IPv6 Routing Protocols

ISP/IXP Workshops

Topics

- **Configuring IPv6 in IOS**
- **IPv6 Routing Protocols**

IPv6 Configuration

- **In order to enable IPv6 the following global command should be entered:**

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

- **To configure a global IPv6 or unique local IPv6 address the following interface command should be entered:**

  Router (config-if)# **ipv6 address X:X..X:X/prefix**

- **To configure an EUI-64 based IPv6 address (not so useful on a router) the following interface command should be entered:**

  Router (config-if)# **ipv6 address X:X::/prefix eui-64**

IPv6 Configuration

- **Note that by configuring an IPV6 address you will have a global or unique-local IPv6 address and a link-local IPv6 address which is**

  FE80::interface-id

- **The local-link IPv6 address is constructed automatically by concatenating FE80 with Interface ID as soon as IPv6 is enabled on the interface either by assigning an IPv6 address or simply by entering the command**

  Router(config-if)# ipv6 enable

IPv6 Configuration

```
R1E# conf t
R1E(config)# ipv6 unicast-routing
R1E(config)# ^Z

R1E#sh ipv6 interface
Ethernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::A8BB:CCFF:FE00:1E00
  No global unicast address is configured
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1E00
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled

 <snip>
```

IPv6 Configuration

```
R1E#sh ipv6 interface
Ethernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::A8BB:CCFF:FE00:1E00
  Global unicast address(es):
    2001:DB8::A8BB:CCFF:FE00:1E00, subnet is 2001:DB8::/64 [EUI]
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1E00
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  Hosts use stateless autoconfig for addresses.
```

Static Routing

- **Syntax is:**

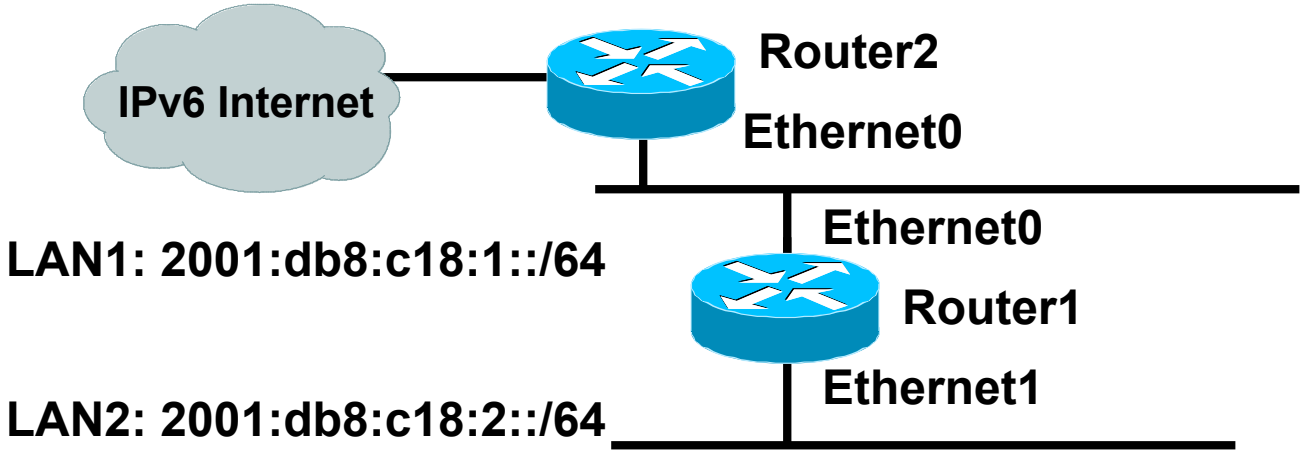
  ipv6 route *ipv6-prefix/prefix-length {ipv6-address | interface-type interface-number} [administrative-distance]*

- **Static Route**

```
Router(config)# ipv6 route 2001:db8::/64 2001:db8:0:CC00::1 110
```

Routes packets for network 2001:db8::/64 to a networking device at 2001:db8:0:CC00::1 with an administrative distance of 110

Default Routing Example




```
ipv6 unicast-routing

interface Ethernet0
 ipv6 address 2001:db8:c18:1::a/64
 ipv6 nd prefix-advertisement 2001:db8:c18:1::/64
43200 43200 onlink autoconfig

interface Ethernet1
 ipv6 address 2001:db8:c18:2::a/64
 ipv6 nd prefix-advertisement 2001:db8:c18:2::/64
43200 43200 onlink autoconfig

ipv6 route ::/0 <address of R2 ethernet0>
```

Default Route to Router2

Dynamic Routing Protocols in IPv6

- **Dynamic Routing in IPv6 is unchanged from IPv4:**
  - **IPv6 has 2 types of routing protocols: IGP and EGP**
  - **IPv6 still uses the longest-prefix match routing algorithm**
- **IGP**
  - **RIPng (RFC 2080)**
  - **Cisco EIGRP for IPv6**
  - **OSPFv3 (RFC 2740)**
  - **Integrated IS-ISv6 (draft-ietf-isis-ipv6-06)**
- **EGP**
  - **MP-BGP4 (RFC 2858 and RFC 2545)**

RIPng

- For the ISP industry, simply don't go here
- ISPs do not use RIP in any form unless there is absolutely no alternative
  - And there usually is
- RIPng was used in the early days of the IPv6 test network
  - Sensible routing protocols such as OSPF and BGP rapidly replaced RIPng when they became available

EIGRP for IPv6

- **Cisco EIGRP has had IPv6 protocol support added**
  - **Just another protocol module (IP, IPX, AppleTalk) with three new TLVs:**
    - **IPv6_REQUEST_TYPE (0X0401)**
    - **IPv6_METRIC_TYPE (0X0402)**
    - **IPv6_EXTERIOR_TYPE (0X0403)**
  - **Router-ID is still 32-bit, protocol is still 88**
- **Uses similar CLI to existing IPv4 protocol support**
- **Easy deployment path for existing IPv4 EIGRP users**
- **In IOS Release 12.4 onwards**

EIGRP for IPv6

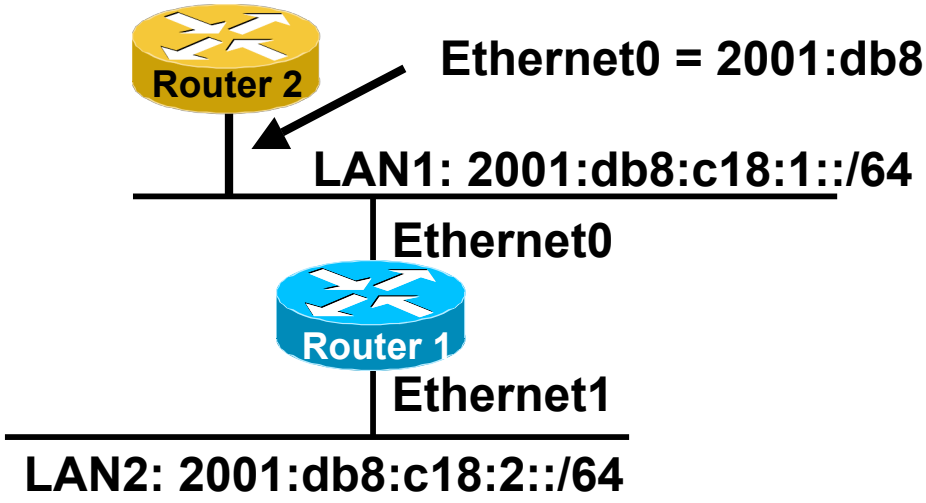
- **Some differences:**

  Hellos are sourced from the link-local address and destined to FF02::A (all EIGRP routers). This means that neighbors do not have to share the same global prefix (with the exception of explicitly specified neighbors where traffic is unicasted).

  Automatic summarization is disabled by default for IPv6 (unlike IPv4)

  No split-horizon in the case of EIGRP for IPv6 (because IPv6 supports multiple prefixes per interface)

EIGRP for IPv6—Configuration & Display




```
Router2#
ipv6 router eigrp 100
 Router-id 10.10.10.1

interface Ethernet0
 ipv6 address 2001:db8:c18:1::/64 eui-64
 ipv6 enable
 ipv6 eigrp 100
```

```
Router1#show ipv6 eigrp neighbor
IPv6-EIGRP neighbors for process 100
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
0   FE80::260:3eff:fe47:1530  E0              14 00:01:43    1     4500  0   1
```

```
Router1#show ipv6 eigrp topology all-links
IPv6-EIGRP Topology Table for AS(100)/ID(10.10.10.1)
Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status
P 2001:db8:c18:1::/64, 1 successors, FD is 28160, serno 1
        via Connected, Ethernet0
        via FE80::260:3eff:fe47:1530 (30720/28160), Ethernet0
```

Neighbour Identified by Link-Local Address

OSPFv3 overview

- OSPFv3 is OSPF for IPv6 (RFC 2740)
- Based on OSPFv2, with enhancements
- Distributes IPv6 prefixes
- Runs directly over IPv6
- Ships-in-the-night with OSPFv2

Differences from OSPFv2

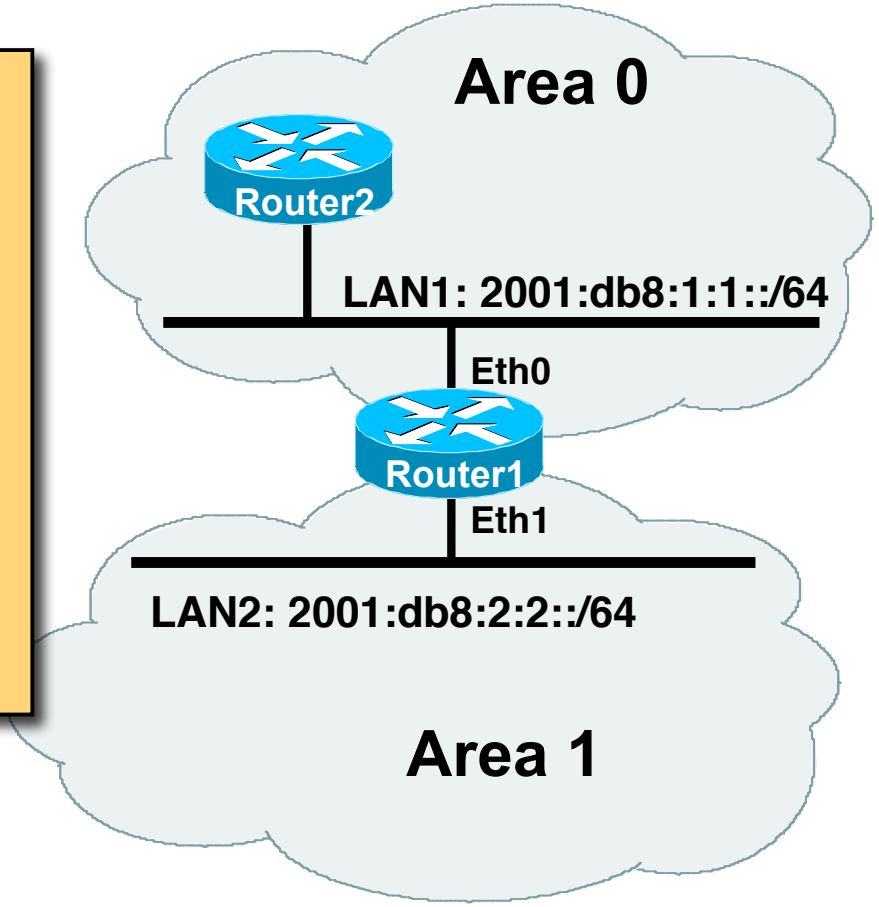
- Runs over a link, not a subnet
  - Multiple instances per link
- Topology not IPv6 specific
  - Router ID
  - Link ID
- Standard authentication mechanisms
- Uses link local addresses
- Generalized flooding scope
- Two new LSA types

OSPFv3 configuration example

```
Router1#
 interface Ethernet0
  ipv6 address 2001:db8:1:1::1/64
  ipv6 ospf 1 area 0

 interface Ethernet1
  ipv6 address 2001:db8:2:2::2/64
  ipv6 ospf 1 area 1

 ipv6 router ospf 1
  router-id 1.1.1.1
  area 1 range 2001:db8:2::/48
```



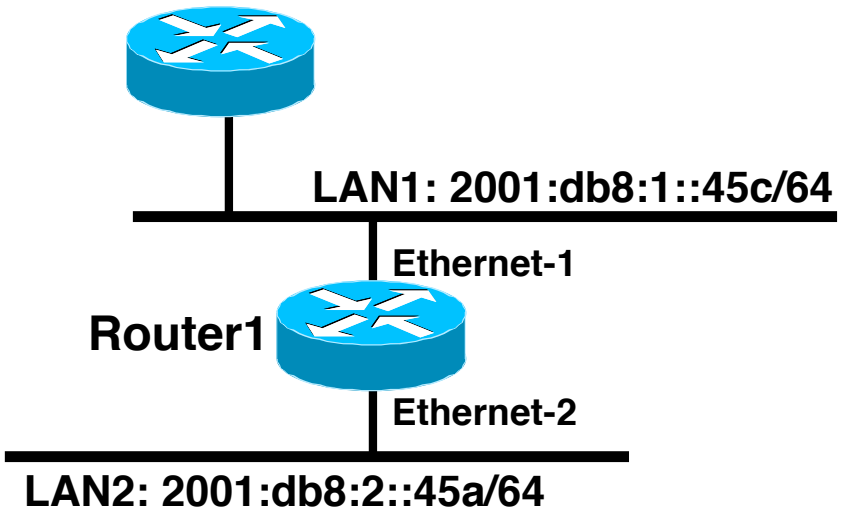
IS-IS Standards History

- IETF ISIS for Internets Working Group
- ISO 10589 specifies OSI IS-IS routing protocol for CLNS traffic
  - Tag/Length/Value (TLV) options to enhance the protocol
  - A Link State protocol with a 2 level hierarchical architecture.
- RFC 1195 added IP support, also known as Integrated IS-IS (I/IS-IS)
  - I/IS-IS runs on top of the Data Link Layer
  - Requires CLNP to be configured
- Internet Draft defines how to add IPv6 address family support to IS-IS
  - www.ietf.org/internet-drafts/draft-ietf-isis-ipv6-06.txt
- Internet Draft introduces Multi-Topology concept for IS-IS
  - www.ietf.org/internet-drafts/draft-ietf-isis-wg-multi-topology-11.txt

IS-IS for IPv6

- 2 Tag/Length/Values added to introduce IPv6 routing
- IPv6 Reachability TLV (0xEC)
  - External bit
  - Equivalent to IP Internal/External Reachability TLV's
- IPv6 Interface Address TLV (0xE8)
  - For Hello PDUs, must contain the Link-Local address
  - For LSP, must only contain the non-Link Local address
- IPv6 NLPID (0x8E) is advertised by IPv6 enabled routers

Cisco IOS IS-IS dual IP configuration



Dual IPv4/IPv6 configuration. Redistributing both IPv6 static routes and IPv4 static routes.

```
Router1#
interface ethernet-1
 ip address 10.1.1.1 255.255.255.0
 ipv6 address 2001:db8:1::45c/64
 ip router isis
 ipv6 router isis

interface ethernet-2
 ip address 10.2.1.1 255.255.255.0
 ipv6 address 2001:db8:2::45a/64
 ip router isis
 ipv6 router isis

router isis
 address-family ipv6
  redistribute static
  exit-address-family
 net 42.0001.0000.0000.072c.00
 redistribute static
```

Multi-Topology IS-IS extensions

- **New TLVs attributes for Multi-Topology extensions.**

  ***Multi-topology TLV*: contains one or more multi-topology ID in which the router participates. It is theoretically possible to advertise an infinite number of topologies. This TLV is included in IIH and the first fragment of a LSP.**

  ***MT Intermediate Systems TLV*: this TLV appears as many times as the number of topologies a node supports. A MT ID is added to the extended IS reachability TLV type 22.**

  ***Multi-Topology Reachable IPv4 Prefixes TLV*: this TLV appears as many times as the number of IPv4 announced by an IS for a give n MT ID. Its structure is aligned with the extended IS Reachability TLV Type 236 and add a MT ID.**

  ***Multi-Topology Reachable IPv6 Prefixes TLV*: this TLV appears as many times as the number of IPv6 announced by an IS for a given MT ID. Its structure is aligned with the extended IS Reachability TLV Type 236 and add a MT ID.**

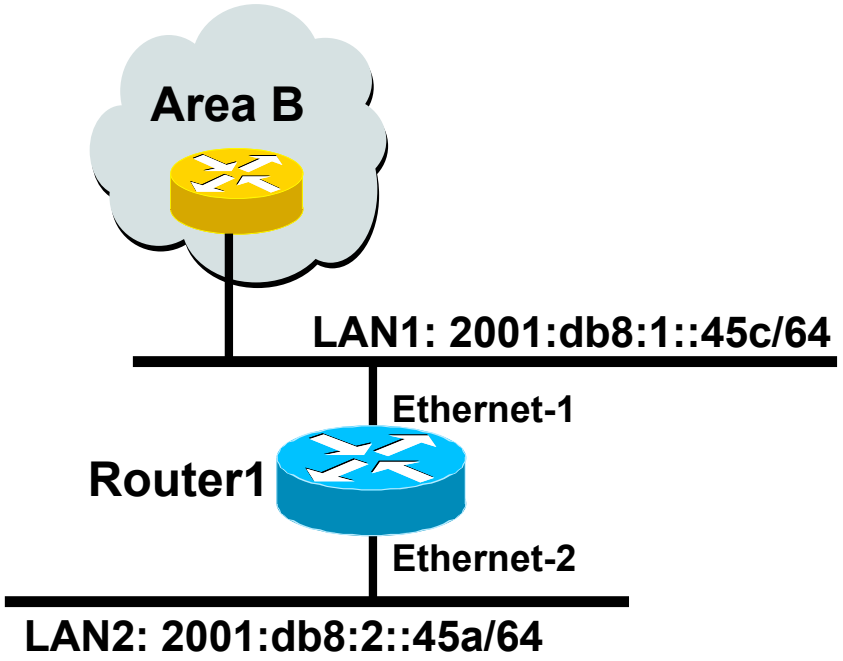
- **Multi-Topology ID Values**

  Multi-Topology ID (MT ID) standardized and in use in Cisco IOS:

  MT ID #0 – "standard" topology for IPv4/CLNS

  MT ID #2 – IPv6 Routing Topology.

Multi-Topology ISIS configuration example



- The optional keyword *transition* may be used for transitioning existing IS-IS IPv6 single SPF mode to MT IS-IS
- Wide metric is mandated for Multi-Topology to work

```
Router1#
interface ethernet-1
 ip address 10.1.1.1 255.255.255.0
 ipv6 address 2001:db8:1::45c/64
 ip router isis
 ipv6 router isis
 isis ipv6 metric 20

interface ethernet-2
 ip address 10.2.1.1 255.255.255.0
 ipv6 address 2001:db8:2::45a/64
 ip router isis
 ipv6 router isis
 isis ipv6 metric 20

router isis
 net 49.0000.0100.0000.0000.0500
 metric-style wide
 !
 address-family ipv6
  multi-topology
 exit-address-family
```

Multi-Protocol BGP for IPv6 – RFC2545

- **IPv6 specific extensions**

  Scoped addresses: Next-hop contains a global IPv6 address and/or potentially a link-local address

  NEXT_HOP and NLRI are expressed as IPv6 addresses and prefix

  Address Family Information (AFI) = 2 (IPv6)

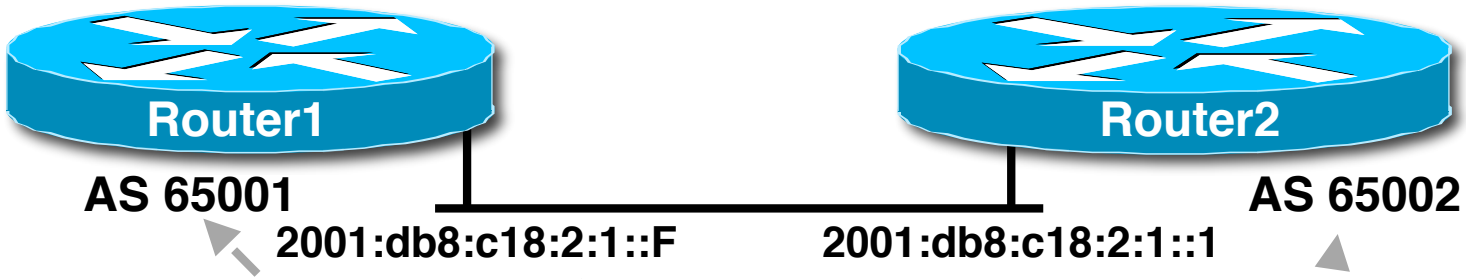
    Sub-AFI = 1 (NLRI is used for unicast)

    Sub-AFI = 2 (NLRI is used for multicast RPF check)

    Sub-AFI = 3 (NLRI is used for both unicast and multicast RPF check)

    Sub-AFI = 4 (label)

A Simple MP-BGP Session




```
Router1#
interface Ethernet0
 ipv6 address 2001:db8:c18:2:1::F/64
!
router bgp 65001
 bgp router-id 10.10.10.1
 no bgp default ipv4-unicast
 neighbor 2001:db8:c18:2:1::1 remote-as 65002
 address-family ipv6
  neighbor 2001:db8:c18:2:1::1 activate
  neighbor 2001:db8:c18:2:1::1 prefix-list bgp65002in in
  neighbor 2001:db8:c18:2:1::1 prefix-list bgp65002out out
  exit-address-family
```

Routing Protocols for IPv6 Summary

- **Support for IPv6 in the major routing protocols**
- **More details for OSPF, ISIS and BGP in following presentations**

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