Implementation IPV6 in Mikrotik RouterOS

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Introduction

TEDDY YULISWAR

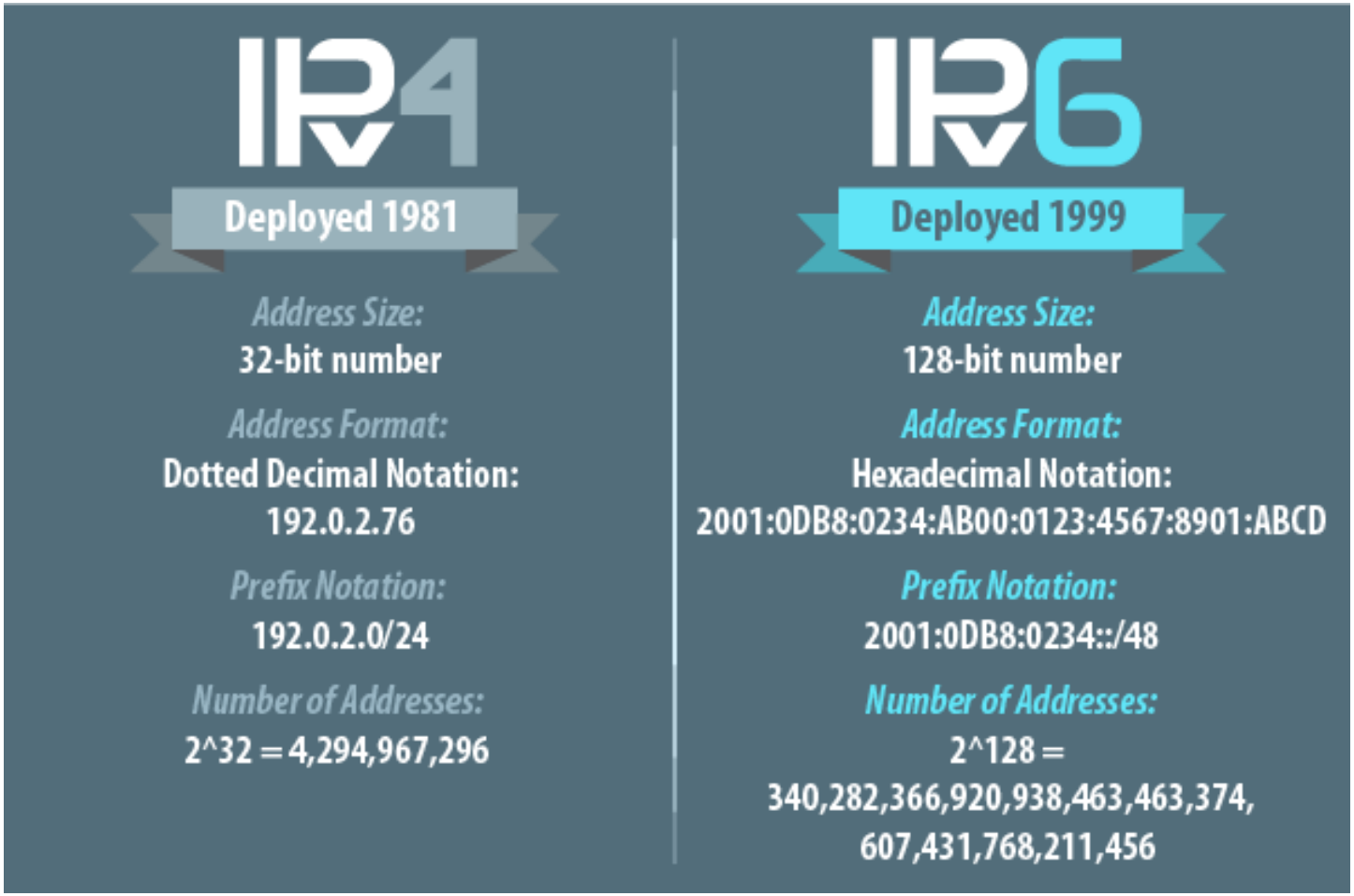
- MTCNA, MTCRE, MTCTCE, MTCINE

- Place of Hanging out :
  - Politeknik Negeri Padang
  - PT. Gnet Biaro Akses (Golden Net) (ISP)
  - LPSE Tanah Datar
  - Kelompok Pengguna Linux Indonesia (KPLI) Padang
- Teaching Internet for Junior High School Student in rural area in Tanah Datar (Social Activity)

What is IPV6

- To Transition from IPv4 to IPv6
- More than 20+ years will be occur.
- What do we do until then?
- Dual Stack Because IPv6 is not backward compatible with IPv4, Both will run at the same time for years to come.

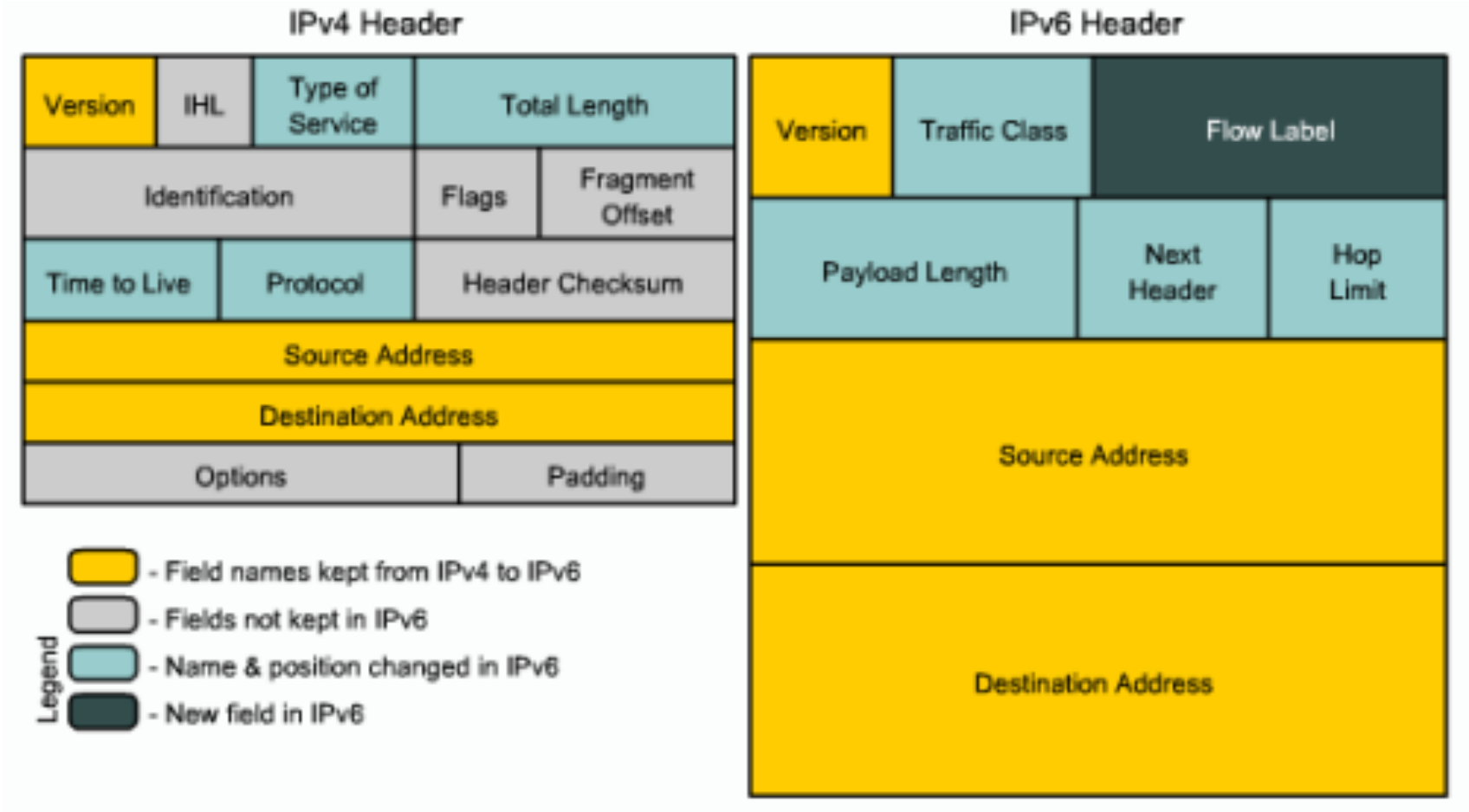
What is IPV6?


IPv4
Deployed 1981
Address Size:
32-bit number
Address Format:
Dotted Decimal Notation:
192.0.2.76
Prefix Notation:
192.0.2.0/24
Number of Addresses:
2^32 = 4,294,967,296
IPv6
Deployed 1999
Address Size:
128-bit number
Address Format:
Hexadecimal Notation:
2001:0DB8:0234:AB00:0123:4567:8901:ABCD
Prefix Notation:
2001:0DB8:0234::/48
Number of Addresses:
2^128 =
340,282,366,920,938,463,463,374,
607,431,768,211,456

What is IPV6

- Expanded Addressing Capabilities
- Header Format Simplification
- Improved Support for Extensions and Options
- Flow Labeling Capability

Header Comparison



Neighbor Discovery Protocol (NDP)

- Replace ARP Function in IPV4
- It operates in the Link Layer of the Internet model (RFC 1122)
- Responsible for address autoconfiguration of nodes
- Responsible for discovery of other nodes on the link, d
- Determining the link layer addresses of other nodes
- Duplicate address detection
- Finding available routers and Domain Name System (DNS) servers
- Address prefix discovery, and maintaining reachability information about the paths to other active neighbor nodes (RFC 4861)

Address Expression

IPv6 addresses are represented a little bit different than IPv4 addresses. For IPv6, the 128-bit address is divided in eight 16-bit blocks, and each 16-bit block is converted to a 4-digit hexadecimal number and separated by colons. The resulting representation is called **colon-hexadecimal**.

In example above IPv6 address in binary format is converted to **colon-hexadecimal** representation

```
0010000000000001 0000010001110000 0001111100001001 0000000100110001
0000000000000000 0000000000000000 0000000000000000 0000000000001001
```

```
2001:0470:1f09:0131:0000:0000:0000:0009
```

IPv6 address can be further simplified by removing leading zeros in each block:

```
2001:470:1f09:131:0:0:0:9
```

As you can see IPv6 addresses can have long sequences of zeros. These contiguous sequence can be compressed to **::**

```
2001:470:1f09:131::9
```

Prefix

IPv6 prefix is written in address/prefix-length format. Compared to IPv4 decimal representation of network mask cannot be used.
Prefix examples:

2001:470:1f09:131::/64

2001:db8:1234::/48

2607:f580::/32

2000::/3

Type of IPV6 Addresses

IPv6 has three types of addresses, which can be categorized by type and scope:

1. Unicast addresses. A packet is delivered to one interface.
2. Multicast addresses. A packet is delivered to multiple interfaces.
3. Anycast addresses. A packet is delivered to the nearest of multiple interfaces (in terms of routing distance).

- **IPv6 does not use broadcast messages.**

Unicast Addresses

Packets addressed to a unicast address are delivered only to a single interface. To this group belong:

- globally unique addresses and can be used to connect to addresses with global scope anywhere.
- link-local addresses
- site-local addresses (FEC0::/48) - deprecated
- special purpose addresses
- compatibility addresses

Global unicast address can be automatically assigned to the node by ***Stateless Address auto-configuration***.

Link-local address

A link-local address is required on every IPv6-enabled interface, applications may rely on the existence of a link-local address even when there is no IPv6 routing, that is why link-local address is generated automatically for every active interface using it's interface identifier (calculated EUI-64 from MAC address if present).

Address prefix is always FE80::/64 and IPv6 router never forwards link-local traffic beyond the link.

These addresses are comparable to the auto-configuration addresses 169.254.0.0/16 of IPv4.

A link-local address is also required for Neighbor Discovery processes.

Special purpose address

Address	Description
`Unspecified address (::/128)`	Never assigned to an interface or used as a destination address, used only to indicate the absence of an address. Equivalent to IPv4 0.0.0.0 address.
`loopback address (::1/128)`	Used to identify a loopback interface, enabling a node to send packets to itself. It is equivalent to the IPv4 loopback address of 127.0.0.1.

Compatibility address

Address	Description
`IPv4 compatible address`	used by dual-stack nodes that are communicating with IPv6 over an IPv4 infrastructure. When the IPv4-compatible address is used as an IPv6 destination, IPv6 traffic is automatically encapsulated with an IPv4 header and sent to the destination by using the IPv4 infrastructure. Address is written in following format `::w.x.y.z`, where w.x.y.z is the dotted decimal representation of a public IPv4 address.
`IPv4 mapped address`	used to represent an IPv4-only node to an IPv6 node. It is used only for internal representation. The IPv4-mapped address is never used as a source or destination address for an IPv6 packet. The IPv6 protocol does not support the use of IPv4-mapped addresses. Address is written in following format: `::ffff:w.x.y.z`, where w.x.y.z is the dotted decimal representation of a public IPv4 address.
`2002::/16`	this prefix is used for 6to4 addressing. Here, an address from the IPv4 network 192.88.99.0/24 is also used.

Multicast address

Most important multicast aspects are:

- traffic is sent to a single address but is processed by multiple hosts;
- group membership is dynamic, allowing hosts to join and leave the group at any time;
- in IPv6, Multicast Listener Discovery (MLD) messages are used to determine group membership on a network segment, also known as a link or subnet;
- host can send traffic to the group's address without belonging to the corresponding group.

A single IPv6 multicast address identifies each multicast group. Each group's reserved IPv6 address is shared by all host members of the group who listen and receive any IPv6 messages sent to the group's address.

Multicast address consists of the following parts: [1]

- The first 8 bits in multicast address is always 1111 1111 (which is FF in hexadecimal format).
- *Flag* uses the 9th to 12th bit and shows if this multicast address is predefined (well-known) or not. If it is well-known, all bits are 0s.
- *Scope ID* indicates to which scope multicast address belongs, for example, Scope ID=2 is link-local scope.
- *Group ID* is used to specify a multicast group. There are predefined group IDs, such as Group ID=1 - all nodes. Therefore, if multicast address is ff02::1, that means Scope ID=2 and Group ID=1, indicating all nodes in link-local scope. This is analogous to broadcast in IPv4.

Here is the table of reserved IPV6 addresses for multicasting:

Here is the table of reserved IPV6 addresses for multicasting:

Address	Description
`FF02::1`	The all-nodes address used to reach all nodes on the same link.
`FF02::2`	The all-routers address used to reach all routers on the same link.
`FF02::5`	The all-Open Shortest Path First (OSPF) routers address used to reach all OSPF routers on the same link.
`FF02::6`	The all-OSPF designated routers address used to reach all OSPF designated routers on the same link.
`FF02::1:FFXX:XXXX`	The solicited-node address used in the address resolution process to resolve the IPv6 address of a link-local node to its link-layer address. The last 24 bits (XX:XXXX) of the solicited-node address are the last 24 bits of an IPv6 unicast address.

The following table is a partial list of IPv6 multicast addresses that are reserved for IPv6 multicasting and registered with the Internet Assigned Numbers Authority (IANA). For complete list of assigned addresses read IANA document.

Anycast address

Anycast address is a new type of address incorporated in IPv6.

Anycasting is a new networking paradigm supporting service–oriented Addresses where an identical address can be assigned to multiple nodes providing a specific service. An anycast packet (i.e., one with an anycast destination address) is delivered to one of these nodes with the same anycast address.

Anycast address is not assigned a specific address range. It is assigned from unicast address range.

Interface Identifier

The last 64 bits of an IPv6 address are the interface identifier that is unique to the 64-bit prefix of the IPv6 address. There are several ways how to determine interface identifier:

- EUI-64;
- randomly generated to provide a level of anonymity;
- manually configured.

EUI-64

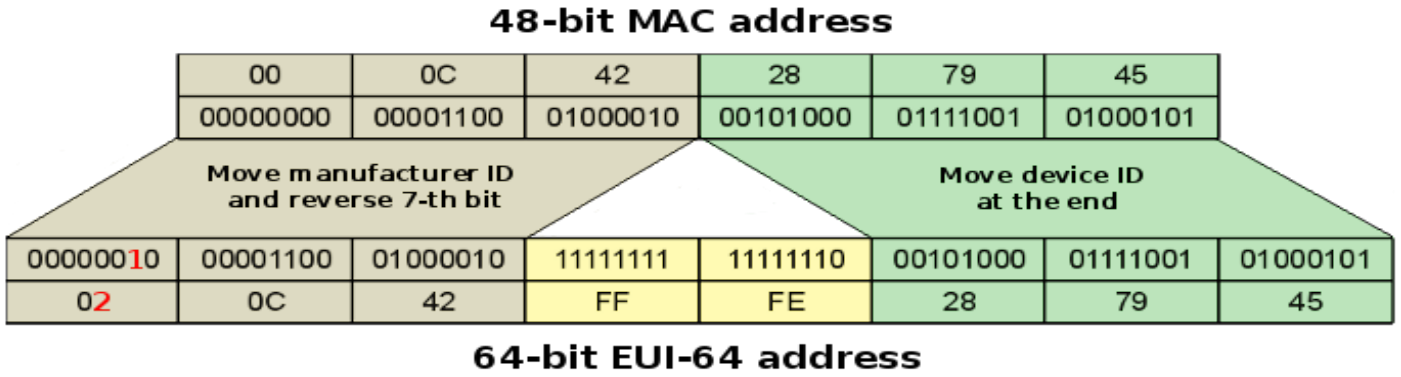
Traditional interface identifiers for network adapters are 48-bit MAC address. This address consists of a 24-bit manufacturer ID and a 24-bit board ID.

IEEE EUI-64 is a new standard for network interface addressing. The company ID is still 24-bits in length, but the extension ID is 40 bits, creating a much larger address space for a network adapters.

To create an EUI-64 address from the interface MAC address:

- 0xFFFE is inserted into the MAC address between the manufacturer ID and the board ID.
- seventh bit of the first byte is reversed.

Lets make an example with following MAC address 00:0C:42:28:79:45.



When the result is converted to colon-hexadecimal notation, we get the interface identifier 20C:42FF:FE28:7945. As the result, corresponds link-local address is

FE80::**20C:42FF:FE28:7945**/64

In RouterOS, if the *eui-64* parameter of an address is configured, the last 64 bits of that address will be automatically generated and updated using interface identifier.

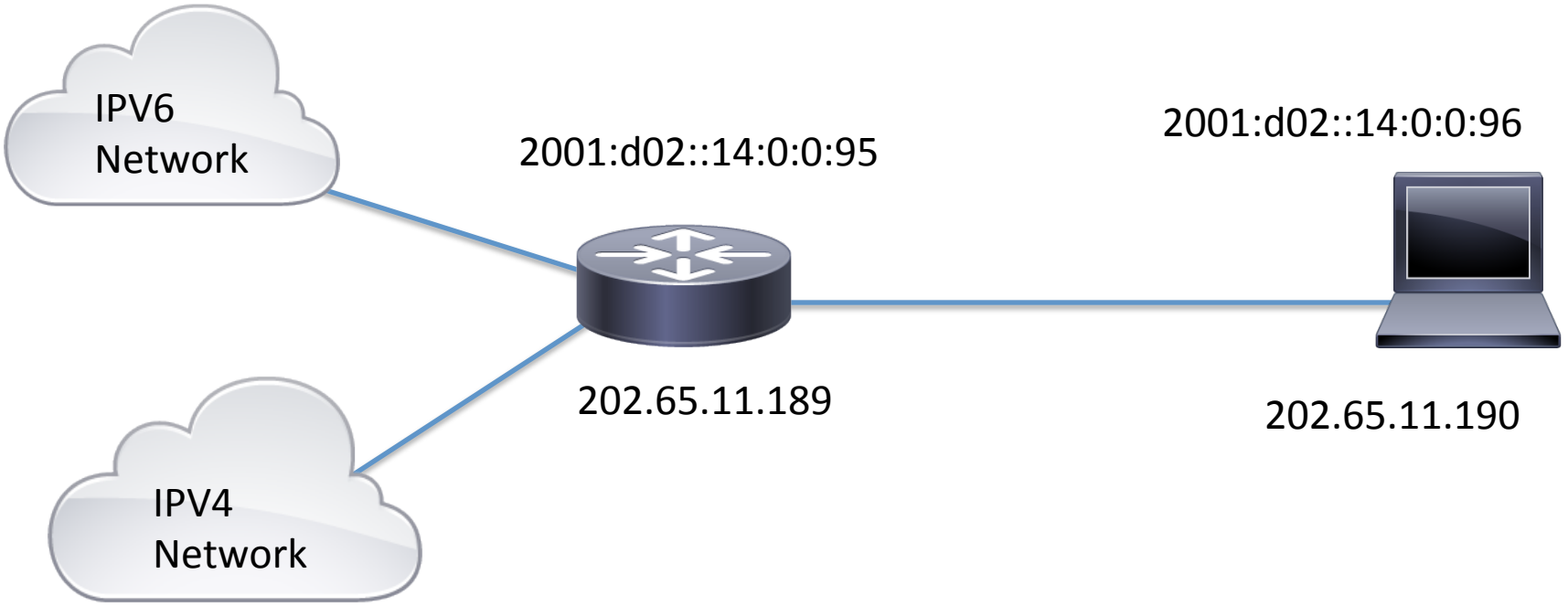
The last bits must be configured to be zero for this case. Example:

```
[admin@MikroTik] > ipv6 address add address=fc00:3::/64 interface=ether3 eui-64=yes
[admin@MikroTik] > ipv6 address print
Flags: X - disabled, I - invalid, D - dynamic, G - global, L - link-local
 #    ADDRESS                                     INTERFACE                   ADVERTISE
 ...
 5  G fc00:3::20c:42ff:fe1d:3d4/64                ether3                      yes
[admin@MikroTik] > interface ethernet set ether3 mac-address=10:00:00:00:00:01
[admin@MikroTik] > ipv6 address print
Flags: X - disabled, I - invalid, D - dynamic, G - global, L - link-local
 #    ADDRESS                                     INTERFACE                   ADVERTISE
 ...
 5  G fc00:3::1200:ff:fe00:1/64                   ether3                      yes
```

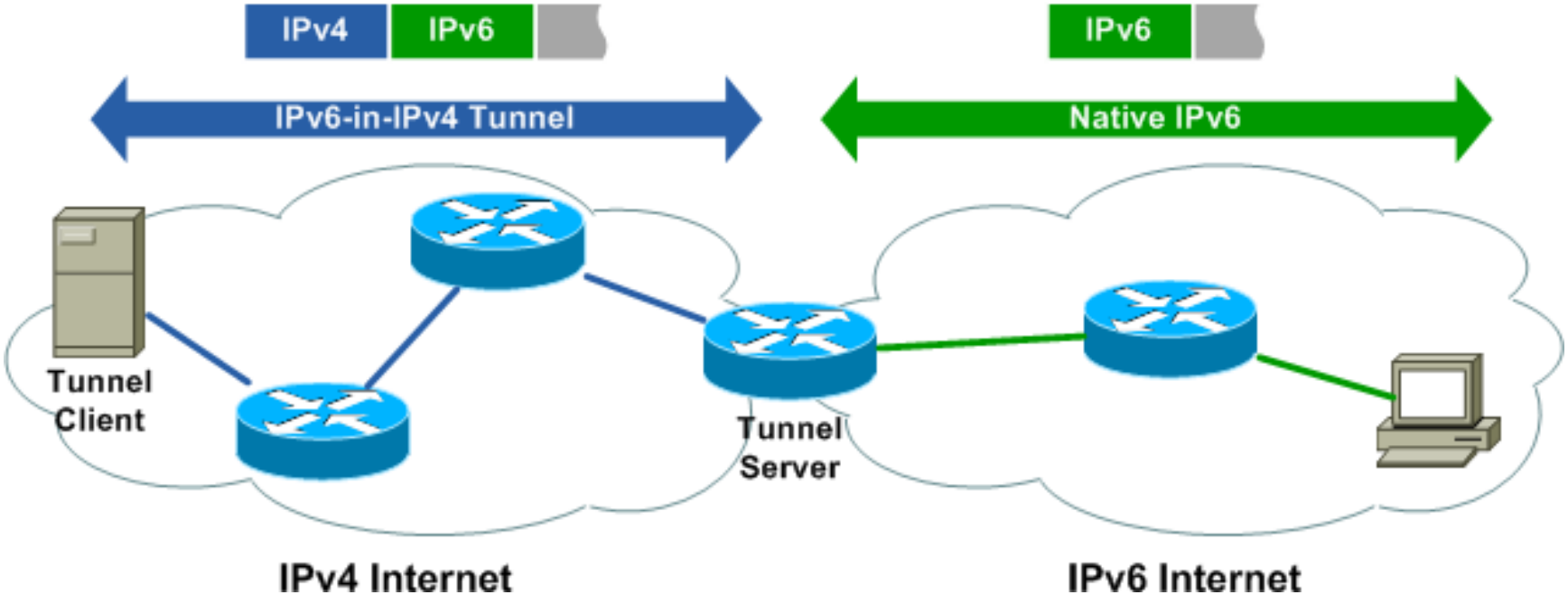
IPV6 Transition Methods

- **Dual Stack** – Running both IPv4 and IPv6 on the same devices
- **Tunneling** – Transporting IPv6 traffic through an IPv4 network transparently
- **Translation** – Converting IPv6 traffic to IPv4 traffic for transport and vice versa.

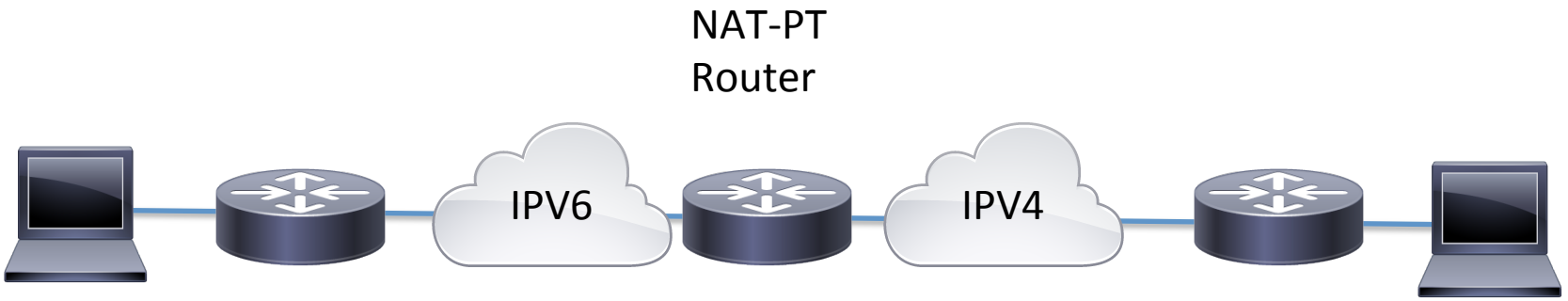
Dual Stack


IPV6
Network
2001:d02::14:0:0:95
2001:d02::14:0:0:96
202.65.11.189
202.65.11.190
IPV4
Network

Tunneling


IPv4
IPv6
IPv6
IPv6-in-IPv4 Tunnel
Native IPv6
Tunnel
Client
Tunnel
Server
IPv4 Internet
IPv6 Internet

Translation

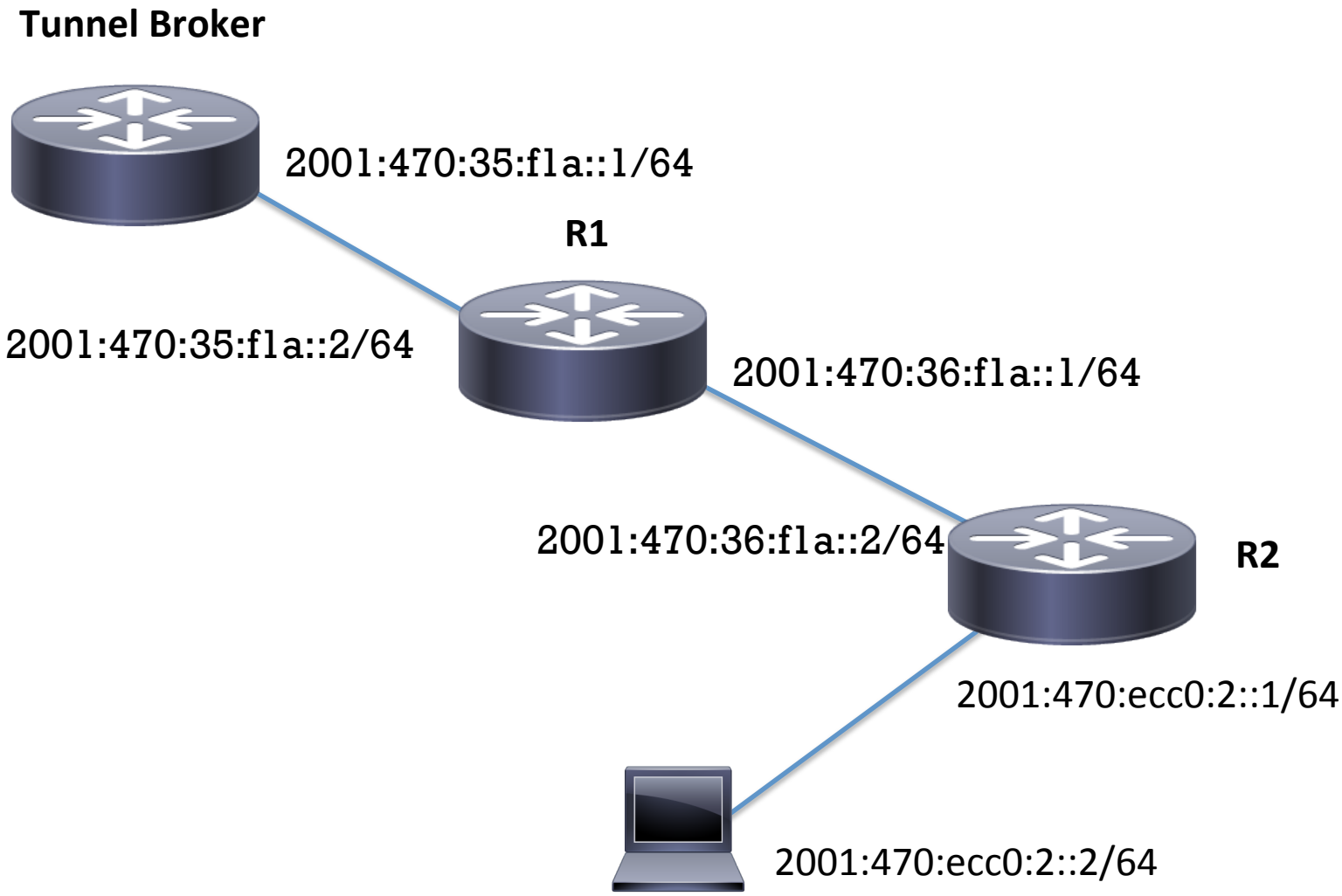


Not Yet Supported in Router OS

My First IPV6 Network in Mikrotik Router OS

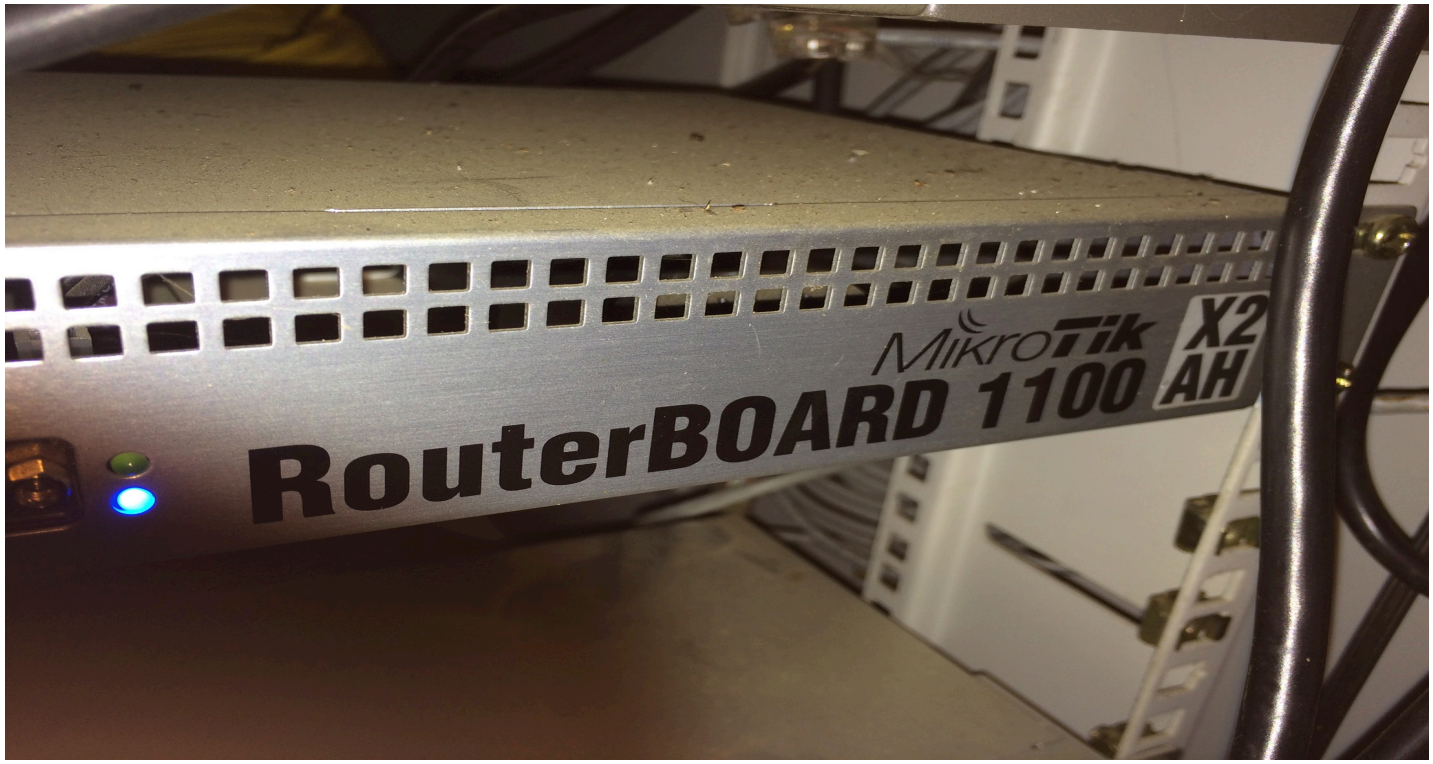
- My main gateway (R1) has only IPv4 internet connectivity and ISP is not providing IPv6 services. Our network consists of two isolated network segments Lan1 and Lan2.
- To enable IPv6 we will need to create a tunnel to IPv6 tunnel broker which will transit our IPv6 traffic over IPv4 network.

Network Topology



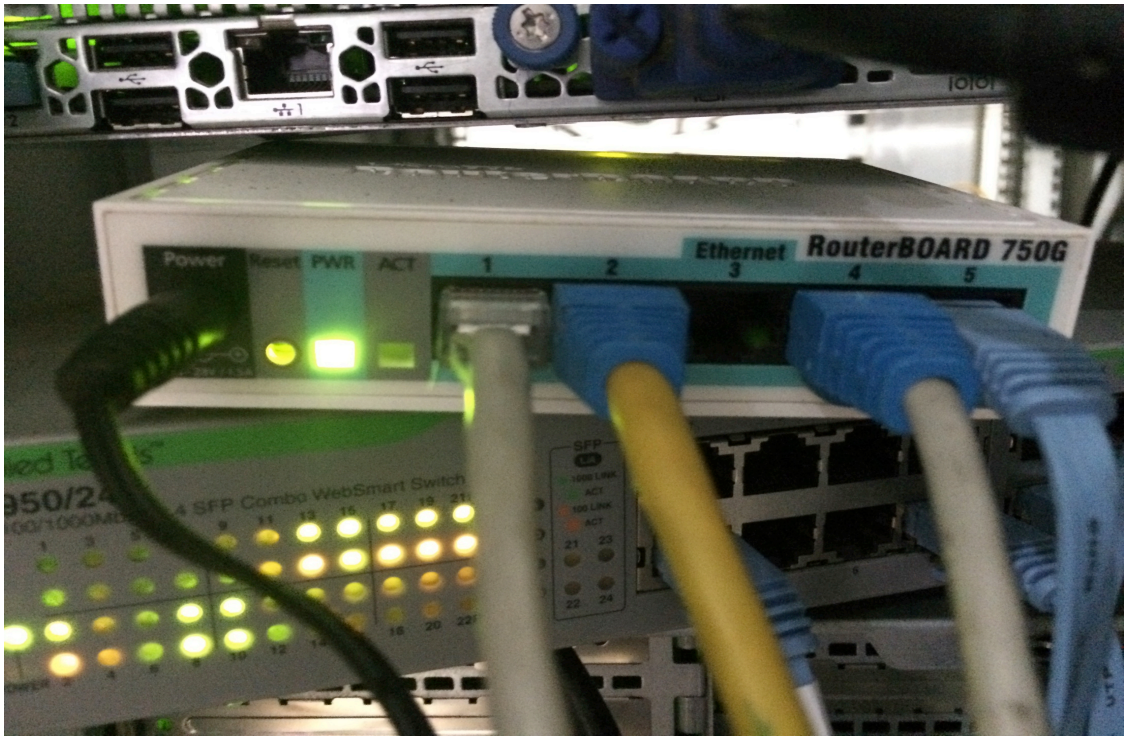
Specification Hardware

- Main Gateway (R1) : RB1100 AH X2

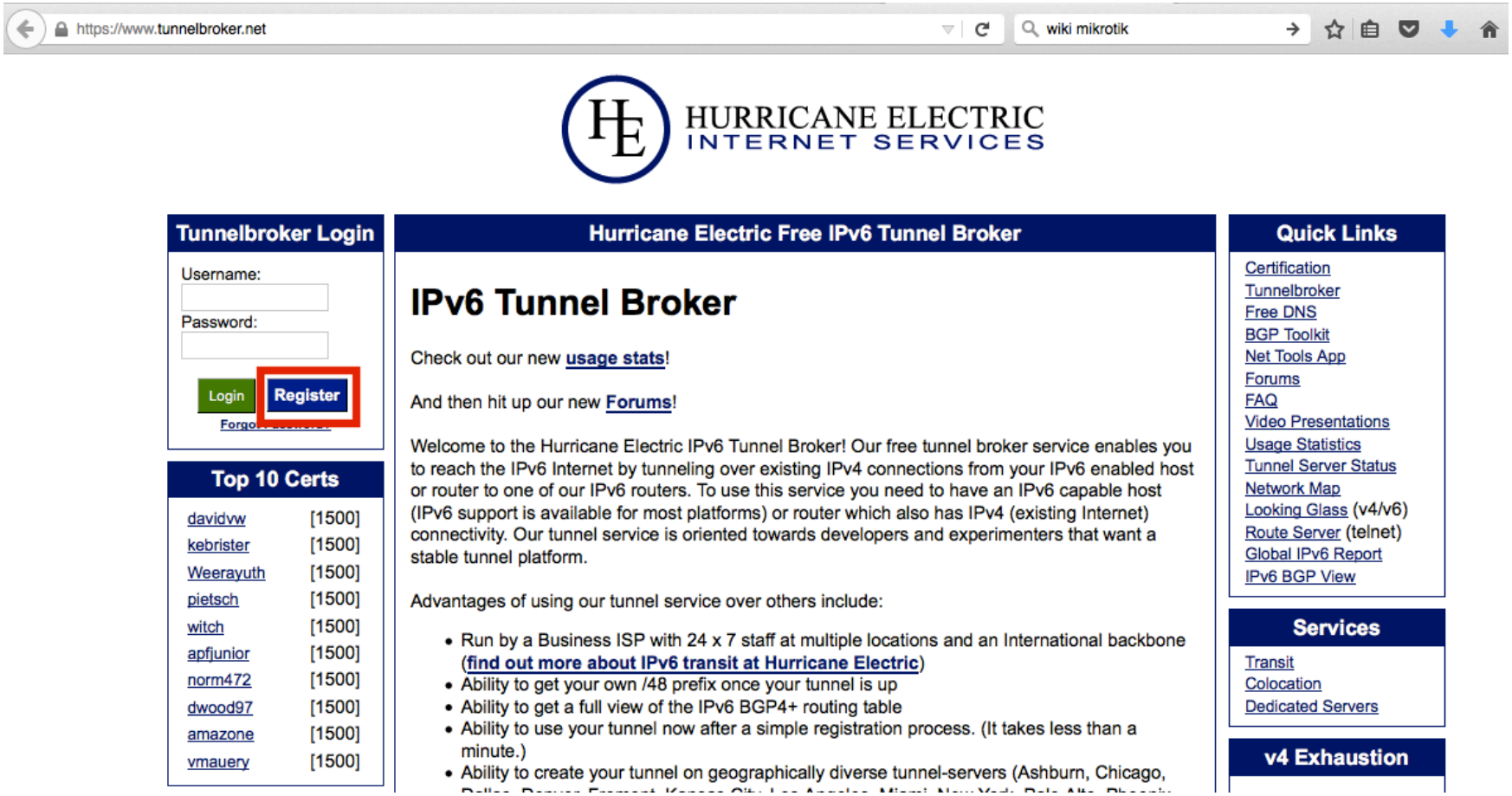


Spesification Hardware

- Distribution Router (R2) : RB750G



1. Registration at Hurricane Electric tunnel broker services : www.tunnelbroker.net



HE.net IPv6 Tunnel Broker Registration

After successfully completing registration, an email will be sent to the listed email address with your account password.

* = Required Information

* Account Name:

* Email:

* First Name:

* Last Name:

Company Name:

* Country: Select One

* Address:

* City:

* State/Region:

* ZIP/Postal Code:

* Phone:

I have read and agreed to the **Terms of Service**

Register

2. After registration click on "Create regular tunnel", enter your IP address and choose closest server to your location. That's it tunnel is now allocated.
3. Now go to tunnel details, where you will see all the parameters for successful tunnel creation and allocated IPv6 address block. As we have two separate lan segments we will need /48 address block, allocate it by clicking on "allocate".

Server IPv6 Address:	2001:470:**35**:f1a::1/64
Client IPv4 Address:	**202.62.10.195**
Client IPv6 Address:	2001:470:**35**:f1a::2/64

Routed IPv6 Prefixes

Routed /64:	2001:470:**36**:f1a::/64
Routed /48:	2001:470:ecc0::/48 **[X]**

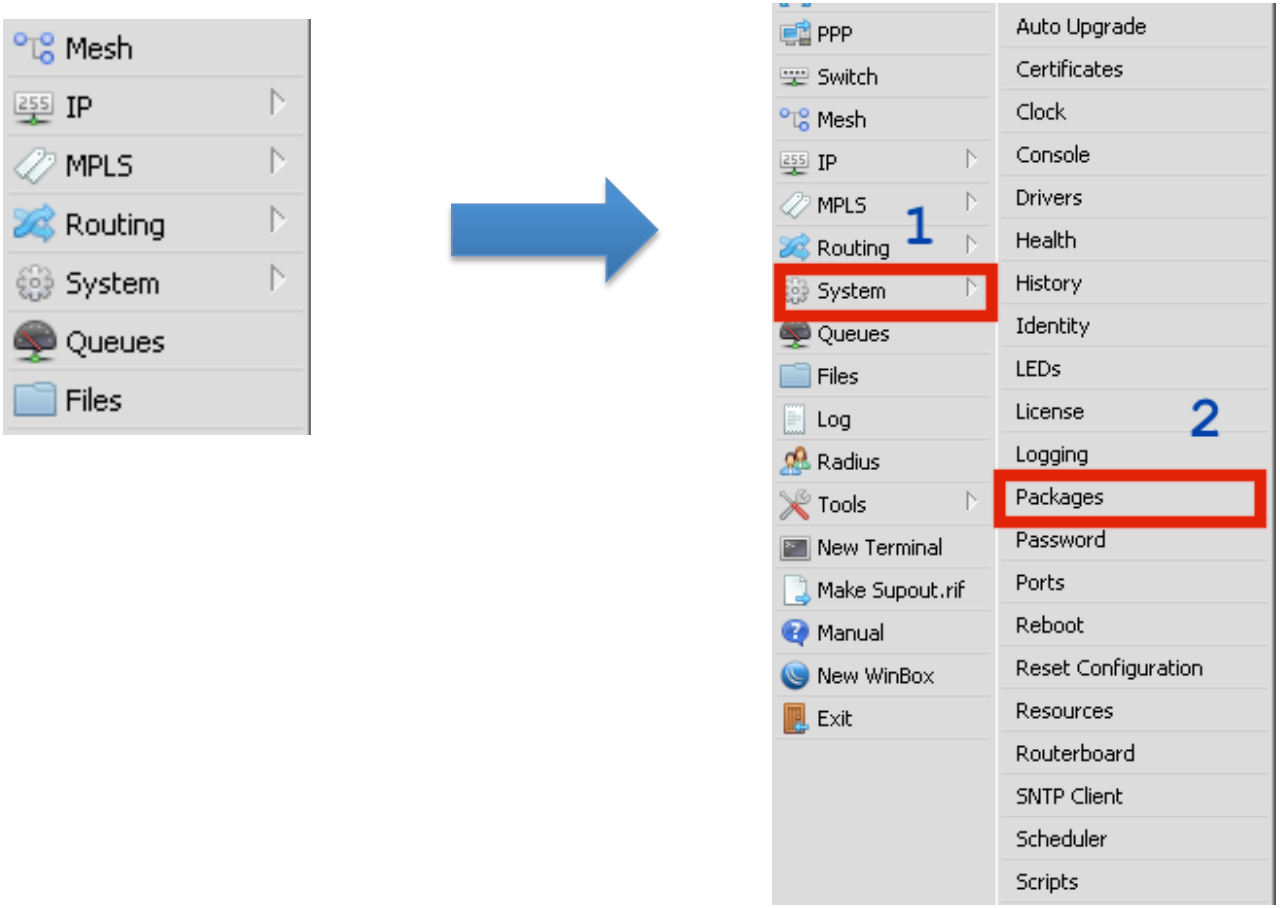
Available DNS Resolvers

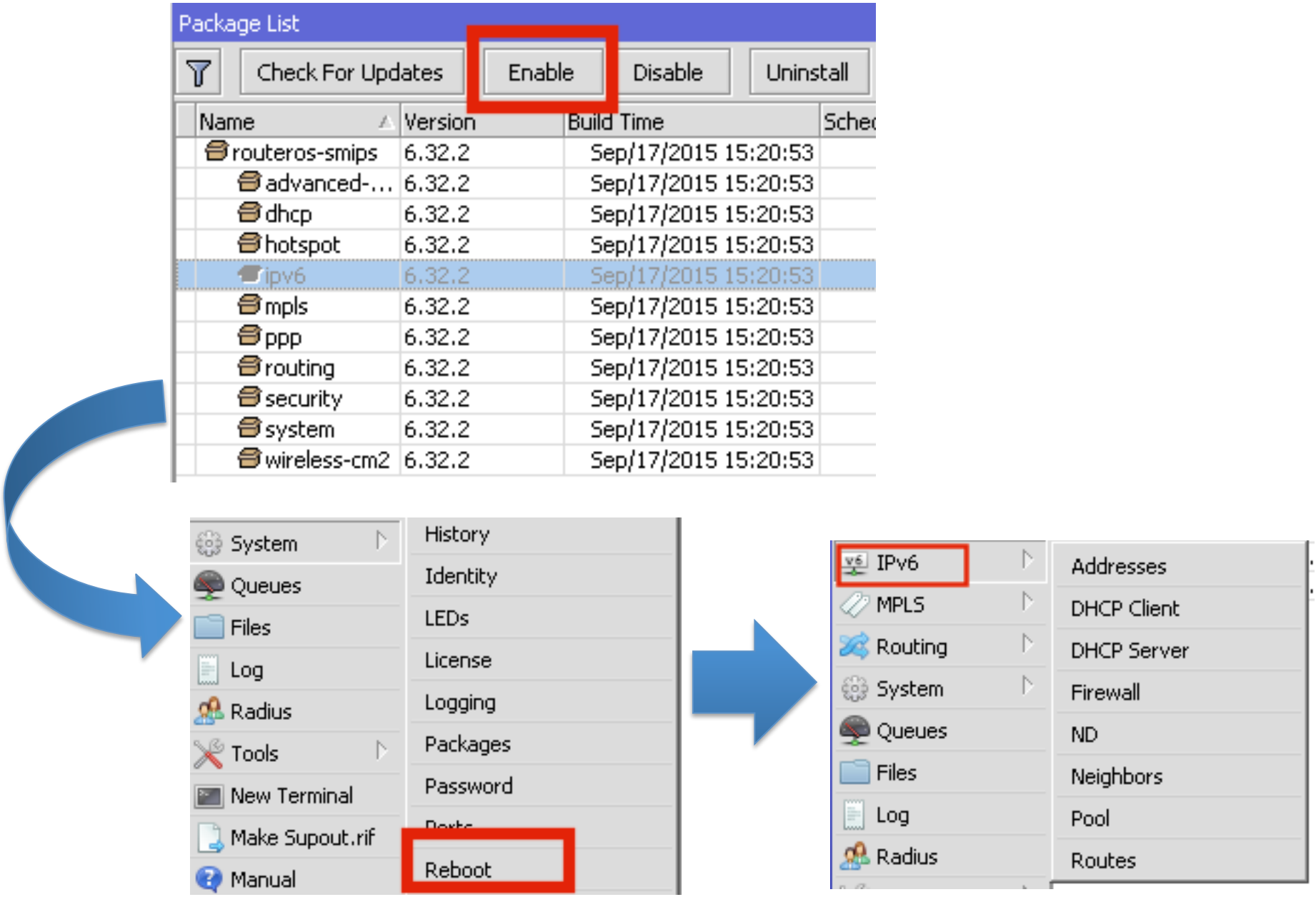
Anycasted IPv6 Caching Nameserver:	2001:470:20::2
Anycasted IPv4 Caching Nameserver:	74.82.42.42

rDNS Delegations Edit

rDNS Delegated NS1:	ns1.he.net
rDNS Delegated NS2:	ns2.he.net
rDNS Delegated NS3:	ns3.he.net

4. In default packages Router OS Mikrotik in Routerboard still not installed IPV6 Packages, so follow this step :




Package List
Check For Updates
Enable
Disable
Uninstall
Name
Version
Build Time
routeros-smips 6.32.2 Sep/17/2015 15:20:53
advanced-... 6.32.2 Sep/17/2015 15:20:53
dhcp 6.32.2 Sep/17/2015 15:20:53
hotspot 6.32.2 Sep/17/2015 15:20:53
ipv6 6.32.2 Sep/17/2015 15:20:53
mpls 6.32.2 Sep/17/2015 15:20:53
ppp 6.32.2 Sep/17/2015 15:20:53
routing 6.32.2 Sep/17/2015 15:20:53
security 6.32.2 Sep/17/2015 15:20:53
system 6.32.2 Sep/17/2015 15:20:53
wireless-cm2 6.32.2 Sep/17/2015 15:20:53
System
Queues
Files
Log
Radius
Tools
New Terminal
Make Supout.rif
Manual
History
Identity
LEDs
License
Logging
Packages
Password
Reboot
IPv6
MPLS
Routing
System
Queues
Files
Log
Radius
Addresses
DHCP Client
DHCP Server
Firewall
ND
Neighbors
Pool
Routes

Configuration in Main Gateway (R1)

```
# ipv4 connectivity to ISP

/ip address add address=202.62.10.195/24 interface=ether1
/ip route add gateway=202.62.10.193

# ipv6 service
/interface 6to4 add comment="Hurricane Electric IPv6 Tunnel Broker" disabled=no \
local-address=202.62.10.195 mtu=1280 name=tunnel-IPV6 remote-address=216.218.221.42
/ipv6 route add comment="" disabled=no distance=1 dst-address=2000::/3 gateway=2001:470:35:f1a::1 scope=30 target-scope=10
/ipv6 route add comment="" disabled=no distance=1 dst-address=::/0 gateway=tunnel-IPV6 scope=30 target-scope=10

/ipv6 address add address=2001:470:35:f1a::2/64 advertise=no disabled=no eui-64=no interface=tunnel-IPV6

#Lan1

/ipv6 address add address=2001:470:36:f1a::1/64 advertise=yes disabled=no eui-64=no interface=tunnel-IPV6

# routing between segments

/routing ospf-v3 instance set default router-id=10.10.10.1 distribute-default=if-installed-as-type-1 \ redistribute-connected=as-type-1
/routing ospf-v3 interface add area=backbone interface=ether3

# DNS
/ip dns set allow-remote-requests=yes servers=2001:4860:4860::8844,2001:4860:4860::8888,8.8.8.8,8.8.4.4
```

Configuration in Distribution Router (R2)

```
# ipv6 service


/ipv6 address add address=2001:470:36:f1a::2/64 advertise=no disabled=no eui-64=no interface=ether2 comment="gateway"
/ipv6 route add comment="" disabled=no distance=1 dst-address=2000::/3 gateway=2001:470:36:f1a::1 scope=30 target-scope=10
/ipv6 route add comment="" disabled=no distance=1 dst-address=::/0 gateway=ether2 scope=30 target-scope=10


#Lan2

/ipv6 address add address=2001:470:ecc0:2::1/64 advertise=yes disabled=no eui-64=no interface=ether1


# routing between segments

/routing ospf-v3 instance set default router-id=10.10.10.2 distribute-default=if-installed-as-type-1 \ redistribute-connected=as-type-1
/routing ospf-v3 interface add area=backbone interface=ether2

/ip dns
set allow-remote-requests=yes servers="2001:470:36:f1a::1,2001:4860:4860::8844,2001:4860:4860::8888,8.8.8.8,8.8.4.4"
```

Contact me :

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Thank You