ISIS for IPv6

ISP Training Workshops

Topics Covered

- IS-IS standardisation
- IS-IS for IPv6
- Multi-Topology IS-IS

ISIS Standards History

- IETF ISIS for IP 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

ISIS Standards History

- RFC5308 adds IPv6 address family support to IS-IS

- RFC5120 defines Multi-Topology concept for IS-IS

  - Permits IPv4 and IPv6 topologies which are not identical

  - Permits gradual roll out of IPv6 without impacting IPv4 operations

Integrated IS-IS for IPv6 Overview

- 2 Tag/Length/Values (TLV) added to support IPv6 routing

- IPv6 Reachability TLV (0xEC)

  - Describes network reachability such as IPv6 routing prefix, metric information and some option bits; the option bits indicates the advertisement of IPv6 prefix from a higher level, redistribution from other routing protocols.

  - Equivalent to IP Internal/External Reachability TLVs described in RFC1195

Integrated IS-IS for IPv6 Overview

- IPv6 Interface Address TLV (0xE8)
  - Contains 128 bit address
  - For Hello PDUs, must contain the link-local address (FE80::/10)
  - For LSP, must only contain the non link-local address
- A new Network Layer Protocol Identifier (NLPID) is defined
  - Allowing IS-IS routers with IPv6 support to advertise IPv6 prefix payload using 0x8E value (IPv4 and OSI uses different values)

ISIS for IPv6

IS-IS for IPv6

- IS-IS for IPv6 is available across all Cisco IOS releases
- A single SPF runs per level for OSI, IPv4 and IPv6
  - All routers in an area must run the same set of protocols [IPv4-only, IPv6-only, IPv4-IPv6]
  - L2 routers don't have to be configured similarly but no routing hole must exist

Simple SPF rules (1)

- If IS-IS is used for both IPv4 and IPv6 in an area, both protocols must support the same topology within this area.
  - Could set "no adjacency-check" between L2 routers, but must be used with caution
- All interfaces configured with IS-ISv6 must support IPv6
  - Can't be configured on DPT as it is not supported
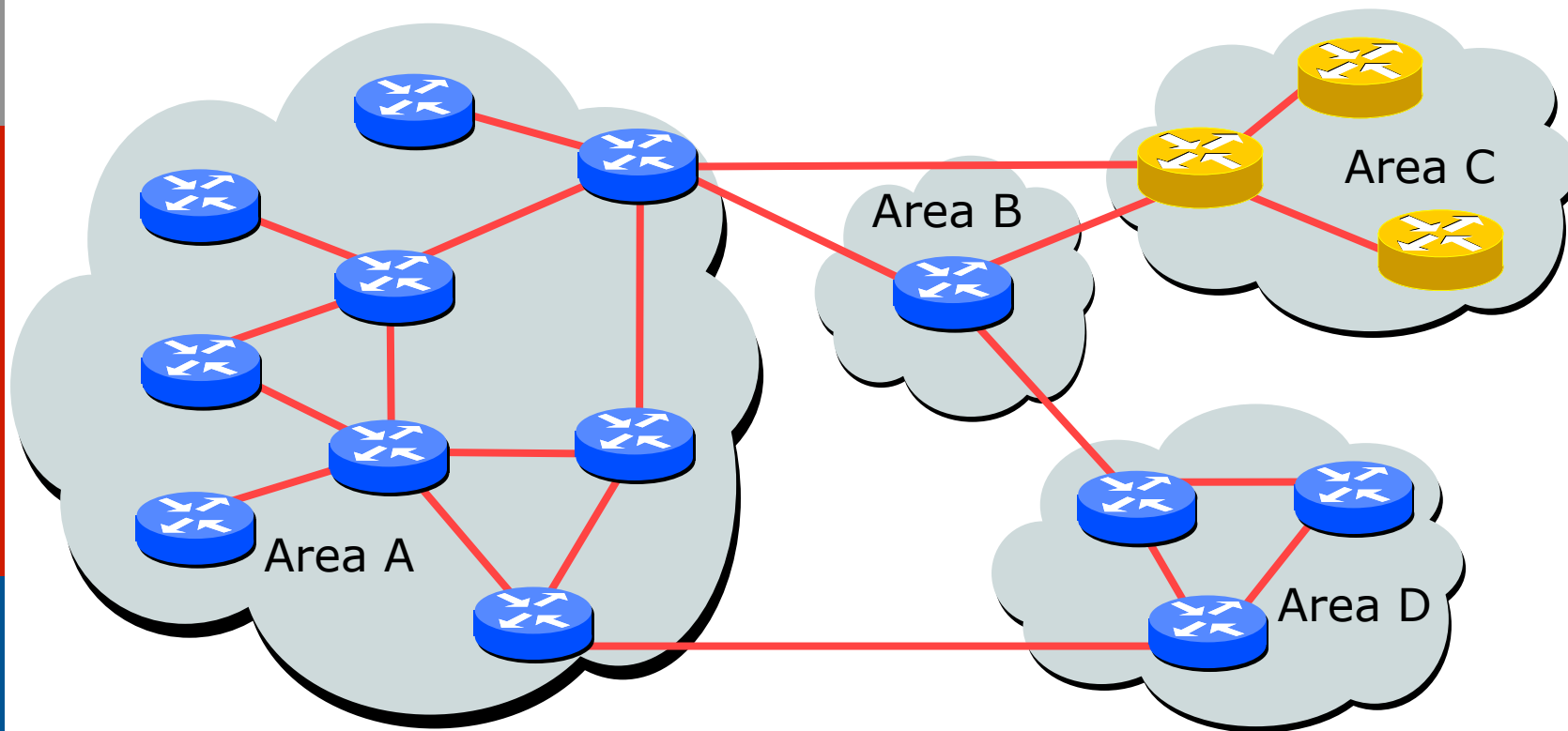 - Can't be configured on MPLS/TE since IS-ISv6 extensions for TE are not yet defined

Simple SPF rules (2)

- All interfaces configured with IS-IS for both protocols must support both of them
  - IPv6 configured tunnel won't work, GRE should be used in this configuration
- Otherwise, consider Multi-Topology IS-IS (separate SPF)

Single SPF IS-IS for IPv6 restrictions

- IS-IS for IPv6 uses the same SPF for both IPv4 and IPv6.
- Therefore:
  - Not really suitable for an existing IPv4 IS-IS network where operator wants to turn on scattered IPv6 support
  - If using IS-IS for both IPv4 and IPv6 then the IPv4 and IPv6 topologies MUST match exactly. Cannot run IS-IS IPv6 on some interfaces, IS-IS IPv4 on others.
  - Will only form adjacencies with similarly-configured routers. E.g. An IS-IS IPv6-only router will not form an adjacency with an IS-IS IPv4/IPv6 router. (Exception is over L2-only interface)
  - Cannot join two IPv6 areas via an IPv4-only area. L2 adjacencies will form OK but IPv6 traffic will black-hole in the IPv4 area.

IS-IS Hierarchy & IPv6 example

IPv4-IPv6 enabled router

IPv4-only enabled router

Configuring IS-IS for IPv6

- Configure generic IS-IS interface attributes
    - eg., circuit type, priority, etc
- Configure IS-IS for IPv6 on interfaces
    - Interface must be IPv6 enabled, eg. IPv6 address set
- Configure IS-IS router mode attributes
    - Some router-mode commands have no effect on IPv6, eg. Metric-style, mpls, traffic-share,…
- Configure IS-IS for IPv6 specific attributes
    - IPv6 attributes are configured via the IPv6 address-family sub-mode of router-mode.

13

IS-IS for IPv6 Specific Attributes (1)

- ❑ Entering address-family sub-mode

  `[no]` **`address-family ipv6`**

- ❑ IPv6 address-family sub-mode.

  `[no]` **`adjacency-check`**

  - ■ Enables or disables adjacency IPv6 protocol-support checks. If checking is enabled (default condition when IS-IS IPv6 is configured) then the router will not form an adjacency with a neighbor not supporting IS-IS IPv6.

  `[no]` **`distance <1-254>`**

  - ■ Sets the administrative distance of IS-IS IPv6. Note that the administrative distance is applied to routes in the IPv6 routing table only.

14

IS-IS for IPv6
Specific Attributes (2)

`[no] maximum-paths <1-4>`

- Sets the maximum number of paths allowed for a route learnt via IS-IS IPv6. Note that this applies to the IPv6 routing table only.

`[no] default-information originate [route-map <name>]`

- Configures origination of the IPv6 default route (::) by IS-IS. Used in the same manner as the existing IPv4 default-information command.

`[no] summary-prefix <prefix> [level-1|level-2|level-1-2]`

- Configures IPv6 summary prefixes. Command is used in same manner as the existing IPv4 summary-prefix command.

IS-IS for IPv6
Specific Attributes (3)

```
[no] redistribute <protocol> [metric <value>]
   [metric-type {internal|external}] [level-1|
   level-1-2|level-2] [route-map <name>]
```

- Configures redistribution of routes learnt from other IPv6 sources into IS-IS. Command is used in same manner as existing IPv4 redistribute command.

```
[no] redistribute isis {level-1|level-2} into
   {level-1|level-2} distribute-list <prefix-list-
   name>
```

- Configures IS-IS inter-area redistribution of IPv6 routes. Command is used in same manner as existing IPv4 redistribute isis command.

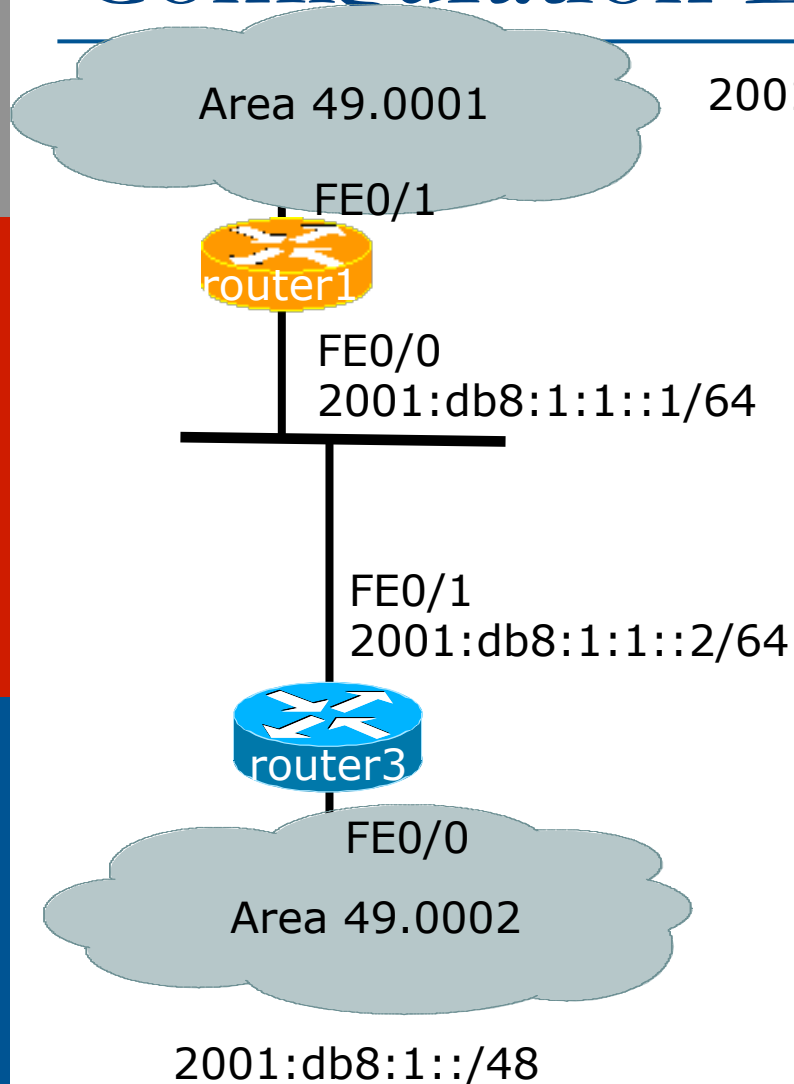❑ Leaving address-family sub-mode

`exit-address-family`

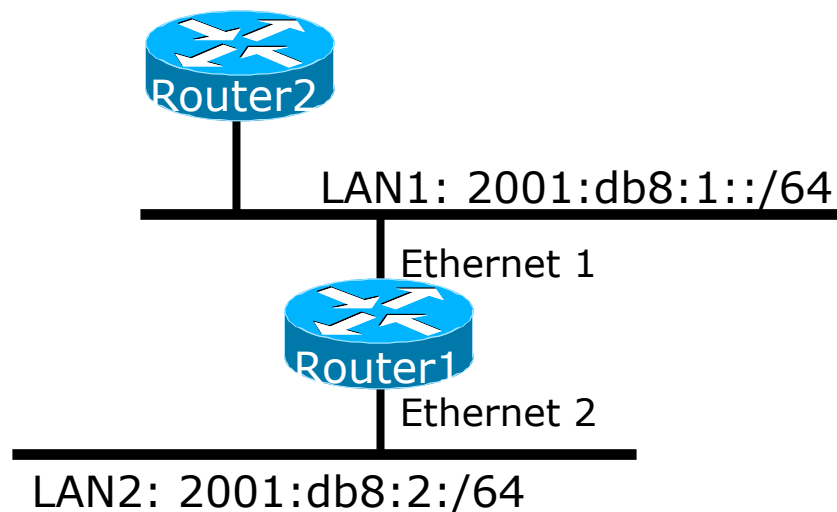❑ Showing the I/IS-ISv6 configuration

`show ipv6 protocols [summary]`

16

ISIS for IPv6 Configuration Example

Area 49.0001

2001:db8:1::/48

FE0/1

router1

FE0/0
2001:db8:1:1::1/64

FE0/1
2001:db8:1:1::2/64

router3

FE0/0

Area 49.0002

2001:db8:1::/48

```
Router1#
 interface fastethernet0/0
  ipv6 address 2001:db8:1:1::1/64
  ipv6 router isis
  isis circuit-type level-2-only

 router isis
  net 49.0001.1921.6801.0001.00
  address-family ipv6
   redistribute static
  exit-address-family
```

IS-IS dual stack configuration

LAN1: 2001:db8:1::/64

Ethernet 1

Router1

Ethernet 2

LAN2: 2001:db8:2:/64

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::1/64
 ip router isis
 ipv6 router isis

interface ethernet 2
 ip address 10.2.1.1 255.255.255.0
 ipv6 address 2001:db8:2::1/64
 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
```

ISIS Display (1)

```
Router1#show ipv6 route is-is

IPv6 Routing Table - 14 entries

Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea

Timers: Uptime/Expires


I1  2001:DB8:1000::/64 [115/20]

    via FE80::210:7BFF:FEC2:ACCC, Ethernet1, 00:10:12/never

I1  2001:DB8:2000::/64 [115/10]

    via FE80::210:7BFF:FEC2:ACCC, Ethernet1, 00:05:19/never

I1  2002:49::/64 [115/10]

    via FE80::210:7BFF:FEC2:ACCC, Ethernet1, 00:05:19/never
```

ISIS Display (2)

```
Router3#sho clns is-neigh detail

System Id        Interface    State  Type Priority  Circuit Id        Format
brum-45a         Et1          Up     L1   64         router3.01        Phase V
  Area Address(es): 47.0023.0001.0000.0001.0002.0001
  IPv6 Address(es): FE80::210:7BFF:FEC2:ACCC
  Uptime: 00:06:56

IS-IS Level-1 Link State Database:
LSPID                LSP Seq Num   LSP Checksum  LSP Holdtime    ATT/P/OL
router3.00-00      * 0x00000003    0xA745        732             0/0/0
  Area Address: 47.0023.0001.0000.0001.0002.0001
  NLPID:        0x8E
  Hostname: Router3
  IPv6 Address: 3F02::45C
  IPv6 Address: 2001:db8:2000::45C
  Metric: 10       IPv6 2001:db8:1000::/64
  Metric: 10       IPv6 3F02::/64
  Metric: 10       IPv6 2001:db8:2000::/64
  Metric: 10       IS router3.02
  Metric: 10       IS router3.01
router3.01-00      * 0x00000001    0x96DB        733             0/0/0
  Metric: 0        IS router3.00
  Metric: 0        IS router1.00
router1.00-00        0x00000005    0xDDBA        1027            0/0/0
  Area Address: 47.0023.0001.0000.0001.0002.0001
  NLPID:        0x8E
  Hostname: Router1
  IPv6 Address: 2001:db8:1000::45A
  Metric: 10       IPv6 2001:db8:1000::/64
  Metric: 10       IS router3.01
  Metric: 0        IPv6-Ext 2001:db8:2000::/64
  Metric: 0        IPv6-Ext 2002:49::/64
```

Multi-topology ISIS

Multi-Topology IS-IS extensions

- IS-IS for IPv6 assumes that the IPv6 topology is the same as the IPv4 topology
  - Single SPF running, multiple address families
  - Some networks may be like this, but some others may not be
- Multi-Topology IS-IS solves this problem
  - New TLV attributes introduced
  - New Multi-Topology ID #2 for IPv6 Routing Topology
  - Cisco IOS now maintains two topologies:
    - ISO/IPv4 Routing Topology
    - IPv6 Routing Topology

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.

23

Multi-Topology IS-IS Restrictions

- This feature is not compatible with the previous single SPF model
    - New TLV are used to transmit and advertise IPv6 capabilities
    - All routers that run IS-IS for IPv6 need to enable multi-topology within the network
    - A transition mode (see later) is provided for existing IS-IS IPv6 network to migrate to Multi-Topology IS-IS IPv6
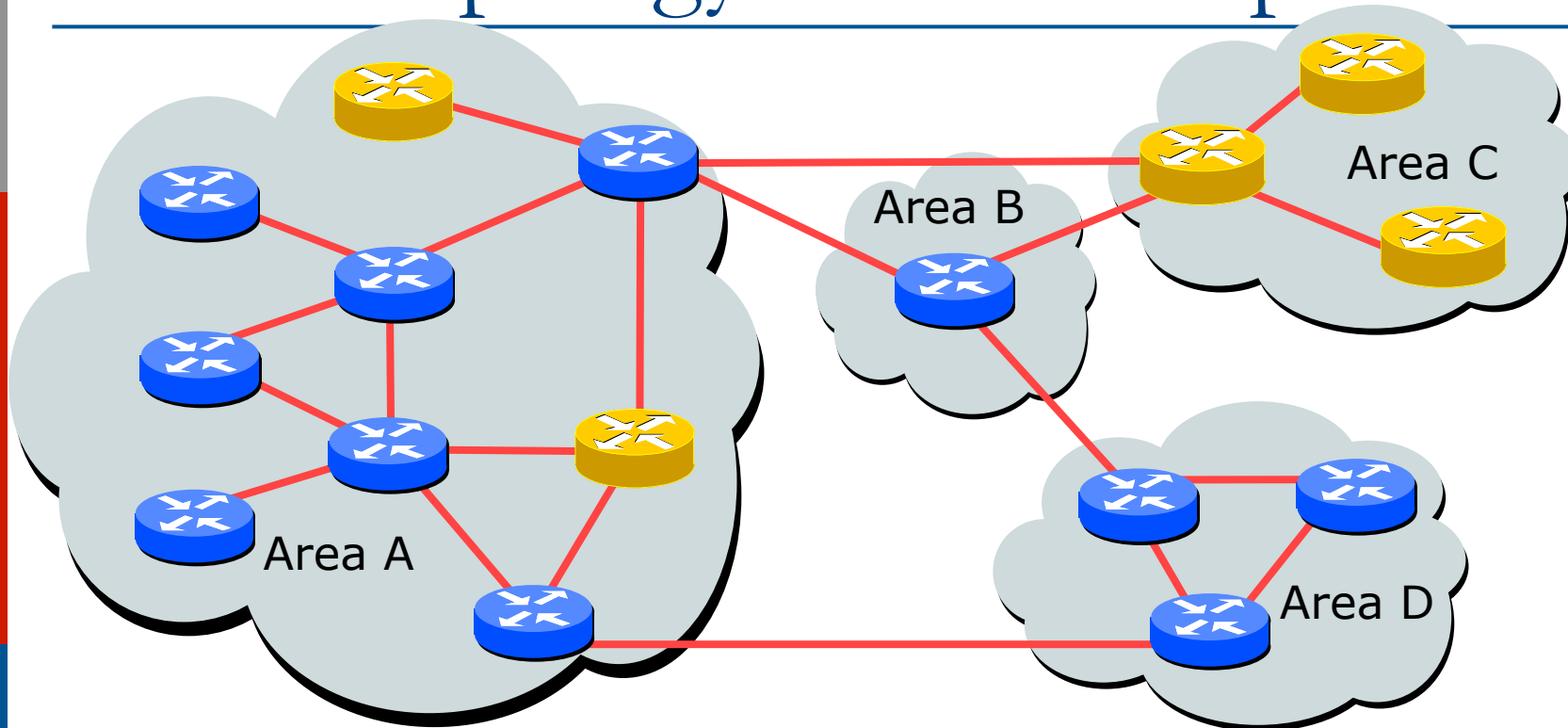
Multi-Topology IS-IS Restrictions

- IPv4 or IPv6 or IPv4/IPv6 may be configured on the interface for either level-1, level-2 or level-1-2

- If IPv4 and IPv6 are configured on the same interface, they must be running the same IS-IS level

  - IPv4 cannot be configured to run on ISIS level-1 only on an interface while IPv6 is configured to run ISIS level-2 only on the same interface.

Multi-Topology IS-IS Restrictions

- All routers on a LAN or point-to-point link must have at least one common supported topology (IPv4 or IPv6) when operating in Multi-Topology IS-IS mode

  - N.B. a router that is not operating in Multi-Topology IS-IS IPv6 mode cannot form adjacency with Multi-Topology IS-IS IPv6 router, even though IPv6 is the common supported topology. However, if IPv4 is the common supported topology between those two routers, adjacency should be formed.

- Wide metrics are required to be enabled globally within the Autonomous System

  - (Default for most ISPs these days anyway)

26

Multi-Topology IS-IS example

Area C

Area B

Area A

Area D

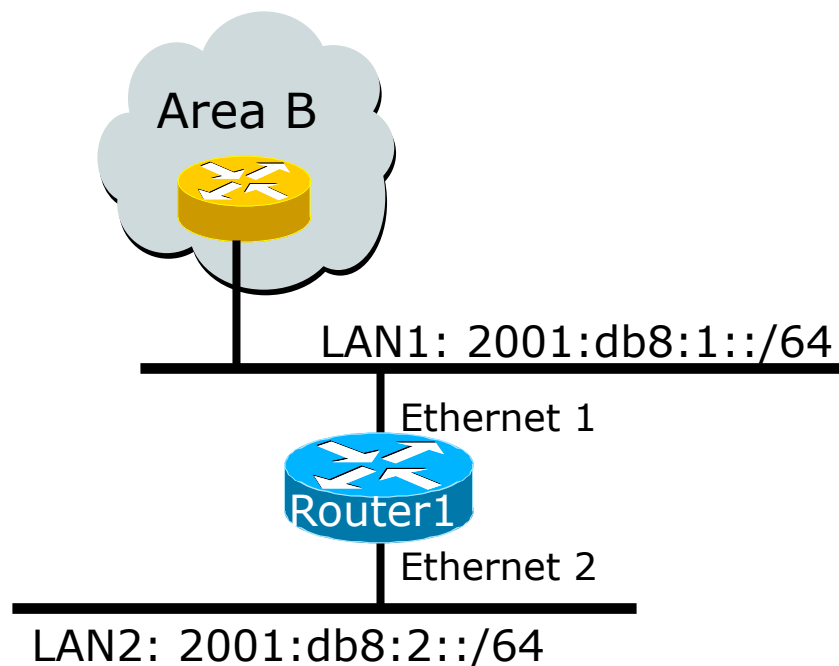IPv4-IPv6 enabled router

IPv4-only enabled router

The Multi-Topology software will create two topologies inside Area:
IPv4 and IPv6.
IPv4-only routers will be excluded from the IPv6 topology

27

Multi-Topology ISIS Configuration example

Area B

LAN1: 2001:db8:1::/64

Ethernet 1

Router1

Ethernet 2

LAN2: 2001:db8:2::/64

- ☐ 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::1/64
 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::1/64
 ip router isis
 ipv6 router isis
 isis ipv6 metric 20

router isis isp
 net 49.0000.0100.0000.0500.00
 metric-style wide
 !
 address-family ipv6
  multi-topology
 exit-address-family
```

Narrow to Wide Metrics Transition

- When migrating from narrow to wide metrics, care is required
  - Narrow and wide metrics are NOT compatible with each other
  - Migration is a two stage process, using the "transition" keyword

- Networks using narrow metrics should first configure across all routers:

```
router isis isp
 metric-style transition
```

- Once the whole network is changed to transition support, the metric style can be changed to wide:

```
router isis isp
 metric-style wide
```

Multi-Topology IS-IS Display

```
Router# show clns neighbors detail
System Id    Interface    SNPA    State  Holdtime    Type    Protocol
2653         Se0/1        *HDLC*    Up         25    L1L2    M-ISIS
          Area Address(es): 49.0000.01
          IP Address(es): 192.168.0.6*
          IPv6 Address(es): FE80::204:C1FF:FEDB:2FA0
          Uptime: 00:01:22
          Topology: IPv4, IPv6

Router# show isis database detail
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num      LSP Checksum     LSP Holdtime      ATT/P/OL
2651.00-00    0x0000000F        0x0161           1066              0/0/0
          Area Address: 49.0000.01
          Topology: IPv4 (0x0) IPv6 (0x2)
          NLPID: 0xCC 0x8E
          Hostname: 2651
          IP Address: 192.168.0.2
          IPv6 Address: 2001:db8:2::1
          Metric: 10 IS-Extended 2652.00
          Metric: 10 IS-Extended 2653.01
          Metric: 10 IS (MT-IPv6) 2653.01
          Metric: 10 IP 192.168.0.0/30
          Metric: 20 IP 192.168.0.4/30
          Metric: 10 IP 192.168.1.0/24
          Metric: 20 IPv6 (MT-IPv6) 2001:db8:1::/64
          Metric: 10 IPv6 (MT-IPv6) 2001:db8:2::/64
```

ISIS for IPv6

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