Address Space Management

Transitioning to IPv6

IPv4 and IPv6

IPv4:	4 octets
11000000.10101000.11001001.0111000	
192.168.201.113	
4,294,467,295 IP addresses	

- **Currently, there are approximately 1.3 billion usable IPv4 addresses available.**

IPv6:	16 octets
11010001.11011100.11001001.01110001.11010001.11011100. 11001100.01110001.11010001.11011100.11001001.01110001. 11010001.11011100.11001001.01110001	
A524:72D3:2C80:DD02:0029:EC7A:002B:EA73	
3.4 x 10^{38} IP addresses	

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Why Do We Need a Larger Address Space?

- Internet population
  - Approximately 973 million users in November 2005
  - Emerging population and geopolitical address space
- Mobile users
  - PDA, pen tablet, notepad, and so on
  - Approximately 20 million in 2004
- Mobile phones
  - Already 1 billion mobile phones delivered by the industry
- Transportation
  - 1 billion automobiles forecast for 2008
  - Internet access in planes, for example, Lufthansa
- Consumer devices
  - Sony mandated that all its products be IPv6-enabled by 2005
  - Billions of home and industrial appliances

IPv6 Advanced Features

Larger address space:

- Global reachability and flexibility
- Aggregation
- Multihoming
- Autoconfiguration
- Plug-and-play
- End-to-end without NAT
- Renumbering

Mobility and security:

- Mobile IP RFC-compliant
- IPsec mandatory (or native) for IPv6

Simpler header:

- Routing efficiency
- Performance and forwarding rate scalability
- No broadcasts
- No checksums
- Extension headers
- Flow labels

Transition richness:

- Dual stack
- 6to4 and manual tunnels
- Translation

IPv6 Address Representation

Format:

- x:x:x:x:x:x:x:x, where x is a 16-bit hexadecimal field
  - Case-insensitive for hexadecimal A, B, C, D, E, and F
- Leading zeros in a field are optional
- Successive fields of zeros can be represented as :: only once per address

Examples:

- 2031:0000:130F:0000:0000:09C0:876A:130B
  - Can be represented as 2031:0:130f::9c0:876a:130b
  - Cannot be represented as 2031::130f::9c0:876a:130b
- FF01:0:0:0:0:0:0:1 → FF01::1
- 0:0:0:0:0:0:0:1 → ::1
- 0:0:0:0:0:0:0:0 → ::

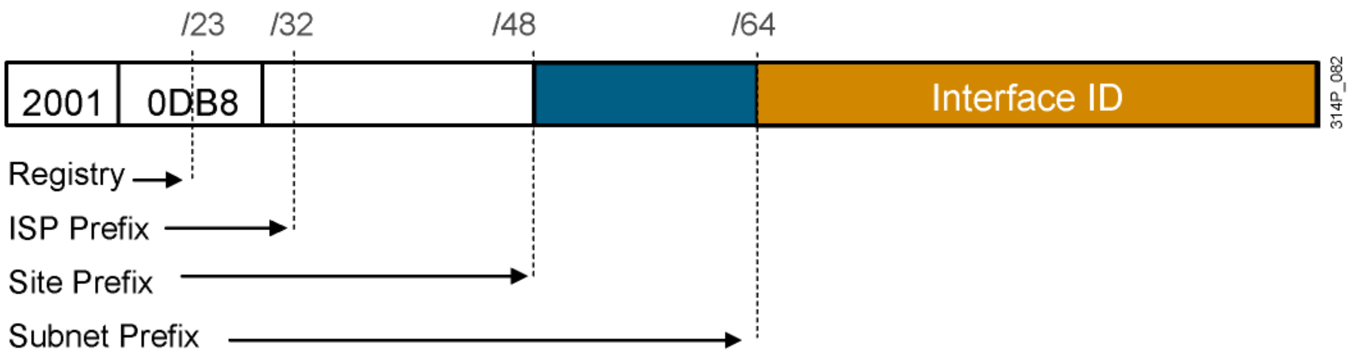
IPv6 Address Types

- **Unicast:**
  - Address is for a single interface
  - IPv6 has several types (for example, global, reserved, link-local, and site-local)
- **Multicast:**
  - One-to-many
  - Enables more efficient use of the network
  - Uses a larger address range
- **Anycast:**
  - One-to-nearest (allocated from unicast address space)
  - Multiple devices share the same address
  - All anycast nodes should provide uniform service
  - Source devices send packets to anycast address
  - Routers decide on closest device to reach that destination
  - Suitable for load balancing and content delivery services

IPv6 Unicast Addressing

- Types of IPv6 unicast addresses:
  - Global: Starts with 2000::/3 and assigned by IANA
  - Reserved: Used by the IETF
  - Private: Link local (starts with FE80::/10)
  - Loopback (::1)
  - Unspecified (::)
- A single interface may be assigned multiple IPv6 addresses of any type: unicast, anycast, or multicast.
- IPv6 addressing rules are covered by multiple RFCs.
  - Architecture defined by RFC 4291

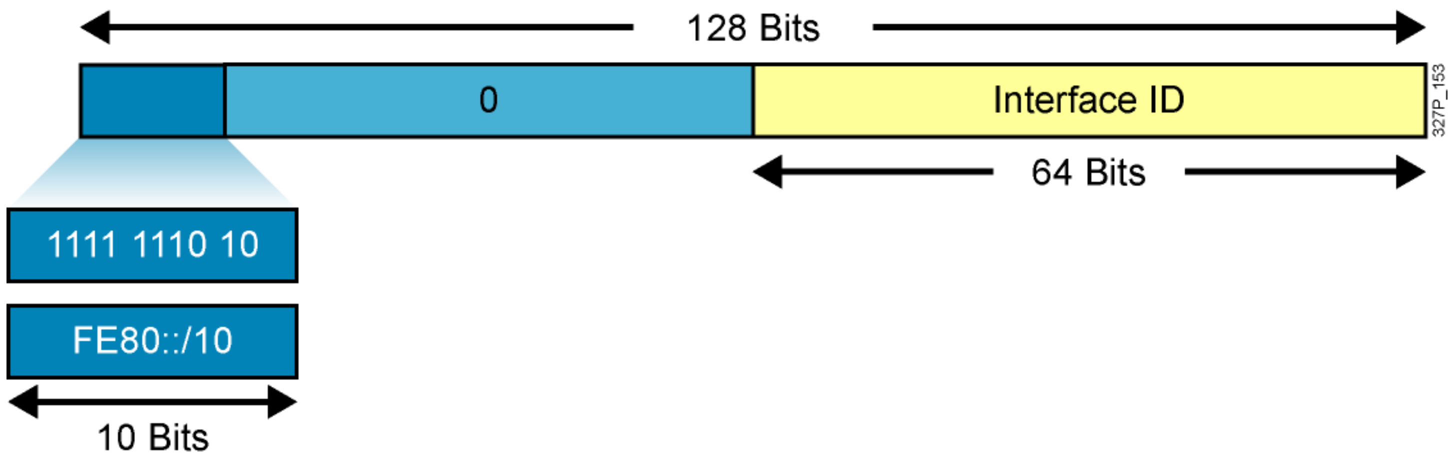
IPv6 Global Unicast (and Anycast) Addresses



IPv6 has the same address format for global unicast and for anycast addresses.

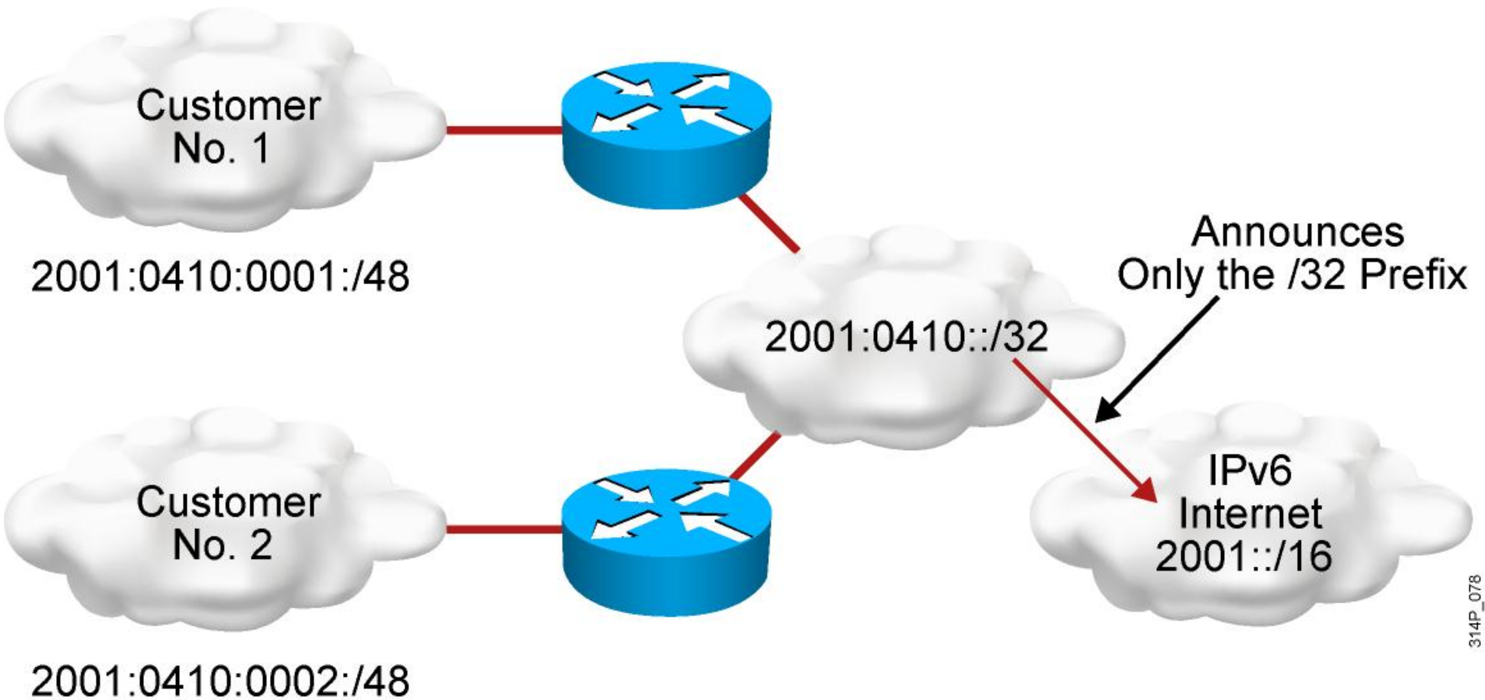
- **Uses a global routing prefix—a structure that enables aggregation upward,**
  eventually to the ISP.
- **A single interface may be assigned multiple addresses of any type (unicast, anycast, multicast).**
- **Every IPv6-enabled interface contains at least one loopback (::1/128) and one link-local address.**
- **Optionally, every interface can have multiple unique local and global addresses.**

Link-Local Addresses



- Link-local addresses have a scope limited to the link and are dynamically created on all IPv6 interfaces by using a specific link-local prefix FE80::/10 and a 64-bit interface identifier.
- Link-local addresses are used for automatic address configuration, neighbor discovery, and router discovery. Link-local addresses are also used by many routing protocols.
- Link-local addresses can serve as a way to connect devices on the same local network without needing global addresses.
- When communicating with a link-local address, you must specify the outgoing interface because every interface is connected to FE80::/10.

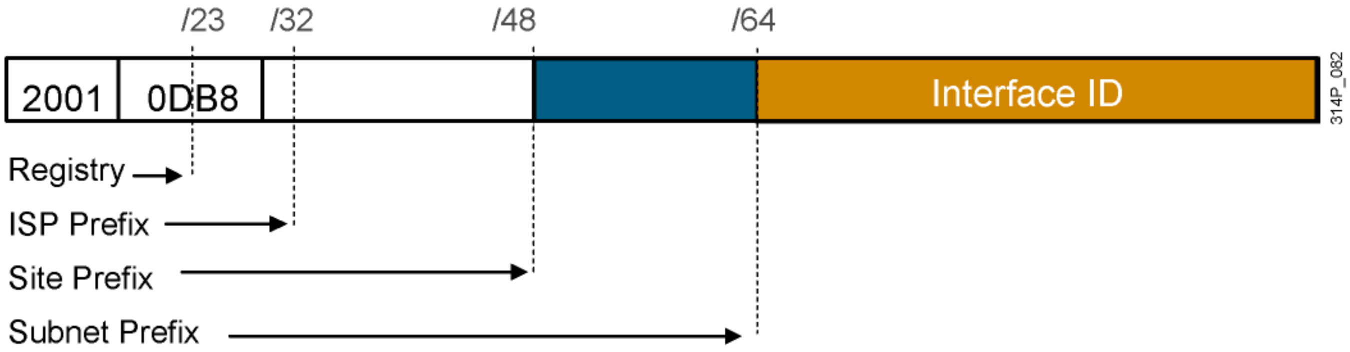
Larger Address Space Enables Address Aggregation



Address aggregation provides the following benefits:

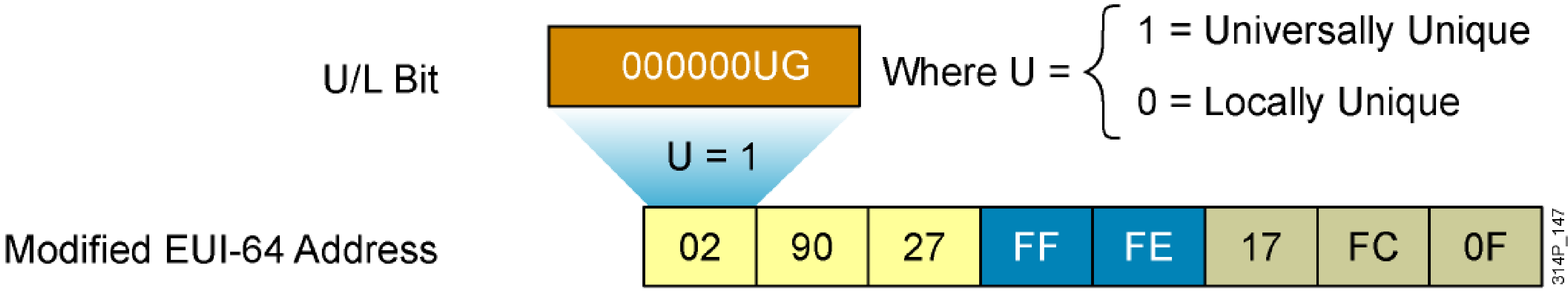
- **Aggregation of prefixes announced in the global routing table**
- **Efficient and scalable routing**
- **Improved bandwidth and functionality for user traffic**

Assigning IPv6 Global Unicast Addresses



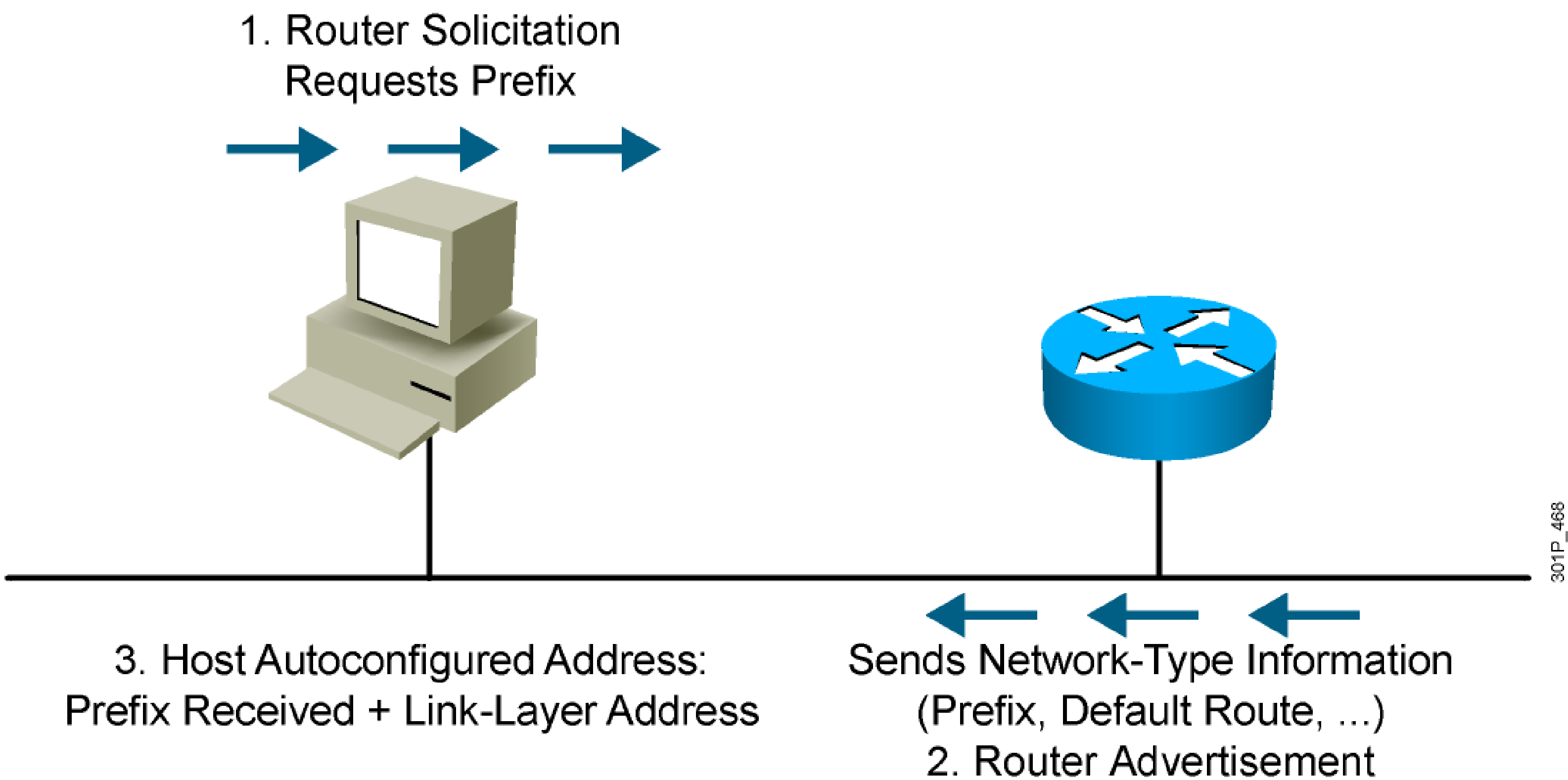
- Static assignment
  - Manual interface ID assignment
  - EUI-64 interface ID assignment
- Dynamic assignment
  - Stateless autoconfiguration
  - DHCPv6 (stateful)

IPv6 EUI-64 Interface Identifier



- **Cisco can use the EUI-64 format for interface identifiers.**
- **This format expands the 48-bit MAC address to 64 bits by inserting "FFFE" into the middle 16 bits.**
- **To make sure that the chosen address is from a unique Ethernet MAC address, the U/L bit is set to 1 for global scope (0 for local scope).**

Stateless Autoconfiguration

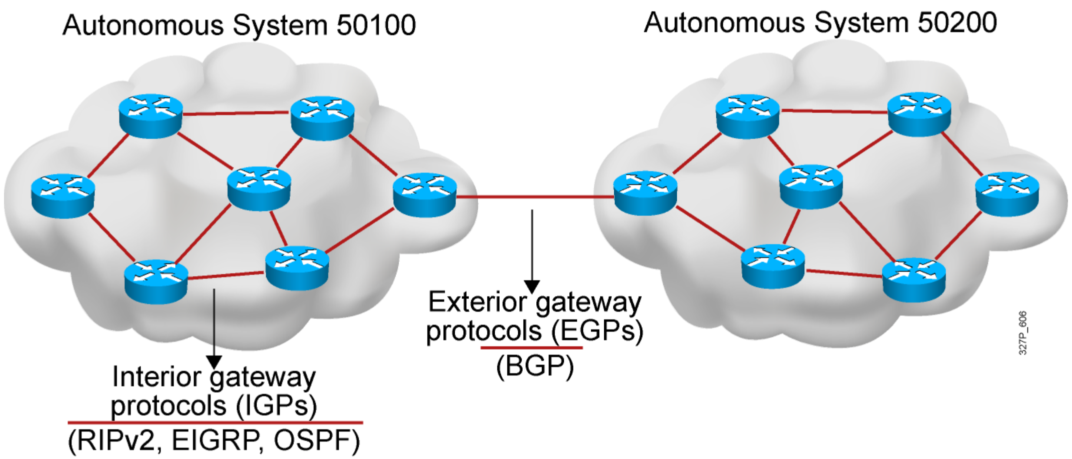


DHCPv6 (Stateful)

DHCPv6 is an updated version of DHCP for IPv4:

- **Supports new addressing**
- **Enables more control than stateless autoconfiguration**
- **Can be used for renumbering**
- **Can be used for automatic domain name registration of hosts using dynamic DNS**

IPv6 Routing Protocols



- **IPv6 routing types:**
  - **Static**
  - **RIPng (RFC 2080)**
  - **OSPFv3 (RFC 2740)**
  - **IS-IS for IPv6**
  - **MP-BGP4 (RFC 2545/2858)**
  - **EIGRP for IPv6**
- **The ipv6 unicast-routing command is required to enable IPv6 before any routing protocol is configured.**

RIPng (RFC 2080)

Similar IPv4 features:

- Distance vector, radius of 15 hops, split horizon, and poison reverse
- Based on RIPv2

Updated features for IPv6:

- IPv6 prefix, next-hop IPv6 address
- Uses the multicast group FF02::9, the all-rip-routers multicast group, as the destination address for RIP updates
- Uses IPv6 for transport
- Named RIPng

OSPF Version 3 (OSPFv3) (RFC 2740)

Similar to IPv4

- Same mechanisms, but a major rewrite of the internals of the protocol

Updated features for IPv6

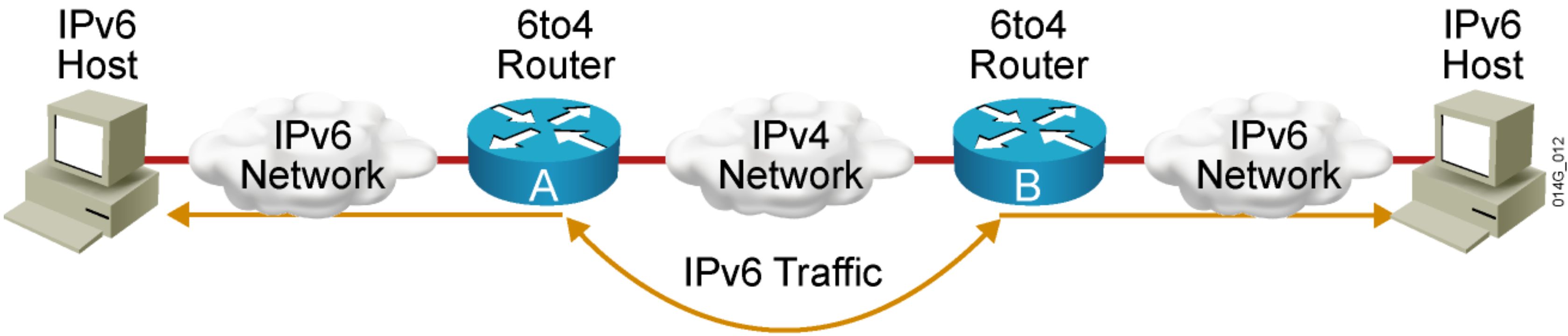
- Every IPv4-specific semantic removed
- Carry IPv6 addresses
- Link-local addresses used as source
- IPv6 transport
- OSPF for IPv6 currently an IETF proposed standard

OSPFv3 Differences from OSPFv2

OSPFv3 protocol processing is per link, not per subnet

- IPv6 connects interfaces to links.
- Multiple IPv6 subnets can be assigned to a single link.
- Two nodes can talk directly over a single link, even though they do not share a common subnet.
- The terms “network” and “subnet” are being replaced with “link.”
- An OSPF interface now connects to a link instead of to a subnet.

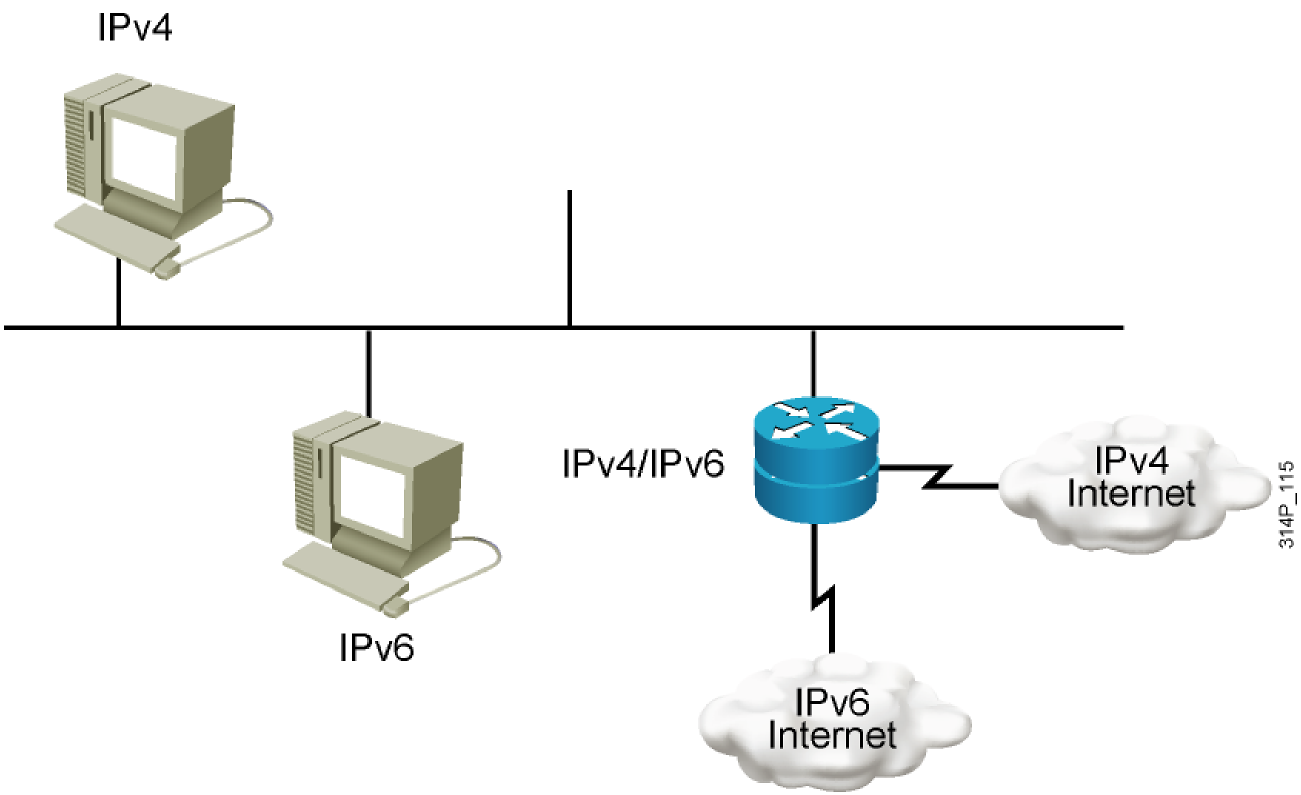
IPv4-to-IPv6 Transition



Transition richness means:

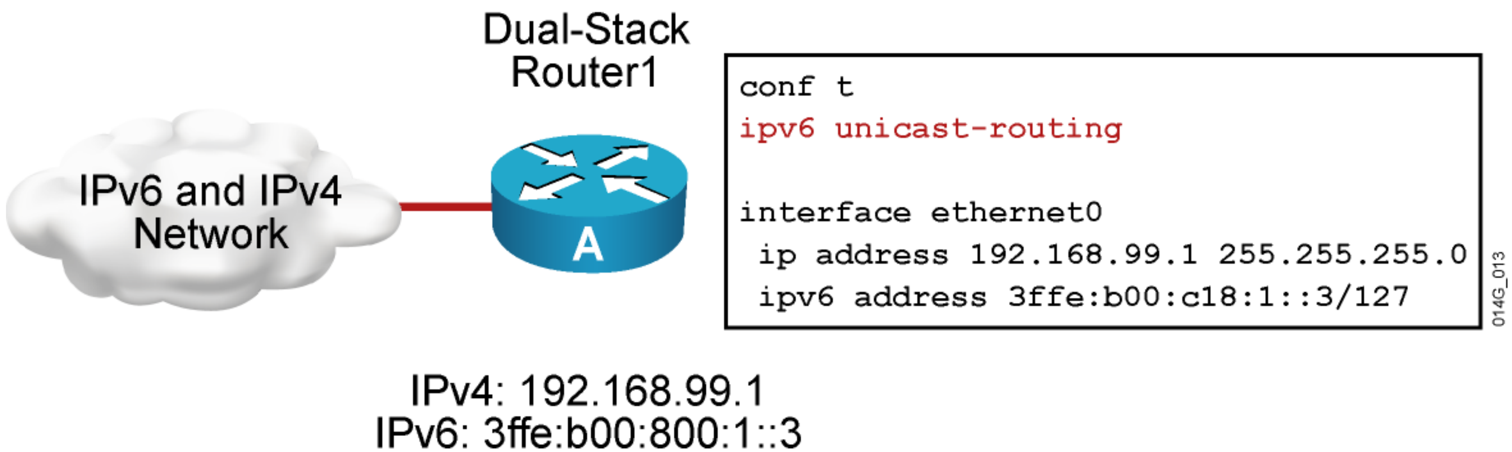
- **No fixed day to convert; no need to convert all at once**
- **Different transition mechanisms are available:**
  - **Dual stack**
  - **Manual tunnel**
  - **6to4 tunnel**
  - **ISATAP tunnel**
  - **Teredo tunnel**
- **Different compatibility mechanisms:**
  - **Proxying and translation (NAT-PT)**

Cisco IOS Dual Stack



Dual stack is an integration method in which a node has implementation and connectivity to both an IPv4 and IPv6 network.

Cisco IOS Dual Stack (Cont.)



When both IPv4 and IPv6 are configured on an interface, the interface is considered dual-stacked.

Enabling IPv6 on Cisco Routers

```
RouterX(config)#
```

```
ipv6 unicast-routing
```

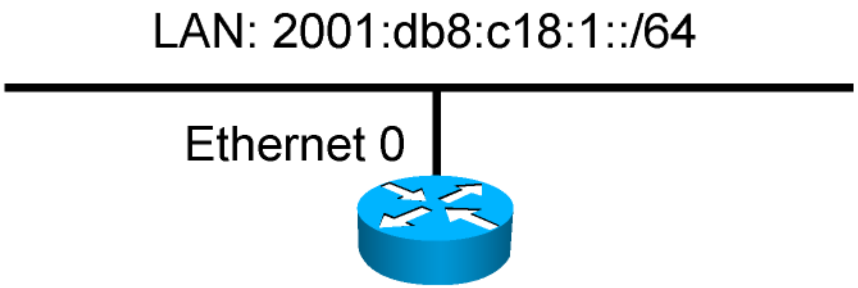
- Enables IPv6 traffic forwarding

```
RouterX(config-if)#
```

`ipv6 address` *`ipv6prefix/prefix-length`* `eui-64`

- Configures the interface IPv6 addresses

IPv6 Address Configuration Example




```
ipv6 unicast-routing
interface Ethernet0
 ipv6 address 2001:db8:c18:1::/64 eui-64
```

MAC address: 0260.3e47.1530

```
RouterX# show ipv6 interface Ethernet0
Ethernet0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::260:3EFF:FE47:1530
Global unicast address(es):
    2001:DB8:C18:1:260:3EFF:FE47:1530, subnet is 2001:DB8:C18:1::/64
  Joined group address(es):
    FF02::1:FF47:1530
    FF02::1
    FF02::2
  MTU is 1500 bytes
```

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Configuring and Verifying RIPng for IPv6

RouterX(config)#

```
ipv6 router rip tag
```

- **Creates and enters RIP router configuration mode**

RouterX(config-if)#

```
ipv6 rip tag enable
```

- **Configures RIP on an interface**

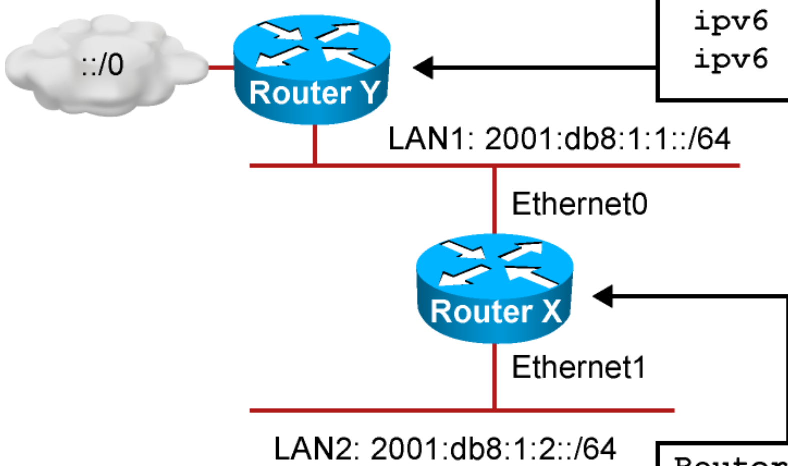
```
show ipv6 rip
```

- **Displays the status of the various RIP processes**

```
show ipv6 route rip
```

- **Shows RIP routes in the IPv6 route table**

RIPng for IPv6 Configuration Example




```
RouterY#
ipv6 unicast-routing
ipv6 router rip RT0

interface Ethernet0
 ipv6 address 2001:db8:1:1::/64 eui-64
 ipv6 rip RT0 enable
```

```
RouterX#
ipv6 unicast-routing
ipv6 router rip RT0

interface Ethernet0
 ipv6 address 2001:db8:1:1::/64 eui-64
 ipv6 rip RT0 enable

interface Ethernet1
 ipv6 address 2001:db8:1:2::/64 eui-64
 ipv6 rip RT0 enable
```

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Configuring OSPFv3 in Cisco IOS Software

- Similar to OSPFv2
  - Prefixes existing interface and EXEC mode commands with “ipv6”
- Interfaces configured directly
  - Replaces network command
- “Native” IPv6 router mode
  - Not a submode of router ospf command

Enabling OSPFv3 Globally

```
ipv6 unicast-routing
!
ipv6 router ospf 1
 router-id 2.2.2.2
```

Enabling OSPFv3 on an Interface

```
interface Ethernet0/0
 ipv6 address 3FFE:FFFF:1::1/64
 ipv6 ospf 1 area 0
```

OSPFv3 Configuration Example

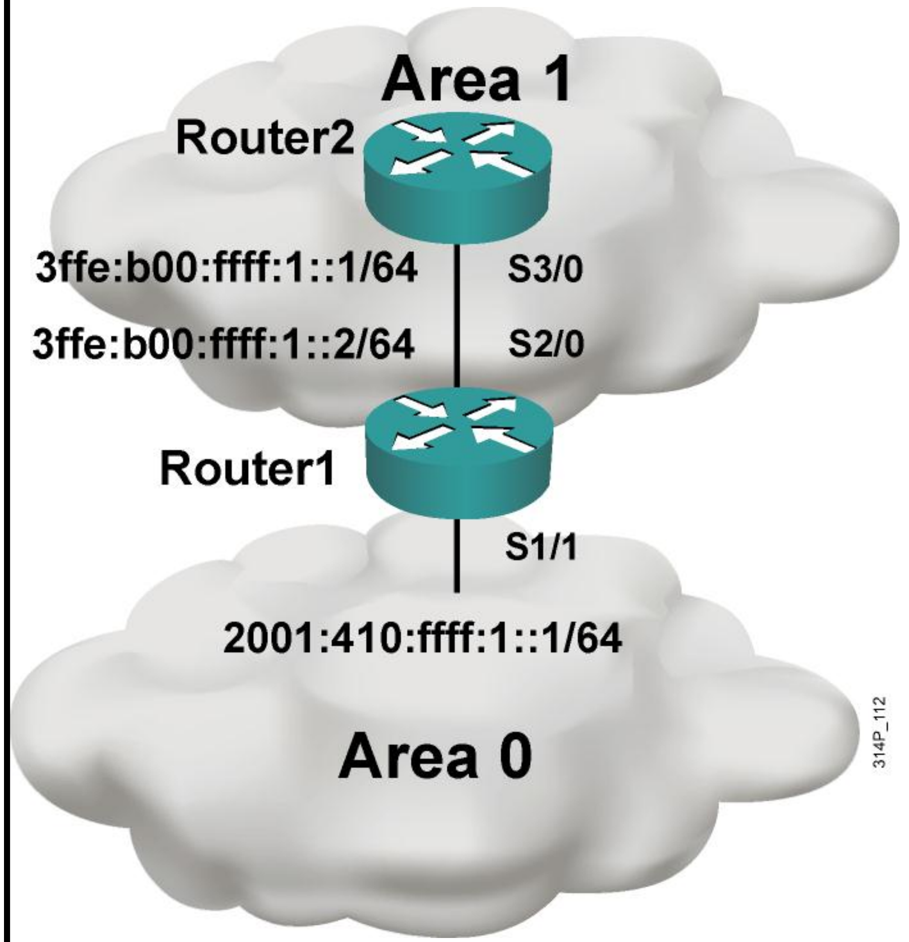
```
Router1#
interface S1/1
 ipv6 address 2001:410:FFFF:1::1/64
 ipv6 ospf 100 area 0

interface S2/0
 ipv6 address 3FFE:B00:FFFF:1::2/64
 ipv6 ospf 100 area 1

 ipv6 router ospf 100
   router-id 10.1.1.3


Router2#
interface S3/0
 ipv6 address 3FFE:B00:FFFF:1::1/64
 ipv6 ospf 100 area 1

ipv6 router ospf 100
   router-id 10.1.1.4
```



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