IPv6 using Mikrotik RouterOS

What is IPv6

- Transition from IPv4 to IPv6
- Going on for 20+ years
- Dual Stack - 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

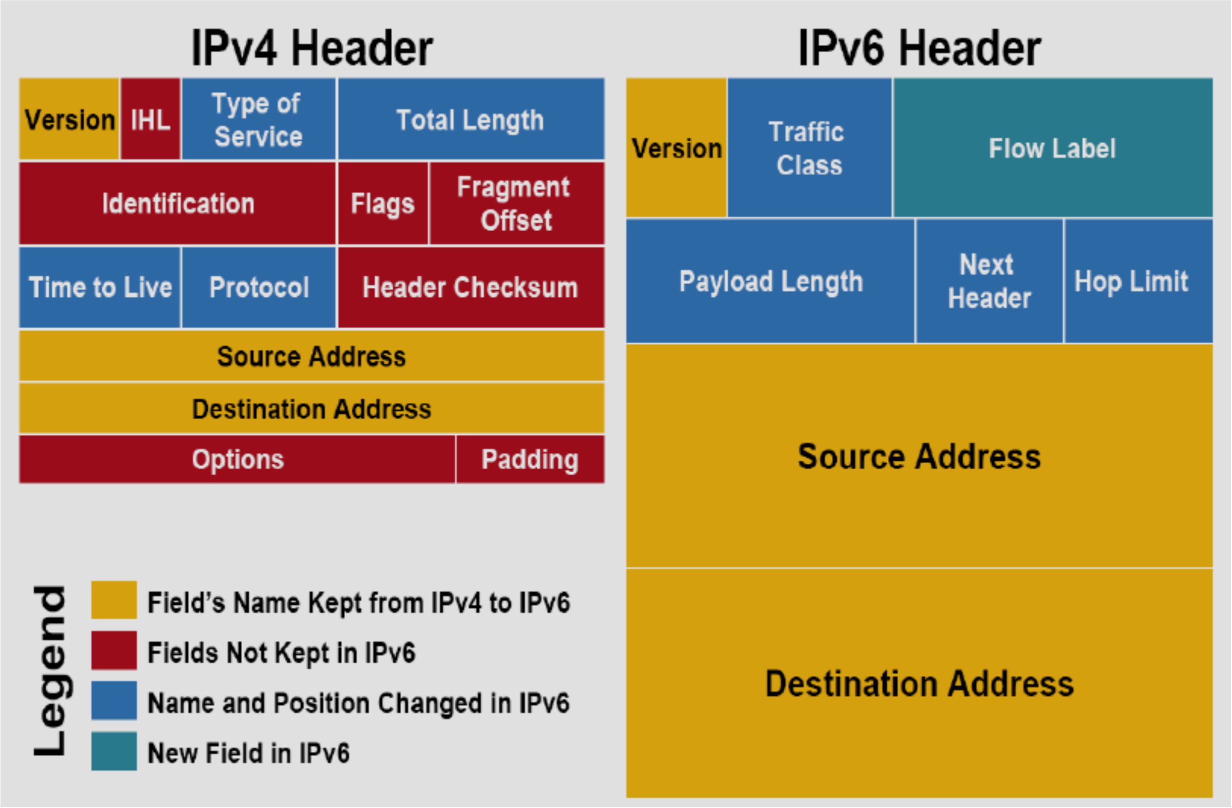
Prefix Notation:
2001:0DB8:0234::/48

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)

- Replaces ARP functionality in IPv4
- Operates in Layer 2of the Internet model (RFC 1122)
- Responsible for address autoconfiguration of nodes
- Responsible for discovery of other nodes on the link
- Determining the layer 2 (MAC) addresses of other nodes
- Duplicate address detection
- Finds available routers and DNS servers
- Address prefix discovery, and maintaining reachability information about the paths to other active neighbour 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
```

IPv6 Prefix

IPv6 prefixes are written in address/prefix-length format. Dotted 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. This includes:

- globally unique addresses and can be used to connect to anywhere on the internet - these are assigned to LIRs by the RIRs – the LIRs then assign ranges to end customers
- link-local addresses
- unique local addresses (FC00::/7)
- special purpose addresses
- compatability addresses

Global unicast address can be automatically assigned to the node using ***Stateless Address Autoconfiguration (SLAAC) or DHCPv6***

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 the link-local address is generated automatically for every active interface using it's interface identifier (calculated using EUI-64 from MAC address if present).

Address prefix is always FE80::/64 and an IPv6 router never routes or 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 required for the 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.

For example, the global IPv4 address *192.0.2.4* has the corresponding 6to4 prefix *2002:c000:0204::/48*

This 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 see related IANA document.

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.

Interface Identifer

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 (Extended Unique Identifier)

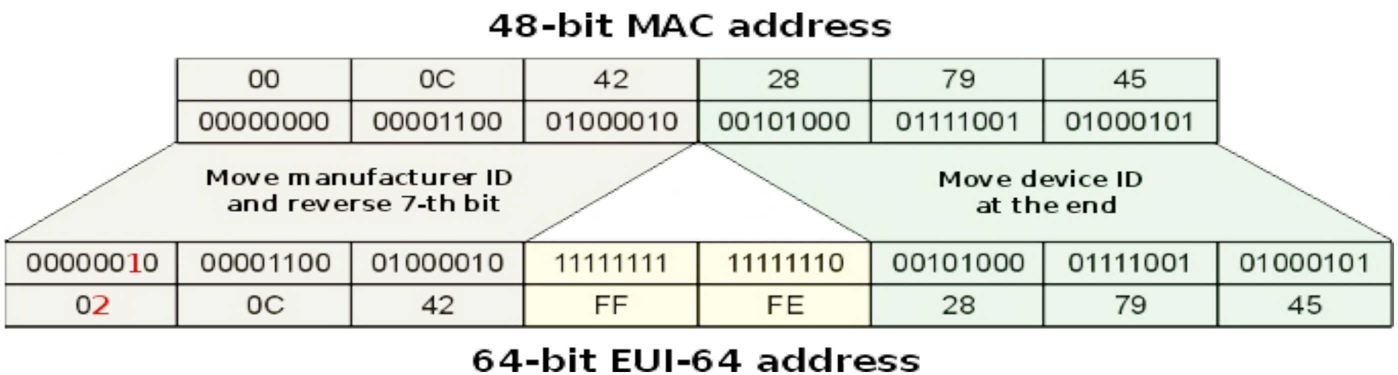
Traditional interface identifiers for network adapters are 48-bit MAC address. This address consists of a 24-bit manufacturer ID and a 24-bit board ID.

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:

1. 0xFFFE is inserted into the MAC address between the manufacturer ID and the board ID.
2. seventh bit of the first byte is reversed.

EUI-64 Example - 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 a result, the corresponding 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 the interface identifier.

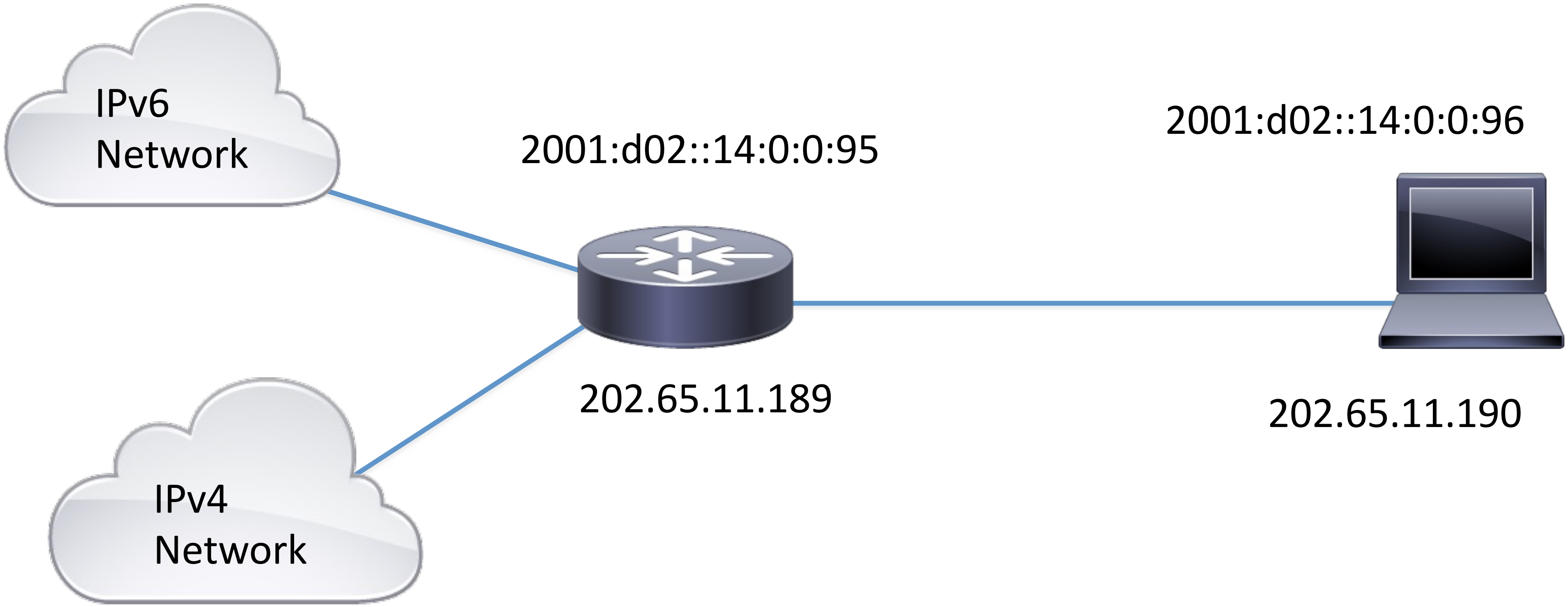
RouterOS Example

```
[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

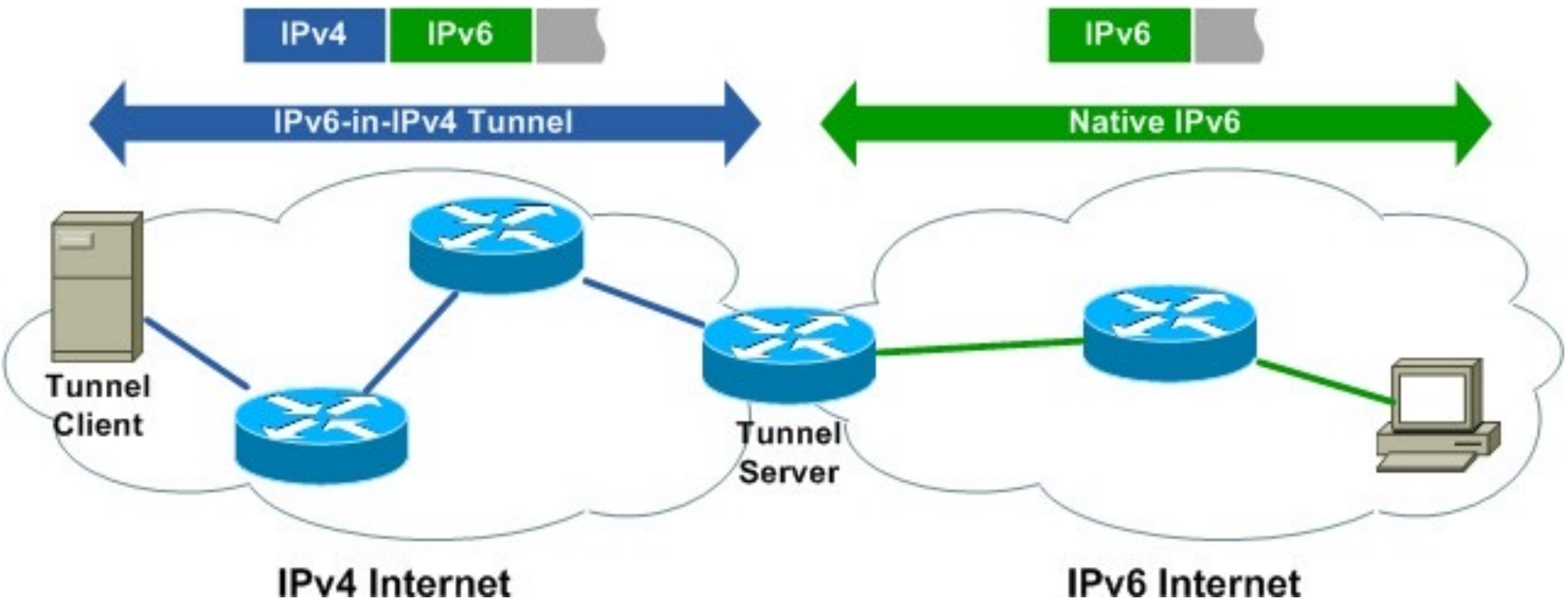
- **Dual Stack** – Running both IPv4 and IPv6 on the same devices
- **Tunneling** – Transporting IPv6 traffic through an IPv4 network transparently
- **Translation** – Converting IPv6 traffic to IPv4 traffic for transport and vice versa.

Dual Stack

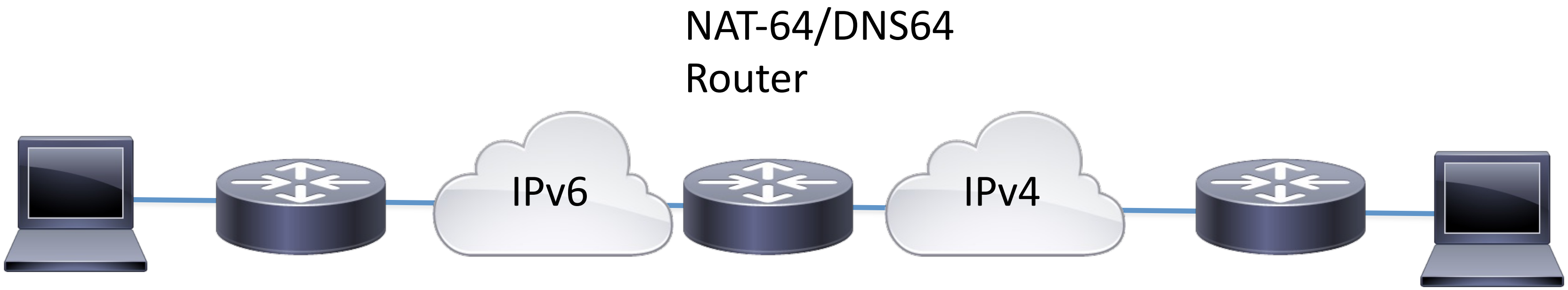


IPv6
Network
IPv4
Network
2001:d02::14:0:0:95
202.65.11.189
2001:d02::14:0:0:96
202.65.11.190

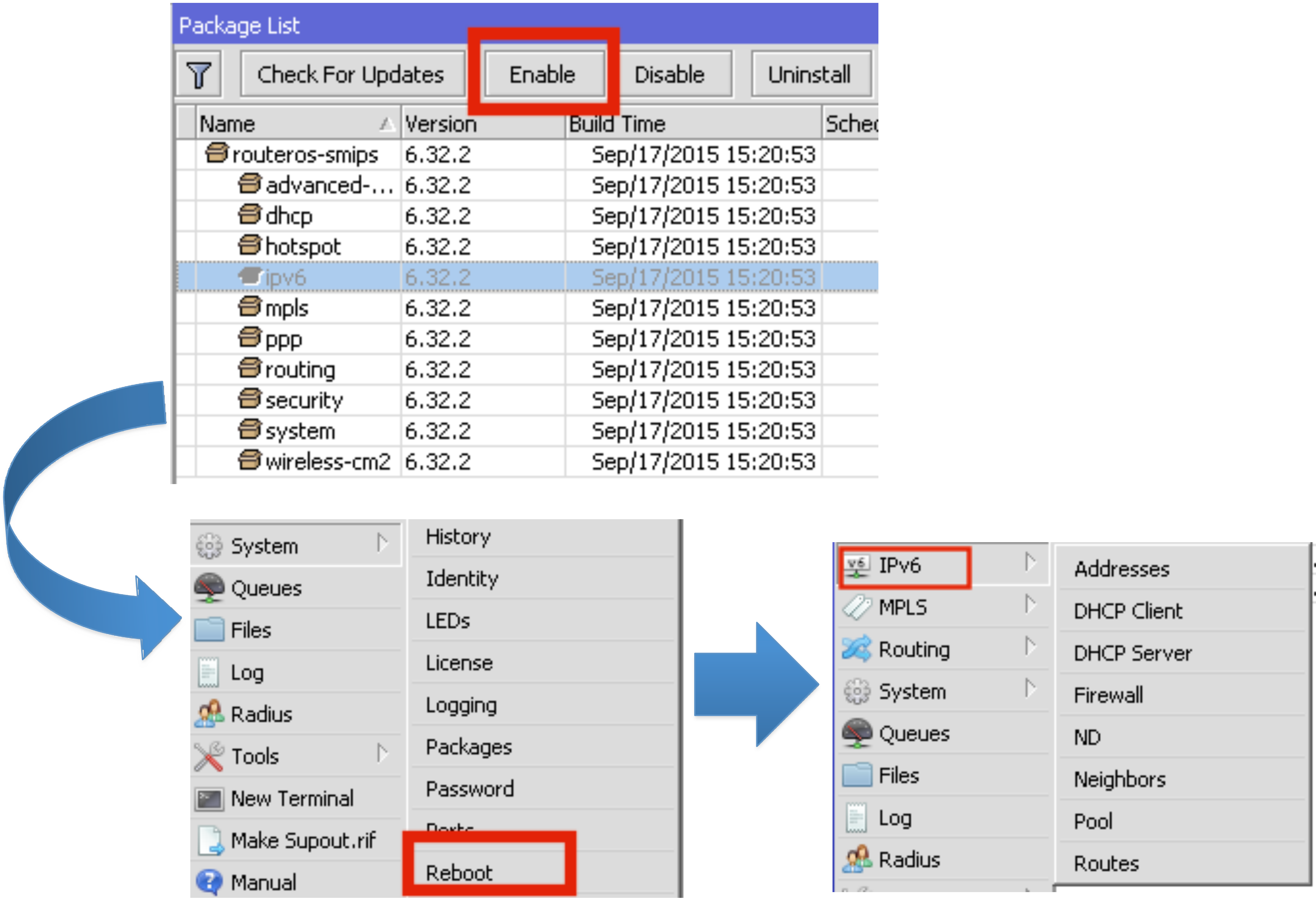
Tunneling


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

Translation



Not Yet Supported in Router OS



Package List
Check For Updates
Enable
Disable
Uninstall
Name
Version
Build Time
Schec
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

Mikrotik IPv6 Example

- Details covered in the lecture