

# Introduction to OSPF



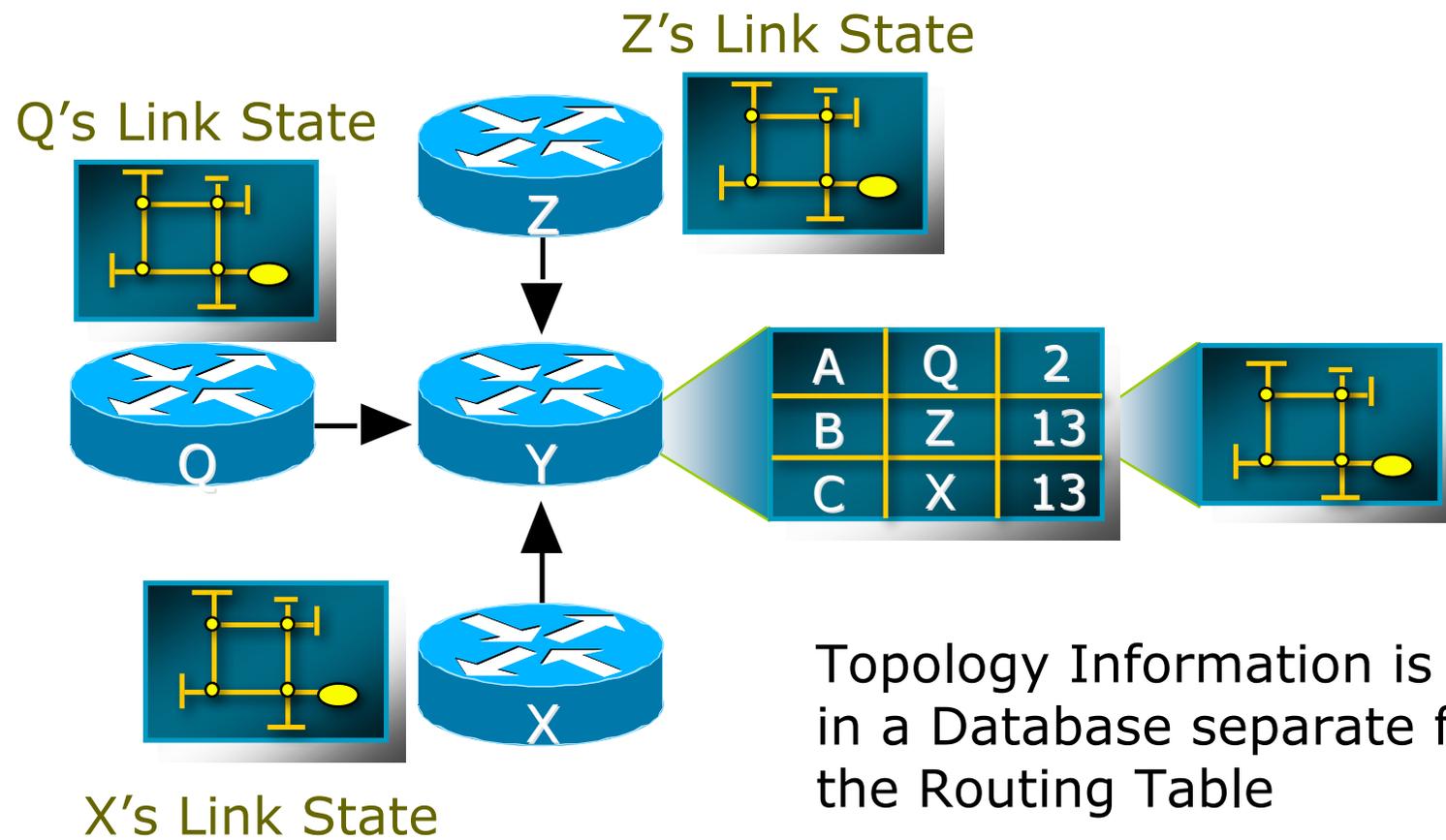
ISP Training Workshops

# OSPF

---

- 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



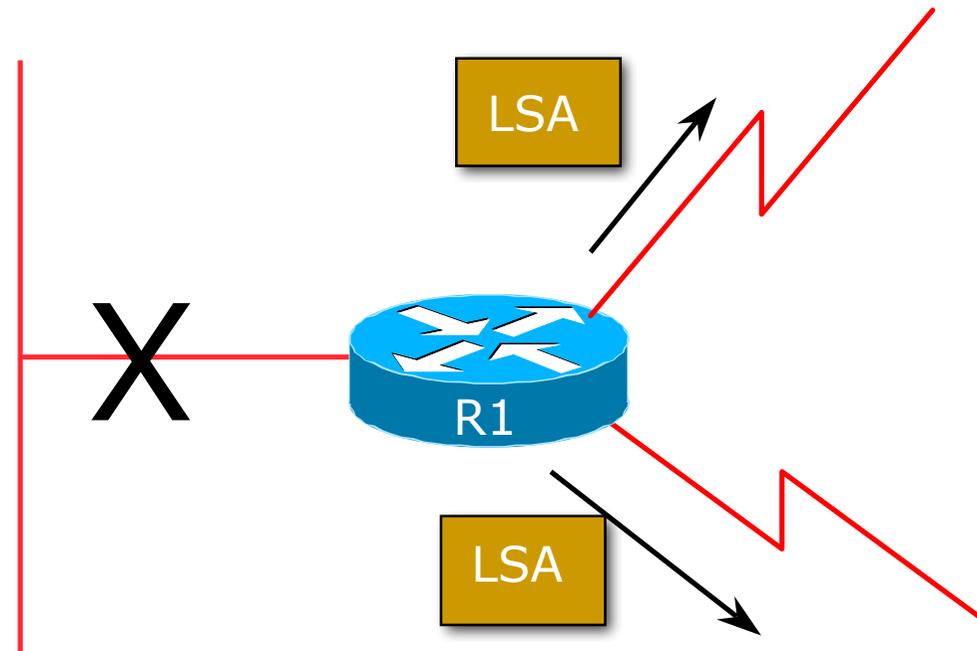
# Link State Routing

---

- 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

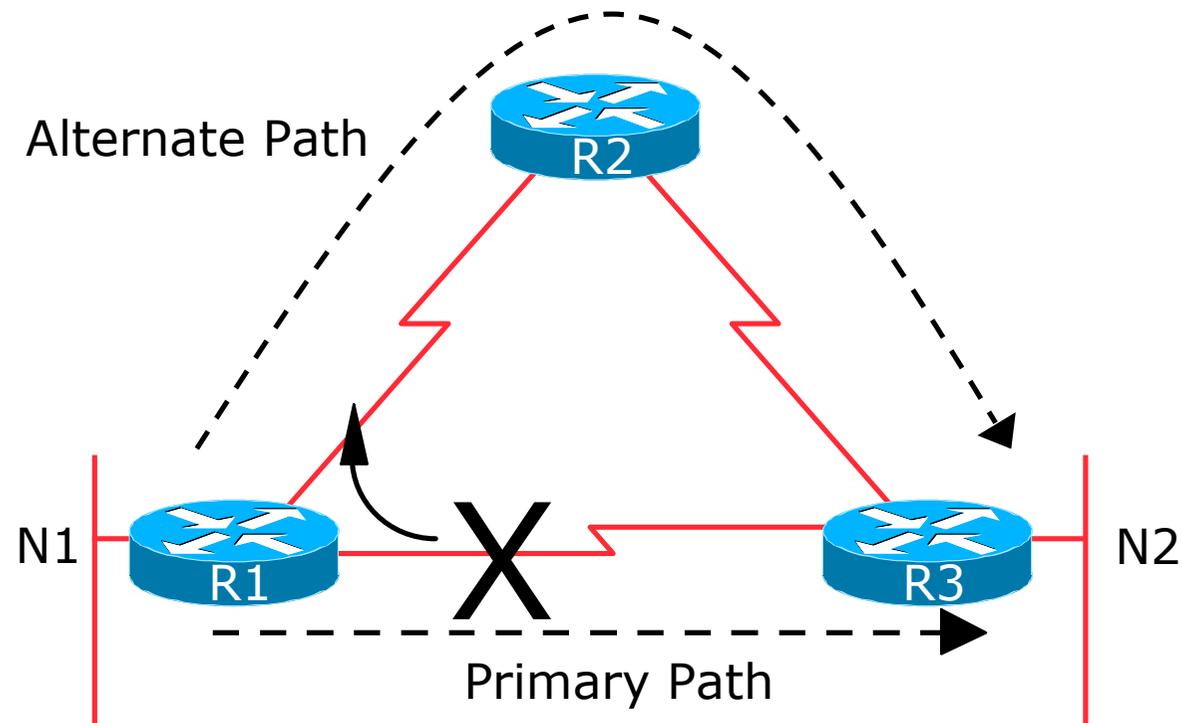
---



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

# Fast Convergence

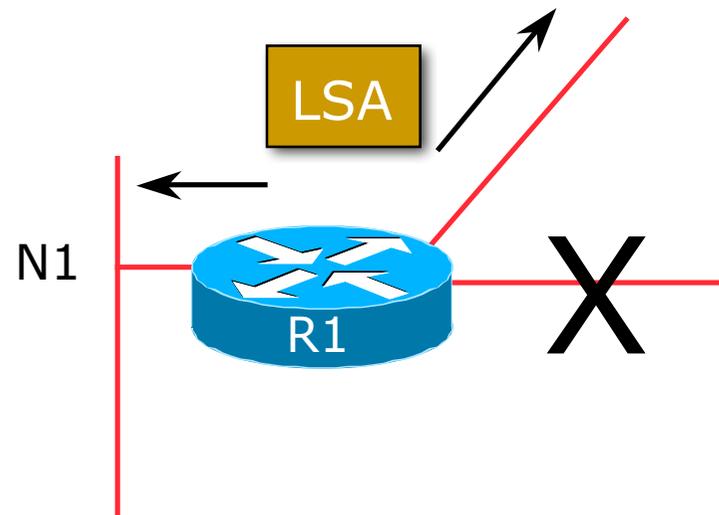
- Detection Plus LSA/SPF
  - Known as the Dijkstra Algorithm



# Fast Convergence

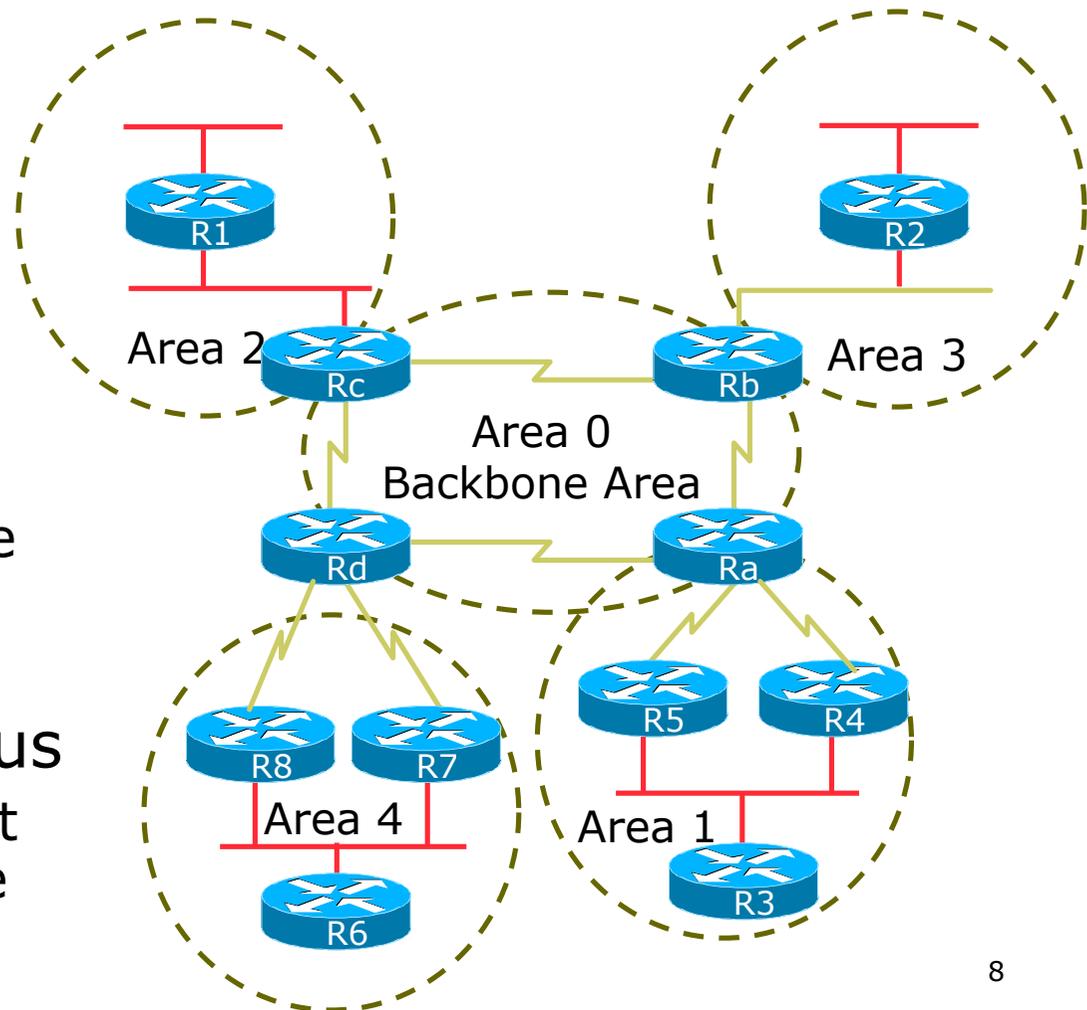
---

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



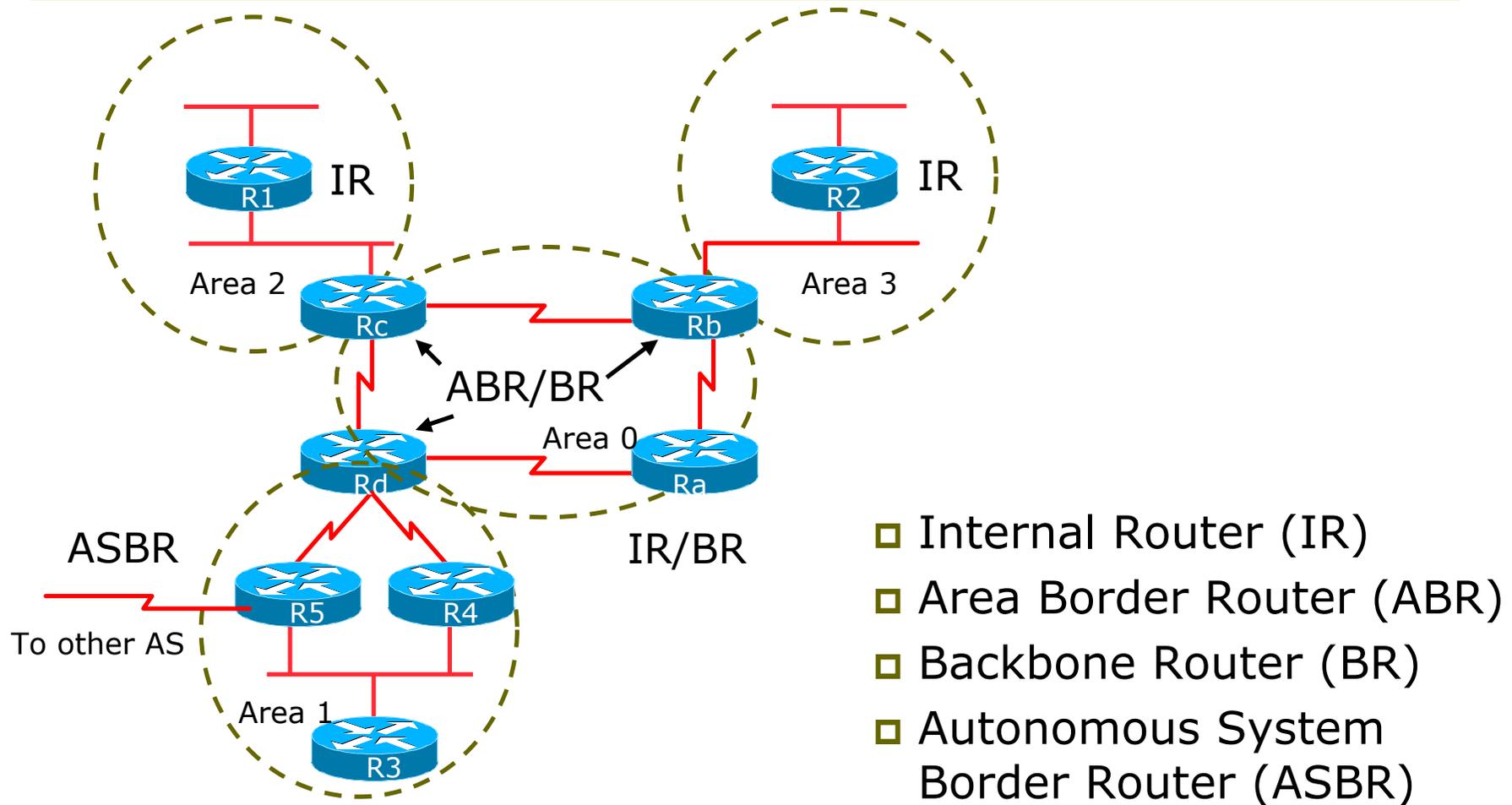
# OSPF Areas

- 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





# Classification of Routers

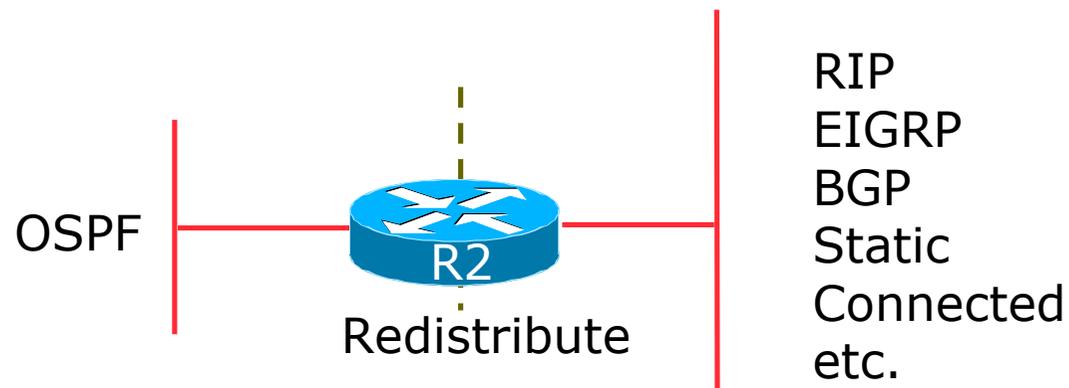




# External Routes

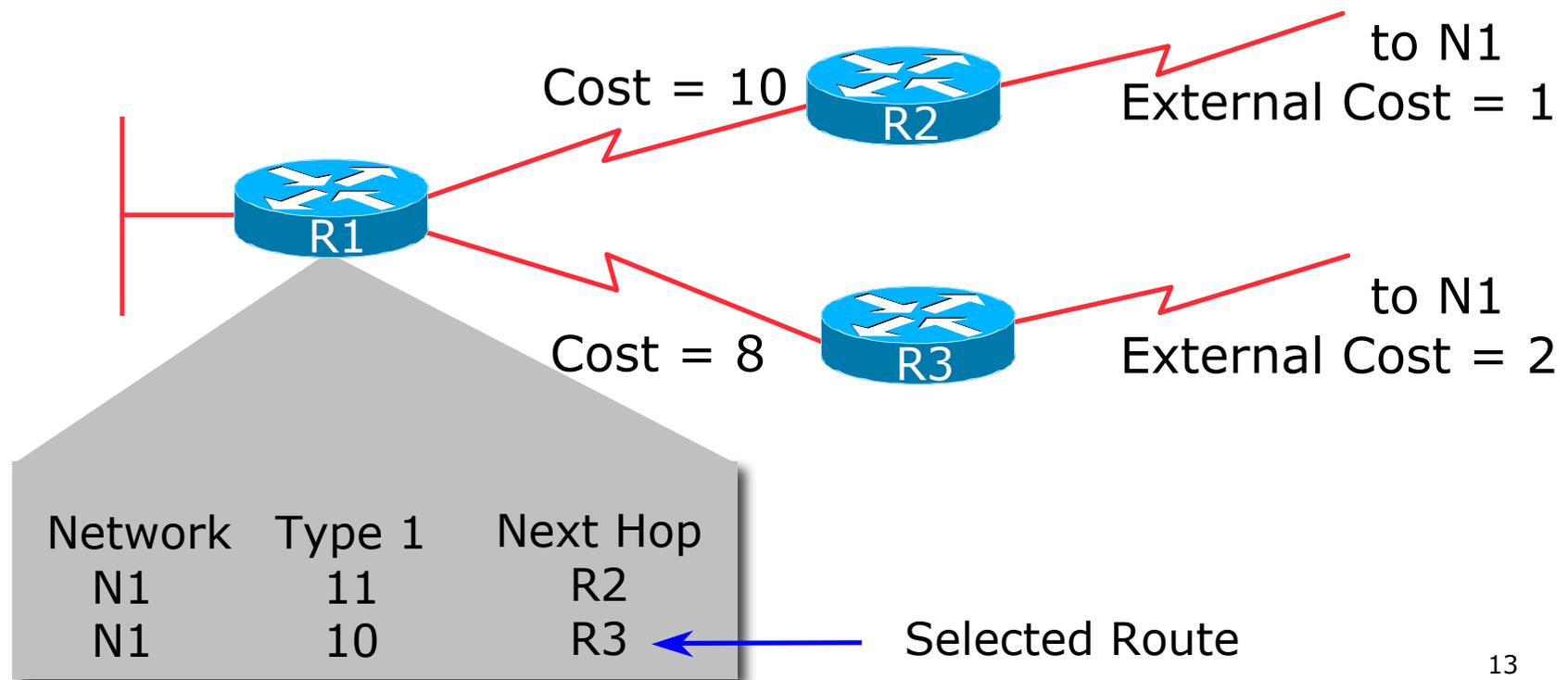
---

- ❑ 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)



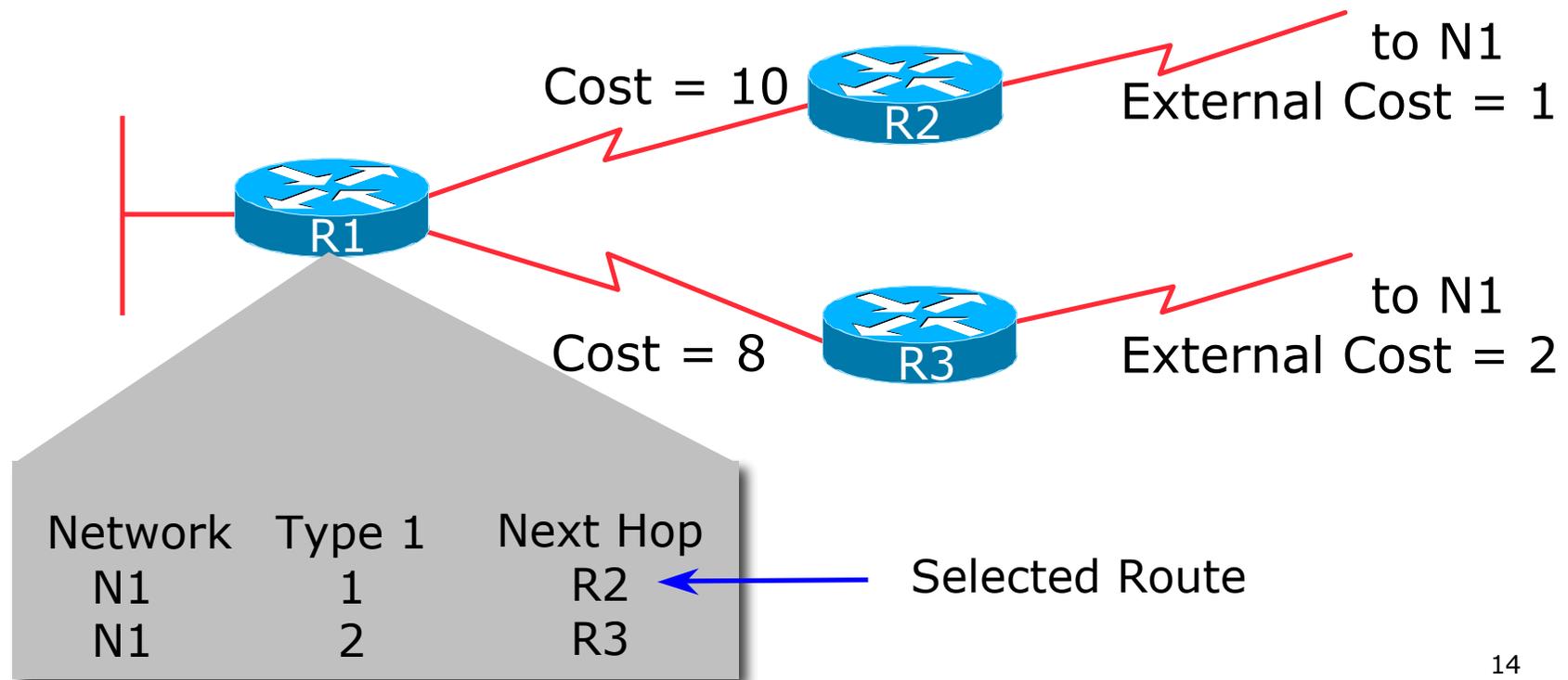
# External Routes

- 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

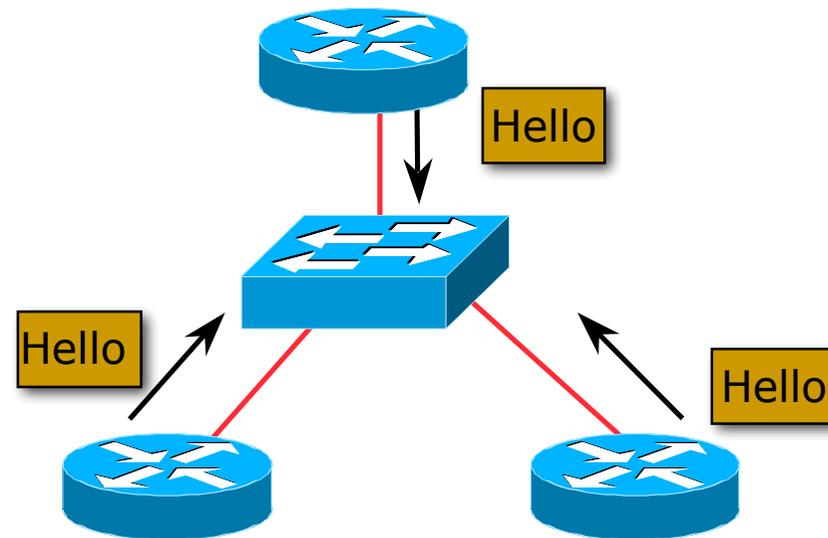
---

- ❑ 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

---

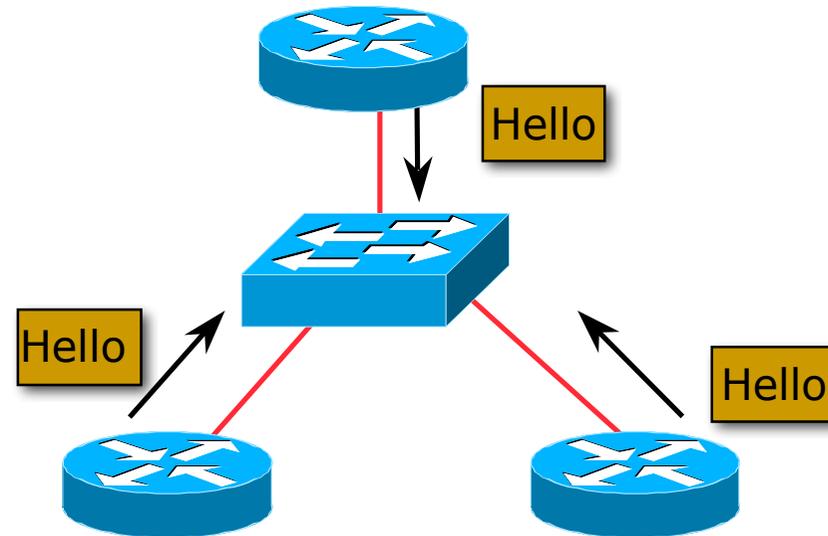
- ❑ Responsible for establishing and maintaining neighbour relationships
- ❑ Elects designated router on multi-access networks



# The Hello Packet

---

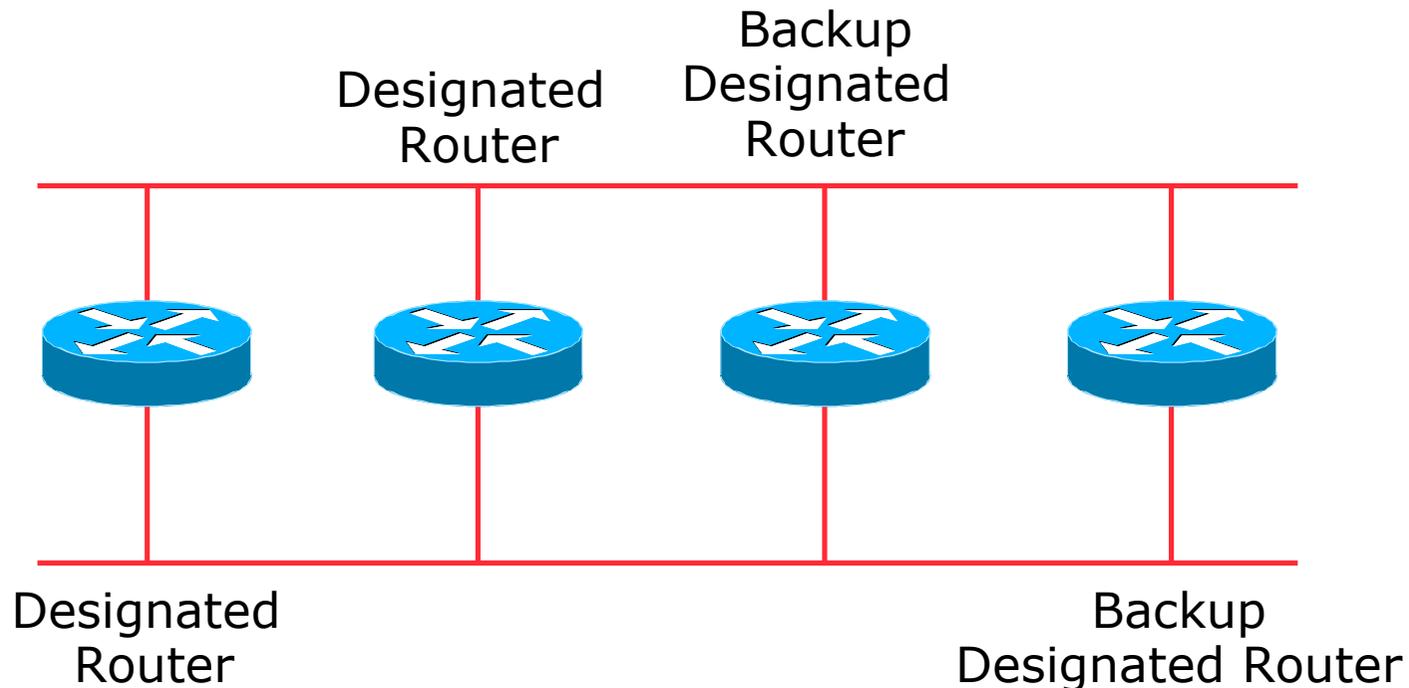
- Contains:
  - Router priority
  - Hello interval
  - Router dead interval
  - Network mask
  - List of neighbours
  - DR and BDR
  - Options: E-bit, MC-bit,... (see A.2 of RFC2328)



# Designated Router

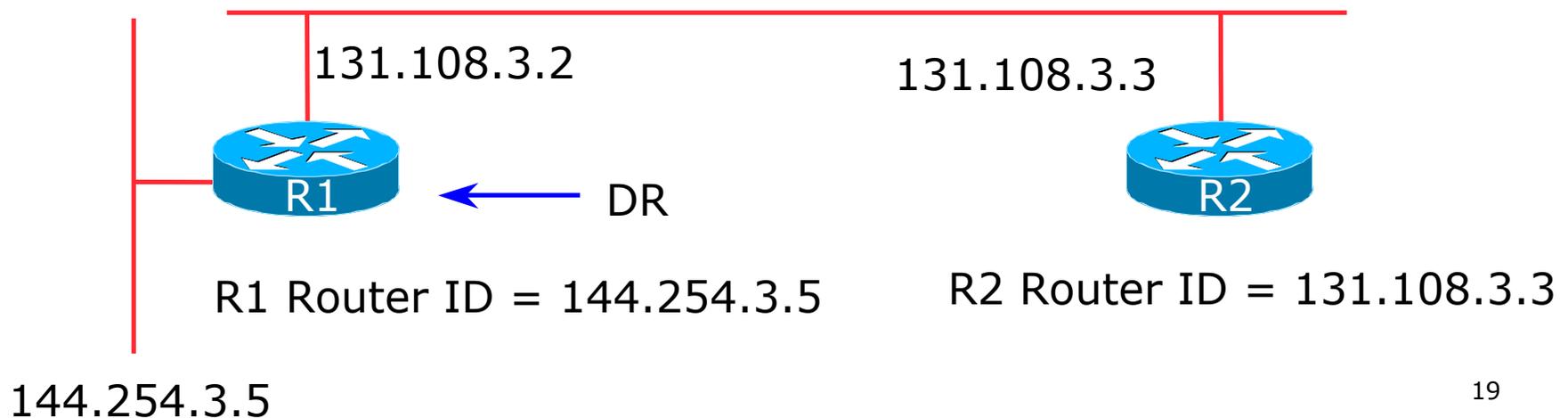
---

- 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

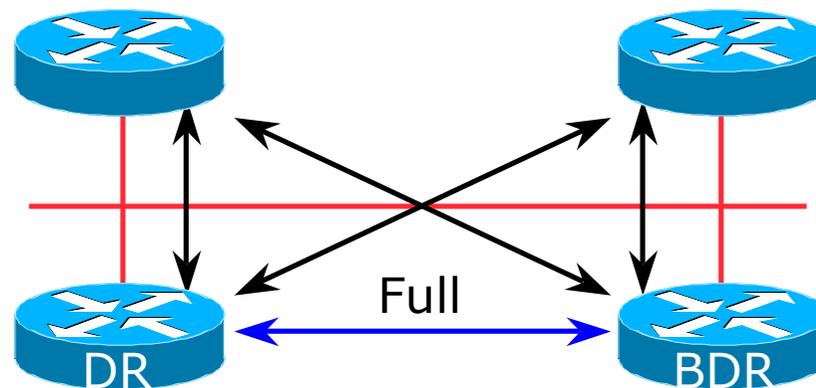


# Neighbouring States

---

## □ Full

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

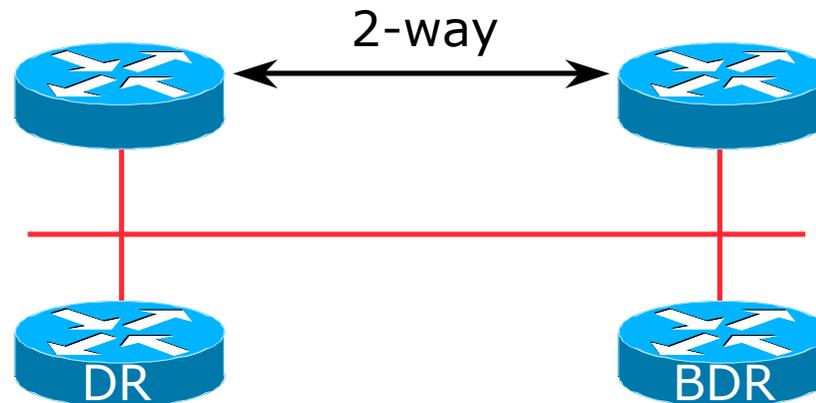


# Neighbouring States

---

## □ 2-way

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



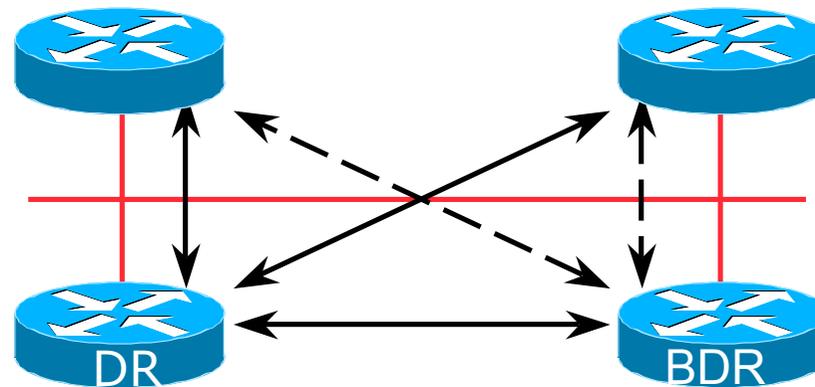
# When to Become Adjacent

---

- ❑ 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

---

- ❑ 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

---

- ❑ 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

---

## □ 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)

---

- ❑ 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 inter-area routes are advertised into the backbone
- ❑ Type 4 is the information about the ASBR

# External LSA (Type 5 and 7)

---

- 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

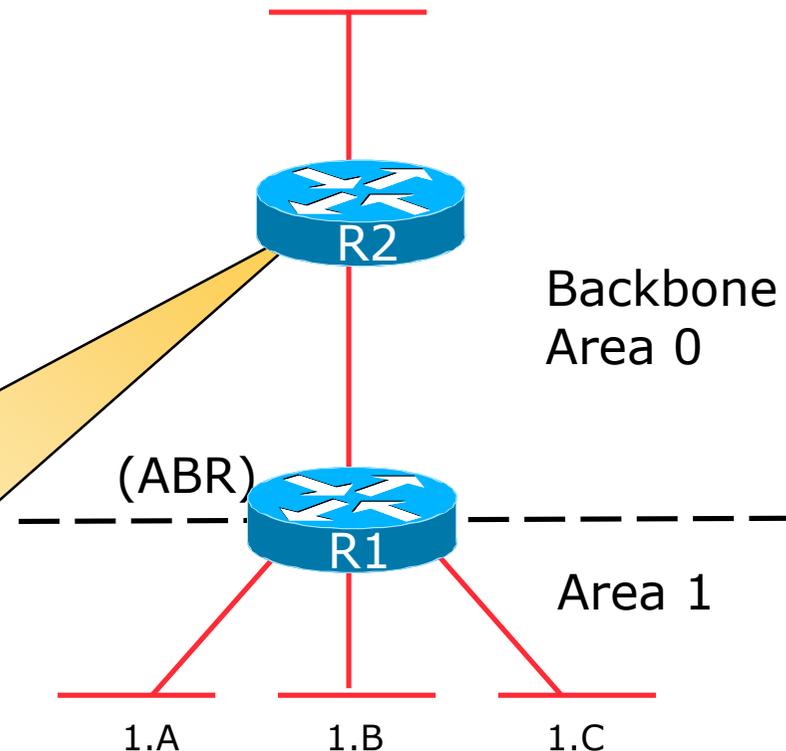
- Prefix or all subnets
- Prefix or all networks
- 'Area range' command

With summarisation

Network	Next Hop
1	R1

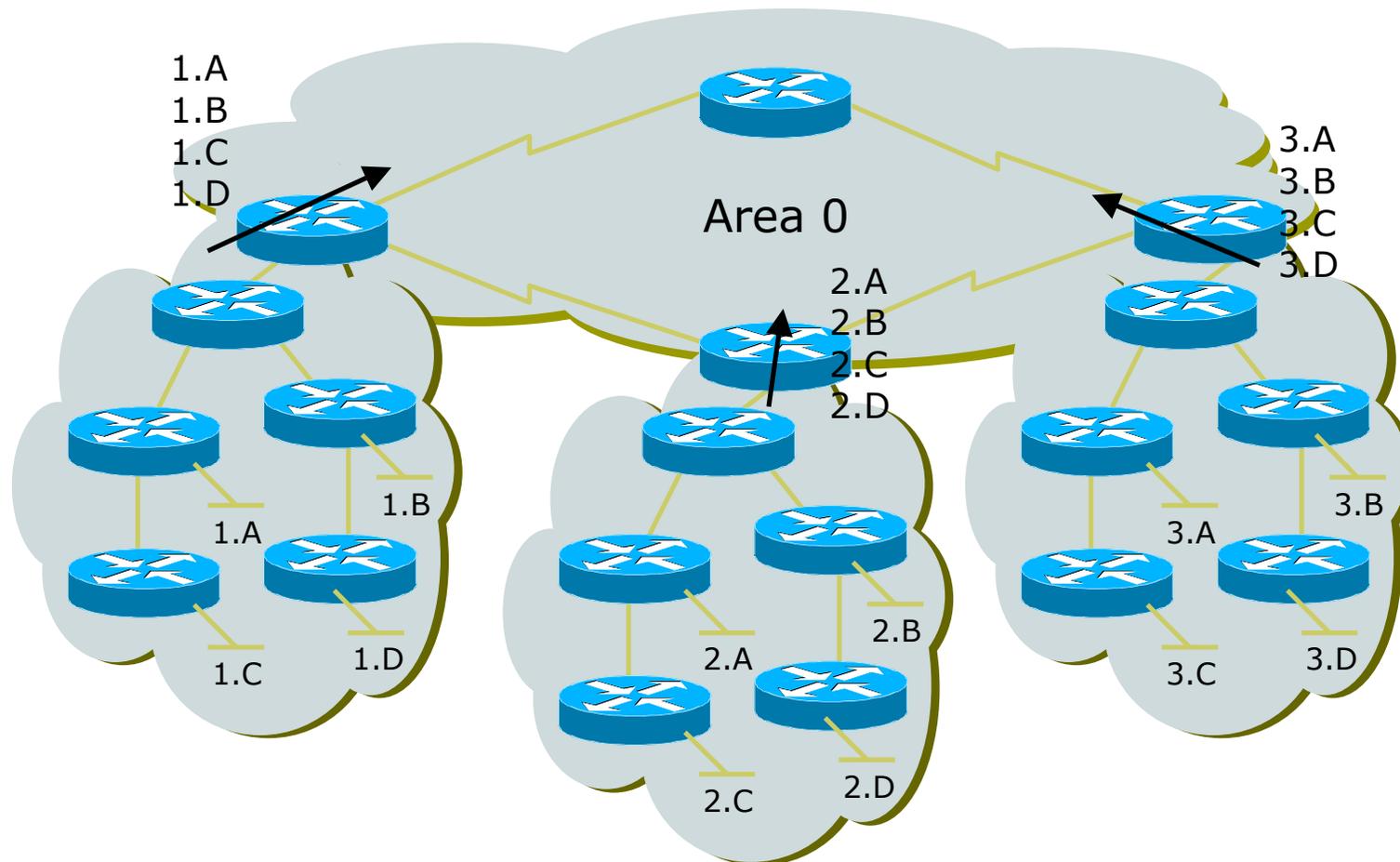
Without summarisation

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



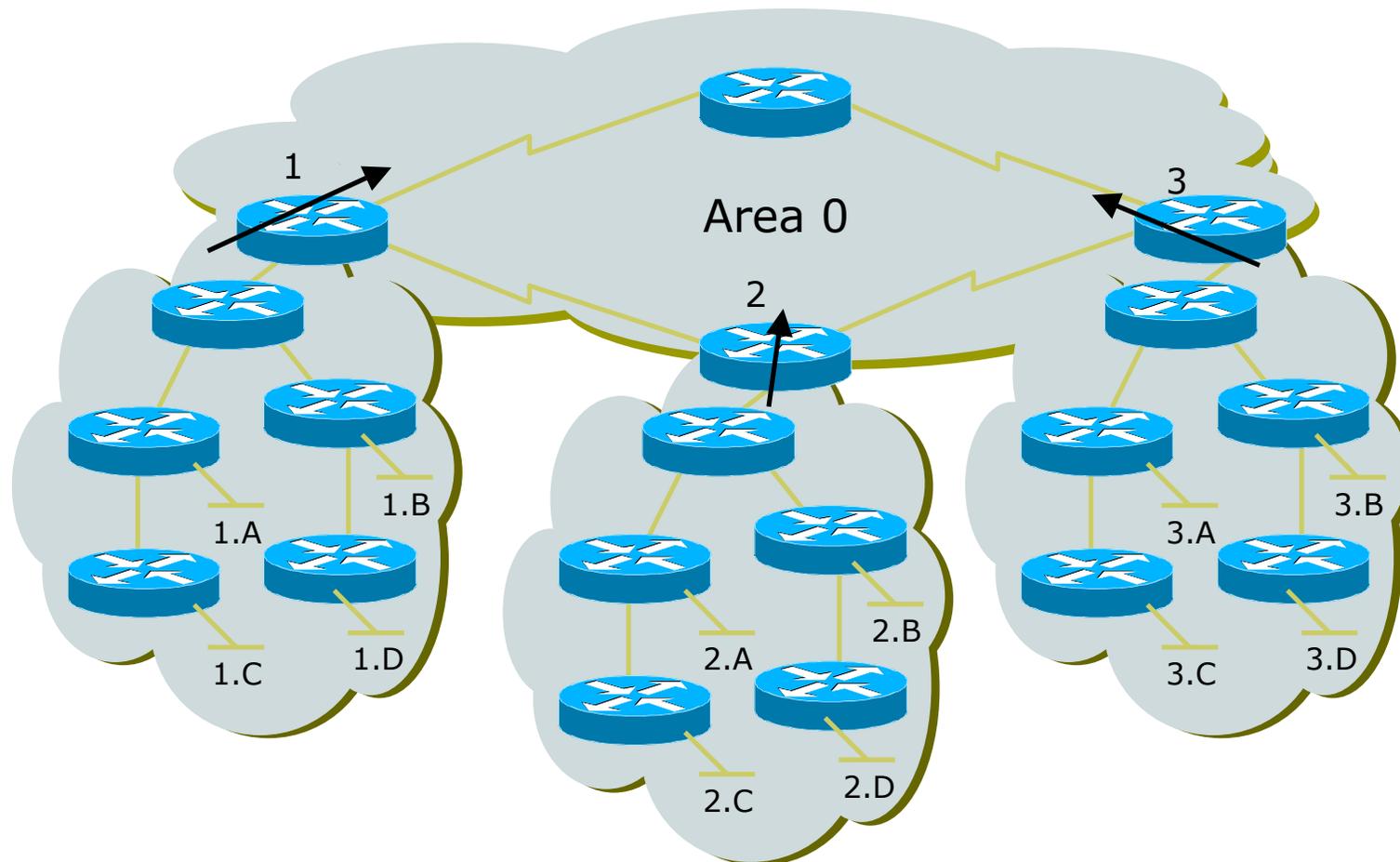
# No Summarisation

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



# With Summarisation

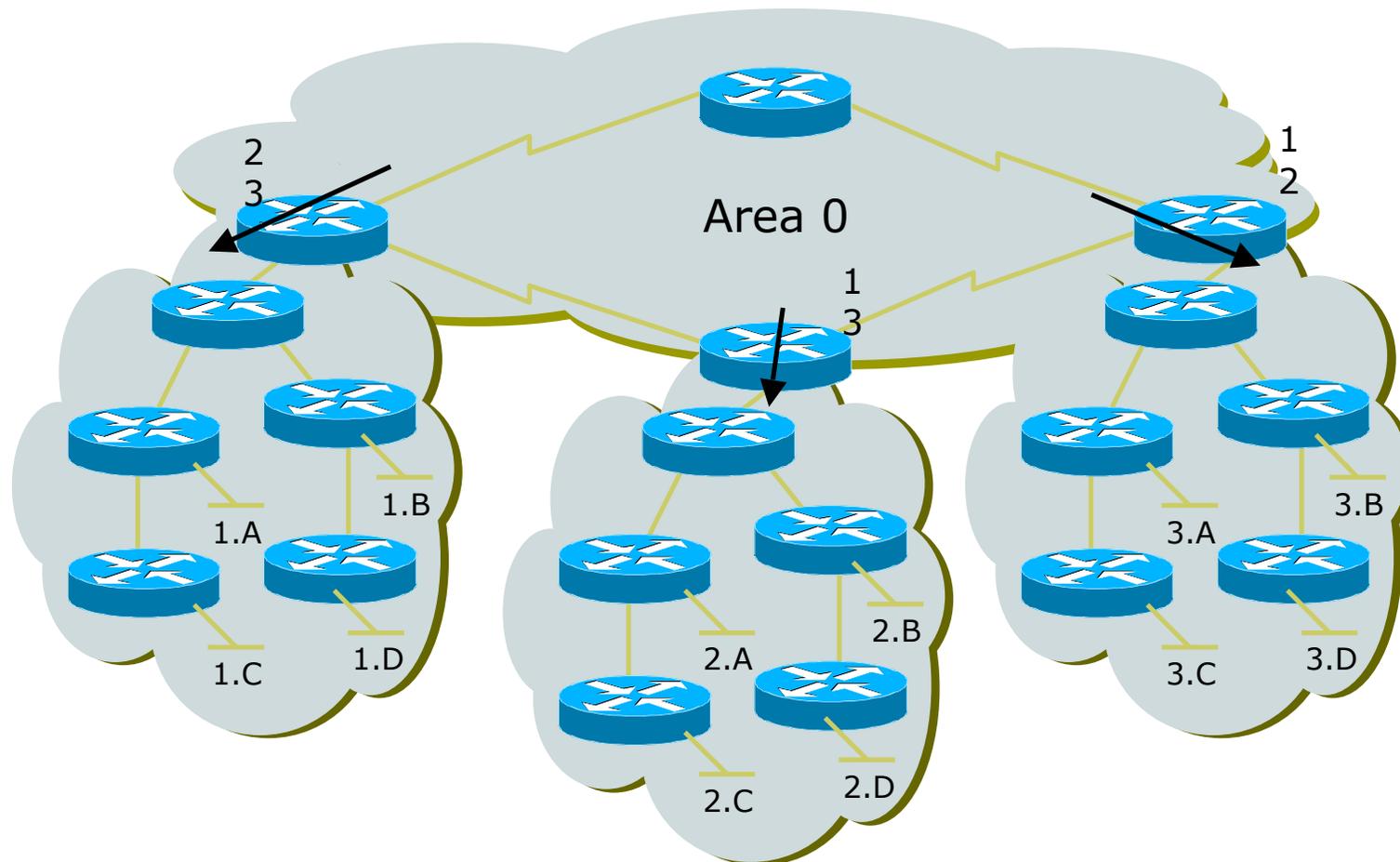
- ❑ Only summary LSA advertised out of each area
- ❑ Link state changes do not propagate out of the area





# With Summarisation

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



# Types of Areas

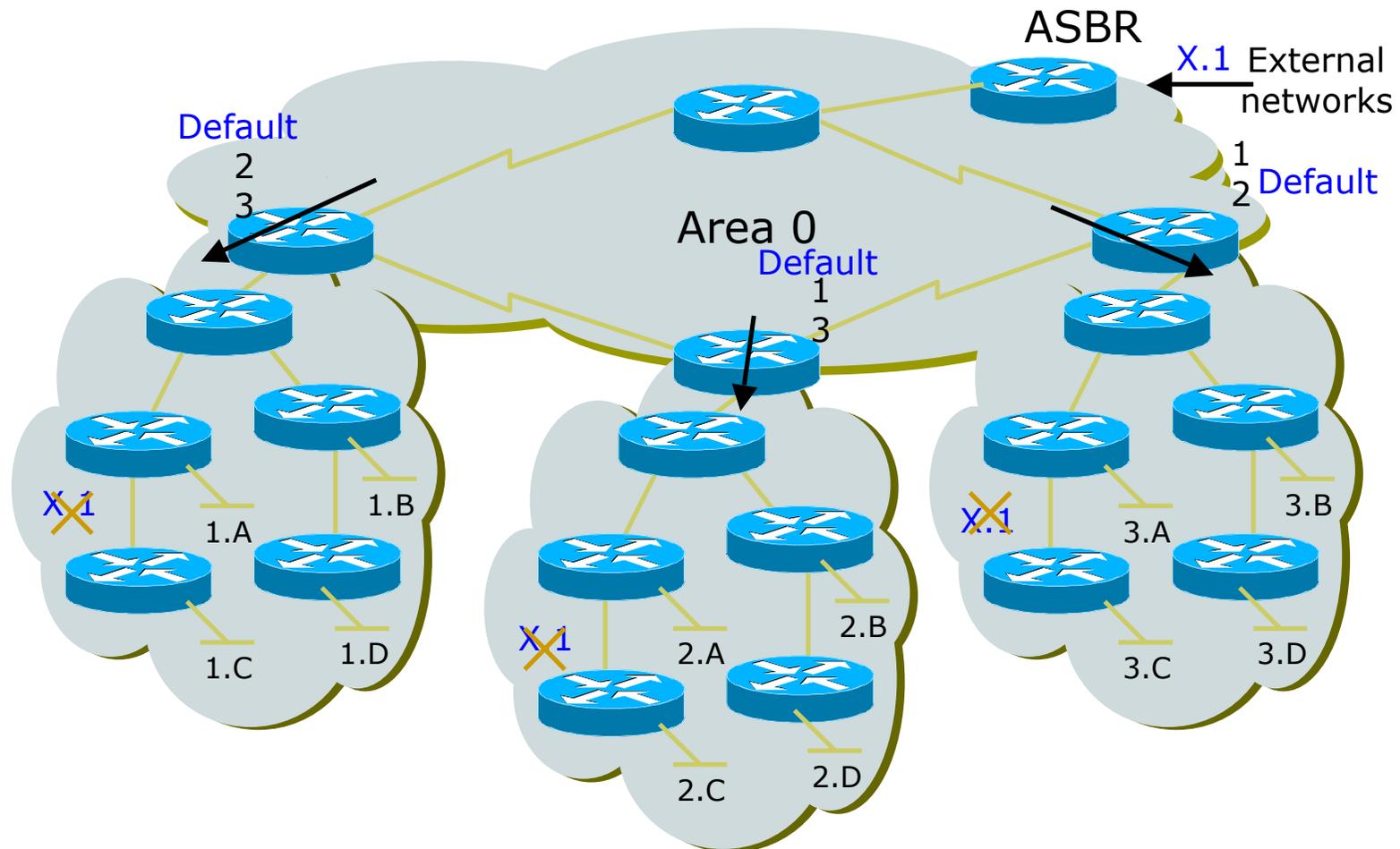
---

- ❑ 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



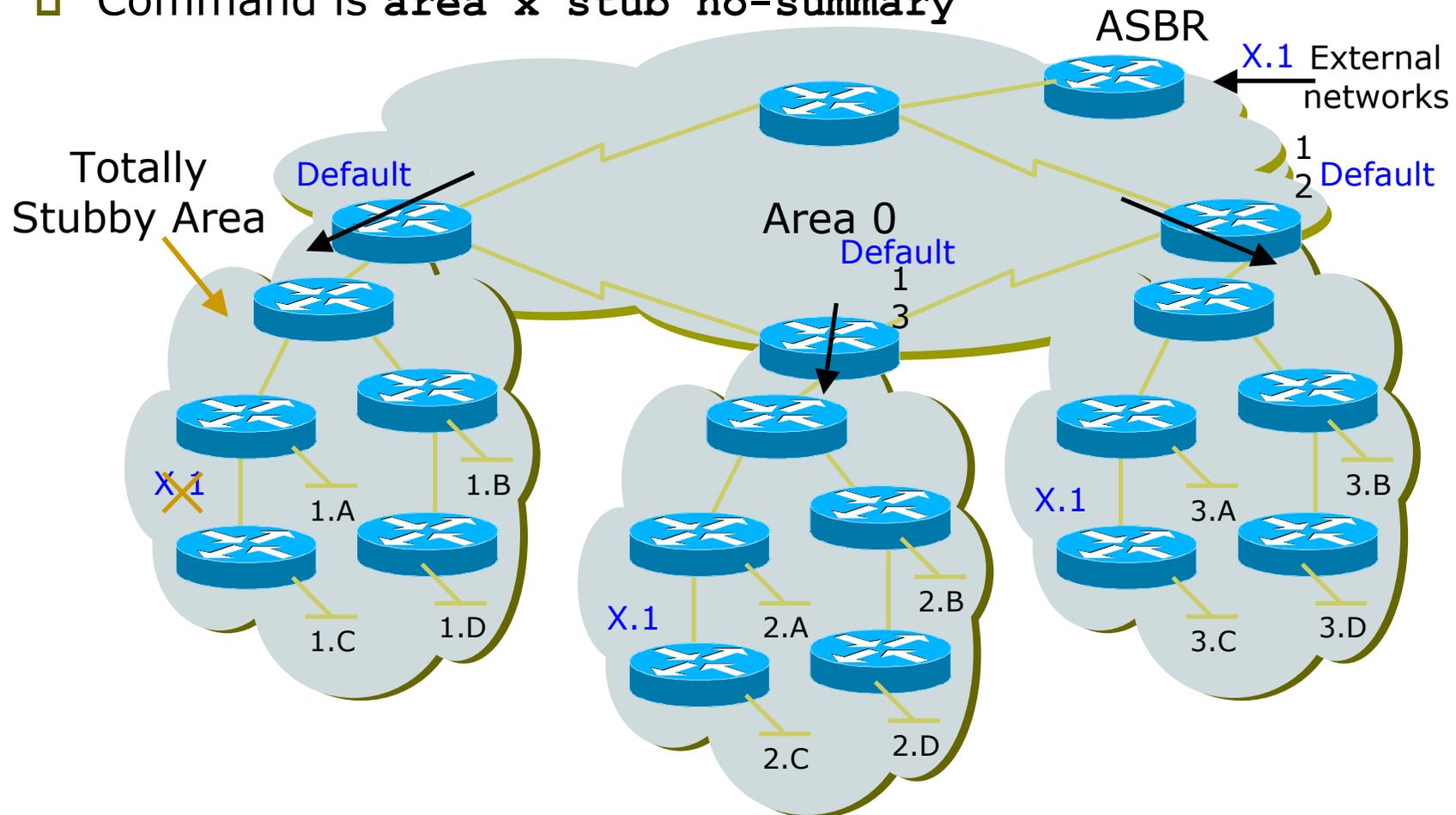
# Normal Stub Area

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



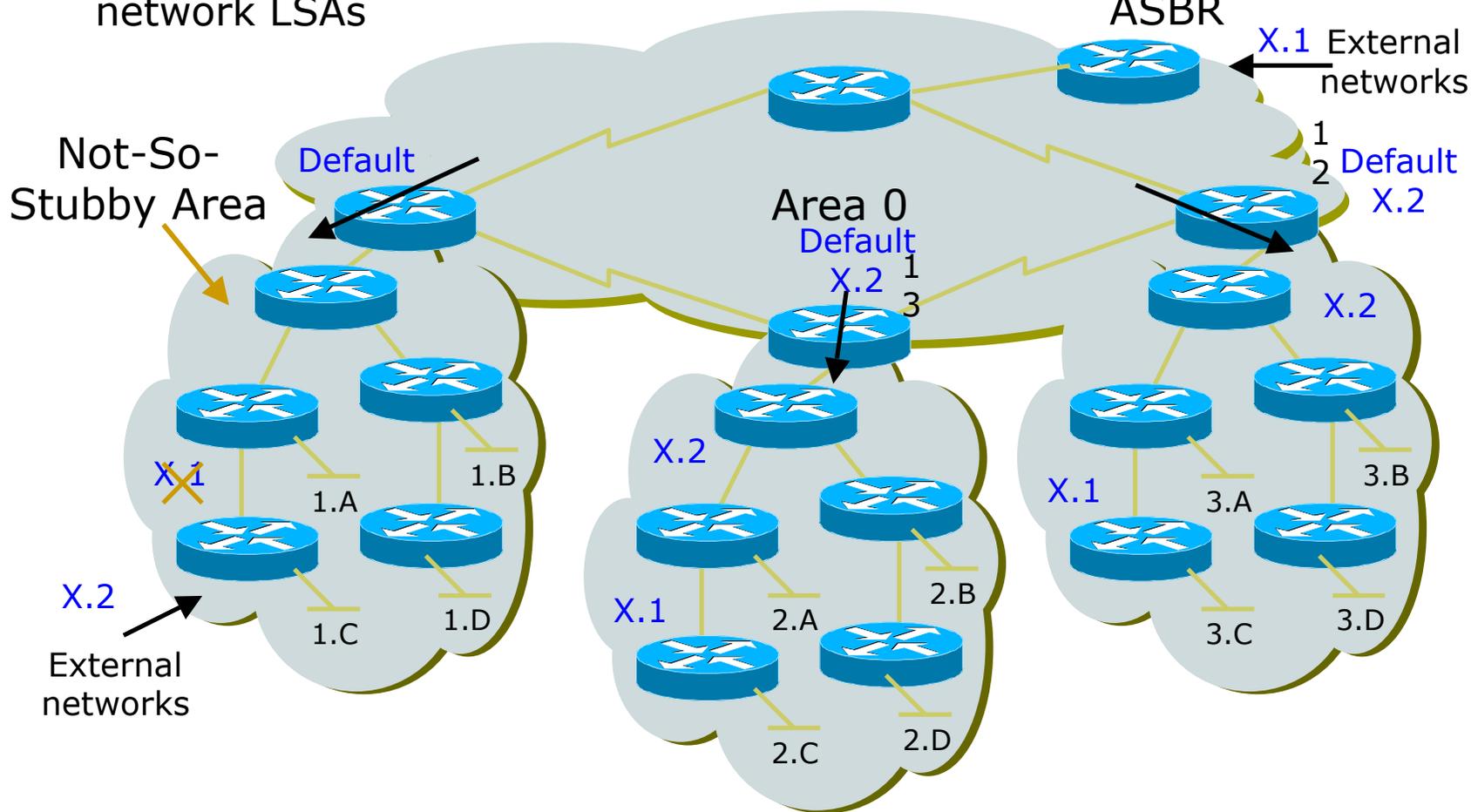
# Totally Stubby Area

- 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



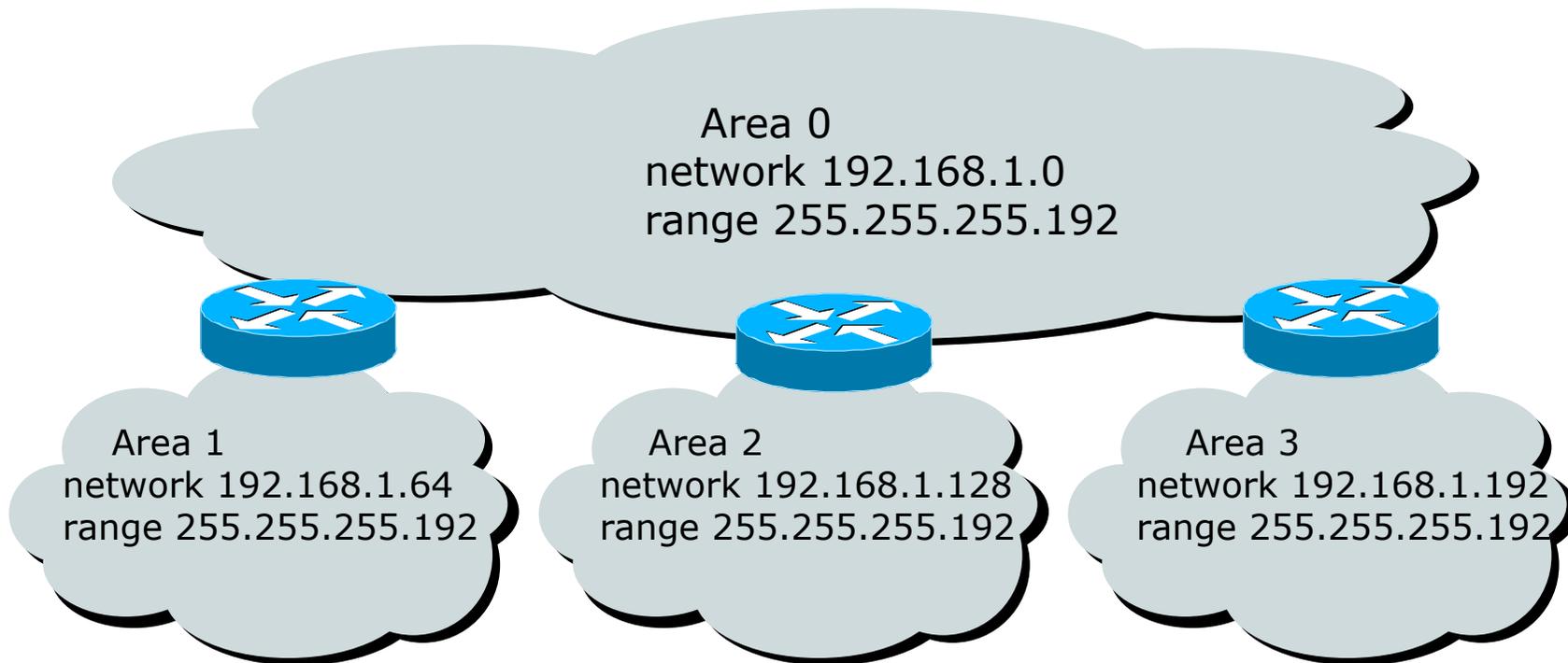
# ISP Use of Areas

---

- 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

---



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

# Summary

---

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

# Introduction to OSPF



ISP Training Workshops