

# Introduction to OSPF



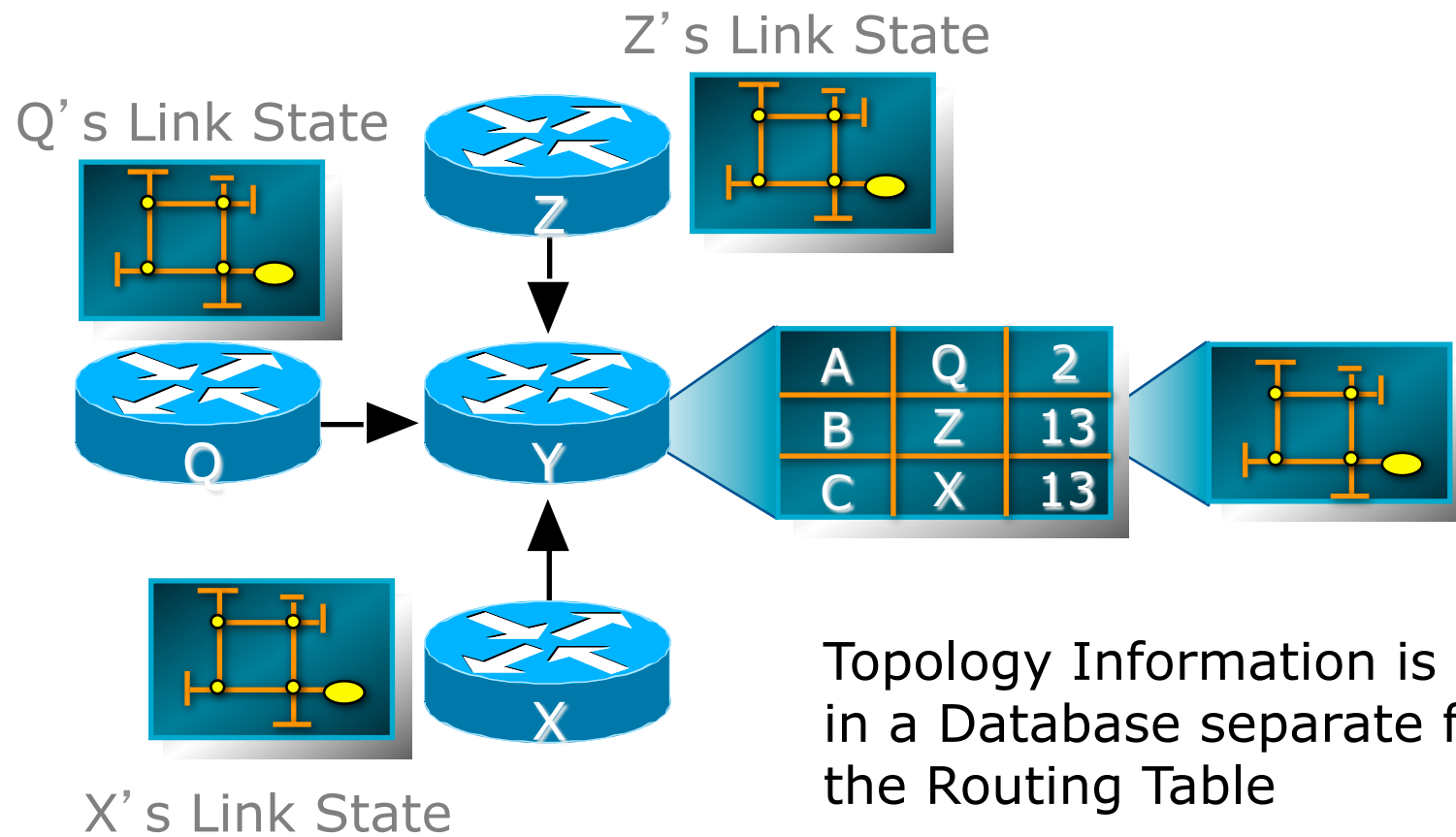
ISP Workshops

# OSPF

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- ❑ Open Shortest Path First
- ❑ Link state or SPF technology
- ❑ Developed by OSPF working group of IETF (RFC 1247)
- ❑ OSPFv2 standard described in RFC2328
- ❑ Designed for:
  - TCP/IP environment
  - Fast convergence
  - Variable-length subnet masks
  - Discontiguous subnets
  - Incremental updates
  - Route authentication
- ❑ Runs on IP, Protocol 89

# Link State



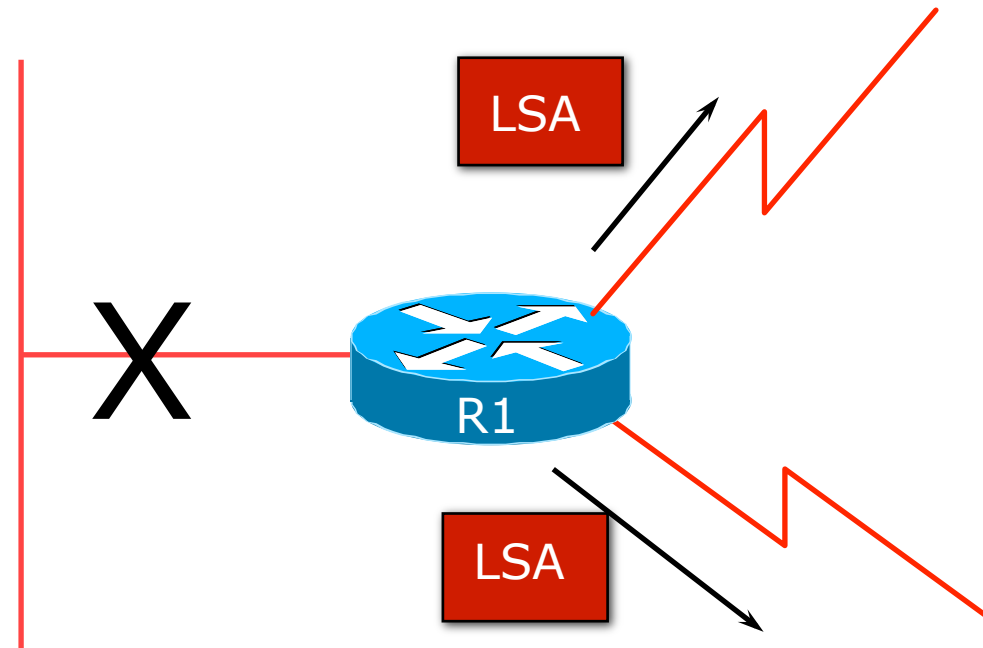
# Link State Routing

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- ❑ 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 table

# Low Bandwidth Utilisation

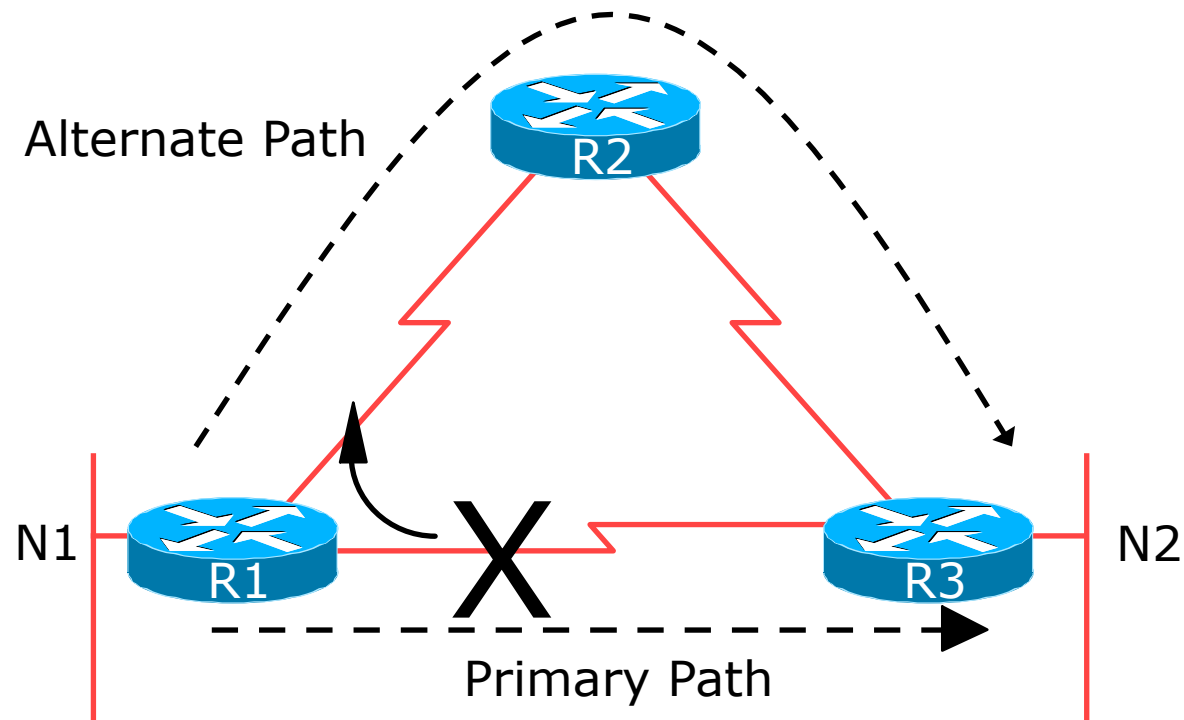
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- ❑ Only changes propagated
- ❑ Uses multicast on multi-access broadcast networks

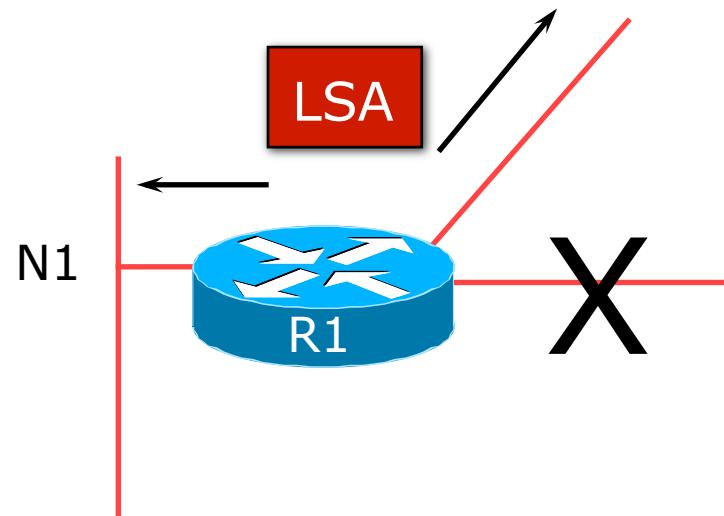
# Fast Convergence

- Detection Plus LSA/SPF
  - Known as the Dijkstra Algorithm



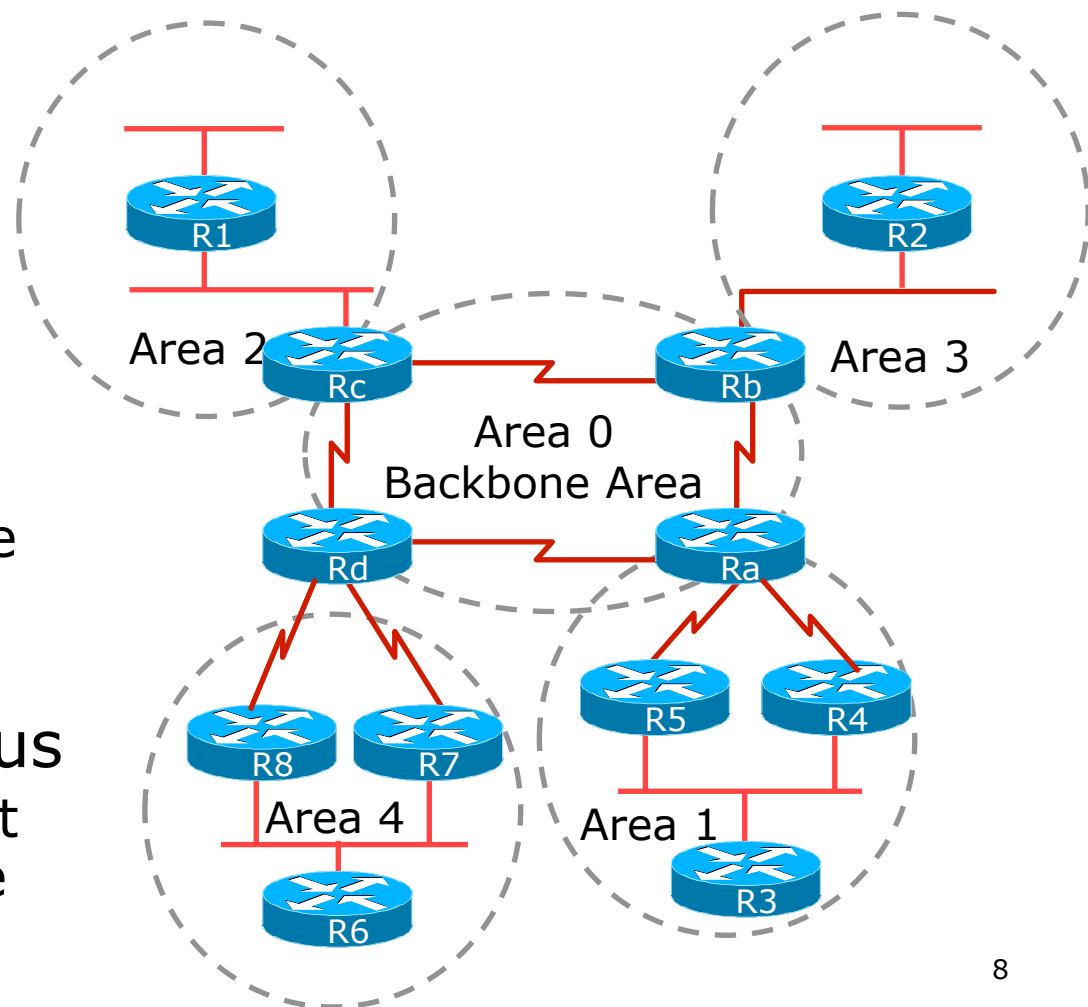
# Fast Convergence

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



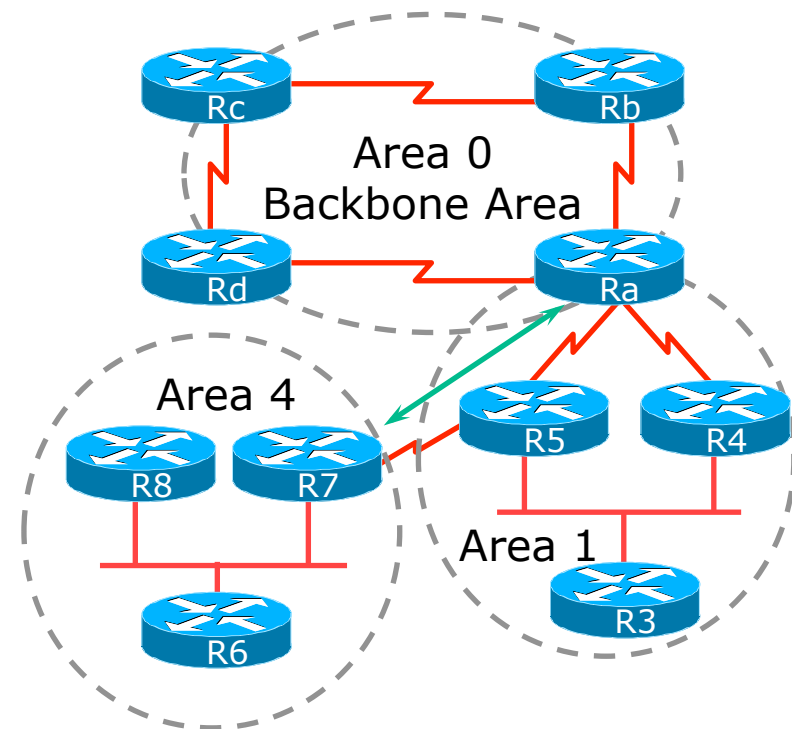
# OSPF Areas

- ❑ Area is a group of contiguous hosts and networks
  - Reduces routing traffic
- ❑ Per area topology database
  - Invisible outside the area
- ❑ Backbone area **MUST** be contiguous
  - All other areas must be connected to the backbone

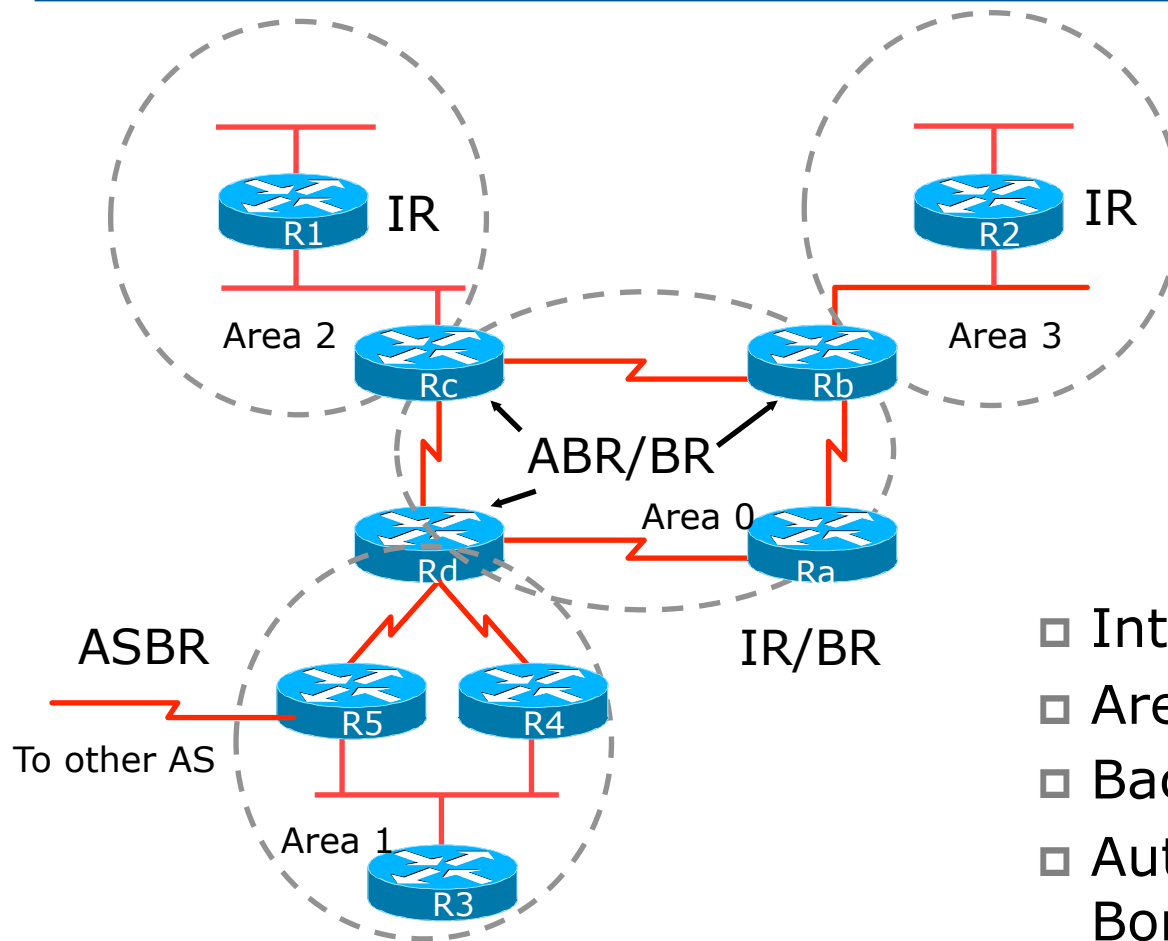


# Virtual Links between OSPF Areas

- ❑ Virtual Link is used when it is not possible to physically connect the area to the backbone
- ❑ **ISPs avoid designs which require virtual links**
  - Increases complexity
  - Decreases reliability and scalability

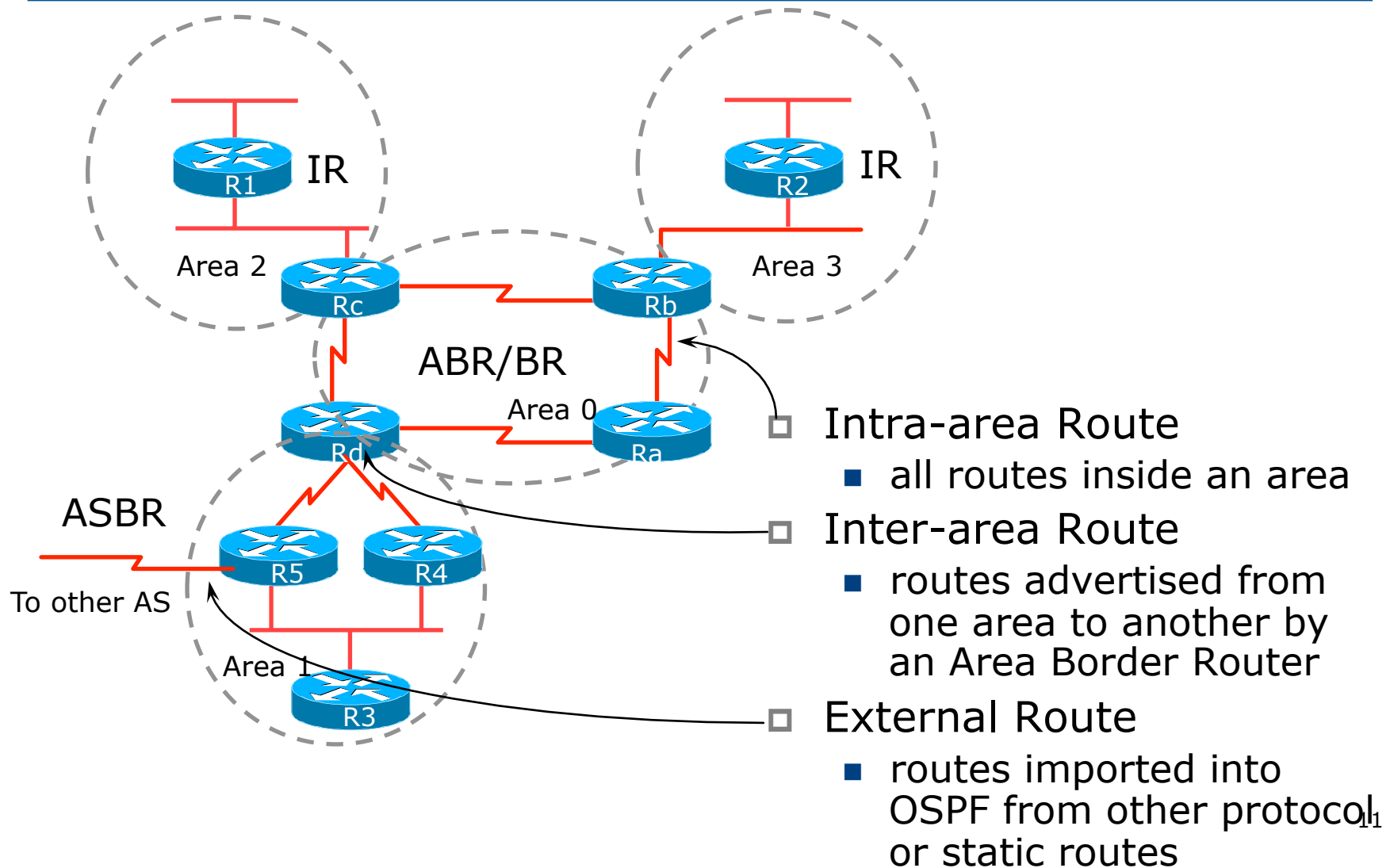


# Classification of Routers



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

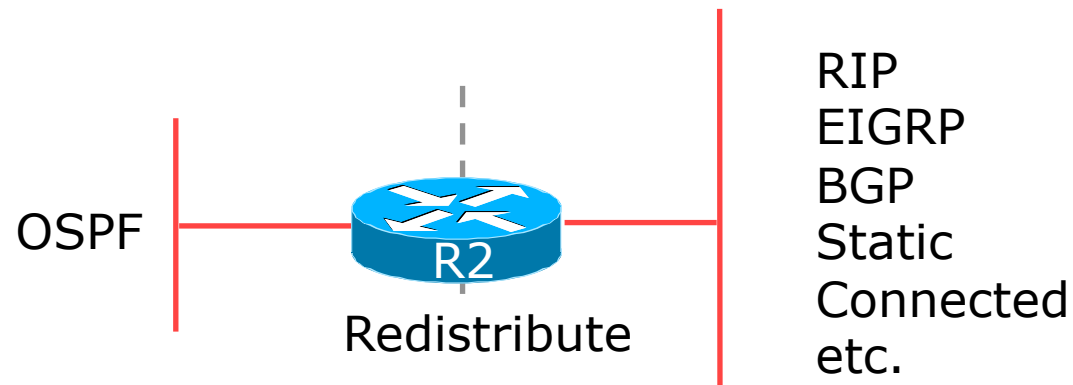
# OSPF Route Types



# External Routes

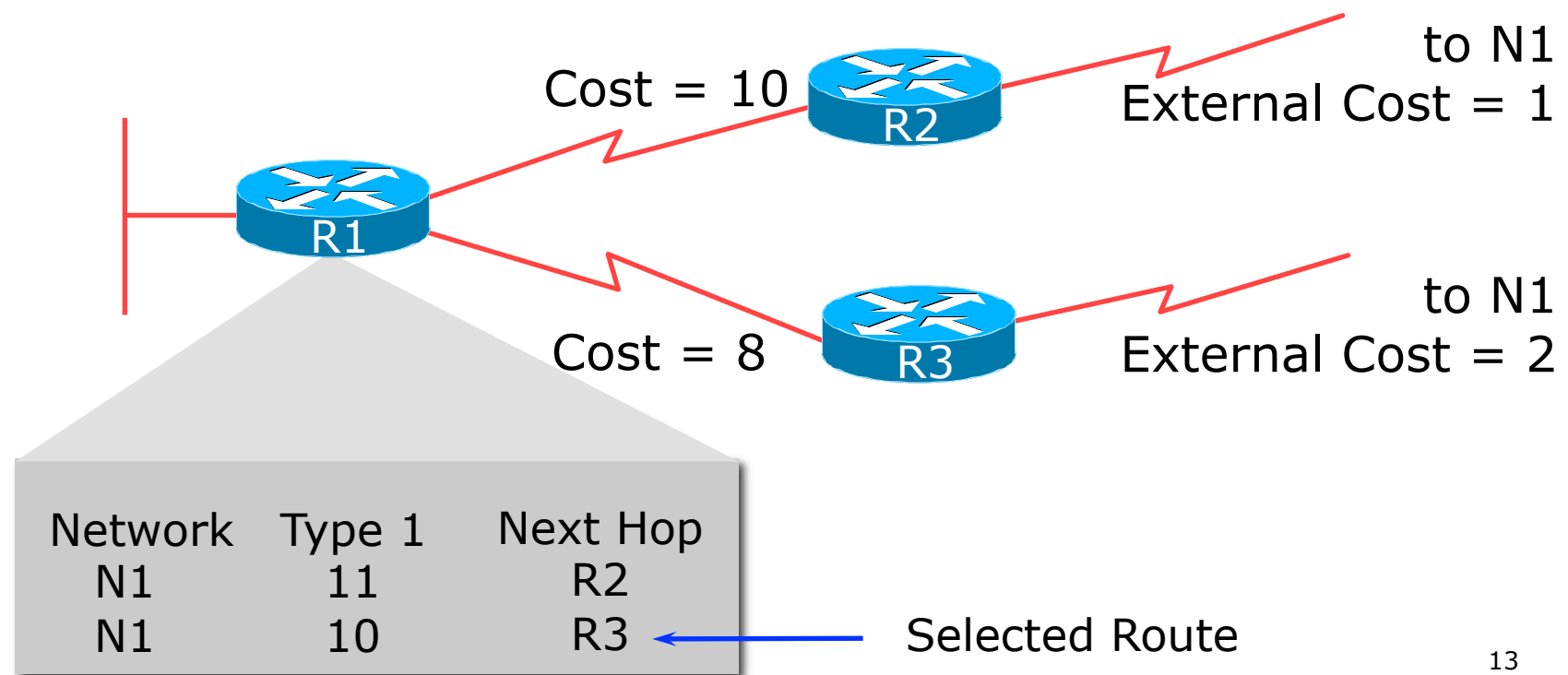
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- ❑ Prefixes which are redistributed into OSPF from other protocols
- ❑ Flooded unaltered throughout the AS
  - **Recommendation: Avoid redistribution!!**
- ❑ OSPF supports two types of external metrics
  - Type 1 external metrics
  - Type 2 external metrics (Cisco IOS default)



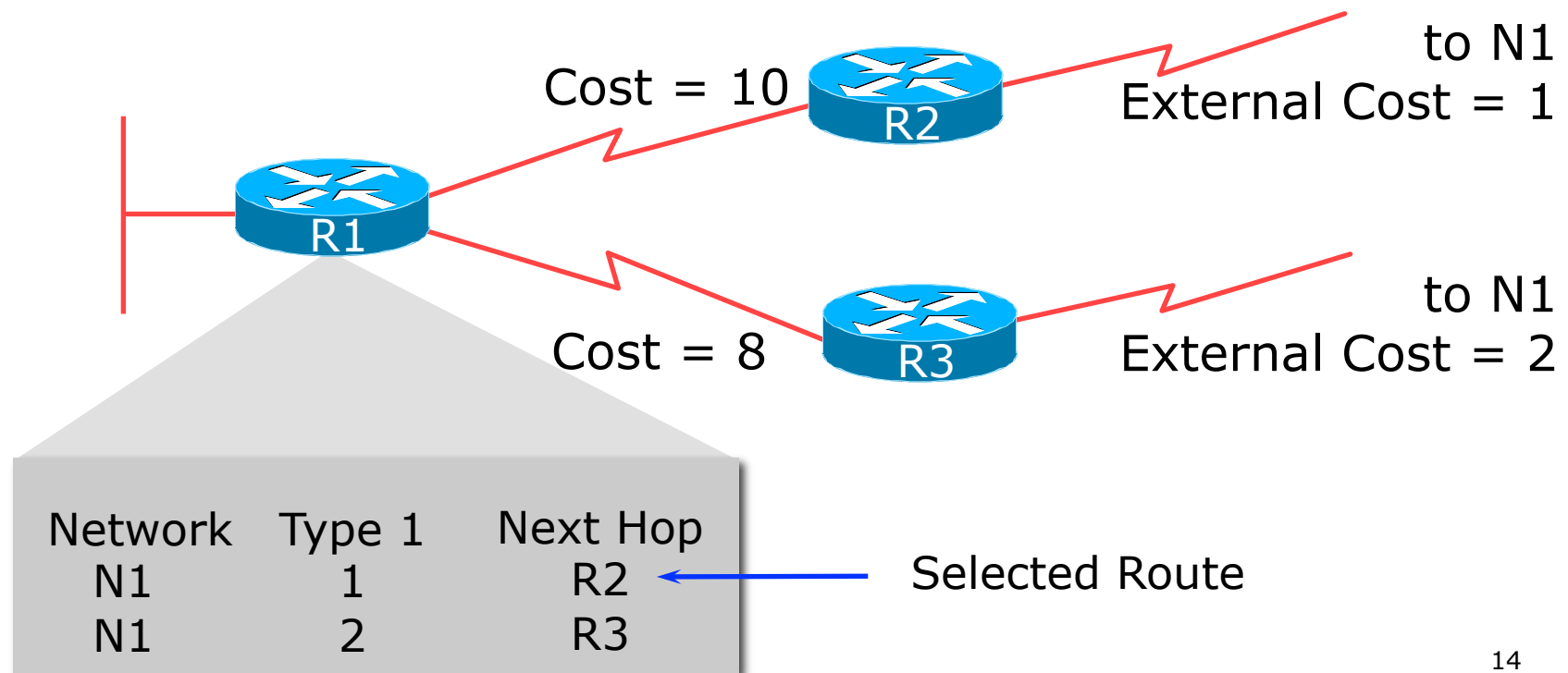
# External Routes

- 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

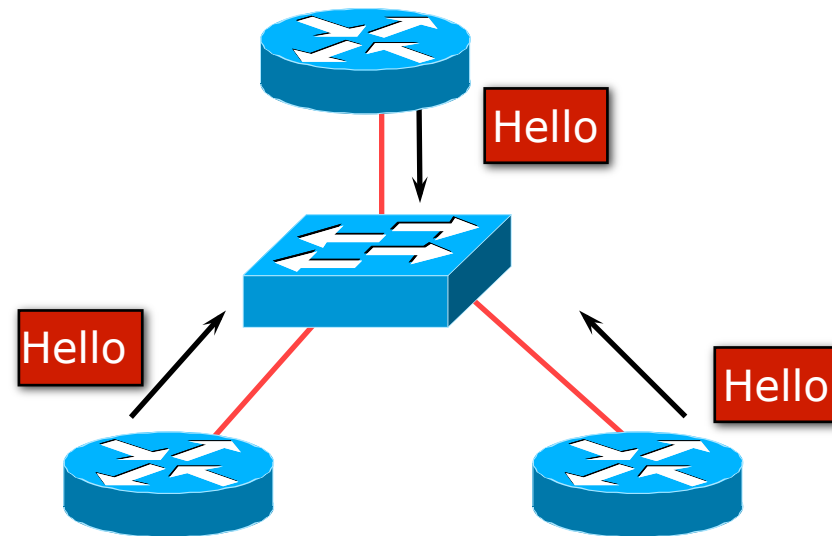
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- ❑ A router has a separate LS database for each area to which it belongs
- ❑ All routers belonging to the same area have identical database
- ❑ SPF calculation is performed separately for each area
- ❑ LSA flooding is bounded by area
- ❑ Recommendation:
  - Limit the number of areas a router participates in!!
  - 1 to 3 is fine (typical ISP design)
  - >3 can overload the CPU depending on the area topology complexity

# The Hello Protocol

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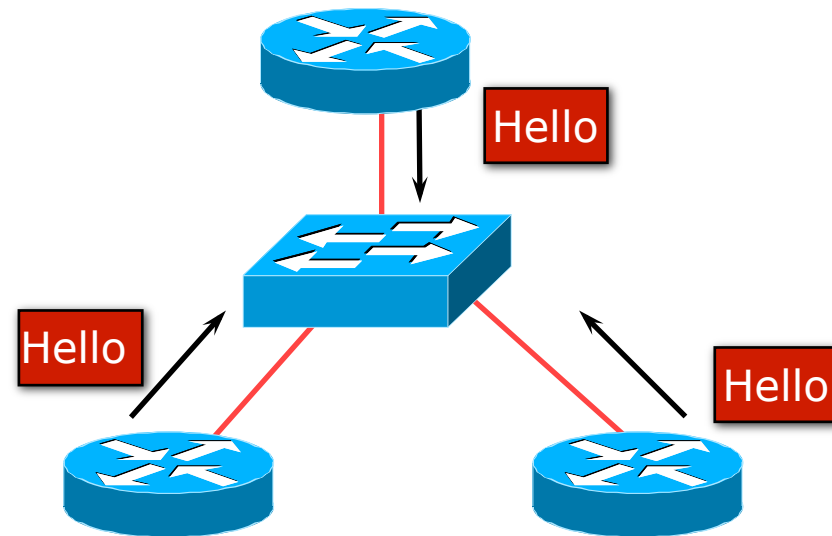
- ❑ Responsible for establishing and maintaining neighbour relationships
- ❑ Elects designated router on multi-access networks



# The Hello Packet

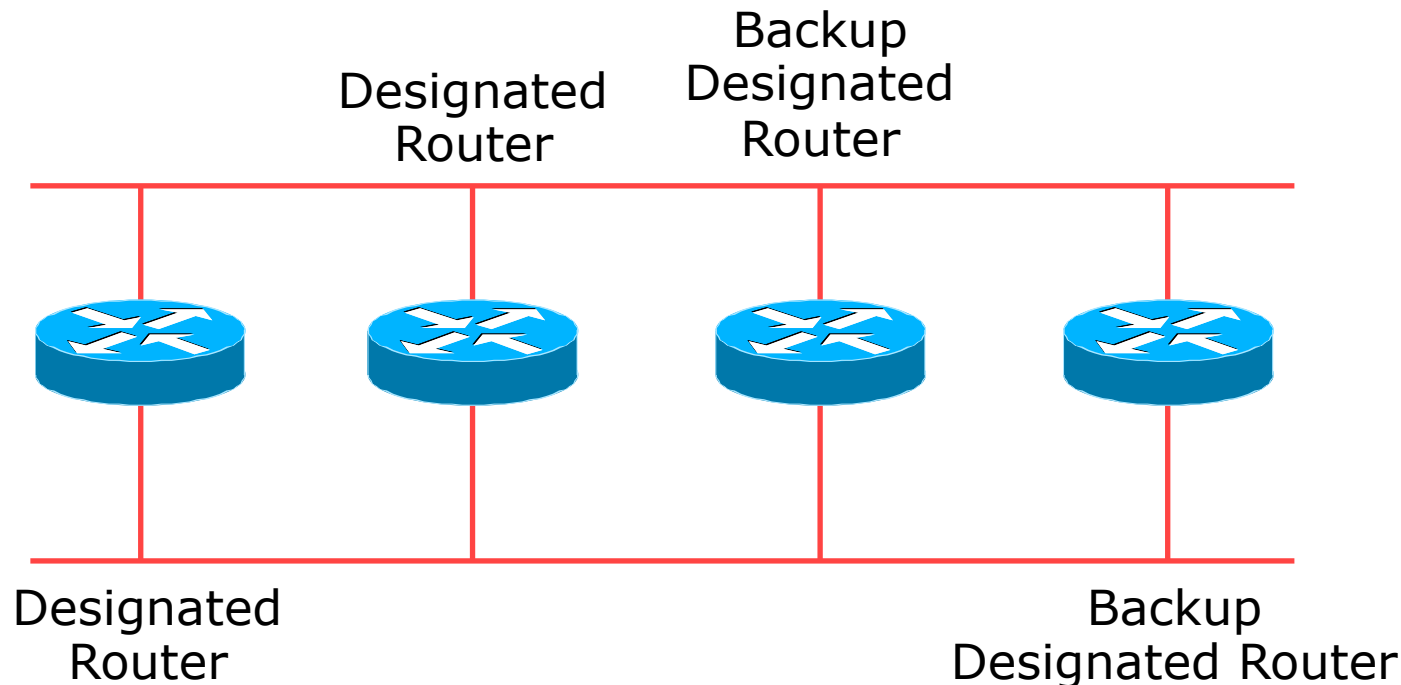
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- Contains:
  - Router priority
  - Hello interval
  - Router dead interval
  - Network mask
  - List of neighbours
  - DR and BDR
  - Options: E-bit, MC-bit,... (see A.2 of RFC2328)



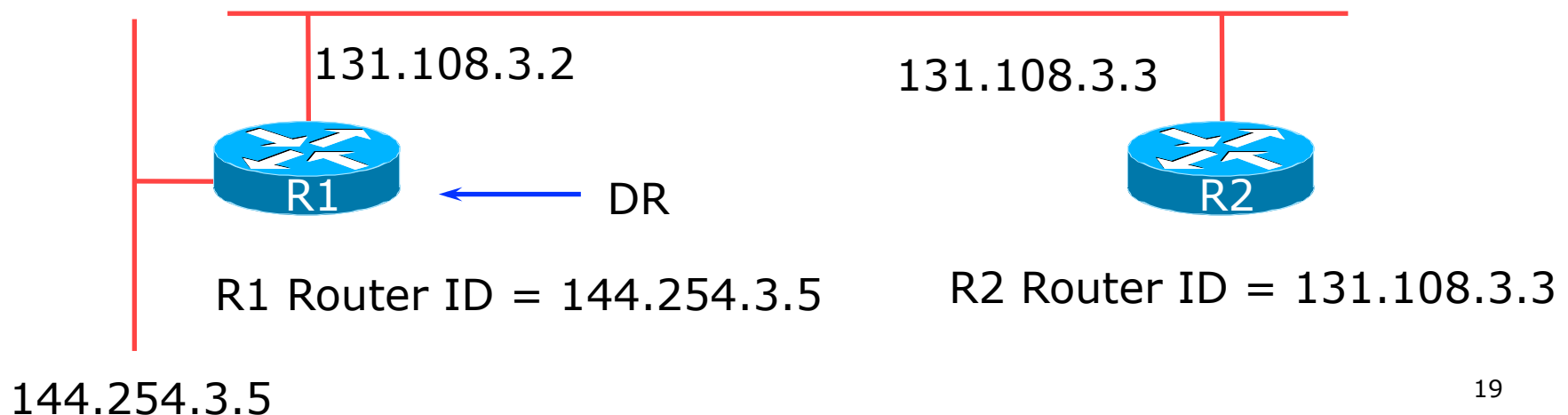
# Designated Router

- ❑ There is ONE designated router per multi-access network
  - Generates network link advertisements
  - Assists in database synchronization



# Designated Router by Priority

- ❑ Configured priority (per interface)
  - ISPs configure high priority on the routers they want as DR/BDR
- ❑ Else determined by highest router ID
  - Router ID is 32 bit integer
  - Derived from the loopback interface address, if configured, otherwise the highest IP address

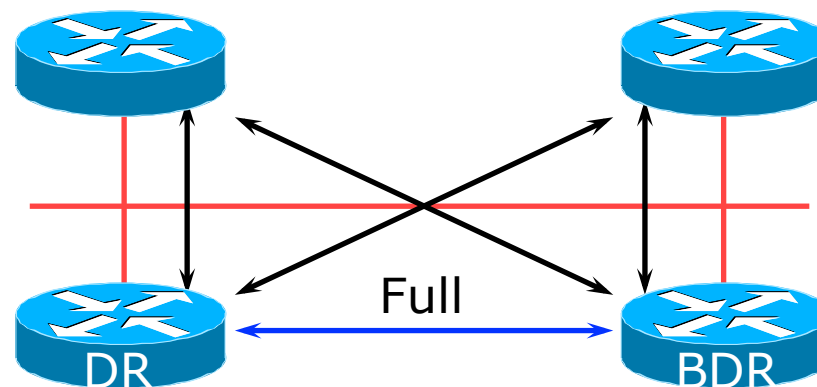


# Neighbouring States

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## □ Full

- Routers are fully adjacent
- Databases synchronised
- Relationship to DR and BDR

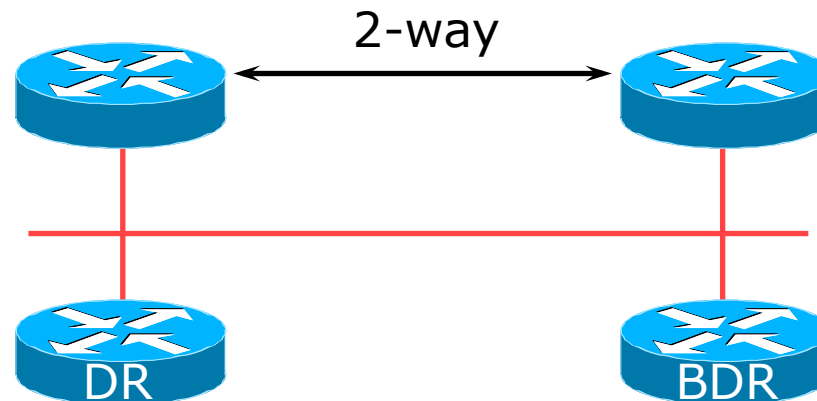


# Neighbouring States

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## □ 2-way

- Router sees itself in other Hello packets
- DR selected from neighbours in state 2-way or greater

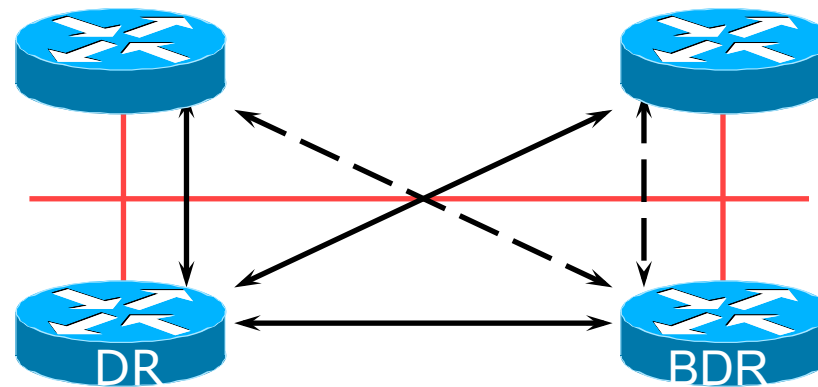


# When to Become Adjacent

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

# LSAs Propagate Along Adjacencies



- LSAs acknowledged along adjacencies

# Broadcast Networks

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- ❑ IP Multicast used for Sending and Receiving Updates
  - 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)

# Routing Protocol Packets

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- ❑ 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

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## □ Six distinct type of LSAs

- Type 1 : Router LSA
- Type 2 : Network LSA
- Type 3 & 4: Summary LSA
- Type 5 & 7: External LSA (Type 7 is for NSSA)
- Type 6: Group membership LSA
- Type 9, 10 & 11: Opaque LSA (9: Link-Local, 10: Area)

## Router LSA (Type 1)

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- ❑ 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)

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- ❑ 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)

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

## External LSA (Type 5 and 7)

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- ❑ 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
- ❑ (Type 7 LSAs used to describe external LSA for one specific OSPF area type)

# Inter-Area Route Summarisation

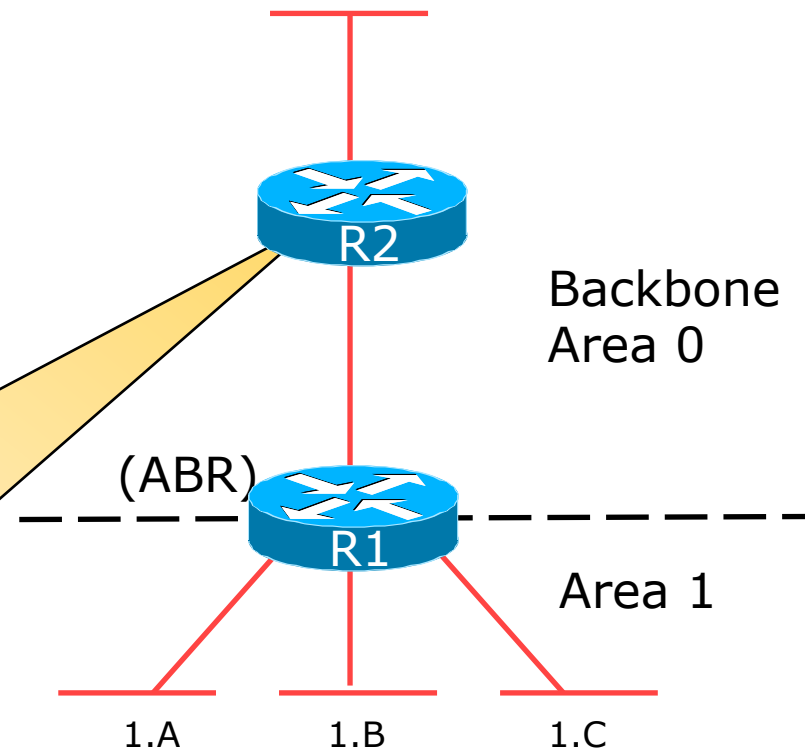
- ❑ Prefix or all subnets
- ❑ Prefix or all networks
- ❑ 'Area range' command

With  
summarisation

Network	Next Hop
1	R1

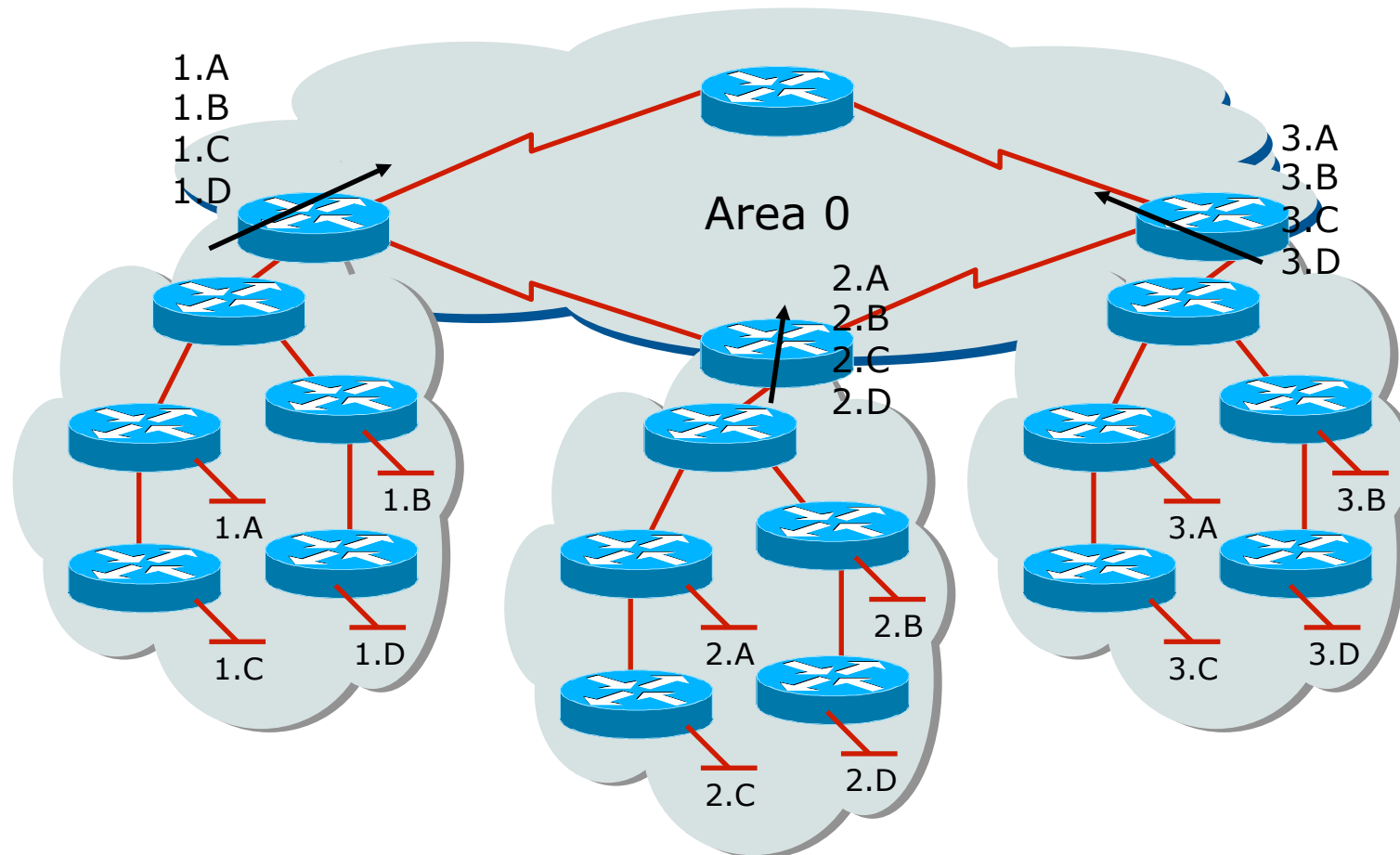
Without  
summarisation

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



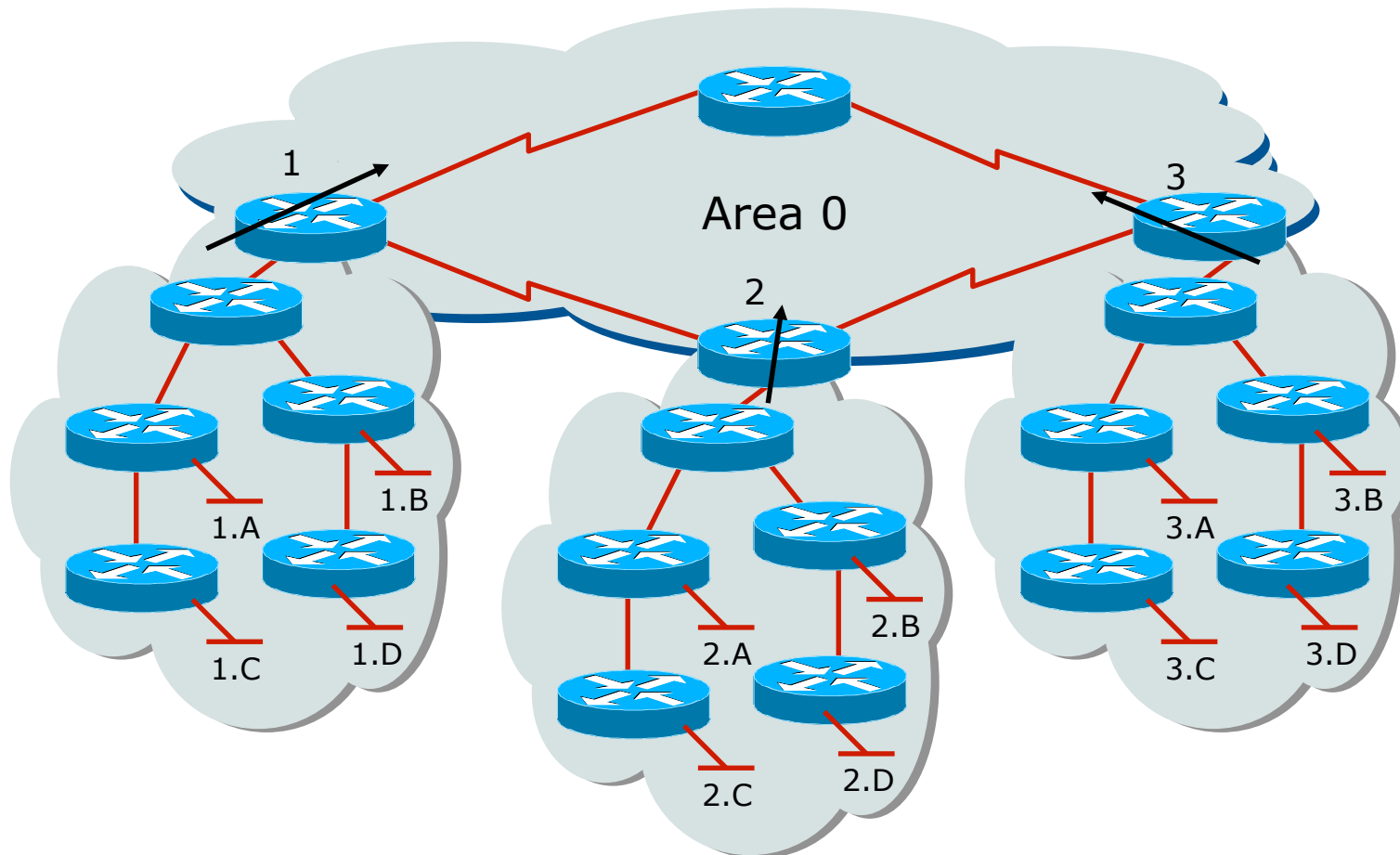
# No Summarisation

- ❑ Specific Link LSA advertised out of each area
- ❑ Link state changes propagated out of each area



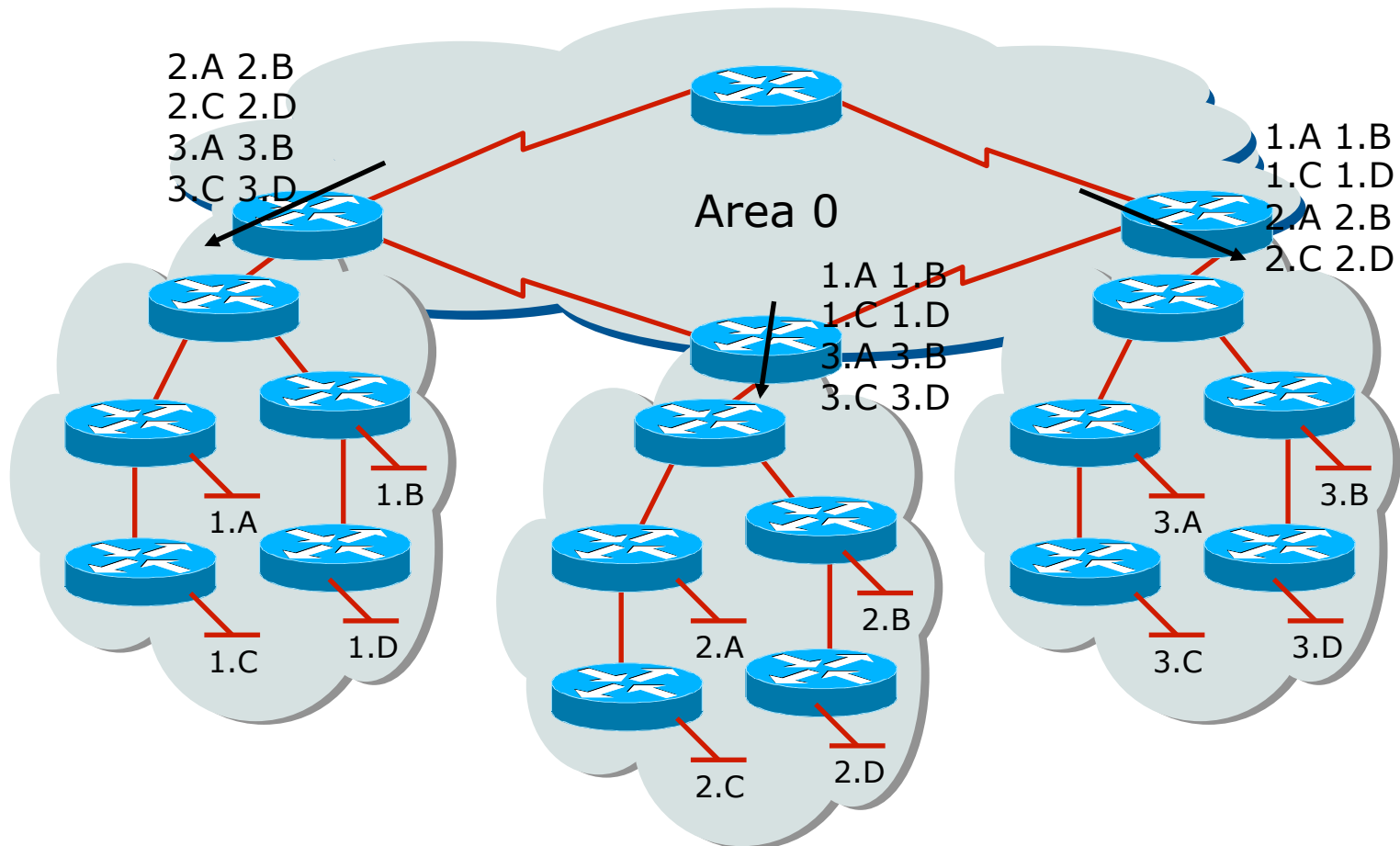
# With Summarisation

- ❑ Only summary LSA advertised out of each area
- ❑ Link state changes do not propagate out of the area



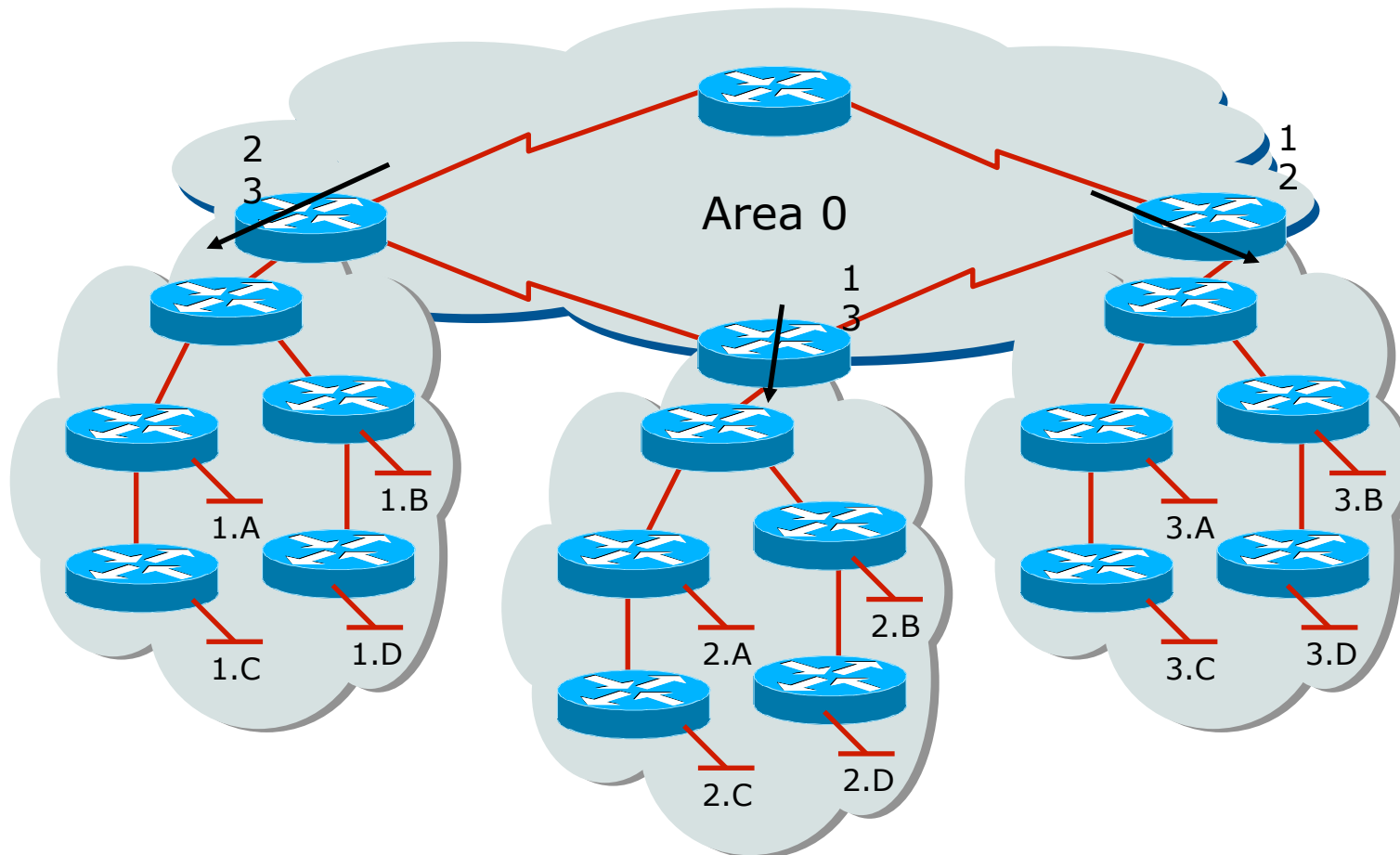
# No Summarisation

- ❑ Specific Link LSA advertised in to each area
- ❑ Link state changes propagated in to each area



# With Summarisation

- ❑ Only summary link LSA advertised in to each area
- ❑ Link state changes do not propagate in to each area



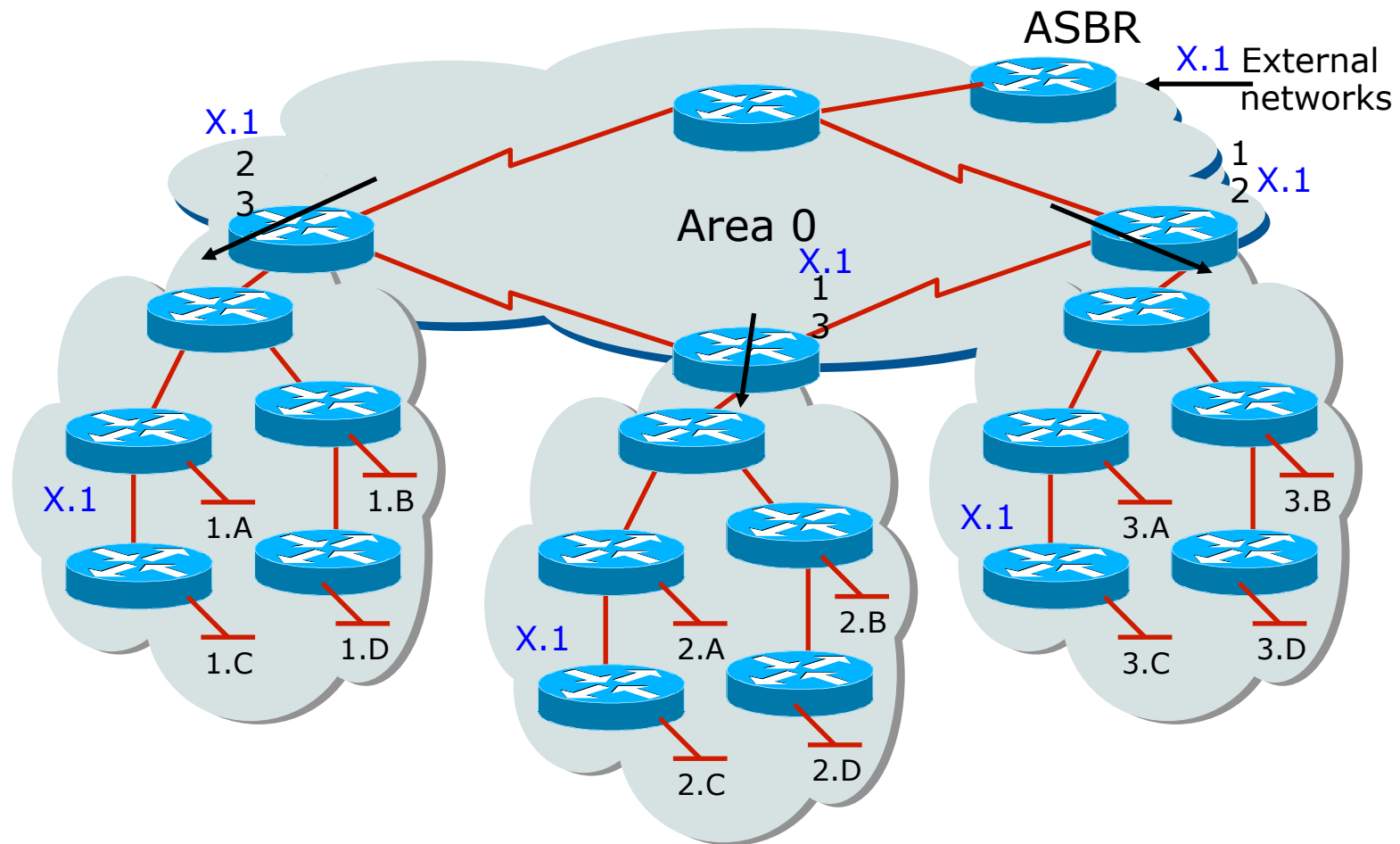
# Types of Areas

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- ❑ Regular
- ❑ Stub
- ❑ Totally Stubby
- ❑ Not-So-Stubby
- ❑ **Only “regular” areas are useful for ISPs**
  - Other area types handle redistribution of other routing protocols into OSPF – ISPs don’t redistribute anything into OSPF
- ❑ The next slides describing the different area types are provided for information only

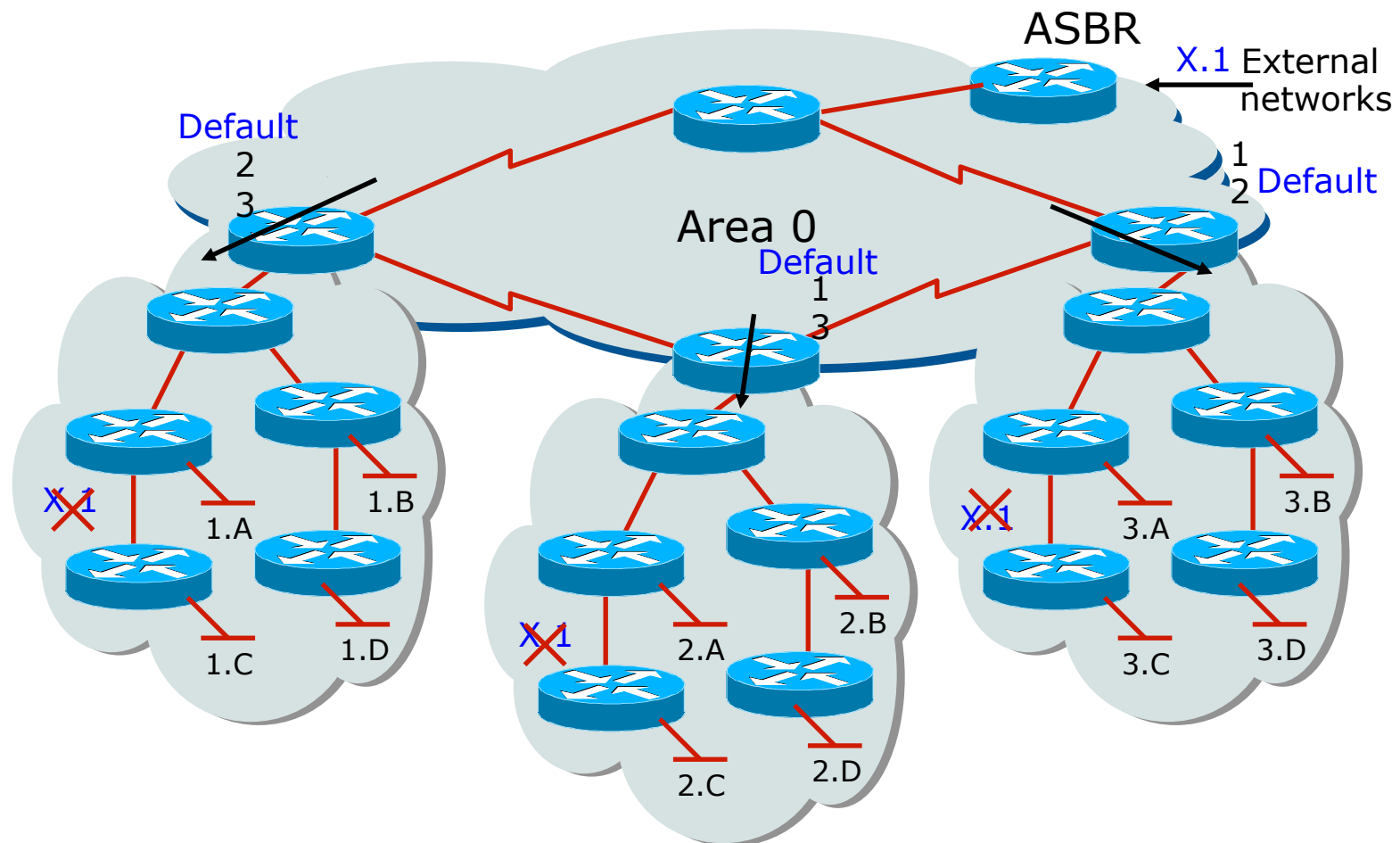
# Regular Area (Not a Stub)

- From Area 1's point of view, summary networks from other areas are injected, as are external networks such as X.1



# Normal Stub Area

- Summary networks, default route injected
- Command is **area x stub**

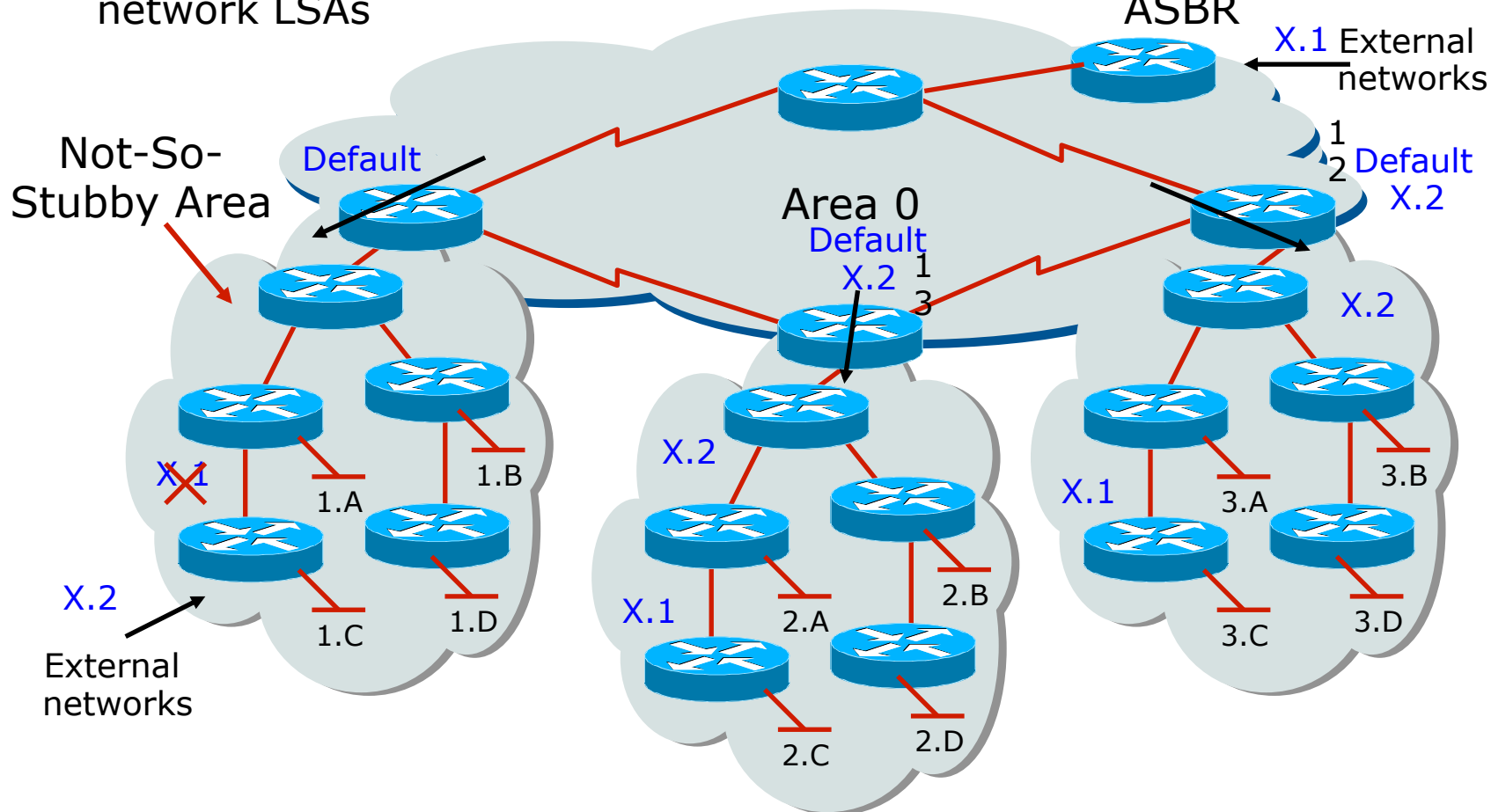


- ❑ Only a default route injected
  - Default path to closest area border router
- ❑ Command is **area x stub no-summary**



# Not-So-Stubby Area

- Capable of importing 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



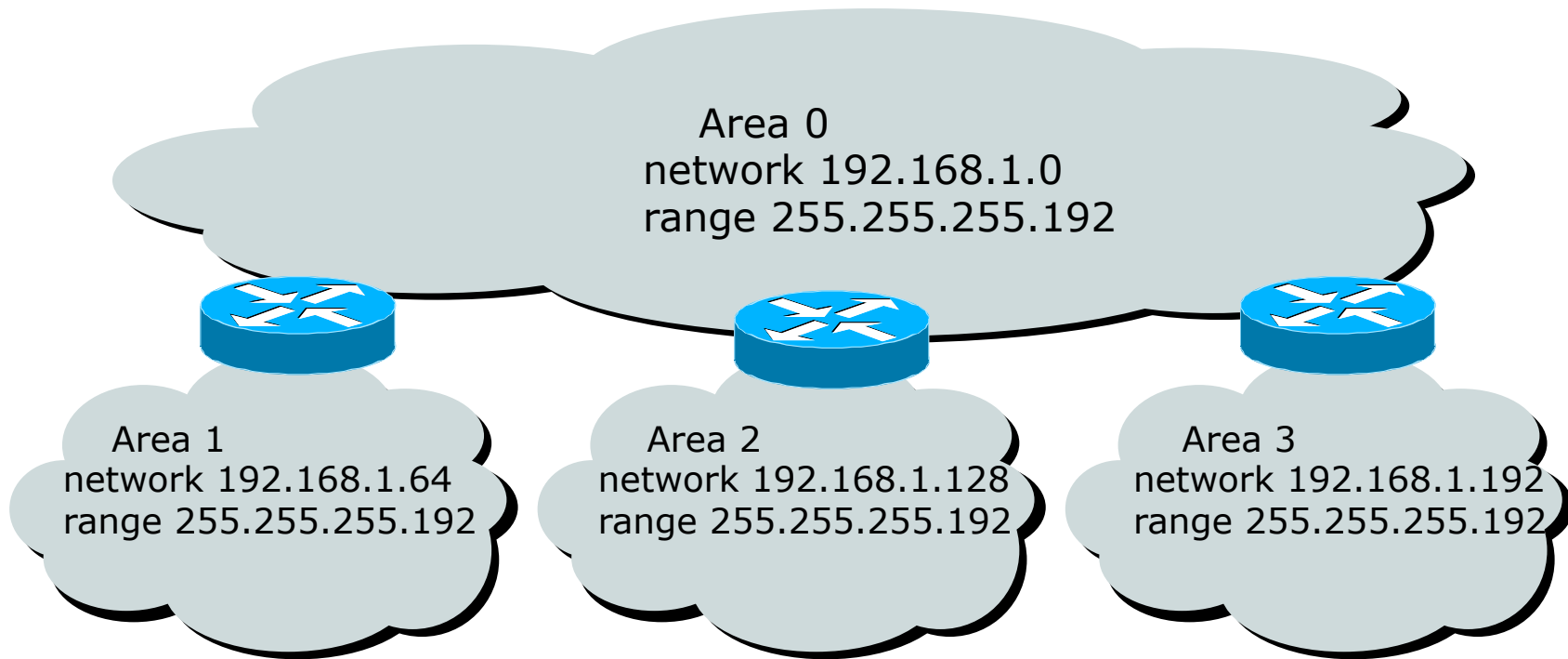
# ISP Use of Areas

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- ❑ ISP networks use:
  - Backbone area
  - Regular area
- ❑ Backbone area
  - No partitioning
- ❑ Regular area
  - Summarisation of point to point link addresses used within areas
  - Loopback addresses allowed out of regular areas without summarisation (otherwise iBGP won't work)

# Addressing for Areas

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- ❑ Assign contiguous ranges of subnets per area to facilitate summarisation

# Summary

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- ❑ Fundamentals of Scalable OSPF Network Design
  - Area hierarchy
  - DR/BDR selection
  - Contiguous intra-area addressing
  - Route summarisation
  - Infrastructure prefixes only

# Introduction to OSPF



ISP Workshops