Cisco Networking Academy
Mind Wide Open

IPv6 for a Small Network

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Agenda

- CCNA & IPv6
- IPv6 Address Overview
- IPv6 Address Assignment
- Tunneling in IPv6
- Q & A

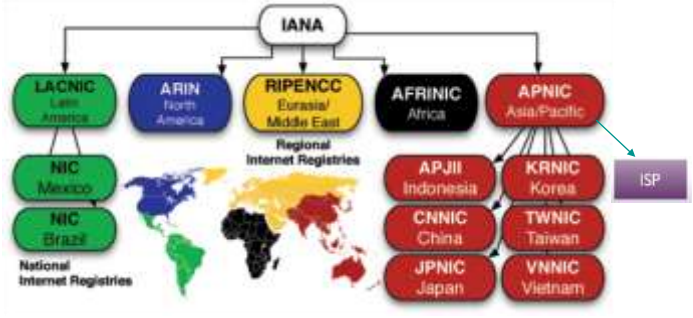
CCNA Routing and Switching Scope and Sequence (DRAFT)

- **Introduction to Networks and Network Basics**
  - Understand and describe the importance of addressing and naming schemes at various layers of data networks in IPv4 and IPv6 environments
- **Routing Protocols**
  - Configure and troubleshoot advanced operations of routers and implement RIP, OSPF, and EIGRP routing protocols for IPv4 and IPv6
  - Configure, monitor, and troubleshoot ACLs for IPv4 and IPv6
- **Switched Networks**
  - Configure and troubleshoot DHCP and DNS operations for IPv4 and IPv6

IPv6 Address Overview

IPv4 Address Allocation

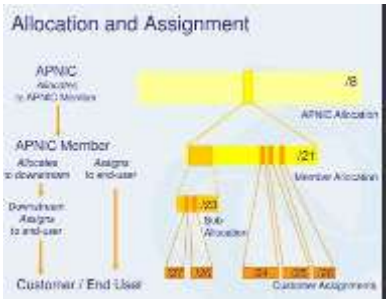
Regional Internet Registry

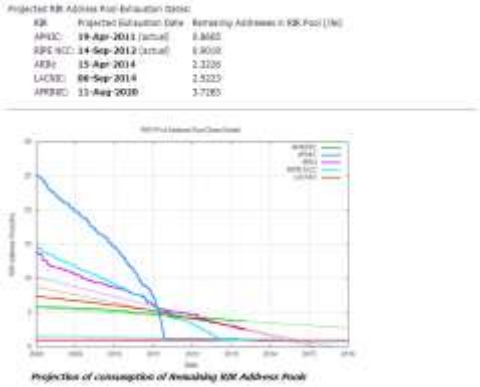


- Internet Assigned Numbers Authority (IANA) is responsible for the global coordination of the DNS Root, IP addressing, and other Internet protocol resources.
- In February 2011, IANA runs out of IPv4 addresses.

IPv4 Exhaustion Status

- http://labs.apnic.net/ipv4/report.html

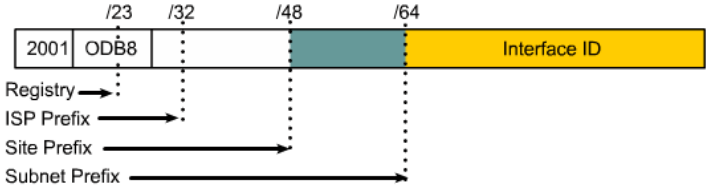




- On 15 April 2011, the APNIC pool reached the last /8 of available IPv4 addresses, triggering the Final /8 policy.
- APNIC members can each request one, and only one, small slice (a /22, or 1024 addresses) of the final /8.

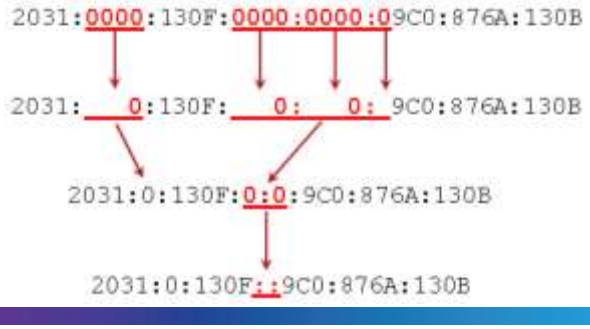
IPv6 Addressing Overview

- The 128-bit IPv6 address is written using 32 hexadecimal numbers.
- The format is `x:x:x:x:x:x:x:x`, where `x` is a 16-bit hexadecimal field, therefore each `x` represents four hexadecimal digits.
- Example address:
  - `2035:0001:2BC5:0000 : 0000:087C:0000:000A`



Abbreviating IPv6 Addresses

- Leading 0s within each set of four hexadecimal digits can be omitted.
  - 09C0 = 9C0
  - 0000 = 0
- A pair of colons ("::") can be used, *once* within an address, to represent any number ("a bunch") of successive zeros.



IPv6 Unicast Address Scopes

- Link-local addresses—only on single link, not routed
  - **FE80::/10 prefix**
- Unique-local addresses—routed within private network
  - **FC00::/7 prefix**
    - **FD00::/8 prefix range have similar properties as those of the IPv4 private address ranges**
- Global unicast addresses—globally routable
  - **2000::/3 prefix**
    - **2001 prefix most common**

Multiple IPv6 Addresses per Interface

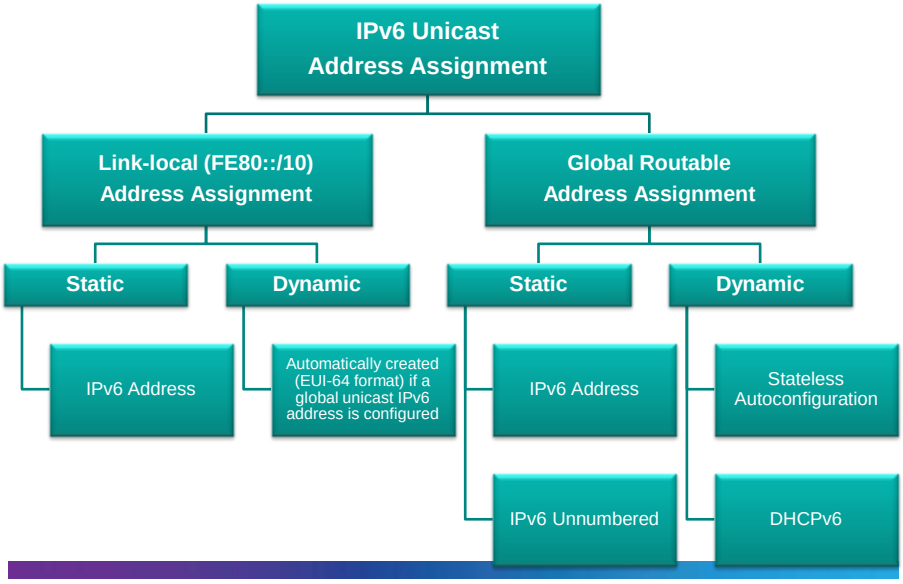
- An interface can have multiple global IPv6 addresses.
- Typically, an interface is assigned a link-local and one (or more) global IPv6 address.
- For example, an Ethernet interface can have:
  - **Link-local address**

    (FE80::21B:D5FF:FE5B:A408)
  - **Global unicast address**

    (2001:8:85A3:4289:21B:D5FF:FE5B:A408)
- The Link-local address is used for local device communication.
- The Global address is used to provide Internet reachability.

IPv6 Address Assignment

IPv6 Unicast Addresses



Enable IPv6 Routing

- Enable the forwarding of IPv6 unicast datagrams.

```
Router(config)#
ipv6 unicast-routing
```

- This command is required before configuring any form of IPv6 routing (static or dynamic).
- Also required to support autoconfiguration of end devices.
- The **no ipv6 unicast-routing** command disables IPv6 routing capabilities of the router.

Assigning a Static Global Unicast Address


```
R1(config)# ipv6 unicast-routing
R1(config)# interface fa0/0
R1(config-if)# ipv6 address 2001:1::1/64
R1(config-if)#
```


Assigning a Link-Local Address

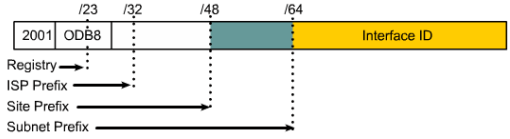

```
R1(config)# interface fa0/0
R1(config-if)# ipv6 address FE80::1 ?
link-local use link-local address
R1(config-if)# ipv6 address FE80::1 link-local
R1(config-if)# end
R1#
```

- The prefix mask is not required because they are not routed.

Assigning a Static Global Unicast Address


```
R1# show ipv6 interface fa0/0
FastEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1 [TEN]
  Global unicast address(es):
    2001:1::1, subnet is 2001:1::/64 [TEN]
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  Hosts use stateless autoconfig for addresses.
R1#
```


Ethernet EUI-64 IPv6 Addresses



- The first 64 bits are the network portion of the address. The interface ID (second 64-bits) is the host portion of the address.
- The interface ID on an Ethernet link can be based on the 48-bit MAC address of the interface with an additional 16-bit **0xFFFE** inserted in the middle of the MAC address.

Universal/Local (U/L) Bit

The seventh bit in an interface identifier is referred to as the universal/local bit, or U/L bit.

- If the U/L bit = 0, the address is locally administered. The network administrator has overridden the manufactured address and specified a different address.
- If the U/L bit = 1, the IEEE has administered the address.

E.g., to make our address a universally administered address, the address 0090:27FF:FE17:FC0C would become 0290:27FF:FE17:FC0C.

Configuring an EUI-64 IPv6 Global Address

```
R1# config t
R1(config)# int fa0/1
R1(config-if)# ipv6 add 2001::/64 eui-64
R1(config-if)# ipv6 enable
R1(config-if)# do show ipv6 interface fa0/1

FastEthernet0/1 is administratively down, line protocol is down
  IPv6 is enabled, link-local address is FE80::211:92FF:FE54:E2A1
[TEN]
  Global unicast address(es):
    2001::211:92FF:FE54:E2A1, subnet is 2001::/64 [EUI/TEN]
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF54:E2A1
  MTU is 1500 bytes

<output omitted>
```

IPv6 Address Configuration in Windows 7

Address Autoconfiguration

- Types of Autoconfiguration
  - Stateful (DHCPv6) - Configuration is based on the use of an address configuration protocol, such as DHCPv6. It is usually used when there is no routers present on the local link.
  - Stateless - Configuration of addresses is based on the Router Advertisement messages.
  - Both (Stateless DHCPv6) - Configuration is based on the Router Advertisement messages that include Prefix information and other configurations from DHCPv6.

Stateful DHCPv6

```
R1(config)#ipv6 dhcp pool GBPOOL
R1(config-dhcpv6)# dns-server 2001:DB8:1000::11
R1(config-dhcpv6)# domain-name cisco.com
R1(config-dhcpv6)# address prefix 2001:DB8:1000::/64 lifetime 36000 36000
R1(config-if)#interface GigabitEthernet0/0
R1(config-if)#ipv6 address 2001:DB8:1000::1/64
R1(config-if)#ipv6 enable
R1(config-if)#ipv6 nd managed-config-flag
R1(config-if)#ipv6 dhcp server GBPOOL
```


Linux – Ubuntu 12.04 LTS

/etc/network/interfaces

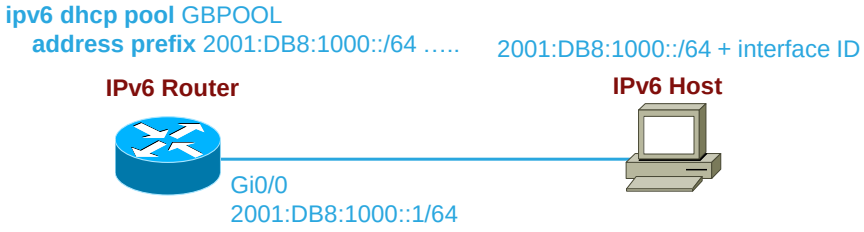
```
auto eth0
iface eth0 inet6 dhcp
```

Ubuntu 12.04 LTS

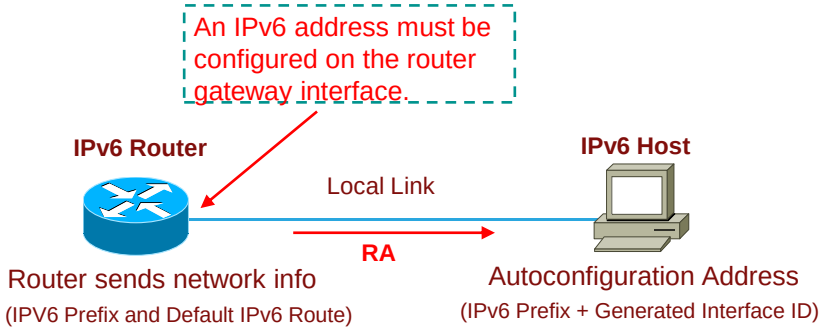
```
ssh start/running, process 3461
gmkan@folsom:/etc/network$ ifconfig
eth0      Link encap:Ethernet  HWaddr 08:00:27:3b:34:db
          inet addr:172.18.124.120  Bcast:172.18.124.255  Mask:255.255.255.128
          inet6 addr: 2001:db8:1000:0:b8b8:e052:eae9:b53a/64 Scope:Global
          inet6 addr: fe80::a00:27ff:fe3b:34db/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:302 errors:0 dropped:0 overruns:0 frame:0
          TX packets:231 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:45333 (45.3 KB)  TX bytes:73436 (73.4 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:229 errors:0 dropped:0 overruns:0 frame:0
          TX packets:229 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:26399 (26.3 KB)  TX bytes:26399 (26.3 KB)

virbr0    Link encap:Ethernet  HWaddr b2:cc:77:d3:7f:16
          inet addr:192.168.122.1  Bcast:192.168.122.255  Mask:255.255.255.0
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```


MAC OS X Lion

Host Address from DHCPv6?



Stateless Address Autoconfiguration



Procedures of Stateless Address Autoconfig

- Step1: the PC generates a link-local address (FE80::/10)
  Duplicate Address Detection (DAD) is used to ensure uniqueness
- Step 2: the PC asks the router for information
  - network address
  - network mask
  - gateway address
- Step 3: the PC generates an Interface ID,
  - randomly or using EUI-64

Which Method of Address Autoconfiguration?

Each RA message contains an **"M"** and **"O"** flags.

- "M" is Managed Address Configuration flag indicating whether the host should use stateful autoconfiguration.
- "O" is Other Stateful Configuration flag which indicates whether hosts should use stateful autoconfiguration for any other information (excluding addresses).

- M=1, O=0 or 1: All information (including Prefix、DNS, etc.) are obtained from DHCPv6. (Stateful DHCPv6)
- M=0, O=0: Clients can only get Prefix, but no other information such as DNS. (Stateless autoconfiguration – Cisco default)
- M=0, O=1: Clients get Prefix from RA, but other information such as DNS are obtained from DHCPv6. (Stateless DHCPv6)

- Set M=1:

  Router(config-if)# **ipv6 nd managed-config-flag**

- Set O=1:

  Router(config-if)# **ipv6 nd other-config-flag**

StateLess Address Auto Configuration (SLAAC)

R1(config)#ipv6 unicast-routing

R1(config)#interface GigabitEthernet0/0

R1(config-if)#ipv6 address 2001:DB8:1000::/64 eui-64

R1(config-if)#ipv6 enable ; enable link-local address using eui-64

R1(config-if)#no shutdown

•

Host Generated Interface IDs

- SLAAC
  - Temporary IPv6 addresses (privacy extension) are typically used by client applications when initiating communication, such as a Web browser, and are not registered in DNS.
  - Public IPv6 addresses are typically used by server applications for incoming connections, such as a Web server, and are registered in DNS. Public IPv6 addresses can have randomly generated or EUI-64-based interface IDs.
- DHCPv6
  - Non-temporary IPv6 addresses can be used for Dynamic DNS registration,

IPv6 Autoconfiguration Behavior for Windows

- Computers running Windows Vista, Windows Server 2008 and later versions by default generate random interface IDs for autoconfigured IPv6 addresses, including public and link-local addresses, rather than EUI-64-based interface IDs.
- You can disable this default behavior with the command:

netsh interface ipv6 set global randomizeidentifiers=disabled

Enable EUI-64

netsh interface ipv6 set privacy state=disabled

Disable privacy extension

Ubuntu 12.04 LTS

Set privacy extension by default

/etc/sysctl.d/10-ipv6-privacy.conf

Enable

net.ipv6.conf.all.use_tempaddr = 2
net.ipv6.conf.default.use_tempaddr = 2

Disable

net.ipv6.conf.all.use_tempaddr = 2
net.ipv6.conf.default.use_tempaddr = 2

sudo service procps restart

MAC OS X Lion

Set privacy extension by default

Enable

sysctl -w
net.inet6.ip6.use_tempaddr=1

Disable

sysctl -w
net.inet6.ip6.use_tempaddr=0

StateLess DHCPv6

R1(config)#ipv6 dhcp pool IPV6_DHCPPOOL

R1(config-dhcpv6)#dns-server 2001:DB8:1000::11

R1(config-dhcpv6)#domain-name cisco.com

!

R1(config)#interface GigabitEthernet0/0

R1(config-if)#ipv6 address 2001:DB8:1000::1/64

R1(config-if)#ipv6 enable

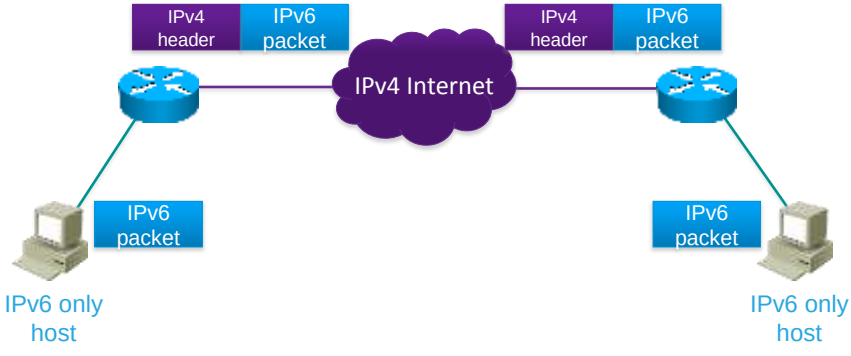
R1(config-if)#ipv6 nd other-config-flag

R1(config-if)#ipv6 dhcp server IPV6_DHCPPOOL

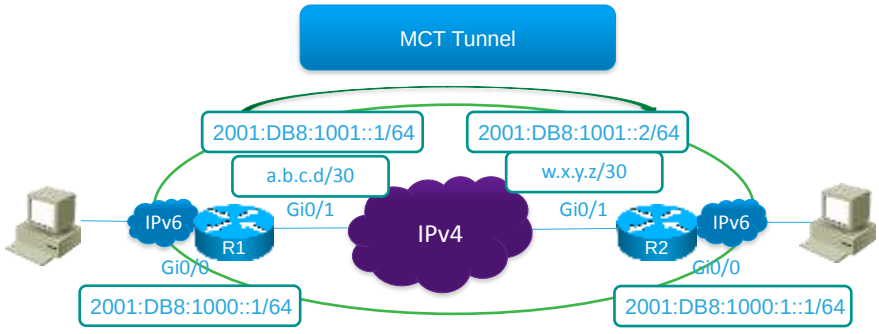
Tunneling in IPv6

Tunneling for IPv6

- The Internet is not going to migrate all at once
- We will have IPv6 islands that need to be connected

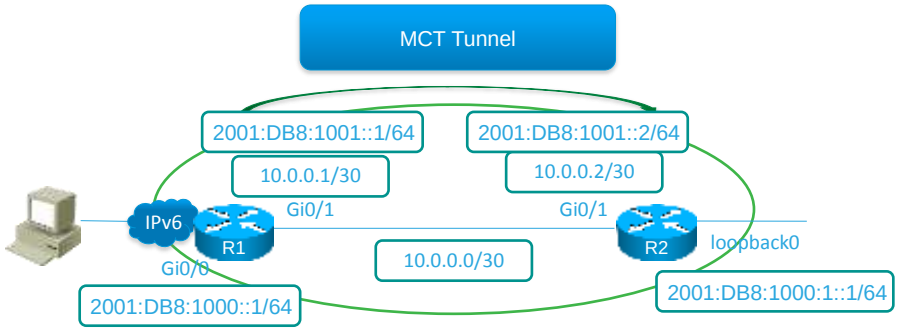


Manually Configured Tunneling in IPv6



Manually Configured Tunneling in IPv6

- Example



Configure MCT Tunnel

```
R1(config)#ipv6 unicast-routing
R1(config)#interface GigabitEthernet0/1
R1(config-if)#ip address 10.0.0.1 255.255.255.252
!
R1(config)#interface Tunnel0
R1(config-if)#ipv6 address 2001:DB8:1001::1/64
R1(config-if)#ipv6 enable
R1(config-if)#tunnel source 10.0.0.1
R1(config-if)#tunnel mode ipv6ip
R1(config-if)#tunnel destination 10.0.0.2
!
R1(config-if)#interface GigabitEthernet0/0
R1(config-if)#ipv6 address 2001:DB8:1000::1/64
R1(config-if)#ipv6 enable
```

Outside IPv4 interface

Outside IPv6 Tunnel interface

Inside IPv6 interface

Routing via Tunnel

- Static Route

R1(config)#ipv6 route 2001:db8:1000:1::/64 tun0

- RIPng

R1(config)#ipv6 router rip R1

R1(config)#interface Tunnel0

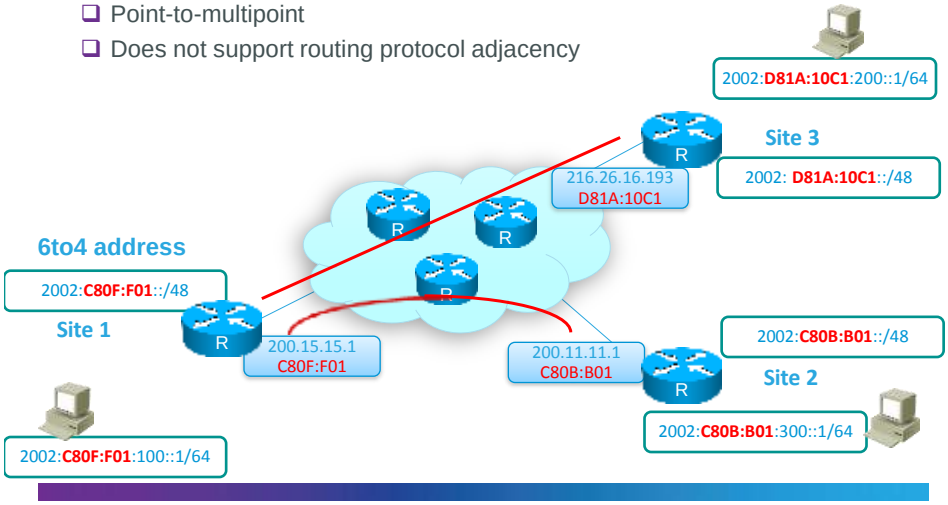
R1(config-if)#ipv6 rip R1 **enable**

R1(config)#interface GigabitEthernet0/0

R1(config-if)#ipv6 rip R1 **enable**

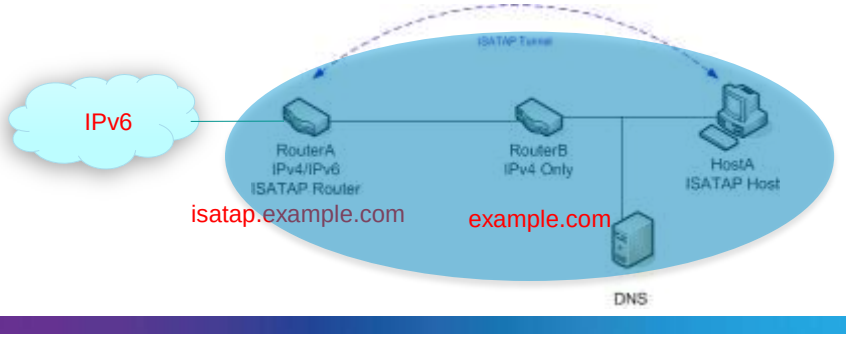
6to4 Tunneling in IPv6

- 6to4 tunneling
  - Point-to-multipoint
  - Does not support routing protocol adjacency



ISATAP Tunneling in IPv6

- Intra-Site Automatic Tunnel Addressing Protocol (ISATAP). This internal network has RouterB in place that is not IPv6 capable . ISATAP provides a solution for the hosts behind this device! Dynamic tunneling will be done from these hosts to the ISATAP router (RouterA).



References

- http://lms.netacad.net/file.php/3541/html/index28a.html

Questions?

Thank you.

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