INTERNETWORK expert

Building Scalable Cisco Internetworks (BSCI)

Internet Protocol Version 6
(IPv6)

http://www.INE.com

Why IPv6?

- Main motivation for IPv6 is lack of IPv4 address space
- IPv4 uses 32-bits
  - 2^{32} = 4,294,967,296 max addresses
- IPv6 uses 128-bits
  - 2^{128} = 34,028,236,692,938,463,463,374,607,431,770,000,000+

IPv4 vs. IPv6 Addressing Format

- IPv4 Dotted Decimal
  - 1.2.3.4
  - Each place denotes 1 byte
- IPv6 Hexadecimal
  - XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX
  - Two characters = one byte

RFC 2373: IP Version 6 Addressing Architecture

```
2.4 Address Type Representation

   The specific type of an IPv6 address is indicated by the leading bits
   in the address.  The variable-length field comprising these leading
   bits is called the Format Prefix (FP).  The initial allocation of
   these prefixes is as follows:

   Allocation                          Prefix       Fraction of
                                       (binary)     Address Space
   ----------------------------------  --------     -------------
   Aggregatable Global Unicast Addresses 001        1/8
   Link-Local Unicast Addresses        1111 1110 10 1/1024
   Site-Local Unicast Addresses        1111 1110 11 1/1024
   Multicast Addresses                 1111 1111    1/256
```

IPv6 Address Space

- Four main address types
  - Global Unicast
    - 2000… – 3FFF…
  - Site Local
    - FEC0…
  - Link Local
    - FE80…
  - Multicast
    - FF…

Modified EUI-64 Addressing

- IPv6 host addresses are generated from interface MAC address
- MAC address is 48-bits
- IPv6 host address is 64-bits
- Extra 16 bits derived as follows:
  - MAC 1234.5678.9012
  - Invert 7th most significant bit
    - 1034.5678.9012
  - Insert "FFFE" in middle
    - 1034:56FF:FE78:9012

IPv6 Address Resolution

- Ethernet
  - ICMPv6 ND replaces ARP
- NBMA
  - Static resolution on multipoint interfaces
  - Inverse Neighbor Discover not yet implemented

ICMPv6 Neighbor Discovery

- ICMPv6 ND
- Replaces IPv4 ARP
- NS – Neighbor Solicitation
  - Ask for information about neighbor
- NA – Neighbor Advertisement
  - Advertise yourself to other neighbors
- RS – Router Solicitation
  - Ask for information about local routers
- RA – Router Advertisement
  - Advertise yourself as an active router

ICMPv6 Neighbor Discovery

- Send neighbor solicitation to solicited node multicast
  - FF02:0:0:0:0:1:FF00::/104 + 24 low-order bits
- If no reply address is unique
  - Duplicate Address Detection (DAD)
- Send unsolicited neighbor advertisement to announce yourself
  - Sent to all hosts multicast
    - FF02::1
    - Essentially the same as 255.255.255.255

IPv6 Routing Overview

- IPv6 unicast routing off by default
  - `ipv6 unicast-routing`
- Dynamic routing through
  - RIPng
  - OSPFv3
  - IS-IS
  - BGP
- Dynamic information recurses to remote link-local address
  - Layer 3 to layer 2 resolution on multipoint NBMA medias

IPv6 Static Routing

- Same static routing implications as IPv4
  - To next-hop
    - Resolve next-hop
  - To multipoint interface
    - Resolve final destination
  - To point-to-point interface
    - No resolution required

IPv6 Routing

- RIPng & OSPFv3
  - Use separate processes
- BGP & IS-IS
  - Use the same process
  - Different Address families

RIPng Overview

- RFC 2080 - RIPng
- Similar in operation to RIPv1 / RIPv2
- UDP port 521 multicast to FF02::9
- Configuration
  - Interface level `ipv6 rip [process] enable`
  - Automatically enables global process
- Split-horizon enabled globally
  - `no split-horizon` on multipoint NBMA

OSPFv3 Overview

- RFC 2740 - OSPFv3
- Similar in operation to OSPFv2
- Router-id is IPv4 address
  - Use `router-id` command if no IPv4 configured
- Configuration
  - Interface level `ipv6 ospf [process-id] area [area-id]`
  - Automatically enables global process

OSPFv3 Over NBMA

- Same network types as OSPFv2
  - Broadcast
    - DR/BDR Election
  - Non-broadcast
    - DR/BDR Election
    - Unicast updates to link-local address
  - Point-to-point
  - Point-to-multipoint
  - Point-to-multipoint non-broadcast
    - Unicast updates to link-local address

BGP for IPv6 Overview

- Same process for IPv4 and IPv6
  - Uses address-family configuration
- Normal BGP rules apply
  - Requires underlying IGP transport
  - iBGP loop prevention
    - Don't advertise iBGP learned routes to other iBGP neighbors
    - Exception through route-reflection / confederation
  - EBGP loop prevention
    - Don't accept routes with your own AS in the path
  - Same best-path selection process

Tunneling IPv6 over IPv4

- Static tunnels
  - GRE
    - Default tunnel mode
  - IPv6IP
    - Less overhead, no CLNS transport
- Automatic tunnels
  - 6to4
    - Imbeds IPv4 address into IPv6 prefix to provide automatic tunnel endpoint determination
  - ISATAP
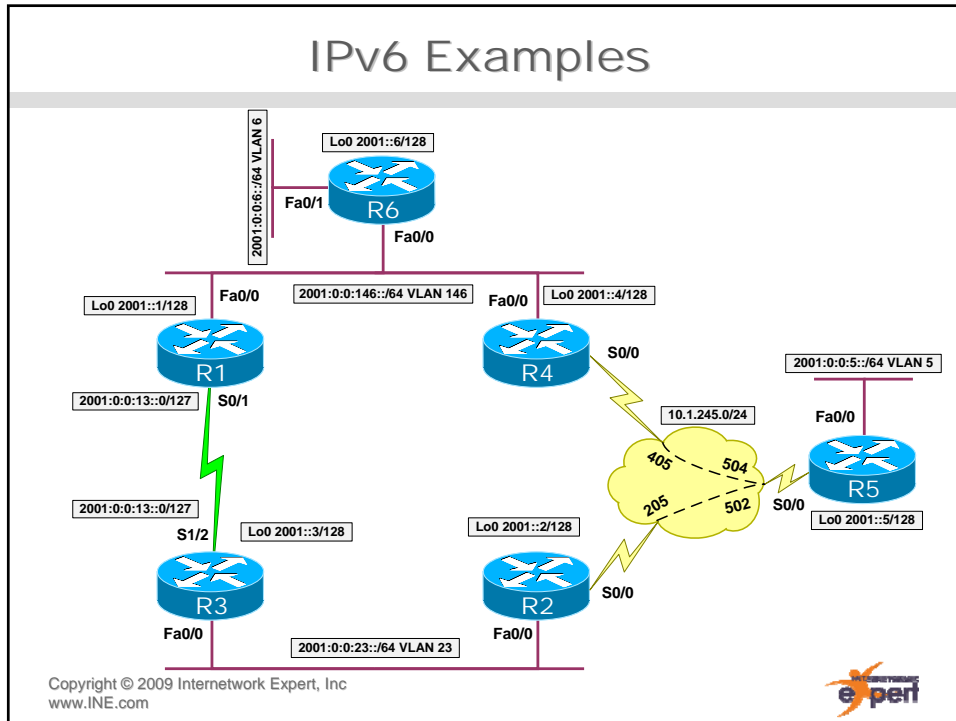   - Automatic host to router and host to host tunneling

Automatic 6to4 Tunneling

- Derives destination IPv4 router from address imbedded inside IPv6 destination
- 2002:*border-router-IPv4-address*::/48
- Single /48 subnetted amongst site
- Only one tunnel needed for all destinations

IPv6 Examples

IPv6 Q&A