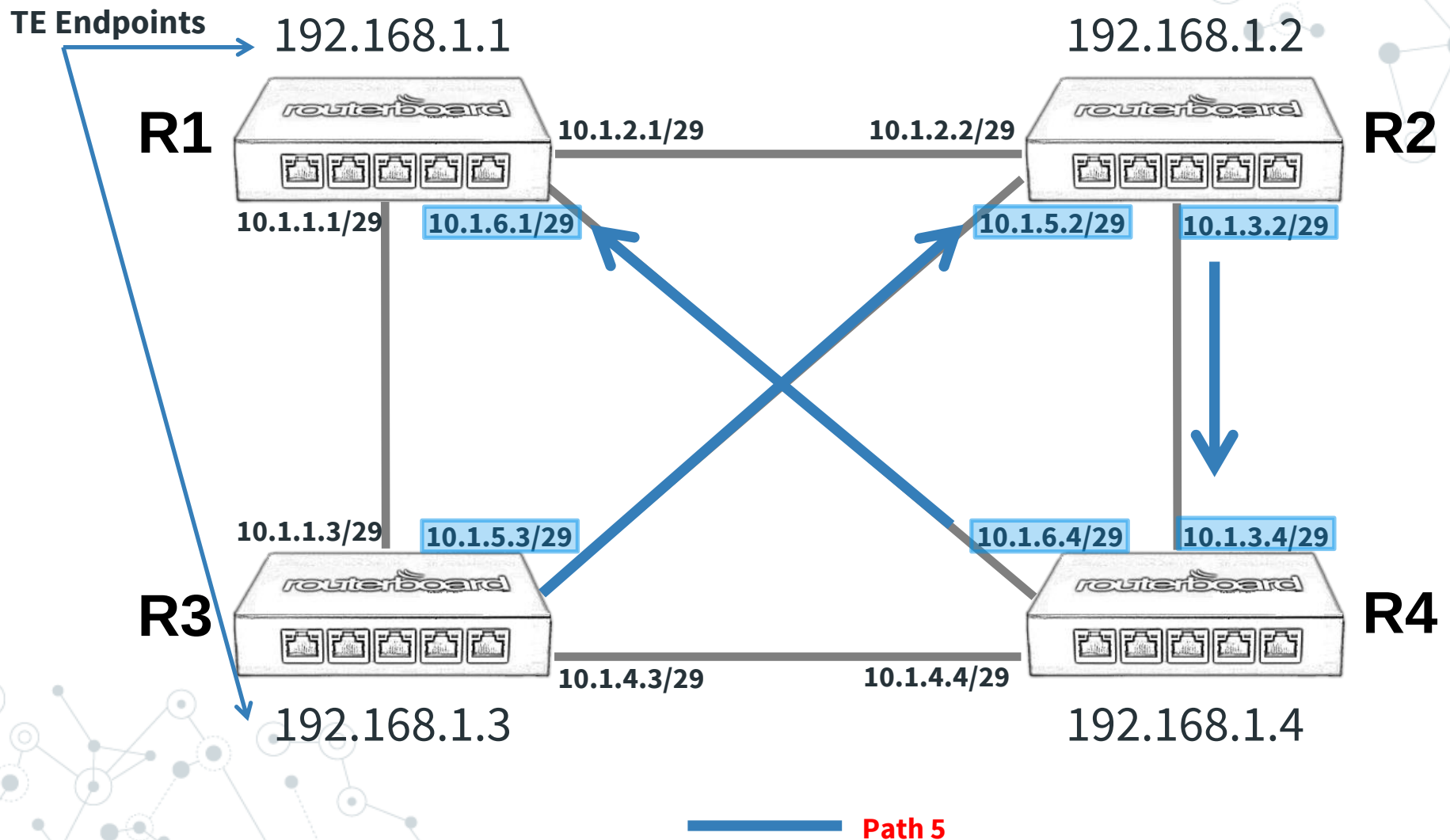
Possible paths from R3 to R1



Possible paths from R3 to R1



Possible paths from R3 to R1



Set up TE unidirectional paths on R3

Traffic Eng

Interface	Tunnel Path	Path State	Resv. State	Traffic Eng Interface
+ - ✓ ✗ ⌵				
Name	Use CSPF	Hops		
r3-r1	no			
r3-r2-r1	no	10.1.5.2:strict, 10.1.2.2:strict, 10.1.2.1:strict		
r3-r2-r4-r1	no	10.1.5.2:strict, 10.1.3.2:strict, 10.1.3.4:strict, 10.1.6.4:strict, 10.1.6.1:strict		
r3-r4-r1	no	10.1.4.4:strict, 10.1.6.4:strict, 10.1.6.1:strict		
r3-r4-r2-r1	no	10.1.4.4:strict, 10.1.3.4:strict, 10.1.3.2:strict, 10.1.2.2:strict, 10.1.2.1:strict		

Repeat the exact setup
as on **R1**

Tunnel Path <r3-r2-r1>

Name: r3-r2-r1

☐ Use CSPF

Setup Priority:

Holding Priority:

Record Route:

Affinity Include All:

Affinity Include Any:

Affinity Exclude:

Reoptimize Interval:

Hops: 10.1.5.2 : strict

10.1.2.2 : strict

10.1.2.1 : strict

OK

Cancel

Apply

Disable

Copy

Remove

Set up TE tunnel on R1

Traffic Eng

Interface Tunnel Path Path State Resv. State Traffic Eng Interface

+ - ✓ ✗ [icon] [icon]

	Name	Type	L2 MTU	Tx
R	traffic-eng-downstream-r3	Traffic Eng Interface	65535	

Interface <traffic-eng-downstream-r3>

General TE Bandwidth Status Status Traffic

Name: traffic-eng-downstream-r3

Type: Traffic Eng Interface

MTU: 1500

L2 MTU: 65535

From Address: 192.168.1.1

To Address: 192.168.1.3

Bandwidth: 250M

Primary Path: r1-r3

Secondary Paths: r1-r2-r3, r1-r4-r3, r1-r2-r4-r3, r1-r4-r2-r3

OK Cancel Apply Disable Comment Copy Remove Torch

Interface <traffic-eng-downstream-r3>

General TE Bandwidth Status Status Traffic

Primary Retry Interval: 00:01:00

Setup Priority: [dropdown]

Holding Priority: [dropdown]

Record Route: ☒

Affinity Include All: [dropdown]

Affinity Include Any: [dropdown]

Affinity Exclude: [dropdown]

Reoptimize Interval: 00:00:05

OK Cancel Apply Disable Comment Copy Remove Torch

Set up TE tunnel on R3

Traffic Eng				
Interface	Tunnel Path	Path State	Resv. State	Traffic Eng Interface
     				
	Name	Type	L2 MTU	Tx
R	 traffic-eng-upstream-r1	Traffic Eng Interface	65535	

Interface <traffic-eng-upstream-r1>

General TE Bandwidth Status Status Traffic

Name: traffic-eng-upstream-r1

Type: Traffic Eng Interface

MTU: 1500

L2 MTU: 65535

From Address: 192.168.1.3

To Address: 192.168.1.1

Bandwidth: 250M

Primary Path: r3-r1

Secondary Paths: r3-r2-r1

r3-r4-r1

r3-r4-r2-r1

r3-r2-r4-r1

OK Cancel Apply Disable Comment Copy Remove Torch

Interface <traffic-eng-upstream-r1>

General TE Bandwidth Status Status Traffic

Primary Retry Interval: 00:01:00

Setup Priority:

Holding Priority:

Record Route: ☒

Affinity Include All:

Affinity Include Any:

Affinity Exclude:

Reoptimize Interval: 00:00:05

OK Cancel Apply Disable Comment Copy Remove Torch

TE effects on R3

Traffic Eng				
Interface	Tunnel Path	Path State	Resv. State	Traffic Eng Interface
+ - ✓ ✗ ⌵				
Interface	Bandwidth (bps)	TE Metric	Remaining Bw.	
bonding1	1G	1	750.0 Mbps	
bonding2	1G	1	1000.0 Mbps	
bonding3	1G	1	1000.0 Mbps	

Traffic Eng

Interface

Tunnel Path

Path State

Resv. State

Traffic Eng Interface



	Src.	Dst.	Bandwidth	Out Interface	Out Next Hop
ER	192.168.1.1:1	192.168.1.3:4	250.0 Mbps		
LFP	192.168.1.3:1	192.168.1.1:18	250.0 Mbps	bonding1	10.1.1.1

R1 routing (download traffic)

The screenshot displays a network configuration interface. The 'Route List' window shows a table of routes. The selected route, 172.16.0.0/24, is highlighted. A detailed view of this route is shown in the foreground, with a red box highlighting the 'Dst. Address' and 'Gateway' fields.

	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
DAo	192.168.1.4	10.1.6.4 reachable bonding2	110		
DAo	192.168.1.3	10.1.1.3 reachable bonding1	110		
DAo	192.168.1.2	10.1.2.2 reachable bonding3	110		
DAC	192.168.1.1	lo0 reachable	0		192.168.1.1
AS	172.16.0.0/24	traffic-eng-downstream-r3 reachable	1		
DAC	10.1.6.0/29				
DAo	10.1.5.0/29				
DAo	10.1.4.0/29				
DAo	10.1.3.0/29				
DAC	10.1.2.0/29				
DAC	10.1.1.0/29				
DAC	10.0.0.0/24				
DAS	0.0.0.0/0				

Route <172.16.0.0/24>

General Attributes

Dst. Address: 172.16.0.0/24

Gateway: traffic-eng-downstream-r3 reachable

Check Gateway: [dropdown]

Type: unicast

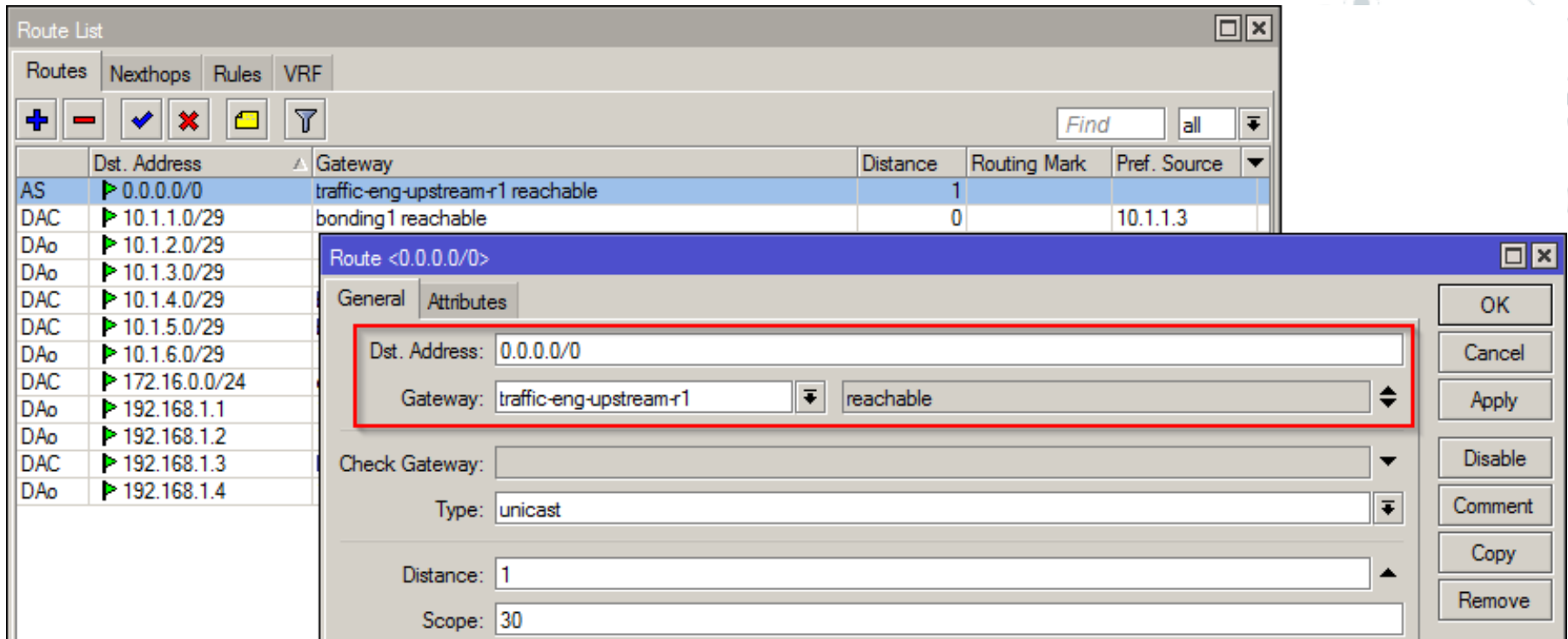
Distance: 1

Scope: 30

Buttons: OK, Cancel, Apply, Disable, Comment, Copy, Remove

From **R1** push the traffic for 172.16.0.0/24 through the TE tunnel

R3 routing (upload traffic)



The screenshot displays the Mikrotik WinBox interface. The 'Route List' window is open, showing a table of routes. The 'AS' row is selected, showing the default route (0.0.0.0/0) with a gateway of 'traffic-eng-upstream-r1' and a distance of 1. The 'Route <0.0.0.0/0>' configuration window is also open, showing the 'General' tab. The 'Dst. Address' is set to '0.0.0.0/0', the 'Gateway' is 'traffic-eng-upstream-r1', and the 'Type' is 'unicast'. The 'Distance' is set to 1 and the 'Scope' is 30. A red box highlights the 'Dst. Address' and 'Gateway' fields in the configuration window.

	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
AS	0.0.0.0/0	traffic-eng-upstream-r1 reachable	1		
DAC	10.1.1.0/29	bonding1 reachable	0		10.1.1.3
DAo	10.1.2.0/29				
DAo	10.1.3.0/29				
DAC	10.1.4.0/29				
DAC	10.1.5.0/29				
DAo	10.1.6.0/29				
DAC	172.16.0.0/24				
DAo	192.168.1.1				
DAo	192.168.1.2				
DAC	192.168.1.3				
DAo	192.168.1.4				

Route <0.0.0.0/0>

General Attributes

Dst. Address: 0.0.0.0/0

Gateway: traffic-eng-upstream-r1 reachable

Check Gateway:

Type: unicast

Distance: 1

Scope: 30

OK Cancel Apply Disable Comment Copy Remove

From **R3** push all traffic through the TE tunnel

Final checks and test

- ◎ Check if DNS is working on all routers
- ◎ Check that MPLS TE opaque LSAs exist
- ◎ Check if you need NAT on the border
- ◎ Test if it's working from customer
- ◎ Verify that tunnels are pushing traffic correctly (only TX) and that reservations are met on the bonding interfaces that have the active paths attached

Customer test

Terminal

```
[admin@Management] > /tool traceroute mikrotik.com
```

#	ADDRESS	LOSS	SENT	LAST	AVG	BEST	WORST
1	172.16.0.1	0%	15	0.2ms	0.5	0.2	5.1
2	192.168.1.1	0%	15	0.3ms	0.4	0.2	1.5
3	10.0.0.254	0%	15	0.6ms	1.3	0.6	4.4
4	85.204.99.149	0%	15	5.4ms	6.5	5.4	11.1
5	81.183.1.104	0%	15	20.5ms	22	19.1	36.7
6	80.81.194.165	0%	15	68.9ms	71	68.3	75
7	195.13.224.86	0%	15	70.5ms	71.1	70.5	73
8	159.148.147.196	0%	14	68.2ms	69.4	68.2	71.8

```
-- [Q quit|D dump|C-z pause]
```

A decorative graphic in the bottom right corner consisting of a network of interconnected circles and lines. The circles vary in size and are some are solid grey, some are white with a grey outline, and some are dashed. The lines are thin and grey, connecting the circles in a web-like structure.

1 item out of 8

1 item out of 8



Thank you!

Any questions?





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