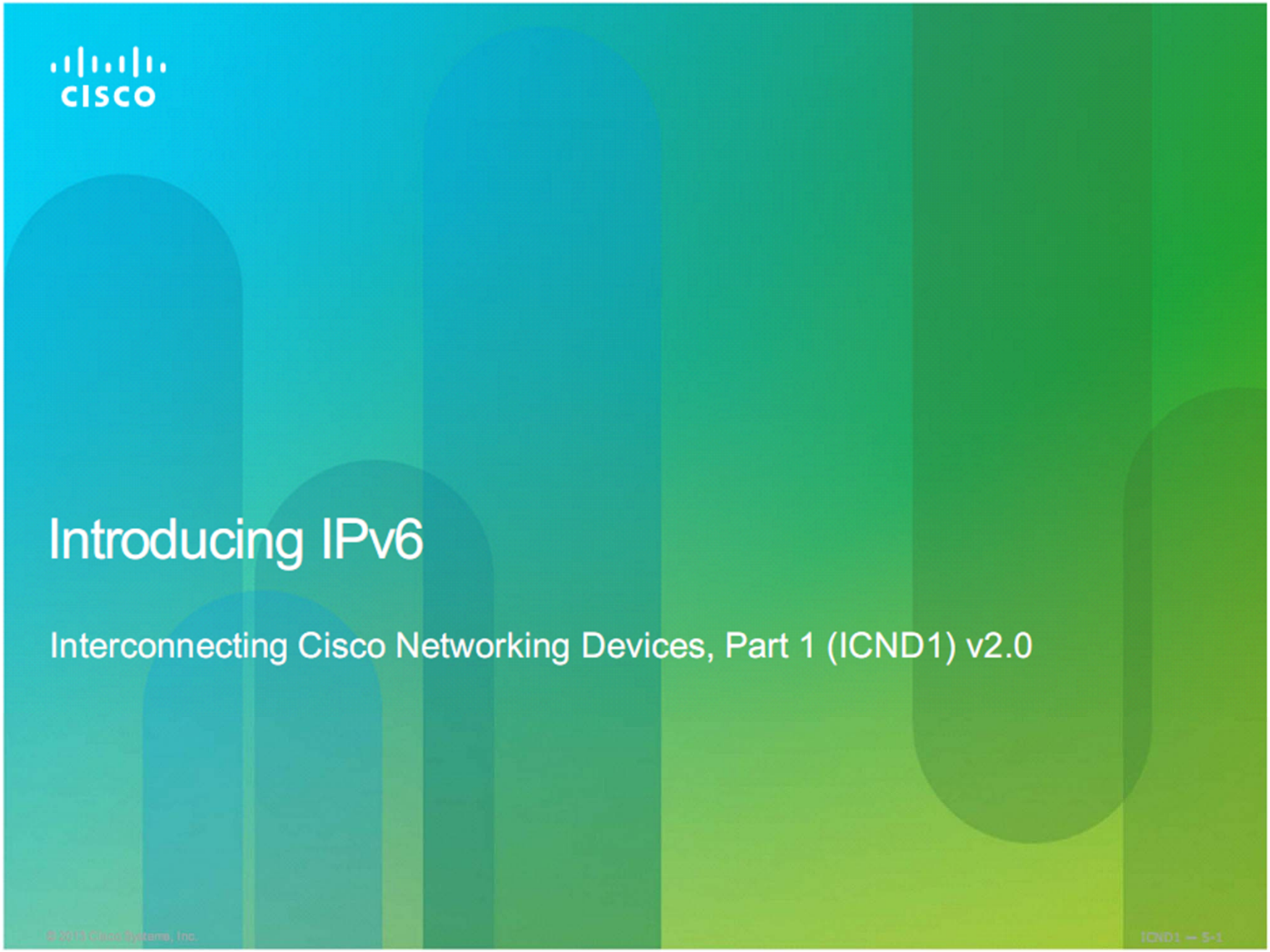

Introducing IPv6
Interconnecting Cisco Networking Devices, Part 1 (ICND1) v2.0

Introducing Basic IPv6

Introducing IPv6

IPv4 Addressing Exhaustion Workarounds

- To extend the lifetime and usefulness of IPv4 and circumvent address shortage, several mechanisms were created:
  - CIDR
  - VLSM
  - NAT
  - DHCP
- Over the years, hardware support has been added to devices to support IPv4 enhancements.

Problems with IPv4 Addressing Workarounds

- NAT breaks the end-to-end model of IP.
- NAT inhibits end-to-end network security.
- Some applications are not NAT friendly.
- The merging of private networks is difficult if overlapping IP address ranges are used.

IPv6 Features

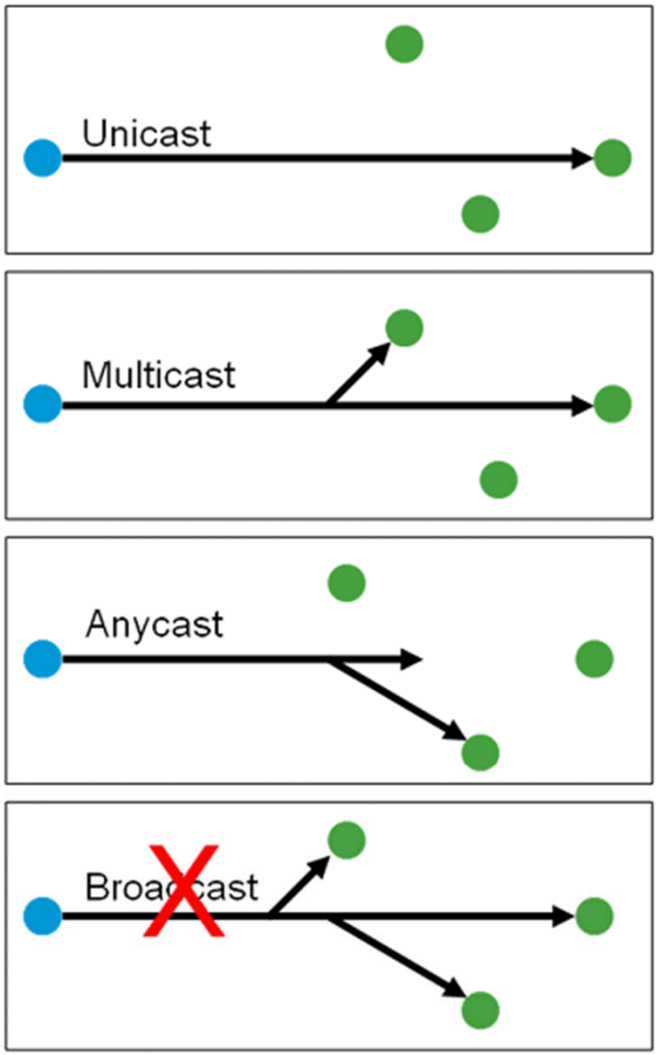
- **Larger address space:** Global reach capability, flexibility, aggregation, multihoming, autoconfiguration, “plug-and-play,” renumbering
- **Simpler header:** Routing code streamlined, simpler processing in hardware
- **Security and mobility:** Built into the standard, not as extensions
- **Transition richness:** Several mechanisms available, including “dual-stacking”

IPv6 Addresses

Address representation follows:

- Format is x:x:x:x:x:x:x:x, where x is a 16-bit hexadecimal field:
  - Example: 2001:0DB8:010F:0001:0000:0000:0000:0ACD
- Leading zeros in a field are optional:
  - Example: 2001:DB8:10F:1:0:0:0:ACD
- Successive fields of 0 are represented as "::" but only once in an address:
  - Example: 2001:DB8:10F:1::ACD

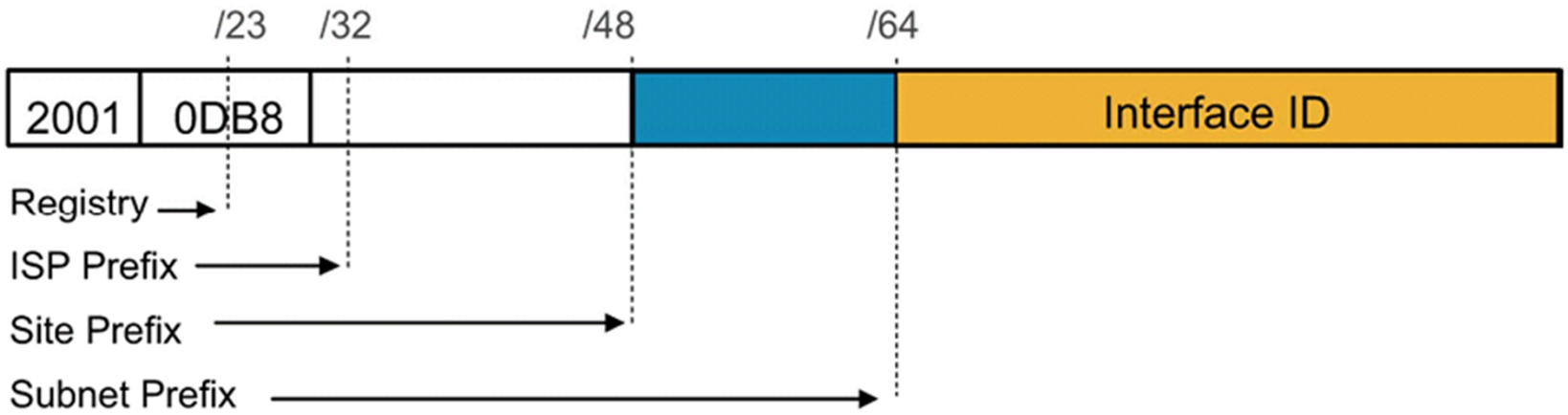
IPv6 Address Types



IPv6 Unicast Addresses

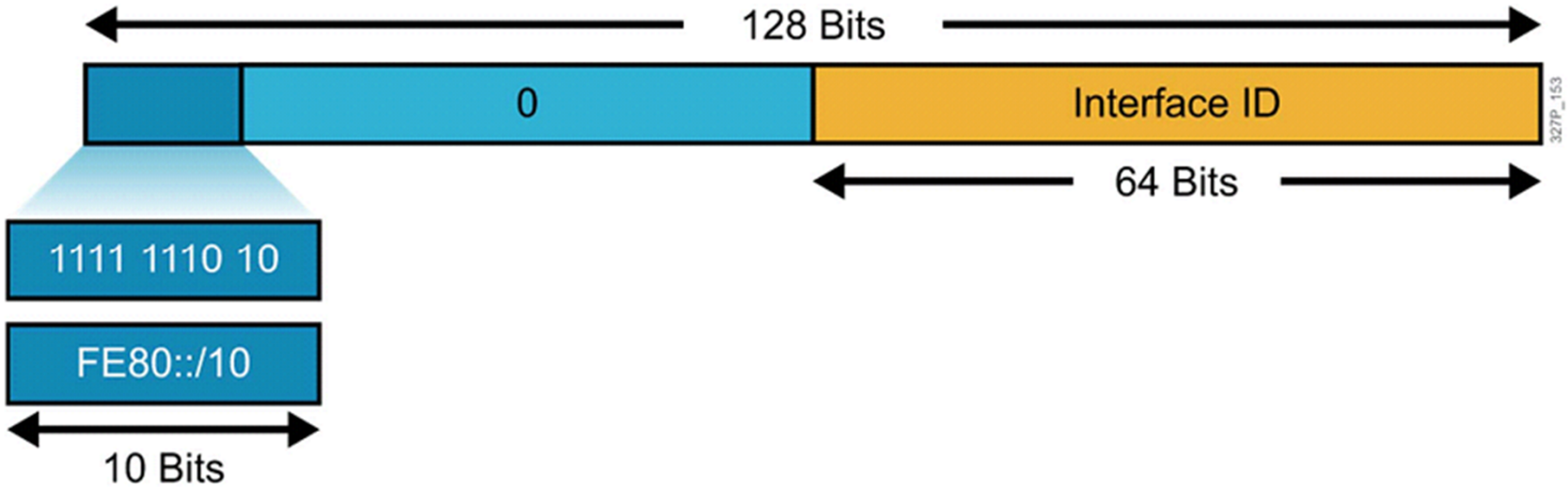
Types of IPv6 unicast addresses:

- **Global:** Starts with 2000::/3 and assigned by the Internet Assigned Numbers Authority



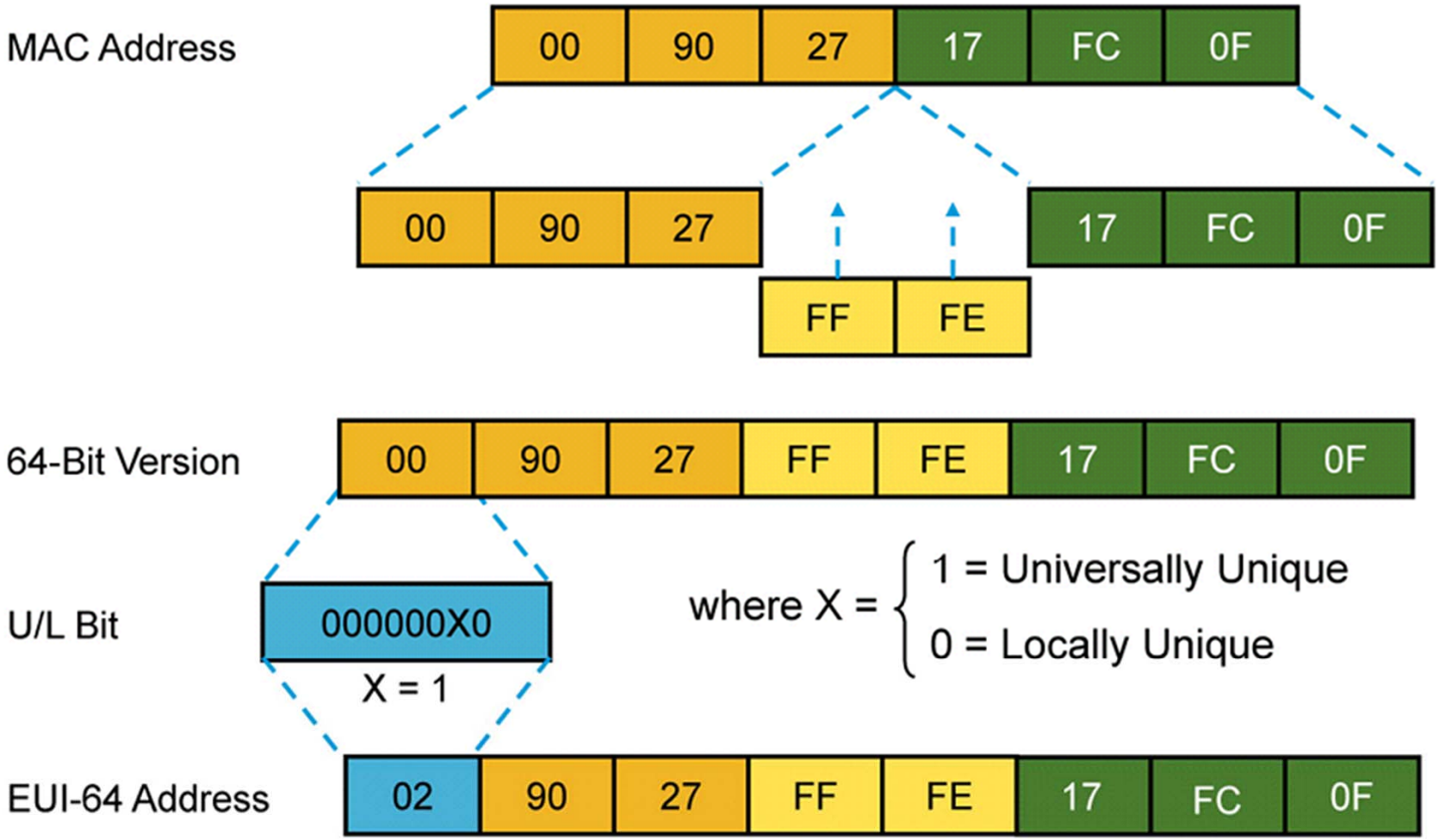
IPv6 Unicast Addresses (Cont.)

- **Private:** Link local (starts with FE80::/10)



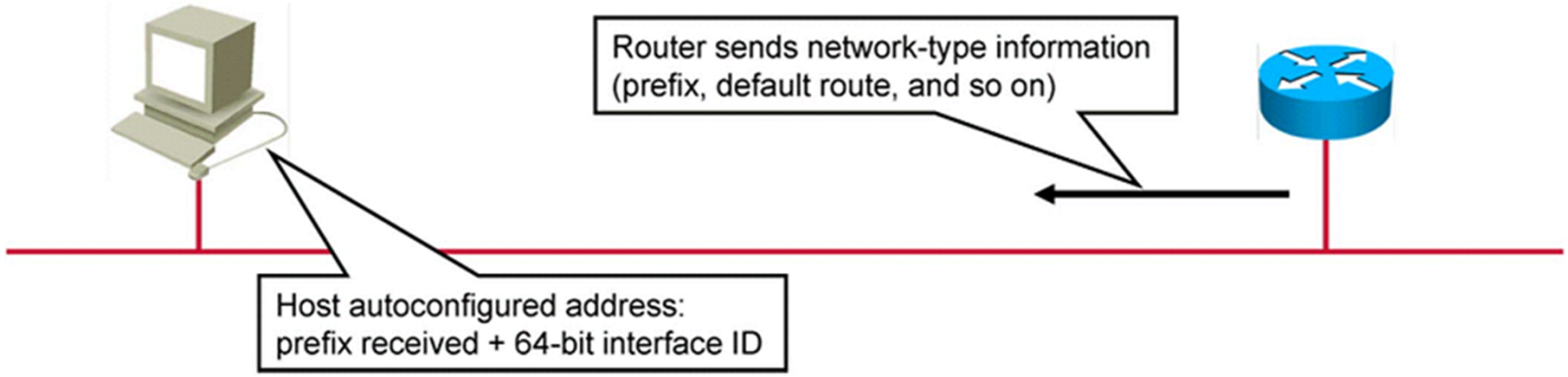
- **Loopback** (::1)
- **Unspecified** (::)
- **Reserved:** Used by the IETF

EUI-64 Interface ID Assignment



IPv6 Addresses Allocation

- Manual assignment with or without EUI-64
- Stateless autoconfiguration: Uses neighbor discovery mechanisms to find routers and dynamically create IPv6 addresses
- Stateful autoconfiguration: Uses a DHCPv6 server to assign IPv6 addresses and additional parameters to hosts



Basic IPv6 Connectivity

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

- Enables IPv6 routing on Cisco routers

```
Router(config-if)#ipv6 address 2001:db8:D1A5:C900::1/64
```

- Configures the interface with a specific IPv6 address

Cisco IOS IPv6 Configuration Example

IPv6 configuration on the Branch router:

```
Branch(config)#ipv6 unicast-routing
Branch(config)#interface GigabitEthernet 0/1
Branch(config-if)#ipv6 address 2001:db8:D1A5:C900::1/64
```

IPv6 configuration on the headquarters router:

```
HQ(config)#ipv6 unicast-routing
HQ(config)#interface GigabitEthernet 0/1
HQ(config-if)#ipv6 address 2001:db8:D1A5:C900::2/64
```

Cisco IOS IPv6 Configuration Example (Cont.)

Cisco IOS IPv6 verification:

- Displays IPv6 interface status

```
Branch#show ipv6 interface GigabitEthernet 0/1
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::FE99:47FF:FEE5:2599
  No Virtual link-local address(es):
  Description: Link to HQ
  Global unicast address(es):
    2001:DB8:D1A5:C900::1, subnet is 2001:DB8:D1A5:C900::/64
  < output omitted >
```

- Verifies IPv6 connectivity

```
Branch#ping 2001:db8:D1A5:C900::2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:D1A5:C900::2, timeout is 2
seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/4 ms
```

Basic IPv6 Connectivity (Cont.)

Cisco IOS IPv6 verification (Cont.):

- Traces the IPv6 address

```
Branch#traceroute 2001:db8:D1A5:C900::2
Type escape sequence to abort.
Tracing the route to 2001:DB8:D1A5:C900::2

  1 2001:DB8:D1A5:C900::2 0 msec 0 msec 0 msec
```

- Uses Telnet to connect to the IPv6 address

```
Branch#telnet 2001:db8:D1A5:C900::2
Trying 2001:DB8:D1A5:C900::2 ... Open

HQ#
```

- SSH to the IPv6 address

```
Branch#ssh -l ccna 2001:DB8:D1A5:C900::2
Password:
HQ#
```

Summary

- To extend the lifetime and usefulness of IPv4 and circumvent address shortage, several mechanisms were created: CIDR, VLSM, NAT, and DHCP.
- Main IPv6 features are larger address space, simpler header, security, mobility, and transition richness.
- IPv6 addresses are represented as a series of eight 16-bit hexadecimal fields that are separated by colons.
- There are several basic types of IPv6 unicast addresses: global, reserved, private (link-local), loopback, and unspecified.
- IPv6 addresses can be allocated by manual assignment with or without EUI-64. Addresses can also be obtained automatically through stateless or stateful autoconfiguration.
- To enable IPv6 on the router, use the **ipv6 unicast-routing** command.


Understanding IPv6
Introducing IPv6
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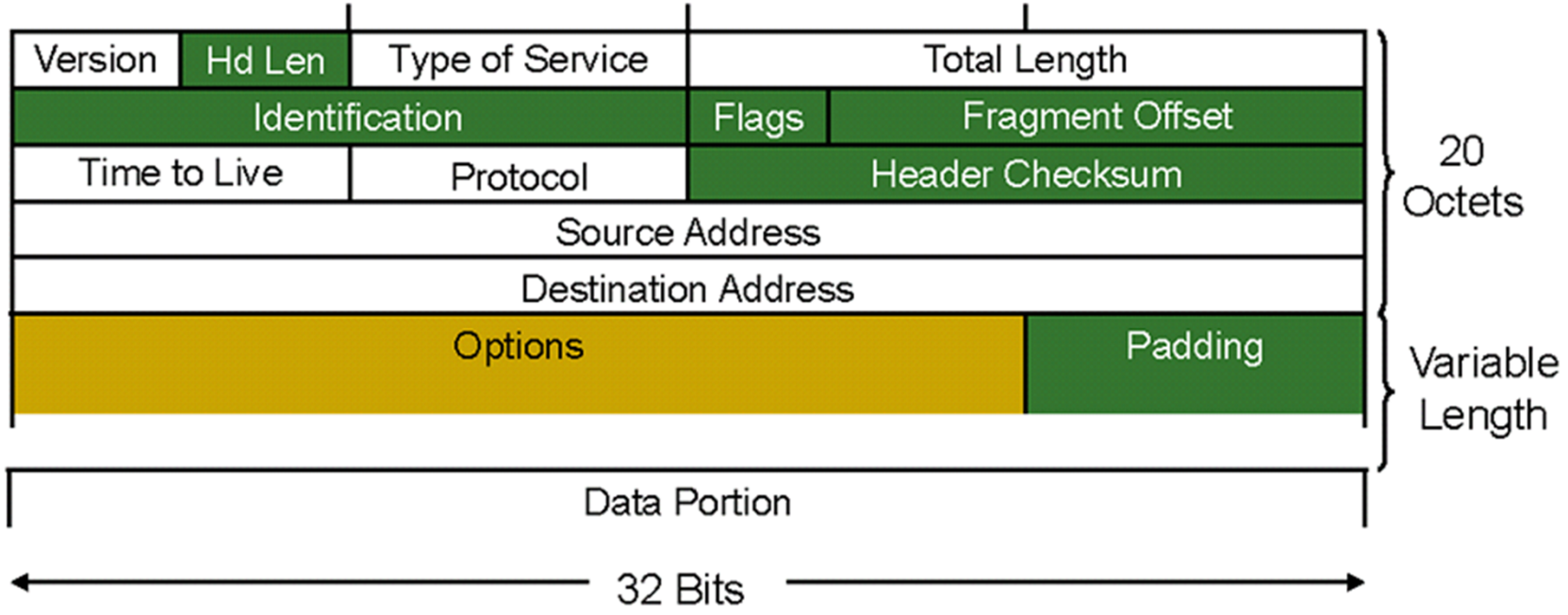
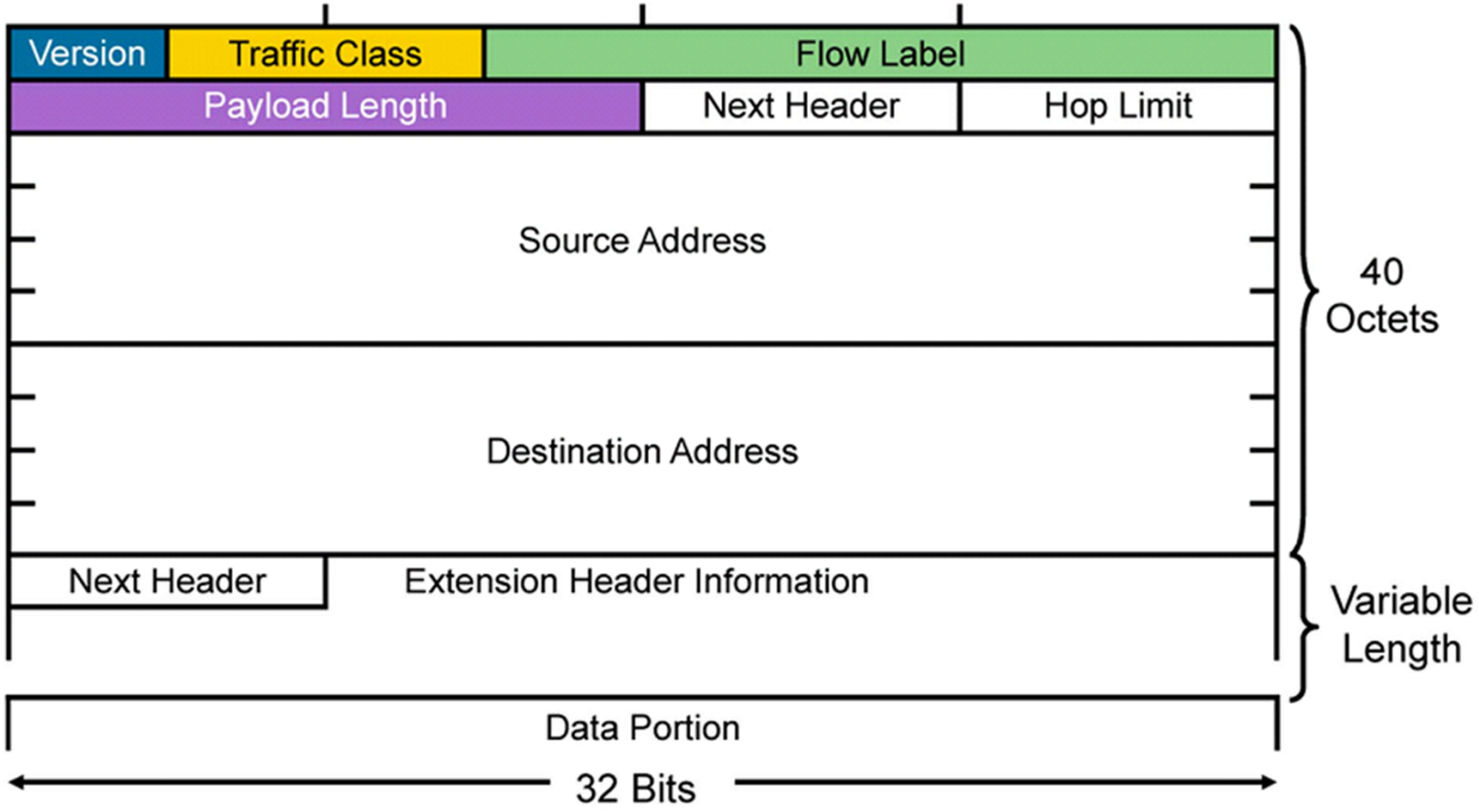
IPv6 Header Changes and Benefits

- IPv4 header format



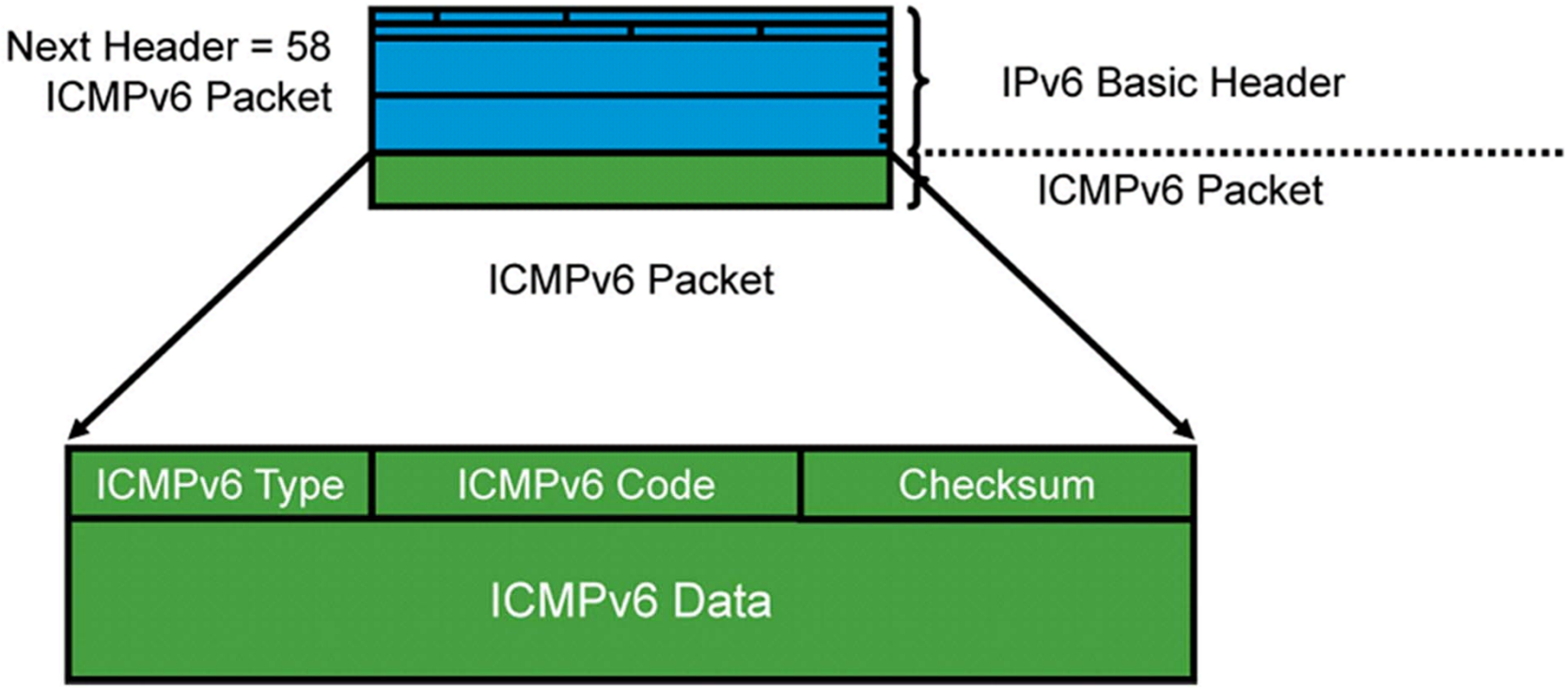
IPv6 Header Changes and Benefits (Cont.)

- IPv6 header format



ICMPv6

- Provides diagnostic (echo, echo reply)
- Router discovery (router solicitation, router advertisement)
- Neighbor discovery (neighbor solicitation, neighbor advertisement)

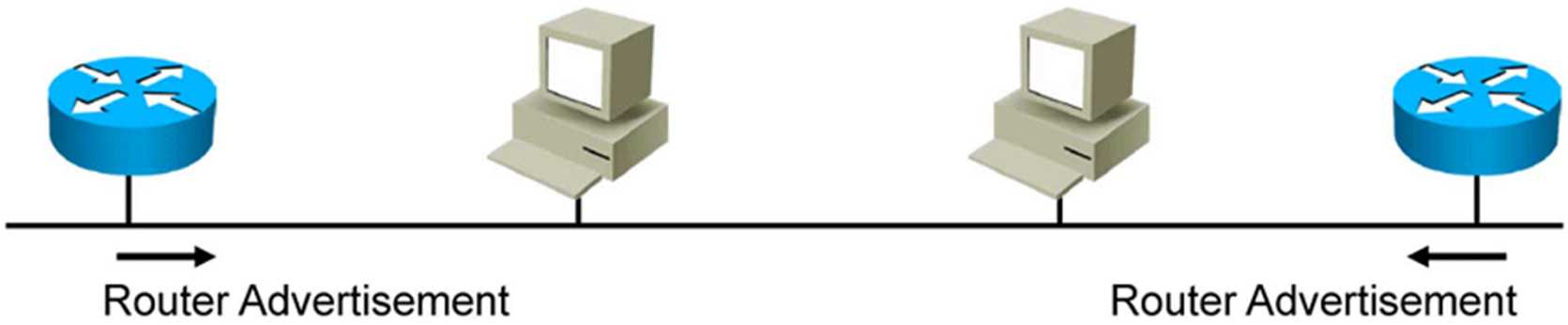


Neighbor Discovery

Neighbor discovery performs the same functions in IPv6 as ARP does in IPv4

- Neighbor discovery:
  - Determines the link layer address of a neighbor
  - Finds neighbor routers on the link
  - Queries for duplicate addresses
  - Is achieved by using ICMPv6 with IPv6 multicast

Stateless Autoconfiguration



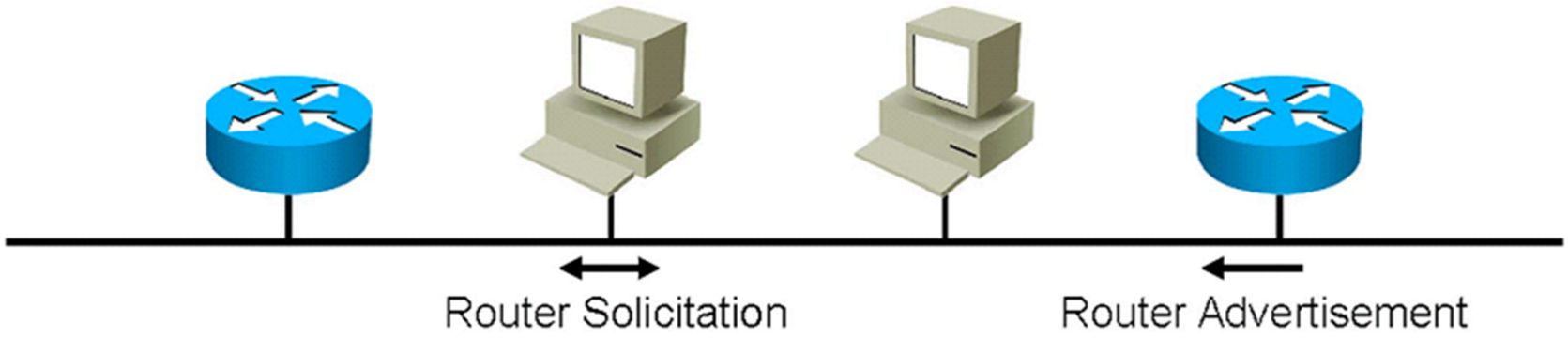
Router advertisement packet:

- ICMP type 134
- Source = router link-local address
- Destination = FF02::1 (all-nodes multicast address)
- Data = options, prefix, lifetime, autoconfiguration flag

Stateless Autoconfiguration (Cont.)

Router solicitations

At boot time, nodes send router solicitations to promptly receive router advertisements.



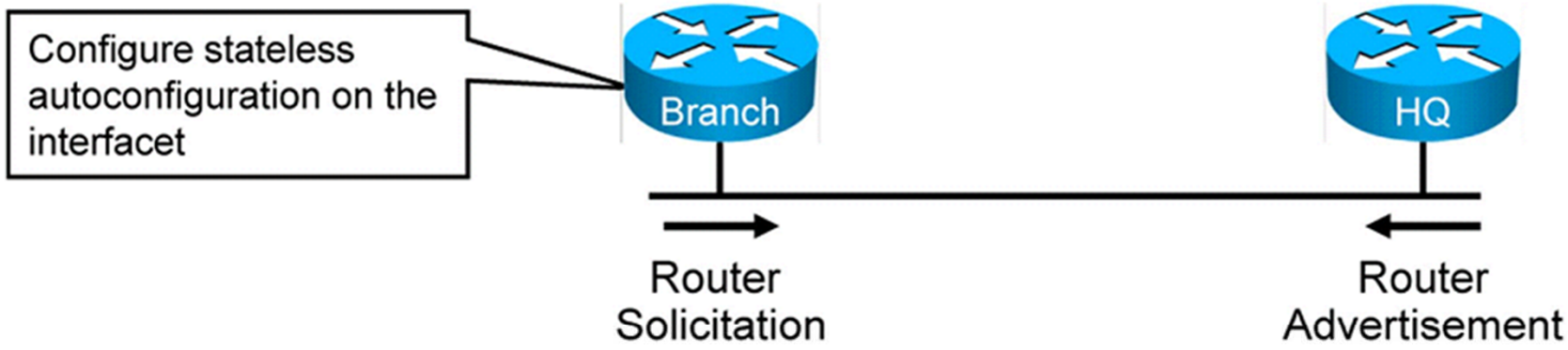
Router solicitation packet:

- ICMP type 133
- Source = :: (unspecified address)
- Destination = FF02::2 (all-routers multicast address)

Stateless Autoconfiguration (Cont.)

- The Branch router configures stateless autoconfiguration on the interface.
- The default route is added, based on route advertisement information, if the default keyword is added.

```
Branch(config-if)#ipv6 address autoconfig [default]
```



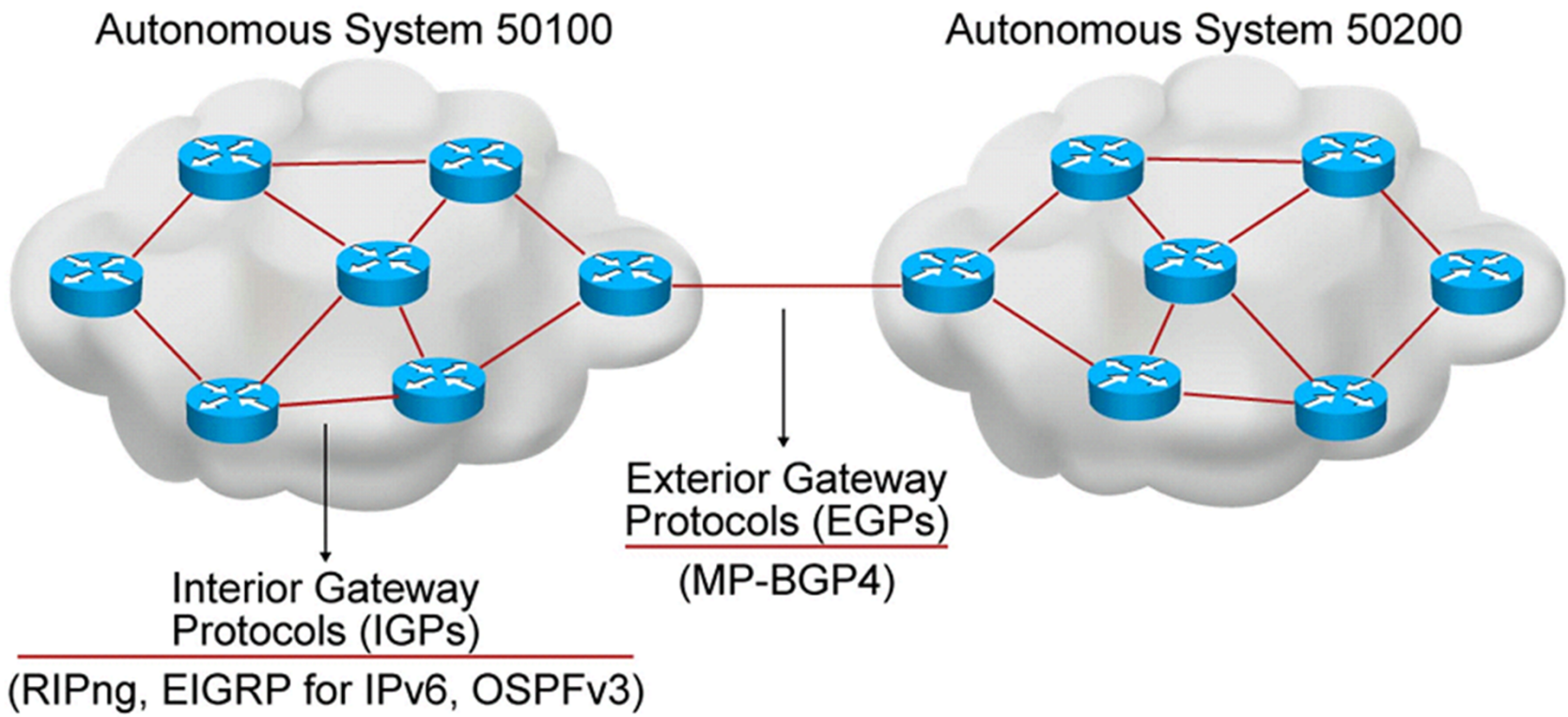
Summary

- The IPv6 header has removed unnecessary fields, resulting in a more streamlined, simpler protocol.
- ICMPv6 provides diagnostic, router, and neighbor discovery.
- Neighbor discovery is a critical process that allows neighbors to determine the link-layer address that is associated with a given IPv6 address.
- Autoconfiguration provides a type of network “plug-and-play” feature, in which devices can assign their own address, based on router-provided information.

Configuring IPv6 Routing

Introducing IPv6

Routing for IPv6

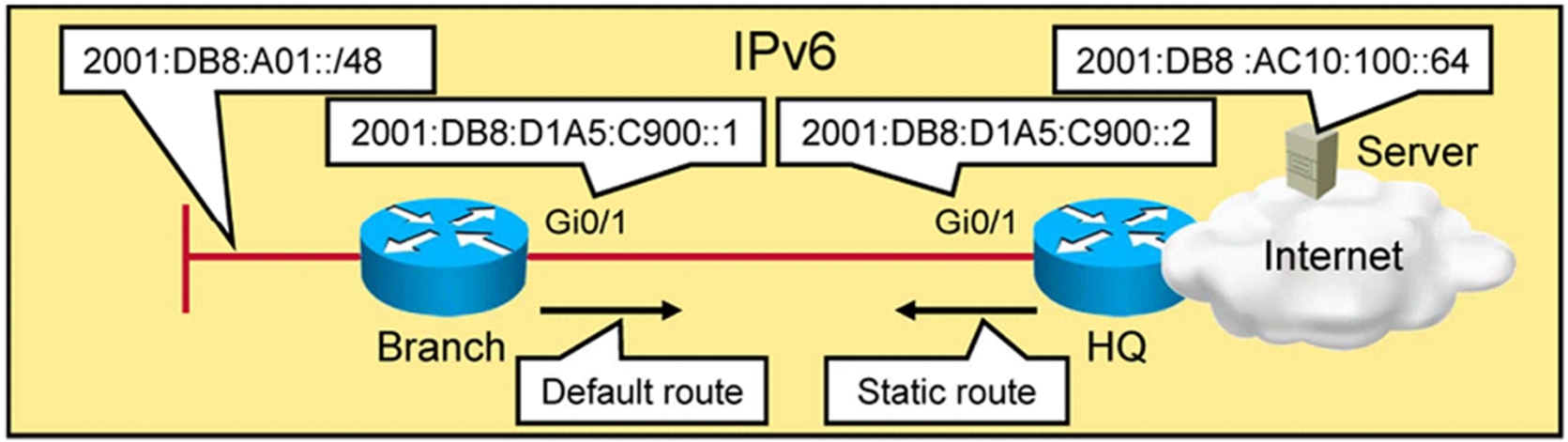


Routing for IPv6 (Cont.)

IPv6 routing types:

- static
- RIPng (RFC 2080)
- EIGRP for IPv6
- OSPFv3 (RFC 2740)
- MP-BGP4 (RFC 2545/2858)

Static Routing



The static IPv6 route is configured on the HQ router:

```
HQ(config)#ipv6 route 2001:DB8:A01::/48 Gi0/1 2001:DB8:D1A5:C900::1
```

The default IPv6 route is configured on the Branch router:

```
Branch(config)#ipv6 route ::/0 Gi0/1 2001:DB8:D1A5:C900::2
```

Static Routing (Cont.)

Verify the static IPv6 route on the HQ router:

```
HQ#show ipv6 route static
IPv6 Routing Table - default - 4 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP
external
       ND - Neighbor Discovery, l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S   2001:DB8:A01::/48 [1/0]
     via 2001:DB8:D1A5:C900::1, GigabitEthernet0/1
```

Static Routing (Cont.)

Verify the default IPv6 route on the Branch router:

```
Branch#show ipv6 route static
IPv6 Routing Table - default - 4 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP
external
       ND - Neighbor Discovery, l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S   ::/0 [1/0]
     via 2001:DB8:D1A5:C900::2, GigabitEthernet0/1
```

Static Routing (Cont.)

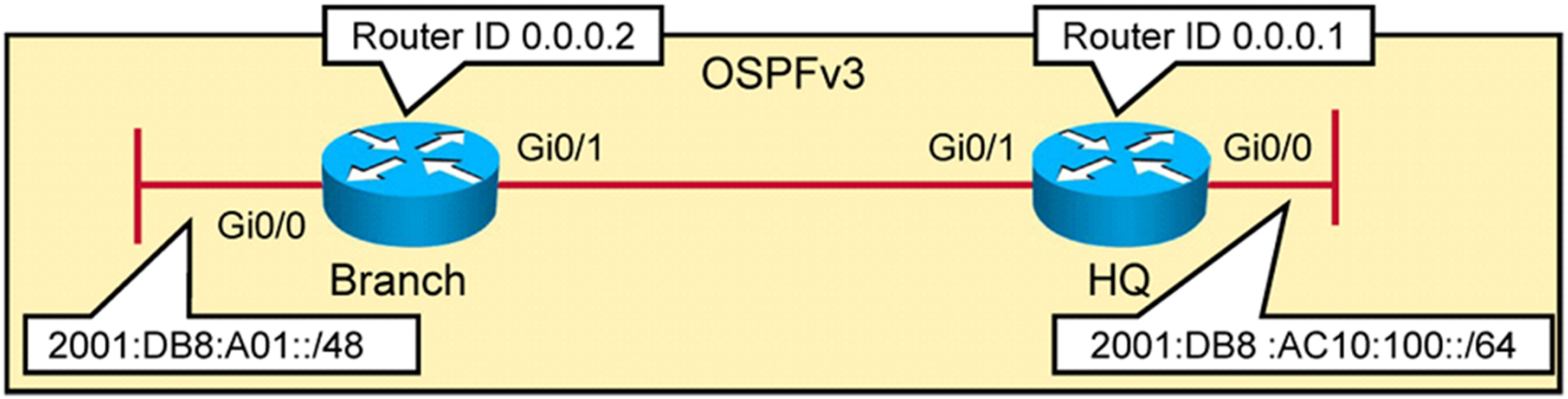
Verify IPv6 connectivity from the Branch router to IPv6 address 2001:db8:AC10:100::64:

```
Branch#ping 2001:db8:AC10:100::64
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:DB8:AC10:100::64, timeout is 2
seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms
```

OSPFv3

- Router ID looks like an IPv4 address.
- Adjacencies and next-hop attributes use link-local addresses.
- IPv6 is used for transport of the LSA.
- OSPFv3 is enabled per link, not per network.

OSPFv3 (Cont.)



OSPFv3 is configured on the HQ router:

```
HQ(config)# interface GigabitEthernet0/0
HQ(config-if)# ipv6 ospf 1 area 0
HQ(config-if)# exit
HQ(config)# interface GigabitEthernet0/1
HQ(config-if)# ipv6 ospf 1 area 0
HQ(config-if)# exit
HQ(config)# ipv6 router ospf 1
HQ(config-rtr)# router-id 0.0.0.1
```

OSPFv3 (Cont.)

OSPFv3 is configured on the Branch router:

```
Branch(config)# interface GigabitEthernet0/0
Branch(config-if)# ipv6 ospf 1 area 0
Branch(config-if)# exit
Branch(config)# interface GigabitEthernet0/1
Branch(config-if)# ipv6 ospf 1 area 0
Branch(config-if)# exit
Branch(config)# ipv6 router ospf 1
Branch(config-rtr)# router-id 0.0.0.2
```

OSPFv3 (Cont.)

Verify the OSPFv3 route on the Branch router:

```
Branch# show ipv6 route ospf
IPv6 Routing Table - default - 6 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP
external
       ND - Neighbor Discovery, l - LISP
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
O   2001:DB8:AC10:100::64/128 [110/1]
     via FE80::FE99:47FF:FEE5:2551, GigabitEthernet0/1
```

Verify the OSPFv3 neighbor on the Branch router:

```
Branch# show ipv6 ospf neighbor

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
0.0.0.1           1   FULL/BDR        00:00:38    4
GigabitEthernet0/1
```

OSPFv3 (Cont.)

Verify OSPFv3 settings on the Branch router:

```
Branch# show ipv6 ospf
 Routing Process "ospfv3 1" with ID 0.0.0.2
 Event-log enabled, Maximum number of events: 1000, Mode: cyclic
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Graceful restart helper support enabled
 Reference bandwidth unit is 100 mbps
< output omitted >
```

Summary

- Cisco supports all of the major IPv6 routing protocols: RIPng, OSPFv3, and EIGRP.
- Configure the IPv6 static and default route by using the **ipv6 route** command.
- OSPFv3 is enabled per link and not per network. OSPFv3 adjacencies use link-local addresses to communicate.

Module Summary

- IPv6 includes a number of features that make it attractive for building global-scale, highly effective networks. The larger address space and autoconfiguration provide important capabilities.
- Neighbor discovery is used on-link for router solicitation and advertisement, for neighbor solicitation and advertisement, and for the redirection of nodes to the best gateway.
- You can use and configure IPv6 static routing in the same way that you would with IPv4. OSPFv3 is one of the dynamic routing protocols that supports IPv6.