Internet Service Provider

D-NET

IPv6 Introduction on MikroTik

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Jakarta, November 6th 2009

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D-NET

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Introduction

- Speaker
  - Christian Dwinantyo
    - NOC Manager @ D-NET
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- Company
  - D-NET
    - A Medium size ISP focus on corporate customers
    - Use MikroTik as CPE router and gateways.

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Acknowledgement

- The material used in this course was created by using :
  - Information and slides provided by APNIC
  - MikroTik Wiki about IPv6 in RouterOS.
    - http://wiki.mikrotik.com
- We acknowledges with thanks and appreciation the contribution and support of APNIC and MikroTik Wiki.

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Overview

- What is IPv6?
  - Enhancement from IPv4
- IPv6 addressing
  - Autoconfiguration
- Why do we need IPv6?
- Transition
  - Dual stack, tunneling, translation
- RouterOS support on IPv6
  - Routing protocols
  - Firewall
  - wireless

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What is IPv6

- RFC2460 :
  - IP version 6 (IPv6) is a new version of the Internet Protocol, designed as the successor to IP version 4 (IPv4) [RFC-791]. The changes from IPv4 to IPv6 fall primarily into the following categories:
    - Expanded Addressing Capabilities
    - Header Format Simplification
    - Improved Support for Extensions and Options
    - Flow Labeling Capability

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Improvement from IPv4

- 128 bits, compared to 32 bits IPv4
- Longer but simpler header
- Neighbor Discovery to replace ARP
- New address types: unicast, multicast and anycast.
- No longer use broadcast
- Autoconfiguration

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Address Space

- IPv4 address space (32 bits):
  - 2^{32} = 4,294,967,296 addresses
- IPv6 address space (128 bits):
  - 2^{128}= 340,282,366,920,938,463,463,374,607,431,768,211,456 addresses

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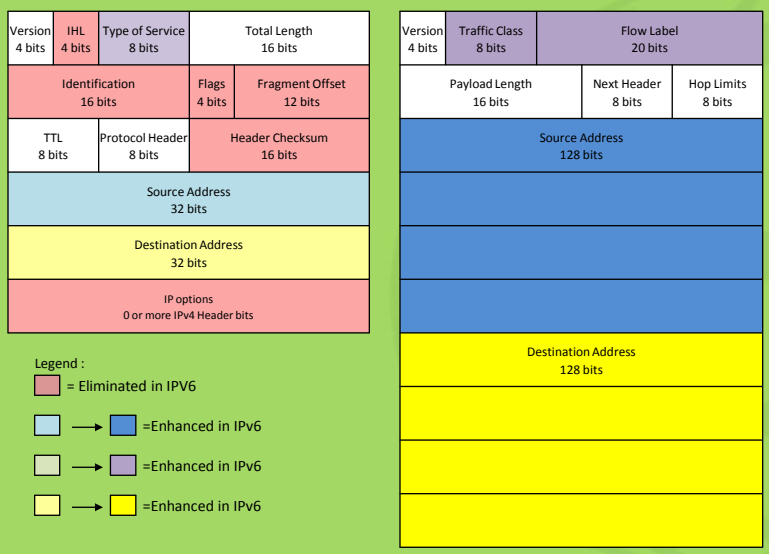
IPv4 and IPv6 header comparison



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Neighbor Discovery Protocol

- Replace ARP function in IPv4.
- Responsible for discovery of other nodes on the link.
- Determining the link layer addresses of other nodes.
- Finding available routers.
- Maintaining reachability information about the paths to other active neighbor nodes.
- Used in address autoconfiguration.

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IPv6 Addressing

- Hexadecimal values of eight 16 bit fields separated by colon.
- Example:
  - 2001:0DB8:124C:C1A2:BA03:6735:EF1C:683D
- Abbreviated form of address
  - 2001:0DB8:0023:0000:0000:036E:1250:2B00
  - 2001:DB8:23:0:0:36E:1250:2B00
  - 2001:DB8:23::36E:1250:2B00
  - (Null value can be used only once)

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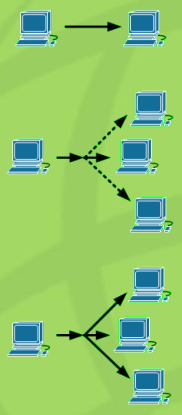
IPv6 Address Types

- Unicast
  - An identifier for a single interface
- Anycast
  - An identifier for a set of interfaces
- Multicast
  - An identifier for a group of interfaces



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IPv6 Addressing – Unicast Address

- Link-Local Address (fe80::/10)
  - Used to communicate between other ipv6 interfaces in the same network link.
  - Only valid on a single link.
  - Auto assigned
  - Not routeable to Internet.
- Global Address
  - Routeable to Internet

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Special IPv6 addresses

- Unspecified address
  - 0:0:0:0:0:0:0:0/128 (::/128)
  - Similar to 0.0.0.0 in IPv4
- Loopback address
  - 0:0:0:0:0:0:0:1/128 (::1/128)
  - Similar to 127.0.0.1 in IPv4
- Link-Local addresses
  - fe80::/10
- Unique Local addresses (ULA)
  - fc00::/7
- Documentation addresses
  - 2001:db8::/32

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IPv6 Addressing – Global Unicast Address

- Global Routing Prefix
  - Assigned to a site , eg. 2404:1b8
  - Designed to be structuted hierarchically by the RIRs and ISPs
- Subnet ID
  - Identifier of a subnet within a site
- Interface ID
  - Unique identifier for a particular interface of a device.

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IPv6 Addressing – Global Unicast Address

- Example: an ISP received 2001:db8/32

- Ipv6 address in a host in that ISP: 2001:db8:1:1:7d9f:26c7:30d3:ee82
  - 2001:db8 → global routing prefix
  - 1:1 → subnet ID
  - 7d9f:26c7:30d3:ee82 → interface ID

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IPv6 Addressing – Interface ID

- The lowest-order 64-bit field addresses
- may be assigned in several different ways:
  - auto-configured from a 48-bit MAC address expanded into a 64-bit EUI-64
  - assigned via DHCP
  - manually configured
  - auto-generated pseudo-random number (to counter some privacy concerns: RFC 3041)
  - possibly other methods in the future

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IPv6 Autoconfiguration

- Using Link-Local to communicate to other devices in the same link.
- Enable Plug and Play
- No manual configuration on client side
- Minimal router configuration
- Stateless → Does not need DHCP server
- Statefull → Need DHCP Server (running DHCPv6)

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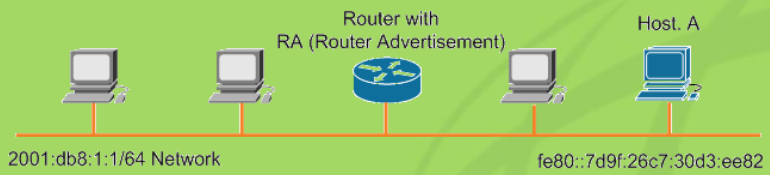
IPv6 Autoconfiguration - Stateless



1. new Host A is turned on, tentative address will be assigned to the new host.
2. Duplicate Address Detection (DAD) is performed, the host transmit a Neighbor Solicitation (NS) message to all-nodes multicast address (FF02::1),
3. If no Neighbor Advertisement (NA) message comes back then the address is unique.
4. fe80:7d9f:26c7:30d3:ee82 will be assigned to Host A.

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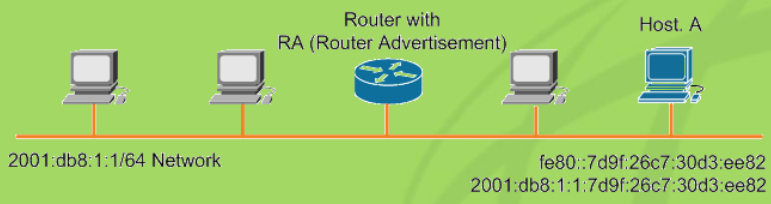
IPv6 Autoconfiguration - Stateless



1. Host. A will send Router Solicitation (RS) request to the all-routers multicast group (FE02::2).
2. The router will reply with Routing Advertisement (RA).
3. The new host will learn the network prefix. E.g, 2001:db8:1:1/64
4. The new host will assigned a new address Network prefix+Interface ID 2001:db8:1:1:7d9f:26c7:30d3:ee82

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Why we need IPv6

- IPv4 exhaustion.
  - Only 10% left
- Considerable number of Internet users growth.
- IPv6 provide larger address space.

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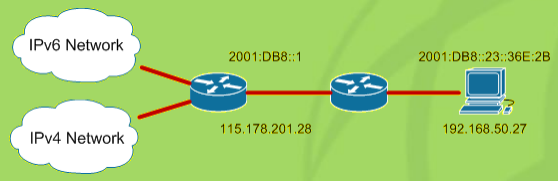
IPv6 Transition Methods

Three basic transition methods:

- Dual Stack



  - IPv4 and IPv6 can coexist in the same device.
  - Smoother transition
  - Need all nodes to be dual stacked.
  - If we can dual stack all nodes, does it mean that we have enough IPv4, thus eliminate the need of IPv6?

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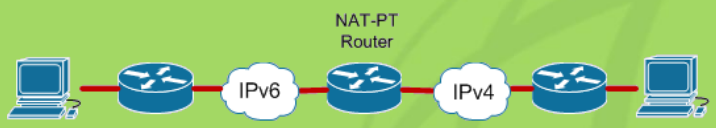
IPv6 Transition Methods

- Tunneling

  - IPv6 data is encapsulated in IPv4
  - A great way to start if your upstream does not support IPv6 connectivity.

IPv6 Transition Methods

- Translation



  - Not yet supported in RouterOS

IPv6 in RouterOS

- MikroTik IPv6 support at the moment (RouterOS 3.28/4.0beta4):
  - static addressing and routing;
  - router advertisement daemon (for address autoconfiguration)
  - dynamic routing: BGP+, OSPFv3, and RIPng protocols
  - DNS name servers;
  - 6in4 (SIT) tunnels;
  - telnet , ping and traceroute;
  - web proxy;
  - sniffer and fetch tools;

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IPv6 in RouterOS

- Features not yet supported:
  - DHCPv6;
  - all PPP (Point-to-point protocols);
  - IPSEC;
  - SSH, FTP, API, Winbox, Webbox access;
  - queues;
  - automatic tunnel creation;
  - policy routing;
  - multicast routing;
  - MPLS;
  - torch, netwatch, bandwidth test and other tools;

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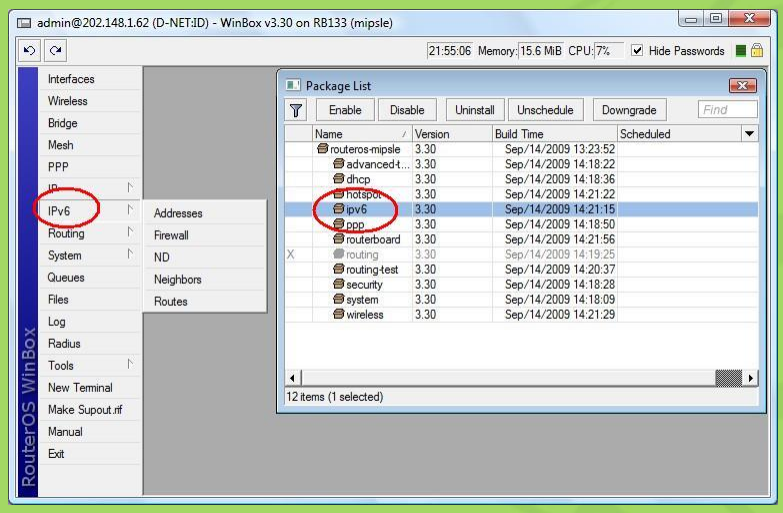
IPv6 setup on RouterOS



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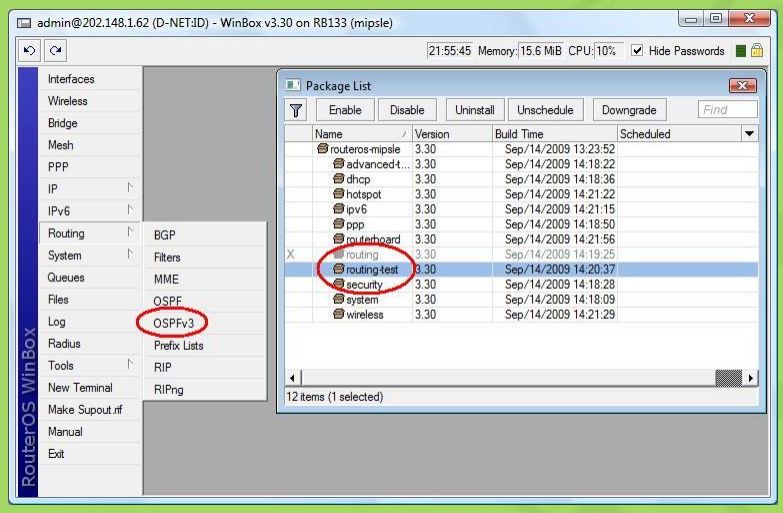
More Routing Protocols on RouterOS



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Static Addressing

Add address:

```
>ipv6 address add address=2404:1b8:0:3::abcd/64
  interface=ether2 advertise=no
```

See all IPv6 addresses:

```
> ipv6 address print
Flags: X - disabled, I - invalid, D - dynamic,
G - global, L - link-local
#    ADDRESS                    INTERFACE ADVERTISE
0 DL fe80::20c:42ff:fe1e:b1c8/64  ether2     no
1 DL fe80::20c:42ff:fe18:f304/64  wlan1      no
2  G 2404:1b8::3:0:0:0:abcd/64    ether2     no
```

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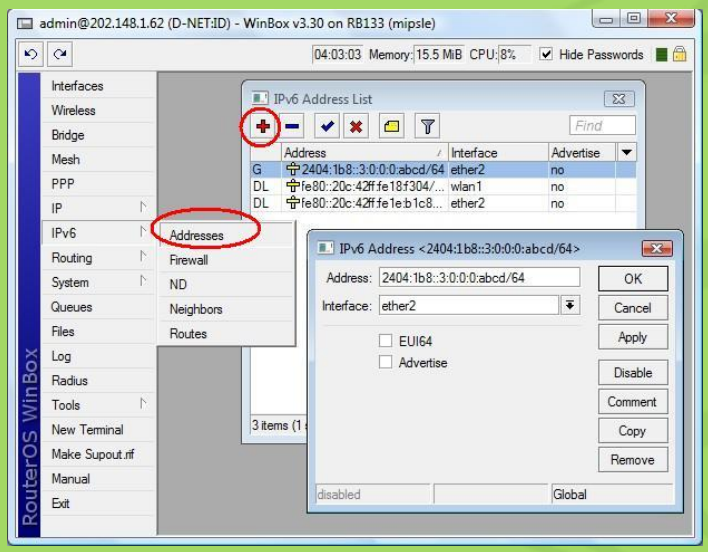
Static Addressing



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Default Route

Add Default Route

```
> ipv6 route add dst-address=::/0 gateway=2404:1b8:0:3::1
```

See all IPv6 route

```
> ipv6 route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, o - ospf,
b - bgp, U - unreachable
#      DST-ADDRESS             GATEWAY          DISTANCE
0 A S  ::/0                    2404:1b8::3:0:0:0:1  1
1 ADC  2404:1b8::3:0:0:0:0/64  ether2               0
```

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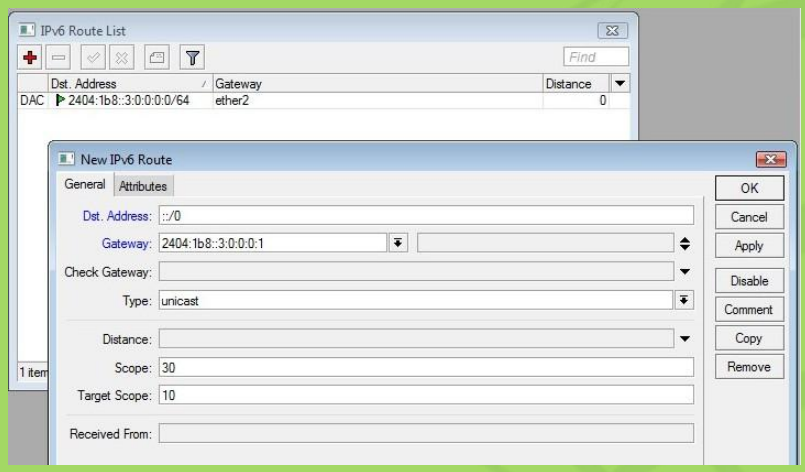
Default Route



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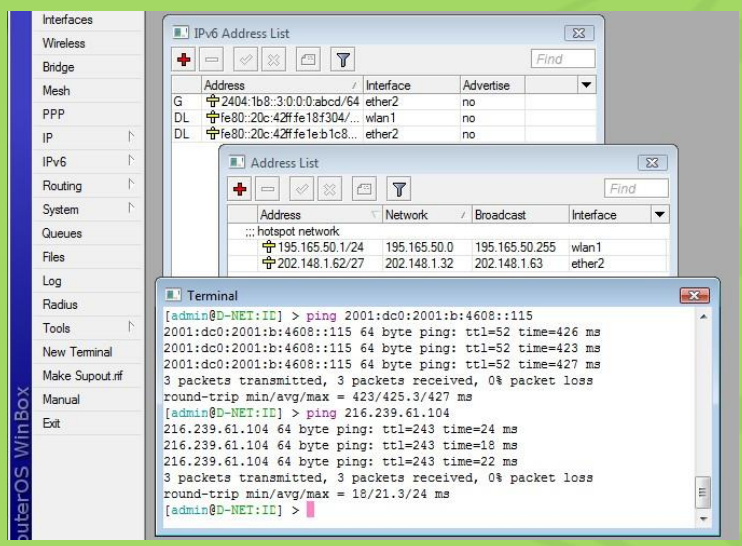
Dual Stack on RouterOS



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Dynamic Routing Protocols

- All dynamic routing protocols (RIPng, OSPFv3, BGP) require a valid Router ID to function.
- Router ID can be:
  - configured manually,
  - one of router's IPv4 addresses
- If no IPv4 addresses are present, the router ID selection process will fail → Dynamic routing protocols will also not work.

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RIPng (RFC 2080)

- Distance-vector, radius of 15 hops
- Based on RIPv2
- Support IPv6
- Uses built-in IPSec feature in IPv6 for authentication
- Uses the multicast group ff02::9, the all-rip-routers multicast group, as the destination address for RIP updates.

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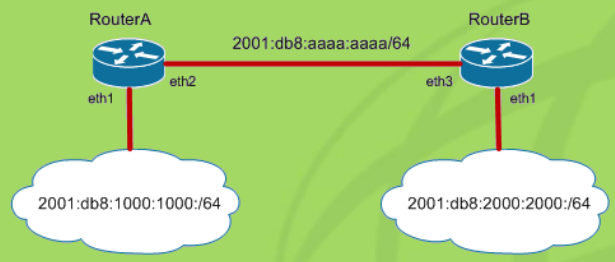
RIPng (RFC 2080)



- Router A
  - eth1 = 2001:db8:1000:1000::1/64
  - eth2 = 2001:db8:aaaa:aaaa::2/64
- Router B
  - eth1 = 2001:db8:2000:2000::1/64
  - eth2 = 2001:db8:aaaa:aaaa::3/64

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RIPng (RFC 2080)

- RouterA dan RouterB
  - `Routing ripng interface add interface=all passive=no`
  - `Routing ripng set redistribute-connected=yes`

Terminal

```
[admin@RouterB] > ipv6 route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, o - ospf, b - bgp, U - unreachable
 #      DST-ADDRESS                GATEWAY                DISTANCE
 0 ADr  2001:db8:1000:1000::/64    fe80::20c:42ff:fe0a:f... 120
 1 ADC  2001:db8:2000:2000::/64    ether1                 0
 2 ADC  2001:db8:aaaa:aaaa::/64    ether3                 0
[admin@RouterB] >
```

MAC Telnet 00:0C:42:0A:FC:EB

```
[admin@RouterA] > ipv6 route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, o - ospf, b - bgp, U - unreachable
 #      DST-ADDRESS                GATEWAY                DISTANCE
 0 ADC  2001:db8:1000:1000::/64    ether1                 0
 1 ADr  2001:db8:2000:2000::/64    fe80::20c:42ff:fe16:3... 120
 2 ADC  2001:db8:aaaa:aaaa::/64    ether2                 0
[admin@RouterA] >
```

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OSPFv3 (RFC 2740)

- Uses the same fundamental mechanisms as OSPFv2
- Not backward compatible with OSPFv2
- Dual stack running OSPF must have both OSPFv2 and OSPFv3 configured.
- no configuration for networks anymore
- and interface configuration becomes mandatory, since OSPFv3 runs on link, not IP subnet, basis.

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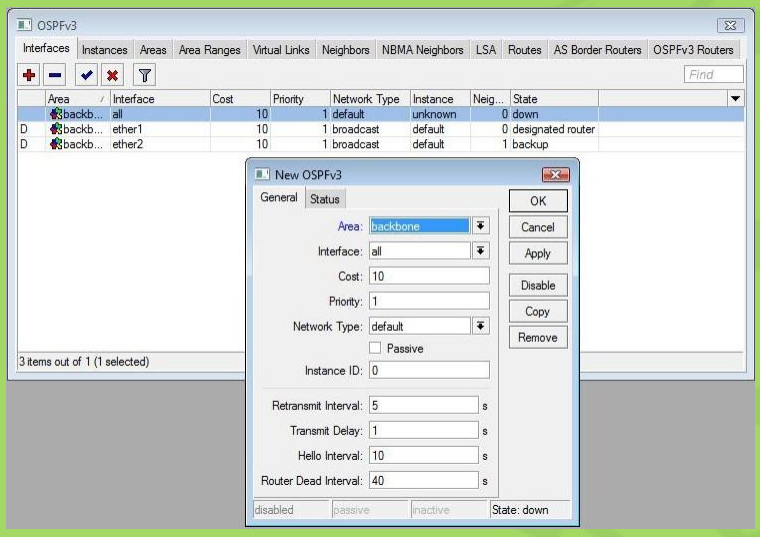
OSPFv3 (RFC 2740)



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OSPFv3 (RFC 2740)

- Using the previous topology, on RouterA and RouterB, we add:
  - `routing ospf-v3 instance add name=default redistribute-static=as-type-1`
  - `routing ospf-v3 area add name=backbone instance=default`
  - `routing ospf-v3 interface add interface=all area=backbone`

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OSPFv3 (RFC 2740)

Terminal

```
[admin@RouterA] > routing ospf-v3 route print
 # DESTINATION                                 STATE           COST
 0 2001:db8:1000:1000::/64                     intra-area      10
 1 2001:db8:2000:2000::/64                     intra-area      20
 2 2001:db8:aaaa:aaaa::/64                     intra-area      10
[admin@RouterA] > ipv6 route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, o - ospf, b - bgp, U - unreachable
 #      DST-ADDRESS                GATEWAY                   DISTANCE
 0 ADC  2001:db8:1000:1000::/64    ether1                    0
 1 ADo  2001:db8:2000:2000::/64    fe80::20c:42ff:fe16:3...  110
 2 ADC  2001:db8:aaaa:aaaa::/64    ether2                    0
[admin@RouterA] >
```

MAC Telnet 00:0C:42:16:32:71

```
[admin@RouterB] > routing ospf-v3 route print
 # DESTINATION                                 STATE           COST
 0 2001:db8:1000:1000::/64                     intra-area      20
 1 2001:db8:2000:2000::/64                     intra-area      10
 2 2001:db8:aaaa:aaaa::/64                     intra-area      10
[admin@RouterB] > ipv6 route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, o - ospf, b - bgp, U - unreachable
 #      DST-ADDRESS                GATEWAY                   DISTANCE
 0 ADo  2001:db8:1000:1000::/64    fe80::20c:42ff:fe0a:f...  110
 1 ADC  2001:db8:2000:2000::/64    ether1                    0
 2 ADC  2001:db8:aaaa:aaaa::/64    ether3                    0
[admin@RouterB] >
```

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BGP (RFC 2545/2858)

- BGP already supports multiple address families
- Example using the same topology, with AS 65530:
- routerA
  - `routing bgp peer add remote-address=2001:db8:aaaa:aaaa::3 remote-as=65530 address-families=ip,ipv6`
  - `routing bgp network add network=2001:db8:1000:1000::/64`
- routerB
  - `routing bgp peer add remote-address=2001:db8:aaaa:aaaa::2 remote-as=65530 address-families=ip,ipv6`

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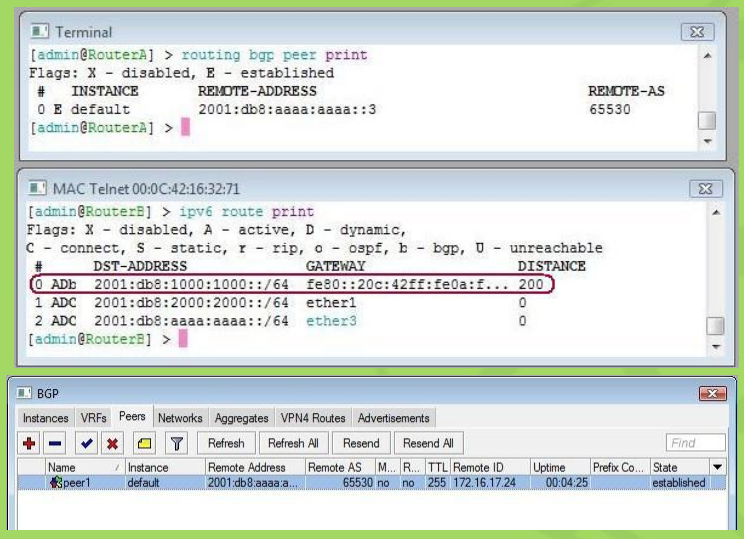
BGP (RFC 2545/2858)



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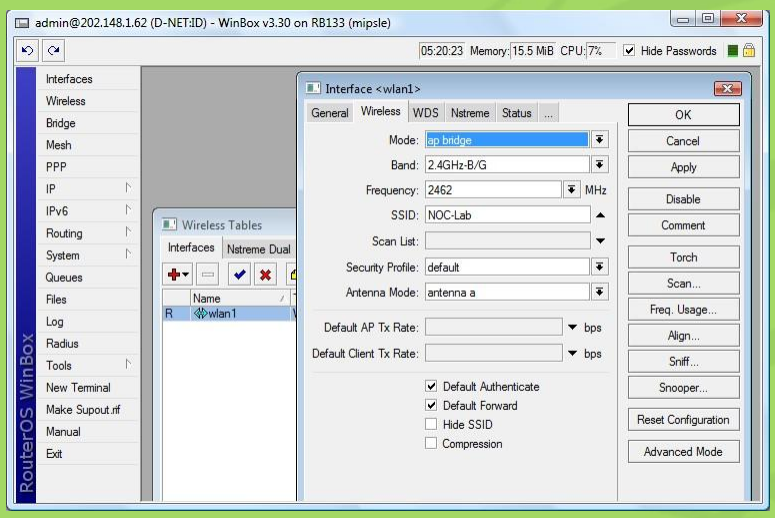
IPv6 Wireless

- Setup wlan Interface



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IPv6 Wireless

Add IPv6 address to wlan interface

```
> ipv6 address add address=2404:1b8:aaaa::1/64
  interface=wlan1 advertise=yes

> ipv6 address print
Flags: X - disabled, I - invalid, D - dynamic, G
  - global, L - link-local
# ADDRESS                          INTERFACE ADVERTISE
0 DL fe80::20c:42ff:fe1e:b1c8/64   ether2     no
1 DL fe80::20c:42ff:fe18:f304/64   wlan1      no
2  G 2404:1b8::3:0:0:0:abcd/64     ether2     no
3  G 2404:1b8:aaaa::1/64           wlan1      yes
```

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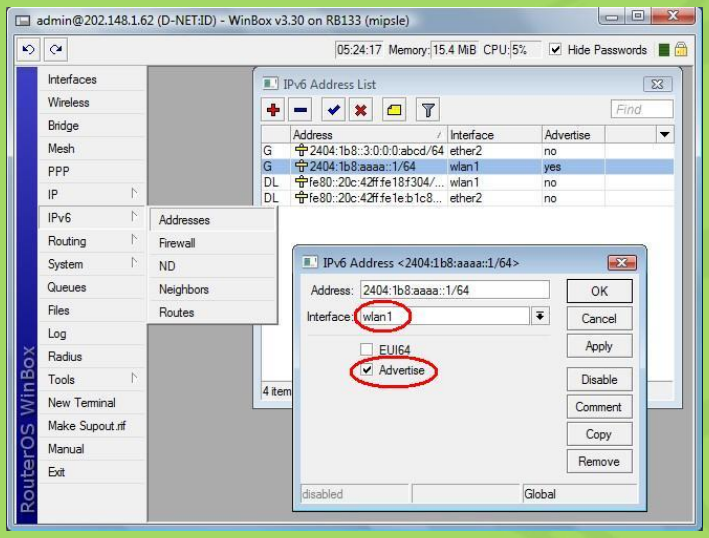
IPv6 Wireless



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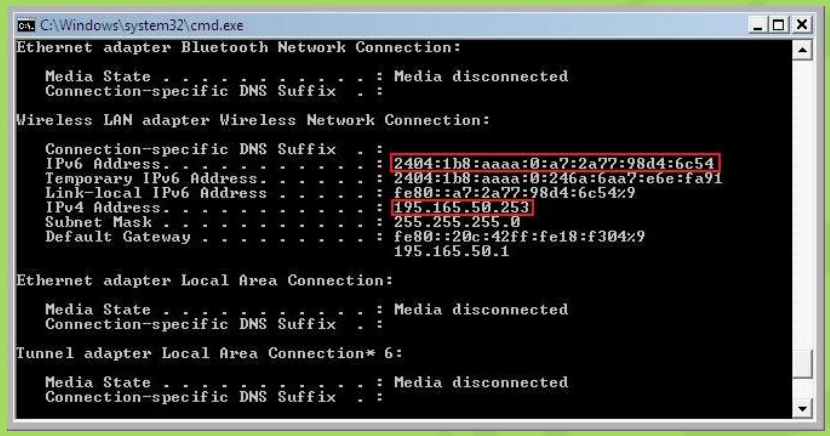
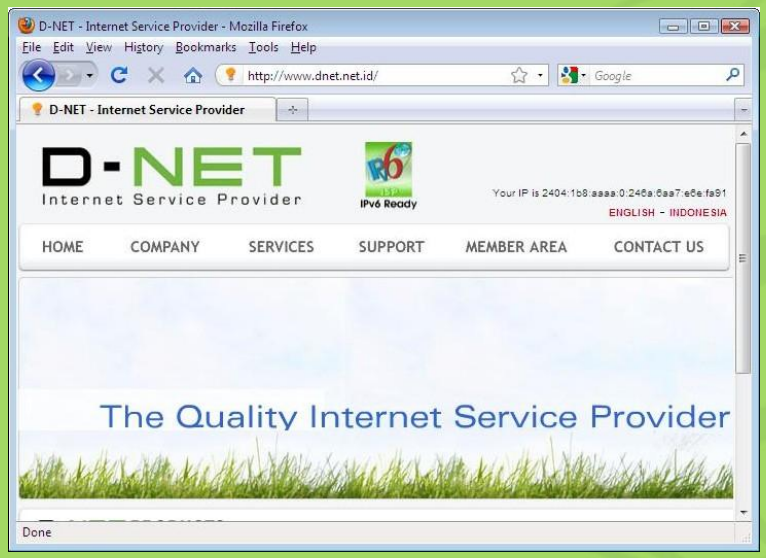
Dual Stack Wireless

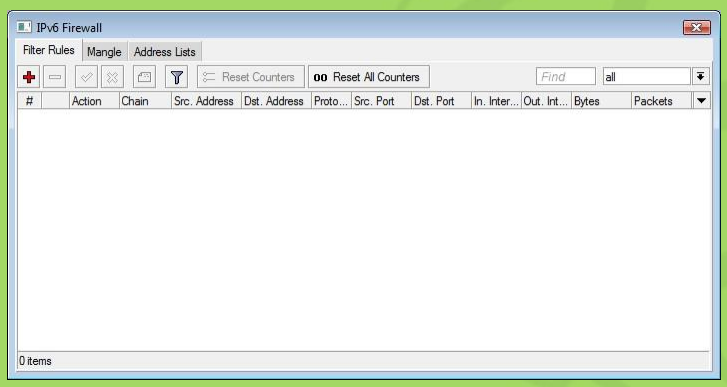


Dual Stack Wireless



Firewall

- Basically the same with IPv4 version
- Support Mangle and Address List



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6to4 Tunneling

- Need a global routable IPv4 address for router interface.
- If you don't have your own AS and IPv6 address block:
  - Sign in at a tunnel broker, eg: www.tunnelbroker.net
  - Click "Create Regular Tunnel"
  - Setup 6to4 interface on RouterOS
  - Time needed : 5 minutes.

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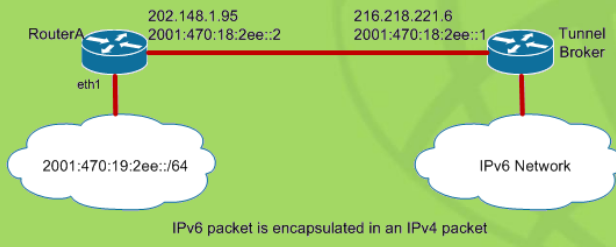
6to4 Tunneling

- After you register, you will get something like this:

Server IPv4 address:	216.218.221.6
Server IPv6 address:	2001:470:18:2ee::1/64
Client IPv4 address:	202.148.1.95
Client IPv6 address:	2001:470:18:2ee::2/64
Anycasted IPv6 Caching Nameserver:	2001:470:20::2
Anycasted IPv4 Caching Nameserver:	74.82.42.42
Routed /64:	2001:470:19:2ee::/64



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6to4 Tunneling

- On RouterOS:

```
>interface 6to4 add comment="Hurricane Electric IPv6 Tunnel
Broker" disabled=no local-address=202.148.1.95 mtu=1280
name=sit1 remote-address=216.218.221.6

>ipv6 route add comment="" disabled=no distance=1 dst-
address=2000::/3 gateway=2001:470:18:2ee::1 scope=30
target-scope=10

>ipv6 address add address=2001:470:18:2ee::2/64
advertise=yes disabled=no eui-64=no interface=sit1

>ipv6 address add address=2001:470:19:2ee::1/64
advertise=yes disabled=no eui-64=no interface=eth1
```

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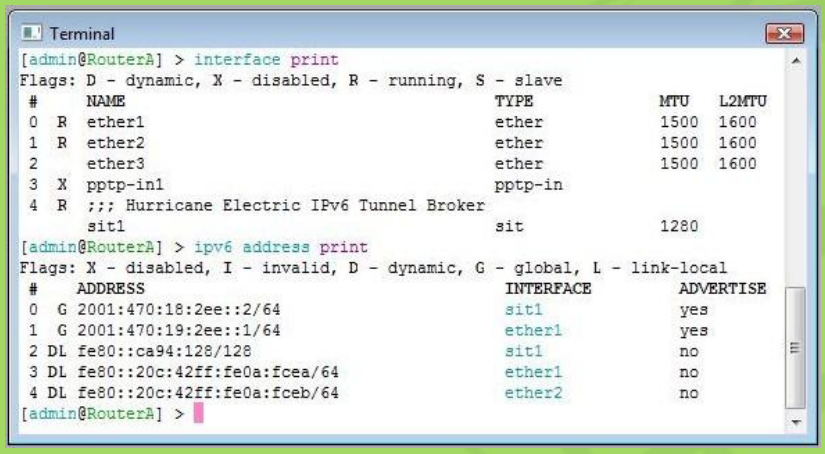
6to4 Tunneling



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6to4 Tunneling

- If you have your own AS and IPv6 address block, you can fill this form:
  - http://www.tunnelbroker.net/ipv6_bgp.php
- Build a 6to4 Tunnel
- Setup a full BGP session though this tunnel

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Thank You!