

Conserving IPv4 Addresses in a Routed Network

MikroTik MUM – Slovenia 2016

Brian Horn – WISP TRACON LLC

Background

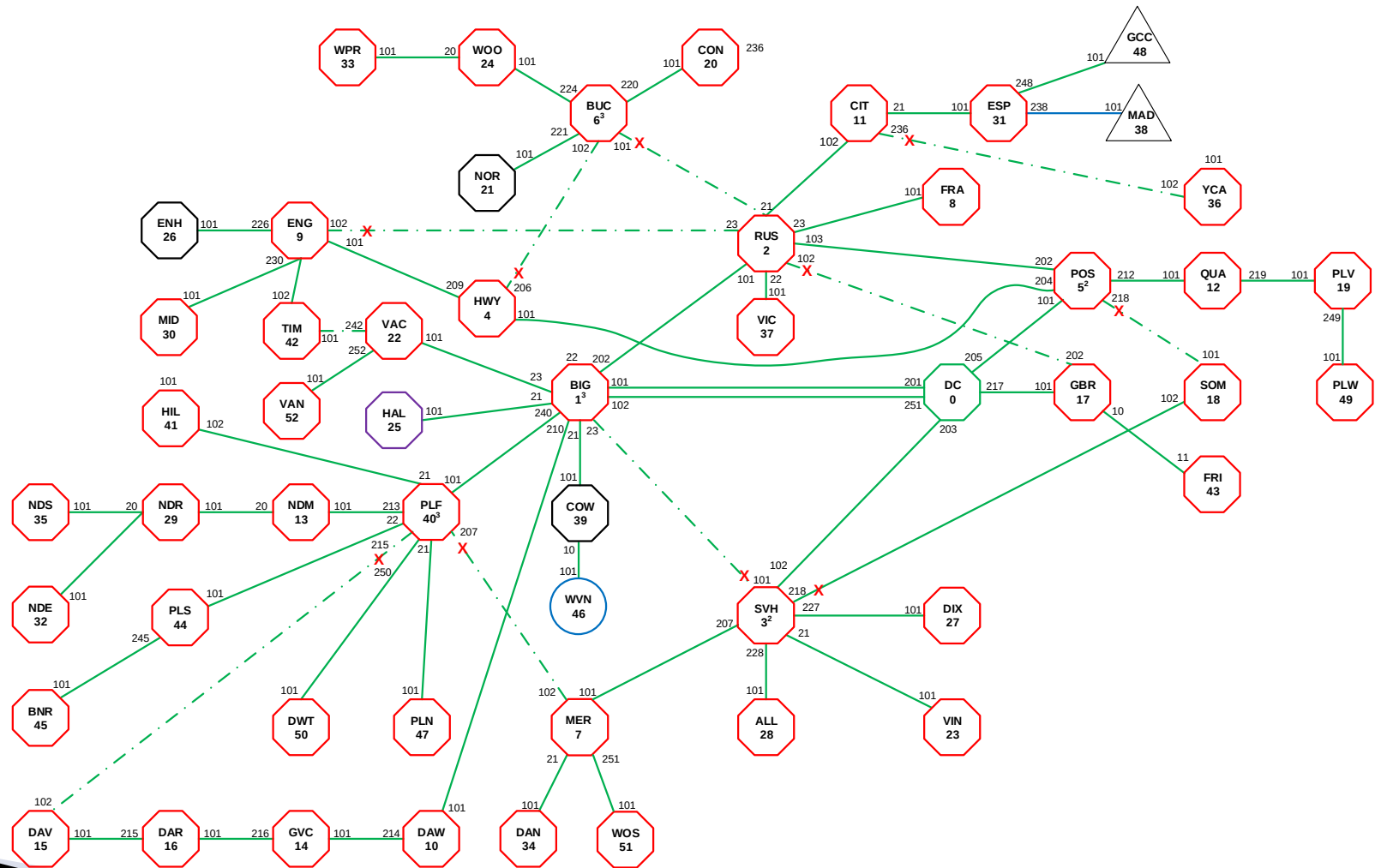
- ▶ WISP TRACON LLC
 - Solutions Training and Consulting Company
 - Operations in North America, Europe and Africa
 - MikroTik Certified Consultants and Trainers

- ▶ Winters Broadband LLC
 - California based WISP
 - Founded 2002
 - ARIN assigned ASN and /22 address block
 - CPE assigned static public IP address
 - Addresses DMCA issues
 - Digital Millennium Copyright Act

Winters Broadband Network – 2012

- ▶ Existing
 - Edge Routed
 - Bridged/Switched backbone with routed subscriber connections
 - Script controlled redundant links
 - 40+ Access Point sites
 - Over 600 CPE's
 - Dual homed Internet connection
- ▶ Plan
 - Migrate to routed OSPF backbone
 - Subnetted by Site location
- ▶ Issues
 - Unable to get additional IPv4 address assignment
 - Subnetting issues – Poor address utilization

Network Architecture – 2012



Subnetting /22

IP Address Block/Site

4	5	6	7
DC	SVH	RUS	MER
GBR		BUC	NDM
BIG	SOM	CON	NDX
	VIN		
GBR	ALL	WOO	DAN
			FRA
HWY	DIX	POS	DAW
HAL			
VAC	NOR	PLF	GVC
	HIL		ESP
ENG	CIT	QUA	DAR
	ESP	PLV	DAV

/28 -- 16 Subnets -- 14 Hosts/Subnet

Network #	IP Range	Broadcast
0	1 ~ 14	15
16	17 ~ 30	31
32	33 ~ 46	47
48	49 ~ 62	63
64	65 ~ 78	79
80	81 ~ 94	95
96	97 ~ 110	111
112	113 ~ 126	127
128	129 ~ 142	143
144	145 ~ 158	159
160	161 ~ 174	175
176	177 ~ 190	191
192	193 ~ 206	207
208	209 ~ 222	223
224	225 ~ 238	239
240	241 ~ 254	255

/26 -- 4 Subnets -- 62 Hosts/Subnet

Network #	IP Range	Broadcast
0	1 ~ 62	63
64	65 ~ 126	127
128	129 ~ 190	191
192	193 ~ 254	255

/27 -- 8 Subnets -- 30 Hosts/Subnet

Network #	IP Range	Broadcast
0	1 ~ 30	31
32	33 ~ 62	63
64	65 ~ 94	95
96	97 ~ 126	127
128	129 ~ 158	159
160	161 ~ 190	191
192	193 ~ 222	223
224	225 ~ 254	255

Subnetting Disadvantages

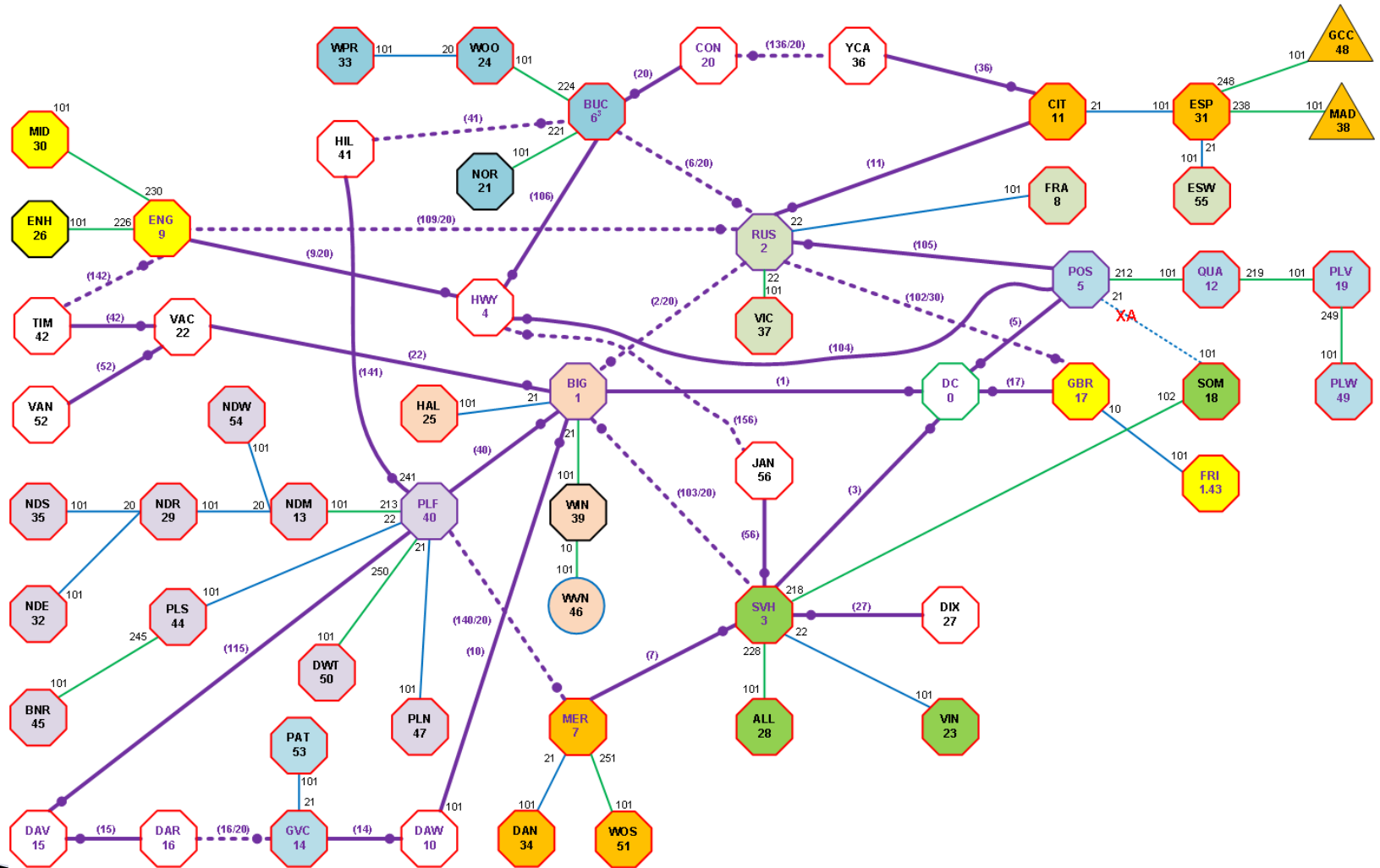
- ▶ Loss of IP addresses
 - Network, Gateway and Broadcast addresses
- ▶ Limit on addresses in subnet
 - What happens when Site address allocation is exhausted?
- ▶ Switching CPE to different AP is complex
 - Requires new IP address assignment

Winters Broadband Network – 2016

- ▶ Fully Routed with OSPF
 - Dual homed – 10 GHz and 1 GHz
- ▶ 56 Access Point sites
- ▶ All CPE's have /32 IP address
- ▶ No configuration issues
- ▶ Roaming supported for survey trucks



Network Architecture – 2016



Documenting your Network

- ▶ Document
 - Do you have a documentation standard?
 - Now would be a good time to implement one
 - Schematics (Visio)
 - IP address assignment
 - Site designations
 - Network schematic
 - What you have now
 - What you want to achieve

Documentation Standards

- ▶ Site/Link Naming Conventions
 - Keep it simple
 - Use 3 character abbreviations for sites
 - e.g. MER, PLF, SVH
 - Assign a unique number to each site
 - e.g. MER = site 7, SVH = site 3
 - Link names based on sites being connected
 - e.g. Link SVHMER or Link MERSVH

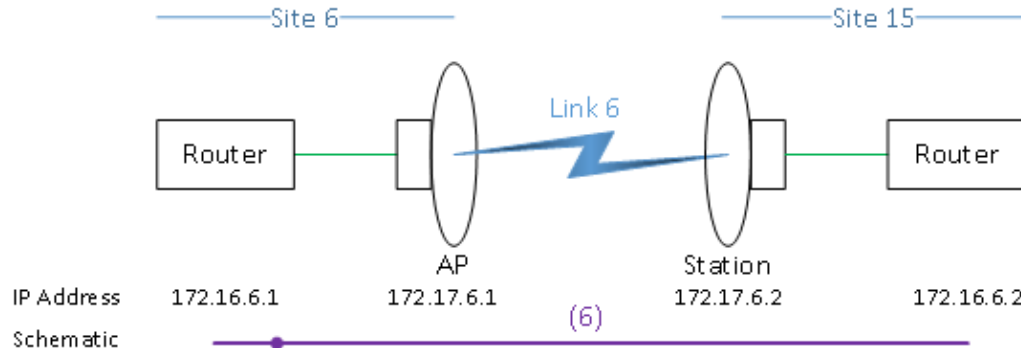
Documentation Standards

- ▶ IP Addresses – Management Network
 - Choose a IP block for network management
 - e.g. 10.0.0.0/16
 - Assign IP addresses as 10.0.X.Y where:
 - X = Site number, 60 reserved for loopback addresses
 - Y = 1 for Site Router (increment if more than one router)
 - 10 for 2.4 GHz AP with omni-directional antenna
 - 11, 12, .. for 2.4 GHz AP's with sector antennas
 - 20 for 5 GHz AP with omni-directional antenna
 - 21, 22, .. For 5 GHz AP's with sector antennas
 - 3x ... For 3.65 GHz AP's
 - 40 Power controller
 - 9x ... For 900 MHz AP's

Documentation Standards

► IP Addresses – OSPF Links

- Choose an IP subnet to be used e.g. 172.16.X.Y/30
 - Where X = Link # and Y = Device #
 - Use lowest site # for link #, if already used +100 to link #



- (6) indicates link 6 with default OSPF cost of 10
- (6/20) indicates link 6 with OSPF cost of 20

► IP Addresses – P2P Wireless Links

- Choose an IP subnet to be used e.g. 172.17.X.Y/30
 - Where X = Link # and Y = Device #
 - Use lowest site # for link #, if already used +100 to link #

Subscriber IP Addresses

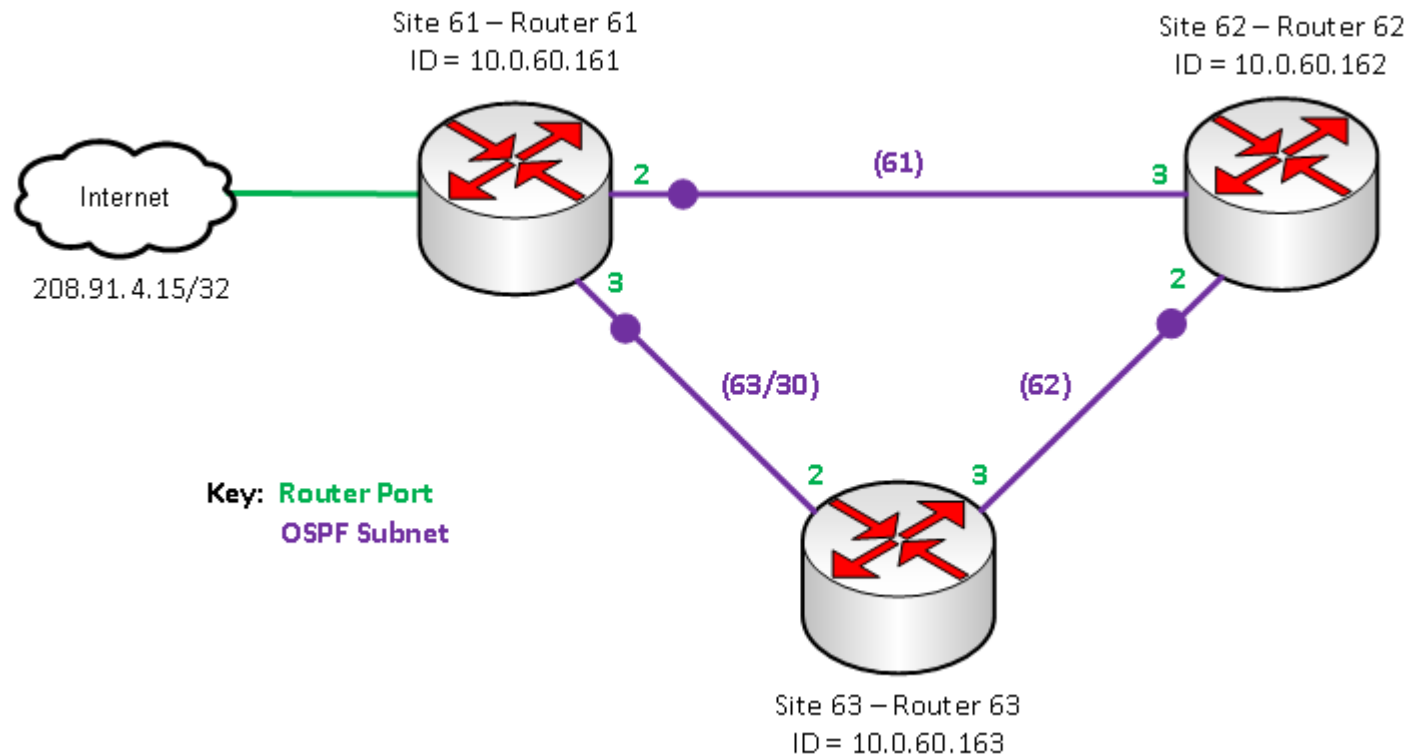
- ▶ Subscriber are assigned a /32 public IP address
 - e.g. 216.206.4.5/32
- ▶ /32 Address allows 100% address utilization
 - Avoid sub-netting and out of address space issues

OSPF Configuration Basics

- ▶ Ensure that all routers are:
 - Running the same version of RouterOS
 - Have been upgraded to the current firmware
 - Have their time zone and SNTP client configured
 - Check the Log for the correct time
 - A small router can be configured to be a NTP server
 - Set the router identity
 - Change the Ethernet port name to indicate its use
 - e.g. Change “ether2” to “ether2 – Link to Site 62”

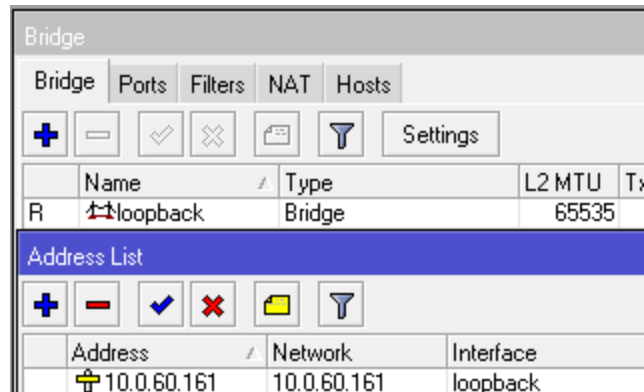
Configuring an OSPF Network

The following configuration steps illustrate the application in a three node network



OSPF Configuration – loopback

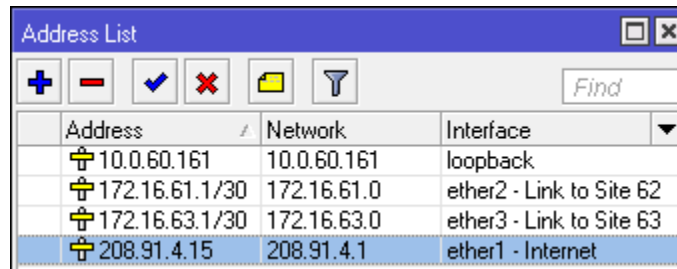
- ▶ Router 61
 - Create “loopback” bridge
 - Add router ID as loopback address



- ▶ Repeat configuration for site 62 and 63 routers

OSPF Configuration – IP Addresses

- ▶ Router 61 – Internet connection site



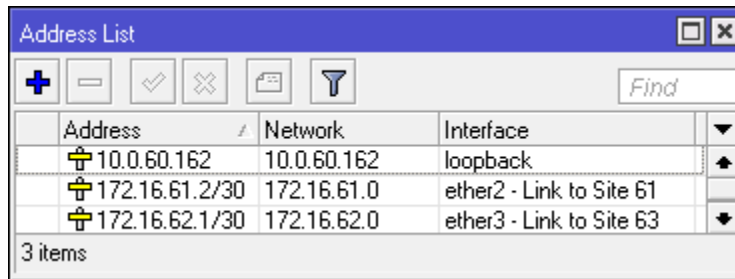
The screenshot shows a window titled 'Address List' with a table containing four rows of IP address information. The table has columns for Address, Network, and Interface. The first row shows a loopback address. The next two rows show OSPF link addresses for interfaces connected to Site 62 and Site 63. The final row, which is highlighted in blue, shows the network gateway address for the Internet connection on ether1.

Address	Network	Interface
10.0.60.161	10.0.60.161	loopback
172.16.61.1/30	172.16.61.0	ether2 - Link to Site 62
172.16.63.1/30	172.16.63.0	ether3 - Link to Site 63
208.91.4.15	208.91.4.1	ether1 - Internet

- Loopback address
- OSPF link addresses
- Network Gateway address
 - /32 Gateway for subscriber assigned addresses
- IP Address of your upstream provider
 - Public IP address gateway for ARIN assigned addresses

OSPF Configuration – IP Addresses

▶ Router 62

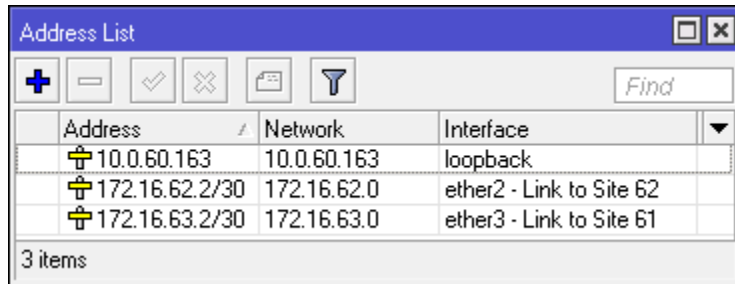


The screenshot shows a window titled "Address List" with a toolbar containing icons for adding, removing, checking, unchecking, saving, and filtering, along with a "Find" search box. The table below lists the IP addresses configured on Router 62.

Address	Network	Interface
10.0.60.162	10.0.60.162	loopback
172.16.61.2/30	172.16.61.0	ether2 - Link to Site 61
172.16.62.1/30	172.16.62.0	ether3 - Link to Site 63

3 items

▶ Router 63



The screenshot shows a window titled "Address List" with a toolbar containing icons for adding, removing, checking, unchecking, saving, and filtering, along with a "Find" search box. The table below lists the IP addresses configured on Router 63.

Address	Network	Interface
10.0.60.163	10.0.60.163	loopback
172.16.62.2/30	172.16.62.0	ether2 - Link to Site 62
172.16.63.2/30	172.16.63.0	ether3 - Link to Site 61

3 items

OSPF Configuration – Instances

- ▶ Router 61

The screenshot displays the OSPF configuration window for Router 61. The 'Instances' tab is selected, showing a table with one instance named 'default' with Router ID '10.0.60.161' and status 'yes'. Below the table, the 'OSPF Instance <default>' configuration is shown with tabs for General, Metrics, MPLS, and Status. The General tab is active, showing fields for Name (default), Router ID (10.0.60.161), and redistribution settings for Default Route, Connected Routes, and Static Routes.

Name	Router ID	Running
* default	10.0.60.161	yes

OSPF Instance <default>

General Metrics MPLS Status

Name: default

Router ID: 10.0.60.161

Redistribute Default Route: always (as type 1)

Redistribute Connected Routes: as type 1

Redistribute Static Routes: no

OSPF Configuration – Instances

► Router 62

OSPF

Interfaces Instances Networks Areas Area Ranges Vir

+ - ✓ ✗ 📁 🏠

Name	Router ID	Running
* default	10.0.60.162	yes

OSPF Instance <default>

General Metrics MPLS Status

Name: default

Router ID: 10.0.60.162

Redistribute Default Route: never

Redistribute Connected Routes: as type 1

Redistribute Static Routes: no

► Router 63

OSPF

Interfaces Instances Networks Areas Area Ranges Vir

+ - ✓ ✗ 📁 🏠

Name	Router ID	Running
* default	10.0.60.163	yes

OSPF Instance <default>

General Metrics MPLS Status

Name: default

Router ID: 10.0.60.163

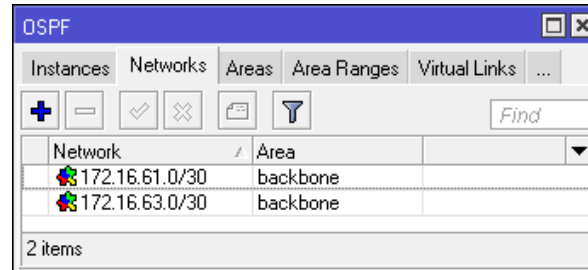
Redistribute Default Route: never

Redistribute Connected Routes: as type 1

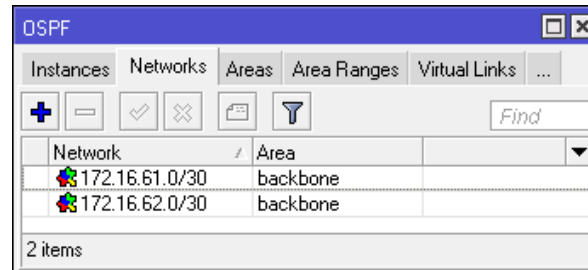
Redistribute Static Routes: no

OSPF Configuration – Networks

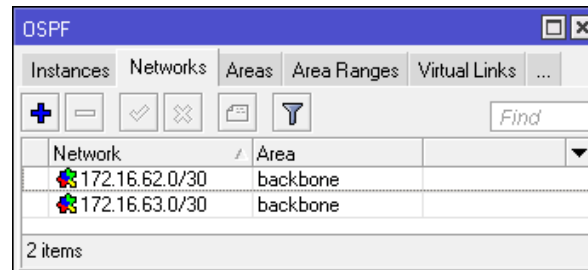
- ▶ Router 61



- ▶ Router 62



- ▶ Router 63



Basic OSPF Configuration Complete

- ▶ At this stage you should have an operational three router OSPF network
- ▶ The status can be checked with:
 - OSPF Interfaces
 - OSPF Neighbors
 - OSPF Routes
 - OSPF LSA

OSPF Interfaces

▶ Router 61

OSPF										
Interfaces										
Interface	Cost	Priority	Authentication	Authentication Key	Network Type	Instance	Area	Neighbors	State	
D ether2 - Link to Site 62	10	1	none	*****	broadcast	default	backbone	1	designated router	
D ether3 - Link to Site 63	10	1	none	*****	broadcast	default	backbone	1	backup	

←
Cost != 30

▶ Router 62

OSPF										
Interfaces										
Interface	Cost	Priority	Authentication	Authentication Key	Network Type	Instance	Area	Neighbors	State	
D ether2 - Link to Site 61	10	1	none	*****	broadcast	default	backbone	1	backup	
D ether3 - Link to Site 63	10	1	none	*****	broadcast	default	backbone	1	designated router	

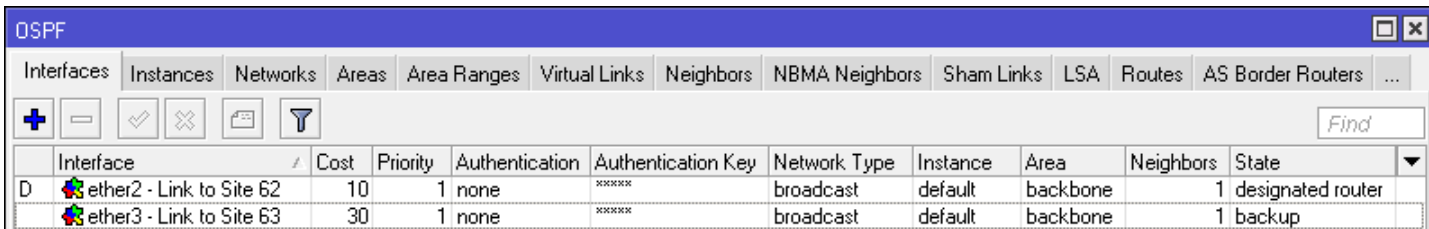
▶ Router 63

OSPF										
Interfaces										
Interface	Cost	Priority	Authentication	Authentication Key	Network Type	Instance	Area	Neighbors	State	
D ether2 - Link to Site 62	10	1	none	*****	broadcast	default	backbone	1	backup	
D ether3 - Link to Site 61	10	1	none	*****	broadcast	default	backbone	1	designated router	

←
Cost != 30

Changing Interface Cost

- ▶ Interfaces are dynamically created with a cost of 10
- ▶ To modify cost
 - Select Interface, Copy, change cost and Apply
 - Interface is replaced by statically configured one



The screenshot shows a software window titled "OSPF" with a tabbed interface. The "Interfaces" tab is selected. Below the tabs are several icons: a plus sign, a minus sign, a checkmark, an X, a folder, and a funnel. To the right of these icons is a "Find" search box. Below the icons is a table with the following columns: Interface, Cost, Priority, Authentication, Authentication Key, Network Type, Instance, Area, Neighbors, and State. The table contains two rows of data.

Interface	Cost	Priority	Authentication	Authentication Key	Network Type	Instance	Area	Neighbors	State
D ether2 - Link to Site 62	10	1	none	xxxxxx	broadcast	default	backbone	1	designated router
D ether3 - Link to Site 63	30	1	none	xxxxxx	broadcast	default	backbone	1	backup

- Change cost must be changed at both ends of link

OSPF Neighbors

- Router 61

OSPF

NetworksAreasArea RangesVirtual LinksNeighborsNBMA NeighborsSham Link



Instance /	Router ID	Address	Interface	State Changes	
 default	10.0.60.162	172.16.61.2	ether2 - Link to Site 62	5	
 default	10.0.60.163	172.16.63.2	ether3 - Link to Site 63	5	

- Router 62

OSPF

NetworksAreasArea RangesVirtual LinksNeighborsNBMA NeighborsSham Link



Instance	Router ID	Address	Interface	State Changes
 default	10.0.60.163	172.16.62.2	ether3 - Link to Site 63	5
 default	10.0.60.161	172.16.61.1	ether2 - Link to Site 61	5

- Router 63

OSPF

NetworksAreasArea RangesVirtual LinksNeighborsNBMA NeighborsSham Link



Instance /	Router ID	Address	Interface	State Changes
 default	10.0.60.162	172.16.62.1	ether2 - Link to Site 62	5
 default	10.0.60.161	172.16.63.1	ether3 - Link to Site 61	17

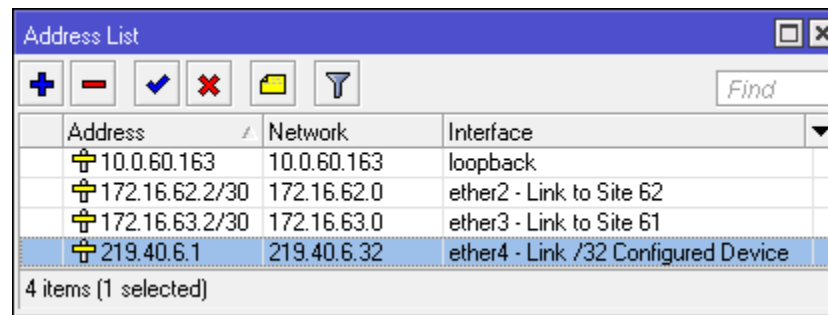
OSPF Routes – Router 61

OSPF							
Networks	Areas	Area Ranges	Virtual Links	Neighbors	NBMA Neighbors	Sham Links	LSA
Routes	AS B...						
Instance	Area	Dst. Address	Gateway	Interface	Cost	State	
default		0.0.0.0/0			1	imported ext 1	
default		10.0.60.161			20	imported ext 1	
default		10.0.60.162	172.16.61.2	ether2 - Link to Site 62	30	ext 1	
default		10.0.60.163	172.16.61.2	ether2 - Link to Site 62	40	ext 1	
default	backbone	172.16.61.0/30	0.0.0.0	ether2 - Link to Site 62	10	intra area	
default	backbone	172.16.62.0/30	172.16.61.2	ether2 - Link to Site 62	20	intra area	
default	backbone	172.16.63.0/30	0.0.0.0, 172.1...	ether3 - Link to Site 63, ...	30	intra area	
default		208.91.4.1			20	imported ext 1	
default		219.40.6.32	172.16.61.2	ether2 - Link to Site 62	40	ext 1	

- ▶ Route Lists shows:
 - Internet connection
 - Loopback addresses
 - OSPF networks
 - /32 connected device 219.40.6.32

Implementing /32 Routing

- ▶ Router 63 to which subscriber is connected



Address	Network	Interface
10.0.60.163	10.0.60.163	loopback
172.16.62.2/30	172.16.62.0	ether2 - Link to Site 62
172.16.63.2/30	172.16.63.0	ether3 - Link to Site 61
219.40.6.1	219.40.6.32	ether4 - Link /32 Configured Device

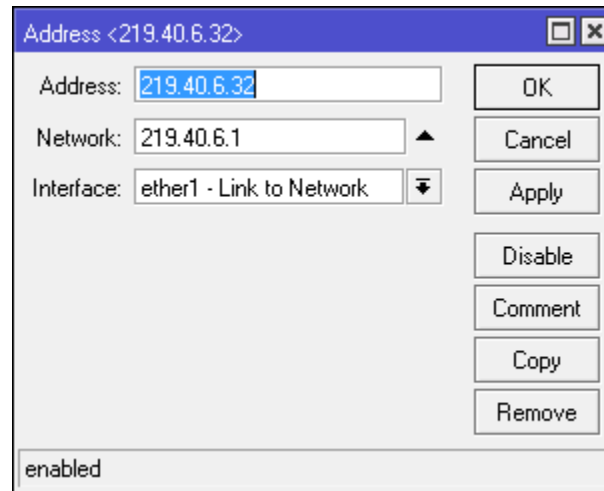
4 items (1 selected)

- Address = Gateway Address
- Network = /32 Address assigned to subscriber

Note : Configure port to support proxy ARP

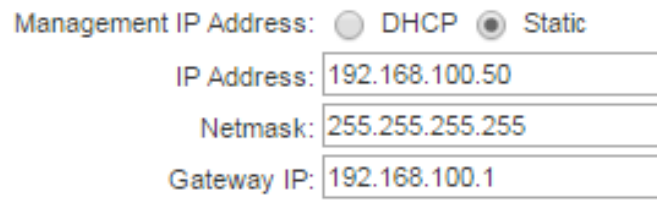
Subscriber /32 Address Configuration

- ▶ MikroTik



A screenshot of the MikroTik WinBox 'Address' configuration window. The title bar reads 'Address <219.40.6.32>'. The window contains three input fields: 'Address' with the value '219.40.6.32', 'Network' with the value '219.40.6.1', and 'Interface' with a dropdown menu showing 'ether1 - Link to Network'. To the right of these fields is a vertical stack of buttons: 'OK', 'Cancel', 'Apply', 'Disable', 'Comment', 'Copy', and 'Remove'. At the bottom left of the window, the status 'enabled' is displayed.

- ▶ Non MikroTik



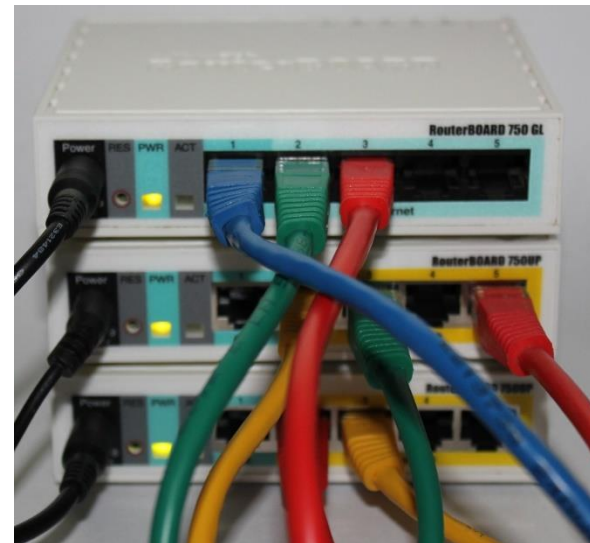
A screenshot of a non-MikroTik IP configuration form. It features a 'Management IP Address' section with two radio buttons: 'DHCP' (unselected) and 'Static' (selected). Below this are three text input fields: 'IP Address' containing '192.168.100.50', 'Netmask' containing '255.255.255.255', and 'Gateway IP' containing '192.168.100.1'.

OSPF – Next Steps

- ▶ Firewall
 - OSPF uses protocol 89
- ▶ OSPF Network Type
 - broadcast, nbma, p2p or ptmp
- ▶ BFD (Bidirectional Forwarding Detection)
 - Faster link failure detection
 - Reduce recover from 10s to 8s
- ▶ Security
 - Add authentication (MD5)

Implementation Guidelines

- ▶ Plan
 - Understand what you want to achieve
 - MikroTik MTCRE training
 - Consultant
- ▶ Document
 - Essential before configuration
- ▶ Prototype
 - Validate your plan
- ▶ Phased Approach
 - One bite at a time



(((•)))
WISP TRACON

The Solutions Training and Consulting Company