ISIS for IPv6

ISP Workshops

Topics Covered

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

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

Integrated IS-IS for IPv6 Overview

- 2 Type/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
- IPv6 Interface Address TLV (0xE8)
  - Contains a 128 bit address
  - For Hello PDUs, must contain the link-local address (FE80::/10)
  - For LSP, must only contain the non link-local address

Integrated IS-IS for IPv6 Overview

- 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

- 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

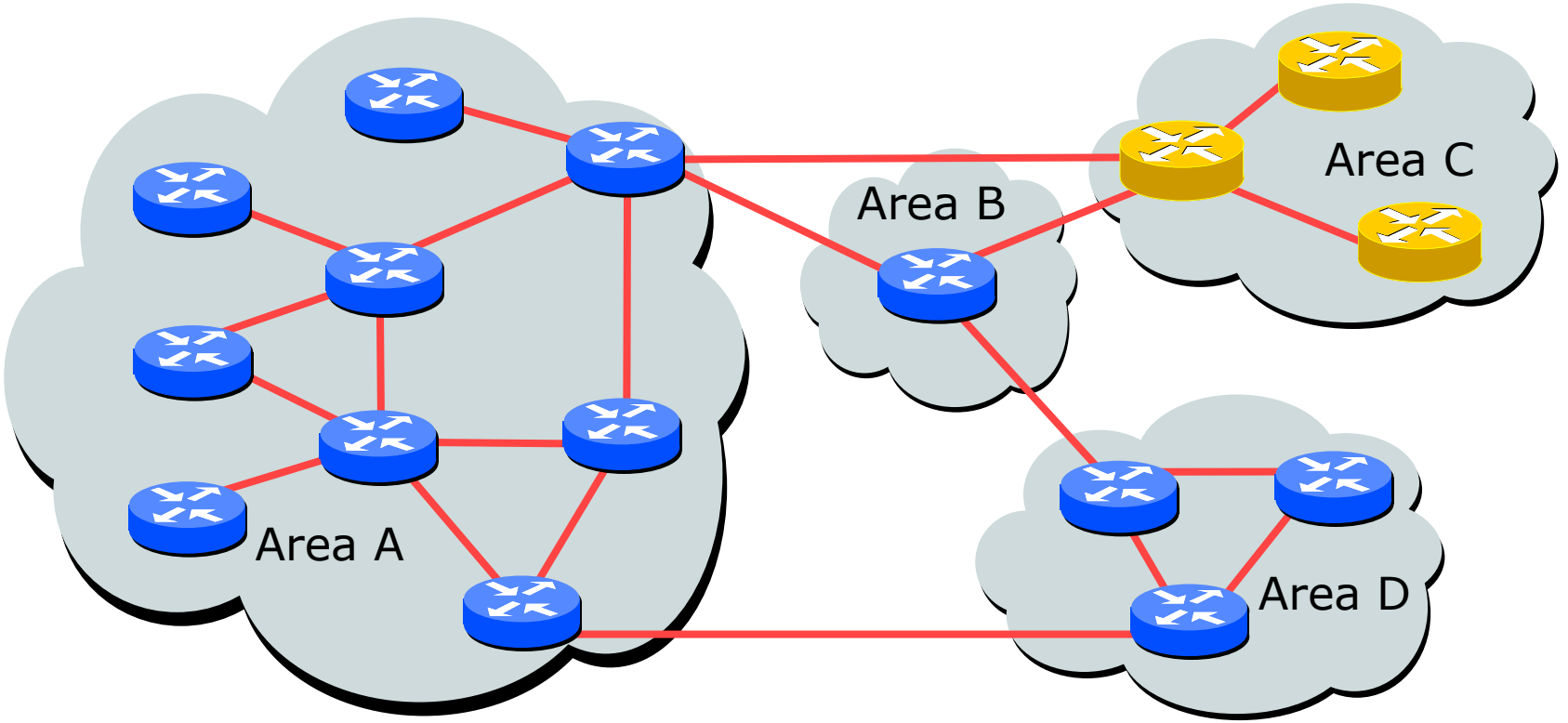
Simple SPF rules

- If IS-IS is used for both IPv4 and IPv6 in an area, both protocols must support the same topology within this area:
  - "no adjacency-check" between L2 routers over-rides this, but must be used with caution
- All interfaces configured with IS-ISv6 must support IPv6
- 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 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.
    - For example, 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

- CLI is familiar:
- IPv6 address family mode enables features specific to IPv6:

```
router isis as64512
 net 49.0001.0001.0001.00
 set-overload-bit on-startup wait-for-bgp
!
 address-family ipv6
  set-overload-bit on-startup wait-for-bgp
!
```

- Configure IS-IS for IPv6 on interfaces
  - Interface must be IPv6 enabled, eg. IPv6 address set

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.

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.

[no] set-overload-bit on-startup wait-for-bgp

- Set overload bit so that the router does not enter transit path until iBGP is running

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.

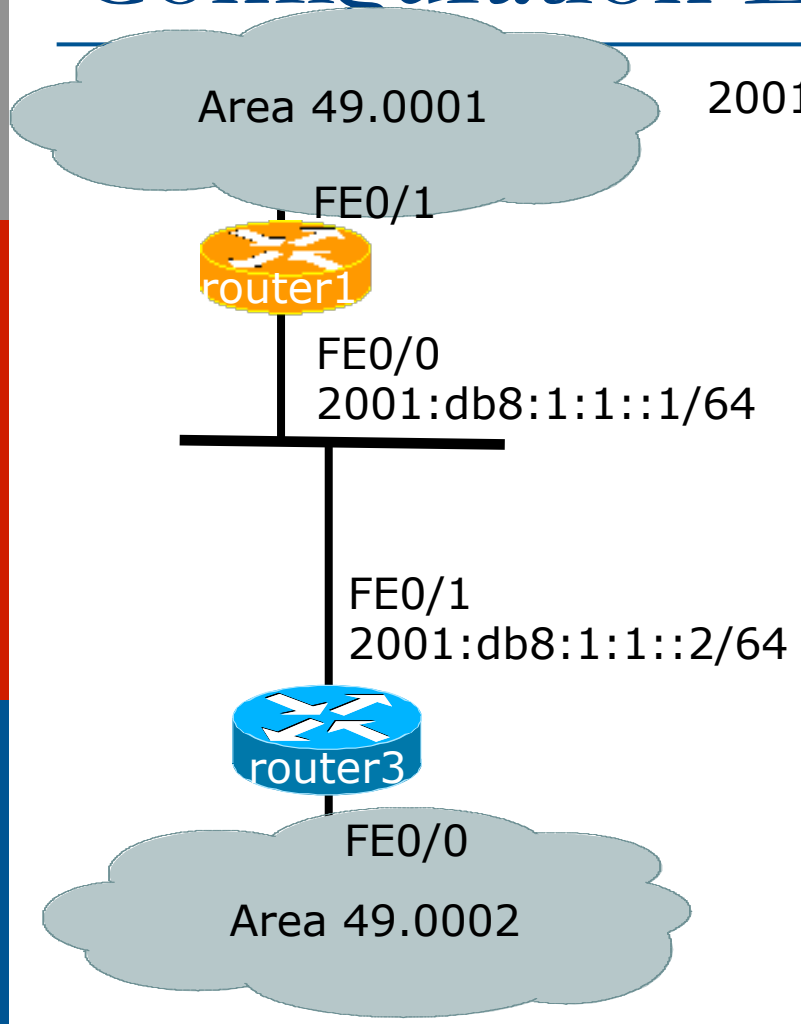
- Leaving address-family sub-mode

  exit-address-family

- Showing the I/IS-ISv6 configuration

  show ipv6 protocols [summary]

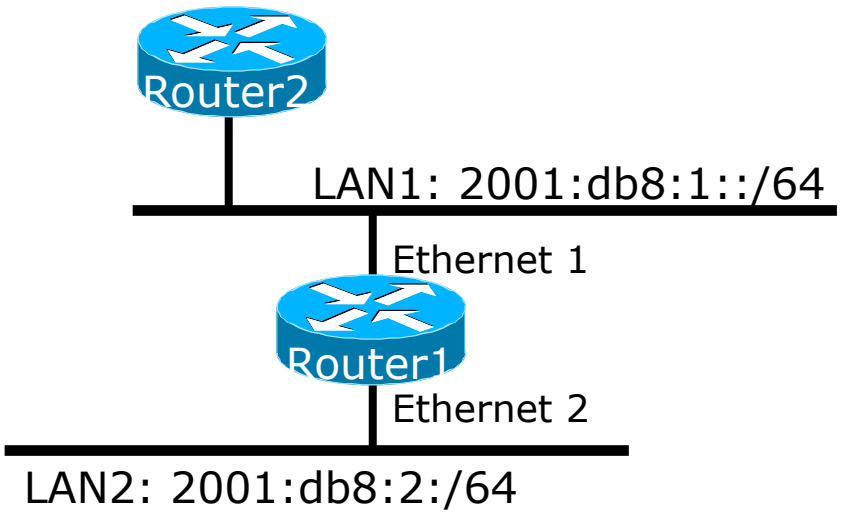
ISIS for IPv6 Configuration Example




```
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



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

ISIS Display (1)

```
router1#sh ipv6 route isis
IPv6 Routing Table - default - 46 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, 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
I2  2001:DB8::2/128 [115/2]
     via FE80::C801:3CFF:FE4F:8, FastEthernet0/0
I2  2001:DB8::3/128 [115/20]
     via FE80::C802:3CFF:FE4F:0, Serial1/0
I2  2001:DB8::4/128 [115/22]
     via FE80::C801:3CFF:FE4F:8, FastEthernet0/0
I2  2001:DB8::5/128 [115/40]
     via FE80::C802:3CFF:FE4F:0, Serial1/0
I2  2001:DB8::6/128 [115/42]
     via FE80::C801:3CFF:FE4F:8, FastEthernet0/0
     via FE80::C802:3CFF:FE4F:0, Serial1/0
```

ISIS Display (2)

```
router1#sh isis ipv6 rib
IS-IS IPv6 process workshop, local RIB
* 2001:DB8::2/128
    via FE80::C801:3CFF:FE4F:8/FastEthernet0/0, type L2  metric 2 LSP [7/8]
* 2001:DB8::3/128
    via FE80::C802:3CFF:FE4F:0/Serial1/0, type L2  metric 20 LSP [2/8]
* 2001:DB8::4/128
    via FE80::C801:3CFF:FE4F:8/FastEthernet0/0, type L2  metric 22 LSP [8/8]
* 2001:DB8::5/128
    via FE80::C802:3CFF:FE4F:0/Serial1/0, type L2  metric 40 LSP [4/8]
* 2001:DB8::6/128
    via FE80::C801:3CFF:FE4F:8/FastEthernet0/0, type L2  metric 42 LSP [5/8]
    via FE80::C802:3CFF:FE4F:0/Serial1/0, type L2  metric 42 LSP [5/8]
* 2001:DB8::7/128
    via FE80::C802:3CFF:FE4F:0/Serial1/0, type L2  metric 60 LSP [A/8]
* 2001:DB8::8/128
    via FE80::C801:3CFF:FE4F:8/FastEthernet0/0, type L2  metric 62 LSP [6/8]
    via FE80::C802:3CFF:FE4F:0/Serial1/0, type L2  metric 62 LSP [6/8]
...
```

ISIS Display (3)

```
Router2#sh clns is-neighbors detail

Tag Workshop:
System Id      Interface   State  Type Priority  Circuit Id         Format
router1        Fa0/0       Up     L2   64        Router2.01         Phase V
  Area Address(es): 49.0001
  IP Address(es):  10.0.15.1*
  IPv6 Address(es): FE80::C800:3CFF:FE4F:8
  Uptime: 00:07:31
  NSF capable
  Interface name: FastEthernet0/0
Router4        Se1/0       Up     L2   0         00                 Phase V
  Area Address(es): 49.0001
  IP Address(es):  10.0.15.18*
  IPv6 Address(es): FE80::C803:3CFF:FE4F:0
  Uptime: 00:07:32
  NSF capable
  Interface name: Serial1/0
Router14       Fa0/1       Up     L2   64        Router14.02        Phase V
  Area Address(es): 49.0001
  IP Address(es):  10.0.15.26*
  IPv6 Address(es): FE80::C80D:3CFF:FE50:6
  Uptime: 00:08:40
  NSF capable
  Interface name: FastEthernet0/1
```

Multi-topology ISIS

Multi-Topology IS-IS extensions

- Multi-Topology is used by ISPs who are deploying IPv6 on an existing IPv4 infrastructure:
  - Running single topology ISIS means that enabling ISIS IPv6 on a point to point link must be done simultaneously at both ends
    - Otherwise the adjacency will go down, leading to possible breakage in the network
  - Adding new routers on a broadcast media in a single topology ISIS is very tricky
    - ISIS for IPv6 must be enabled on all devices on the broadcast media at the same time
    - Otherwise breakage in the network could occur due to adjacencies going down

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
  - Two topologies maintained:
    - ISO/IPv4 Routing Topology
    - IPv6 Routing Topology

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 is provided for existing IS-IS IPv6 network to migrate to Multi-Topology IS-IS IPv6

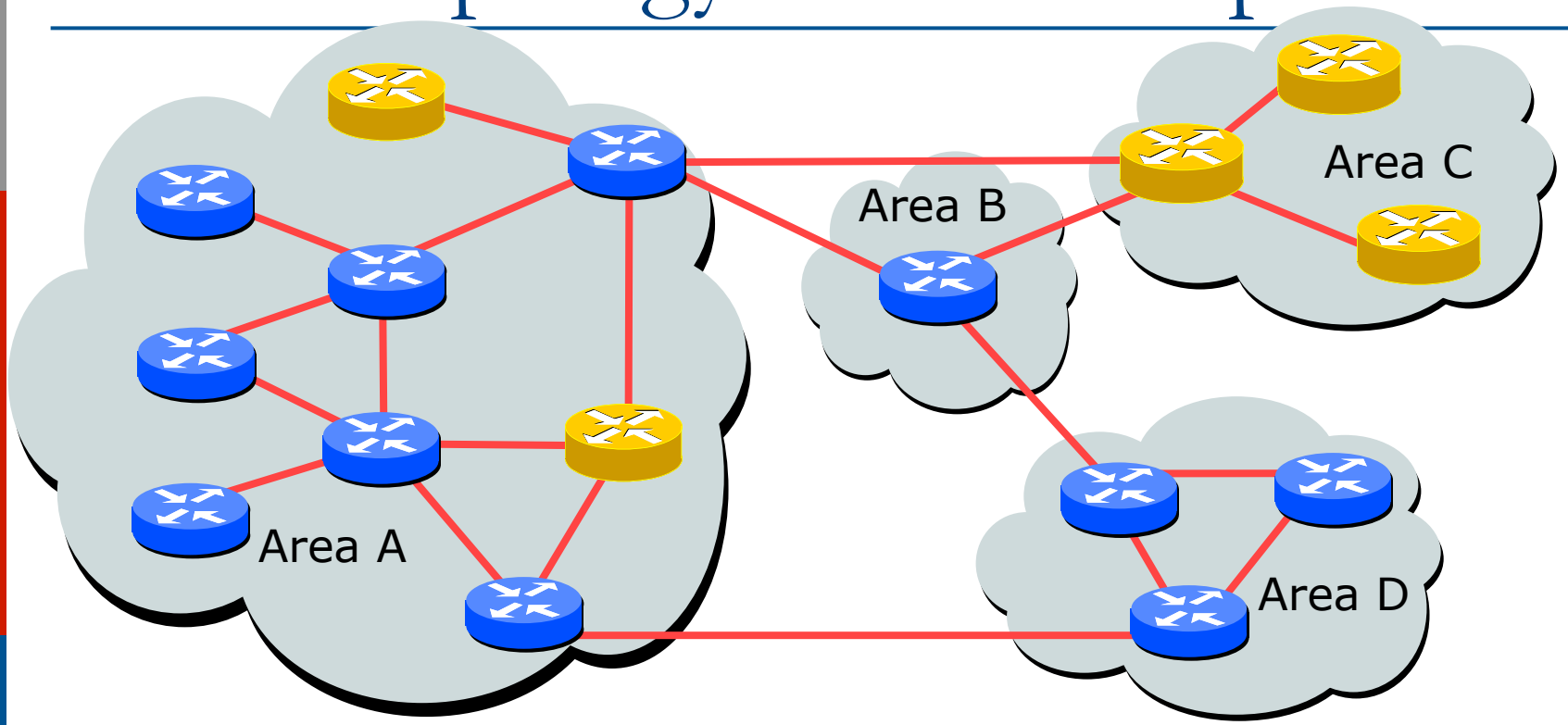
Multi-Topology IS-IS Restrictions

- 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)

Multi-Topology IS-IS example



IPv4-IPv6 enabled router

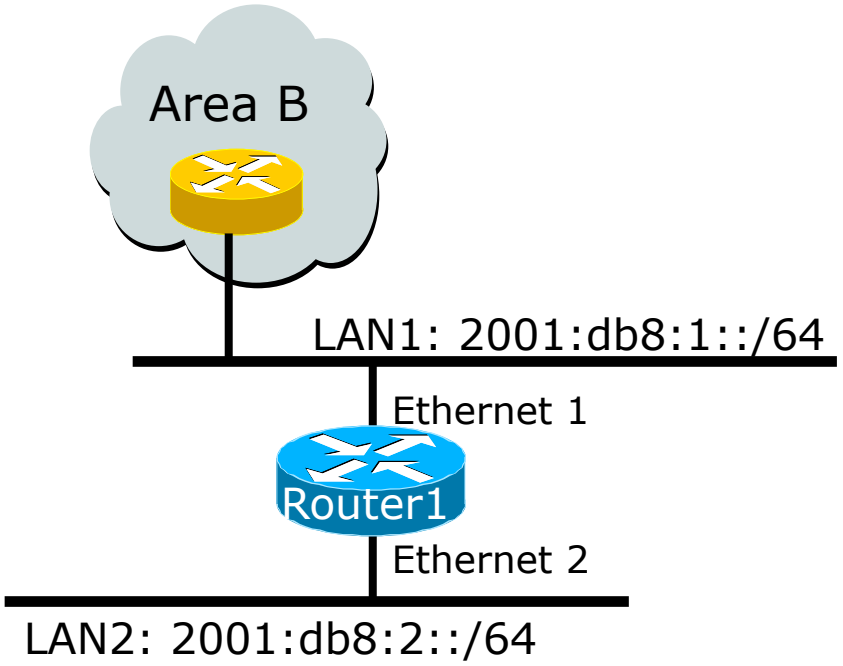
IPv4-only enabled router

The Multi-Topology software will create two topologies inside Area:

IPv4 and IPv6.

IPv4-only routers will be excluded from the IPv6 topology

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::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

```
Router2# show clns neighbors detail
Tag workshop:
System Id      Interface   SNPA            State  Holdtime  Type Protocol
Router2        Fa0/0       ca01.3c4f.0008  Up     7         L2   M-ISIS
  Area Address(es): 49.0001
  IP Address(es):  10.0.15.2*
  IPv6 Address(es): FE80::C801:3CFF:FE4F:8
  Uptime: 00:01:46
  NSF capable
  Topology: IPv4, IPv6
  Interface name: FastEthernet0/0

Router2# show isis database detail
Tag workshop:
IS-IS Level-2 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
router1.00-00       * 0x00000006   0xD3D1        1112              0/0/0
  Area Address: 49.0001
  Topology:     IPv4 (0x0)
                IPv6 (0x2)
  NLPID:        0xCC 0x8E
  Hostname: router1
  IP Address:   10.0.15.241
  IPv6 Address: 2001:DB8::1
  Metric: 2          IS-Extended Router2.01
  Metric: 20         IS-Extended Router3.00
  Metric: 2          IS-Extended Router13.02
  Metric: 2          IS (MT-IPv6) Router2.01
  Metric: 20         IS (MT-IPv6) Router3.00
  Metric: 2          IS (MT-IPv6) Router13.02
```

Multi-Topology IS-IS Support

- In Cisco IOS:
  - Supported in 12.2SRE, 12.2SXH, 12.4T, and 15.0 onwards
  - The commands for MT are in 12.3 and 12.4 but do not work
    - The only workaround is to use single topology or change to the knowing working releases
- In Cisco IOS-XE:
  - Supported in 3.3 or later
- In Cisco IOS-XR:
  - Supported in 3.9 or later
  - Note: MT is enabled by default
- In Juniper JunOS:
  - Supported in 9.0 or later

ISIS for IPv6

ISP Workshops