



# ISIS for IPv6

ISP/IXP Workshops

# Agenda

- IS-IS standardisation
- Cisco IOS IS-IS for IPv6
- Cisco IOS 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
- 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)

# Agenda

- IS-IS standardisation
- Cisco IOS IS-IS for IPv6
- Cisco IOS Multi-Topology IS-IS

# Cisco IOS IS-IS for IPv6

- IS-IS for IPv6 was introduced across Cisco IOS releases
  - 12.2(8)T and above as well as Cisco 12.3M onwards on Cisco 2600 to Cisco 7500 series
  - 12.0(22)S and above on Cisco 12000
  - 12.2(14)S and above on Cisco 7x00 series and Cat.6K [12.2SX]
  - Images are –p– and –js– as CLNS is required for IS-IS
- 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 may not 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.
  - 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 yet supported
  - Can't be configured on MPLS/TE since IS-ISv6 extensions for TE are not yet defined
- 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:

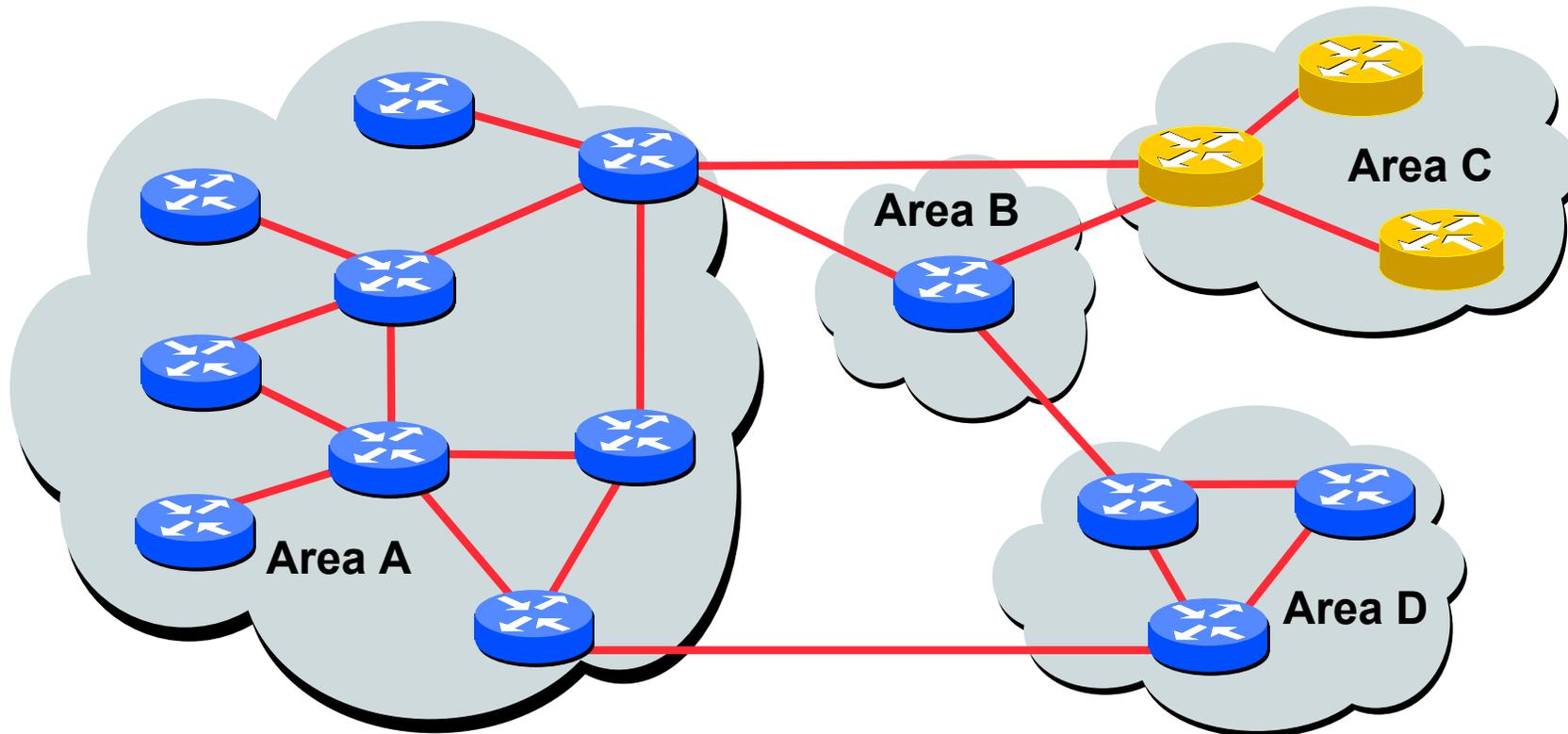
Not really suitable for an existing IPv4 IS-IS network where customer wants to turn on scattered IPv6 support.

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 on Cisco IOS

- 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.

# Cisco IOS IS-IS for IPv6 Specific Attributes

- 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.

```
[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.

# Cisco IOS IS-IS for IPv6 Specific Attributes

```
[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] redistribute <protocol> [metric <value>] [metric-type {internal|external}] [level-1|level-1-2|level-2] [route-map <name>]
```

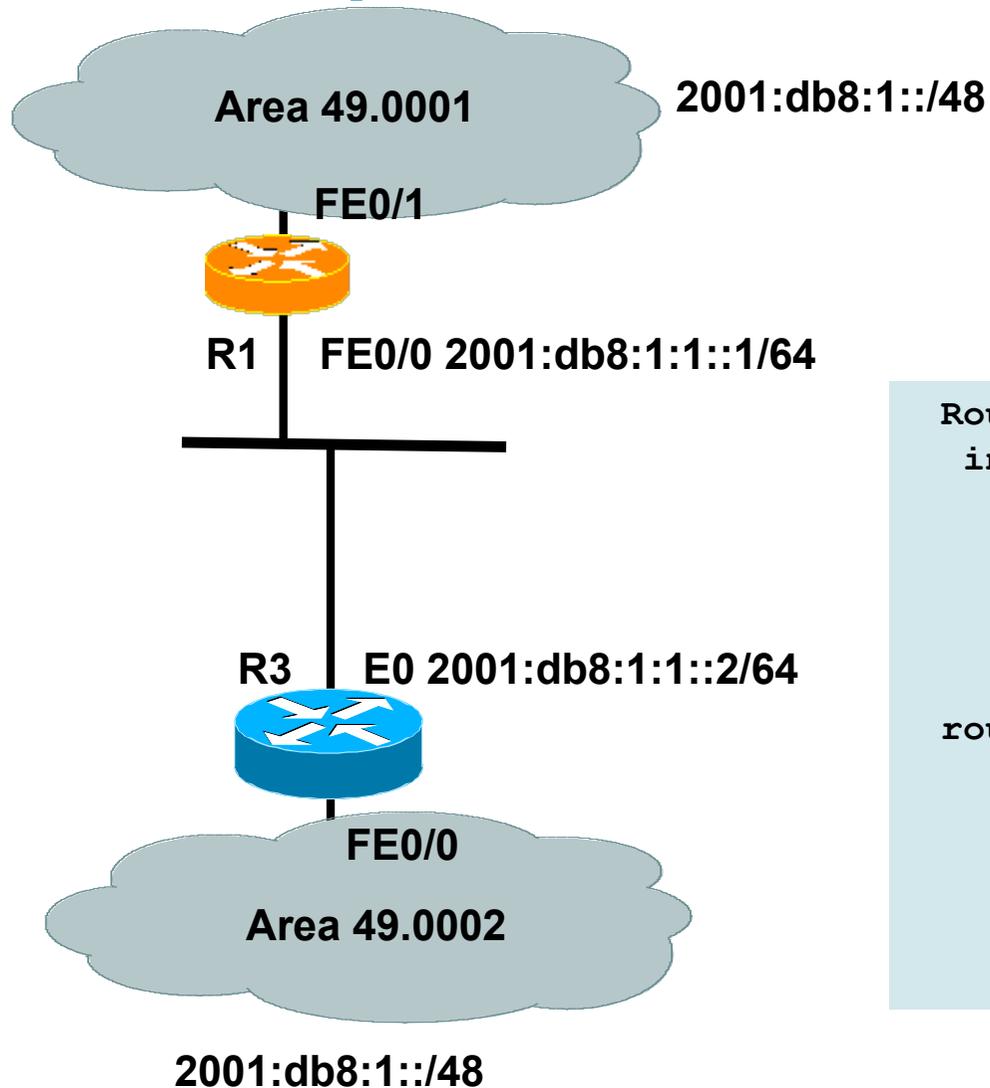
Configures redistribution of routes learnt from other IPv6 sources into IS-IS. Command is used in same manner as existing IPv4 `redistribute` command.

```
[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.

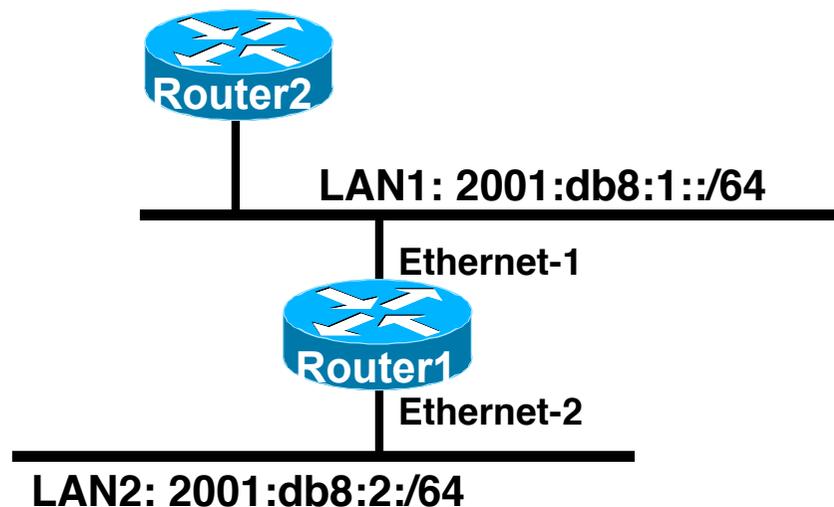
- Leaving address-family sub-mode  
`exit-address-family`
- Showing the I/IS-ISv6 configuration  
`show ipv6 protocols [summary]`

# I/IS-IS for IPv6-Only 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
```

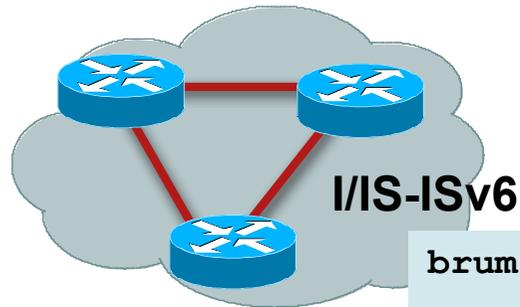
# Cisco IOS IS-IS dual IP configuration



**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::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
```

# Cisco IOS I/IS-IS Display (1)



```
brum-45c#sho ipv6 rou 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
```

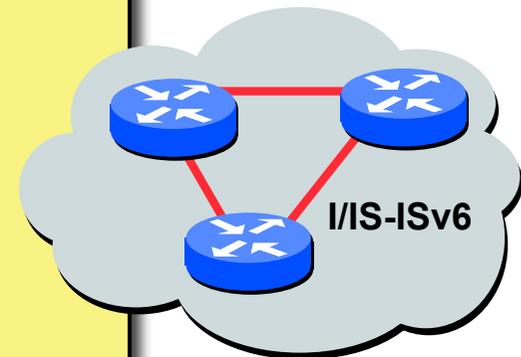
# Cisco IOS I/IS-IS Display (2)

```
brum-45c#sho clns is-neigh detail
```

```
System Id      Interface  State  Type Priority  Circuit Id      Format
brum-45a       Et1       Up     L1    64         brum-45c.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:
```

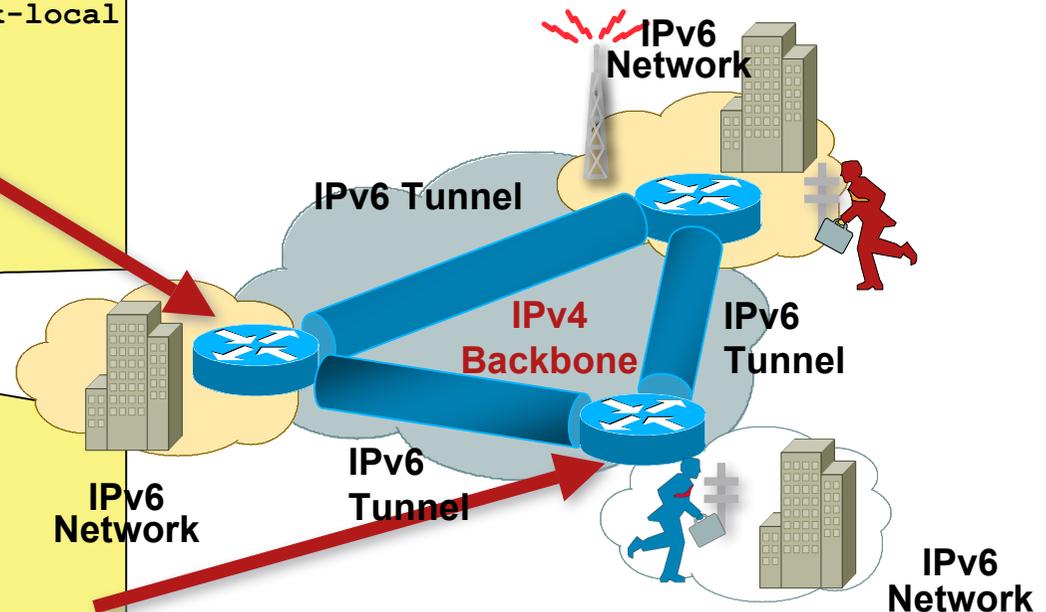
```
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
brum-45c.00-00 * 0x00000003  0xA745        732           0/0/0
Area Address: 47.0023.0001.0000.0001.0002.0001
NLPID:         0x8E
Hostname: brum-45c
IPv6 Address: 3F02::45C
IPv6 Address: 2001:db8:2000::45C
Metric: 10     IPv6 2001:db8:1000::/64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



# IS-IS for IPv6 on IPv6 Tunnels over IPv4

```
interface Tunnel0
  no ip address
  ipv6 address 2001:db8::45A/64
  ipv6 address FE80::10:7BC2:ACC9:10 link-local
  ipv6 router isis
  tunnel source Ethernet1
  tunnel destination 10.42.2.1
  !
router isis
  passive-interface Ethernet2
  net 42.0001.0000.0000.045a.00
```

```
interface Tunnel0
  no ip address
  ipv6 address 2001:db8::45C/64
  ipv6 address FE80::10:7BC2:B280:11 link-local
  ipv6 router isis
  tunnel source Ethernet2
  tunnel destination 10.42.1.1
  !
router isis
  net 42.0001.0000.0000.045c.00
```



IS-IS for IPv6 on an IPv6 Tunnel requires GRE Tunnel, it can't work with IPv6 configured tunnel as IS-IS runs directly over the data link layer

# Agenda

- IS-IS standardisation
- Cisco IOS IS-IS for IPv6
- Cisco IOS Multi-Topology IS-IS

# 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 many others are not
- 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

# Cisco IOS Multi-Topology IS-IS

- Multi-Topology IS-IS was added to Cisco IOS Software to fix the limitations of a single SPF process on networks where both IPv4 and IPv6 topologies cannot be aligned, while maintaining the current IS-IS IPv6 functionalities
- Cisco IOS Software maintains 2 topologies, one for IPv6 and one common topology for IPv4 and ISO.
  - 12.2(15)T and above as well as Cisco 12.3M onwards on Cisco 2600 to Cisco 7500 series
  - 12.0(26)S and above on Cisco 12000
  - 12.2S RLS3 and above on Cisco 7x00 series and Cat.6K [12.2SX]

# 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 given 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:

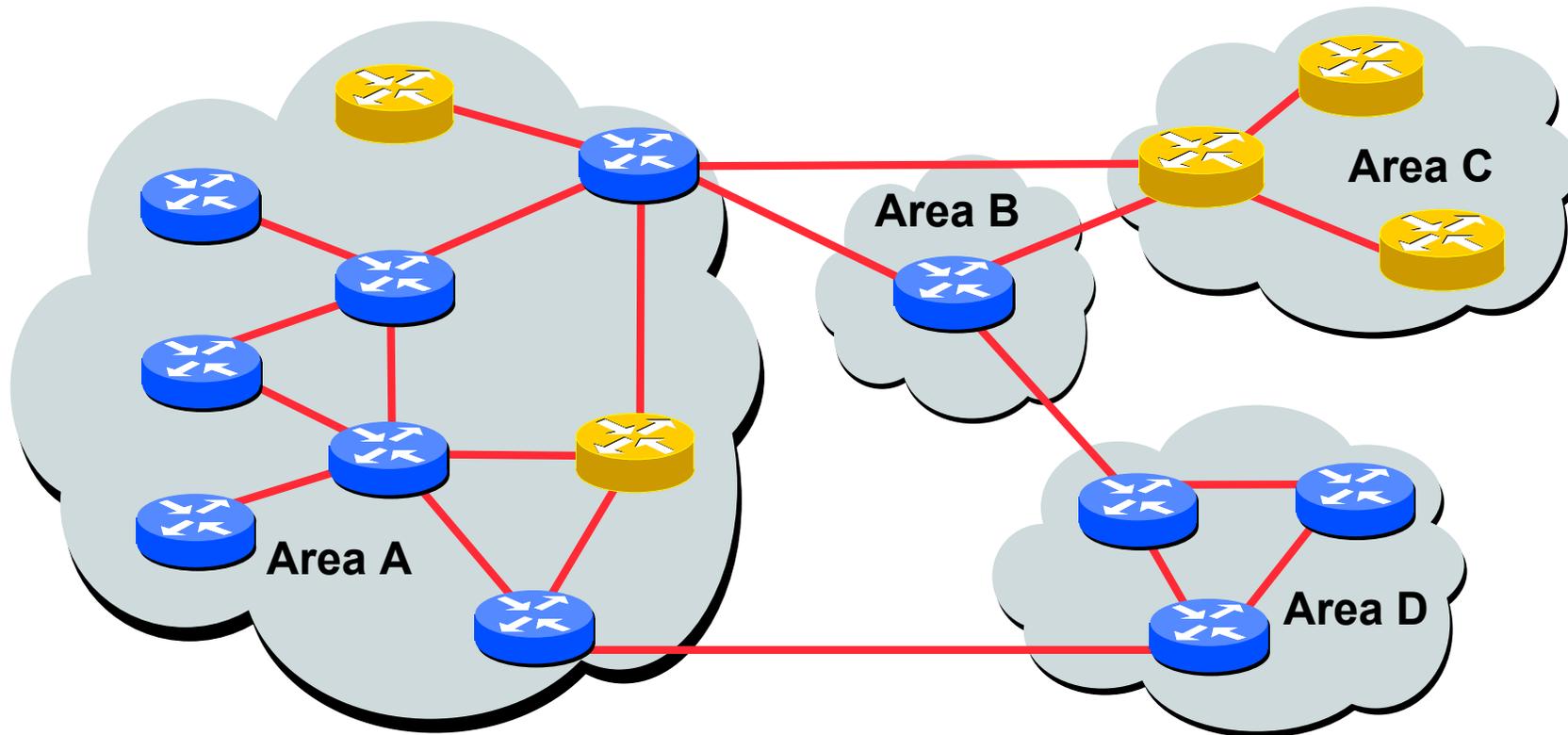
MT ID #0 – “standard” topology for IPv4/CLNS

MT ID #2 – IPv6 Routing Topology.

# Multi-Topology IS-IS Restrictions

- This feature is not compatible with the previous single SPF model, as 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 (refer to documentation) is provided for existing IS-IS IPv6 network to migrate to Multi-Topology IS-IS IPv6.
- IPv4, IPv6, or IPv4/IPv6 may be configured on the interface for either level-1 level-2 or level-1-2. But 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.
- All routers on a LAN or point to point 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 metric is required to be enabled globally on the Autonomous System to run

# Multi-Topology IS-IS example



IPv4-IPv6 enabled router



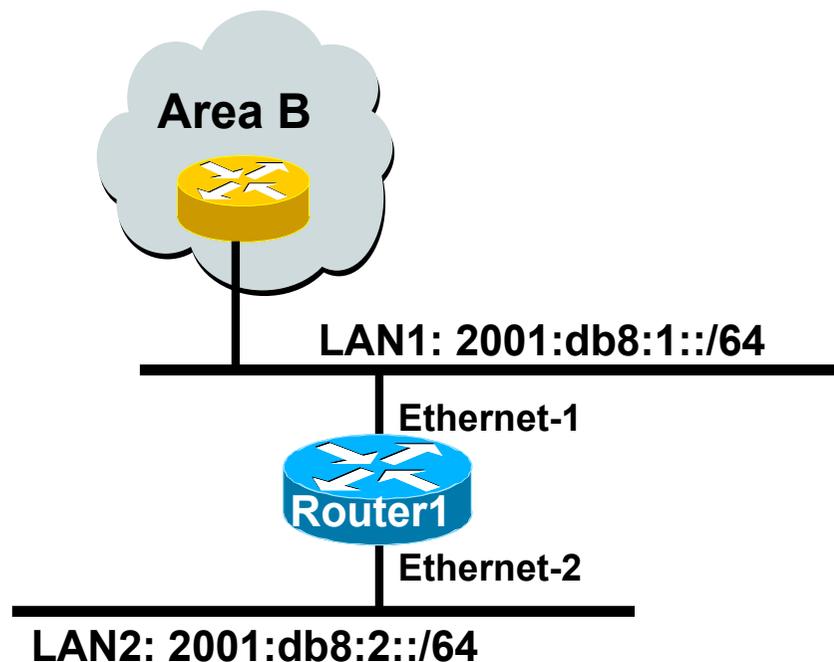
IPv4-only enabled router

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

IPv4 and IPv6.

IPv4-only routers will be excluded from the IPv6 topology

# Cisco IOS 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 49.0000.0100.0000.0000.0500
 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
```

# Cisco IOS Multi-Topology IS-IS Display

Router# show cns neighbors detail

| System Id | Interface | SNPA   | State | Holdtime | Type | Protocol |
|-----------|-----------|--------|-------|----------|------|----------|
| 2653      | Se0/1     | *HDLC* | Up    | 25       | L1L2 | M-ISIS   |

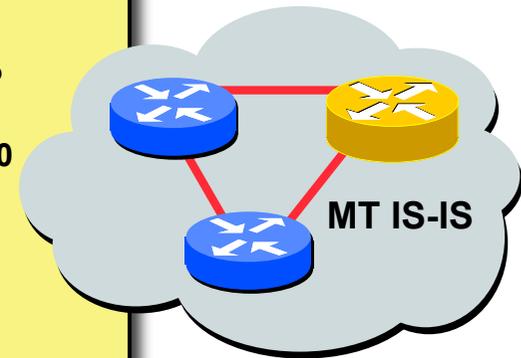
Area Address(es): 49.0000.01  
 IP Address(es): 192.168.0.6\*  
 IPv6 Address(es): FE80::204:C1FF:FEDB:2FA0  
 Uptime: 00:01:22  
 Topology: IPv4, IPv6

2652# show isis database detail

IS-IS Level-2 Link State Database:

| LSPID      | LSP Seq Num | LSP Checksum | LSP   |
|------------|-------------|--------------|-------|
| 2651.00-00 | 0x0000000F  | 0x0161       | 0/0/0 |

Holdtime ATT/P/OL  
 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

ISP/IXP Workshops