



Routing Protocols

Internal and External Routing

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Prerequisites

- You must have followed previously the modules:
 - 010-IPv6 Introduction
 - 020-IPv6 Protocol
 - 030-IPv6 Addressing



Agenda

- Internal Routing
 - Static Routing
 - RIPng
 - IS-IS
 - OSPFv3
- External Routing
 - Multiprotocol BGP



Static Routes

- Static route configuration syntax is the same as in IPv4
- Except Prefix and next-hop are IPv6

IPv4 static route:

```
ip route [ipv4_prefix][ipv4_address_mask][ipv4_if_address]
```

IPv6 static route:

```
ipv6 route [ipv6_prefix/prefix_length][ipv6_if_address]
```

```
ipv6 route ::/0 FastEthernet1/40 FE80::206:2AFF:FE58:7820
```



Static Routes

- It is not recommended to use a global unicast address as a next-hop address
- ICMPv6 redirect messages will not work if used

RFC 2461:

A router must be able to determine the link-local address of each of its neighboring routers in order to ensure that the target address of a Redirect message identifies the neighbor router by its link-local address.

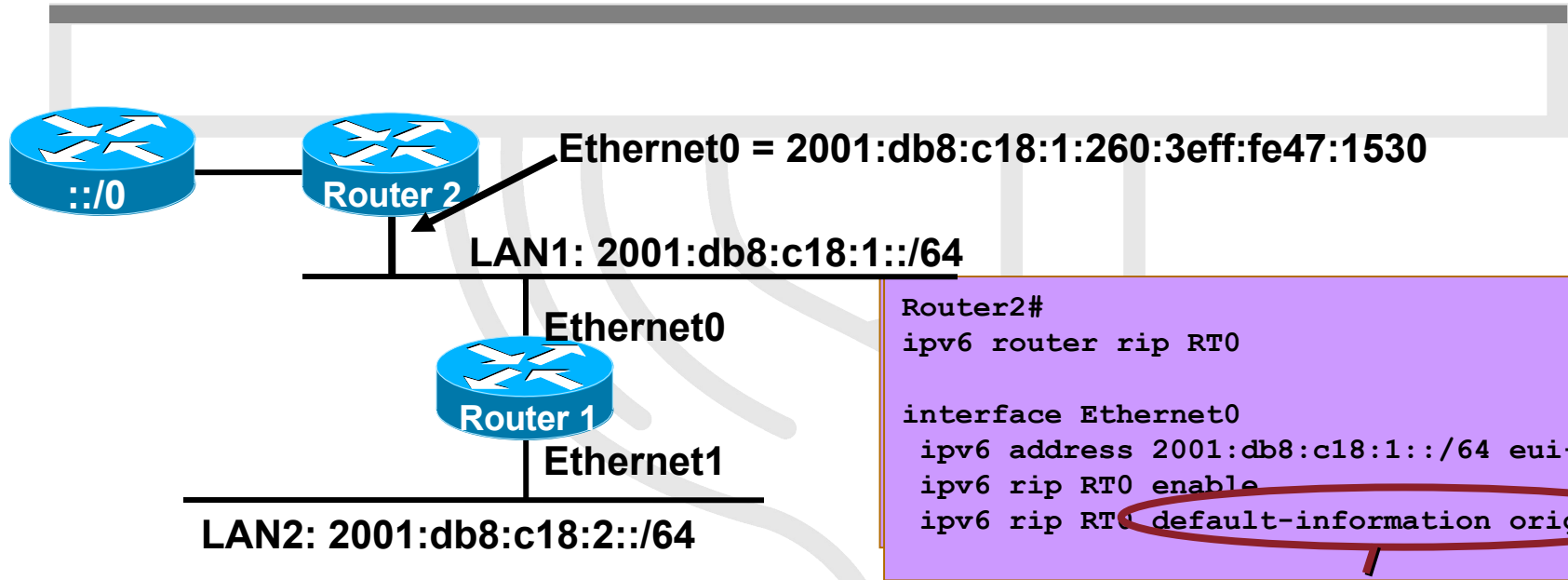


RIPng

- Same as IPv4
 - Based on RIPv2
 - Distance vector, max. 15 hop, split-horizon, ...
- It's an IPv6 only protocol
 - In a dual-stack environment, running RIP, you'll need RIP (IPv4) and RIPng (IPv6)
- IPv6 related functionality
 - Uses IPv6 for transport
 - IPv6 prefix, next-hop IPv6 address
 - For RIP updates, uses multicast address FF02::9
 - Updates are sent on UDP port 521



RIPng Configuration and Display



```
Router2#  
ipv6 router rip RT0  
  
interface Ethernet0  
  ipv6 address 2001:db8:c18:1::/64 eui-64  
  ipv6 rip RT0 enable  
  ipv6 rip RT0 default-information originate
```

```
Router1#  
ipv6 router rip RT0  
  
interface Ethernet0  
  ipv6 address 2001:db8:c18:1::/64 eui-64  
  ipv6 rip RT0 enable  
Interface Ethernet1  
  ipv6 address 3ffe:b00:c18:2::/64 eui-64  
  ipv6 rip RT0 enable
```

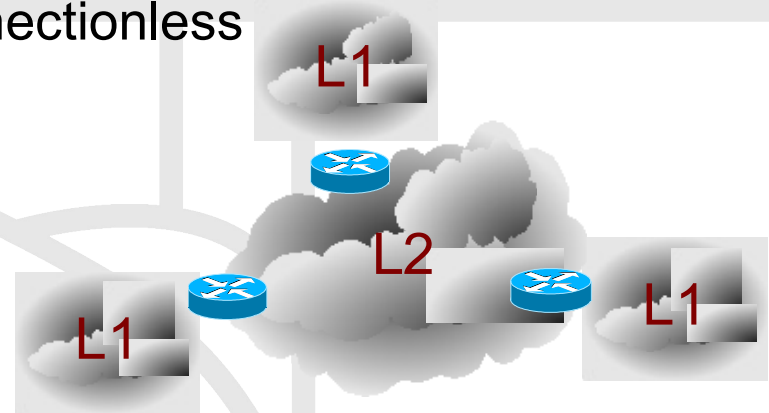
```
Router2# debug ipv6 rip  
RIPng: Sending multicast update on Ethernet0 for RT0  
src=FE80::260:3eff:fe47:1530  
dst=FF02::9 (Ethernet0)  
sport=521, dport=521, length=32  
command=2, version=1, mbl=0, #rte=1  
tag=0, metric=1, prefix=::/0
```

Multicast all Rip-Routers Link-local src address

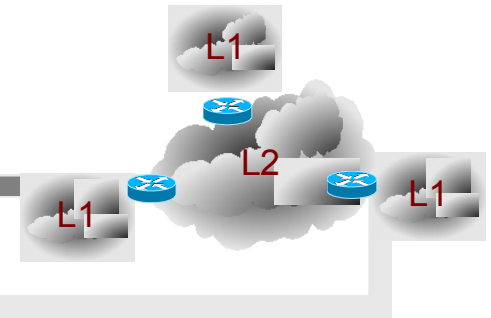


ISISv6

- OSI Protocol - Originally designed as an intra-domain routing protocol for Connectionless Network Service (CLNS) traffic
- Based on two levels
 - L2 = Backbone
 - L1 = Stub
 - L2L1= interconnect L2 and L1
- Runs on top of CNLS
 - Each IS device still sends out LSP (Link State Packets)
 - Send information via TLV's (Tag/Length/values)
 - Neighborship process is unchanged
- **Major operation remains unchanged**



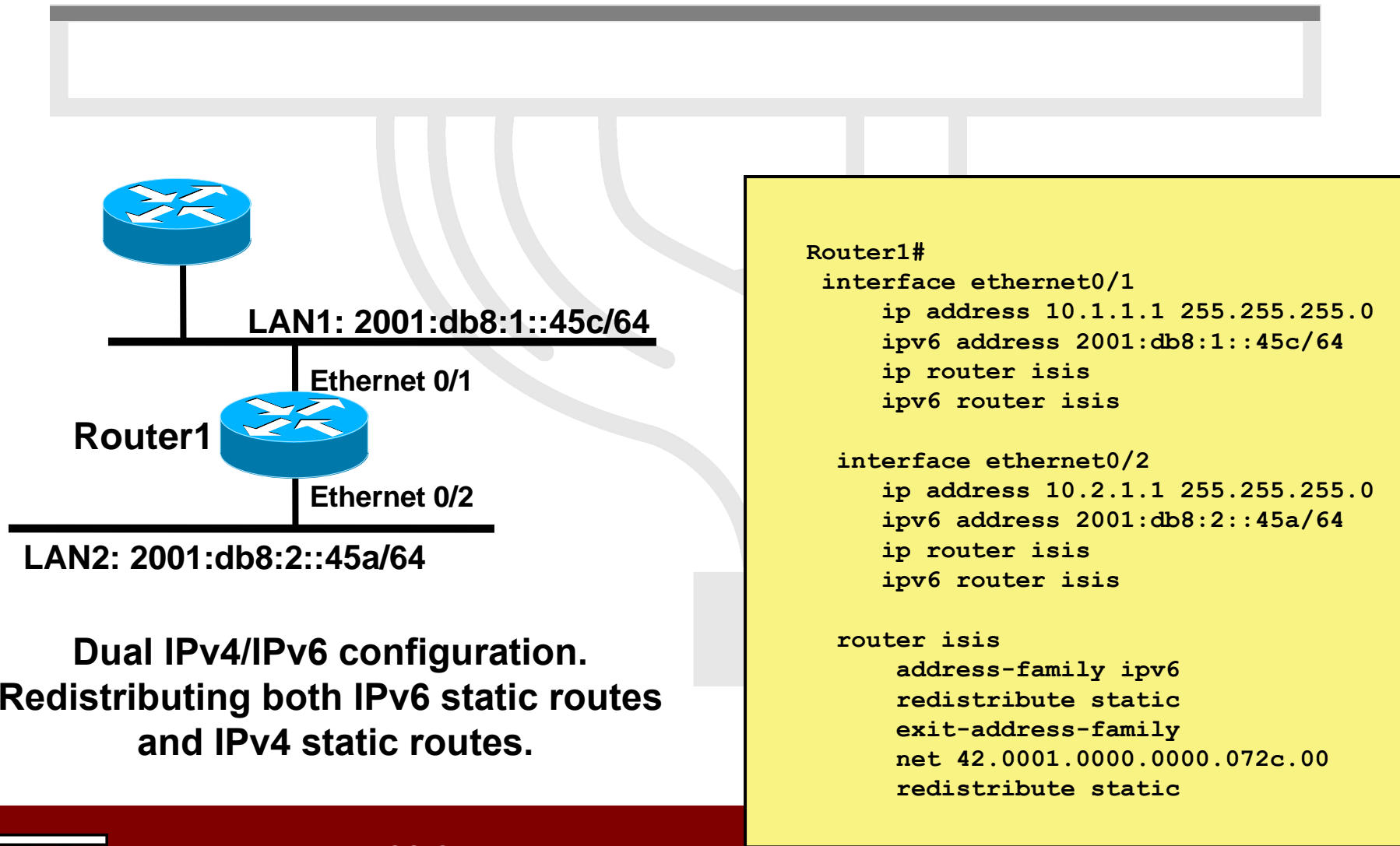
ISISv6 #2



- Updated features:
 - Two new Tag/Length/Values (TLV) for IPv6
 - **IPv6 Reachability** Describes network reach-ability, contains V6 routing prefix & Metric
 - **IPv6 Interface Address**
 - » Contains IPv6 interface address (128 bit vs. 32)
 - » For Hello PDUs, must contain the Link-Local address
 - » For LSP, must only contain the non-Link Local address
 - New network Layer Identifier
 - **IPv6 NLPID**
- **Runs on data link. If tunneled, must be mode GRE not IPV6IP**



Cisco IOS IS-IS dual IP configuration



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

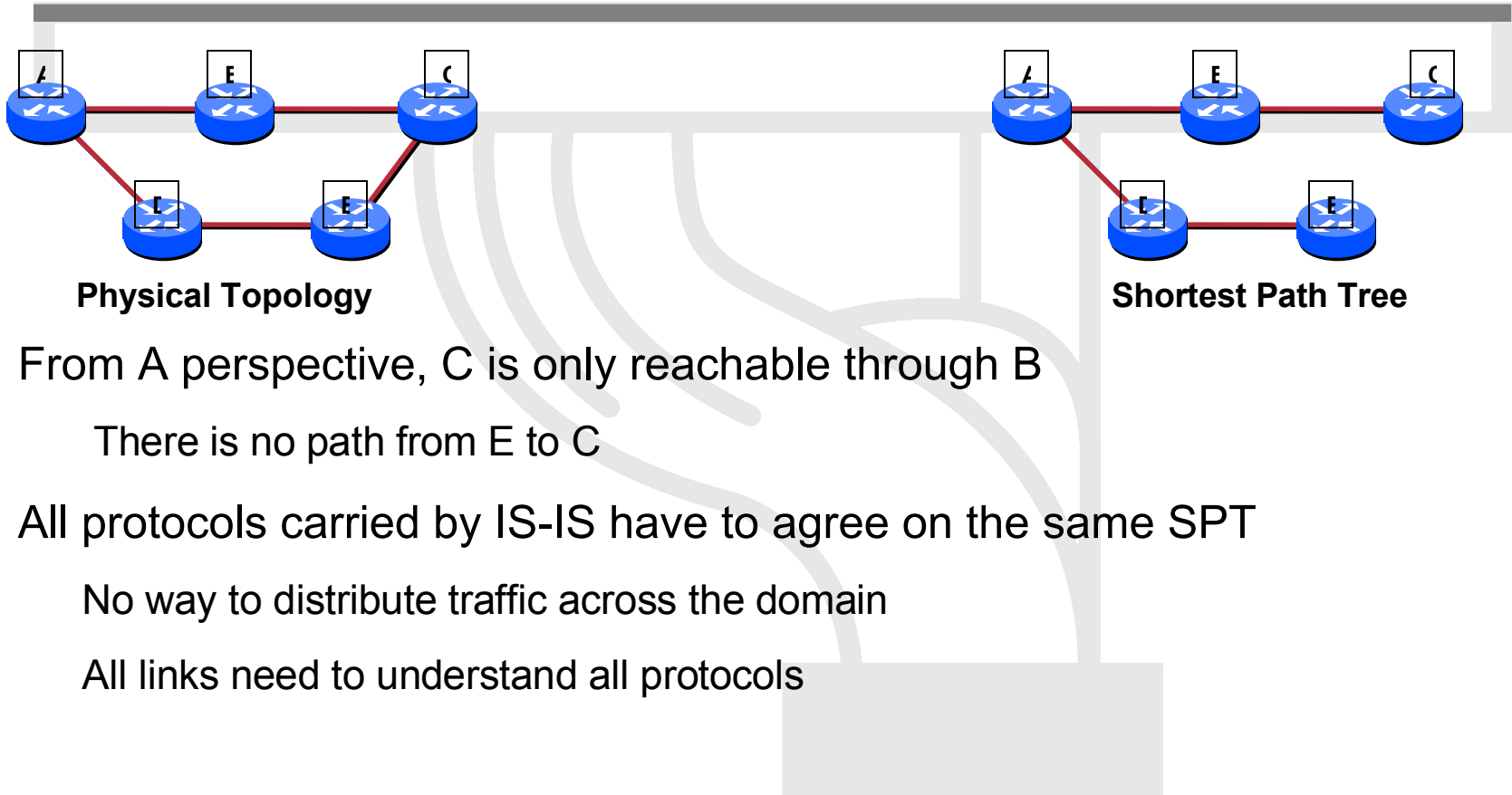


Single SPF rules

- 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
- 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)



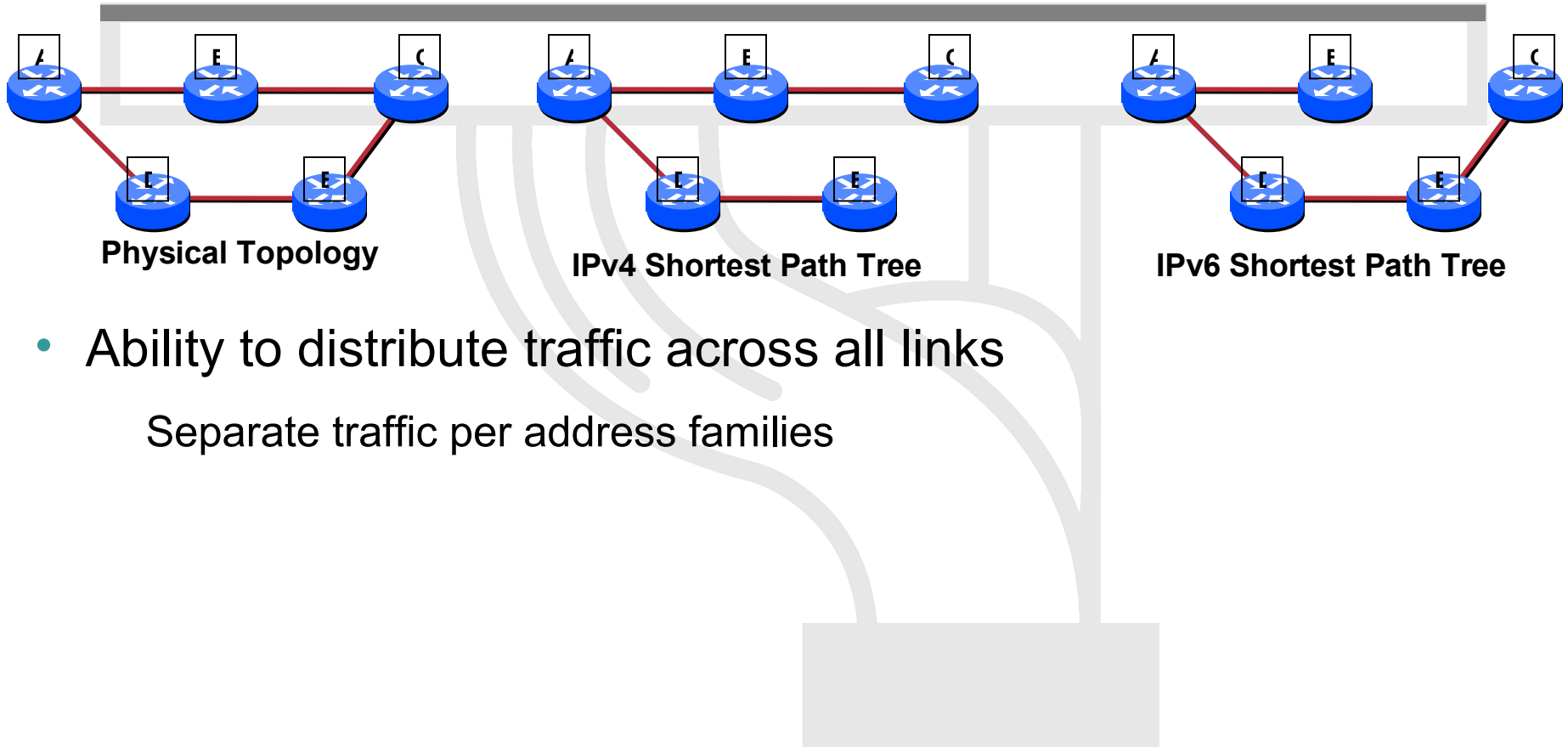
The problem



- From A perspective, C is only reachable through B
There is no path from E to C
- All protocols carried by IS-IS have to agree on the same SPT
No way to distribute traffic across the domain
All links need to understand all protocols



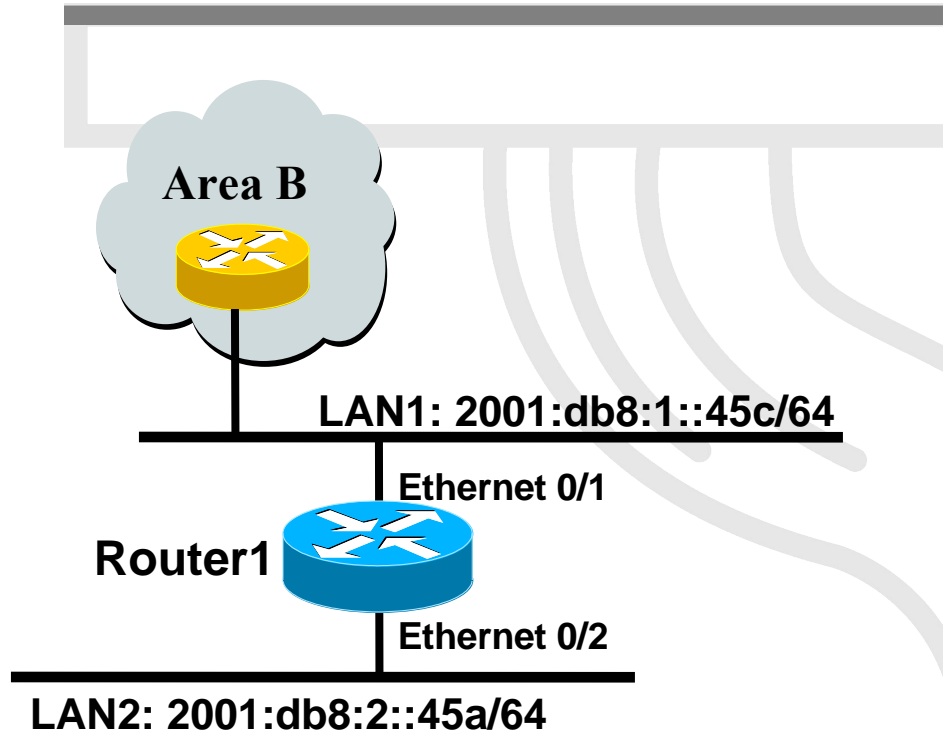
The need



- Ability to distribute traffic across all links
Separate traffic per address families



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 0/1  
 ip address 10.1.1.1 255.255.255.0  
 ipv6 address 2001:db8:1::45c/64  
 ip router isis  
 ipv6 router isis  
 isis ipv6 metric 20
```

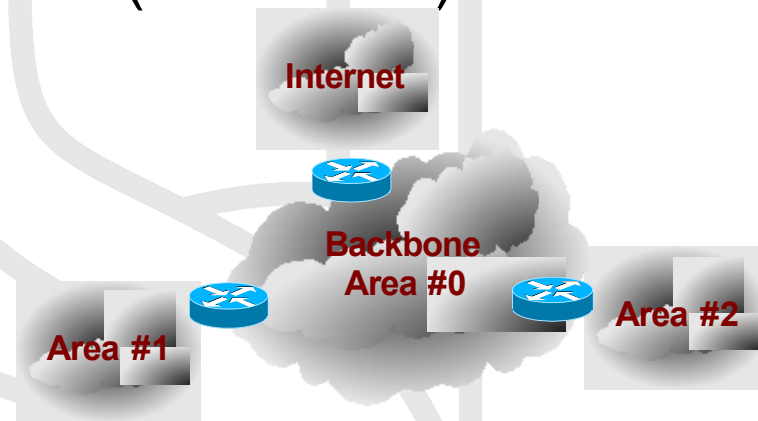
```
interface ethernet 0/2  
 ip address 10.2.1.1 255.255.255.0  
 ipv6 address 2001:db8:2::45a/64  
 ip router isis  
 ipv6 router isis  
 isis ipv6 metric 20
```

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



OSPFv3

- OSPFv3 = OSPF for IPv6 (RFC 2740)
- Based on OSPFv2

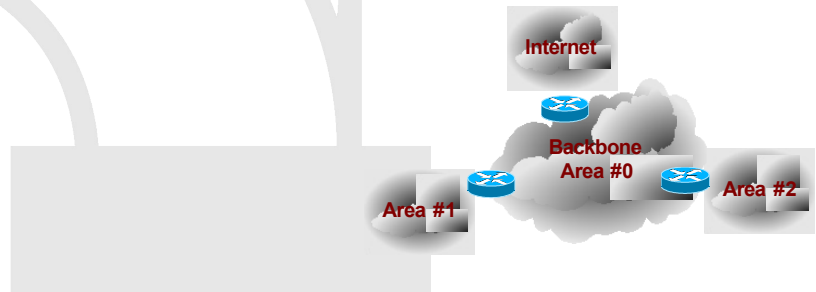


- Topology of an area is invisible from outside the area
 - LSA flooding is bounded by area
 - SPF calculation is performed separately for each area
- All areas must have a connection to the backbone

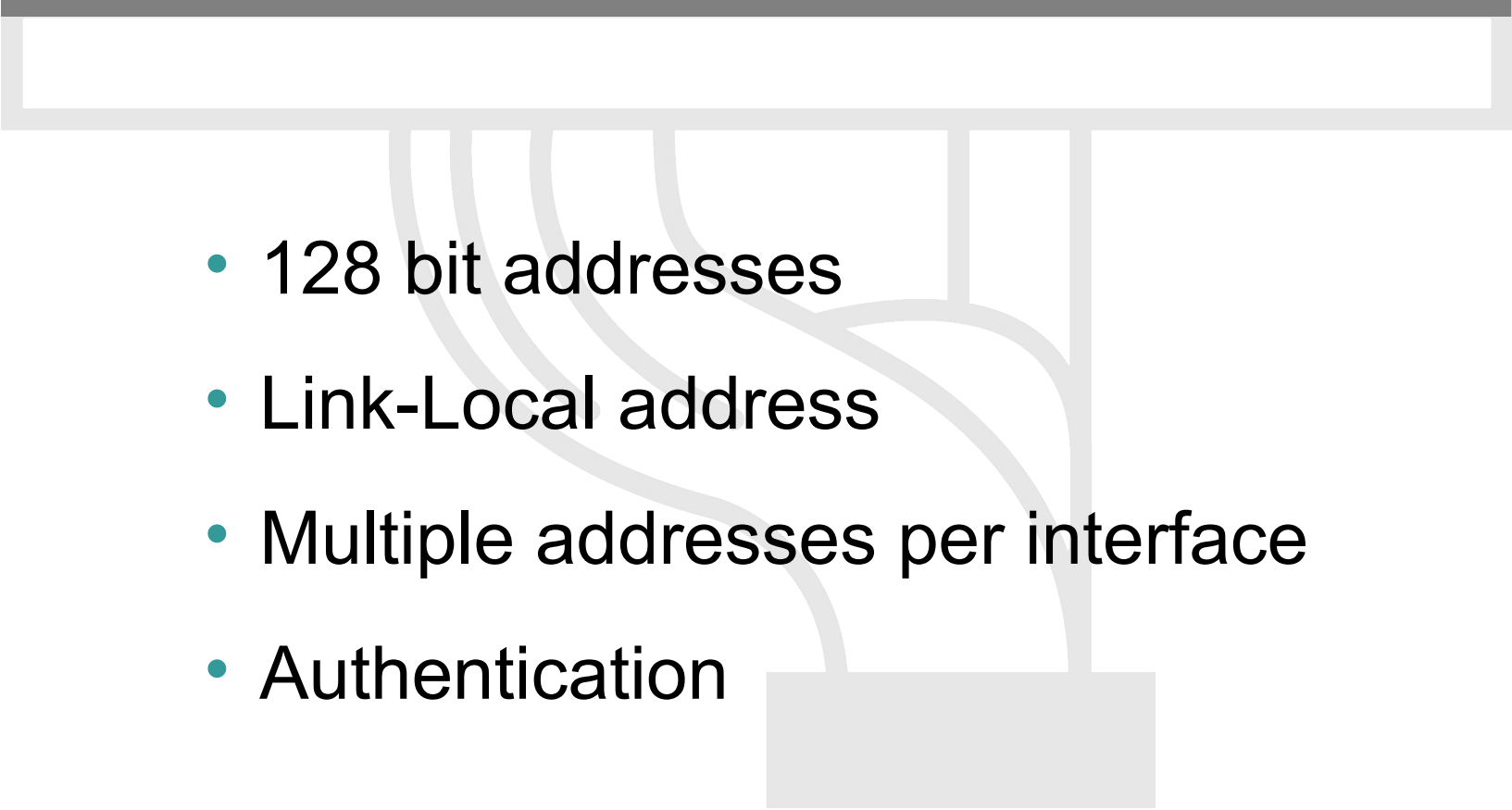


OSPFv3

- OSPFv3 is an IPv6-only protocol
 - In a dual-stack environment, running OSPF, you'll need OSPFv2 (IPv4) and OSPFv3 (IPv6)
 - There is some work-in-progress about extensible mechanisms to enable OSPFv3 with the support for different address families
- Updated Features
 - Runs directly over IPv6 – you can use link-locals
 - Distributes IPv6 prefixes
 - New LSA types
 - Uses the Multicast address
 - ALLSPFRouters (FF02::5)
 - ALLDRouters (FF02::6)



What IPv6 Attributes Affect OSPF?

- 
- 128 bit addresses
 - Link-Local address
 - Multiple addresses per interface
 - Authentication



OSPFv3 / OSPFv2 Differences

- OSPFv3 runs over a link, rather than a subnet
- Multiple instances per link
- OSPFv3 topology not IPv6-specific
 - Router ID
 - Link ID
- Standard authentication mechanisms (IPSec)
- Uses link-local addresses
- Generalized flooding scope



New LSA Types

- Link LSA

 - Informs neighbors of link local address

 - Informs neighbors of IPv6 prefixes on link

- Intra-Area Prefix LSA

 - Associates IPv6 prefixes with a network or router



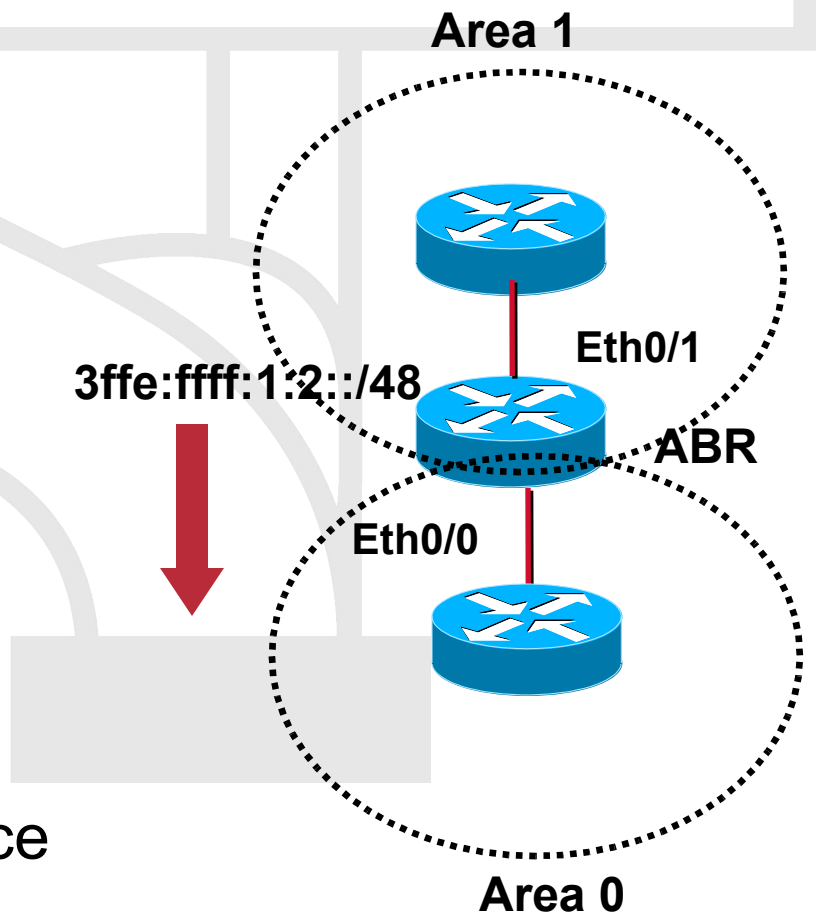
Removal of Address Semantic

- IPv6 address is not present in OSPFv3 packets
 - Exception: LSA payload
- Router-LSA and Network-LSA expressing topology
- Router ID, area ID, LSA link state ID remain a 32 bit number
- Neighbors are always identified by Router ID



ABR Configuration

```
ipv6 unicast-routing
!
interface Ethernet0/0
ipv6 address 2001:db8:1:1::1/64
ipv6 ospf 1 area 0
!
interface Ethernet0/1
ipv6 address 2001:db8:1:2::2/64
ipv6 ospf 1 area 1
!
ipv6 router ospf 1
router-id 2.2.2.2
area 1 range 2001:db8:1:2::/48
```

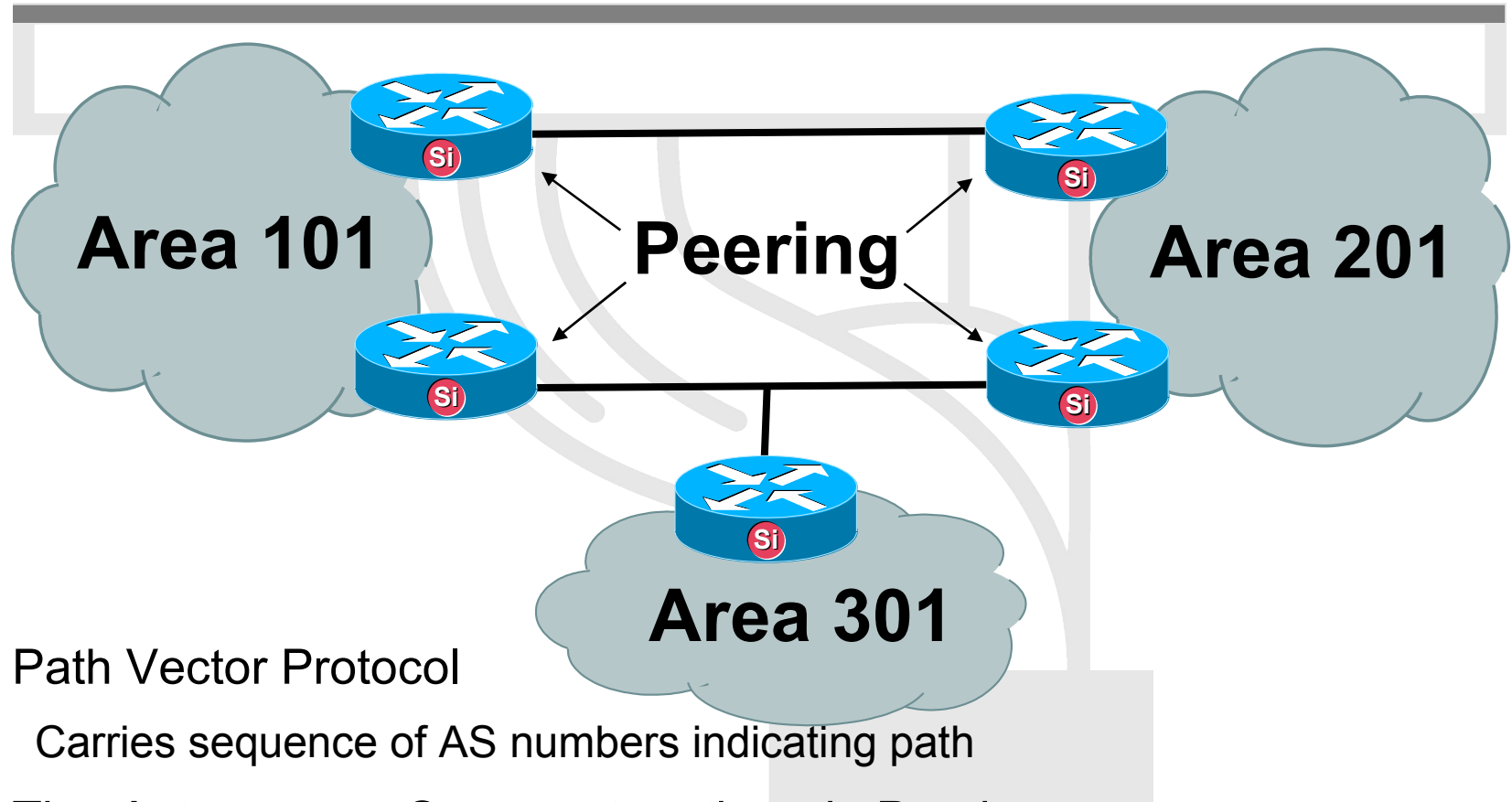


Configuration changed

- IPv4 - specify network
- IPv6 - specification on interface



MP-BGP Basics

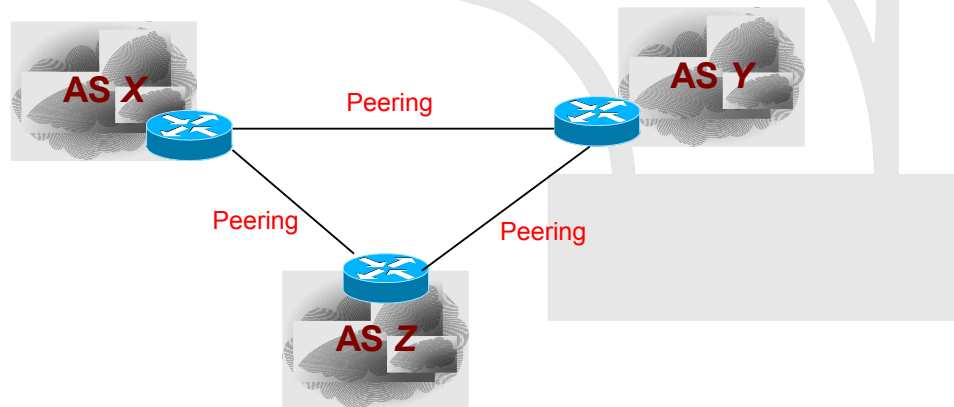


- Path Vector Protocol
 - Carries sequence of AS numbers indicating path
- Ties Autonomous Systems together via Peering
- Multiple address families: ipv4, ipv6, unicast, multicast



Multiprocol BGP

- Exterior Gateway Protocol
- Connect separate routing domains that contain independent routing policies (AS)
- Carries sequences of AS numbers indicating path
- Supports the same features and functionality as IPv4 BGP
- Multiple addresses families: IPv4, IPv6, unicast, multicast



Multiprotocol BGP

- BGP4 carries only 3 types of information which is truly IPv4 specific:
 - NLRI in the UPDATE message contains an IPv4 prefix
 - NEXT_HOP attribute in the UPDATE message contains an IPv4 address
 - BGP ID in AGGREGATOR attribute
- RFC 2858 defines multi-protocols extensions for BGP4
 - this makes BGP4 available for other network layer protocols (IPv6, MPLS...)
 - New BGP4 attributes (optional, transitive):
 - MP_REACH_NLRI
 - MP_UNREACH_NLRI
 - Messages contains triplets:
 - Address Family Information (AFI)
 - Next-Hop Information (must be of the same address family)
 - NLRI
 - Protocol Independent NEXT_HOP attribute
 - Protocol Independent NLRI attribute



BGP-4 Extensions for IPv6

- Address Family Information (AFI) for IPv6
 - AFI = 2 (RFC 1700)
 - Sub-AFI = 1 Unicast
 - Sub-AFI = 2 (Multicast for RPF check)
 - Sub-AFI = 3 for both Unicast and Multicast
 - Sub-AFI = 4 Label
 - Sub-AFI = 128 VPN



BGP-4 Extensions for IPv6

- TCP Interaction

BGP-4 runs on top of TCP

This connection could be setup either over IPv4 or IPv6

- Router ID

When no IPv4 is configured, an explicit bgp router-id needs to be configured

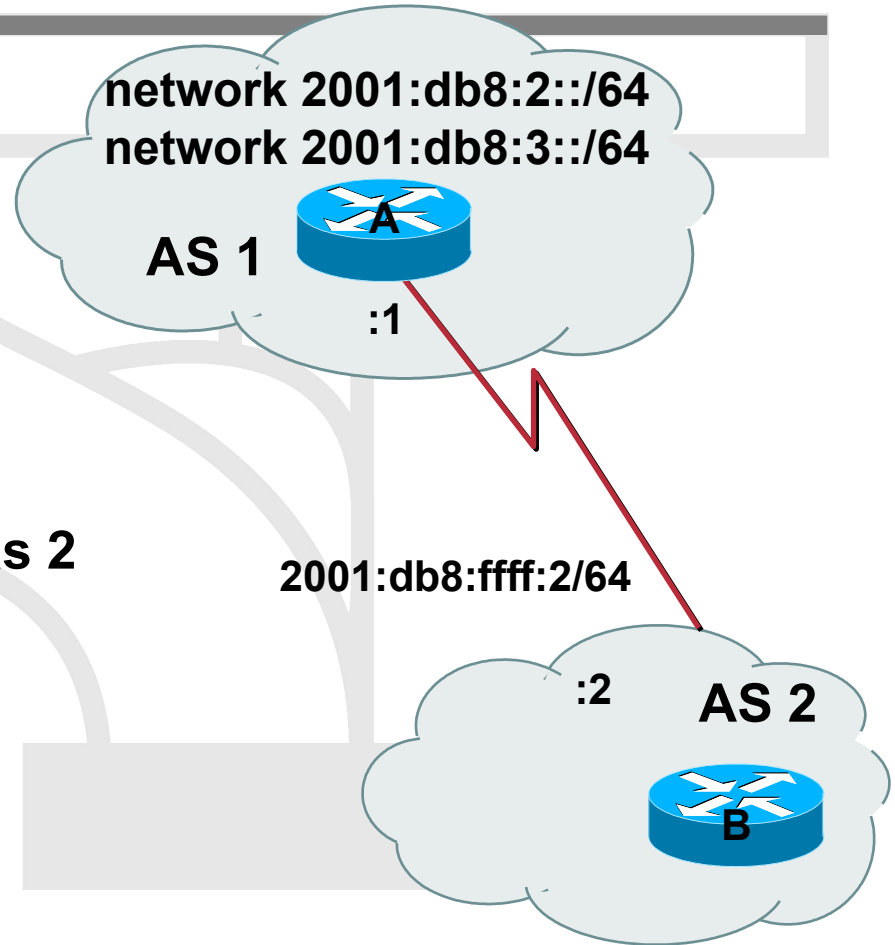
This is needed as a BGP Identifier, this is used as a tie breaker, and is send within the OPEN message



BGP-4 Configurations for IPv6

Router A

```
router bgp 1
no bgp default ipv4 unicast
bgp router-id 1.1.1.1
neighbor 2001:db8:ffff:2::2 remote-as 2
address-family ipv6
neighbor 2001:db8:ffff:2::2 activate
network 2001:db8:2::/64
network 2001:db8:3::/64
```



Conclusions

- All major routing protocols have stable IPv6 support
- And there isn't major differences with IPv4
- In a dual-stack environment, running OSPF, you'll need OSPFv2 (IPv4) and OSPFv3 (IPv6). It may change in a near future.
- In a dual-stack environment, running RIP, you'll need RIPv1/RIPv2 (IPv4) and RIPng (IPv6)

