IPv6 Routing Protocols

ITU/APNIC IPv6 Infrastructure Workshop

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Initial IPv6 Configuration for Cisco IOS

IPv6 Configuration on Cisco IOS

- To enable IPv6 the following global commands are required:

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

  - Also enable IPv6 CEF (not on by default):

```
Router(config)# ipv6 cef
```

  - Also disable IPv6 Source Routing (enabled by default):

```
Router(config)# no ipv6 source-route
```

IPv6 Configuration

- To configure a global 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 the following interface command should be entered:

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

  - EUI-64 is not helpful on a router and is not recommended

IPv6 Configuration

- If no global IPv6 address is required on an interface, yet it needs to carry IPv6 traffic:
  - Enable IPv6 on that interface using:

```
Router(config-if)# ipv6 enable
```

  - Which will result in a link-local IPv6 address being constructed automatically
  - FE80:: is concatenated with the Interface ID to give:
    - FE80::interface-id
- Configuring an IPv6 address (whether global or unique-local) will also result in a link-local IPv6 address being created

IPv6 Configuration

```
Router1# conf t
Router1(config)# no ipv6 source-route
Router1(config)# ipv6 unicast-routing
Router1(config)# ipv6 cef
Router1(config)# interface FastEthernet 0/0
Router1(config-int)# ipv6 enable
Router1(config-int)# ^Z

Router1#sh ipv6 interface fast 0/0
FastEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::A8B9:C0FF:FE00:F11D
  No global unicast address is configured
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:F11D
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
```

IPv6 Configuration – EUI64

```
Router1#sh ipv6 interface fast 0/0
FastEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::A8B9:C0FF:FE00:F11D
  Global unicast address(es):
    2001:DB8::A8B9:C0FF:FE00:F11D, subnet is 2001:DB8::/64 [EUI]
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:F11D
  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.
```

IPv6 Configuration – Static

```
Router1#sh ipv6 int fast 0/0
FastEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::A8B9:C0FF:FE00:F11D
  Global unicast address(es):
    2001:DB8::2, subnet is 2001:DB8::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF08:2
    FF02::1:FF00:F11D
  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.
```

IPv6 Interface Configuration Duplicate Address Detection

- If a point-to-point interface (e.g. POS, HSSI, Serial) is looped:
  - Router sees its address by Solicited Node Multicast
  - Duplicate Address Detection kicks in:

```
Aug 23 09:18:41.263: %IPV6_ND-6-DUPLICATE_INFO: DAD attempt
detected for 2001:DB8:0:3:: on Serial1/1
```

  - Interface automatically disabled for IPv6 traffic (IPv4 traffic is unaffected)
  - This has impact for backbone links (IPv6 traffic takes alternative path) and external peering links (IPv6 peering down, IPv4 peering okay)
- Workaround?
  - Monitoring!

Routing Protocols

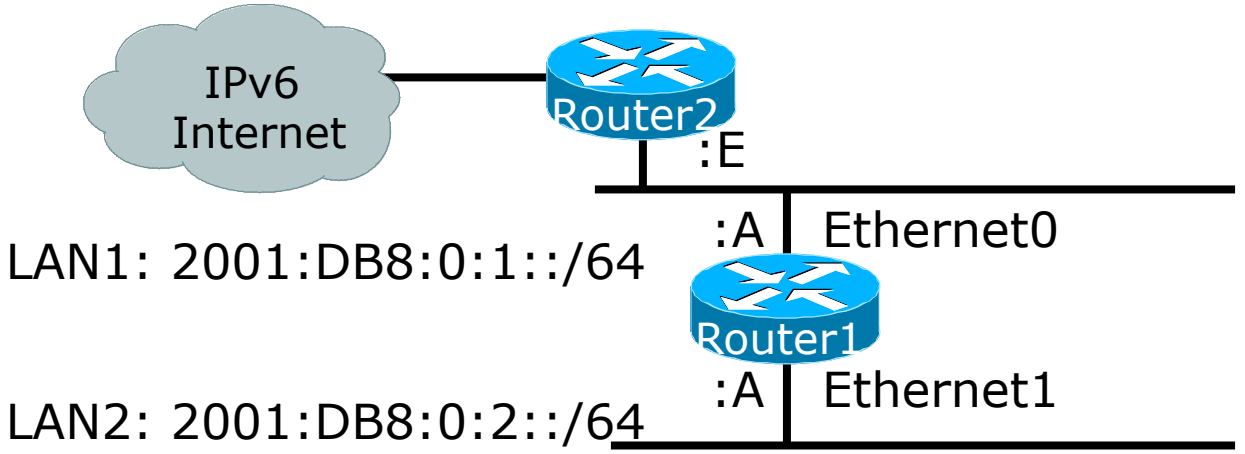
Static Routing

- Syntax is:
  - ipv6 route ipv6-prefix/prefix-length {ipv6-address | interface-type interface-number} [administrative-distance]
- Static Route

```
ipv6 route 2001:DB8::/64 2001:DB8:0:ABCD::1 150
```

  - Routes packets for network 2001:db8::/64 to a networking device at 2001:DB8:0:ABCD::1 with an administrative distance of 150

Default Routing Example




```
ipv6 unicast-routing
!
interface Ethernet0
 ipv6 address 2001:DB8:0:1::A/64
!
interface Ethernet1
 ipv6 address 2001:DB8:0:2::A/64
!
ipv6 route ::/0 2001:DB8:0:1::E
```

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 5340)
  - Integrated IS-ISv6 (RFC 5308)
- EGP
  - MP-BGP4 (RFC 4760 and RFC 2545)

Configuring Routing Protocols

- Dynamic routing protocols require router-id
  - Router-id is a 32 bit integer
  - IOS auto-generates these from loopback interface address if configured, else highest IPv4 address on the router
  - Most ISPs will deploy IPv6 dual stack – so router-id will be automatically created
- Early adopters choosing to deploy IPv6 in the total absence of any IPv4 addressing need to be aware:
  - Router-id needs to be manually configured:

```
ipv6 router ospf 100
 router-id 10.1.1.4
```

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

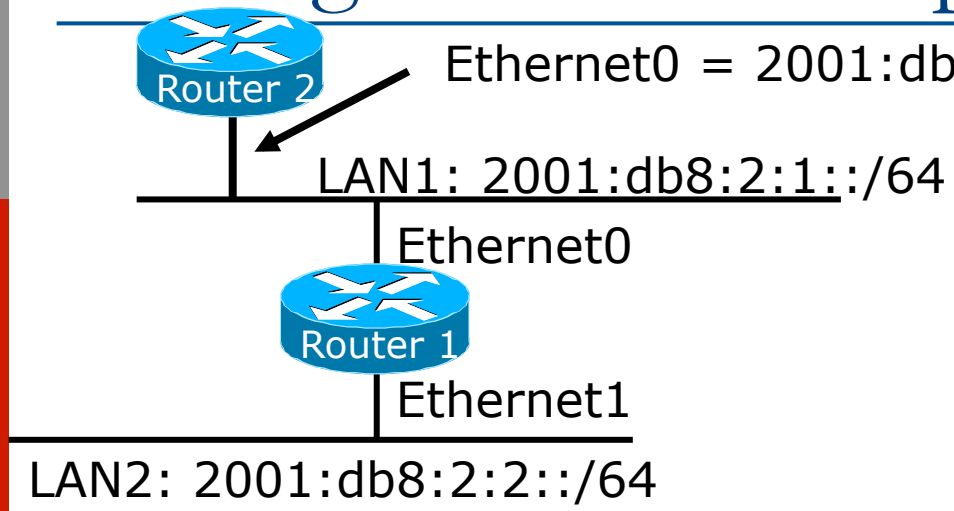
EIGRP for IPv6

- 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 Cisco 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 neighbours where traffic is unicasted).
  - Automatic summarisation 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 1.1.1.1

interface Ethernet0
 ipv6 address 2001:db8:2:1::/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::245:21ff:fe00:feed  E0          14 00:01:43    1 4500   0   1
```

```
Router1#show ipv6 eigrp topology all-links
IPv6-EIGRP Topology Table for AS(100)/ID(1.1.1.1)
Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status
P 2001:db8:2:1::/64, 1 successors, FD is 28160, serno 1
        via Connected, Ethernet0
        via FE80::245:21ff:fe00:feed (30720/28160), Ethernet0
```

Neighbour Identified by Link-Local Address

OSPFv3 overview

- OSPFv3 is OSPF for IPv6 (RFC 5340)
- Based on OSPFv2, with enhancements
- Distributes IPv6 prefixes
- Runs directly over IPv6
- Ships-in-the-night with OSPFv2

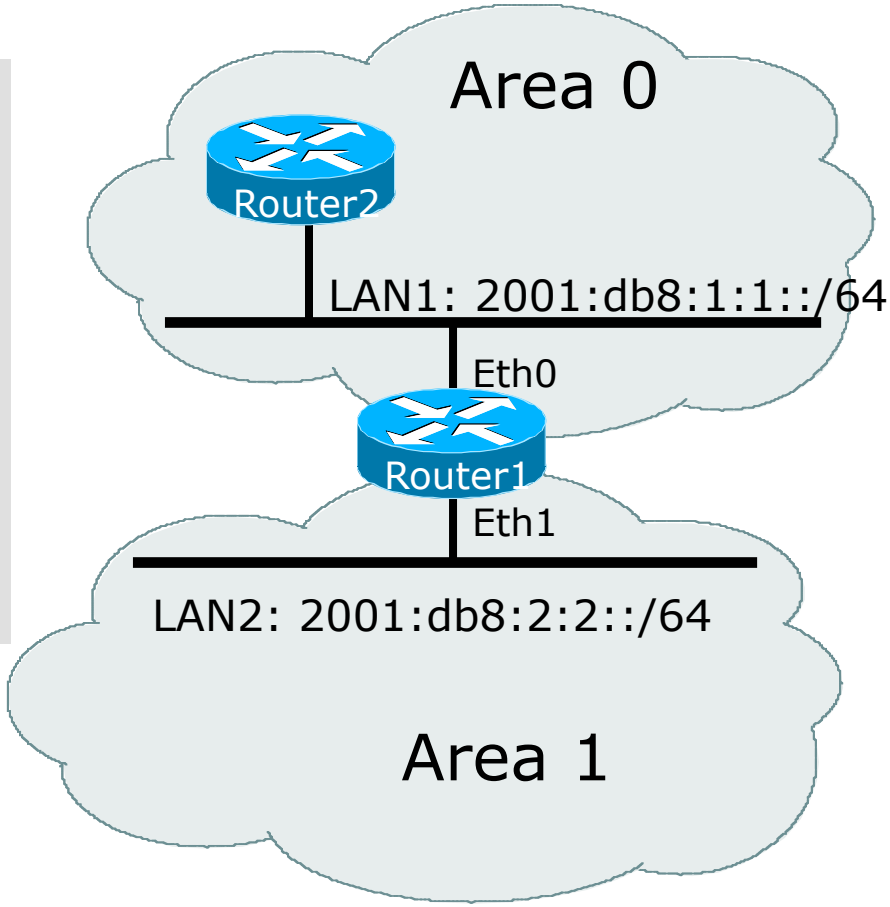
Differences from OSPFv2

- 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
```

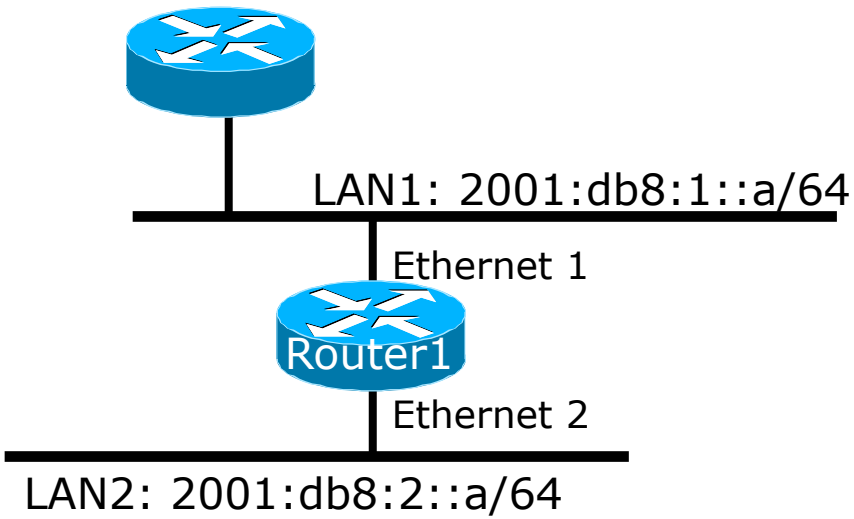
NB: Router-id only required in absence of any ipv4 configuration



ISIS Standards History

- ISO 10589 specifies the OSI IS-IS routing protocol for CLNS traffic
- RFC 1195 added IPv4 support
  - Also known as Integrated IS-IS (I/IS-IS)
  - I/IS-IS runs on top of the Data Link Layer
- RFC5308 adds IPv6 address family support
- RFC5120 defines Multi-Topology concept
  - Permits IPv4 and IPv6 topologies which are not identical
  - Permits roll out of IPv6 without impacting IPv4 operations

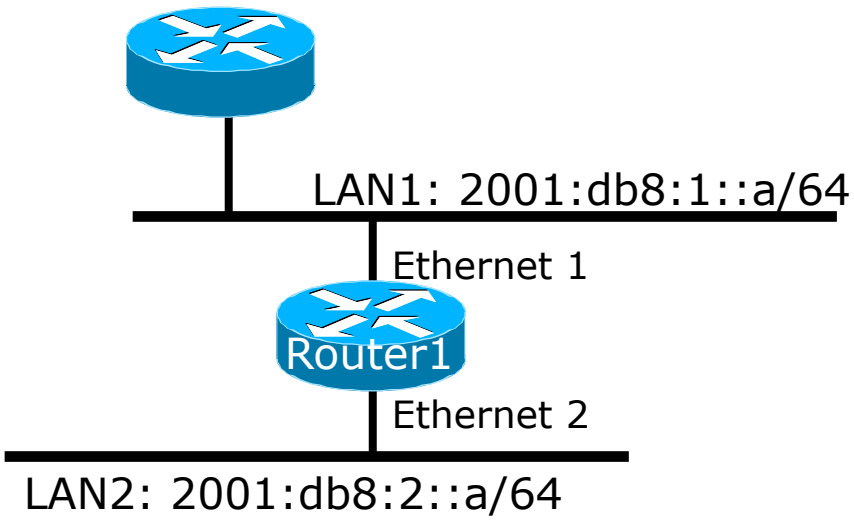
Cisco IOS IS-IS dual stack configuration – single topology



Dual stack IPv4/IPv6 single topology configuration.

```
Router1#
interface ethernet 1
 ip address 10.1.1.1 255.255.255.0
 ipv6 address 2001:db8:1::a/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::a/64
 ip router isis
 ipv6 router isis
!
router isis
 net 42.0001.0000.0000.072c.00
 metric-style wide
!
```

Cisco IOS IS-IS dual stack configuration – multi-topology



Dual stack IPv4/IPv6 multi-topology configuration.

```
Router1#
interface ethernet 1
 ip address 10.1.1.1 255.255.255.0
 ipv6 address 2001:db8:1::a/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::a/64
 ip router isis
 ipv6 router isis
!
router isis
 net 42.0001.0000.0000.072c.00
 metric-style wide
!
 address-family ipv6
  multi-topology
!
```

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:db8:2:1::f/64
!
router bgp 65001
 bgp router-id 10.10.10.1
 no bgp default ipv4-unicast
 neighbor 2001:db8:2:1::1 remote-as 65002
 address-family ipv6
  neighbor 2001:db8:2:1::1 activate
  neighbor 2001:db8:2:1::1 prefix-list bgp65002in in
  neighbor 2001:db8:2:1::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 separate presentations

IPv6 Routing Protocols