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# IPv6 for R&S CCIE Candidates

Johnny Bass
CCIE #6458

BUILT FOR THE HUMAN NETWORK

# About the Presenter

Johnny Bass

- Networking industry since the late 1980s
- CCIE R&S #6458
- CCSI 97168
- Cisco 360 R&S Master Instructor
- Course director for several programs, including Cisco 360 for Route Switch, for Global Knowledge

# Why Are We Here?

- Show of hands, how many of you are currently supporting IPv6?

# CCIE R&S V4.0 IPv6 Section

| **3.00** | **Implement IPv6** |
|---|---|
| 3.10 | Implement IP version 6 (IPv6) addressing and different addressing types |
| 3.20 | Implement IPv6 neighbor discovery |
| 3.30 | Implement basic IPv6 functionality protocols |
| 3.40 | Implement tunneling techniques |
| 3.50 | Implement OSPF version 3 (OSPFv3) |
| 3.60 | Implement EIGRP version 6 (EIGRPv6) |
| 3.70 | Implement filtering and route redistribution |

# Agenda

- **IP version 6 (IPv6) addressing and different addressing types**
- IPv6 neighbor discovery
- Basic IPv6 functionality protocols
- Tunneling techniques
- IPv6 Unicast routing
- Filtering and route redistribution
- IPv6 Multicast
- IPv6 and 3560 switches
- IPv6 NAT protocol translation
- Troubleshooting IPv6
- CCIE R&S
- Q&A

# IPv6 Addressing and Different Addressing Types

- Globally significant addressing
- Link local
- Site local
- Unique local
- Multicast
- Anycast
- Address assignments
  - Static
  - DHCPv6
  - Stateless auto configure
  - IPv4 Compatible

# IPv6 Addressing and Different Addressing Types

| IPv6 Prefix | Allocation |
|---|---|
| 0000::/8 | Reserved by IETF |
| 0100::/8 | Reserved by IETF |
| 0200::/7 | Reserved by IETF |
| 0400::/6 | Reserved by IETF |
| 0800::/5 | Reserved by IETF |
| 1000::/4 | Reserved by IETF |
| 2000::/3 | Global Unicast |
| 4000::/3 | Reserved by IETF |
| 6000::/3 | Reserved by IETF |
| 8000::/3 | Reserved by IETF |
| A000::/3 | Reserved by IETF |
| C000::/3 | Reserved by IETF |
| E000::/4 | Reserved by IETF |
| F000::/5 | Reserved by IETF |
| F800::/6 | Reserved by IETF |
| FC00::/7 | Unique Local Unicast |
| FE00::/9 | Reserved by IETF |
| FE80::/10 | Link Local Unicast |
| FEC0::/10 | Reserved by IETF |
| FF00::/8 | Multicast |

# IPv6 Addressing and Different Addressing Types - Globally Significant Addressing

| | |
|---|---|
| 2001:4200::/23 | AfriNIC |
| 2C00:0000::/12 | AfriNIC |
| 2001:0200::/23 | APNIC |
| 2001:0C00::/23 | APNIC |
| 2001:0E00::/23 | APNIC |
| 2001:4400::/23 | APNIC |
| 2001:8000::/19 | APNIC |
| 2001:A000::/20 | APNIC |
| 2001:B000::/20 | APNIC |
| 2400:0000::/12 | APNIC |
| 2001:0400::/23 | ARIN |
| 2001:1800::/23 | ARIN |
| 2001:4800::/23 | ARIN |
| 2600:0000::/12 | ARIN |
| 2610:0000::/23 | ARIN |
| 2620:0000::/23 | ARIN |
| 2001:1200::/23 | LACNIC |
| 2800:0000::/12 | LACNIC |

| | |
|---|---|
| 2001:0600::/23 | RIPE NCC |
| 2001:0800::/23 | RIPE NCC |
| 2001:0A00::/23 | RIPE NCC |
| 2001:1400::/23 | RIPE NCC |
| 2001:1600::/23 | RIPE NCC |
| 2001:1A00::/23 | RIPE NCC |
| 2001:1C00::/22 | RIPE NCC |
| 2001:2000::/20 | RIPE NCC |
| 2001:3000::/21 | RIPE NCC |
| 2001:3800::/22 | RIPE NCC |
| 2001:4000::/23 | RIPE NCC |
| 2001:4600::/23 | RIPE NCC |
| 2001:4A00::/23 | RIPE NCC |
| 2001:4C00::/23 | RIPE NCC |
| 2001:5000::/20 | RIPE NCC |
| 2003:0000::/18 | RIPE NCC |
| 2A00:0000::/12 | RIPE NCC |

| | |
|---|---|
| 2002:0000::/16 | 6to4 |
| 2001:0000::/23 | IANA |
| 2001:3C00::/22 | IANA |
| 2D00:0000::/8 | IANA |
| 2E00:0000::/7 | IANA |
| 3000:0000::/4 | IANA |

# IPv6 Addressing and Different Addressing Types - Globally Significant Addressing

| Prefix | Subnet ID | Interface/Node ID |
|---|---|---|
| 32 to 56 bits | 32 to 8 bits | 64 bits |

- The interface ID can be either EUI-64, use Privacy Extensions (RFC 3041) or locally configured
  - EUI-64 takes the MAC address and modifies it to fit the 64 bit field

00-DD-011C-DB-80

02- DD-01FF-FE1C-DB-80

2005:0:DEAD:BEEF:2DD:1FF:FE1C:DB80

# IPv6 Addressing and Different Addressing Types - Link Local

| 10 bits | 38 bits | 16 bits | 64 bits |
|---|---|---|---|
| 1111 1110 10 | 0000….0000 | Sub-net ID | Interface ID |

- Link local address (FE80::/10) are assigned to any and all interfaces configured for IPv6, regardless if the interface has a routable address.
- Link local address can be used to speak between devices within the same layer 2 domain
- Link local address are not routable
- They can be used to limit the scope of delivery of packets that not to be routed (such as IGPs)

# IPv6 Addressing and Different Addressing Types - Link Local

| 10 bits | 38 bits | 16 bits | 64 bits |
|---|---|---|---|
| 1111 1110 10 | 0000….0000 | Sub-net ID | Interface ID |

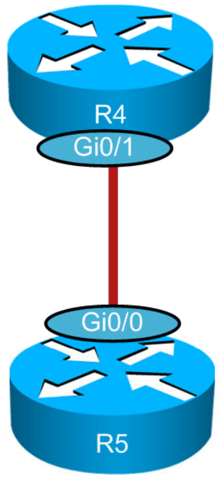
- Link local address are used to source ICMPv6 packets for neighbor discovery and stateless address autoconfiguration
- The interface ID can be either EUI-64, use Privacy Extensions or locally configured

FE80::2DD:1FF:FE1C:DB80

# IPv6 Addressing and Different Addressing Types - Link Local

```
interface GigabitEthernet0/1
 ipv6 enable
```

```
interface GigabitEthernet0/1
 ipv6 address FE80::5 link-local
```



# IPv6 Addressing and Different Addressing Types - Site Local

- IPv6 site-local addresses are similar to IPv4 private addresses. The scope of site local is within an organization.
- Not to be advertised on the Internet
- FEC0::/10

| 10 bits | 38 bits | 16 bits | 64 bits |
|---|---|---|---|
| 1111 1110 11 | 0000….0000 | Sub-net ID | Interface ID |

- Deprecated!

# IPv6 Addressing and Different Addressing Types - Unique Local

- Replaces Site Local
- RFC 4193
- FC00::/7 is to be used within an enterprise
  - FC00::/8 planned to be globally managed
  - FD00::/8 assigned locally by the network administrator
- Not to be advertised on the Internet

| 7 bits | | 40 bits | 16 bits | 64 bits |
|---|---|---|---|---|
| 1111 110 | X | Global ID | Sub-net ID | Interface ID |

# IPv6 Addressing and Different Addressing Types - Multicast

- Multicast - FF00::/8

| 8 bits | 4 bits | 4 bits | 112 bits |
|---|---|---|---|
| 11111111 | Flag | Scope | Group ID |

- Flag bits:

  Only the least significant bit is currently used: 0 is a permanent or well known multicast, 1 is not permanent or transient multicast

- Scope: 1 – Node Local (only useful for multicast to loopback interfaces)
  2 – Link Local
  5 – Site Local
  8 – Organization Local
  E (14) – Global

# IPv6 Addressing and Different Addressing Types - Anycast

- An anycast address is an address that is assigned to more than one interface (typically belonging to different nodes), with the property that a packet sent to an anycast address is routed to the "nearest" interface having that address, according to the routing protocols' measure of distance.
- Subnet anycast address is the prefix with all zeros in the node portion

# IPv6 Addressing and Different Addressing Types - Address Assignments

- Address assignments
  - Static

    ipv6 address 2005:0:DEAD:BEEF::1/64
  - DHCPv6

    ipv6 address dhcp
  - Stateless auto configure

    Ipv6 address autoconfig

# IPv6 Addressing and Different Addressing Types - Address Assignments

- DHCPv6

| | |
|---|---|
| RFC3315 | Dynamic Host Configuration Protocol for IPv6 (DHCPv6) |
| RFC3319 | Dynamic Host Configuration Protocol (DHCPv6) Options for Session Initiation Protocol (SIP) Servers |
| RFC3633 | IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) |
| RFC3646 | DNS Configuration Options for Dynamic Host Configuration Protocol for IPv6 (DHCPv6) |
| RFC3898 | NIS Server Option, NIS Domain Option/NIS+ Server Option, NIS+ Domain Option |
| RFC4075 | Simple Network Time Protocol (SNTP) Configuration Option for DHCPv6 |
| RFC4242 | Information Refresh Time Option for Dynamic Host Configuration Protocol for IPv6 (DHCPv6) |
| RFC4649 | DHCPv6 Relay Agent Remote-ID Option |

# IPv6 Addressing and Different Addressing Types - Address Assignments – DHCPv6

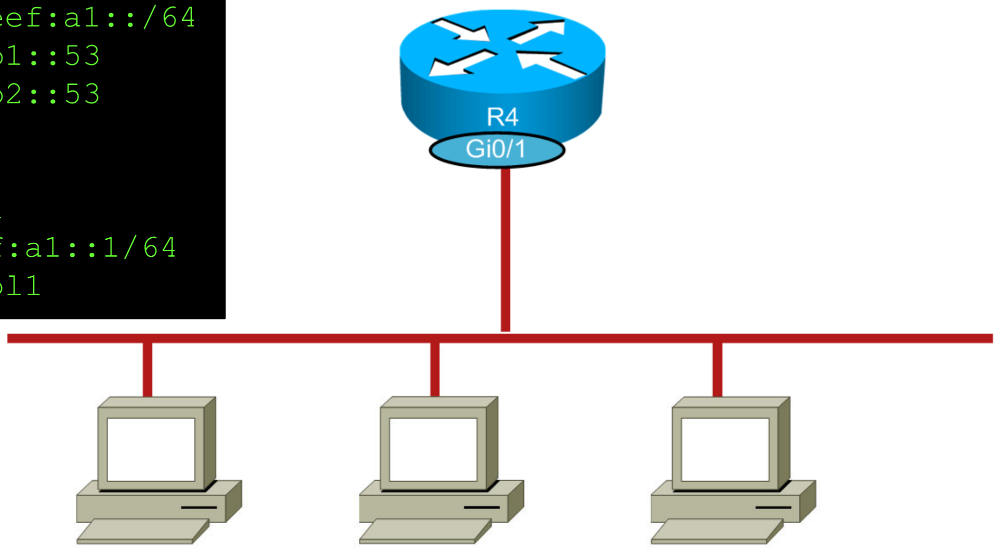
| Message Types | DHCPv4 | DHCPv6 |
|---|---|---|
| Layer 2 MAC address | FF-FF-FF-FF-FF-FF | 33-33-00-00-01-02 |
| Layer 3 address | 255.255.255.255 Broadcast | All on-link DHCPV6-relay agents or servers FF02::1:2 |
| Discovery packet type | DHCP Discovery | Solicit message |
| DHCP server response | DHCP Offer | Advertise message |
| Client to server response to offer | DHCP Request | Request message |
| DHCP server ack to client response | DHCP ACK | Reply message |
| DHCP router relay support | Configured on router to forward DHCP packets | Relay agents use ff05::1:3 All DHCPv6 servers |

# IPv6 Addressing and Different Addressing Types - DHCPv6 Server

- A router can act as a DHCP server
- Operation is similar to IPv4 DHCP
  - Client address are assigned
  - Servers keep a binding table
  - Binding table can be uploaded to another server
- Configuration options
  - DHCP pool name
  - Prefix information
  - Addresses for specific clients
  - DNS servers and domain name

# IPv6 Addressing and Different Addressing Types - DHCPv6 Server

```
ipv6 dhcp pool MyPool1
 address prefix 2005:dead:beef:a1::/64
 dns-server 2005:dead:beef:b1::53
 dns-server 2005:dead:beef:b2::53
 domain-name MyDomain.org
!
interface GigabitEthernet0/1
 ipv6 address 2005:dead:beef:a1::1/64
 ipv6 dhcp server pool MyPool1
```

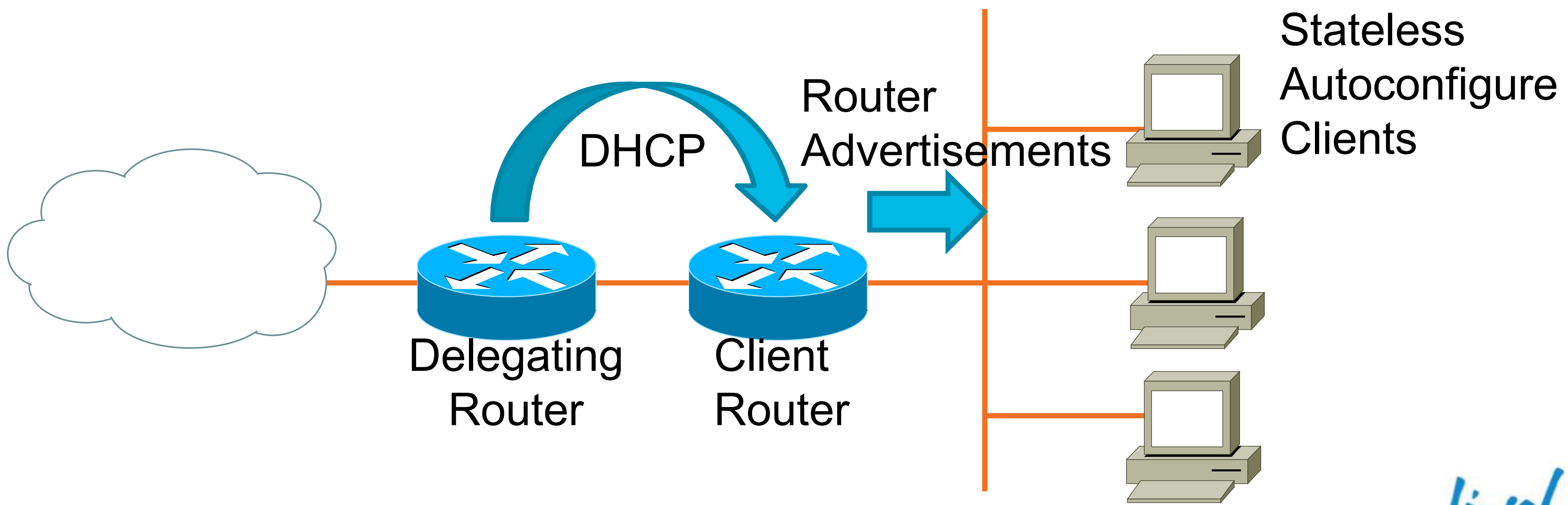


# IPv6 Addressing and Different Addressing Types - DHCPv6 Server

- To store the binding table on another server:
  - `Router(config)#ipv6 dhcp database` *`URL`*
- DHCPv6 client can obtain addressing from a server either through a rapid two-message exchange (solicit, reply) or through a normal four-message exchange (solicit, advertise, request, reply). Default, the four-message exchange is used. When the rapid-commit option is enabled by both client and server, the two-message exchange is used.
  - `Router(config-if)# ipv6 dhcp server MyPool1 rapid-commit`

# IPv6 Addressing and Different Addressing Types - DHCPv6 Delegation

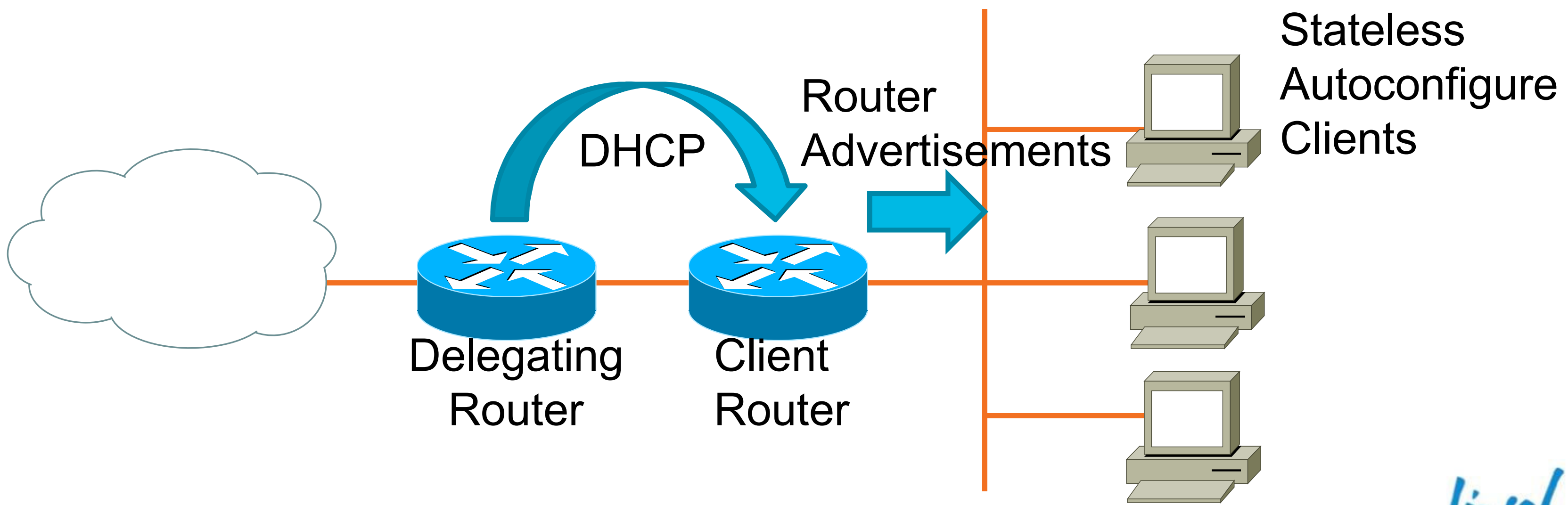
- You can delegate a block of addresses from one server to another to provision
- One device acts as a client to the other, then acts as a server to it's clients



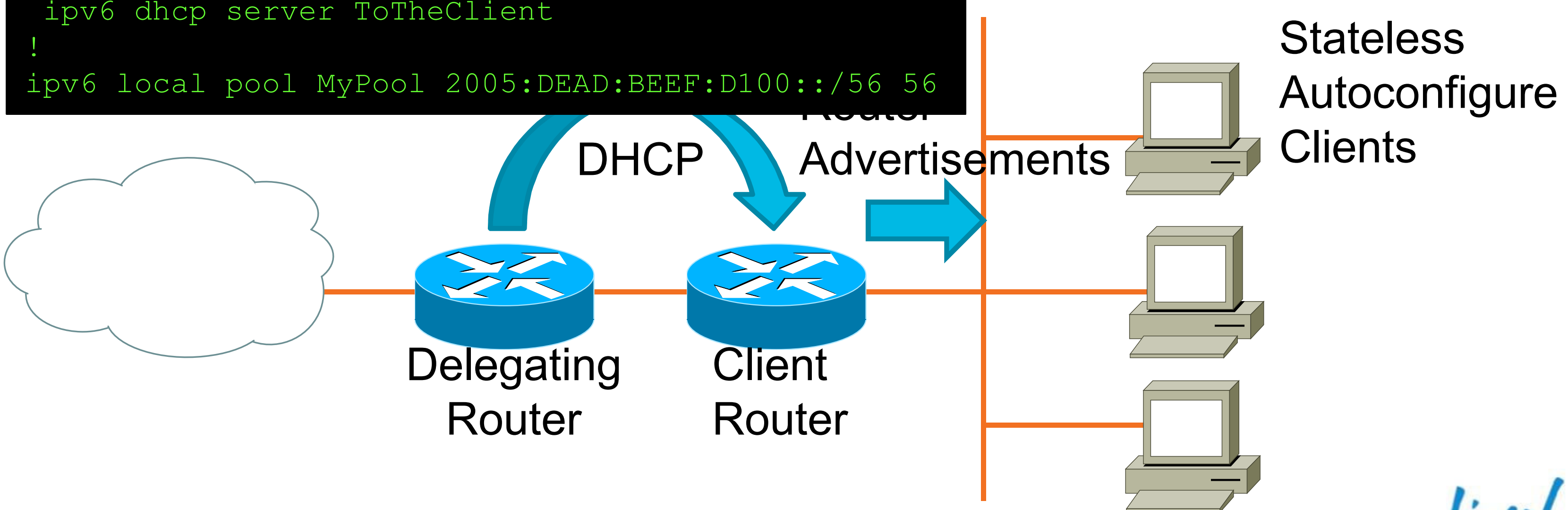
# IPv6 Addressing and Different Addressing Types - DHCPv6 Delegation

- Configure the delegating router
  - Configure a pool of prefixes
  - Enable DHCPv6 on the Client router facing interface



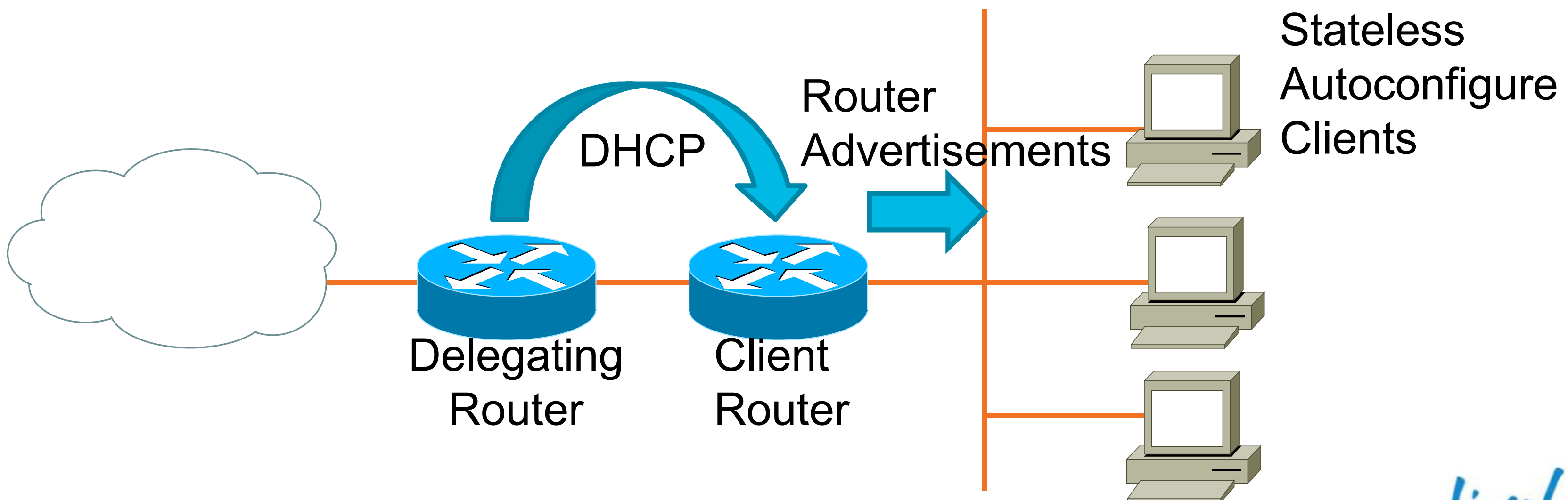
# IPv6 Addressing and Different Addressing Types - DHCPv6 Delegation

```
ipv6 dhcp pool ToTheClient
 prefix-delegation pool MyPool
!
interface GigabitEthernet0/1
 ipv6 address 2005:DEAD:BEEF:C100::1/64
 ipv6 dhcp server ToTheClient
!
ipv6 local pool MyPool 2005:DEAD:BEEF:D100::/56 56
```



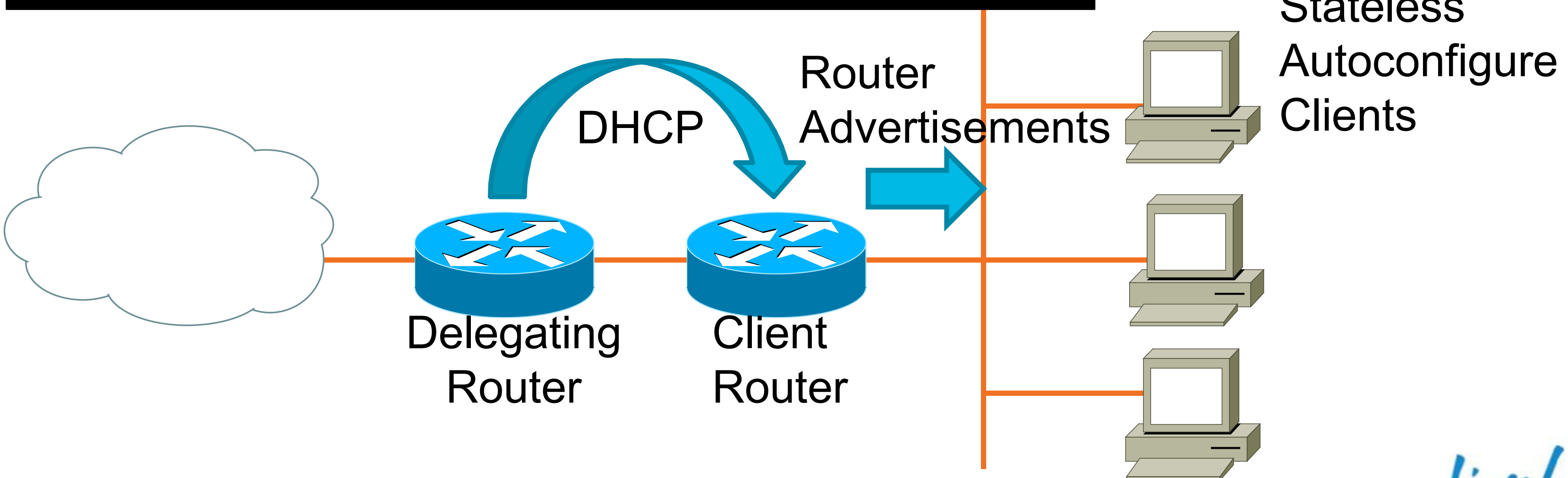
# IPv6 Addressing and Different Addressing Types - DHCPv6 Delegation

- Configure the Client router
  - Interface facing Delegating router is set as DHCP client
  - Host facing interface is rending IPv6 Router Advertisement messages



# IPv6 Addressing and Different Addressing Types - DHCPv6 Delegation

```
interface GigabitEthernet0/0
 ipv6 address 2005:DEAD:BEEF:C100::2/64
 ipv6 dhcp client pd ToTheHost
!
interface GigabitEthernet0/1
 ipv6 address ToTheHost ::1:0:0:0:1/64
```



# IPv6 Addressing and Different Addressing Types - Address Assignments – Autoconfigure

- Stateless Address Autoconfigure (SLAAC)
  - Uses ICMPv6 router discovery
  - Router reports back with prefix(s) for the link and default router

    Options:

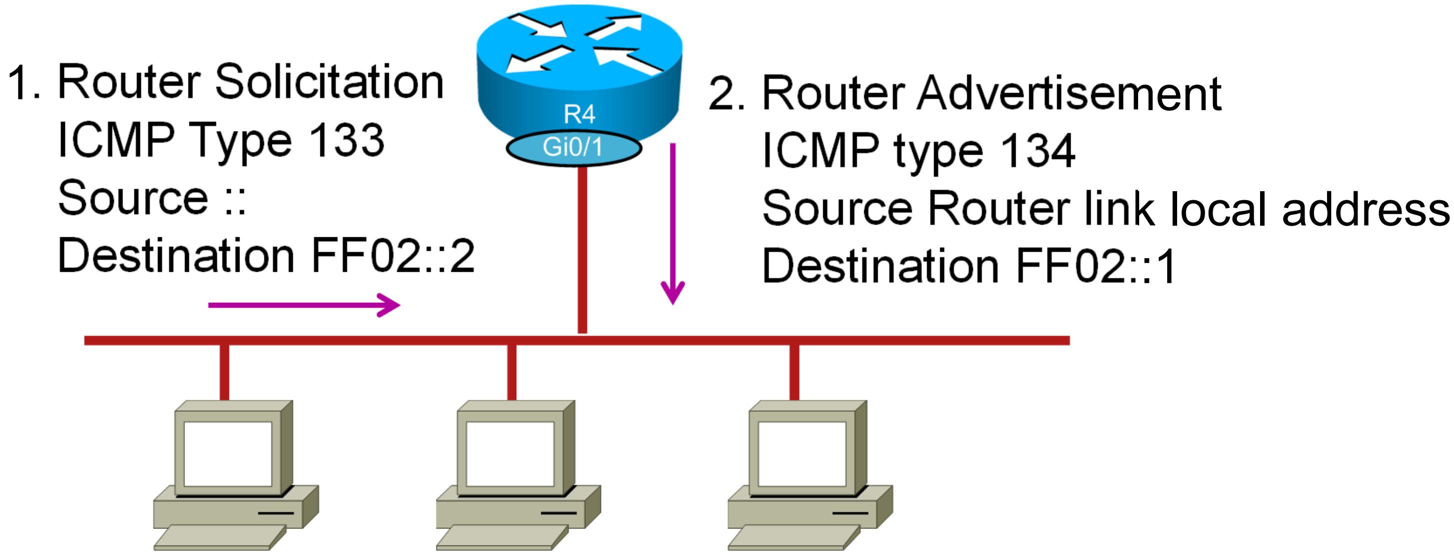
      Lifetime of advertisement

    MTU

    Prefix Length

    Router Priority
  - Host completes IPv6 address with either a preconfigured host portion, use Privacy Extensions or with the IEEE EUI-64 process

# IPv6 Addressing and Different Addressing Types - Address Assignments – Autoconfigure




- Router solicitations are sent by nodes to request router advertisements so to configure their interface

# IPv6 Addressing and Different Addressing Types – IPv4 Compatible

- IPv4-compatible addresses are derived from IPv4 addresses
- This provides a method for connecting IPv6 hosts or sites over the existing IPv4 infrastructure
- IPv6 traffic, when used with IPv4-compatible addresses, does not require the addition of IPv6 routers…Its traffic is encapsulated with an IPv4 header.
- IPv4-compatable Tunnel!
  – We'll get back to this
- ::192.168.14.1

# IPv6 Addressing and Different Addressing Types – IPv4 Verses IPv6

- IPv4
  - 127.0.0.1 (loopback)
  - 0.0.0.0 (undefined)
  - 169.254.0.0/16 (link local)
  - 0.0.0.0/0 (default)
  - 224.0.0.0/8 (link local multicast)
  - 224.0.0.1 (all local nodes)
  - 224.0.0.2 (all local routers)
  - 224.0.0.5 & 6 (OSPFv2)
  - 224.0.0.9 (RIPv2)
  - 224.0.0.10 (EIGRP)
- IPv6
  - ::1 (loopback)
  - :: (undefined)
  - FE80::/10 (link local)
  - ::/0 (default)
  - FF02::/16 (link local multicast)
  - FF02::1 (all local nodes)
  - FF02::2 (all local routers)
  - FF02::5 & 6 (OSPFv3)
  - FF02::9 (RIPng)
  - FF02::A (EIGRPv6)

# Agenda

- IP version 6 (IPv6) addressing and different addressing types
- **IPv6 neighbor discovery**
- Basic IPv6 functionality protocols
- Tunneling techniques
- IPv6 Unicast routing
- Filtering and route redistribution
- IPv6 Multicast
- IPv6 and 3560 switches
- IPv6 NAT protocol translation
- Troubleshooting IPv6
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- Q&A

# IPv6 Neighbor Discovery

- How do we find out the layer 2 address when we have an IPv4 address?
  – ARP
- How do we find out the layer 2 address when we have an IPv6 address?
  – Neighbor discovery
- Neighbor discovery handles the following:
  – Duplicate address detection (DAD)
  – Layer 2 addressing for neighbors
  – Finding neighbors on a link
- Neighbor discovery uses ICMPv6 messages, sent to multicast addresses

# IPv6 Neighbor Discovery

- ICMPv6 messages used for Neighbor discovery are:
  - Type 133: Router Solicitation
  - Type 134: Router Advertisement
  - Type 135: Neighbor Solicitation
  - Type 136: Neighbor Advertisement
  - Type 137: Redirect Message

# IPv6 Neighbor Discovery

- IPv6 Address we are looking for:

| Prefix | Interface ID | Lower 24 bits |
|---|---|---|

- Solicited-Node Multicast Address:

| FF02 | 0 | 0001 | FF | Lower 24 bits |
|---|---|---|---|---|

- Solicited-node address is a link local multicast that has the target node’s least significant 24 bits within it

# IPv6 Neighbor Discovery

- IPv6 Address we are looking for:

| | | |
|---|---|---|
| 2005:DEAD:BEEF:00A1: | 02DD:01FF:FE | 00:0DB8 |

- Solicited-Node Multicast Address:

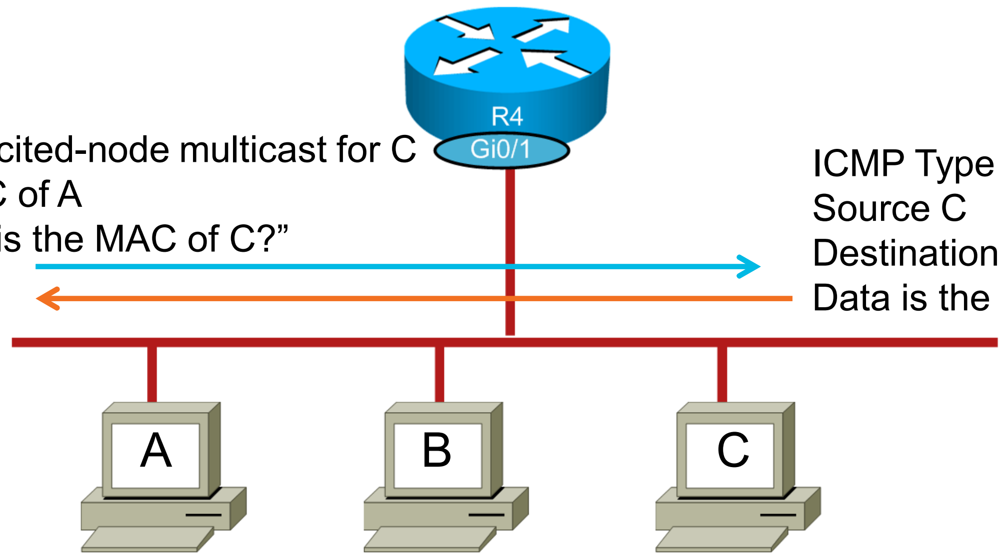
| | | | | |
|---|---|---|---|---|
| FF02 | 0 | 0001 | FF | 00 0DB8 |

- The conversion of layer 3 multicast to layer 2 is to take the last 32 bits of the IPv6 address and prepend 33 33

| | | | | | |
|---|---|---|---|---|---|
| 33 | 33 | FF | 00 | 0D | B8 |

# IPv6 Neighbor Discovery

ICMP Type 135
Source A
Destination Solicited-node multicast for C
Data is the MAC of A
Query is “What is the MAC of C?”




ICMP Type 136
Source C
Destination A
Data is the MAC of C

# IPv6 Neighbor Discovery

- Neighbor Advertisement message:
  – R flag indicates sender is a router
  – S flag is the solicited flag, this is a response to a neighbor solicitation
  – O flag is the override flag and indicates this advertisement should override existing neighbor cache

# Agenda

- IP version 6 (IPv6) addressing and different addressing types
- IPv6 neighbor discovery
- **Basic IPv6 functionality protocols**
- Tunneling techniques
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# Basic IPv6 Functionality Protocols

- DHCP
- FHRP
  - HSRP
  - GLBP
- MTU Path Discovery
- SSH
- Telnet
- Ping
- Traceroute
- DNS

# ICMPv6

- ICMPv6 Error messages:
  - Type 1: Destination Unreachable
  - Type 2: Packet too Big
  - Type 3: Time Exceeded
    - Code 0: Hop Limit Exceeded
    - Code 1: Fragment Reassembly Time Exceeded
  - Type 4: Parameter Problem

# First Hop Redundancy Protocols

- First Hop Redundancy Protocols are used to provide gateway redundancy
- IPv4 has: HSRP (v1 and v2), GLBP, VRRP
- IPv6 has: HSRP and GLBP
  - HSRP for IPv6 must run version 2
- HSRP has one active forwarding device per group
- GLBP has up to four active forwarding devices per group

# FHRP – HSRP

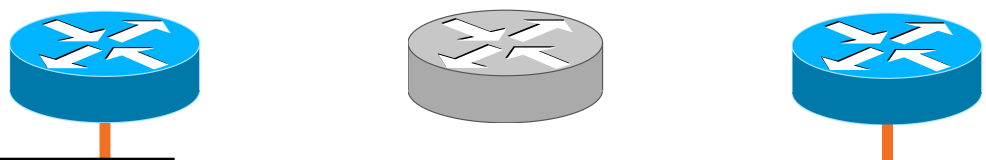
- HSRP version 6 for IPv6
  - This version uses link-local addresses
  - Multicast router announcement messages are transmitted to hosts in the subnet with a virtual link-local address for the default router
- Virtual MAC is derived from the HSRP group
- Virtual link-local address is derived from the virtual HSRP MAC address
- Periodic router announcement messages are sent with the HSRP virtual link-local address of the default router
- HSRP virtual MAC address range is:
  - 0005.73a0.0000 to 0005.73a0.0fff

# FHRP – HSRP

- Priority is a mechanism to control the election of active router within the HSRP group
  - Default is 100; higher is better
  - If priority is equal, then first router up or one with the highest IPv6 address wins
- Preemption can be used to guarantee the active router for a group
- The standby router monitors the status of the group
- HSRP can track objects to control priority (and therefore the active router)
  - Interfaces
  - Routes
  - IP SLA objects

# FHRP – HSRP

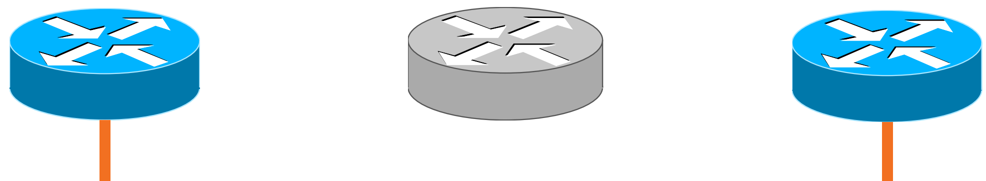
- HSRP group 66 is configured with the following parameters:
  - Automatic virtual IPv6 address
  - Priority
  - Preemption
  - Version



```
interface GigabitEthernet0/0
 ipv6 address 2005:DEAD:BEEF:C100::1/64
 standby version 2
 standby 66 ipv6 autoconfig
 standby 66 priority 110
 standby 66 preempt
```

```
interface GigabitEthernet0/0
 ipv6 address 2005:DEAD:BEEF:C100::2/64
 standby version 2
 standby 66 ipv6 autoconfig
 standby 66 priority 105
 standby 66 preempt
```

# FHRP – HSRP



```
R1# show standby
 GigabitEthernet0/0 - Group 66 (version 2)
   State is active
      2 state changes, last state change 2d23h
   Virtual IP address is FE80::5:73FF:FFA0:42
   Active virtual MAC address is 0005.73a0.0042
     Local virtual MAC address is 0005.73a0.0042 (v2 IPv6 default)
   Hello time 3 sec, hold time 10 sec
     Next hello sent in 1.543 secs
   Preemption enabled
   Active router is local
   Standby router is FE80::200:CFF:FEF6:52CD, priority 105 (expires in 10.464 sec)
   Priority 110 (configured 110)
   Group name is "hsrp-Gi0/1-66" (default)
```

# FHRP – GLBP

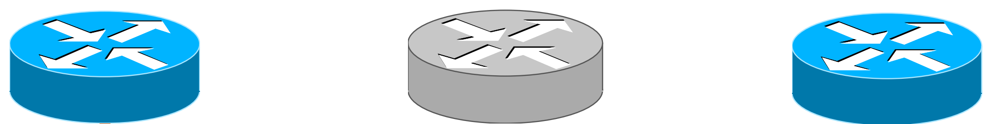
- Gateway Load Balancing Protocol allows for multiple active forwards per group
- You can have up to four active routers within a group (active virtual forwarders (AVF))
- One active virtual gateway (AVG) controls the group
- All routers share a virtual IPv6 address
- Each active forwarder has a unique virtual MAC address
- Same as IPv4

# FHRP – GLBP

- GLBP gateway priority
  - Controls the election of AVG and standby virtual gateway (SVG)
  - Preemption needs to be enable to control which router becomes AVG
    - Preemption is disabled by default
- GLBP gateway weight
  - Weight is used to elect AVF
  - Weight is set with an acceptable range
  - If weight drops below the range, the AVF stops forwarding packets
    - Think tacking
  - Preemption is enable by default

# FHRP – GLBP

- Basic GLBP group 66 is configured with the following parameters:
  - Automatic virtual IPv6 address
  - Priority and Preemption for AVG

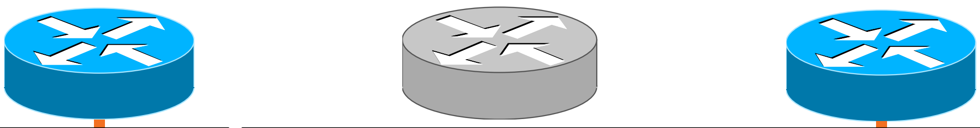


```
interface GigabitEthernet0/0
 ipv6 address 2005:DEAD:BEEF:C100::1/64
 glbp 66 ipv6 autoconfig
 glbp 66 priority 110
 glbp 66 preempt
 glbp 66 weighting 110 lower 95 upper 110
 glbp 66 weighting track 2 decrement 15
!
track 2 interface serial 0/0/0 line-protocol
```

```
interface GigabitEthernet0/0
 ipv6 address 2005:DEAD:BEEF:C100::2/64
 glbp 66 ipv6 autoconfig
 glbp 66 priority 105
 glbp 66 preempt
```

# FHRP – GLBP

- A bit more complex GLBP

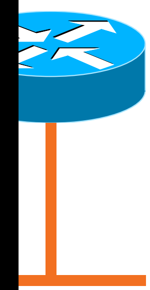


```
interface GigabitEthernet0/0
 ipv6 address 2005:DEAD:BEEF:C100::1/64
 glbp 66 ipv6 autoconfig
 glbp 66 priority 110
 glbp 66 preempt
 glbp 66 weighting 110 lower 95 upper 110
 glbp 66 weighting track 2 decrement 15
!
track 2 interface serial 0/0/0 line-protocol
```

```
interface GigabitEthernet0/0
 ipv6 address 2005:DEAD:BEEF:C100::2/64
 glbp 66 ipv6 autoconfig
 glbp 66 priority 105
 glbp 66 preempt
 glbp 66 weighting 110 lower 95 upper 110
 glbp 66 weighting track 2 decrement 15
!
track 2 interface serial 0/0/0 line-protocol
```

# FH

```
R1# show glbp
GigabitEthernet0/0 - Group 66
  State is Active
    2 state changes, last state change 23:50:33
  Virtual IP address is FE80::7:B4FF:FE04:200 (auto-configured)
  Hello time 5 sec, hold time 18 sec
    Next hello sent in 4.300 secs
  Redirect time 600 sec, forwarder time-out 7200 sec
  Preemption enabled, min delay 60 sec
  Active is local
  Standby is FE80::200:CFF:FEF6:52CD
  Priority 110 (configured)
  Weighting 115 (configured 110), thresholds: lower 95, upper 110
    Track object 2 state Up
  Load balancing: host-dependent
  There are 2 forwardera (1 active)
  Forwarder 1
    State is Active
      1 state change, last state change 23:50:15
    MAC address is 0007.b400.4201 (default)
    Owner ID is 0000.0cf6.52cd
    Redirection enabled
    Preemption enabled, min delay 60 sec
    Active is local, weighting 110
... omitted ...
```



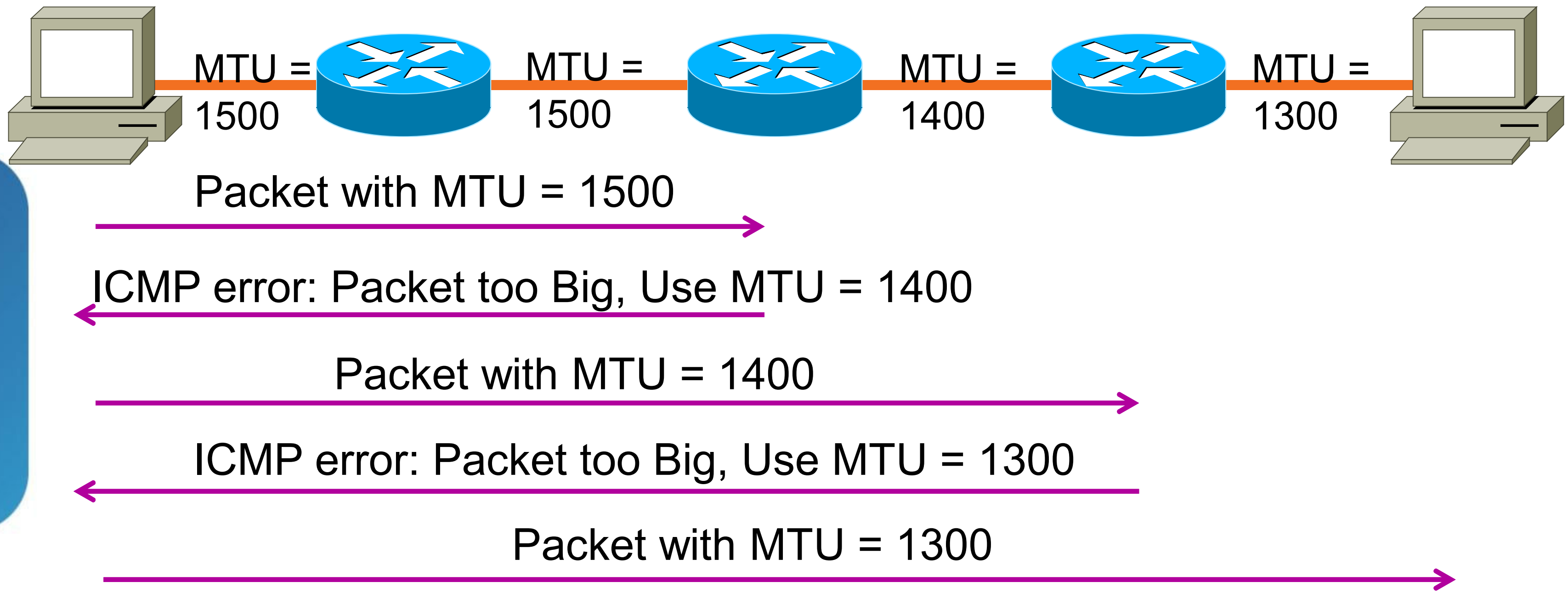
# Basic IPv6 Functionality Protocols

- DHCP
- FHRP
  - HSRP
  - GLBP
- MTU Path Discovery
- SSH
- Telnet
- Ping
- Traceroute
- DNS

# Path MTU Discovery

- Fragmentation is not done by routers (unless they originate the packet), it's done by end devices
- Minimum assumed MTU for IPv6 is 1280 bytes (IPv4 is 68, 576 minimum that can be processed at host)
- Routers send Packet too big message to the sender if the packet is too large
  – ICMPv6 Type 2

# Path MTU Discovery



# Basic IPv6 Functionality Protocols

- DHCP
- FHRP
  - HSRP
  - GLBP
- MTU Path Discovery
- SSH
- Telnet
- Ping
- Traceroute
- DNS

# Basic IPv6 Functionality Protocols

- SSH
  - ssh –l cisco:2005:dead:beef:c100::1
- Telnet
  - telnet 2005:dead:beef:c100::1
- Ping
  - Ping 2005:dead:beef:c100::1
- Traceroute
  - Traceroute 2005:dead:beef:c100::1

ipv6 host Router1 2005:dead:beef:c100::1

# Basic IPv6 Functionality Protocols

- DHCP
- FHRP
  - HSRP
  - GLBP
- MTU Path Discovery
- SSH
- Telnet
- Ping
- Traceroute
- DNS

# Domain Name System

- DNS had to be modified to support the larger address space
  - AAAA for 128 bit address
  - PTR records are for reverse lookups, which is also for IPv4, but uses a new nibble format
  - Current recommendation is to not to automatically generate the PTR database as done with IPv4 to save on memory

# Basic IPv6 functionality protocols

- DHCP
- FHRP
  - HSRP
  - GLBP
- MTU Path Discovery
- SSH
- Telnet
- Ping
- Traceroute
- DNS

# Agenda

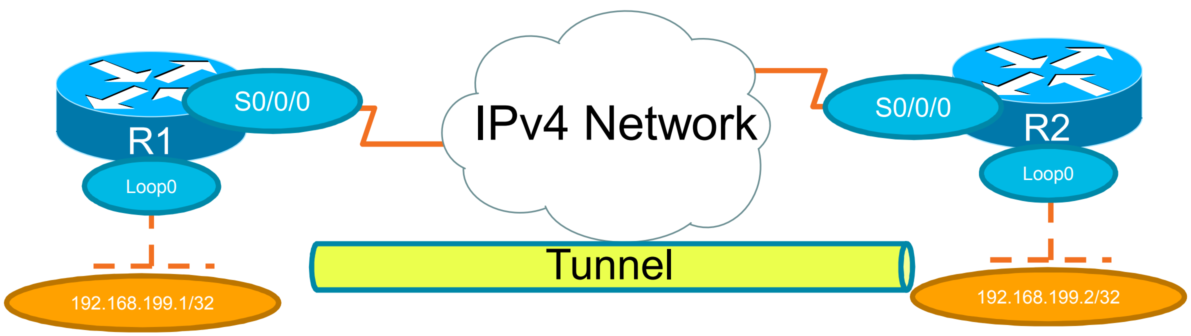
- IP version 6 (IPv6) addressing and different addressing types
- IPv6 neighbor discovery
- Basic IPv6 functionality protocols
- **Tunneling techniques**
- IPv6 Unicast routing
- Filtering and route redistribution
- IPv6 Multicast
- IPv6 and 3560 switches
- IPv6 NAT protocol translation
- Troubleshooting IPv6
- CCIE R&S
- Q&A

# Tunneling Techniques

- IPv4 Compatible tunnel
- 6to4 tunnel
- ISATAP (Intra-Site Automatic Tunnel Addressing Protocol) tunnel
- Teredo
- IPv6 Rapid Deployment (6RD)

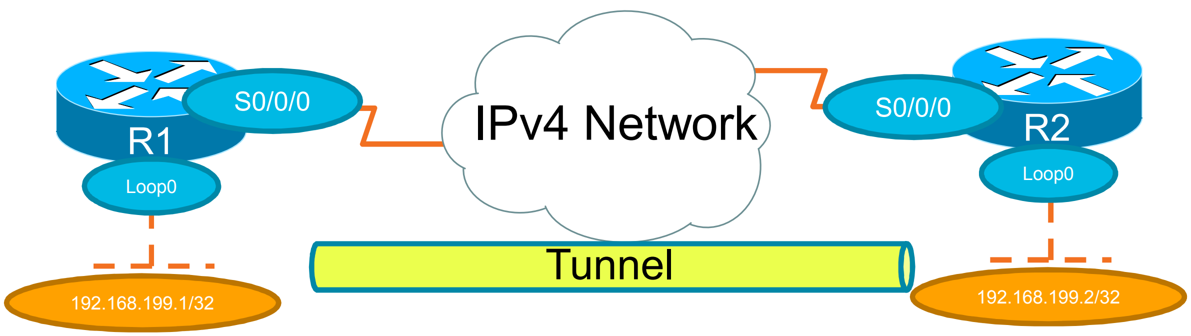
# Tunneling Techniques – IPv4 Compatible Tunnel

- To connecting IPv6 hosts or sites over the existing IPv4 infrastructure
- The addressing for tunnel destination is derived from the lower order 32 bits of the IPv4-compatable address
  – Assuming IPv4 reachability



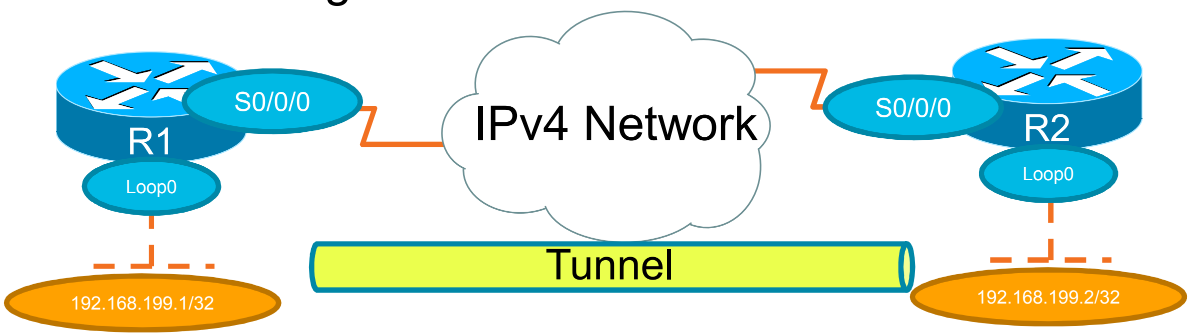
# Tunneling Techniques – IPv4 Compatible Tunnel

```
interface loopback 0
 ip address 192.168.199.1 255.255.255.255
!
interface tunnel 0
 tunnel source loopback 0
 tunnel mode ipv6ip auto-tunnel
!
ipv6 route ::/0 ::192.168.199.2
```



# Tunneling Techniques – 6to4 Tunnel

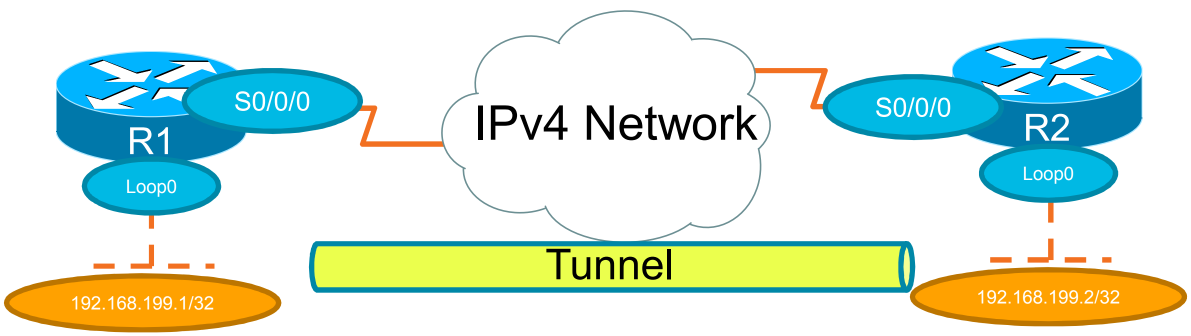
- 6to4 tunnels embeds the IPv4 address as part of the IPv6 address for the tunnel interface
- 6to4 tunnel address must start with 2002 for it's prefix
  - The next 32 bits of the IPv6 address is the IPv4 address in hex
- 6to4 tunnels are considered point to multipoint dynamic tunnels
- There is no defined destination within the tunnel, it's defined with neighbor statements or through static routes.



# Tunneling Techniques – 6to4 Tunnel

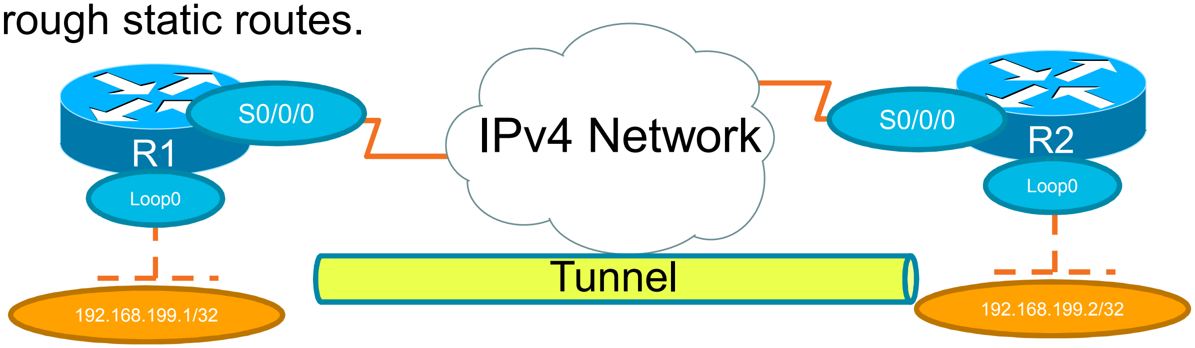
```
interface loopback 0
 ip address 192.168.199.1 255.255.255.255
!
interface tunnel 0
 ipv6 address 2002:C0A8:C701::/48
 tunnel source loopback 0
 tunnel mode ipv6ip 6to4
!
ipv6 route 2002::/16 tunnel 0
ipv6 route ::/0 2002:C0A8:C702::
```

192 = 0xC0
168 = 0xA8
199 = 0xC7
1 = 0x01



# Tunneling Techniques – ISATAP Tunnel

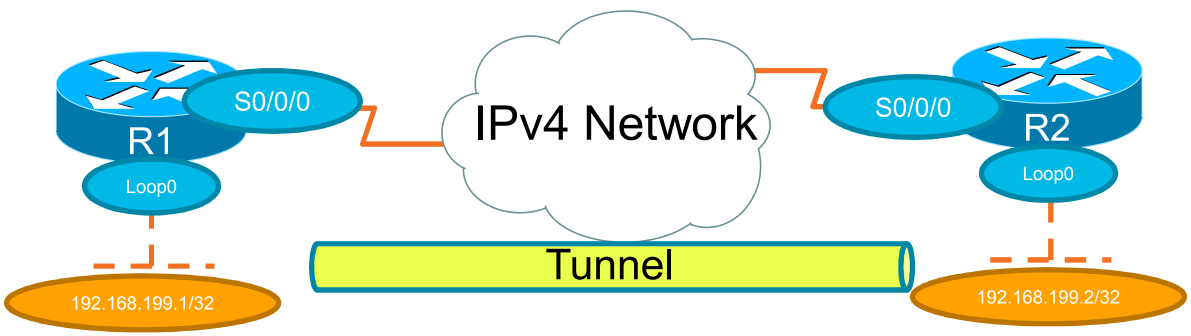
- Like 6to4 tunnels, ISATAP (Intra-Site Automatic Tunnel Addressing Protocol) embeds the IPv4 address as part of the IPv6 address for the tunnel interface
- The prefix can be any assigned /64 prefix
- The last 64 bits are made up of 0000:5EFE and then the IPv4 address in hex
  - If you use EUI-64 with your IPv6 address, the router will configure your last 64 bits for you
- ISATAP tunnels are considered point to multipoint dynamic tunnels
- There is no defined destination within the tunnel, it's defined with neighbor statements or through static routes.



# Tunneling Techniques – ISATAP Tunnel

```
interface loopback 0
 ip address 192.168.199.1 255.255.255.255
!
interface tunnel 0
 ipv6 address 2005:DEAD:BEEF:0:5EFE:C0A8:C701/64
 ipv6 address FE80::5EFE:C0A8:C701 link-local
 tunnel source loopback 0
 tunnel mode ipv6ip ISATAP
!
ipv6 route ::/0 2005:DEAD:BEEF:0:5EFE:C0A8:C702
```

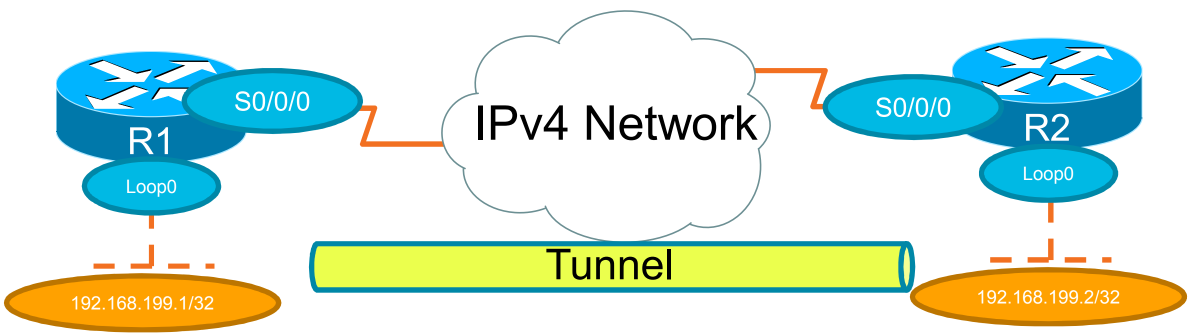
192 = 0xC0
168 = 0xA8
199 = 0xC7
1 = 0x01



# Tunneling Techniques – ISATAP Tunnel

```
interface loopback 0
 ip address 192.168.199.1 255.255.255.255
!
interface tunnel 0
 ipv6 address 2005:DEAD:BEEF::/64 EUI-64
 tunnel source loopback 0
 tunnel mode ipv6ip ISATAP
!
ipv6 route ::/0 2005:DEAD:BEEF:0:5EFE:C0A8:C702
```

| | |
|---|---|
| 192 | = 0xC0 |
| 168 | = 0xA8 |
| 199 | = 0xC7 |
| 1 | = 0x01 |



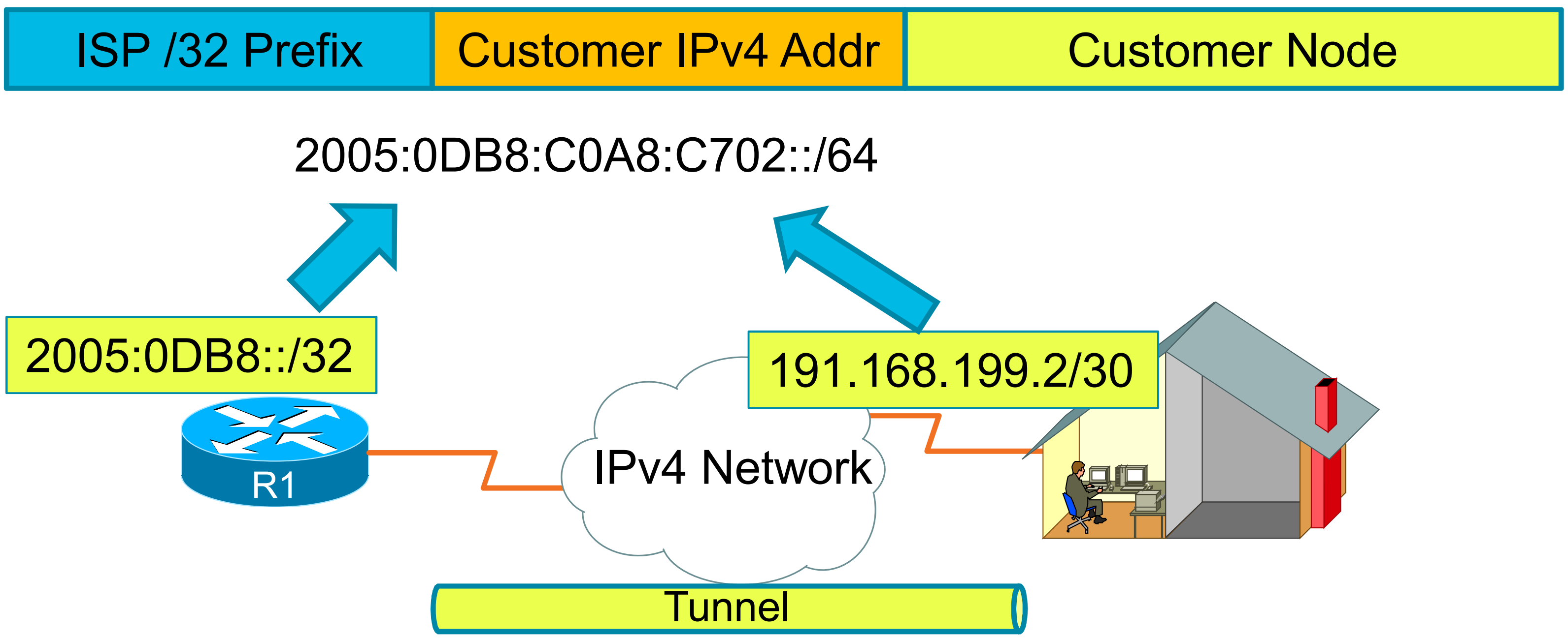
# Tunneling Techniques – Teredo

- **Teredo** is a transition technology that gives IPv6 connectivity across a IPv4
- Teredo operates using a platform independent tunneling protocol encapsulating IPv6 packets within IPv4 User Datagram Protocol (UDP) packets.
- These packets can be routed through an IPv4 network and through NAT devices.

# Tunneling Techniques – 6RD

- IPv6 Rapid Deployment (6RD)
  - Designed to speed up the process to extend IPv6 across the first and last mile
  - Modified 6to4 tunnel
  - Have to have the core setup to support IPv6
  - Intended for ISP to support SOHO customers
  - ISP must have /32 address space to feed from
  - Client has to be configured with the 6RD endpoint (IPv4 address)
  - Client then does a modified SLAAC
    - Gets the /32 from the ISP
    - Next 32 bits is the client's IPv4 address in hex
    - Fills in the last 64 bit normally

# Tunneling Techniques – 6RD



# Agenda

- IP version 6 (IPv6) addressing and different addressing types
- IPv6 neighbor discovery
- Basic IPv6 functionality protocols
- Tunneling techniques
- **IPv6 Unicast routing**
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# IPv6 Unicast Routing

- Static
- RIPng
- OSPF version 3 (OSPFv3)
- EIGRP version 6 (EIGRPv6)
- BGP
- PBR

What about IS-IS? Yes, but it's not on the blueprint, therefore it does not exist!

# IPv6 Unicast Routing – Static

- Directly attached Static Routes

```
ipv6 route 2005:DEAD:BEEF:A100::/64 GigabitEthernet0/1
```

- Recursive Static Routes

```
ipv6 route 2005:DEAD:BEEF:A100::/64 2005:DEAD:BEEF:C100::1
```

- Fully Specific Static Routes

```
ipv6 route 2005:DEAD:BEEF:A100::/64 GigabitEthernet0/1 2005:DEAD:BEEF:C100::1
```

- Floating Static Routes

```
ipv6 route 2005:DEAD:BEEF:A100::/64 2005:DEAD:BEEF:C100::1 130
```

# IPv6 Unicast Routing – RIPng

- RIPng (next generation) for IPv6
  - Detailed in RFC 2080
  - Based on RIPv2, but not interchangeable
  - 15 hop limit
  - Split horizon
  - Same timers, minus the hold down (180 sec flush rather than 240 sec)
  - Runs UDP port 521 on top of IPv6
  - Multicast updates on FF02::9
  - No network command, interface level
  - Named, can have up to four instances per router
  - UP to 64 ECMP (default is 4)

# IPv6 Unicast Routing – RIPng

- RIPv6 has to be enabled per interface

```
R1(config-if)# ipv6 rip name enable
```

- The name has local significance only. It is a process identifier
- Global options for the RIP process like redistribution, timers, etc. can be configured under the RIP routing process

```
R1(config)# ipv6 router rip name
R1(config-rtr)#
```

- Default is generated at the interface

```
R1(config-if)# ipv6 rip name default-information originate
```

# IPv6 Unicast Routing – RIPng

```
ipv6 unicast-routing
!
interface Loopback0
 ipv6 address 2005:DEAD:BEEF:2::2/64
 ipv6 rip MyRip enable
!
interface GigabitEthernet0/1
 ipv6 address 2005:DEAD:BEEF:C001::1/64
 ipv6 rip MyRip enable
!
ipv6 router rip MyRip
```

# IPv6 Unicast Routing – RIPng

- What if they ask you to change the destination address of UDP port number for RIPng

```
ipv6 router rip MyRip
 port 3521 multicast-group ff02::521
```

# IPv6 Unicast Routing – OSPFv3

- OSPF for IPv6
- Based on OSPFv2, with enhancements
  - Multi-area with Area 0 as backbone
  - Stub and NSSA
  - Summarization on the area border routers
  - Basic packet types (Hello, DBD, LSR, LSU, LSA)
  - Mechanisms for neighbor discovery and adjacency formation
  - Interface types (P2P, P2MP, Broadcast, NBMA, Virtual links)
  - LSA flooding and aging
  - Nearly identical LSA types
  - Router ID is still 32 bit number, written in four octets

# IPv6 Unicast Routing – OSPFv3

- Distributes IPv6 prefixes using Type Length Value (TLV) fields
- Runs directly over IPv6
- Ships-in-the-night with OSPFv2
- Adjacencies and next-hop use link-local addresses
  – except for virtual links
- Enabled at the interface, no network (and no wildcard masks)
- LSA has flooding scope
  – Link-local
  – Area
  – Autonomous system
- Uses link-local multicast
  – FF02::5 – All OSPF Routers
  – FF02::6 – All OSPF designated routers

# IPv6 Unicast Routing – OSPFv3

- Two LSA’s have been renamed:
  – Type 3 LSA is now Interarea Prefix LSA
  – Type 4 LSA is now Interarea Router LSA
- Two new LSAs have been added
  – Type 8 LSA is now Link LSA
  – Type 9 LSA is now Intra-Area Prefix LSA

# IPv6 Unicast Routing – OSPFv3

- OSPFv3 has to be enabled per interface

```
R1(config-if)# ipv6 ospf <process-id> area <area>
```

- Global options for the OSPFv3 process can be configured under the OSPFv3 routing process

```
R1(config)# ipv6 router ospf <process-id>
R1(config-rtr)# router-id ?
  A.B.C.D  OSPF router-id in IP address format
```

- When no IPv4 addresses are available you must configure a router-id manually

# Cisco IOS OSPFv3 Specific Attributes

- Configuring area range

```
R1(config-router)#[no] area <area ID> range <prefix>/<prefix length>
```

- Auto summary at the ABR

```
R1(config-router)#[no] area {ipv6-prefix/prefix length} [cost cost]
```

- Configuring summary addresses for external routes

```
R1(config-router)#[no] summary-address <prefix>/<prefix length>
```

- Static neighbor configuration

```
R1(config-if)#[no] ipv6 ospf neighbor ipv6-link-local-address [priority]
[poll-interval seconds] [cost cost] [database-filter all out]
```

# IPv6 Unicast Routing – OSPFv3 Authentication

- Authentication and encryption are used to secure routing updates and prevent attacks
- OSPFv3 uses IPv6's built in security
  - IPsec AH for authentication
  - IPsec ESP for encryption of payload
- Security policy definition on the router is required
  - Key
  - Security parameter index (SPI) value

# IPv6 Unicast Routing – OSPFv3 Authentication

- Configuring authentication between routers

```
R1(config-if)#ipv6 ospf authentication ipsec spi spi md5 key
```

- Authentication at the area level

```
R1(config-router)#area area-id authentication ipsec spi spi md5 key
```

- To configure encryption on an interface between routers

```
R1(config-if)#ipv6 ospf encryption {ipsec spi spi esp encryptin-
algorithm [[key-encryption-type] key] authentication-algorithm
[[key-encryption-type] key]}
```

- Encryption at the area level

```
R1(config-router)#area area-id encryption {ipsec spi spi esp
encryptin-algorithm [[key-encryption-type] key] authentication-
algorithm [[key-encryption-type] key]}
```

# IPv6 Unicast Routing – OSPFv3 Authentication

```
ipv6 unicast-routing
!
interface Loopback0
 ipv6 address 2005:DEAD:BEEF:2::2/64
 ipv6 ospf 1 area 0
!
interface GigabitEthernet0/1
 ipv6 address 2005:DEAD:BEEF:C001::1/64
 ipv6 ospf 1 area 0
!
ipv6 router ospf 1
 router-id 1.1.1.1
```

# IPv6 Unicast Routing – EIGRPv6

- Advanced distance vector protocol
- EIGRP is an integrated routing protocol
  - IPv4
  - IPv6
  - IPX
  - Appletalk
- Supports IPv6 as a separate routing context
- Dynamic or static neighbor discovery
- Built in reliability
- Incremental updates
- Protocol-dependent modules

# IPv6 Unicast Routing – EIGRPv6

- Defusing Update Algorithm (DUAL)
- Three sets of protocol specific tables:
  - Neighbor
  - Topology
  - Routing
- Composite metric:
  - Bandwidth + delay (by default)
    - Slowest link in the path is used (BW = 2.56Tb/slowest link BW)
    - Cumulative delay (delay = 256 * all interface delays in path in 10s microseconds)
- No network commands, interface level configuration

# IPv6 Unicast Routing – EIGRPv6

- Create the EIGRPv6 routing process

```
R1(config)# ipv6 router eigrp as-number
```

- You have to enable the process

```
R1(config-rtr)# no shutdown
```

- To advertise a default route

```
R1(config-rtr)# default-information originate [route-map route-map]
```

- To change the maximum paths for the routing table

```
R1(config-rtr)# maximum-paths number
```

# IPv6 Unicast Routing – EIGRPv6

- Enable EIGRPv6 at the interface

```
R1(config-if)# ipv6 eigrp as-number
```

- To configure a summary

```
R1(config-if)# ipv6 summary-address eigrp as-number prefix/mask [AD]
```

- To disable split horizon

```
R1(config-if)# no ipv6 split-horizon eigrp as-number
```

- To change the bandwidth percentage for EIGRP

```
R1(config-rif)# ipv6 bandwidth-percent eigrp as-number percent
```

  

# IPv6 Unicast Routing – EIGRPv6

- Multi-Protocol BGP for IPv6 (et al)
- Defined in RFC 2545
- Uses new Address Family in BGP
  - NEXT_HOP and NLRI are expressed as IPv6 addresses and prefix.
  - Address Family Information (AFI) = 2 (IPv6)
- Underlying Protocol can be either IPv6 or IPv4
  - Uses TCP Port 179
- Attributes and Route Selection are similar to BGP for IPv4

# IPv6 Unicast Routing – BGP

- Configure peerings using IPv6 (or IPv4)

```
R1(config)# router bgp 1
R1(config-router)# neighbor 2005:DEAD:BEEF:C001::2 remote-as 2
```

- And activate them for IPv6

```
R1(config-router)# address-family ipv6
R1(config-router-af)# 2005:DEAD:BEEF:C001::2 activate
```

- Then configure the prefixes you want to advertise under the IPv6 address-family

```
R1(config-router)# address-family ipv6
R1(config-router-af)# network 2005:DEAD:BEEF:A100::/64
```

# IPv6 Unicast Routing – BGP

```
router bgp 1
 no synchronization
 bgp router-id 1.1.1.1
 bgp log-neighbor-changes
 neighbor remote-as 1
 neighbor 2005:DEAD:BEEF:2::2 update-source Loopback0
 no neighbor 2005:DEAD:BEEF:2::2 activate
 neighbor 2005:DEAD:BEEF:C001::2 remote-as 2
 no neighbor 2005:DEAD:BEEF:C001::2 activate
 no auto-summary
 !
 address-family ipv6
 neighbor 2005:DEAD:BEEF:2::2 activate
 neighbor 2005:DEAD:BEEF:C001::2 activate
 network 2005:DEAD:BEEF:C001::/64
 exit-address-family
```

# IPv6 Unicast Routing – BGP

```
interface FastEthernet0/0
 ip address 180.40.7.66 255.255.255.224
!
interface Tunnel0
 no ip address
 no ip redirects
 ipv6 address 2002:B428:742::/64
 tunnel source FastEthernet0/0
 tunnel mode ipv6ip 6to4
!
ipv6 route 2002::/16 Tunnel0

router bgp 100
 neighbor 2002:b428:701:: remote-as 200
 neighbor 2002:b428:701 :: ebgp-multihop 2
```

# IPv6 Unicast Routing – Policy Based Routing

- PBRv6 has the same basic functionality as PBR for IPv4.
- Create a route map
- Match conditions
  - Access-list
  - Prefix list
  - Ingress interface
  - Size
- Set conditions
  - Next hop address
  - Egress interface
  - IPv6 precedence

# IPv6 Unicast Routing – Policy Based Routing

```
interface GigabitEthernet1/1
ipv6 policy route-map V6PBR
!
route-map V6PBR permit 10
match ipv6 address ThroughR1
set ipv6 next-hop FE80::20F:90FF:FEFB:12A0
!
route-map V6PBR permit 20
match ipv6 address ThroughR3
set ipv6 next-hop FE80::21C:F6FF:FE85:260
!
route-map V6PBR permit 30
set ipv6 next-hop FE80::21C:F6FF:FE85:260 FE80::20F:90FF:FEFB:12A0
!
ipv6 access-list ThroughR1
permit ipv6 2001:213:112:31::/64 any
!
ipv6 access-list ThroughR3
permit ipv6 2001:212:104:11::/64 any
```

# Agenda

- IP version 6 (IPv6) addressing and different addressing types
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# Filtering and Route Redistribution

- IPv6 access lists
- IPv6 prefix lists
- Route maps
- Redistribution issues

# IPv6 Access Lists

- All IPv6 ACLs are:
  - Named
  - Extended
- Very similar to IPv4 named ACL
- Implicit deny all at the end of the ACL is not really a deny all
  - ICMPv6 for neighbor discovery is still enabled, even if not explicitly stated
- No wildcard masks
- IPv6 access lists are sequenced:
  - Individual entries can be added and removed
  - ACLs cannot be resequenced

# IPv6 Access Lists

- IPv6 ACLs can also filter on some of the additional header fields or some of the extended headers:
  - DSCP value
  - Flow label value
  - Fragmentation header (if it is present)
  - Routing header (if it is present and type)
  - Mobility header (if it is present and type)
  - Destination option header (if it is present and type)
  - Authentication header (if it is present)

# IPv6 Access Lists

- To get into the access list configuration
  - **ipv6access-list** *access-list-name*
- Then the match conditions:
  - **permit** *protocol* {*source-ipv6-prefixlprefix-length* | **any** | **host** *source-ipv6-address* | **auth**} [*operator* [*port-number*] ] {*destination-ipv6-prefixlprefix-length* | **any** | **host** *destination-ipv6-address* | **auth**} [*operator* [*port-number*] ] [**dest-option-type** [*doh-number* | *doh-type*]] [**dscp** *value*] [**flow-label** *value*] [**fragments**] [**hbh**] [**log**] [**log-input**] [**mobility**] [**mobility-type** [*mh-number* | *mh-type*]] [**reflect** *name* [**timeout** *value*]] [**routing**] [**routing-type** *routing-number*] [**sequence** *value*] [**time-range** *name*]

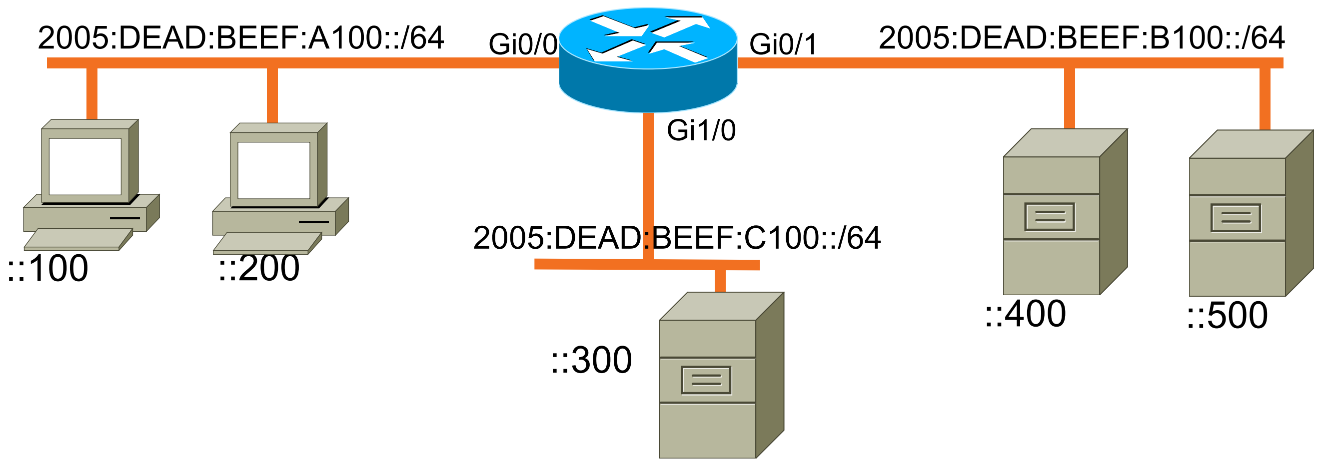
# IPv6 Access Lists

- For ICMP
  - **permit icmp** {*source-ipv6-prefix*/*prefix-length* | **any** | **host** *source-ipv6-address* | **auth**} [*operator* [*port-number*] ] {*destination-ipv6-prefix*/*prefix-length* | **any** | **host** *destination-ipv6-address* | **auth**} [*operator* [*port-number*] ] [*icmp-type* [*icmp-code*] | *icmp-message*] [**dest-option-type** [*doh-number* | *doh-type*]] [**dscp** *value*] [**flow-label** *value*] [**fragments**] [**hbh**] [**log**] [**log-input**] [**mobility**] [**mobility-type** [*mh-number* | *mh-type*]] [**routing**] [**routing-type** *routing-number*] [**sequence** *value*] [**time-range** *name*]
- TCP
  - **permit tcp** {*source-ipv6-prefix*/*prefix-length* | **any** | **host** *source-ipv6-address* | **auth**} [*operator* [*port-number*] ] {*destination-ipv6-prefix*/*prefix-length* | **any** | **host** *destination-ipv6-address* | **auth**} [*operator* [*port-number*] ] [**ack**] [**dest-option-type** [*doh-number* | *doh-type*]] [**dscp** *value*] [**established**] [**fin**] [**flow-label** *value*] [**fragments**] [**hbh**] [**log**] [**log-input**] [**mobility**] [**mobility-type** [*mh-number* | *mh-type*]] [**neq** {*port* | *protocol*}] [**psh**] [**range** {*port* | *protocol*}] [**reflect** *name* [**timeout** *value*]] [**routing**] [**routing-type** *routing-number*] [**rst**] [**sequence** *value*] [**syn**] [**time-range** *name*] [**urg**]

# IPv6 Access Lists

- And UDP
  - **permit udp** {*source-ipv6-prefix*/*prefix-length* | **any** | **host** *source-ipv6-address* | **auth**} [*operator* [*port-number*] ] {*destination-ipv6-prefix*/*prefix-length* | **any** | **host** *destination-ipv6-address* | **auth**} [*operator* [*port-number*] ] [**dest-option-type** [*doh-number* | *doh-type*]] [**dscp** *value*] [**flow-label** *value*] [**fragments**] [**hbh**] [**log**] [**log-input**] [**mobility**] [**mobility-type** [*mh-number* | *mh-type*]] [**neq** {*port* | *protocol*}] [**range** {*port* | *protocol*}] [**reflect** *name* [**timeout** *value*]] [**routing**] [**routing-type** *routing-number*] [**sequence** *value*] [**time-range** *name*]

# IPv6 Access Lists

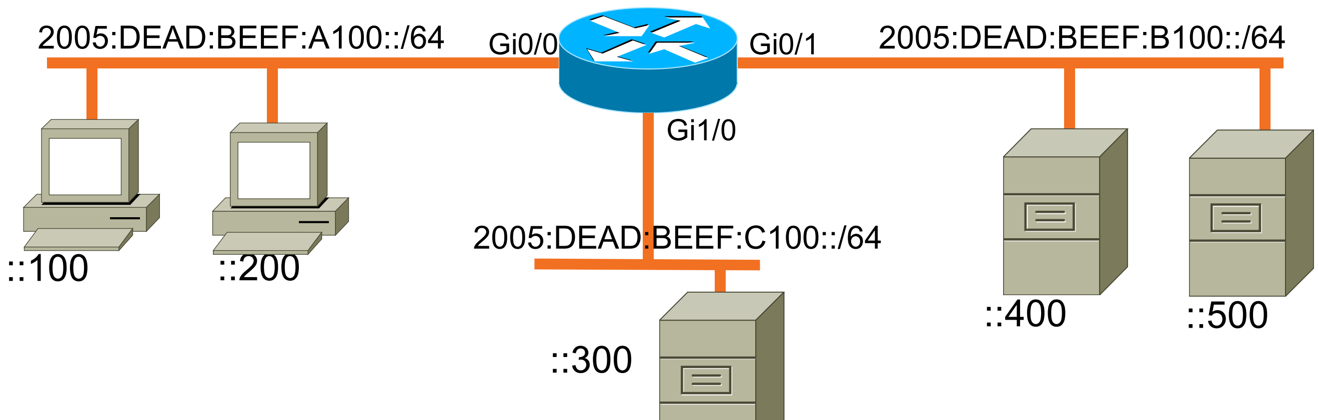



```
Ipv6 access-list MyWebList
 permit tcp 2005:dead:beef:a100::/64 host 2005:dead:beef:b100::400 eq 80
!
Interface GiabitEthernet0/0
 ipv6 traffic-filter MyWebList
```

# IPv6 Access Lists

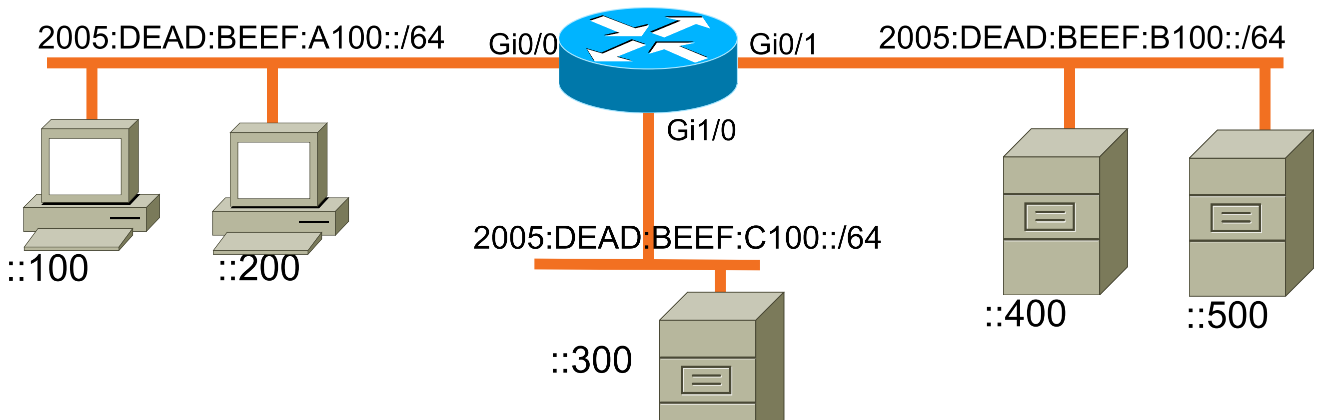
- Reflexive and Time based ACLs are the same as IPv4
- Reflexive ACLs provide access by, based on session initiation
  - Router tracks outbound traffic and automatically creates temporary reverse path rule
- Time based ACLs permit or deny traffic that are linked to a configured time range

# IPv6 Access Lists




```
Ipv6 access-list MyReflectOut
 permit tcp 2005:dead:beef:a100::/64 any eq 80 reflect ref-web
 permit udp 2005:dead:beef:a100::/64 any reflect ref-udp
!
Ipv6 access-list MyReflectIn
 evaluate ref-web
 evaluate ref-udp
!
Interface GiabitEthernet0/1
 ipv6 traffic-filter MyReflectOut out
 ipv6 traffic-filter MyReflectIn in
```

# IPv6 Access Lists




```
Ipv6 access-list MyTimeOut
 permit tcp 2005:dead:beef:a100::/64 any eq 80 time-range Lunch
 deny tcp 2005:dead:beef:a100::/64 any eq 80
 permit ipv6 any any
!
Interface GiabitEthernet0/1
 ipv6 traffic-filter MyTimeOut out
```

# IPv6 Prefix Lists

- IPv6 prefix list operate the same way as prefix list for IPv4 do
- Used for route filtering
- Distribute list for IPv6 can only call prefix list, no ACLs!

- **ipv6 prefix-list** *list-name* [**seq** *seq-number*] {**deny** *ipv6-prefix*/*prefix-length* | **permit** *ipv6-prefix*/*prefix-length* | **description** *text*} [**ge** *ge-value*] [**le** *le-value*]

# Configuring Prefix-Lists

- What will be matched by:
  A. ipv6 prefix-list A permit ::/0 ge 128
  B. ipv6 prefix-list B permit FEC0::/10 ge 11
  C. ipv6 prefix-list C permit ::/0 le 128
  D. ipv6 prefix-list D permit ::/0
  E. ipv6 prefix-list E permit xxxx:xxxx:xxxx:xxxx::/64

# Configuring Prefix-Lists

- What will be matched by:
  A. ipv6 prefix-list A permit ::/0 ge 128
  B. ipv6 prefix-list B permit FEC0::/10 ge 11
  C. ipv6 prefix-list C permit ::/0 le 128
  D. ipv6 prefix-list D permit ::/0
  E. ipv6 prefix-list E permit xxxx:xxxx:xxxx:xxxx::/64

**A. All host routes**
**B. Any site local address space**
**C. All routes**
**D. Just the default route**
**E. A specific prefix with a length of 64 bits**

# Route Maps

- Route maps can be your friend
  - They can be used for Policy based routing
  - Manipulation of attributes
  - Filtering

# Route-maps

- To act as a filter:
  - Match a deny statement

    Route-map MyMap deny 10

     match ipv6 prefix-list MyList

  - Match a permit statement with null

    Route-map MyMap permit 10

     match ipv6 prefix-list MyList

     set interface null0

  - No Match statement*

    Route-map MyMap permit 10

     match ipv6 prefix-list MyList

    Ipv6 prefix-list MyList permit 2005:dead:beef::/48 ge 64 le 64

* Does not work as a filter with PBR

# Redistribution

- Used when you have more than one protocol or static route or connected routes that you would like to inject into a protocol
- Remember, except for BGP, there are no network commands
- Redistribution will not include directly connected interfaces by default
- When redistributing into OSPFv3, metric type can be set
  – Type 2 is default

# Redistribution

- Redistribute connected
  - Only locally connected routes
  - Route maps can be used to control and manipulate attributes

```
R1(config-rtr)# redistribute connected [route-map route-map]
```

- When redistributing static, you can use a route-map to control and some protocols will let you set a tag without the route-map

```
R1(config-rtr)# redistribute static [route-map route-map] [tag tag]
```

- With RIP and EIGRP, you can redistribute with or without the connected interfaces

```
R1(config-rtr)# redistribute rip [include-connected][route-map route-map]
R1(config-rtr)# redistribute eigrp as-number [include-connected][route-map
route-map]
```

# Redistribution

- To redistribute OSPFv3 routes, you can match on the route type
  - Interface, external, nssa-external
  - Type 1 or type 2
- Route maps again can be used for greater control

```
R1(config-rtr)# redistribute ospf process-id [match {internal | external
[1|2] | nssa-external [1|2]}] [route-map route-map]
```

# Agenda

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- Q&A

# IPv6 Multicast

- Multicast - FF00::/8

| 8 bits | 4 bits | 4 bits | 112 bits |
|---|---|---|---|
| 11111111 | Flag | Scope | Group ID |

Flag bits:

Only the least significant bit is currently used for multicast traffic: 0 is a permanent or well known multicast, 1 is not permanent or transient multicast

Scope:

1 – Node Local

2 – Link Local

5 – Site Local

8 – Organization Local

E (14) – Global

# IPv6 Multicast

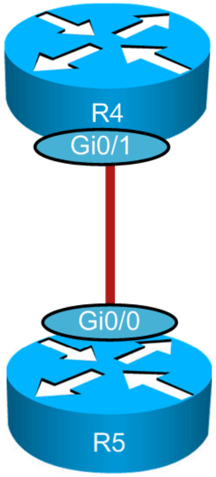
| Service | IPv4 | IPv6 |
|---|---|---|
| Address Range | 32 bit, Class D, 28 bits for groups | 128 bit, 112 bits for groups |
| Routing | Protocol independent multicast (PIM) and MBGP | PIM and MBGP |
| Forwarding | PIM: Dense mode (DM), Sparse mode (SM), bidirectional and source specific multicast (SSM) | PIM: SM, SSM, and bidirectional |
| Group Management | IGMPv1, v2, v3 | MLDv1, v2 |
| Domain control | Boundary border | Scope identifier |
| Interdomain | MSDP with RP in independent PIM domains | Single RP within globally shared domains |

# IPv6 Multicast

- Rendezvous Points
  - Static RP for PIM-SM and Bidir-PIM, no redundancy yet
  - BSR for PIM-SM and Bidir-PIM, with RP redundancy
  - Embedded-RP for PIM-SM only, no redundancy yet

# IPv6 Multicast – Static RP

```
ipv6 multicast-routing
!
interface loopback 0
 no ip address
 ipv6 address 2005:DEAD:BEEF:FFFF::40/128
!
ipv6 pim rp-address 2005:DEAD:BEEF:FFFF::40
```




```
ipv6 multicast-routing
!
ipv6 pim rp-address 2005:DEAD:BEEF:FFFF::40
```

# IPv6 Multicast – Embedded RP

- Embeds the RP address into a multicast group address
- Redefines what was an 8 bit reserved field into a 4 bit reserved and 4 bit R field:
  - – R field allows provision of 16 RPs on embedded address
  - – 32 bit group ID field provides for 232 multicast groups per RP

| 8 | 4 | 4 | 4 | 4 | 8 | 64 | 32 |
|---|---|---|---|---|---|---|---|
| FF | Flags | Scope | Rsvd | RPadr | Plen | Network-Prefix | Group-ID |

  - – Flags – 0RPT (0111 for Embedded RP Address)

Plen = Prefix Length

# IPv6 Multicast – Embedded RP

- Address example:
  - 16 RP addresses per network prefix
  - 232 multicast groups per RP

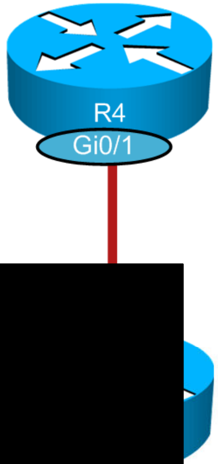
| 8 | Flags | Scope | Rsvd | Rpadr | Plen | Network-Prefix | Group-ID |
|---|---|---|---|---|---|---|---|
| FF | 7 | E | 0 | 1 | 64 | 2005:DEAD:BEEF:00C1 | 1001:4321 |

Embedded multicast: FF7E:0164:2005:DEAD:BEEF:00C1:1001:4321

RP Address:  2005:DEAD:BEEF:00C1::1

# IPv6 Multicast – Embedded RP

- RP to be used as an embedded RP needs to be configured with address/group range
- All other non-RP routers require no special configuration




```
ipv6 multicast-routing
!
ipv6 pim rp-address 2005:DEAD:BEEF:00C1::1 ERP
!
ipv6 access-list ERP
 permit ipv6 any FF7E:0164:2005:DEAD:BEEF:00C1:1001::/96
```

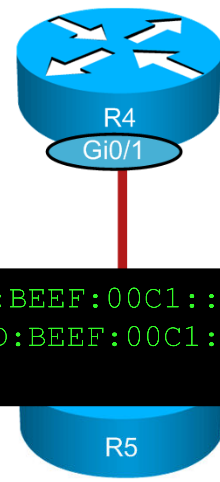
# IPv6 Multicast – Boot Strap Router

- Boot Strap Router (BSR) allows for the dynamic distribution of the RP address to other routers.
- BSR allows for redundant RPs

**ipv6 pim** [**vrf** *vrf-name*] **bsr candidate rp** *ipv6-address* [**group-list** *access-list-name*] [**priority** *priority-value*] [**interval** *seconds*] [**scope** *scope-value*] [**bidir**]

**ipv6 pim** [**vrf** *vrf-name*] **bsr candidate bsr***ipv6-address* [*hash-mask-length*] [**priority** *priority-value*]

# IPv6 Multicast – Boot Strap Router




```
R4(config)# ipv6 pim bsr candidate rp 2005:DEAD:BEEF:00C1::1 priority 0
R4(config)# ipv6 pim bsr candidate bsr 2005:DEAD:BEEF:00C1::1 124 priority 10
```

# IPv6 Multicast – Multicast Listener Discovery

- MLD uses ICMPv6 messages to perform the same functions as IGMP for IPv4 multicast
  - Type 130: Multicast Listener Query
  - Type 131: MLDv1 Multicast Listener Remote
  - Type 132: MLDv1 Multicast Listener Done
  - Type 143: MLDv2 Multicast Listener Report
- MLD version 1 is similar to IGMPv2
- MLD version 2 is similar to IGMPv3

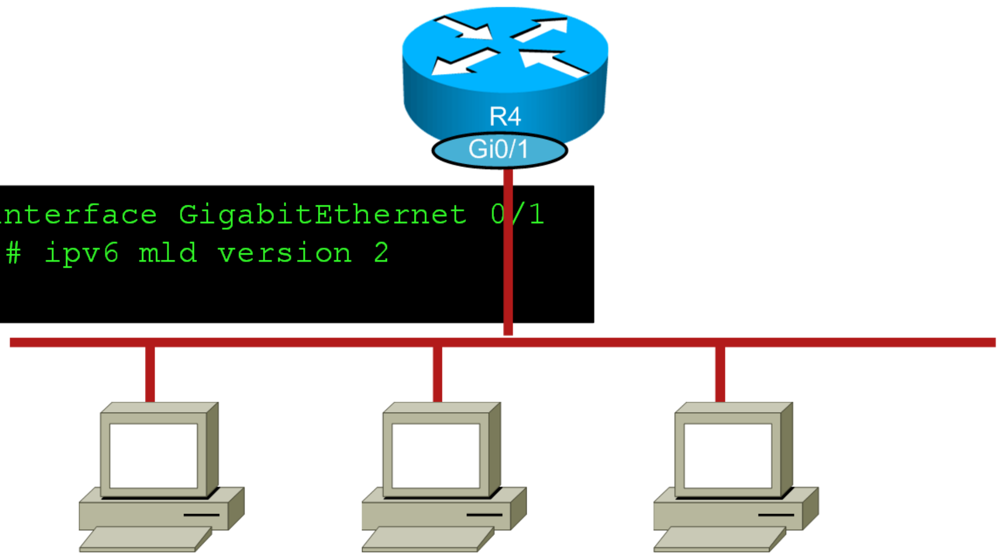
# IPv6 Multicast – MLDv1

| Type | Code | Checksum | |
|---|---|---|---|
| Max Response Delay | | Reserved | |
| Multicast Address | | | |

# IPv6 Multicast – MLDv2

- Support for source filtering
- Interoperable with MLDv1
- Message types:
  - General query
  - Multicast address-specific query
  - Multicast address and source-specific query
  - Current state report
  - State change report

# IPv6 Multicast – MLDv2




```
R4(config)# interface GigabitEthernet 0/1
R4(config-if)# ipv6 mld version 2
```

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- Q&A

# IPv6 and 3560 switches

- Default is that IPv6 is NOT supported
- Have to change the SDM Template
  - To configure the ASIC to allocate resources for IPv6
  - IPv4-and-IPv6 Default

    or
  - IPv4-and-IPv6 Routing if PBRv6 is needed
  - Reload of the switch is needed

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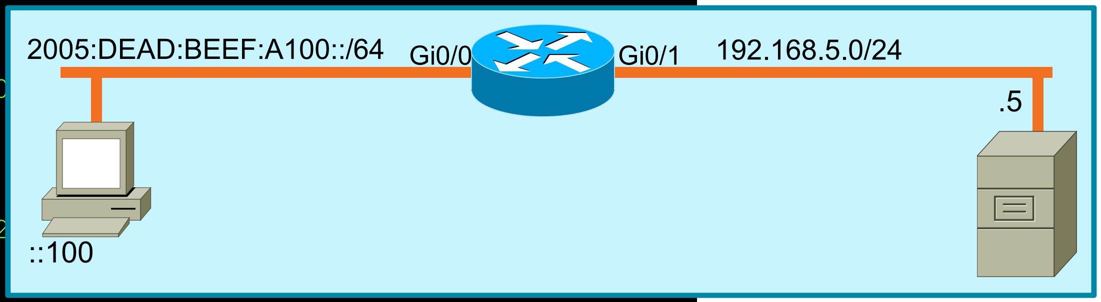
# IPv6 NAT Protocol Translation

- Network Address Translation--Protocol Translation (NAT-PT) is an IPv6 to IPv4 translation mechanism, as defined in RFC 2765 and RFC 2766, allowing IPv6-only devices to communicate with IPv4-only devices and vice versa.
- You somehow have to inject a IPv4 route into the IPv4 domain
- You somehow have to inject a IPv6 route into the IPv6 domain
- You have to set aside a /96 prefix for the IPv4 to IPv6 translation
- You identify the interfaces involved
- You set the translation rule for IPv4 to IPv6
- You set the translation rule for IPv6 to IPv4

# IPv6 NAT Protocol Translation

```
interface Loopback1
description To inject into IPv4 domain
ip address 192.168.55.1 255.255.255.0
!
interface GigabitEthernet0/0
 ipv6 address 2005:DEAD:BEEF:A100
 ipv6 nat
!
interface GigabitEthernet0/1
 ip address 192.168.5.1 255.255.2
 ipv6 nat
!
ipv6 router ospf 1
distribute-list prefix-list NATPT out connected
redistribute connected
!
ipv6 nat v4v6 source 192.168.5.5 2006:5:5::5
ipv6 nat v6v4 source list NATPT pool MyPool
ipv6 nat v6v4 pool MyPool 192.168.55.2 192.168.55.100 prefix-length 24
ipv6 nat prefix 2005:DEAD:BEEF:5::/96
!
ipv6 prefix-list NATPT seq 5 permit 2005:DEAD:BEEF:5::/96
!
ipv6 access-list NATPT
 permit ipv6 any any
```



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# Troubleshooting IPv6

- Show ipv6 cef
- Show ipv6 interface [brief]
- Show ipv6 protocols
- Show ipv6 neighbors

# Troubleshooting RIPng

- Show ipv6 rip
- Show ipv6 rip database
- Show ipv6 route rip
- Debug ipv6 rip
- Clear ipv6 rip database

# Troubleshooting – OSPFv3 Show Commands

- Show ipv6 ospf [*process-id*] [*area-id*] interface [*int*]
- Show ipv6 ospf [*process-id*] [*area-id*]
- Show ipv6 ospf [*process-id*] [*area-id*] neighbor
- Show ipv6 ospf [*process-id*] [*area-id*] database
- Clear ipv6 ospf [*process-id*] {process | force-spf | redistribution | counters [neighbor [neighbor-interface]]}

# Troubleshooting – OSPFv3 Debug Commands

- debug ipv6 ospf adj
- debug ipv6 ospf hello
- debug ipv6 ospf spf
- debug ipv6 ospf flooding
- debug ipv6 ospf events
- debug ipv6 ospf lsa-generation
- debug ipv6 ospf database-timer
- debug ipv6 ospf packets
- debug ipv6 ospf retransmission
- debug ipv6 ospf tree

# Troubleshooting – EIGRPv3

- Show ipv6 eigrp topology
- Show ipv6 eigrp neighbors
- Show ipv6 eigrp interface
- Show ipv6 route eigrp
- Debug ipv6 eigrp
- Debug eigrp packet

# Troubleshooting – BGP

- Show bgp ipv6 unicast [*prefix/length*]
- Show bgp ipv6 unicast summary
- Show bgp ipv6 unicast neighbors [*address*]
- Debug bgp ipv6 unicast

# Troubleshooting – Multicast

- Show ipv6 mroute
- Show ipv6 mld interface
- Show ipv6 mld groups
- Show ipv6 pim interface
- Show ipv6 pim neighbors
- Debug ipv6 mfib
- Debug ipv6 mld
- Debug ipv6 pim

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- Q&A

# CCIE R&S

- The CCIE Route Switch exam has now had IPv6 as a component since 2005 (the written has had it since 2007)
- IPv6 is becoming more of a core competency within the configuration and troubleshooting sections
- Point values can vary from exam to exam
- Points are likely to increase for this topic, while other topics reduce or are eliminated

# Agenda

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# Q&A

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# Final Thoughts

- Get hands-on experience with the Walk-in Labs located in World of Solutions, booth 1042
- Come see demos of many key solutions and products in the main Cisco booth 2924
- Visit www.ciscoLive365.com after the event for updated PDFs, on-demand session videos, networking, and more!
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