



# 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

# 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:

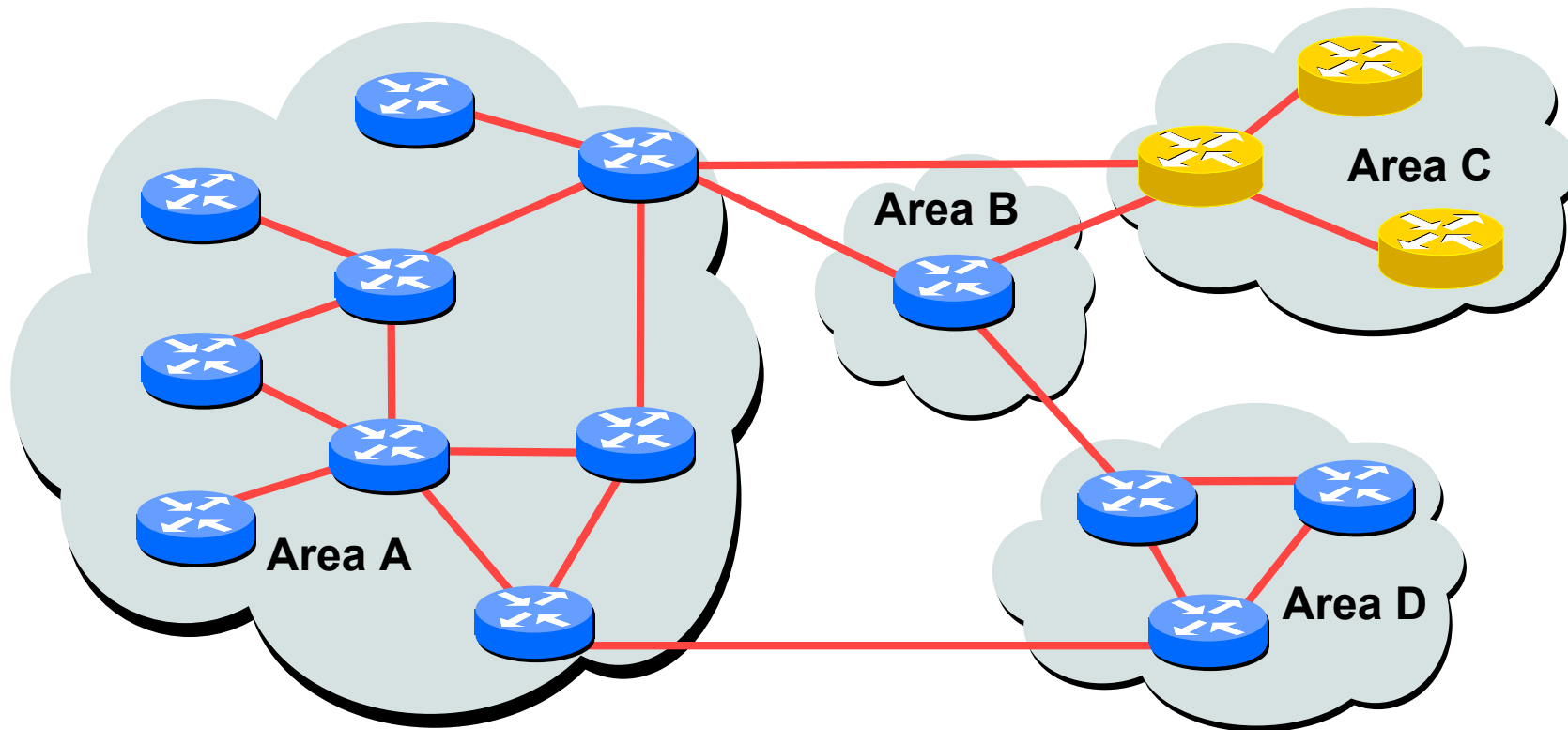
Not really suitable for an existing IPv4 IS-IS network where customer wants to turn on scattered IPv6 support.

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>]
```

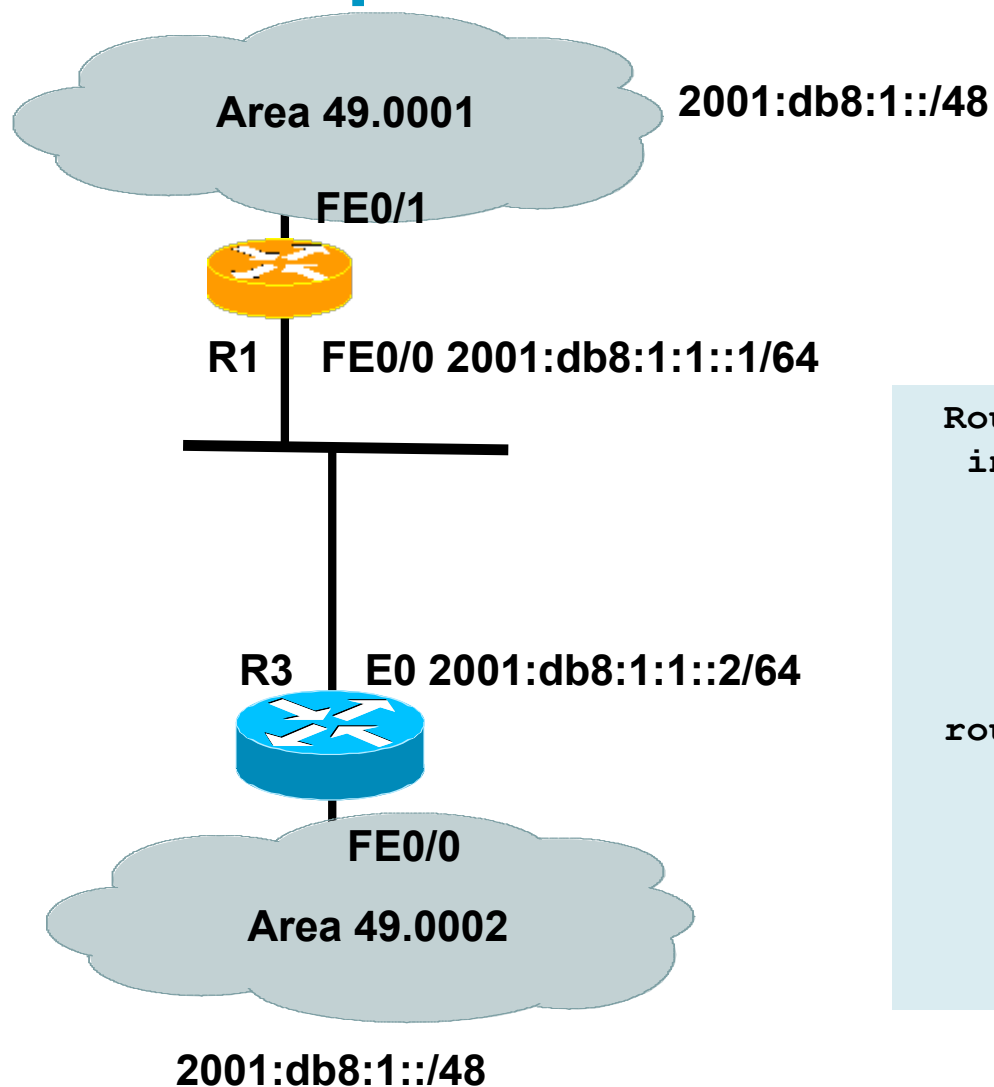
Configures redistribution of routes learnt from other IPv6 sources into IS-IS. Command is used in same manner as existing IPv4 `redistribute` command.

```
[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.

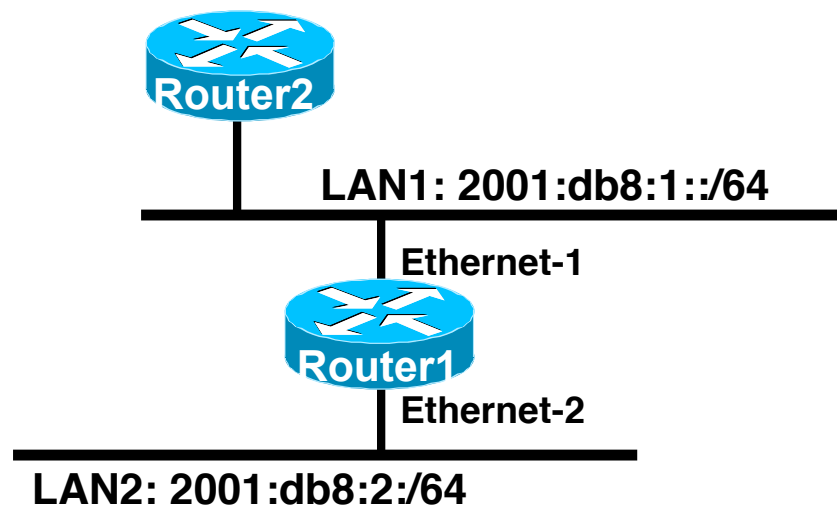
- Leaving address-family sub-mode  
`exit-address-family`
- Showing the I/IS-ISv6 configuration  
`show ipv6 protocols [summary]`

# 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



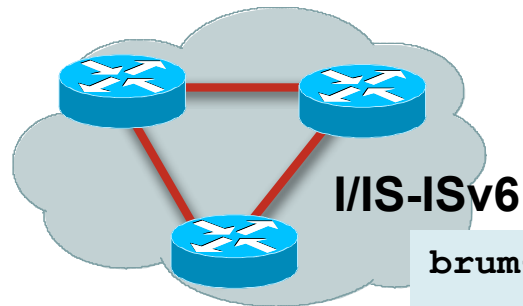
**Dual IPv4/IPv6 configuration.  
Redistributing both IPv6 static routes  
and IPv4 static routes.**

```
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
```



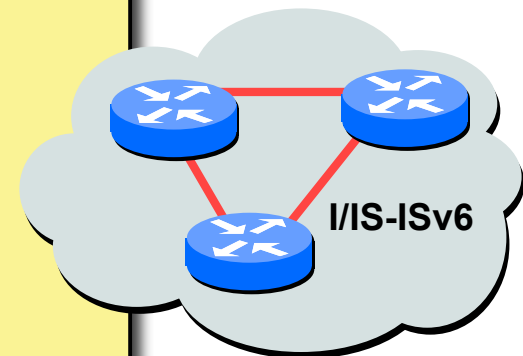
# Cisco IOS I/IS-IS Display (2)

```
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:

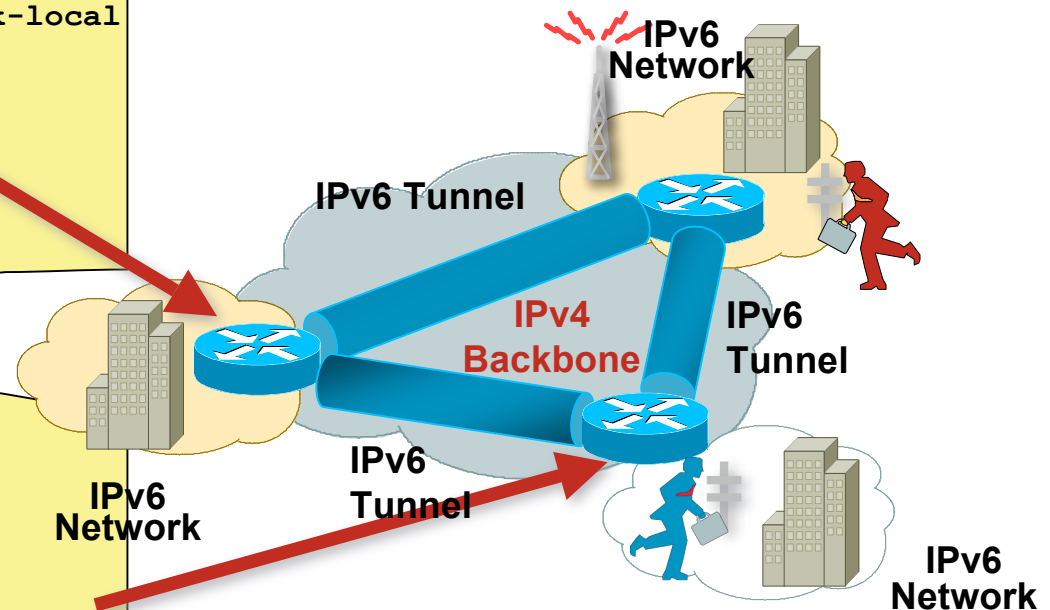
LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
brum-45c.00-00	* 0x00000003	0xA745	732	0/0/0
Area Address: 47.0023.0001.0000.0001.0002.0001				
NLPID: 0x8E				
Hostname: brum-45c				
IPv6 Address: 3F02::45C				
IPv6 Address: 2001:db8:2000::45C				
Metric: 10 IPv6 2001:db8:1000::/64				
Metric: 10 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:

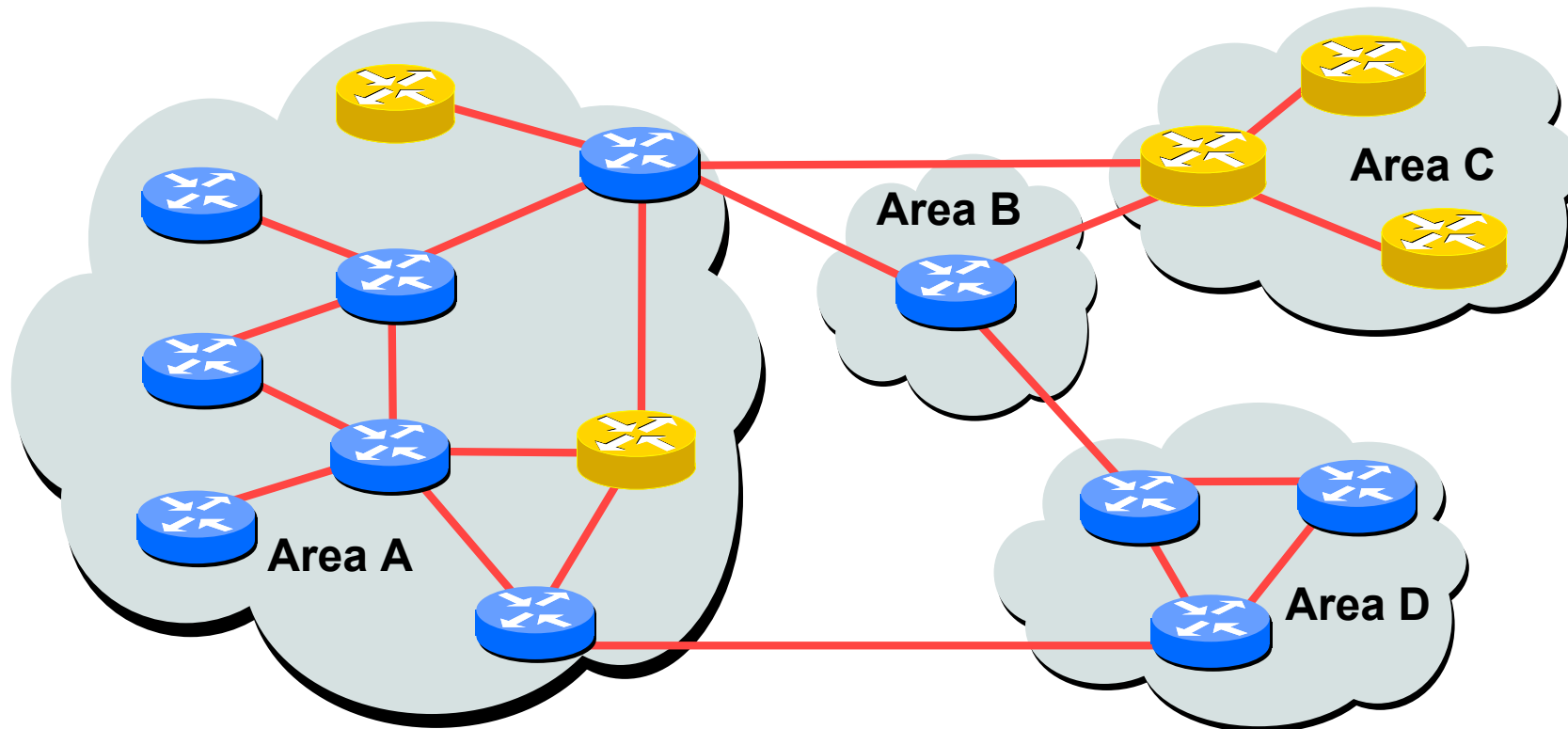
MT ID #0 – “standard” topology for IPv4/CLNS

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

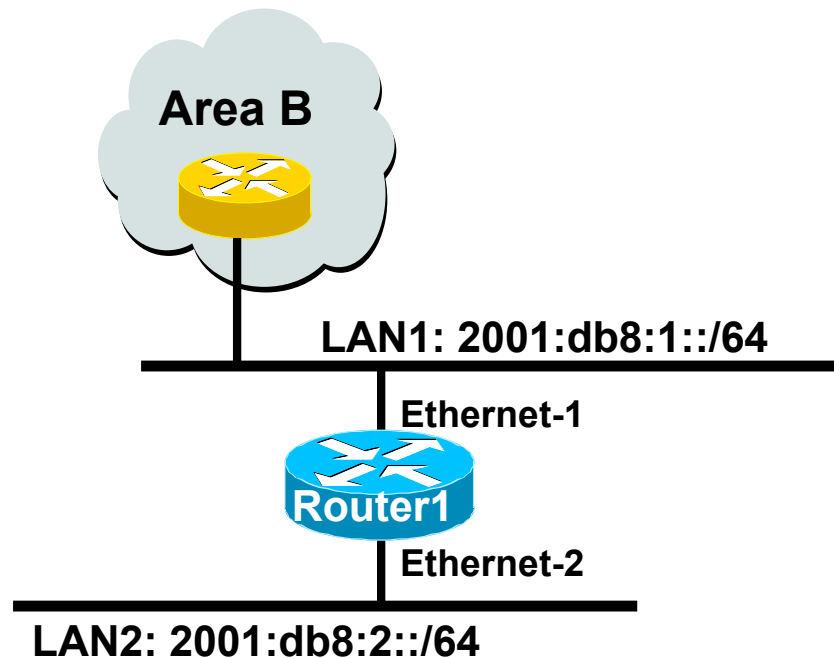
The Multi-Topology software will create two topologies inside Area:

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

# Cisco IOS 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

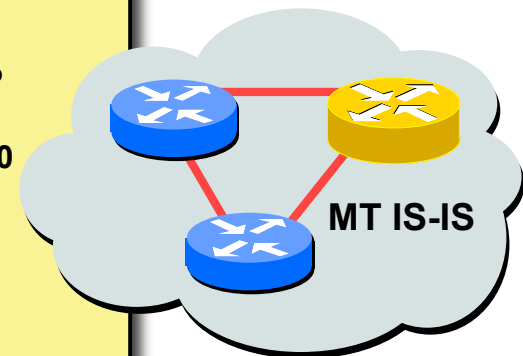
Area Address(es): 49.0000.01  
IP Address(es): 192.168.0.6\*  
IPv6 Address(es): FE80::204:C1FF:FEDB:2FA0  
Uptime: 00:01:22  
Topology: IPv4, IPv6

2652# show isis database detail

IS-IS Level-2 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP
2651.00-00	0x0000000F	0x0161	1066

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





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