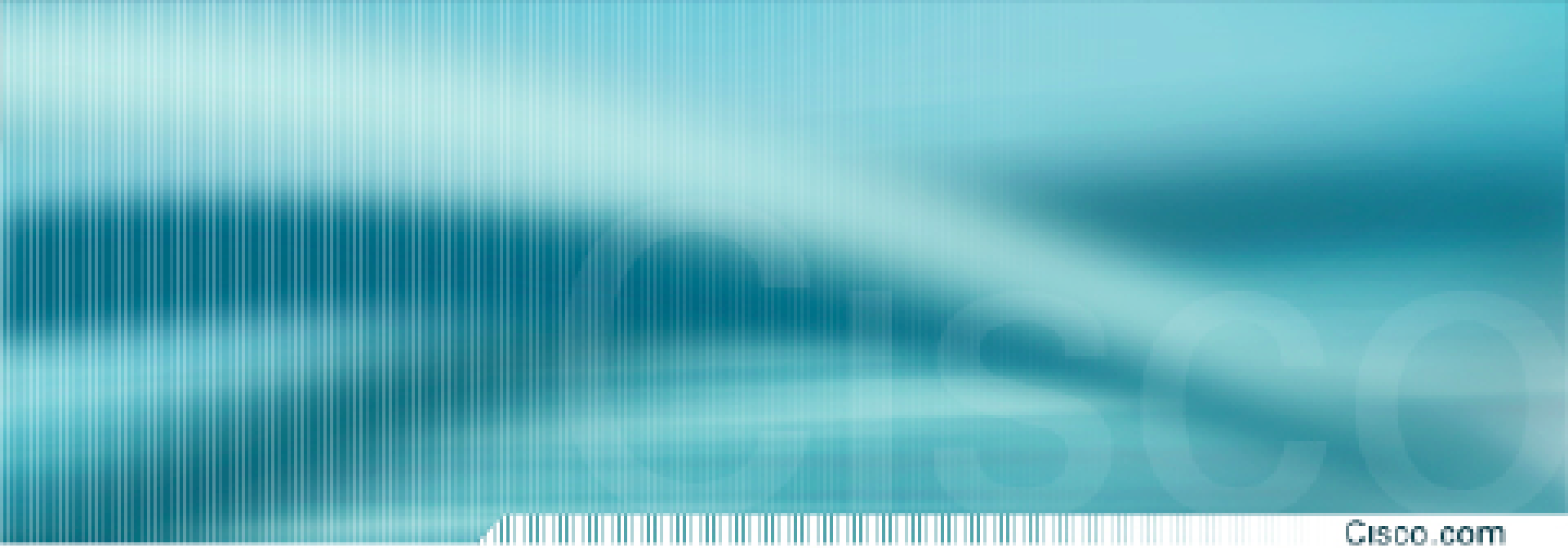


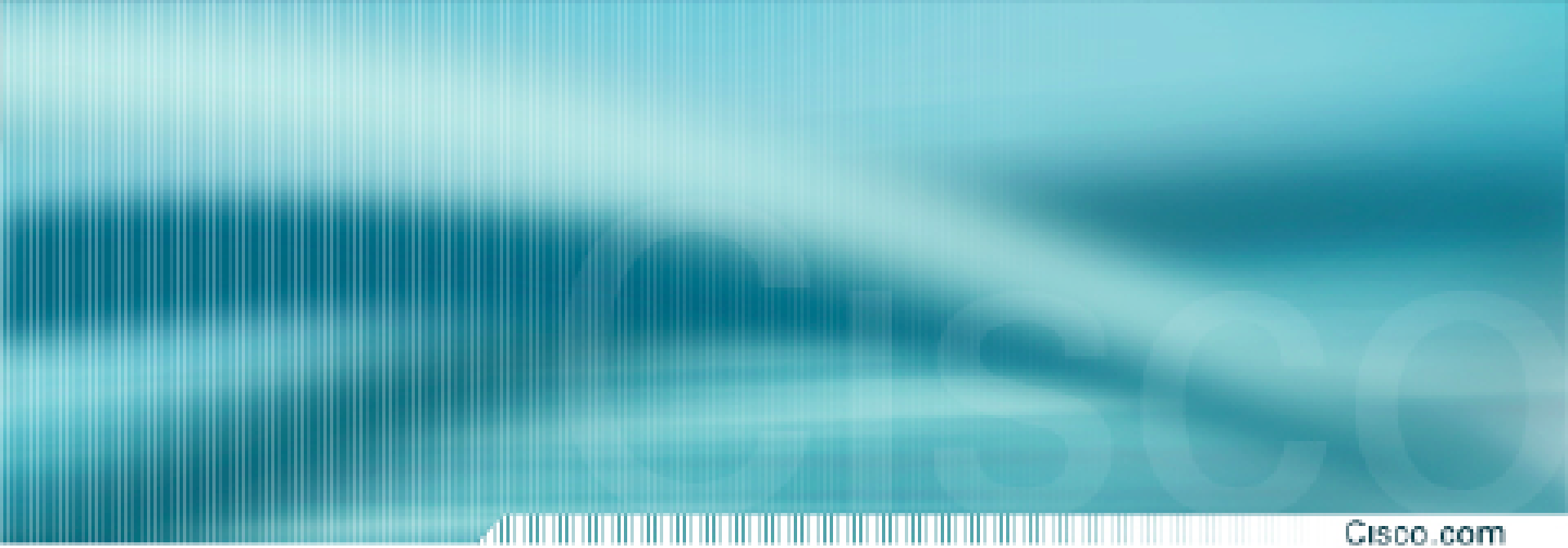
Introduction to OSPF

ISP/IXP Workshops

Agenda

Cisco.com

- OSPF Primer
- OSPF in Service Provider Networks
- OSPF BCP – Adding Networks
- OSPF Command Summary



OSPF Primer

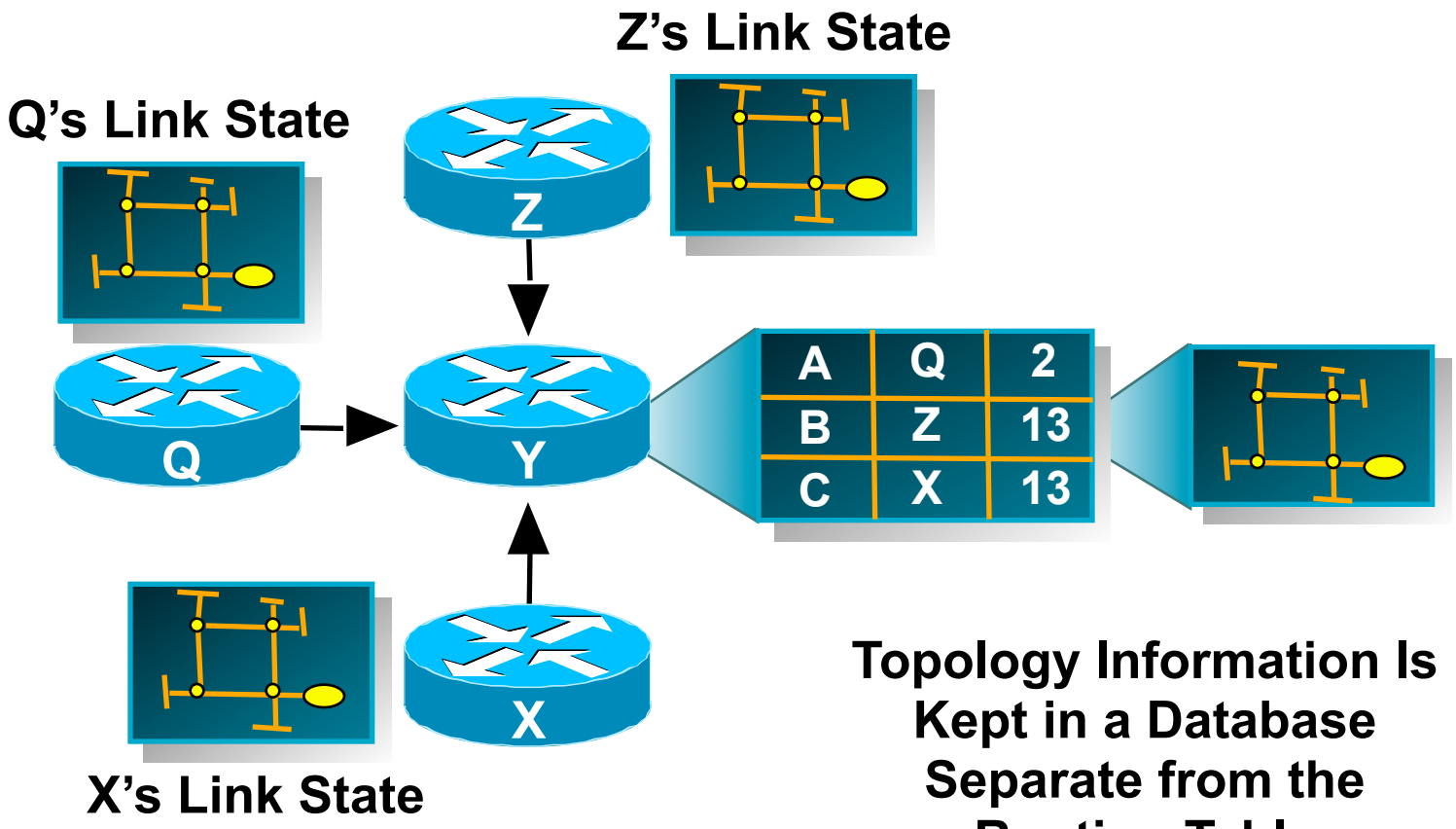
OSPFv2

- April 1998 was the most recent revision (RFC 2328)
- OSPF uses a 2-level hierarchical model
- SPF calculation is performed independently for each area
- Typically faster convergence than DVRPs
- Relatively low, steady state bandwidth requirements

OSPF

- Open Shortest Path First
- Link state or SPF technology
- Developed by OSPF working group of IETF (RFC 1247)
- Designed for TCP/IP Internet environment
- Fast convergence
- Variable-length subnet masks
- Discontiguous subnets
- No periodic updates
- Route authentication
- Delivered two years after IGRP
- OSPF standard described in RFC2328

Link State



Topology Information Is Kept in a Database Separate from the Routing Table

Link State Routing

- Neighbour discovery
- Constructing a Link State Packet (LSP)
- Distribute the LSP

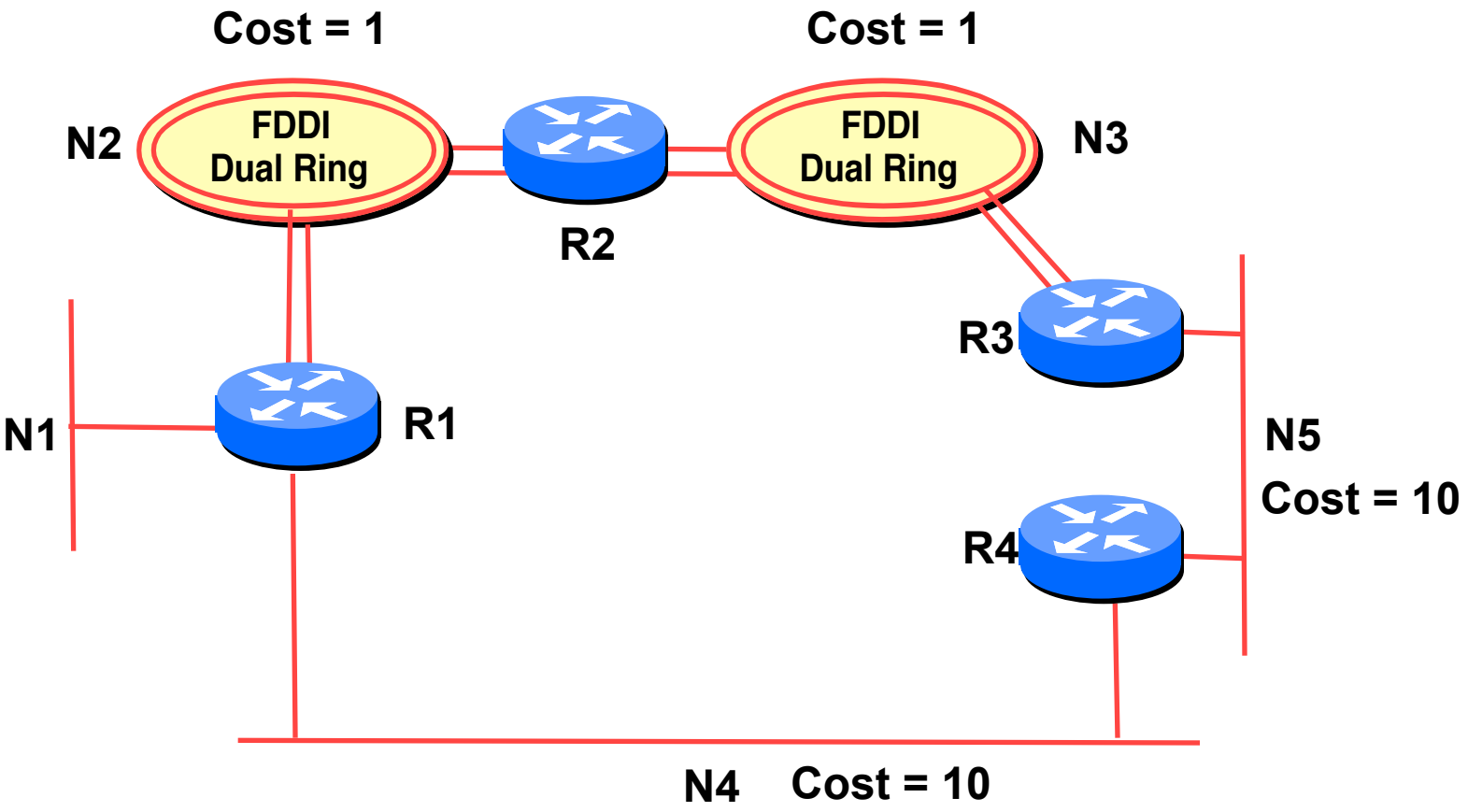
  (Link State Announcement – LSA)
- Compute routes
- On network failure

  New LSPs flooded

  All routers recompute routing tables

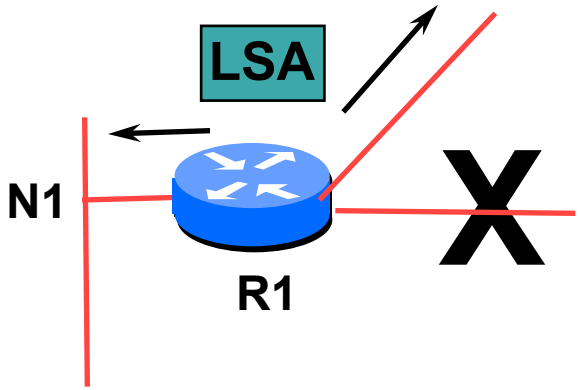
Optimal Path Utilisation

The optimal path is determined by the sum of the interface costs: Cost = 10^8/BW



Fast Convergence

- **Finding a new route**
  - **LSA flooded throughout area**
  - **Acknowledgement based**
  - **Topology database synchronised**
  - **Each router derives routing table to destination networks**



Utilises IP Multicast for Sending/Receiving Updates

- **Broadcast networks**

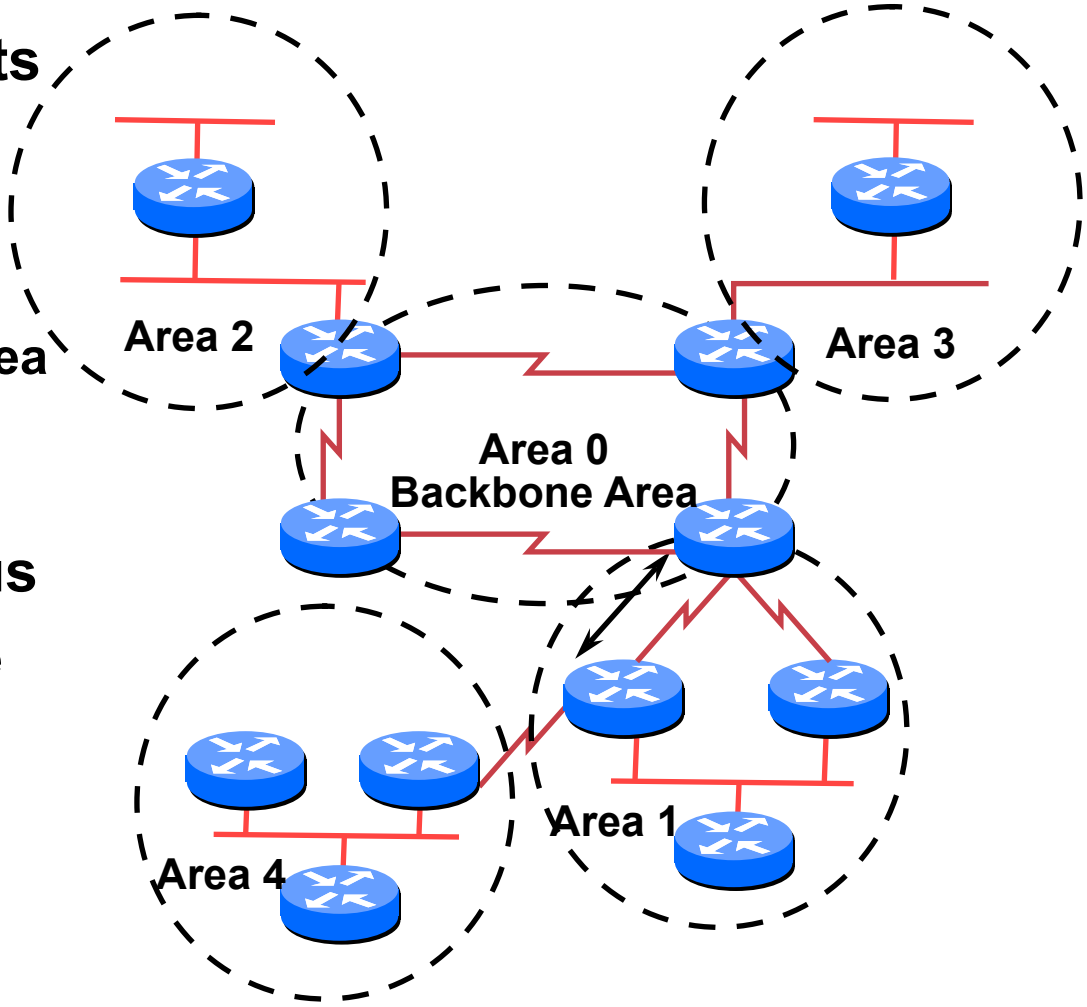
  All routers must accept packets sent to AllSPFRouters (224.0.0.5)

  All DR and BDR routers must accept packets sent to AllDRouters (224.0.0.6)

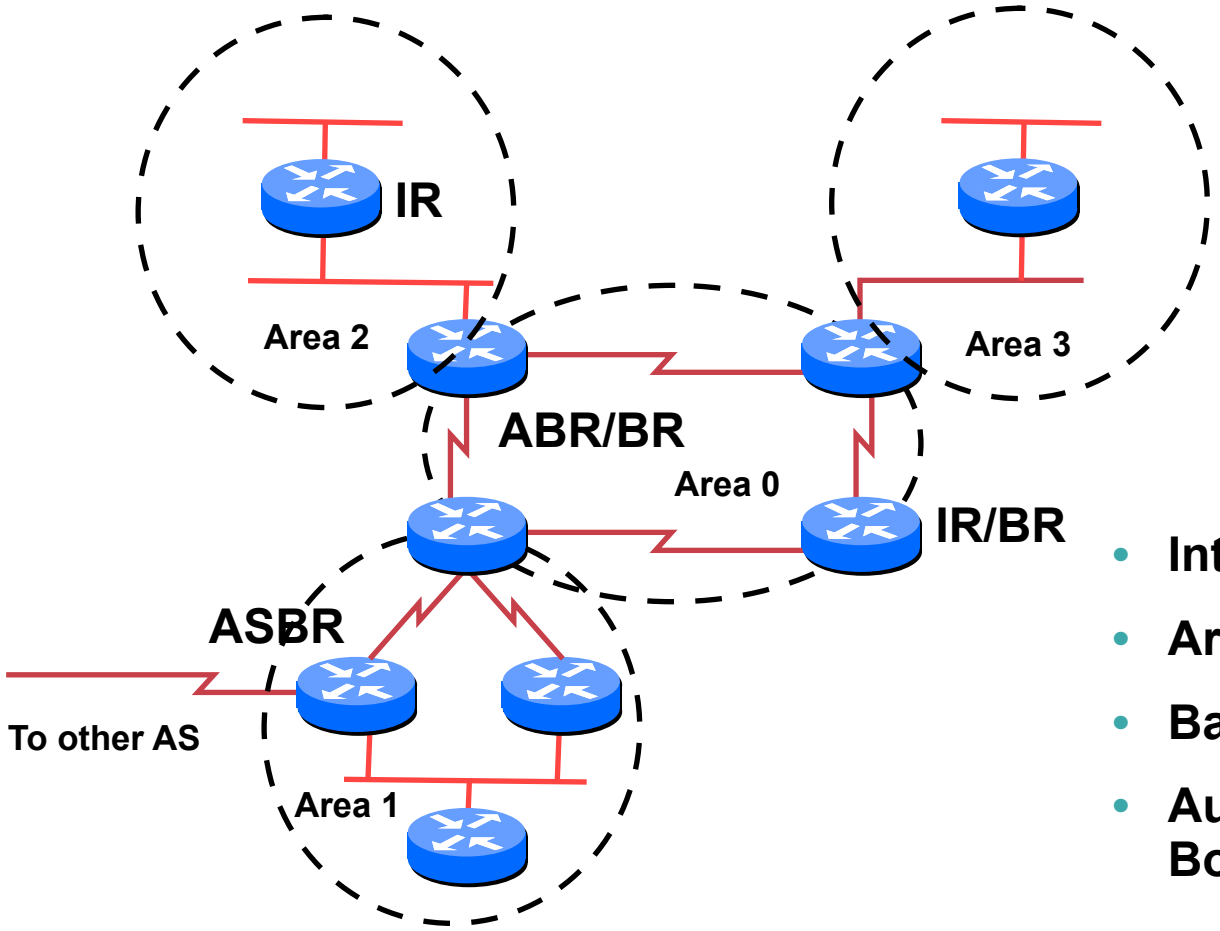
- **Hello packets sent to AllSPFRouters (Unicast on point-to-point and virtual links)**

OSPF Areas

- Group of contiguous hosts and networks
- Per area topological database
  - Invisible outside the area
  - Reduction in routing traffic
- Backbone area contiguous
  - All other areas must be connected to the backbone
- Virtual Links

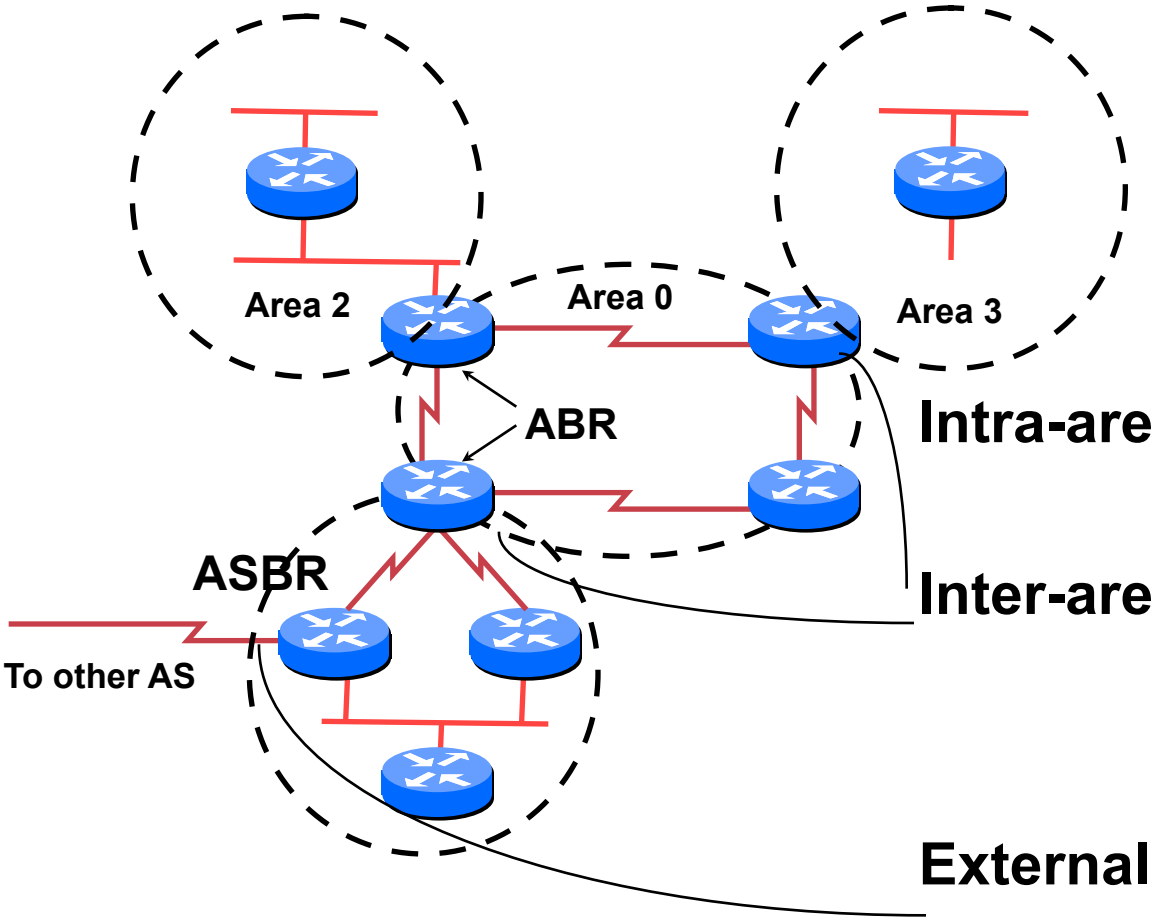


Classification of Routers



- Internal Router (IR)
- Area Border Router (ABR)
- Backbone Router (BR)
- Autonomous System Border Router (ASBR)

OSPF Route Types



Intra-area Route

all routes inside an area

Inter-area Route

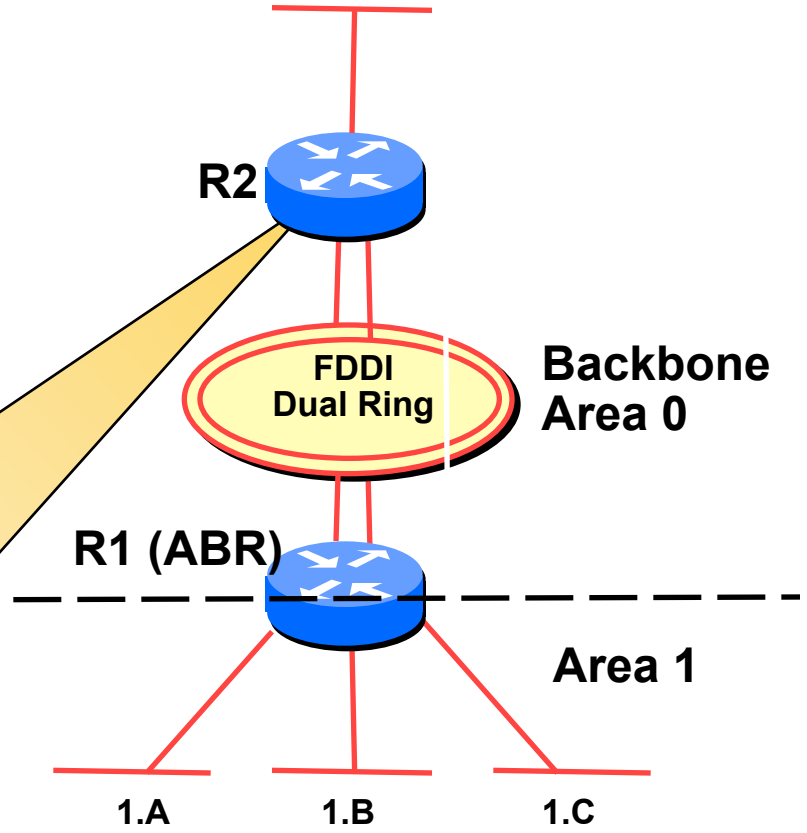
routes advertised from one area to another by an Area Border Router

External Route

routes imported into OSPF from other protocol or static routes

Inter-Area Route Summarisation

- Prefix or all subnets
- Prefix or all networks
- ‘Area range’ command



With summarisation

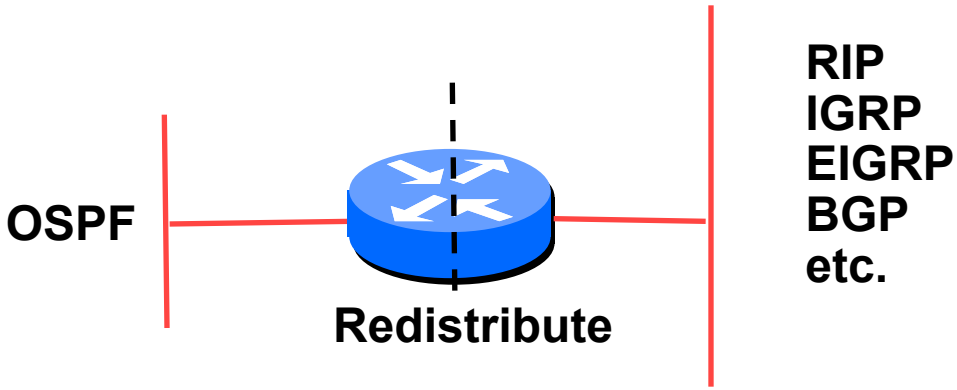
Network	Next Hop
1	R1

Without summarisation

Network	Next Hop
1.A	R1
1.B	R1
1.C	R1

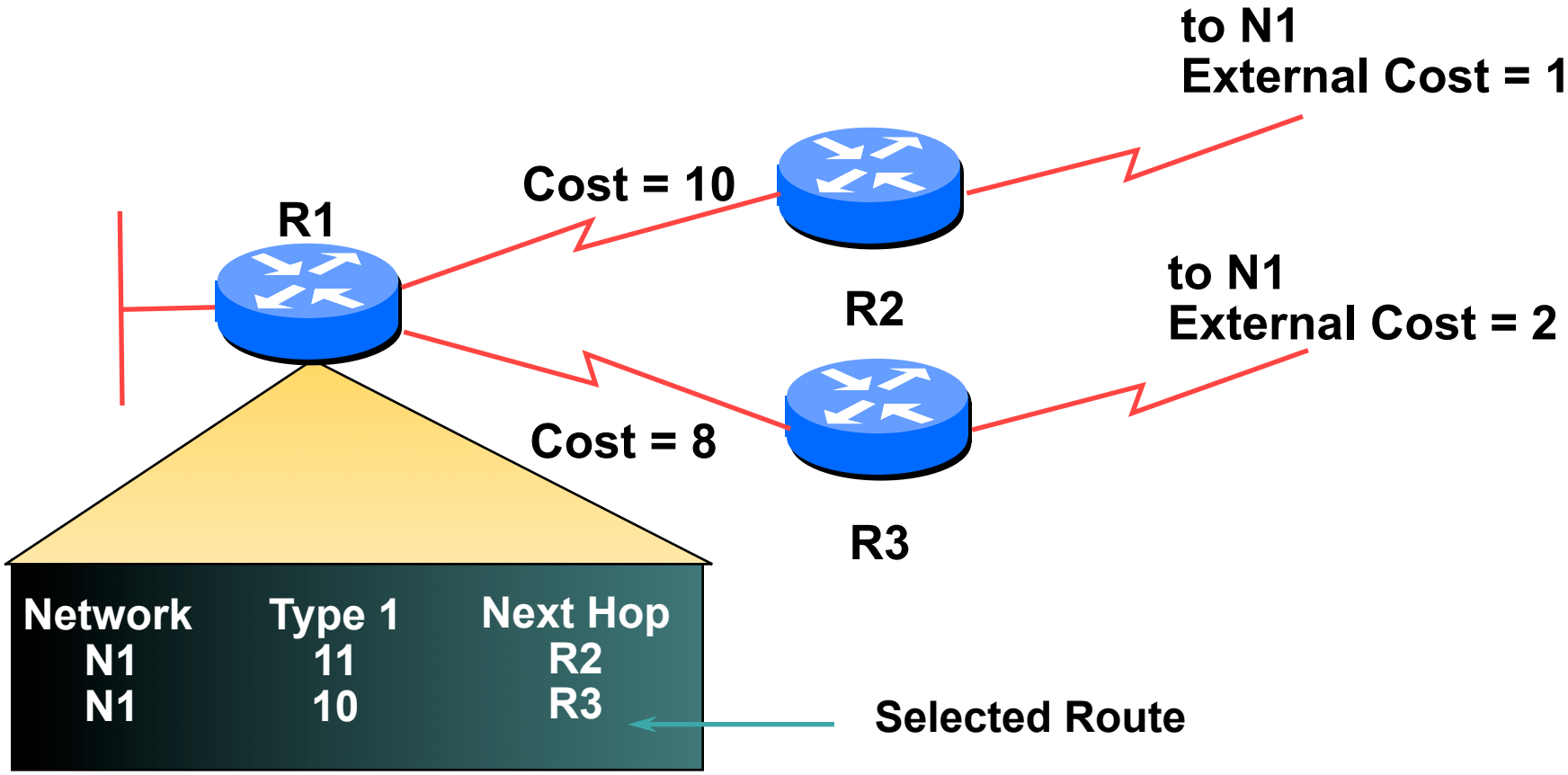
External Routes

- Redistributed into OSPF
- Flooded unaltered throughout the AS
- OSPF supports two types of external metrics
  - Type 1 external metrics
  - Type 2 external metrics (Default)



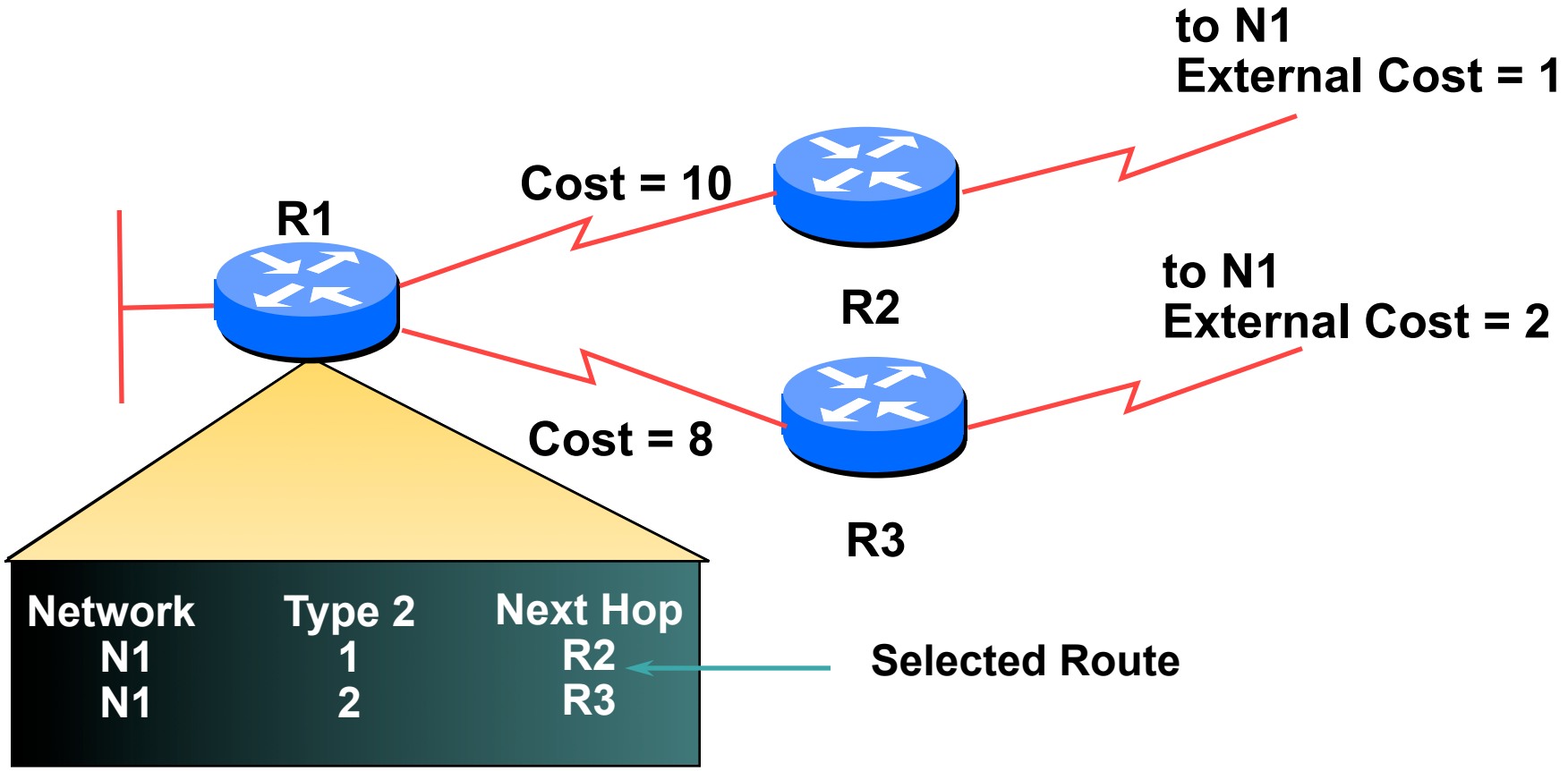
External Routes

- Type 1 external metric: metrics are added to the summarised internal link cost



External Routes

- Type 2 external metric: metrics are compared without adding to the internal link cost



Topology/Link State Database

Cisco.com

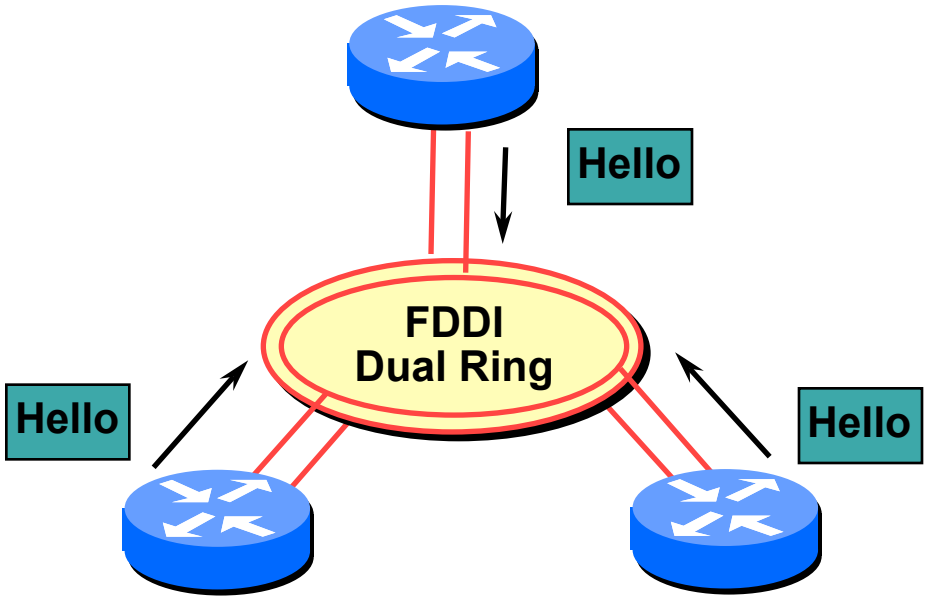
- A router has a separate LS database for each area to which it belongs
- All routers belonging to the same area have identical database
- SPF calculation is performed separately for each area
- LSA flooding is bounded by area

Protocol Functionality

- Bringing up adjacencies
- LSA types
- Area classification

The Hello Packet

- Router priority
- Hello interval
- Router dead interval
- Network mask
- Options: T-bit, E-bit
- List of neighbours

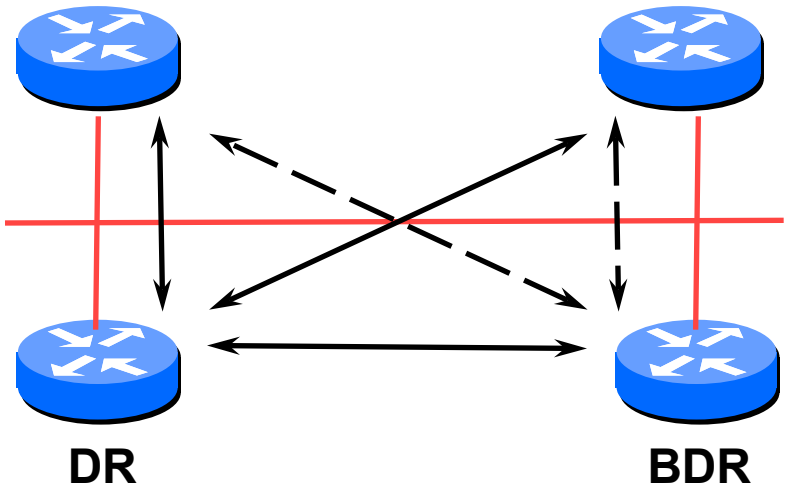


When to Become Adjacent

Cisco.com

- Underlying network is point to point
- Underlying network type is virtual link
- The router itself is the designated router
- The router itself is the backup designated router
- The neighbouring router is the designated router
- The neighbouring router is the backup designated router

LSAs Propagate Along Adjacencies



- LSAs acknowledged along adjacencies

Routing Protocol Packets

- Share a common protocol header
- Routing protocol packets are sent with type of service (TOS) of 0
- Five types of OSPF routing protocol packets
  - Hello – packet type 1
  - Database description – packet type 2
  - Link-state request – packet type 3
  - Link-state update – packet type 4
  - Link-state acknowledgement – packet type 5

Different Types of LSAs

- **Five distinct type of LSAs**

Type 1 :	**Router LSA**
Type 2 :	**Network LSA**
Type 3 and 4:	**Summary LSA**
Type 5 and 7:	**External LSA**

Router LSA (Type 1)

- Describes the state and cost of the router's links to the area
- All of the router's links in an area must be described in a single LSA
- Flooded throughout the particular area and no more
- Router indicates whether it is an ASBR, ABR, or end point of virtual link

Network LSA (Type 2)

- Generated for every transit broadcast and NBMA network
- Describes all the routers attached to the network
- Only the designated router originates this LSA
- Flooded throughout the area and no more

Summary LSA (Type 3 and 4)

- Describes the destination outside the area but still in the AS
- Flooded throughout a single area
- Originated by an ABR
- Only intra-area routes are advertised into the backbone
- Type 4 is the information about the ASBR

External LSA (Type 5)

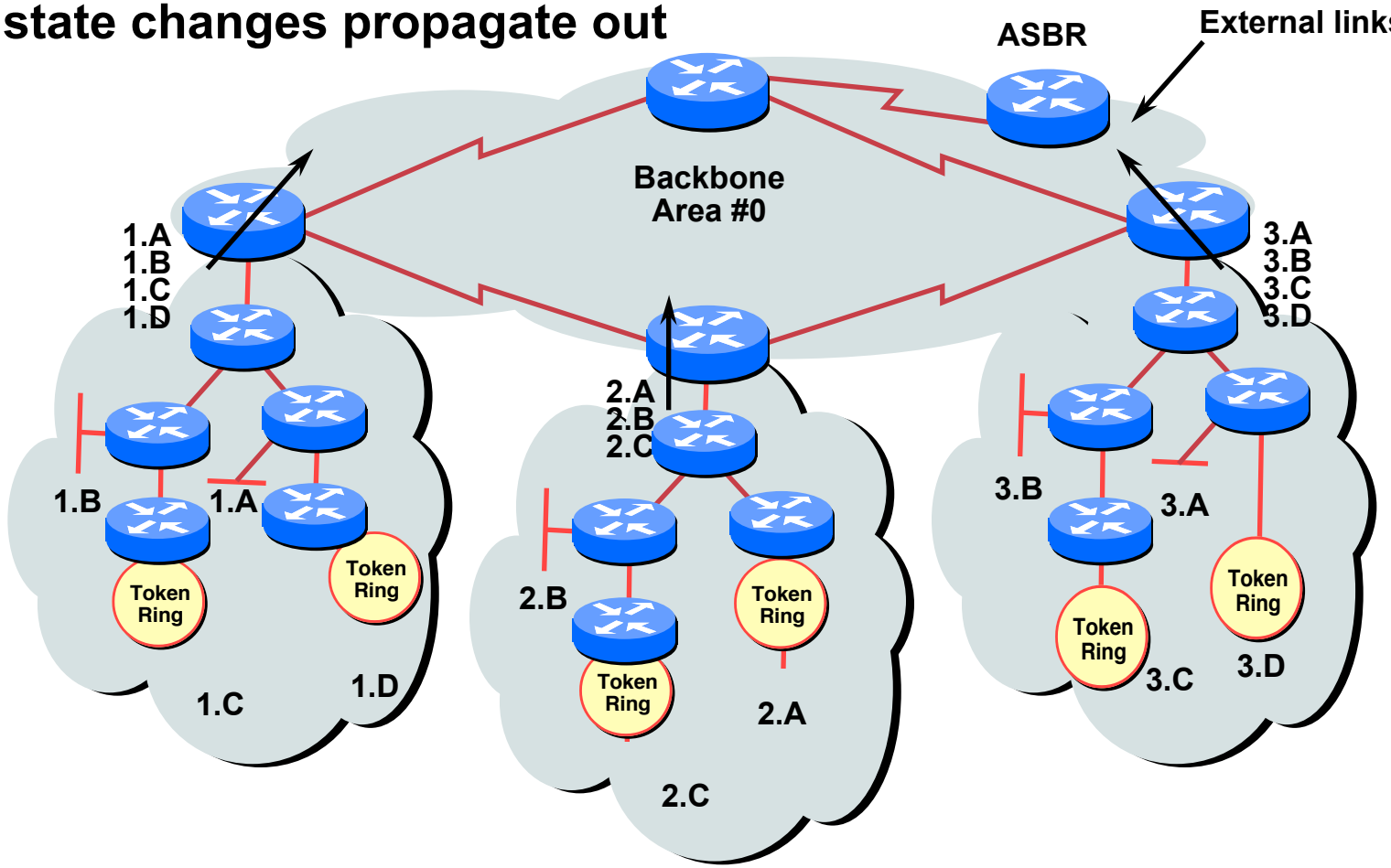
- Defines routes to destination external to the AS
- Default route is also sent as external
- Two types of external LSA:

  E1: Consider the total cost up to the external destination

  E2: Considers only the cost of the outgoing interface to the external destination

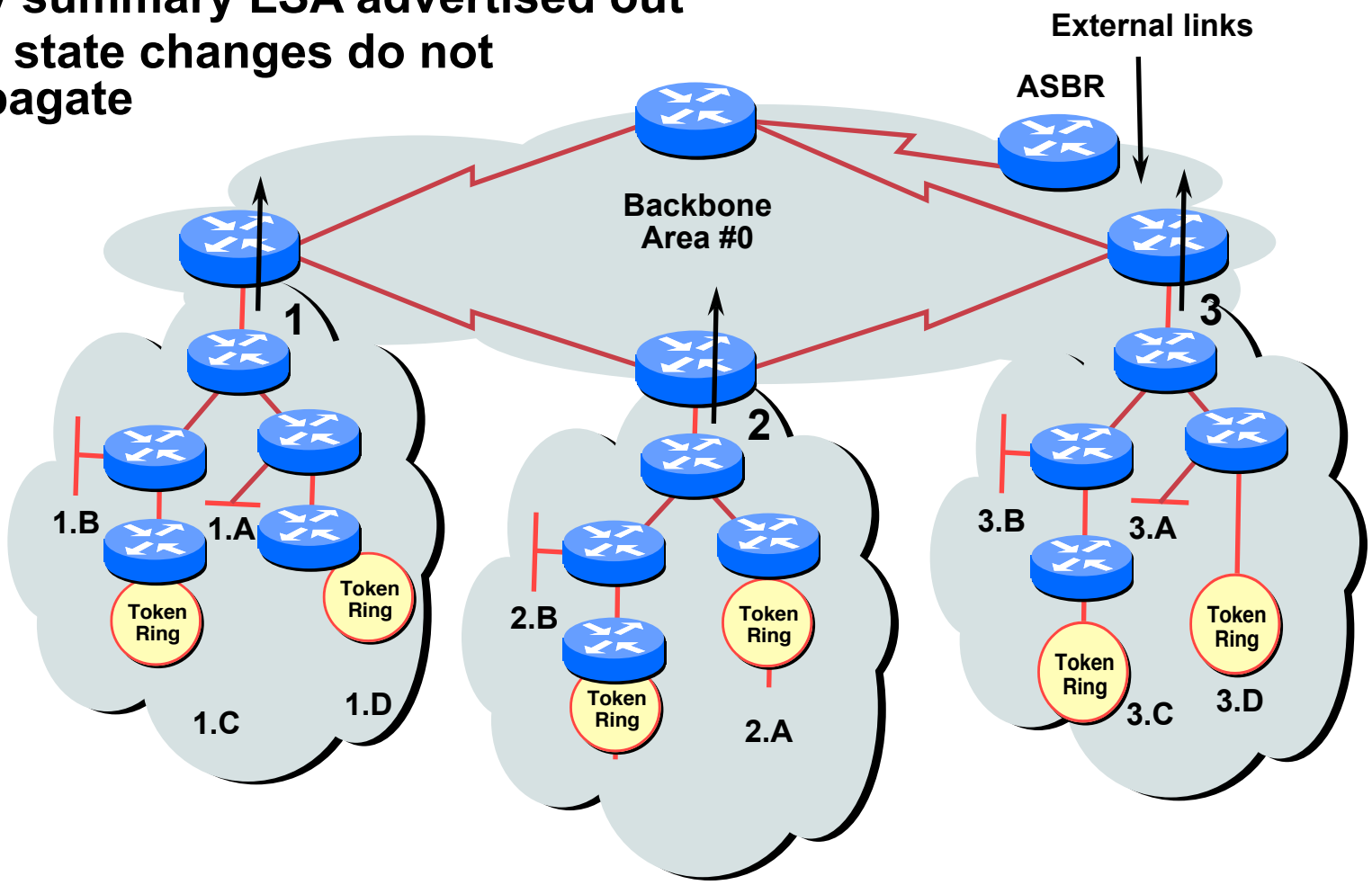
Not Summarised: Specific Links

- Specific link LSA advertised out
- Link state changes propagate out



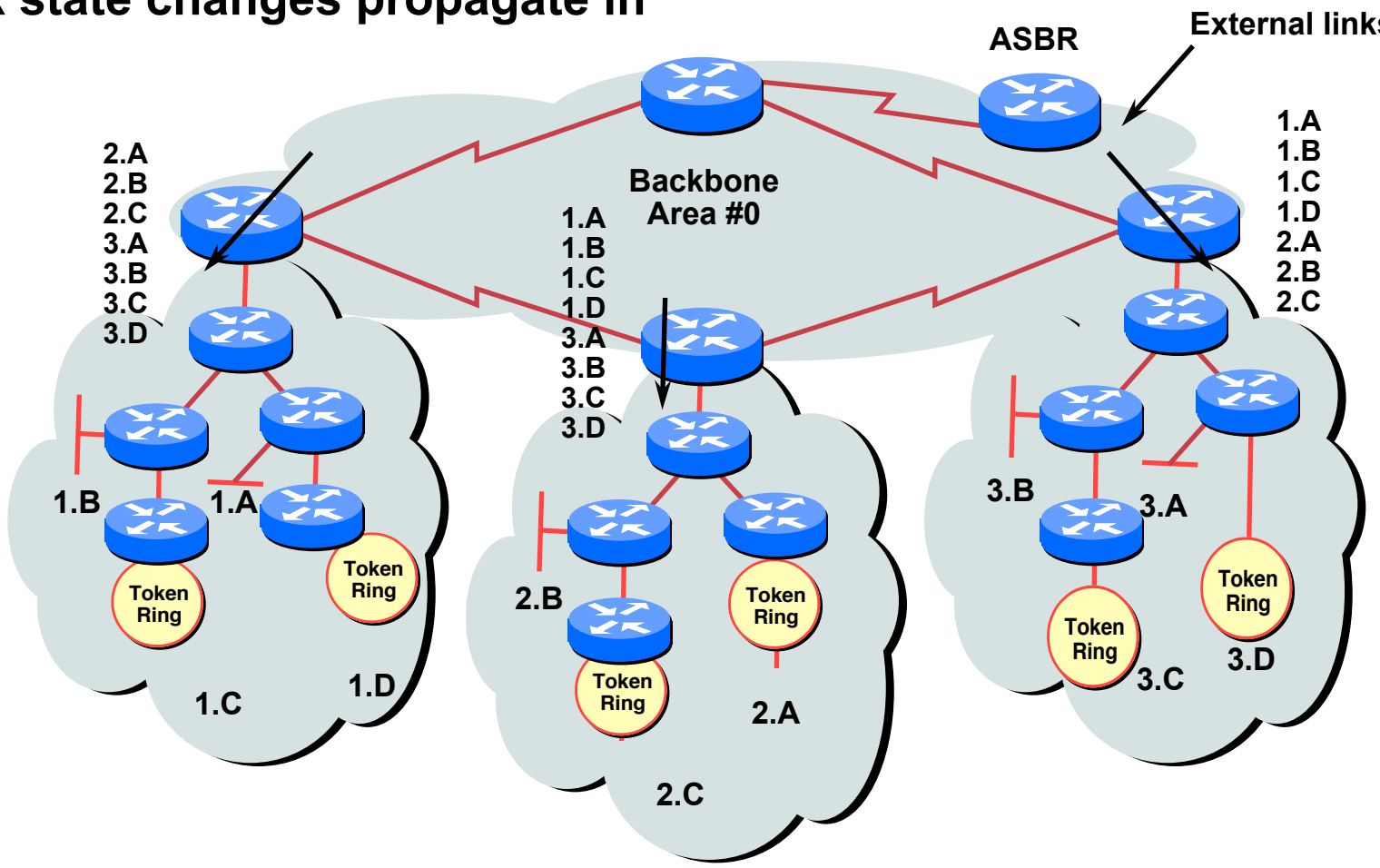
Summarised: Summary Links

- Only summary LSA advertised out
- Link state changes do not propagate



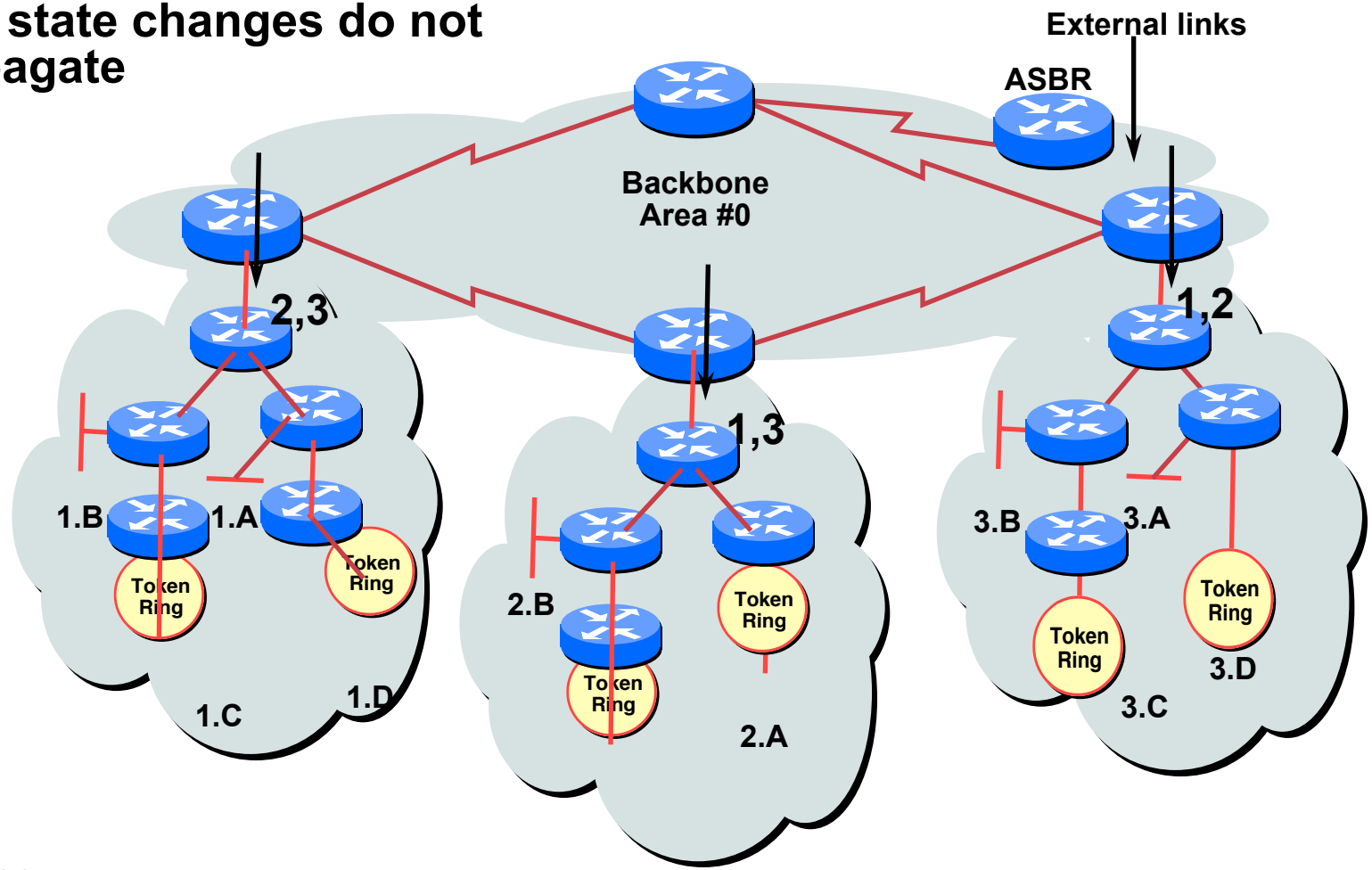
Not Summarised: Specific Links

- Specific link LSA advertised in
- Link state changes propagate in



Summarised: Summary Links

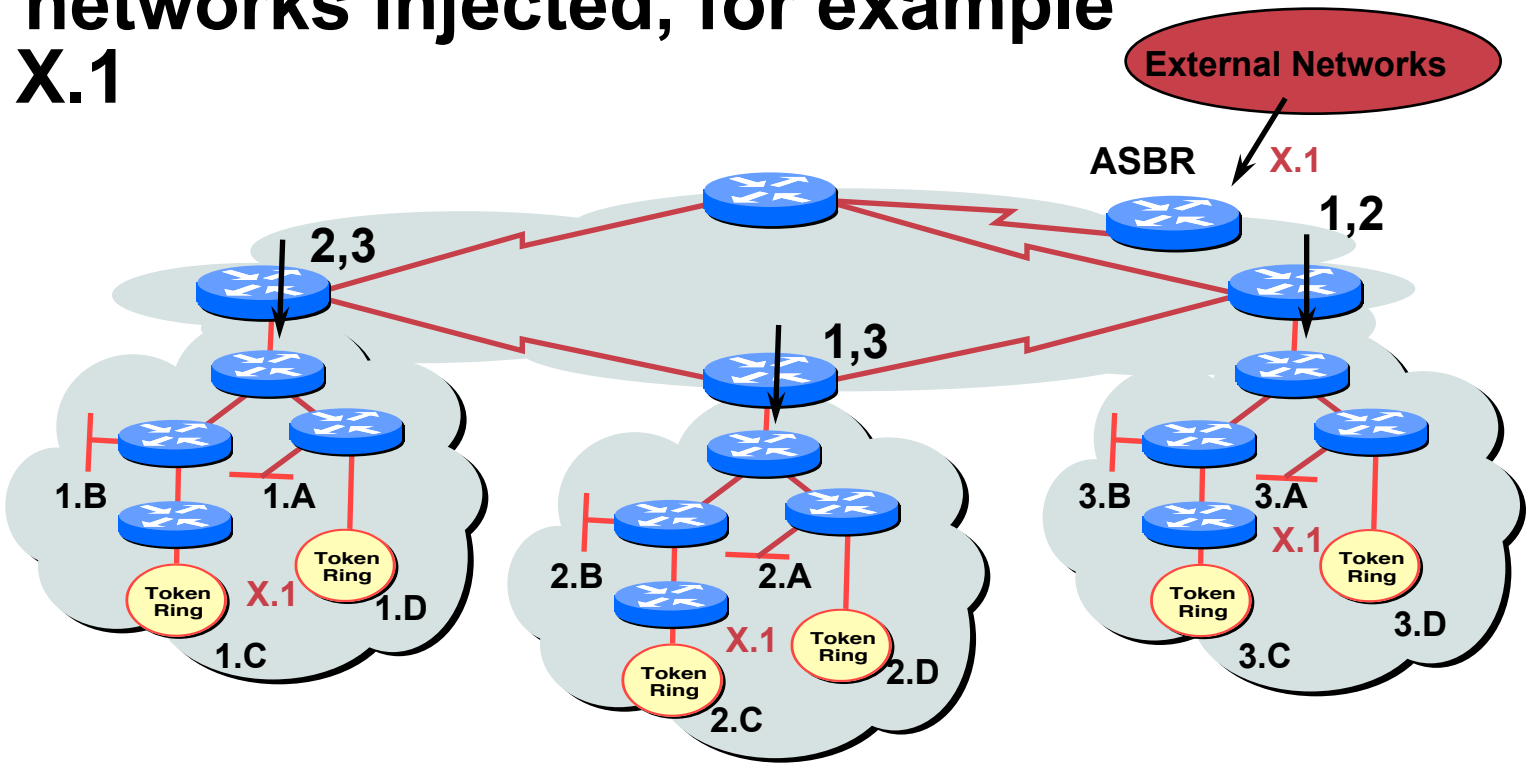
- Only summary LSA advertised in
- Link state changes do not propagate



Regular Area (Not a Stub)

From area 1's viewpoint

- Summary networks from other areas injected
- External networks injected, for example network X.1

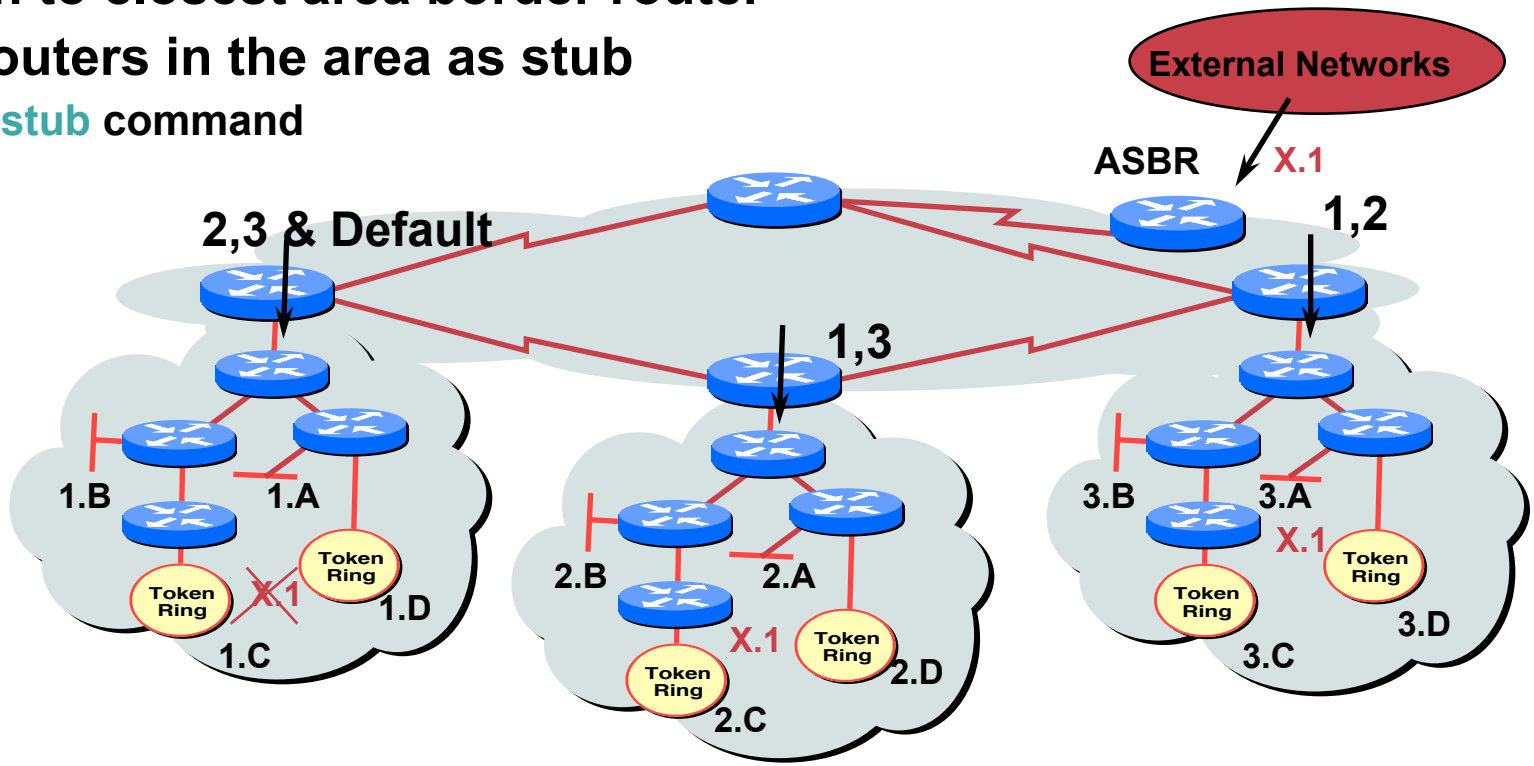


Normal Stub Area

From area 1's viewpoint

- Summary networks from other areas injected
- Default network injected into the area - represents external links
- Default path to closest area border router
- Define all routers in the area as stub

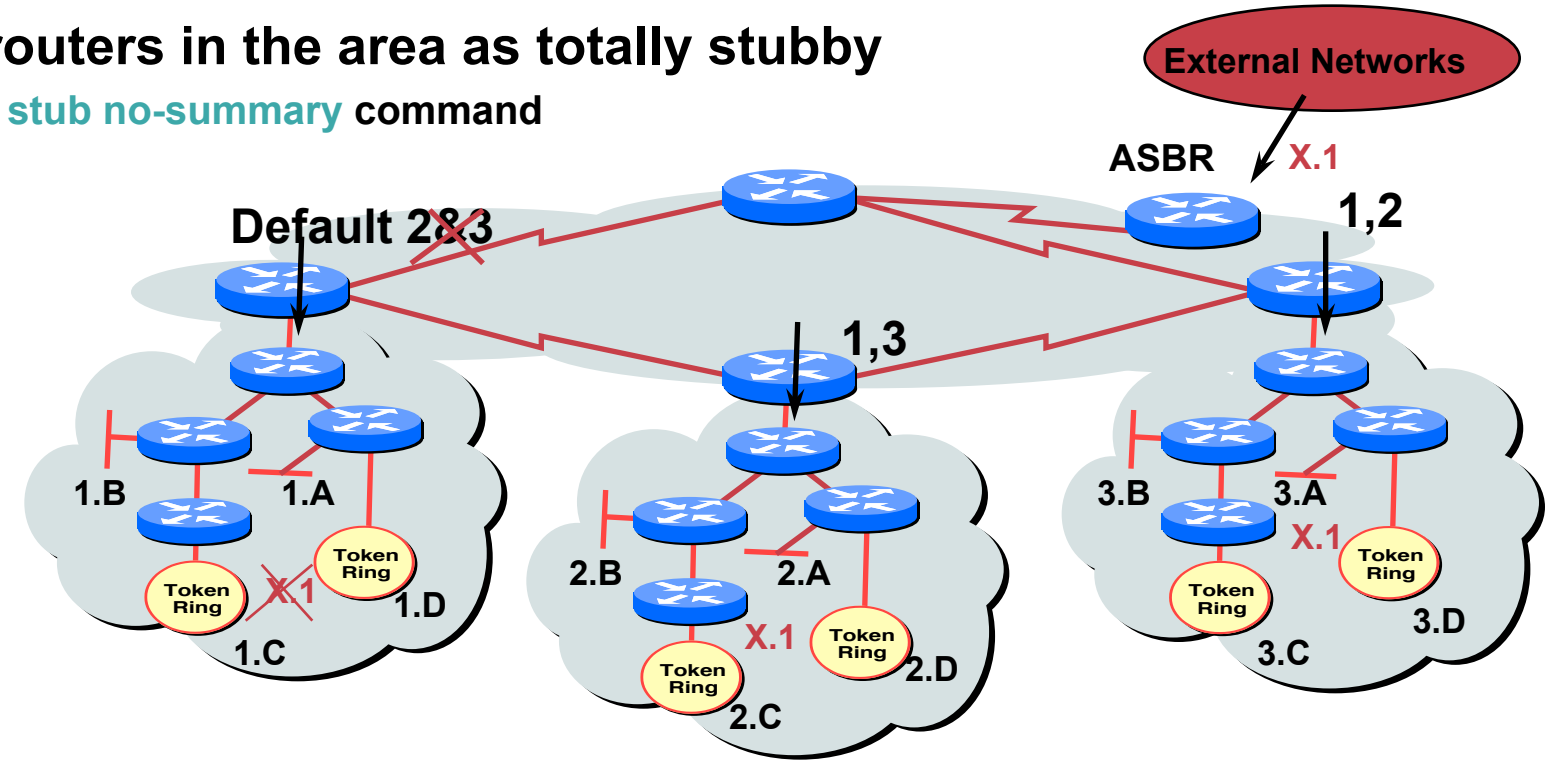
  area x stub command



Totally Stubby Area

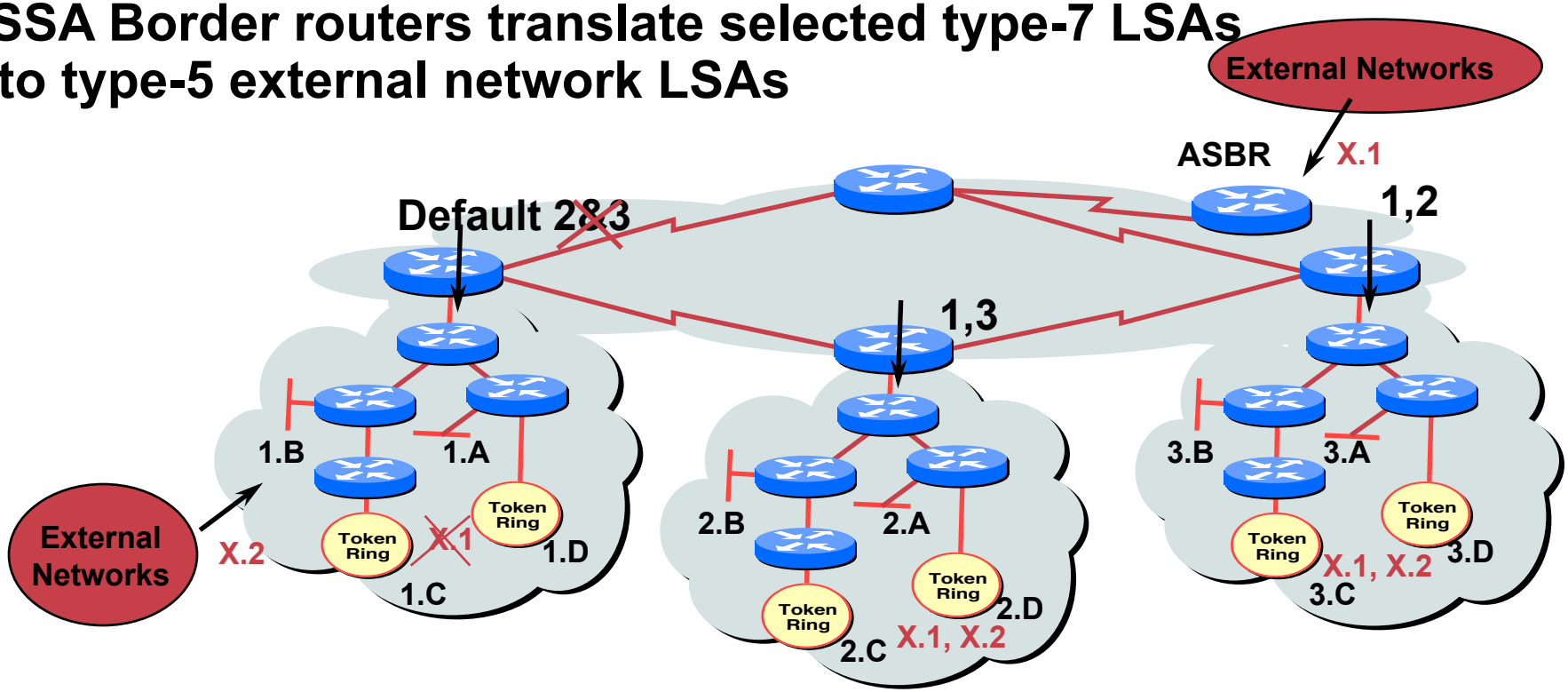
From area 1's viewpoint

- Only a default network is injected into the area
  - Represents external networks and all inter-area routes
- Default path to closest area border router
- Define all routers in the area as totally stubby
  - area x stub no-summary command



Not-So-Stubby Area

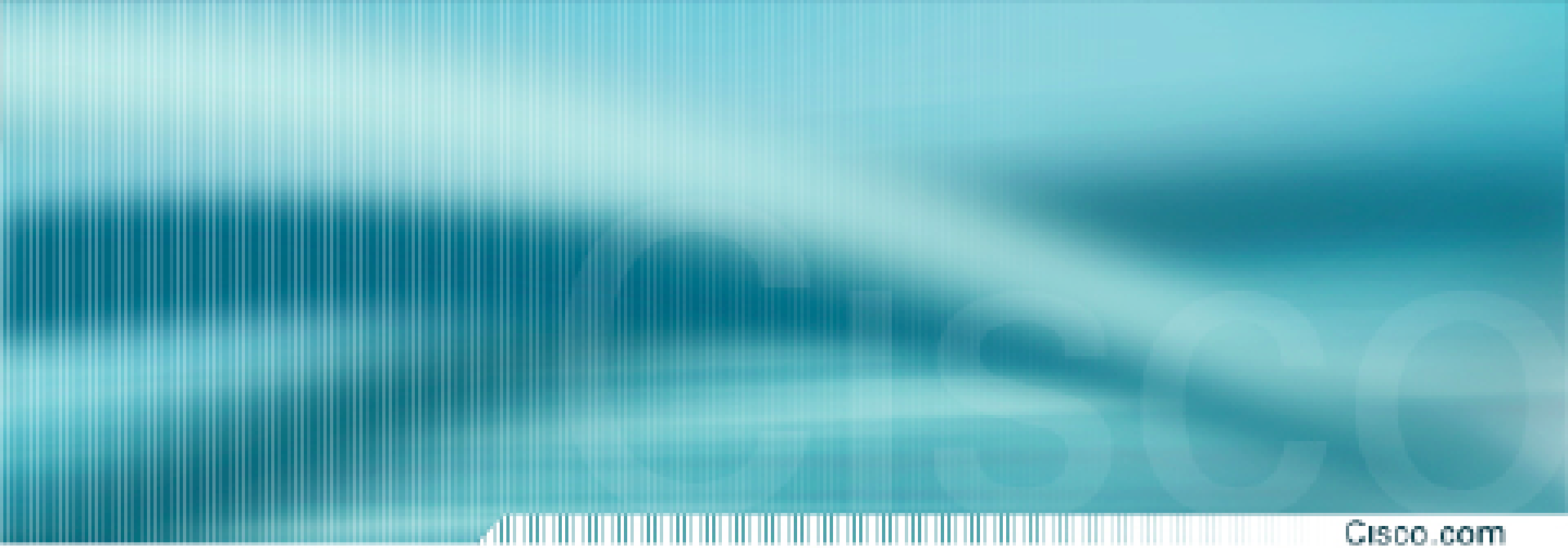
- Capable of importing external routes in a limited fashion
- Type-7 LSA's carry external information within an NSSA
- NSSA Border routers translate selected type-7 LSAs into type-5 external network LSAs



Summary

Cisco.com

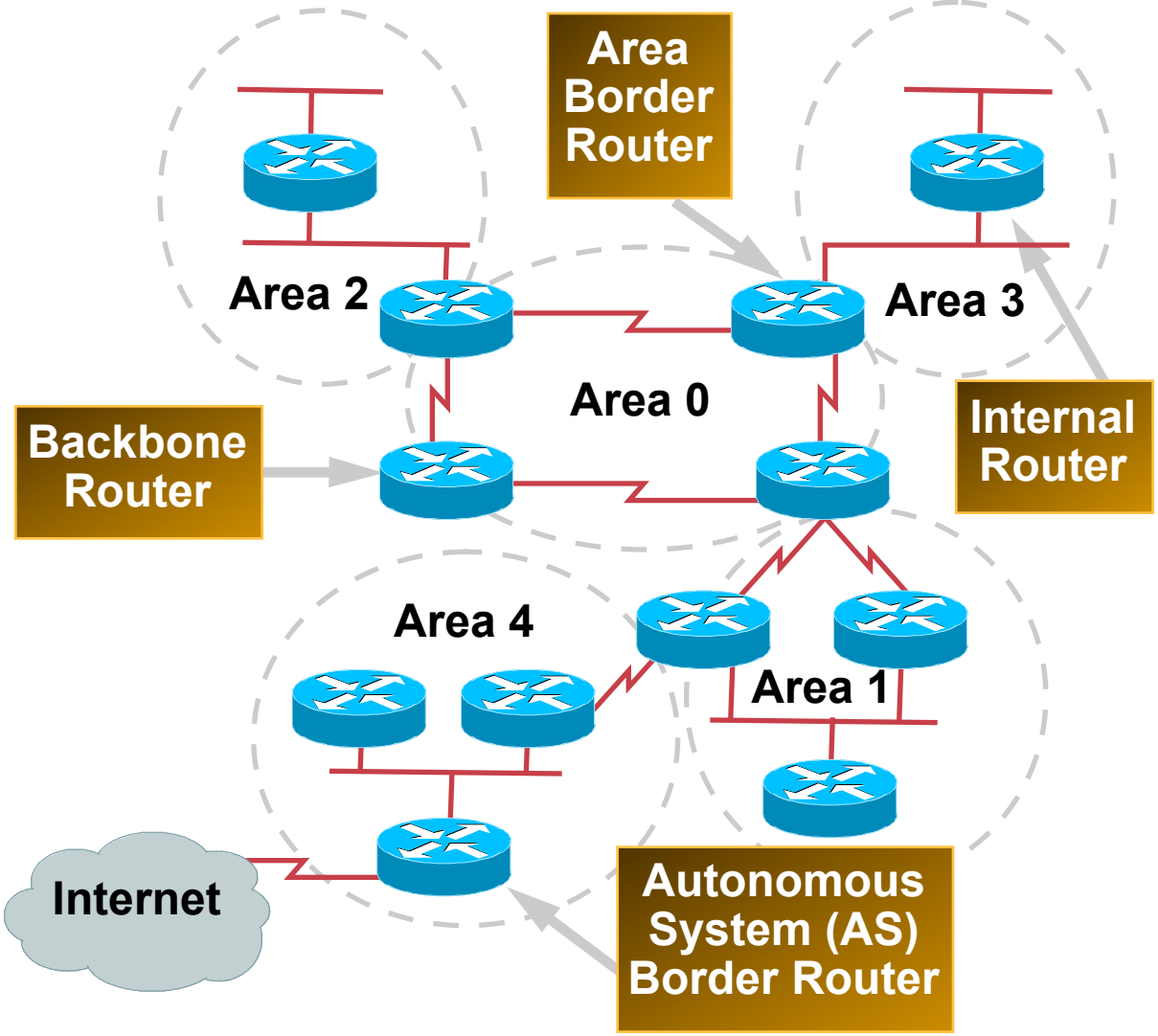
- **Scalable OSPF Network Design**
  - **Area hierarchy**
  - **Stub areas**
  - **Contiguous addressing**
  - **Route summarisation**



OSPF Design In Service Provider Networks

OSPF Areas and Rules

Backbone area (0) must be present
All other areas must have connection to backbone
Backbone must be contiguous
Do not partition area (0)



OSPF Design

- **OSPF design and Addressing go together.**
  - **Objective is to keep the Link State Data Base *lean.***
  - **Create address hierarchy to match topology**
  - **Separate Blocks for infrastructure, customer interfaces, customers, etc.**

OSPF Design

- Examine physical topology
  - Is it meshed or hub-and-spoke?
- Try to use as Stubby an area as possible
  - It reduces overhead and LSA counts
- Push the creation of a backbone
  - Reduces mesh and promotes hierarchy

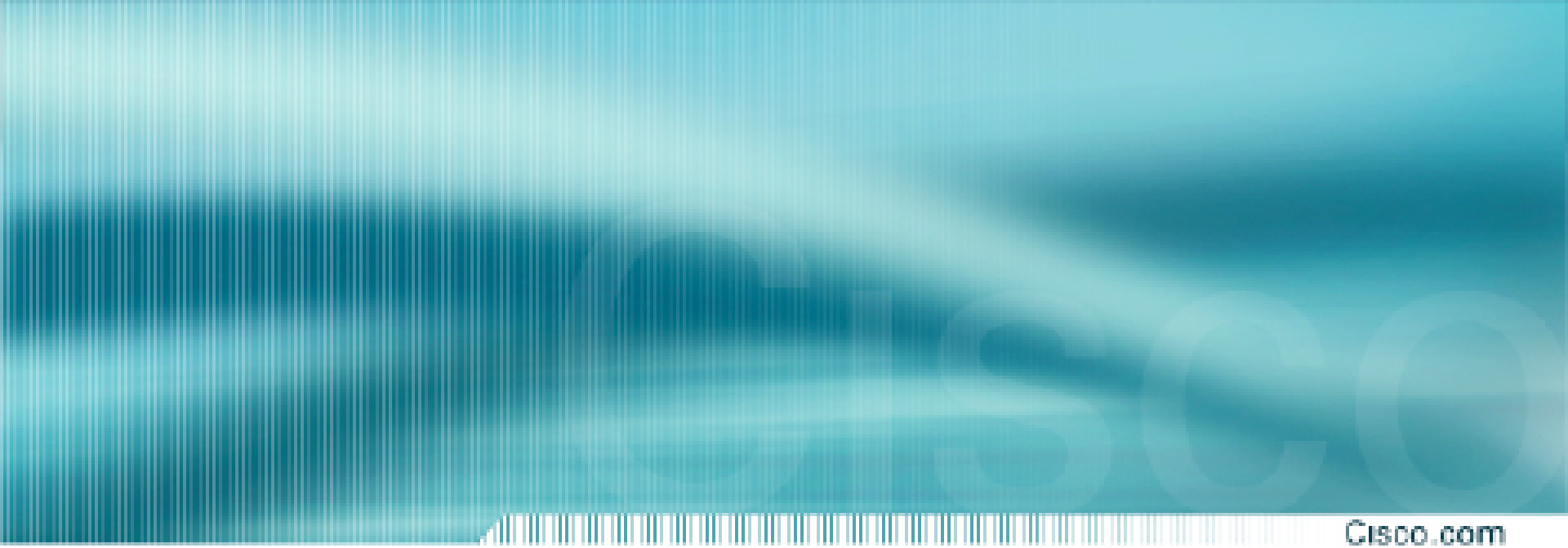
OSPF Design

Cisco.com

- One SPF per area, flooding done per area
  - Watch out for overloading ABRs
- Different types of areas do different flooding
  - Normal areas
  - Stub areas
  - Totally stubby (stub no-summary)
  - Not so stubby areas (NSSA)

OSPF Design

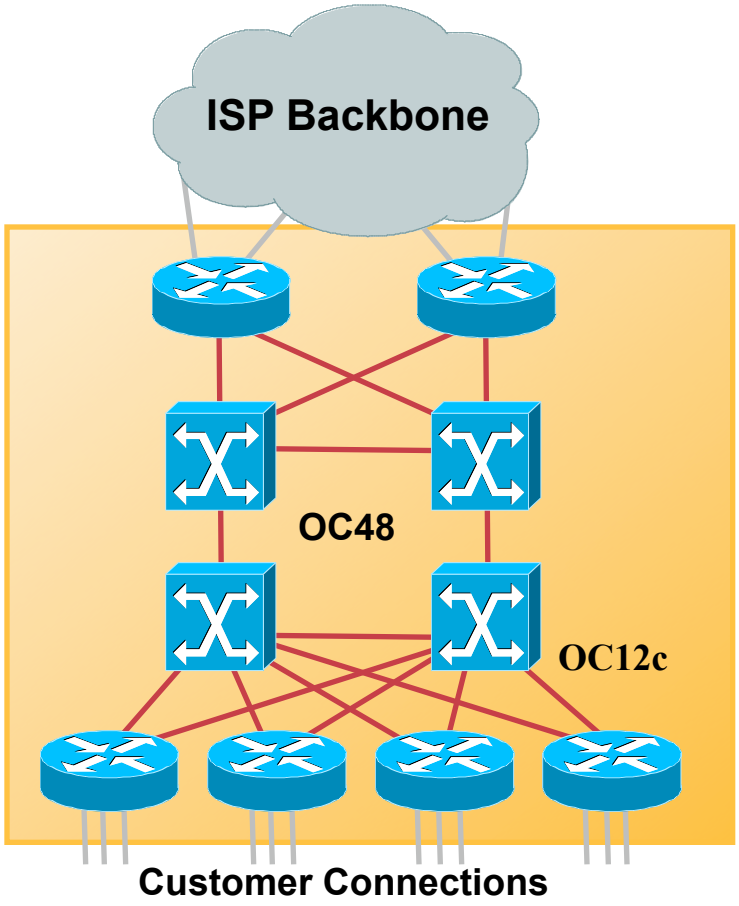
- **Redundancy**
  - **Dual Links out of each area – using metrics (cost) for traffic engineering**
  - **Too much redundancy…**
    - **Dual links to backbone in stub areas must be the same – other wise sub-optimal routing will result**
    - **Too Much Redundancy in the backbone area without good summarization will effect convergence in the area 0**



OSPF BCP
Adding Networks

OSPF – Adding Networks

- **BCP – Individual OSPF Network statement for each infrastructure link.**
  - **Have separate IP address blocks for *infrastructure* and *customer links.***
  - **Use *IP Unnumbered* Interfaces or BGP to carry /30s to customers**
  - **OSPF should only carry infrastructure routes in an ISP's network.**



OSPF – Adding Networks (Method One)

- **redistribute connected subnets**

  Works for all connected interfaces on the router but sends networks as external type-2s – which are not summarized

```
router ospf 100
 redistribute connected subnets
```

- **Not recommended**

OSPF – Adding Networks

- **Specific network statements**

  Every interface needs a OSPF network statement. Interface that should not be broadcasting OSPF Hello packets needs *passive-interface.*

```
router ospf 100
 network 192.168.1.1 0.0.0.3 area 51
 network 192.168.1.5 0.0.0.3 area 51
 passive interface Serial 1/0
```

OSPF – Adding Networks

Cisco.com

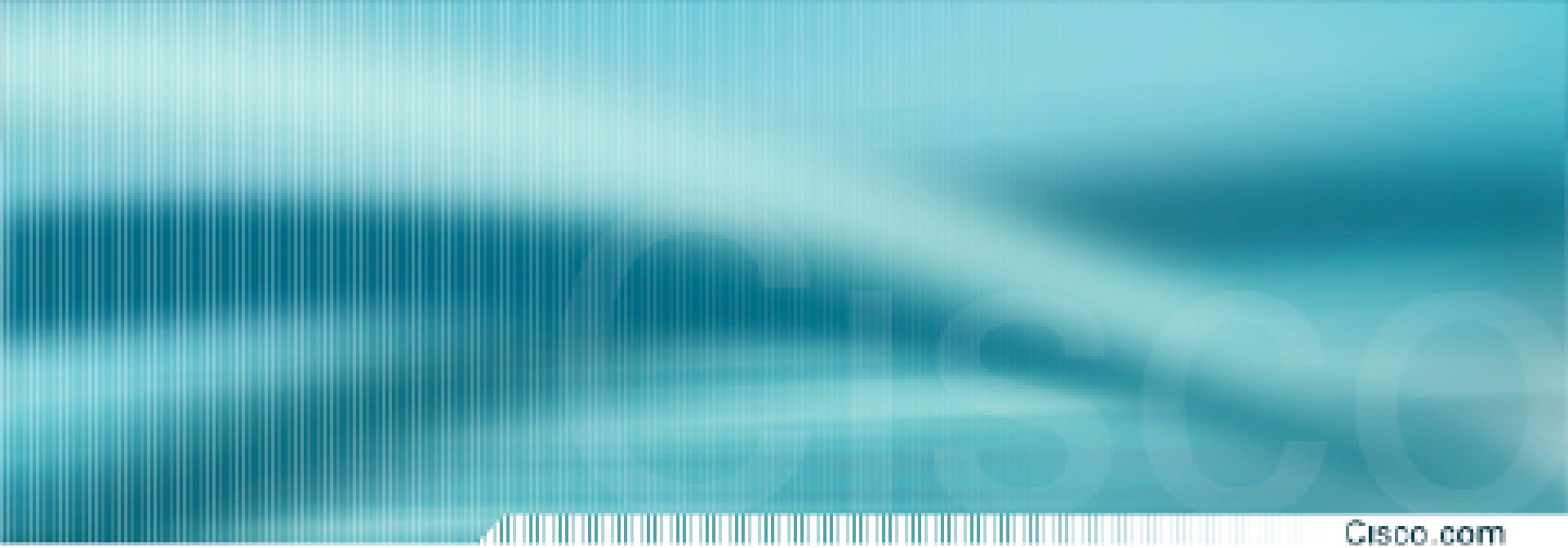
- **Network statements – wildcard mask**

  Every interface covered by wildcard mask used in OSPF network statement. Interfaces that should not be broadcasting OSPF Hello packets need *passive-interface* or *default passive-interface.*

```
router ospf 100
 network 192.168.1.0 0.0.0.255 area 51
 default passive-interface default
 no passive interface POS 4/0
```

OSPF – Adding Networks

- **Key Theme when selecting a technique: Keep the Link State Database Lean**
  - **Increases Stability**
  - **Reduces the amount of information in the Link State Advertisements (LSAs)**
  - **Speeds Convergence Time**



OSPF – New and Useful Features

OSPF Cost: Reference Bandwidth

- **Bandwidth used in Metric calculation**

  Cost = 10^8/BW

  Not useful for BW > 100 Mbps

- **Syntax:**

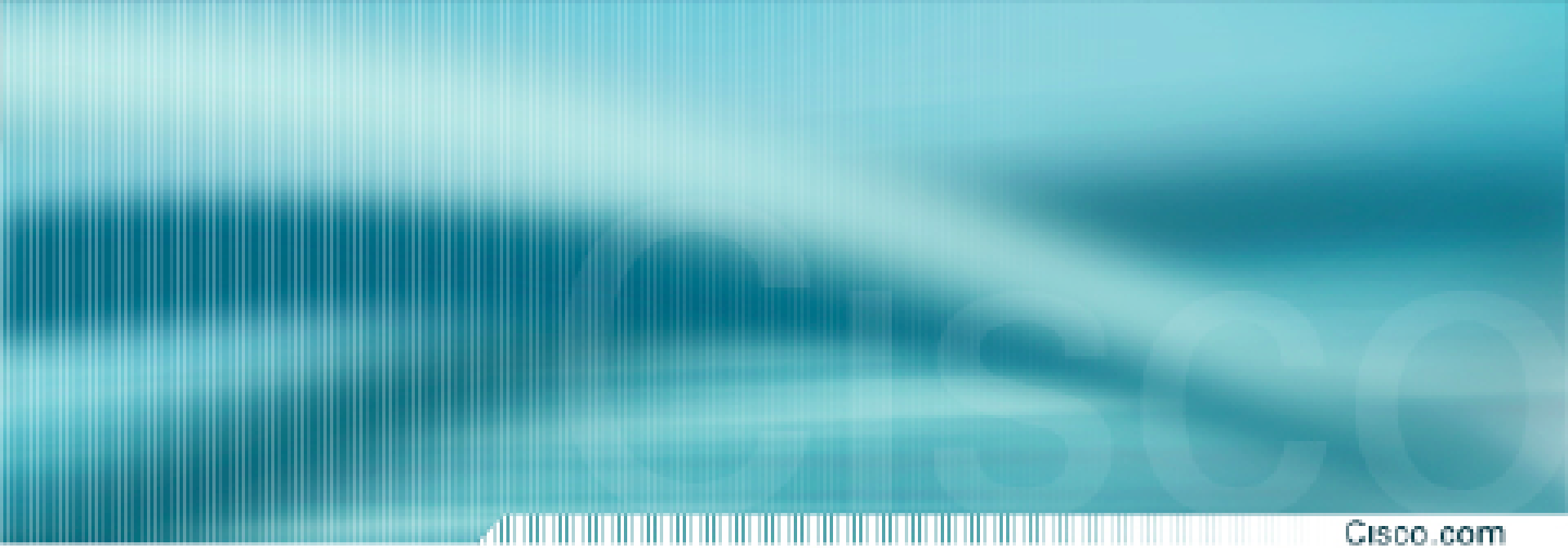
  ospf auto-cost reference-bandwidth <reference-bandwidth>

- **Default reference bandwidth still 100 Mbps for backward compatibility**

OSPF Router ID

- If the loopback interface exists and has an IP address, that is used as the router ID in routing protocols – stability!
- If the loopback interface does not exist, or has no IP address, the router ID is the highest IP address configured – danger!
- New sub command to manually set the OSPF Router ID:

```
router-id <ip address>
```



Open Shortest Path First v3 summary

OSPFv3 overview

- OSPF for IPv6
- Based on OSPFv2, with enhancements
- Distributes IPv6 prefixes
- Runs directly over IPv6
- Ships-in-the-night with OSPFv2

OSPFv3 / OSPFv2 Similarities

Cisco.com

- **Basic packet types**

  Hello, DBD, LSR, LSU, LSA

- **Mechanisms for neighbor discovery and adjacency formation**
- **Interface types**

  P2P, P2MP, Broadcast, NBMA, Virtual

- **LSA flooding and aging**
- **Nearly identical LSA types**

OSPFv3 / OSPFv2 Differences

Cisco.com

- OSPFv3 runs over a link, rather than a subnet
- Multiple instances per link
- OSPFv2 topology not IPv6-specific
  - Router ID
  - Link ID
- Standard authentication mechanisms
- Uses link-local addresses
- Generalized flooding scope
- Two new LSA types

Link LSA

- A link LSA per link
- Link local scope flooding on the link with which they are associated
- Provide router link local address
- List all IPv6 prefixes attached to the link
- Assert a collection of option bit for the Router-LSA

Inter-Area Prefix LSA

- Describes the destination outside the area but still in the AS
- Summary is created for one area, which is flooded out in all other areas
- Originated by an ABR
- Only intra-area routes are advertised into the backbone
- Link-local addresses must never be advertised in inter-area-prefix-LSAs

Configuring OSPFv3

- **Similar to OSPFv2**

  Prefixing existing Interface and Exec mode commands with "ipv6"

- **Interfaces configured directly**

  Replaces `network` command

- **"Native" IPv6 router mode**

  Not a sub-mode of `router ospf`

Configuration Modes in OSPFv3

Cisco.com

- **Entering router mode**

  [no] ipv6 router ospf <process ID>

- **Entering interface mode**

  [no] ipv6 ospf <process ID> area <area ID>

- **Exec mode**

  [no] show ipv6 ospf [<process ID>]

  clear ipv6 ospf [<process ID>]

Cisco IOS OSPFv3 Specific Attributes

- **Configuring area range**

  [no] area <area ID> range <prefix>/<prefix length>

- **Showing new LSA**

  show ipv6 ospf [<process ID>] database link

  show ipv6 ospf [<process ID>] database prefix

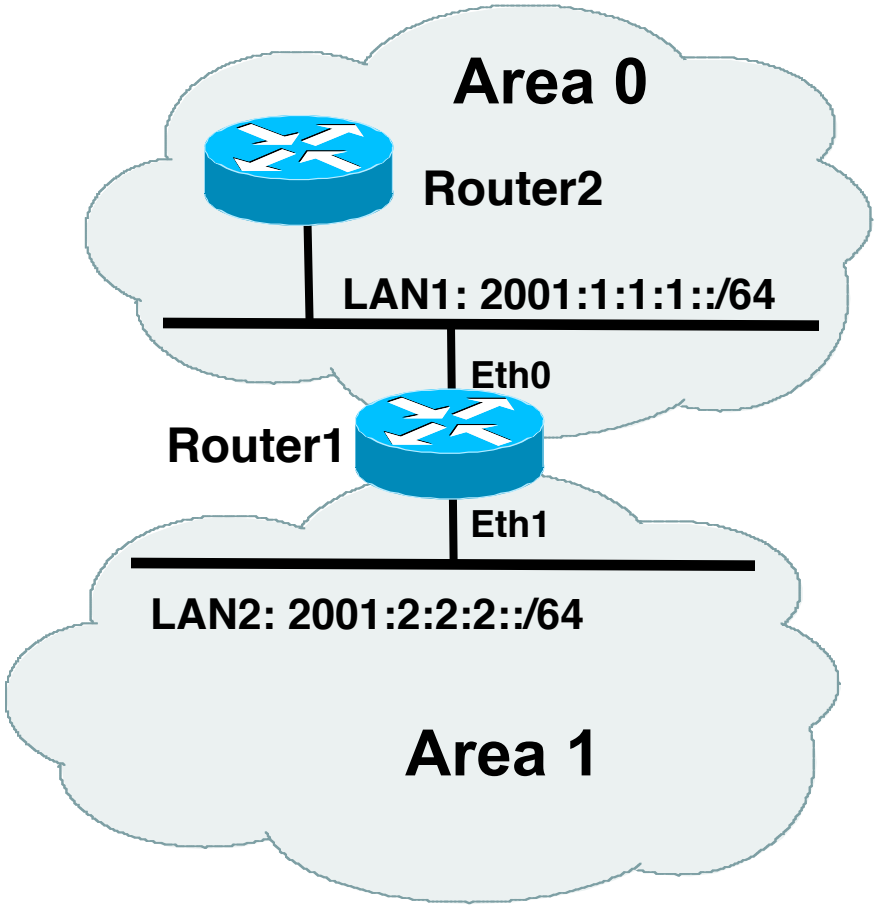
OSPFv3 Debug Commands

Cisco.com

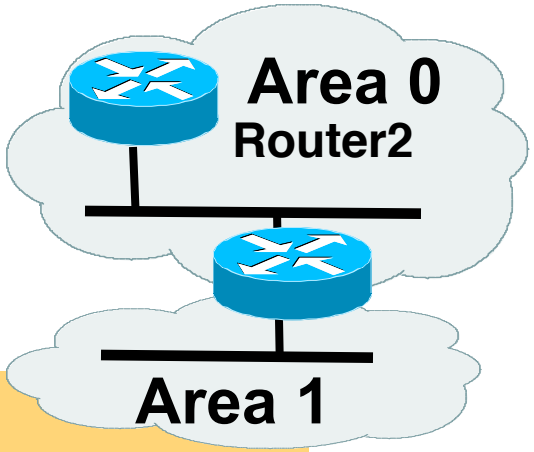
- **Adjacency is not appearing**
  - [no] debug ipv6 ospf adj
  - [no] debug ipv6 ospf hello
- **SPF is running constantly**
  - [no] debug ipv6 ospf spf
  - [no] debug ipv6 ospf flooding
  - [no] debug ipv6 ospf events
  - [no] debug ipv6 ospf lsa-generation
  - [no] debug ipv6 ospf database-timer
- **General purpose**
  - [no] debug ipv6 ospf packets
  - [no] debug ipv6 ospf retransmission
  - [no] debug ipv6 ospf tree

OSPFv3 configuration example


```
Router1#
 interface Ethernet0
   ipv6 address 2001:1:1:1::1/64
   ipv6 ospf 1 area 0

 interface Ethernet1
    ipv6 address 2001:2:2:2::2/64
    ipv6 ospf 1 area 1

 ipv6 router ospf 1
  router-id 1.1.1.1
  area 1 range 2001:2:2::/48
```



Cisco IOS OSPFv3 Display




```
Router 2# show ipv6 route ospf
IPv6 Routing Table - 9 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
O   2001:1:1:2::1/128 [110/1]
     via FE80::205:5FFF:FEAF:2C38, Ethernet0
OI  2001:2:2::/48 [110/2]
     via FE80::205:5FFF:FEAF:2C38, Ethernet0
```

Cisco IOS OSPFv3 Database Display

Cisco.com

```
Router2# show ipv6 ospf database

OSPF Router with ID (3.3.3.3) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
0               1.1.1.1         2009        0x8000000A 0x2DB1   1
0               3.3.3.3         501         0x80000007 0xF3E6   1

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
7               1.1.1.1         480         0x80000006 0x3BAD

                Inter Area Preëx Link States (Area 0)

ADV Router      Age         Seq#       Preëx
1.1.1.1         1761        0x80000005  2001:2:2:2::/64
1.1.1.1         982         0x80000005  2001:2:2:4::2/128

                Link (Type-8) Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Interface
11              3.3.3.3         245         0x80000006 0xF3DC   Lo0
7               1.1.1.1         236         0x80000008 0x68F    Fa2/0
7               3.3.3.3         501         0x80000008 0xE7BC   Fa2/0

                Intra Area Preëx Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Ref lstype
0               1.1.1.1         480         0x80000008 0xD670   0x2001
107             1.1.1.1         236         0x80000008 0xC05F   0x2002
0               3.3.3.3         245         0x80000006 0x3FF7   0x2001
```

Cisco IOS OSPFv3 Detailed LSA Display

Cisco.com

```
show ipv6 ospf 1 database inter-area prefix

  LS age: 1714
  LS Type: Inter Area Prefix Links
  Link State ID: 0
  Advertising Router: 1.1.1.1
  LS Seq Number: 80000006
  Checksum: 0x25A0
  Length: 36
  Metric: 1
  Prefix Address: 2001:2:2:2::
  Prefix Length: 64, Options: None

 show ipv6 ospf 1 database link

  LS age: 283
  Options: (IPv6 Router, Transit Router, E-Bit, No Type 7-to-5, DC)
  LS Type: Link-LSA (Interface: Loopback0)
  Link State ID: 11 (Interface ID)
  Advertising Router: 3.3.3.3
  LS Seq Number: 80000007
  Checksum: 0xF1DD
  Length: 60
  Router Priority: 1
  Link Local Address: FE80::205:5FFF:FEAC:1808
  Number of Prefixes: 2
  Prefix Address: 2001:1:1:3::
  Prefix Length: 64, Options: None
  Prefix Address: 2001:1:1:3::
  Prefix Length: 64, Options: None
```

Conclusion

- Based on existing OSPFv2 implementation
- Similar CLI and functionality
- Fully functional EFT available now
- Cisco IOS Software availability:

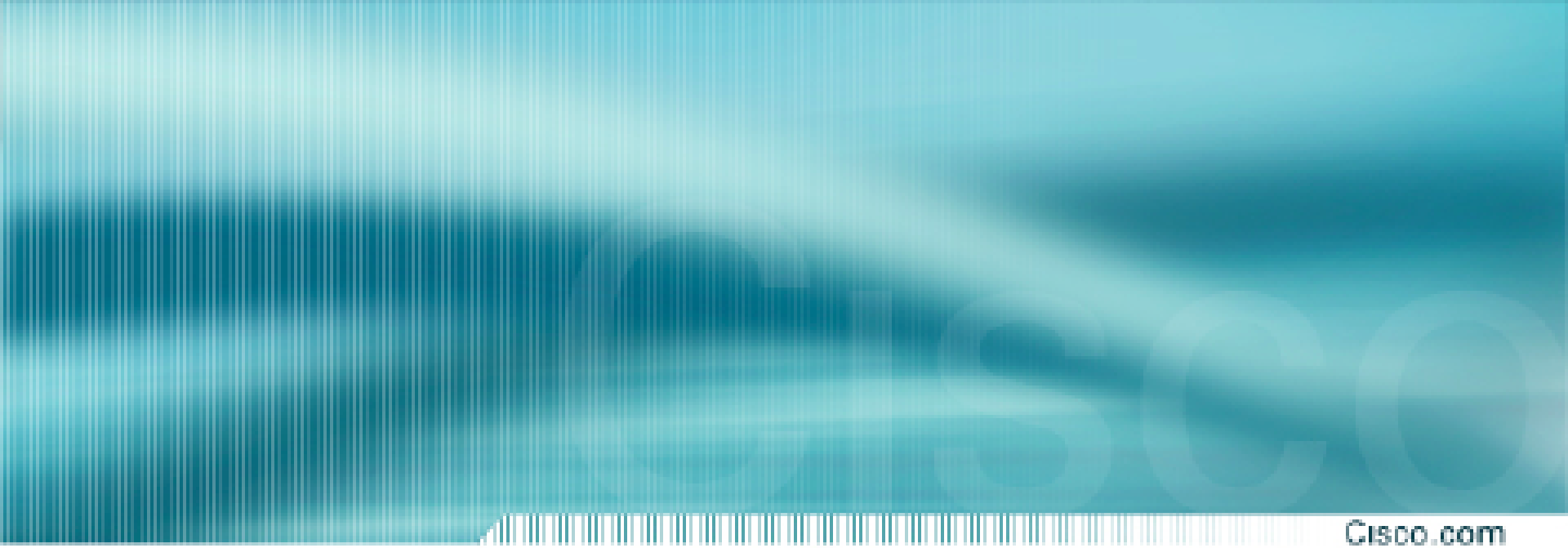
  Release 12.2(15)T

  Release 12.2(RLS3)S for Cisco 7000 Series Routers and Cisco Catalyst 6000 Series Switches

  Release 12.0(24)S the Cisco 12000 Series Internet Routers

References

- RFC 2740 “OSPF for IPv6”
- RFC 2328 “OSPF version 2”



Cisco IOS IS-IS for IPv6

Agenda

-
- **IS-IS for IPv6**
- **Multi-Topology IS-IS**

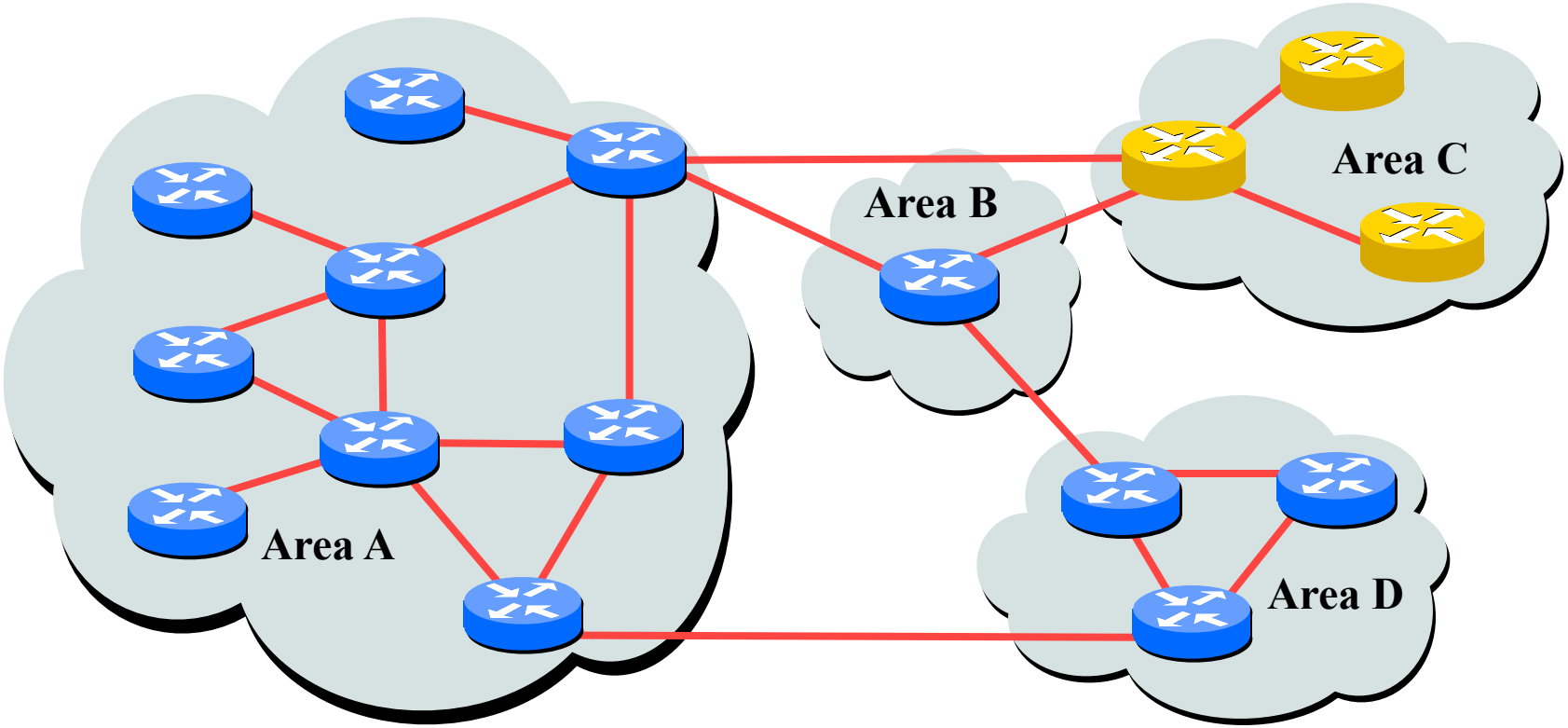
Single SPF rules

- 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 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.
- Cannot join two IPv6 areas via an IPv4-only area.

IS-IS Hierarchy & IPv6 example



IPv4-IPv6 enable router

IPv4-only enable router

Configuring IS-IS for IPv6 on 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.

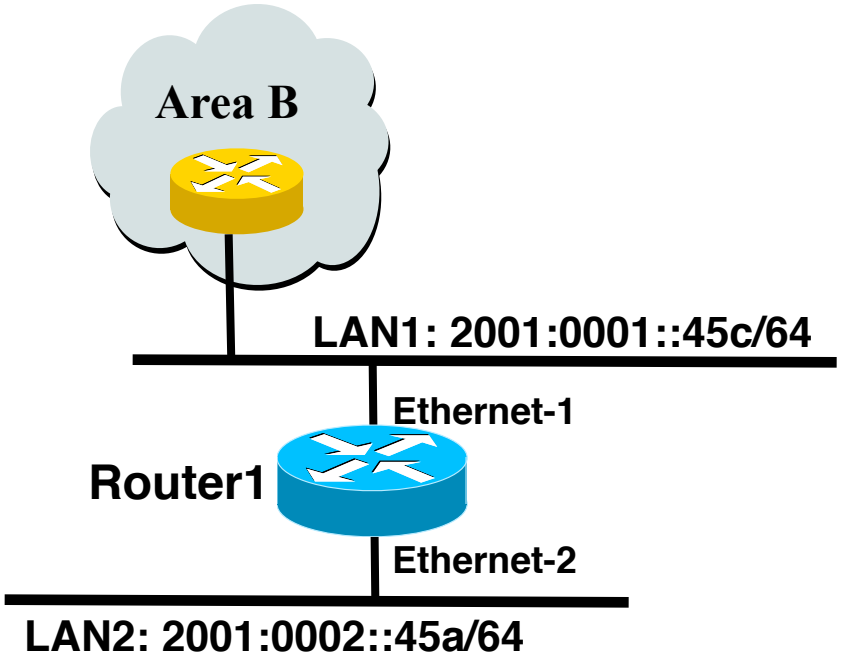
- Leaving address-family sub-mode

  exit-address-family

- Showing the I/IS-ISv6 configuration

  Show ipv6 protocols [summary]

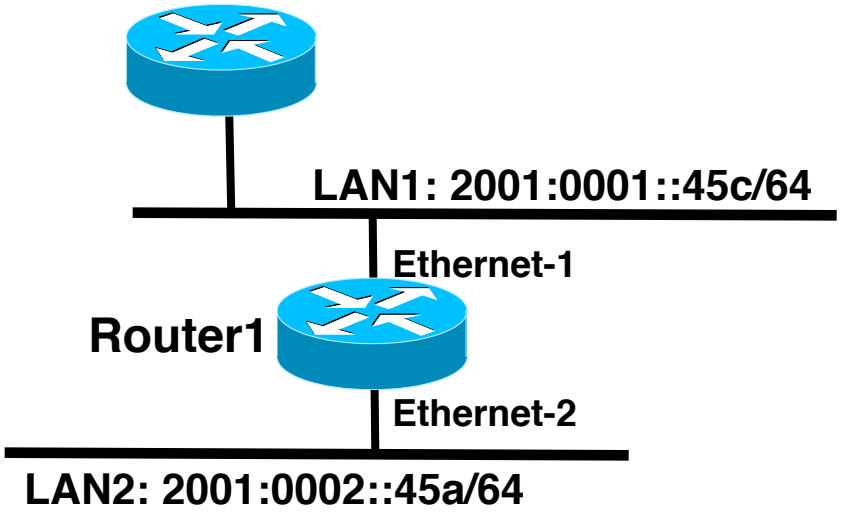
Cisco IOS IS-IS for IPv6-only configuration example



IPv6-only configuration.
Redistributing IPv6 static routes.

```
Router1#
 interface ethernet-1
     ipv6 address 2001:0001::45c/64
     ipv6 router isis
     isis circuit-type level-2-only

  interface ethernet-2
     ipv6 address 2001:0002::45a/64
     ipv6 router isis

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

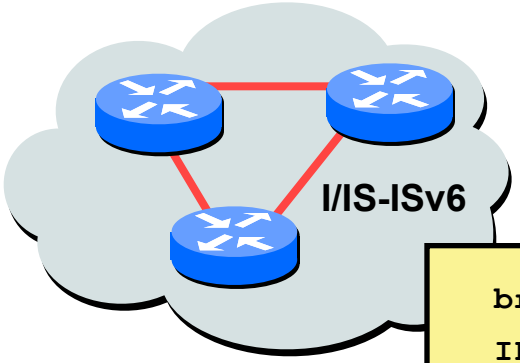
Cisco IOS IS-IS dual IP configuration



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 2001:0001::45c/64
     ip router isis
     ipv6 router isis

  interface ethernet-2
     ip address 10.2.1.1 255.255.255.0
     ipv6 address 2001:0002::45a/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
```

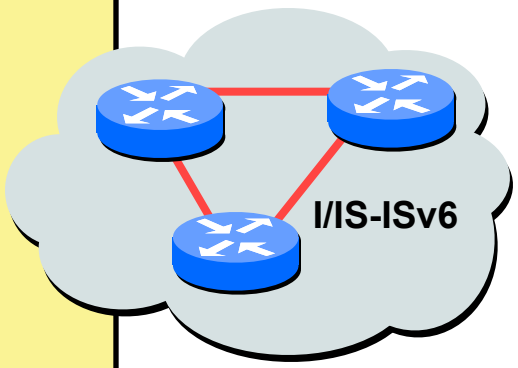
Cisco IOS IS-IS Display (1)




```
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  2001:45A:1000::/64 [115/20]
     via FE80::210:7BFF:FEC2:ACCC, Ethernet1, 00:10:12/never
I1  2001:72B: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 IS-IS Display (2)

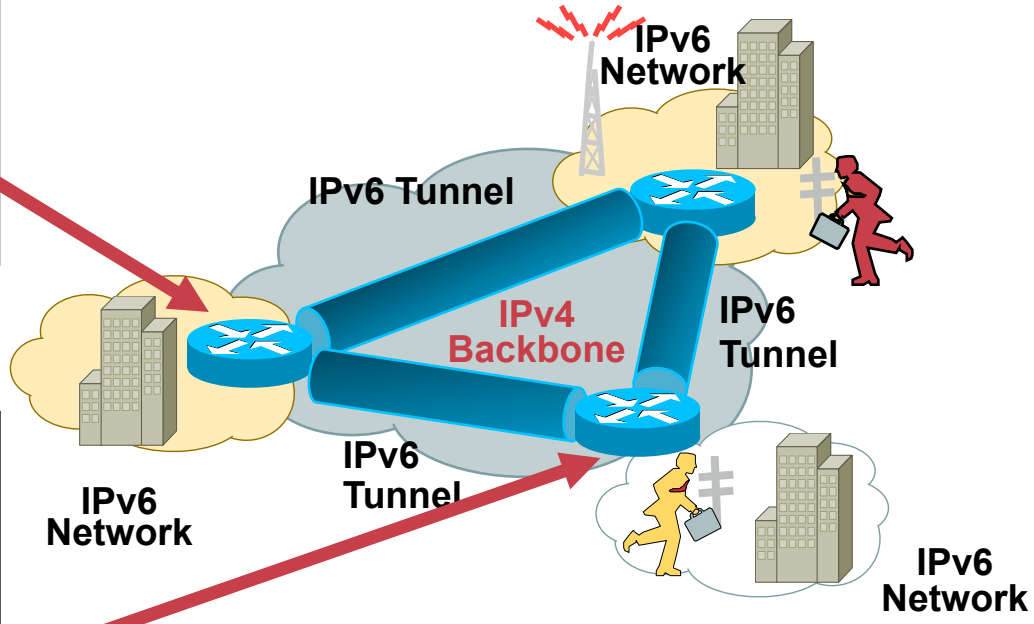

```
brum-45c#sho clns is-neigh detail

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: 2001:45C:2000::45C
  Metric: 10         IPv6 2001:45C:1000::/64
  Metric: 10         IPv6 3F02::/64
  Metric: 10         IPv6 2001:45C: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: 2001:45A:1000::45A
  Metric: 10         IPv6 2001:45A:1000::/64
  Metric: 10         IS brum-45c.01
  Metric: 0          IPv6-Ext 2001:72B: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 2001:0001::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 2001:0001::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

- IOS IS-IS for IPv6
- Multi-Topology IS-IS

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.**

  IS-IS has been extended by additions of new Type Length Value (TLVs).This IS-IS extension impacts adjacency forming, prefix advertisement and Intermediate Systems reachability.

- **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 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 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.

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 are expected 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.

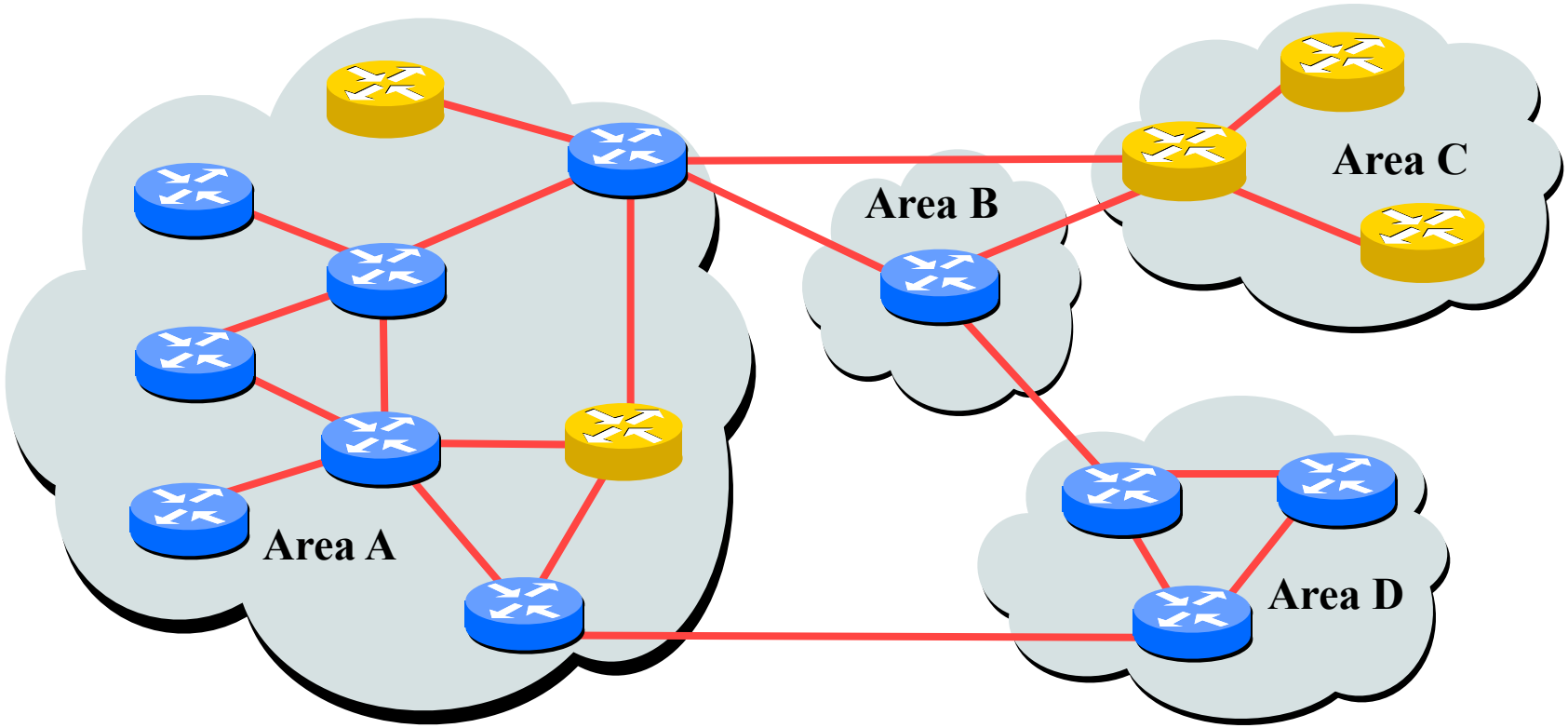
- · IPv4, IPv6, or IPv4/IPv6 may be configured on the interface for either level -1 level-2 or level-1-2. But if IPv4 and IPv6 are configured on the same interface, they must be running the same IS-IS level

  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. However, 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

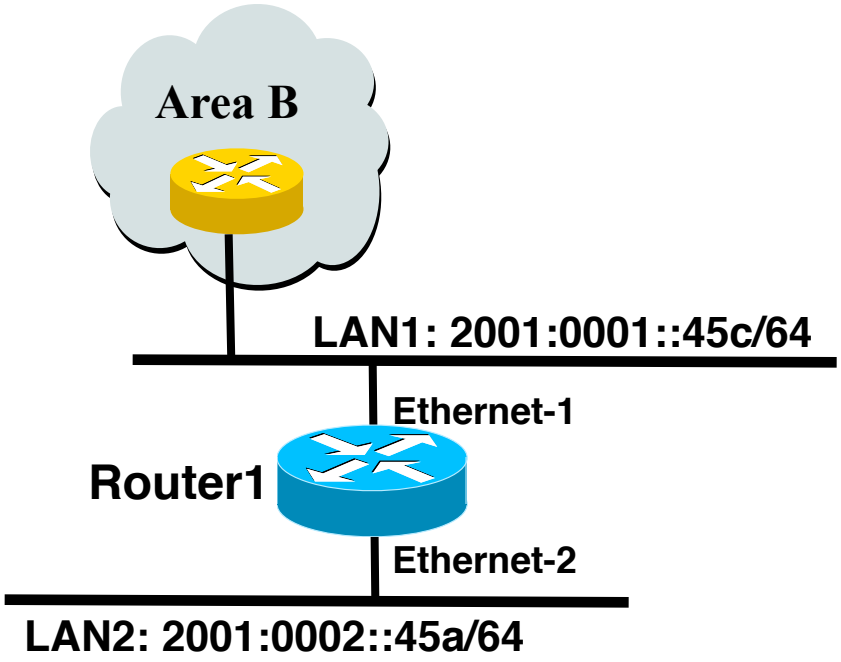


IPv4-IPv6 enable router

IPv4-only enable 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 IS-IS configuration example

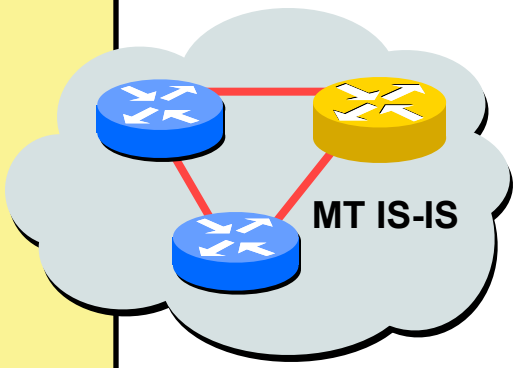


- The optional keyword *transition* may be used for transitioning existing IS-IS IPv6 single SPF mode to MT IS-IS.
- Wide metric is mandated for Multi-Topology to work.

```
Router1#
 interface ethernet-1
    ip address 10.1.1.1 255.255.255.0
    ipv6 address 2001:0001::45c/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 2001:0002::45a/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 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: 3FFF:FFFF: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) 3FFF:FFFF:1::/64
               Metric: 10 IPv6 (MT-IPv6) 3FFF:FFFF:2::/64
```



IS-IS Standards

- IETF IS-IS for IP Internets WG
  - http://www.ietf.org/html.charters/isis-charter.html
- 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
- Draft RFC defines how to add IPv6 address family support to IS-IS
  - http://www.ietf.org/internet-drafts/draft-ietf-isis-ipv6-05.txt
- Draft RFC introduces Multi-Topology concept for IS-IS
  - http://www.ietf.org/internet-drafts/draft-ietf-isis-wg-multi-topology-06.txt