

Networking 201 with RouterOS

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Outline

- What is routing
 - How it works
- Static routing
 - Failover
 - Recursive routing
- Dynamic routing
 - OSPF
- RouterOS implementation
 - ROS 6 vs. ROS 7

RMHAM Netops: The folks behind the curtain

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- James KI0KN
- Jeff K0JSC
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- ED KA8JMW
- Statistics Jan 2024
 - 246 sites
 - 810 devices
- Our motto: DFIU
 - Fix your mistakes before Observium alerts!
- Many sites are accessible only during the summer, or require driving 4 hours

IP basics

- In order to communicate we **must** have
 - Unique IP address 10.30.20.7
 - Netmask 255.255.255.0 (or /24)
 - Default gateway 10.30.20.1
 - Compact notation 10 . 30 . 20 . 7 / 24 , 10 . 30 . 20 . 1
- Nice to have
 - DNS server (must be an IP address)
 - NTP server (can be FQDN or IP address)

Switching, bridging and routing

- On an ethernet network
 - A **hub** will send all packets to all devices
 - A **switch** will send packets based on MAC address
- On an IPv4 network
 - A **bridge** will forward packets based in MAC address
 - Learns all MAC addresses on each interface
 - IPv4 uses ARP to translate IP to MAC
 - A **router** will forward packets base in policy
 - Routes (rules) determine where to send packets

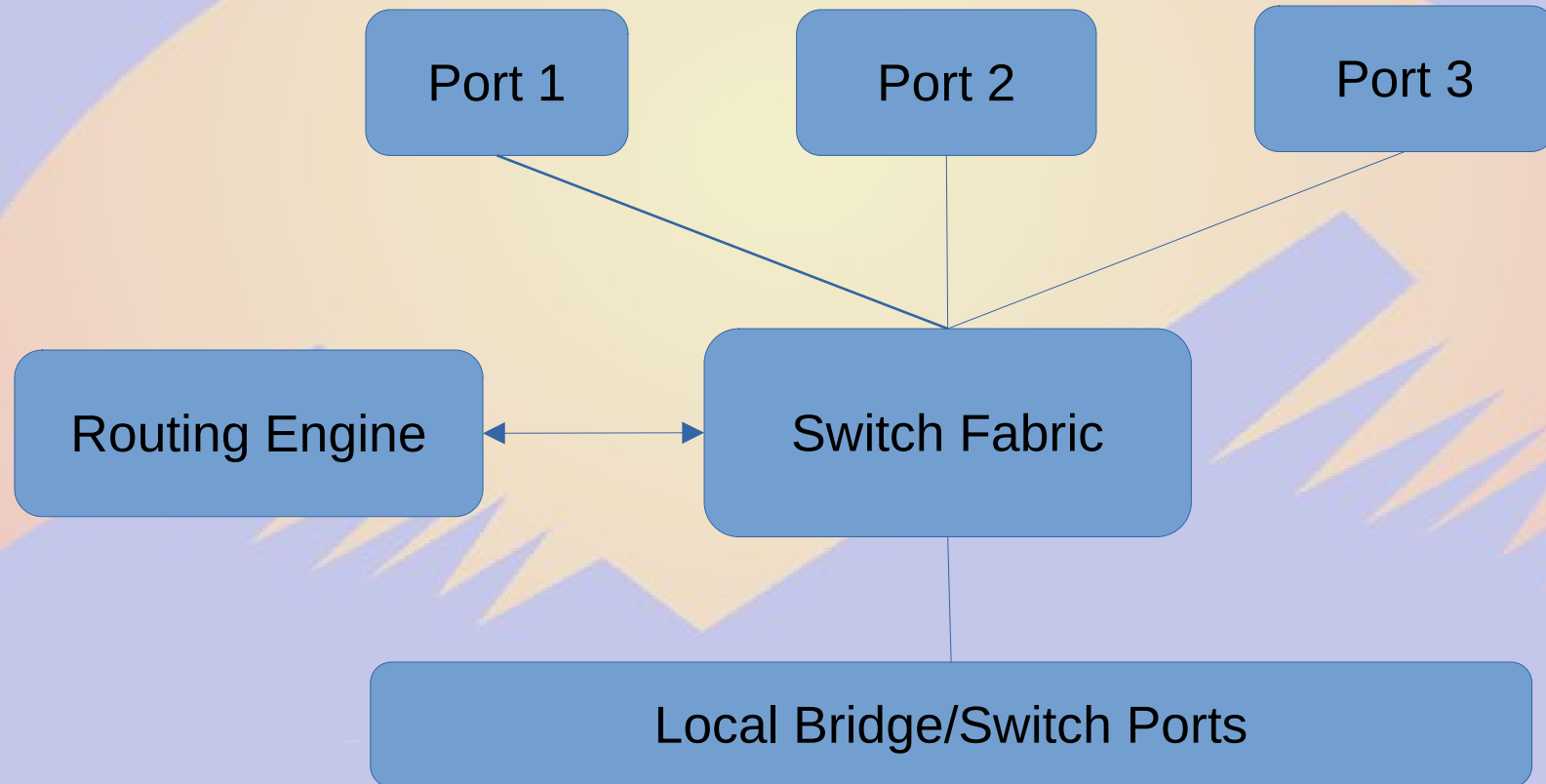
Common Terminology

- interface *Physical or virtual port*
- WAN *Network connecting to the rest of the world*
- LAN *Local network*
- VPN *Virtual Private Network (encapsulate tunnel)*
- bridge *Switch or network that is local on the router*

Lab 1: Bridging

- Bridge from AC0KQ to Saddleback
- Subnet 10.20.17.0/24
 - 10.20.17.1 Saddleback ether4
 - 10.20.17.3 QRT AP bridge
 - 10.20.17.4 LHG station bridge
 - 10.20.17.5 switch
 - 10.20.17.2 AC0KQ ether1
- All devices can communicate via 802.x

Anatomy of a router



Configuring Routing

- Static routing
 - Manually set routes
- Dynamic routing
 - Learn routes from neighbors
 - Open Shortest Path First (OSPF)
 - Selects path with lowest cumulative weight
 - Border Gateway Protocol (BGP)
 - Gets list of routes from neighbor
- Equal Cost Multi-Path (ECMP)
 - *A topic for another day*

Subnets and CIDR

- A subnet is a contiguous range of IP addresses
- Prior to 1993 subnets were fixed class A, B, C
- Post 1993 Classless Inter-Domain Routing (CIDR) defines subnets based on a **netmask**
- Devices within a subnet communicate directly
- Router passes packets between subnets

Subnet address example 10.11.12.128/28

- 16 addresses: network + 14 usable hosts + broadcast
 - blue=network part, red=host part, CIDR breaks anywhere
- Network 10.11.12.128 00001010000010110000110010000000
- Netmask 255.255.255.240 11111111111111111111111111110000
- Low host 10.11.12.129 00001010000010110000110010000001
- High host 10.11.12.142 00001010000010110000110010001110
- Broadcast 10.11.12.143 00001010000010110000110010001111

Static Routing

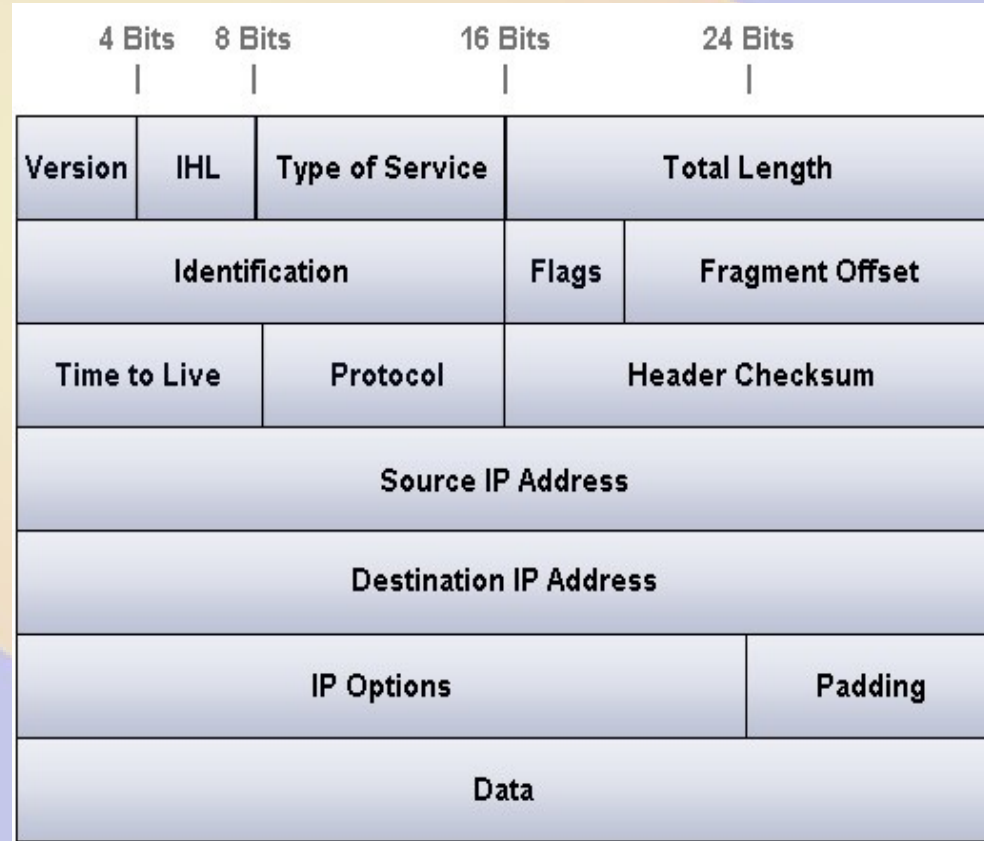
- Decides output port based on **best** network match
 - Best means smallest subnet, i.e. most network bits
 - Routes may overlap
 - 10.0.0.0/8 gw0
 - 10.11.0.0/16 gw1
 - 10.11.12.0/24 gw2
- Default route is the fallback
 - 0.0.0.0/0 matches any address
- Routing weight breaks tie when more than one best match

Route to closest matching subnet

- Routing is to closest matching subnet
 - dst-address=0.0.0.0/0 gateway=gw0
 - dst-address=10.0.0.0/8 gateway=gw1
 - dst-address=10.0.0.0/16 gateway=gw2
 - dst-address=10.45.0.0/16 gateway=gw3
 - dst-address=10.30.20.0/24 gateway=gw4
- Where do these go?
 - 10.30.20.7 => gw4
 - 10.45.0.5 => gw3
 - 10.30.10.5 => gw2
 - 10.0.2.1 => gw2

Anatomy of an IP packet

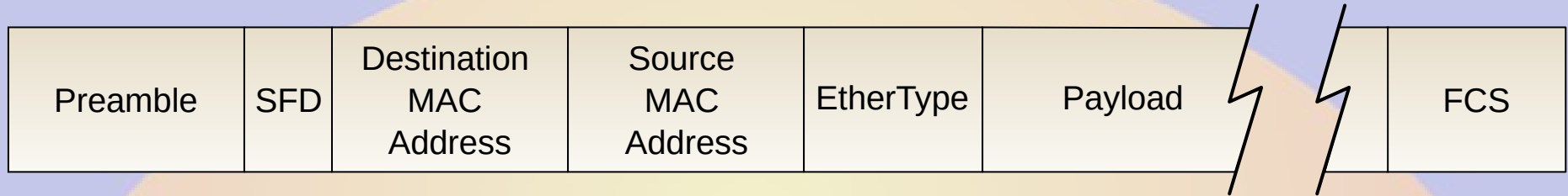
- Always big-endian
- Version=4
- IHL=IP Hdr Len
- Type of Service
 - Min delay
 - Max throughput
- Flags & Frag Off
 - Large packets
- Protocols add additional header in data section



Router changes to IP packet header

- Every router that forwards the packet decrements TTL
 - When $TTL=0$, send back *Destination Unreachable*
- Source and Destination IP is never changed
- Rest of packet is usually not changed unless packet is too large for the next transmission link
 - TCP/IP is clever about avoiding this
- *How do we get the packet to the right router?*

Anatomy of an Ethernet Frame



- Preamble (7 bytes) and SFD are fixed bit patterns
- Ether type 0x0800 means IPv4
- MAC address is 6 bytes
- FCS is 4 byte CRC checksum
- ***To forward an encapsulated IP packet via ethernet, the destination MAC address must be discoverable by ARP***

Routing nuts and bolts

- Router compares **destination** IP address with routes
 - AND netmask of route and address (zeroes host bits)
 - Compare route and to masked IP address and select best match
 - Forward packet encapsulated in ethernet frame with destination MAC address of gateway
- Killer fact: Gateway must be directly reachable via ethernet*
 - MAC address of gateway must be discoverable (ARP)
 - Router and gateway must share a subnet

*If using a different transport mechanism than ethernet, the gateway must still be directly reachable using the addressing of the physical transport layer.

You can only route to gateways that are on **local** subnets. Example: Squaw

- Ports

- bridge 10.30.30.1/24
- ether1 10.20.13.1/24
- ether2 10.20.5.1/24

- Routes

- dst-address=10.0.0.0/8 gateway=10.20.13.2
- dst-address=10.0.0.0/16 gateway=10.20.5.2
- dst-address=10.30.60.0/24 gateway=10.20.5.2
- dst-address=10.30.120.0/24 gateway=10.20.5.2

The IP source address is the subnet address on the first link

- Ports
 - bridge 10.30.30.1/24
 - ether1 10.20.13.1/24
 - ether2 10.20.5.1/24
- ping from **router** to 10.30.20.1 goes via ether1
 - dst-address=10.30.20.1
 - src-address=**10.20.13.1**
 - Forwarded to gateway=10.20.13.2
- ping from device attached to bridge has source **10.30.30.X**
 - It's default gateway would be 10.30.30.1

Traceroute

- Traceroute sends a packet with a TTL of 1,2,3,4,...
 - When TTL reaches 0, router replies with *Destination Unreachable*
 - Determines routes along the path
- Linux & OSX traceroute use UDP packets by default
 - -I use ICMP instead, but requires root
 - Windows uses ICMP

Common Routing SNAFUs

- Missing default route
 - Some packets have nowhere to go
- No return route
 - Destination sends return packets to wrong interface
- Split routes
 - Return packet follow a different path
 - Multiple different equal-weight paths
- Flapping VPN
 - VPN trying to tunnel across itself
- *Lots of other creative ways to mess it up*

Network Address Translation (NAT)

- **src-nat or masquerade**
 - Rewrites **source** IP on forwarded packets
 - For TCP & UDP also rewrite **source port**
 - Rewrites **destination** IP on returned packets
 - For TCP and UDP also rewrite **destination port**
- **dst-nat or port forwarding**
 - Rewrites **destination** IP on forwarded packets
 - For TCP & UDP also rewrite the **source port**
 - Rewrites **source** IP on returned packets
 - For TCP & UDP also rewrite the **destination port**

Common NAT SNAFUs

- Split routes
 - Forward and reverse packets must traverse the **same router** and typically also the **same interface**
 - Works best with single external interface
- Router loses state
 - Reboot, power loss, ...
 - Timeout
 - Prevent using KEEPALIVE

Lab 2: Simple routing

- Add Demo to NetLab
- Local sub net 10.30.80.0/24
 - 10.30.80.1 Bridge IP
- WAN1 Buckhorn via DHCP
- *Why does my laptop not work?*

Example Static Route

- Interfaces

- ether1-WAN 128.138.32.18/24 ISP
- ovpn-thor 172.16.20.77/24 VPN to Thorodin
- bridge1 192.168.27.1/24 Local switch

- Routes

- direct 128.138.32.0/24 gw ether1 *To reach ISP gw*
- direct 172.16.20.0/24 gw ovpn-thor *To reach VPN server*
- direct 192.168.27.0/24 gw bridge1 *To reach local devices*
- static 10.0.0.0/8 gw 172.16.20.1 *To reach RMHAM*
- static 192.168.0.0/16 gw 172.16.20.1 *To reach QTH sites*
- static default gw 128.138.32.1 *Everything else*

How to set up static routes

- The default route must handle any traffic
- Other gateways handle selected traffic
- Set the narrowest subnet that will steer traffic to the gateway
`ip route add dst-address=10.0.0.0/8 gateway=172.16.20.1`
- Nest routes for specific subnets
 - 10.30.0.0/16 gw 172.16.11.1
 - All 10.30.0.0/16 traffic goes here
 - 10.0.0.0/8 gw 172.16.20.1
 - All 10.0.0.0/8 traffic except 10.30.0.0/16 goes here
 - ***Say what you want, not what you don't want***

Failover

- Set primary and secondary based on distance

```
/ip route
add gateway=128.138.32.1 distance=1
add gateway=66.23.48.1 distance 2
```
- If **128.138.32.1** is up, default traffic goes there
- If **128.138.32.1** is down, default is **66.23.48.1**
 - Up or down is determined by ethernet link status
 - **check-gateway=ping** detects status with ping
 - Important if link is bridged

Lab 3: Failover

- Local sub net 10.30.80.0/24
 - 10.30.80.1 Bridge IP
- WAN1 Buckhorn (primary)
- WAN2 Lee Hill (secondary)

Recursive Failover

- What if the ISP is down?
 - Default gateway shows up but packets die there
- Recursive routes test end-to-end connectivity
 - Ping reliable target

```
/ip route  
add dst-address=8.8.8.8/32 gateway=128.138.32.1 target-scope=11  
add gateway=8.8.8.8 distance=1 check=gateway=ping  
add gateway=66.23.48.1 distance=2
```

Recursive Failover in WinBox

The image displays two side-by-side WinBox route configuration windows. The left window is titled "Route <1.1.1.1/32->165.140.185.113>" and the right window is titled "Route <0.0.0.0/0->1.1.1.1>". Both windows have tabs for "General", "Status", and "MPLS".

Left Window (Route 1.1.1.1/32):

- Dst. Address: 1.1.1.1/32
- Gateway: 165.140.185.113
- Immediate Gateway: 165.140.185.113%ether7-mtnbb
- Local Address: (empty)
- Check Gateway: (empty) ▼
- ☐ Suppress Hw Offload
- Distance: 1 ▲
- Scope: 10 ▲** (highlighted with a red box)
- Target Scope: 10 ▲
- VRF Interface: (empty) ▼
- Routing Table: main ▼
- Pref. Source: (empty) ▲
- ☐ Blackhole

Right Window (Route 0.0.0.0/0):

- Dst. Address: 0.0.0.0/0
- Gateway: 1.1.1.1
- Immediate Gateway: 165.140.185.113%ether7-mtnbb
- Local Address: (empty)
- Check Gateway: ping ▼ ▲
- ☐ Suppress Hw Offload
- Distance: 2 ▲
- Scope: 30 ▲
- Target Scope: 11 ▲** (highlighted with a red box)
- VRF Interface: (empty) ▼
- Routing Table: main ▼
- Pref. Source: (empty) ▲
- ☐ Blackhole

Both windows have a vertical column of buttons on the right: OK, Cancel, Apply, Disable, Comment, Copy, and Remove. At the bottom of each window is a status bar with labels: enabled, active, static, Hw Offloa..., ECMP, and inactive.

What is OSPF

- Open Shortest Path First
 - RFC 2328
 - Interior Gateway Protocol
- Link State Routing Protocol
 - Cheapest possible path
 - Route cost is sum of link costs
 - Does not consider traffic volume
- Practical for up to 1000 routers
- Can use multiple areas if necessary

How does OSPF work?

- Each router tells neighbors what subnets it can reach
 - Static routes
 - Directly attached routes
 - Routes learned from other OSPF routers
- Each router learns "best" way to get to all subnets
 - Cumulative route cost (Dijkstra's Algorithm)

Three Laws of OSPF

1. No static route on a router running OSPF should point at another router running OSPF.
2. All static routes not on the RMHAM network must be filtered on the source router.*
3. If a subnet requires a static route on more than one router, then OSPF needs to be enabled on the connected router. Conversely, if a router is connected to only one OSPF router, it should not run OSPF.

*RouterOS 7 allows better inbound filtering but this is still a good rule.

Terminology (1)

- Autonomous System (AS)
 - Group of routers using the same protocol
 - All of the RMHAM network
- Hello Protocol
 - Part of OSPF used to establish neighbors
- Flooding
 - Part of OSPF to exchange link state database

Terminology (2)

- Gateway = router
 - Border Router = OSPF “edge”
 - Designated Router (DR) = Link “Master”
 - Backup Designated Router (BDR) = Standby DR
- Link = A connection between routers
 - broadcast = link with multiple routers possible
 - Default for ethernet
 - Elects DR and BDR
 - point-to-point = link with just two devices
 - Default for VPN and serial

Router ID

- Automatically selected as the lowest IP address of all interfaces
- Must never go down
 - Many examples use a loopback
- Bridge address is natural choice for RMHAM
- Assign on OSPF>Instance

OSPF Areas

- top level area is called “backbone”
- routers knows all links in their area
 - calculates shortest path from them
- Multi-area routers export adjacent area
 - only compound route cost, not detail
- Single area recommended for <50 routers
 - less complex, more DFIU

RouterOS 6 vs. RouterOS 7

- Routing engine complete rewrite in RouterOS 7
- Static routing largely unchanged
 - Recursive routing slightly different
- OSPF configuration is completely different
 - Templates for selected interfaces
- Routing filters completely different
 - Free format
 - Authoritative (RouterOS 6 filters would not filter some subnets)

RMHAM Routing

- Backbone Routers use OSPF
 - Finds fewest RF links from point to point
 - VPN links serve as backup (cost +10 links)
- Connected routers use static routes
 - Static route on backbone router where the link connects is distributed by OSPF
 - Connected router direct RMHAM traffic to backbone
- Parts of the network remains statically routed

RouterOS 6: Configuring OSPF Step 1

Session Setting Dashboard

Session 10.30.50.1

Safe Mode

OSPF Instance <default>

General Metrics MPLS Status

Name default

Router ID 10.30.50.1

Redistribute Default Route never

Redistribute Connected Route as type 1

Redistribute Static Route as type 1

Redistribute RIP Route no

Redistribute BGP Route no

Redistribute Other OSPF Route no

In Filter ospf-in

Out Filter ospf-out

OK

Cancel

Apply

Disable

Comment

Copy

Remove

inBox

Quick Set

CAPsMAN

Interfaces

Wireless

Bridge

PPP

Switch

Mesh

IP

MPLS

Routing

System

Queues

Files

Log

Radius

Tools

New Terminal

LCD

MetaROUTER

RouterOS 6: Configuring OSPF Step 2

Session Setting Dashboard

Safe Mode Session 10.30.5...

OSPF

Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LSA Routes ...

+ - ✓ ✗ [Icon] [Icon] Find

Network	Area
10.0.0.0/8	backbone
172.16.0.0/16	backbone
192.168.0.0/16	backbone

Session Setting Dashboard

Safe Mode Session 10.30.5...

OSPF

Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LSA Routes ...

+ - ✓ ✗ [Icon] [Icon] Find

	Area Name	Instance	Area ID	Type	Default Cost	Interfaces	Active Interfaces	Neighbors
*	backbone	default	0.0.0.0	default		5	5	4

RouterOS 6: Configuring OSPF Step 3

- All interfaces are automatically added
- Weights are only needed for VPN and rare cases where the cost (link weight) is not 10
- Default ethernet type is broadcast

Session Setting: Dashboard

Safe Mode Session: 10.30.50.1

OSPF

Interfaces Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LSA Routes AS Border Routers Area Border Routers

+ - ✓ ✗ [icon] Find

Interface	Cost	Priority	Authentic.	Authenticatio.	Network Type	Instance	Area	Neig...	State
bridge1-LAN	10	1	none	*****	broadcast	default	backbone	0	designated router
ether1-BADGER	10	1	none	*****	broadcast	default	backbone	1	backup
ether2-WEST...	10	1	none	*****	broadcast	default	backbone	1	backup
ether3-ALMA...	10	1	none	*****	broadcast	default	backbone	1	backup
ether4-SQUAW	10	1	none	*****	broadcast	default	backbone	1	backup

RouterOS 6: Configuring OSPF Step 4

- Only add static routes you absolutely must
 - A default static route
 - VPNs and routers NOT running OSPF

The screenshot shows the RouterOS 6 web interface. The top navigation bar includes 'Session', 'Setting', and 'Dashboard'. Below this, there are buttons for 'Safe Mode' and a session ID '10.30.5...'. The left sidebar contains a menu with 'Quick Set', 'CAPsMAN', 'Interfaces', 'Wireless', 'Bridge', 'PPP', 'Switch', and 'Mesh'. The main content area is titled 'Route List' and has tabs for 'Routes', 'Nexthops', 'Rules', and 'VRF'. The 'Routes' tab is selected, showing a table of routes. A red box highlights the first row, which is the default static route for AS: 0.0.0.0/0 with gateway 10.20.6.2 reachable ether3-ALMAGRE. Below this row, there is a warning message: '!!! Westcreek DO NOT DELETE'. The second row shows a route for XS: 10.30.115.0/24 with gateway 10.20.16.2.

	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
AS	0.0.0.0/0	10.20.6.2 reachable ether3-ALMAGRE	1		
!!! Westcreek DO NOT DELETE					
XS	10.30.115.0/24	10.20.16.2	1		

RouterOS 6: Configuring OSPF Step 5

- Add ospf-out filter
- Match the subnet, not WAN address
- prefix-length
 - omit if just one
 - wildcard for multiple
 - 24-32 wildcards /24
- Actions=discard

The screenshot shows the 'Route Filter <72.19.163.96/29>' configuration window. The 'Chain' is set to 'ospf-out' and the 'Prefix' is '72.19.163.96/29'. The 'enabled' checkbox at the bottom is checked.

Matchers	BGP	Actions	BGP Actions
Chain	ospf-out		
Prefix	<input type="checkbox"/>	72.19.163.96/29	
Prefix Length			
Match Chain			
Protocol			
Distance			
Scope			
Target Scope			
Pref. Source			
Routing Mark			
Route Comment			
Route Tag			
Route Targets			
<input type="checkbox"/> Invert Route Targets			
Site Of Origin			
<input type="checkbox"/> Invert Site Of Origin			
Address Family			
OSPF Type			
<input type="checkbox"/> Invert Match			

enabled

OSPF discovers its neighbors

Session Setting Dashboard

Safe Mode Session 10.30.5...

OSPF

Interfaces Instances Networks Areas Area Ranges Virtual Link Neighbors NBMA Neighbors Sham Links LSA Routes AS Border Routers Area Border

Instance	Router ID	Address	Interface	State Change
default	10.30.60.1	10.20.14.2	ether1-BADGER	5
default	10.30.120.1	10.20.6.2	ether3-ALMAGRE	6
default	10.30.30.1	10.20.5.1	ether4-SQUAW	9
default	10.30.115.1	10.20.16.2	ether2-WESTCREEK	8

OSPF distributes link database

LSA = Link State Advertisement

Session Setting Dashboard

Safe Mode Session 10.30.5...

RouterOS WinBox

OSPF

Interfaces Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Link LSA Routes AS Border Routers Area Border Routers

Find

Instance	Area	Type	ID	Originator	Sequence Number	Age (s)	
default		as externa	10.30.28.0	10.30.20.1	80000012	194	
default	backbone	router	10.0.8.1	10.0.8.1	80002f7f	183	
default		as externa	10.120.125.0	10.0.11.1	80000ebb	1386	
default		as externa	192.168.94.0	10.30.20.1	80000075	301	
default		as externa	192.168.227.0	10.30.20.1	80000054	1066	
default		as externa	192.168.110.0	192.168.11.1	80000004	1305	
default		as externa	10.30.110.0	10.30.20.1	80000453	904	
default	backbone	router	10.30.160.1	10.30.160.1	80002a70	874	
default	backbone	network	10.20.32.1	10.30.150.1	8000006d	1240	
default	backbone	network	10.20.2.1	10.30.20.1	800003fe	246	
default	backbone	router	10.30.20.1	10.30.20.1	8000a4c6	694	
default	backbone	network	10.5.5.2	10.0.2.1	8000002c	1290	
default	backbone	router	10.0.13.1	10.0.13.1	800002e2	1279	
default		as externa	10.30.254.0	10.30.20.1	800002b3	542	
default		as externa	192.168.226.0	10.30.20.1	8000074b	904	
default		as externa	10.30.106.0	10.30.32.1	8000024f	803	
default		as externa	10.15.0.0	10.30.20.1	800001cc	869	
default		as externa	10.16.0.0	10.30.20.1	800001cc	869	
default		as externa	10.17.0.0	10.30.20.1	800001cc	869	
default		as externa	10.18.0.0	10.30.20.1	800001cc	869	
default	backbone	router	10.0.11.1	10.0.11.1	80001250	594	
default		as externa	10.30.116.0	10.30.115.1	80000870	1485	
default		as externa	10.30.132.0	10.30.20.1	80000147	871	
default	backbone	network	10.5.1.1	10.0.11.1	80000021	594	
default		as externa	10.0.1.0	10.0.11.1	80000ebe	1356	
default		as externa	10.30.40.0	10.30.20.1	800001cc	869	
default		as externa	192.168.80.0	10.30.20.1	80000093	933	
default		as externa	10.30.90.0	10.30.20.1	80000681	1033	
default		as externa	10.101.0.0	10.0.11.1	80000ebb	1386	
default	backbone	router	10.30.115.1	10.30.115.1	80000984	606	
default		as externa	10.30.81.0	10.30.80.1	80000220	1349	
default		as externa	10.30.24.0	10.30.20.1	80000022	922	

126 items

Each instance finds shortest path

Session Setting Dashboard

Safe Mode Session 10.30.5...

RouterOS WinBox

OSPF

Interfaces Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LSA Routes AS Border Routers Area Border Routers

Find all

Instance	Area	Dst. Address	Gateway	Interface	Cost	State
default	backbone	172.16.120.5	10.20.6.2	ether3-AL...	110	intra area
default	backbone	172.16.101.12	10.20.6.2	ether3-AL...	40	intra area
default	backbone	10.20.6.0/24	0.0.0.0	ether3-AL...	10	intra area
default	backbone	10.20.14.0/24	0.0.0.0	ether1-BA...	10	intra area
default	backbone	192.168.111.0/24	10.20.5.1	ether4-SQ...	60	ext 1
default	backbone	10.0.9.0/24	10.20.6.2	ether3-AL...	40	intra area
default	backbone	10.5.7.0/24	10.20.6.2	ether3-AL...	40	intra area
default	backbone	172.16.101.20	10.20.6.2	ether3-AL...	40	intra area
default	backbone	192.168.106.0/24	10.20.5.1	ether4-SQ...	60	ext 1
default	backbone	10.20.26.0/24	10.20.16.2	ether2-WE...	220	intra area
default	backbone	172.16.101.1	10.20.6.2	ether3-AL...	50	intra area
default	backbone	10.30.211.0/24	10.20.5.1	ether4-SQ...	60	ext 1
default	backbone	172.16.20.1	10.20.5.1	ether4-SQ...	50	intra area
default	backbone	192.168.0.0/24	10.20.6.2	ether3-AL...	40	intra area
default	backbone	10.0.8.0/24	10.20.14.2	ether1-BA...	21	intra area
default	backbone	10.20.22.0/24	10.20.5.1	ether4-SQ...	30	intra area
default	backbone	192.168.11.0/24	10.20.5.1	ether4-SQ...	40	intra area
default	backbone	10.5.1.0/24	10.20.6.2	ether3-AL...	40	intra area
default	backbone	10.0.11.0/24	10.20.6.2	ether3-AL...	40	intra area
default	backbone	172.16.120.1	10.20.6.2	ether3-AL...	130	intra area
default	backbone	10.0.13.0/24	10.20.6.2	ether3-AL...	50	intra area
default	backbone	10.1.1.0/24	10.20.6.2	ether3-AL...	150	ext 1
default	backbone	10.5.10.0/24	10.20.6.2	ether3-AL...	40	intra area
default	backbone	172.16.20.35	10.20.5.1	ether4-SQ...	40	intra area
default	backbone	10.30.116.0/24	10.20.16.2	ether2-WE...	40	ext 1
default	backbone	172.16.20.22	10.20.5.1	ether4-SQ...	180	intra area
default	backbone	172.16.20.108	10.20.5.1	ether4-SQ...	40	intra area
default	backbone	10.1.2.0/24	10.20.6.2	ether3-AL...	40	intra area
default	backbone	10.20.1.0/24	10.20.5.1	ether4-SQ...	50	intra area
default	backbone	10.20.29.0/24	10.20.5.1	ether4-SQ...	60	ext 1
default	backbone	172.16.20.76	10.20.5.1	ether4-SQ...	40	intra area
default	backbone	172.16.101.4	10.20.6.2	ether3-AL...	40	intra area

204 items

OSPF adds routes (DAo)

Session Setting Dashboard

Safe Mode Session 10.30.5...

RouterOS WinBox

Quick Set
CAPsMAN
Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
LCD
MetaROUTER
Partition
Make Supout.rif
Manual
New WinBox
Exit

Route List

Routes Nexthops Rules VRF

Find all

Filter

	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
AS	0.0.0.0/0	10.20.6.2 reachable ether3-ALMAGRE	1		
DAo	10.0.0.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.1.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.2.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.3.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.4.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.5.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.8.0/24	10.20.14.2 reachable ether1-BADGER	110		
DAo	10.0.9.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.10.0/24	10.20.16.2 reachable ether2-WESTCREEK	110		
DAo	10.0.11.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.12.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.13.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.1.1.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.1.2.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.1.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.2.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.3.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.4.0/24	10.20.14.2 reachable ether1-BADGER	110		
DAo	10.5.5.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.7.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.10.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.11.0.0/24	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.11.3.0/24	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.11.8.0/24	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.15.0.0/16	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.16.0.0/16	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.16.0.250	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.17.0.0/16	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.18.0.0/16	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.20.0.0/24	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.20.1.0/24	10.20.5.1 reachable ether4-SQUAW	110		

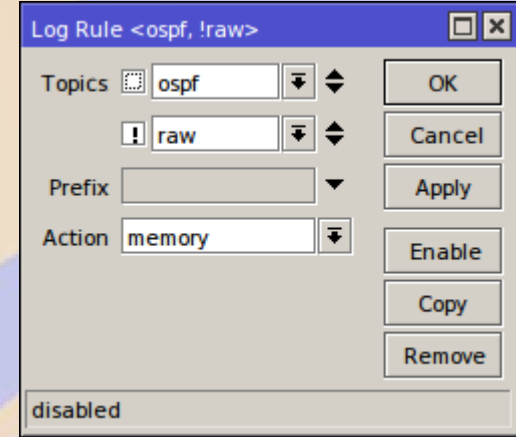
207 items

Lab 4: OSPF

- Undo NAT
- RouterID 10.30.80.1 (Bridge IP)
- Distribute connected routes
- Networks 10.0.0.0/8

Debugging

- Add log rule for OSPF
 - /system logging add topics=ospf,!raw
- Weird log entries may require a reboot of the router
 - database out of date



Border routers are the edge of the OSPF Autonomous System

Session Setting Dashboard

Safe Mode Session 10.30.5...

OSPF

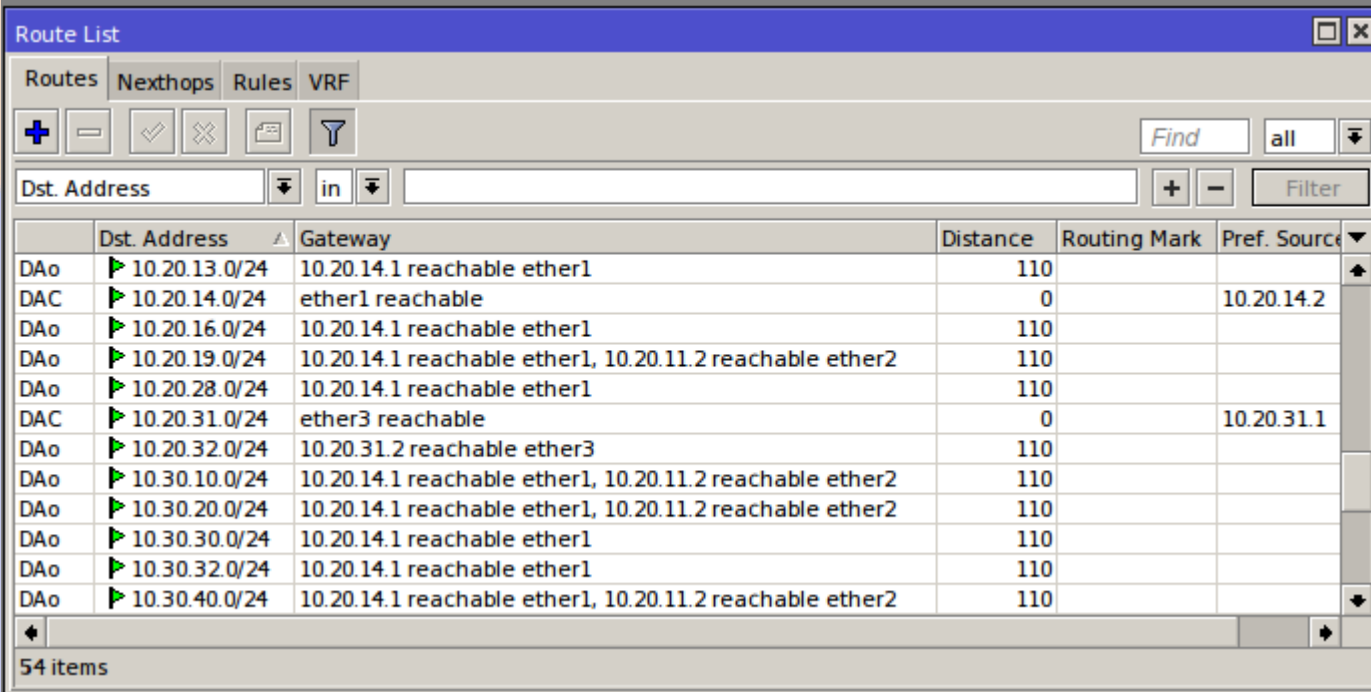
Interfaces Instances Networks Areas Area Ranges Virtual Links Neighbors NBMA Neighbors Sham Links LSA Routes AS Border Routers Area Border Routers

Find

Instance	Router ID	Gateway	Interface	Cost	State	
default	10.30.20.1	10.20.5.1	ether4-SQUAW	30	intra area	
default	10.30.32.1	10.20.5.1	ether4-SQUAW	20	intra area	
default	192.168.73.1	10.20.5.1	ether4-SQUAW	40	intra area	
default	10.30.80.1	10.20.5.1	ether4-SQUAW	40	intra area	
default	10.30.115.1	10.20.16.2	ether2-WESTCREEK	10	intra area	
default	10.0.11.1	10.20.6.2	ether3-ALMAGRE	30	intra area	
default	10.30.120.1	10.20.6.2	ether3-ALMAGRE	10	intra area	
default	10.1.2.1	10.20.6.2	ether3-ALMAGRE	30	intra area	
default	192.168.11.1	10.20.5.1	ether4-SQUAW	30	intra area	

Avoid split routes

- Make sure weights are symmetric
- Weight your preferred path lower
- **DO NOT ADD STATIC ROUTES**



Route List

Routes Nexthops Rules VRF

Find all

Dst. Address in

	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
DAo	10.20.13.0/24	10.20.14.1 reachable ether1	110		
DAC	10.20.14.0/24	ether1 reachable	0		10.20.14.2
DAo	10.20.16.0/24	10.20.14.1 reachable ether1	110		
DAo	10.20.19.0/24	10.20.14.1 reachable ether1, 10.20.11.2 reachable ether2	110		
DAo	10.20.28.0/24	10.20.14.1 reachable ether1	110		
DAC	10.20.31.0/24	ether3 reachable	0		10.20.31.1
DAo	10.20.32.0/24	10.20.31.2 reachable ether3	110		
DAo	10.30.10.0/24	10.20.14.1 reachable ether1, 10.20.11.2 reachable ether2	110		
DAo	10.30.20.0/24	10.20.14.1 reachable ether1, 10.20.11.2 reachable ether2	110		
DAo	10.30.30.0/24	10.20.14.1 reachable ether1	110		
DAo	10.30.32.0/24	10.20.14.1 reachable ether1	110		
DAo	10.30.40.0/24	10.20.14.1 reachable ether1, 10.20.11.2 reachable ether2	110		

54 items

VPN Problems

- When the VPN drops, the dynamically created interface on the server is deleted and properties assigned to it is lost
 - Solution: Create a permanent instance by copying the dynamic interface after it connects.
- When OSPF discovers the WAN address of the VPN endpoint can be reached via RF, it will try to run the VPN over RF
 - Solution: Filter the WAN address so that other routers do not discover it

VPN Setup Procedure

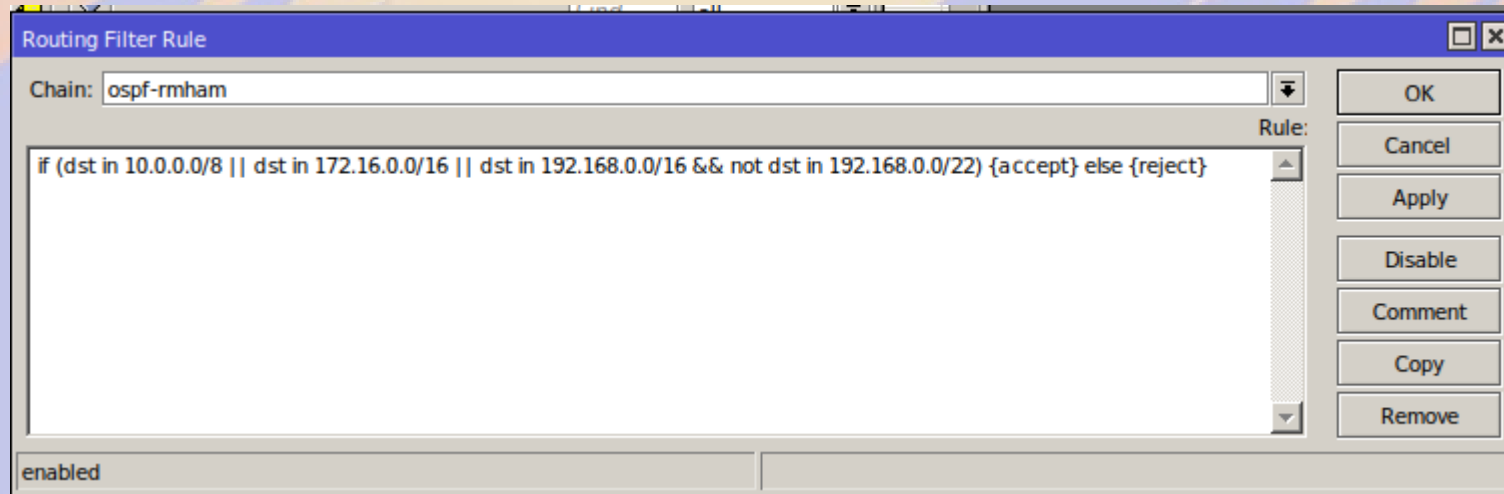
- Add secret on VPN server
- Add VPN on client
- On the server copy the dynamic interface
 - Create a permanent interface name
- On the OSPF>Interfaces tab set the cost
- Add an ospf-out filter to prevent WAN export

RouterOS 7

- RouterOS 7 is a significant improvement
 - OSPF neighbors are added explicitly (templates)
 - Filters are authoritative for input and output
- RouterOS 7 is a work in progress
 - Very active development
- RMHAM is gradually adopting RouterOS 7
 - Upgrade is robust, but does require some manual fixes
 - Not recommended for older 16MB routers

RouterOS 7: Configuring OSPF Step 1

- Create filters to only allow
 - 10.0.0.0/8 and 172.16.0.0/16
 - 192.168.4.0/24 - 192.168.255.0/24
 - All others are filtered
- Selective accept rather than selective reject



RouterOS 7: Configuring OSPF Step 2

OSPF Instance <default-v2>

Name:

Version:

VRF:

Router ID:

Routing Table:

Originate Default:

Redistribute: ☒ connected ☒ static ☐ rip ☐ ospf ☐ bgp ☒ vpn ☐ dhcp ☐ fantasy ☐ modem ☐ bgp-mpls-vpn

Out Filter Select:

Out Filter:

In Filter:

Domain ID:

Domain Tag:

MPLS TE Address:

MPLS TE Area:

enabled

OK
Cancel
Apply
Disable
Comment
Copy
Remove

RouterOS 7: Configuring OSPF Step 3

OSPF Interface Template

Interfaces: ether1-thor

Area: backbone-v2

Networks:

Network Type: ptp

Prefix List

Instance ID: 0

Cost: 10

Priority: 1

☐ Passive

Authentication:

Auth. Key:

Auth. ID: 1

Vlink Transit Area

Vlink Neighbor ID:

Use BFD: ☐

Retransmit Interval: 00:00:05

Transmit Delay: 1

Hello Interval: 00:00:10

Dead Interval: 00:00:40

enabled

OK Cancel Apply Disable Comment Copy Remove

OSPF Interface Template

Interfaces: ovpn-ac0kq

Area: backbone-v2

Networks:

Network Type: ptp

Prefix List

Instance ID: 0

Cost: 5000

Priority: 128

☐ Passive

Authentication:

Auth. Key:

Auth. ID:

Vlink Transit Area

Vlink Neighbor ID:

Use BFD:

Retransmit Interval: 00:00:05

Transmit Delay: 1

Hello Interval: 00:00:10

Dead Interval: 00:00:40

enabled

OK Cancel Apply Disable Comment Copy Remove

OSPF Interface Template

Interfaces:

Area: backbone-v2

Networks: 172.16.11.0/24

Network Type: ptp

Prefix List

Instance ID: 0

Cost: 5000

Priority: 128

☐ Passive

Authentication:

Auth. Key:

Auth. ID:

Vlink Transit Area

Vlink Neighbor ID:

Use BFD:

Retransmit Interval: 00:00:05

Transmit Delay: 1

Hello Interval: 00:00:10

Dead Interval: 00:00:40

enabled

OK Cancel Apply Disable Comment Copy Remove

Interface Template Notes

- You must explicitly add a template for OSPF
 - Interface sets properties for that interface
 - Network can set properties for multiple interfaces (e.g. VPN)
- Network type is usually point-to-point
 - Use broadcast only when multiple routers share subnet
 - PtP detects link up/down much faster
 - Priority only matters for broadcast
 - Highest value becomes DR

Upgrading from RouterOS 6 to RouterOS 7

- Physical access is important
 - RoMON is your friend
- Most settings are upgraded correctly
 - OSPF VPN connections are lost
 - Interface templates are over-specified
 - Remove networks or interfaces
 - Recursive routes are broken
 - Update scope and target scope
 - Routing filters should be improved

Resources

- <https://wiki.mikrotik.com/wiki/Manual:TOC>
- <https://www.prinmath.com/ham/mikrotik-failover.htm>
- <https://www.prinmath.com/ham/routers7>