

Introduction to OSPF



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Routing and Forwarding

- Routing is not the same as Forwarding
- Routing is the building of maps
 - Each routing protocol usually has its own routing database
 - Routing protocols populate the forwarding table
- Forwarding is passing the packet to the next hop device
 - Forwarding table contains the best path to the next hop for each prefix
 - There is only ONE forwarding table

OSPF Background

- Developed by IETF – RFC1247
 - Designed for Internet TCP/IP environment
- OSPF v2 described in RFC2328/STD54
 - For IPv4 only
- OSPF v3 described in RFC2740
 - Mainly for IPv6
 - Supports the IPv4 address family also
- Link state/Shortest Path First Technology
- Dynamic Routing
- Fast Convergence
- Route authentication

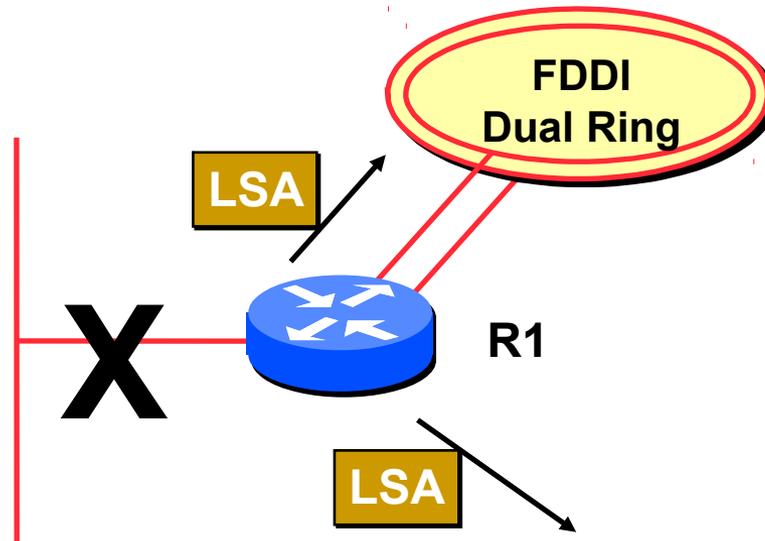
Link State Algorithm

- Each router contains a database containing a map of the whole topology
 - Links
 - Their state (including cost)
- All routers have the same information
- All routers calculate the best path to every destination
- Any link state changes are flooded across the network
 - “Global spread of local knowledge”

Link State Routing

- Automatic neighbour discovery
 - Neighbours are physically connected routers
- Each router constructs a Link State Packet (LSP)
 - Distributes the LSP to neighbours...
 - ...using an LSA (Link State Announcement)
- Each router computes its best path to every destination
- On network failure
 - New LSPs are flooded
 - All routers recompute routing table

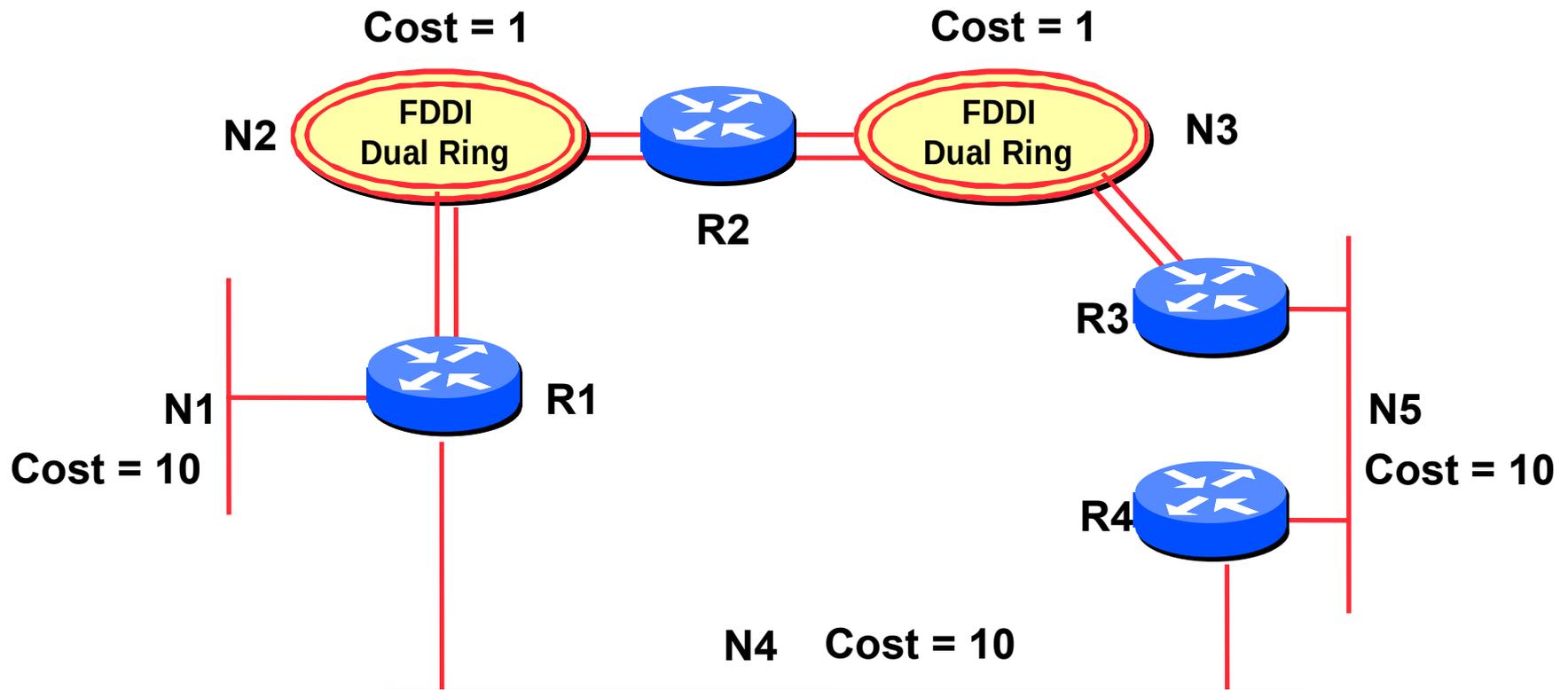
Low Bandwidth Requirements



- ❑ Only changes are propagated
- ❑ Multicast used on multi-access broadcast networks
 - 224.0.0.5 used for all OSPF speakers
 - 224.0.0.6 used for DR and BDR routers

“Shortest Path First”

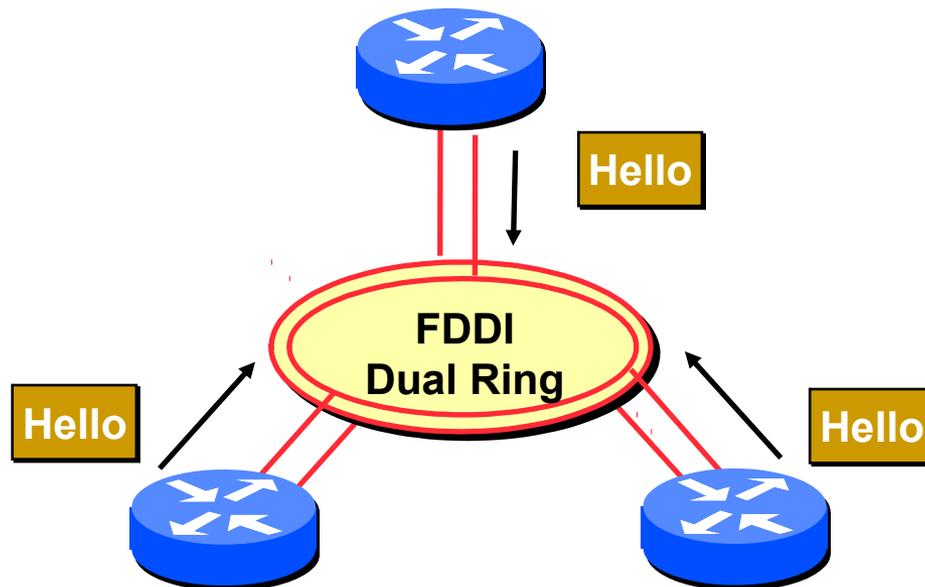
- The optimal path is determined by the sum of the interface costs



OSPF: How it works

□ Hello Protocol

- Responsible for establishing and maintaining neighbour relationships
- Elects Designated Router on broadcast networks



OSPF: How it works

□ Hello Protocol

- Hello Packets sent periodically on all OSPF enabled interfaces
- Adjacencies formed between **some** neighbours

□ Hello Packet

- Contains information like Router Priority, Hello Interval, a list of known neighbours, Router Dead Interval, and the network mask

OSPF: How it works

- Trade Information using LSAs
 - LSAs are added to the OSPF database
 - LSAs are passed on to OSPF neighbours
- Each router builds an identical link state database
- SPF algorithm run on the database
- Forwarding table built from the SPF tree

OSPF: How it works

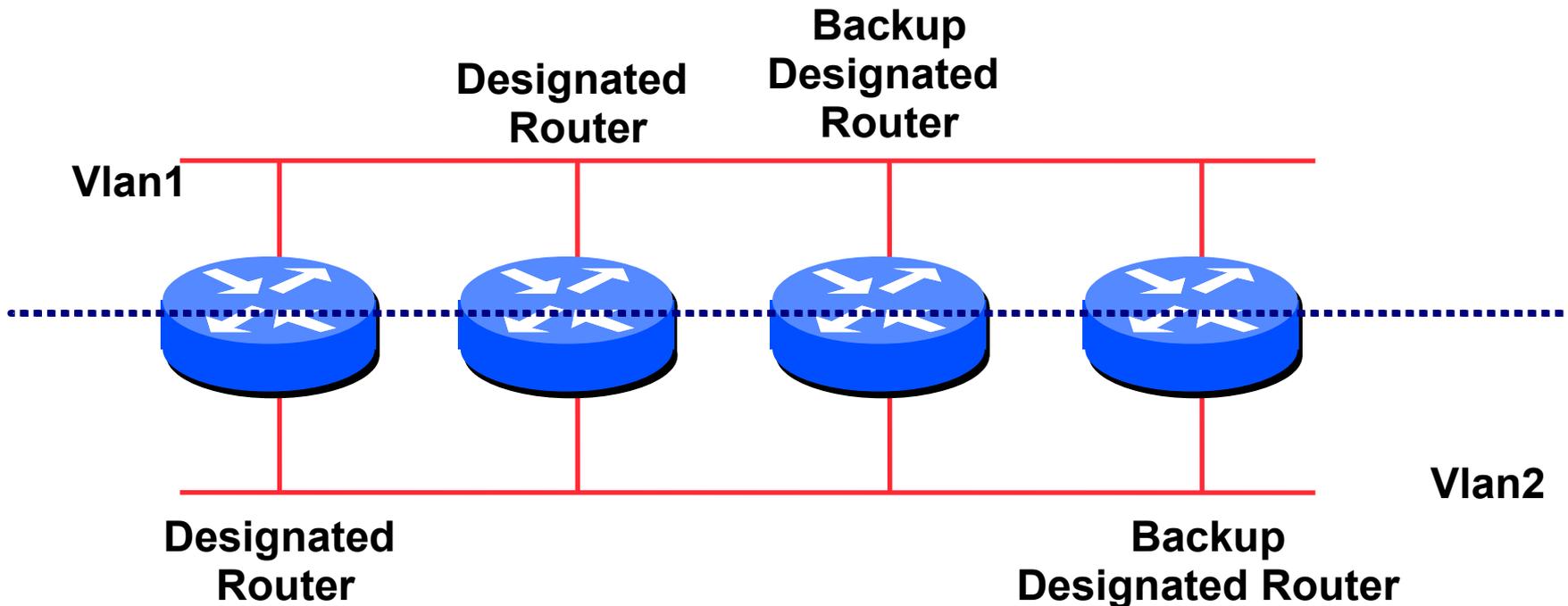
- When change occurs:
 - Announce the change to all OSPF neighbours
 - All routers run the SPF algorithm on the revised database
 - Install any change in the forwarding table

Broadcast Networks

- These are network technologies such as Ethernet and FDDI
- Introduces Designated and Backup Designated routers (DR and BDR)
 - Only DR and BDR form full adjacencies with other routers
 - The remaining routers remain in a “2-way” state with each other
 - If they were adjacent, we’d have n-squared scaling problem
 - If DR or BDR “disappear”, re-election of missing router takes place

Designated Router

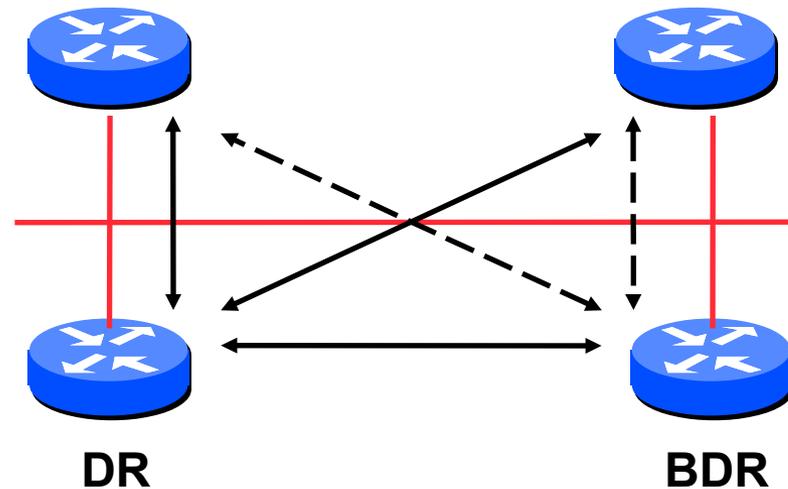
- One per multi-access network
 - Generates network link advertisements for the multi-access network
 - Speeds database synchronisation



Designated Router

- All routers are adjacent to the DR
 - All routers are adjacent to the BDR also
- All routers exchange routing information with DR
 - All routers exchange routing information with the BDR
- DR updates the database of all its neighbours
 - BDR updates the database of all its neighbours
- This scales! $2n$ problem rather than having an n -*squared* problem.

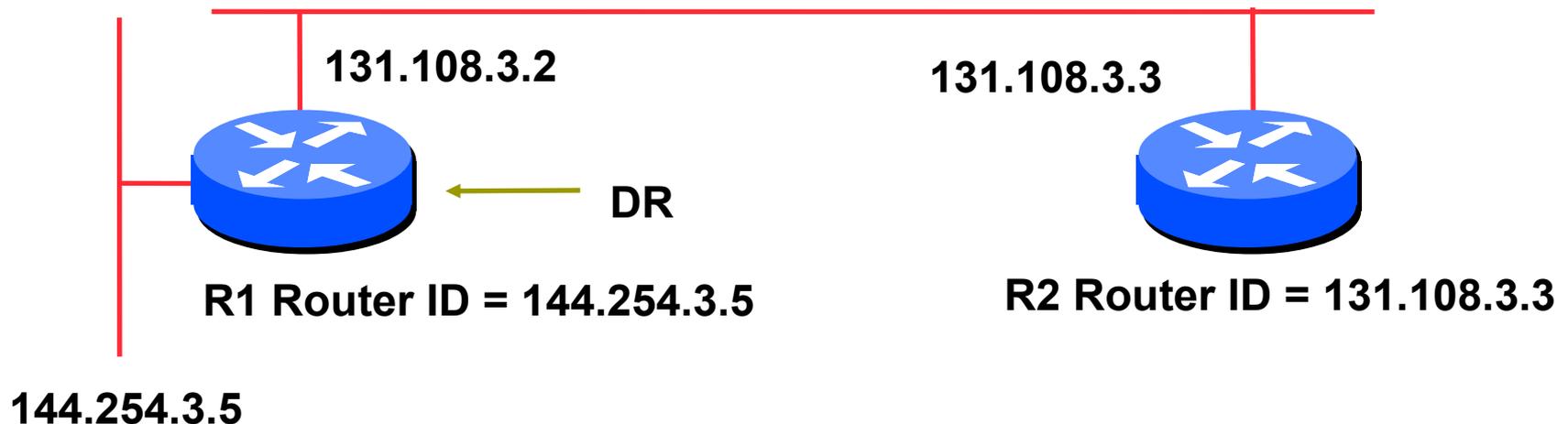
Designated Router



- ❑ Adjacencies only formed with DR and BDR
- ❑ LSAs propagate along the adjacencies

Designated Router Priority

- Determined by interface priority
- Otherwise by highest router ID
 - (For Cisco IOS, this is address of loopback interface, otherwise highest IP address on router)

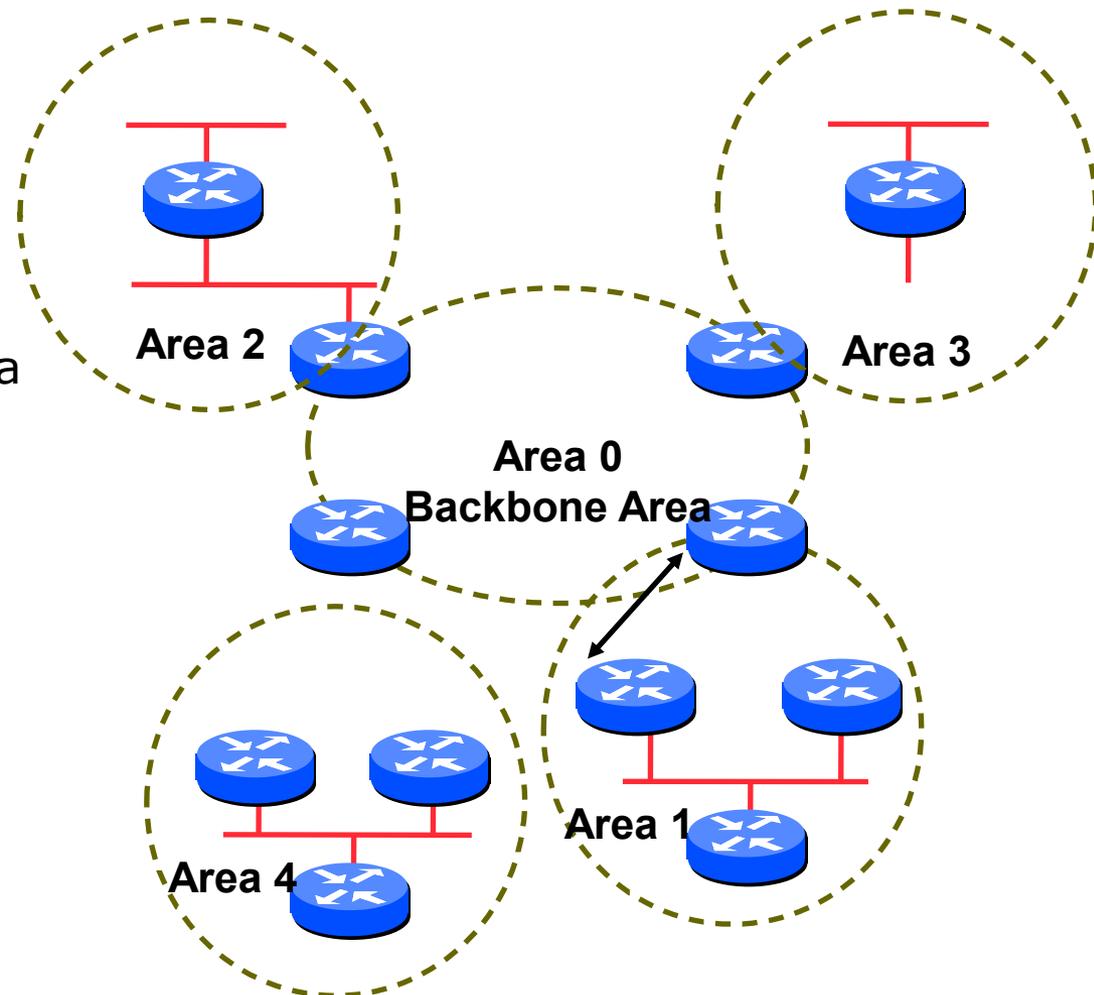


More Advanced OSPF

- OSPF Areas
- Router Classification
- OSPF route types
- Route authentication
- Equal cost multipath

OSPF Areas

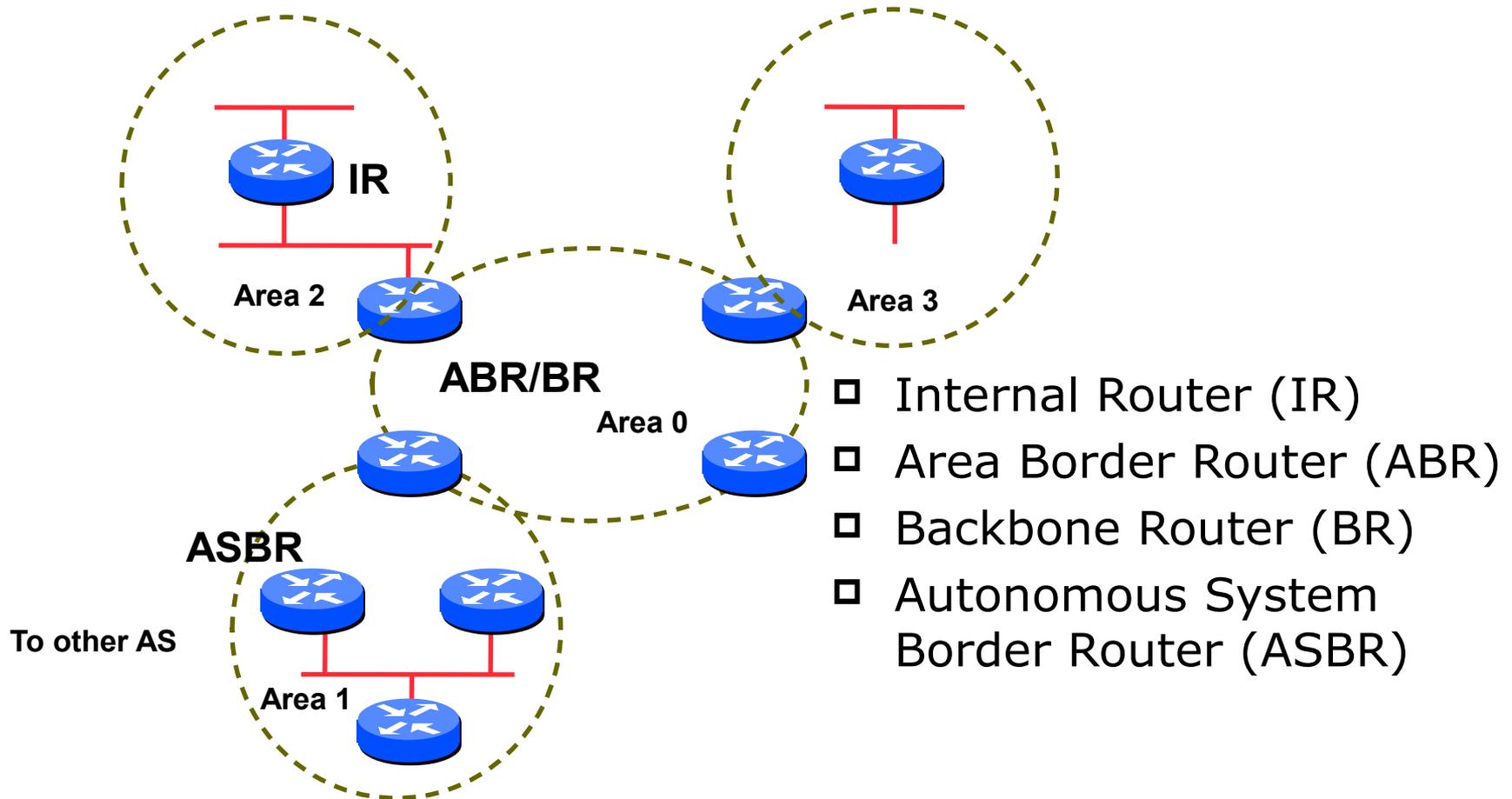
- ❑ Group of contiguous hosts and networks
- ❑ Per area topological database
 - Invisible outside the area
 - Reduction in routing traffic
- ❑ Backbone area contiguous
 - All other areas must be connected to the backbone
- ❑ Virtual Links



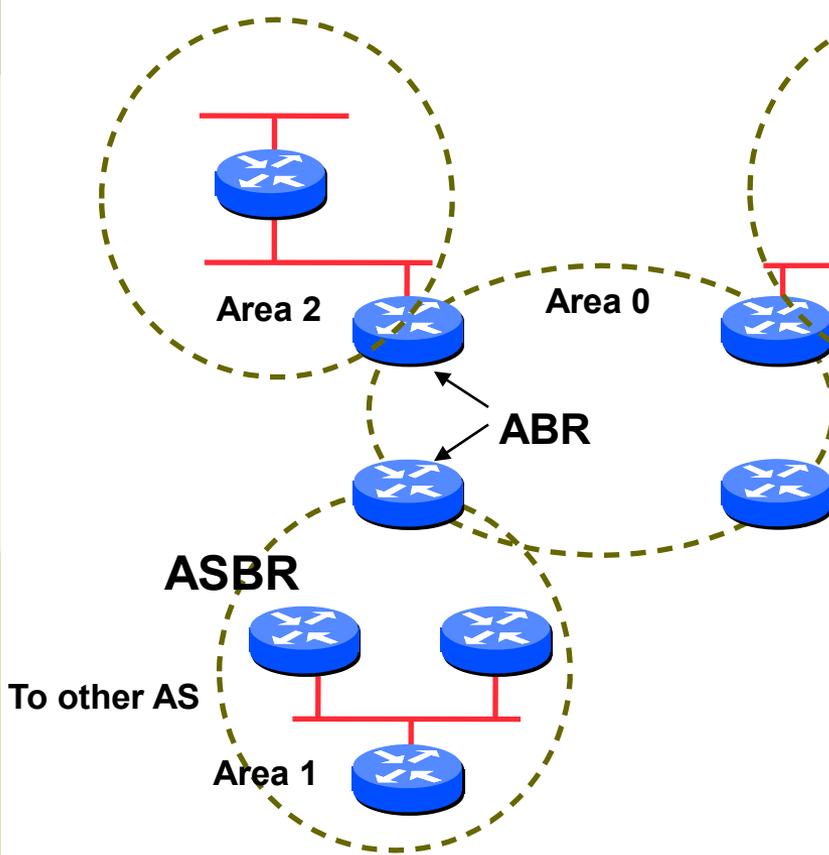
OSPF Areas

- ❑ Reduces routing traffic in area 0
- ❑ Consider subdividing network into areas
 - Once area 0 is more than 30+ routers (though areas with 200+ routers in an area are known to work fine)
 - Once area 0 topology starts getting complex
 - Less often today but when a group of routers is over an expensive small link e.g vsat
- ❑ Area design often mimics typical ISP core network design
- ❑ Virtual links are used for “awkward” connectivity topologies (...) **please do not use these.**

Classification of Routers



OSPF Route Types



- Intra-Area route
 - All routes inside an area
- Inter-Area route
 - Routes advertised from one area to another area by an ABR
- External route
 - Routes imported into OSPF from another routing protocol by an ASBR

Route Authentication

- ❑ Now recommended to use route authentication for OSPF
 - ... and all other routing protocols
- ❑ Susceptible to denial of service attacks
 - OSPF runs on TCP/IP
 - Automatic neighbour discovery
- ❑ Route authentication – Cisco example:

```
router ospf <pid>
  network 192.0.2.0 0.0.0.255 area 0
  area 0 authentication
interface ethernet 0/0
  ip ospf authentication-key <password>
```

Equal Cost Multipath

- If n paths to same destination have equal cost, OSPF will install n entries in the forwarding table
 - Loadsharing over the n paths
 - Useful for expanding links across an ISP backbone
 - Don't need to use hardware multiplexors
 - Don't need to use static routing

Summary

- Link State Protocol
- Shortest Path First
- OSPF operation
- Broadcast networks
 - Designated and Backup Designated Router
- Advanced Topics
 - Areas, router classification, external networks, authentication, multipath

OSPFv3



OSPFv3 overview

- OSPF for IPv6
- Based on OSPFv2, with enhancements
- Distributes IPv6 prefixes
- Can distribute IPv4 prefixes (if supported)
- Runs directly over IPv6
- “Ships in the night” with OSPFv2

OSPFv3 / OSPFv2 Similarities

- 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 ageing
- Nearly identical LSA types

v2, v3 Differences

OSPFv3 runs on a Link instead of per IP Subnet

- A link by definition is a medium over which two nodes can communicate at link layer
- In IPv6 multiple IP subnets can be assigned to a link and two nodes in different subnets can communicate over this link. Therefore, OSPFv3 runs per link instead of per IP subnet.
- **This is specific to (earlier versions of) IOS.**

v2, v3 Differences (Cont.)

Separation of prefix & topology information

- ❑ OSPFv2 carries IP address information in Type 1 & Type 2 LSA's.
- ❑ Makes routers announce both their IP addresses and topology information in the same LSA's.
- ❑ A change in an IP address means a Type 1 LSA is originated. But because Type 1 LSA's also carry topology information, a full SPF is run in the local OSPF area – unnecessary; only IP address is affected.
- ❑ So only Type 3, 4, 5 and 7 LSA's trigger PRC in OSPFv2, as their only purpose is to signal prefix information (external areas).

v2, v3 Differences (Cont.)

Generalization of Flooding Scope

- ❑ In OSPFv3 there are three flooding scope for LSAs (link-local scope, area scope, AS scope) and they are coded in LS type explicitly
- ❑ In OSPFv2 initially only area and AS wide flooding was defined; later opaque LSAs introduced link local scope as well

v2, v3 Differences (Cont.)

Explicit Handling of Unknown LSA

- ❑ The handling of unknown LSA is coded via U-bit in LS type
- ❑ When U bit is set, the LSA is flooded with the corresponding flooding scope, as if it was understood
- ❑ When U bit is clear, the LSA is flooded with link local scope
- ❑ In v2 unknown LSA were discarded

v2, v3 Differences (Cont.)

Authentication is Removed from OSPF

- ❑ Authentication in OSPFv3 has been removed
 - OSPFv3 relies on IPv6 authentication header since OSPFv3 runs over IPv6
- ❑ AuthType and Authentication field in the OSPF packet header have been suppressed
- ❑ AH (Authentication Header) provides authentication
- ❑ ESP (Encapsulating Security Payload) provides encryption & integrity
- ❑ ESP, if used alone, provides both authentication and encryption
- ❑ AH supported from 12.3T
- ❑ ESP supported from 12.4T

v2, v3 Differences (Cont.)

OSPF Packet format has been changed

- ❑ The mask field has been removed from Hello packet
- ❑ IPv6 prefix is only present in payload of Link State update packet

Configuring OSPFv3 in Cisco IOS

- Similar to OSPFv2
 - Prefixing existing Interface and Exec mode commands with `"ipv6"`
- Interfaces configured directly
 - Replaces `network` command
 - (Also available in OSPFv2 from IOS 12.4 and most recent 12.0S and 12.2SB, 12.2SR releases).
 - (Called the "Area Command in Interface Mode for OSPFv2" feature).
- "Native" IPv6 router mode
 - Not a sub-mode of `router ospf`

Configuration modes in OSPFv3

- ❑ Entering router mode

```
[no] ipv6 router ospf <process ID>
```

- ❑ Entering interface mode

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

- ❑ Exec mode

```
show ipv6 ospf [<process ID>]
```

```
clear ipv6 ospf [<process ID>]
```

OSPFv3 Specific Attributes – IOS

❑ 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
```

❑ Configuring authentication

■ Under ipv6 router ospf:

```
area 0 authentication ipsec spi 256 md5 <passwd>
```

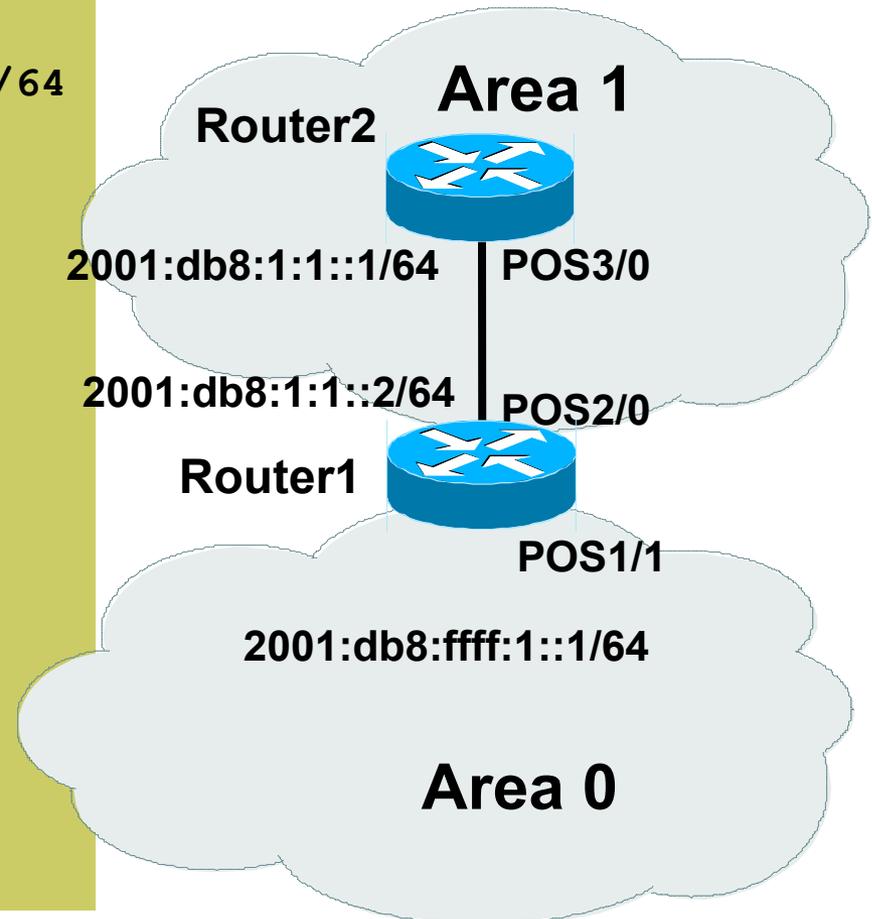
■ Under interface:

```
ipv6 ospf authentication ipsec spi 256 md5 <passwd>
```

OSPFv3 Configuration Example

```
Router1#  
interface POS1/1  
  ipv6 address 2001:db8:FFFF:1::1/64  
  ipv6 ospf 100 area 0  
!  
interface POS2/0  
  ipv6 address 2001:db8:1:1::2/64  
  ipv6 ospf 100 area 1  
!  
ipv6 router ospf 100
```

```
Router2#  
interface POS3/0  
  ipv6 address 2001:db8:1:1::1/64  
  ipv6 ospf 100 area 1  
!  
ipv6 router ospf 100
```



OSPFv3 entries in Routing Table

```
Router2#sh ipv6 route
IPv6 Routing Table - 5 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
OI 2001:db8:FFFF:1::/64 [110/2]
    via FE80::2D0:FFFF:FE60:DFFF, POS3/0
C 2001:db8:1:1::/64 [0/0]
  via ::, POS3/0
L 2001:db8:1:1::1/128 [0/0]
  via ::, POS3/0
L FE80::/10 [0/0]
  via ::, Null0
L FF00::/8 [0/0]
  via ::, Null0
```

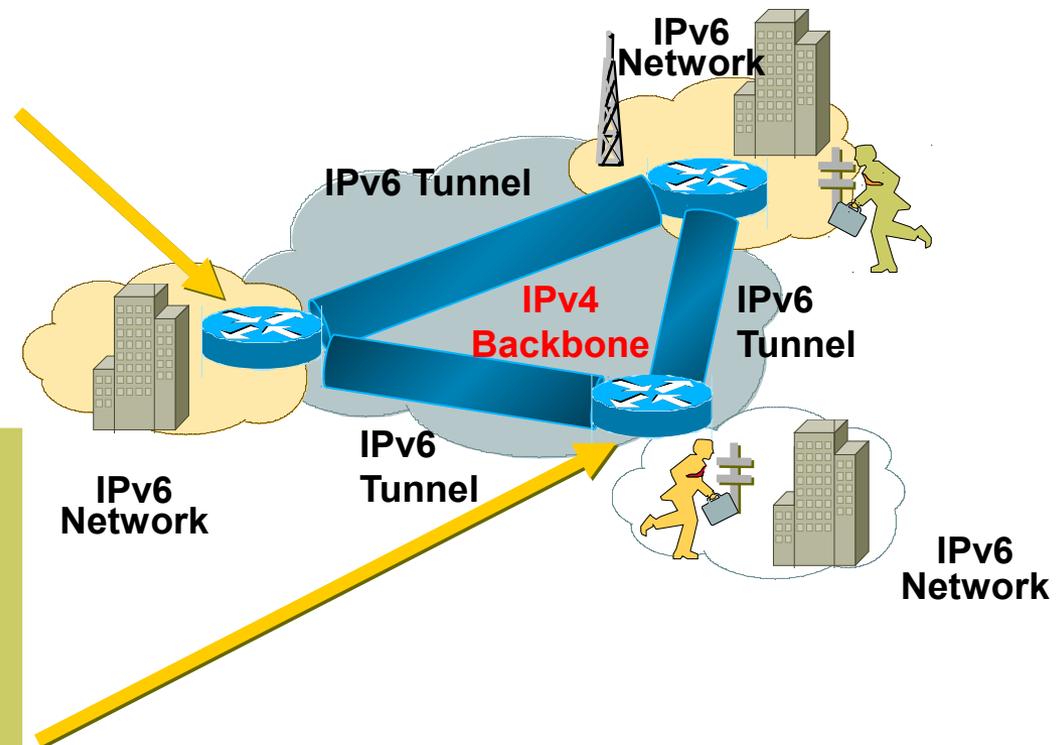
OSPFv3 on IPv6 Tunnels over IPv4

On Router1:

```
interface Tunnel0
no ip address
ipv6 address 2001:db8:1::1/64
ipv6 router ospf 1 area 0
tunnel source 10.42.1.1
tunnel destination 10.42.2.1
tunnel mode ipv6ip
!
ipv6 router ospf 1
```

On Router2:

```
interface Tunnel0
no ip address
ipv6 address 2001:db8:1::2/64
ipv6 router ospf 1 area 0
tunnel source 10.42.2.1
tunnel destination 10.42.1.1
tunnel mode ipv6ip
!
ipv6 router ospf 1
```



Introduction to OSPF



Questions?