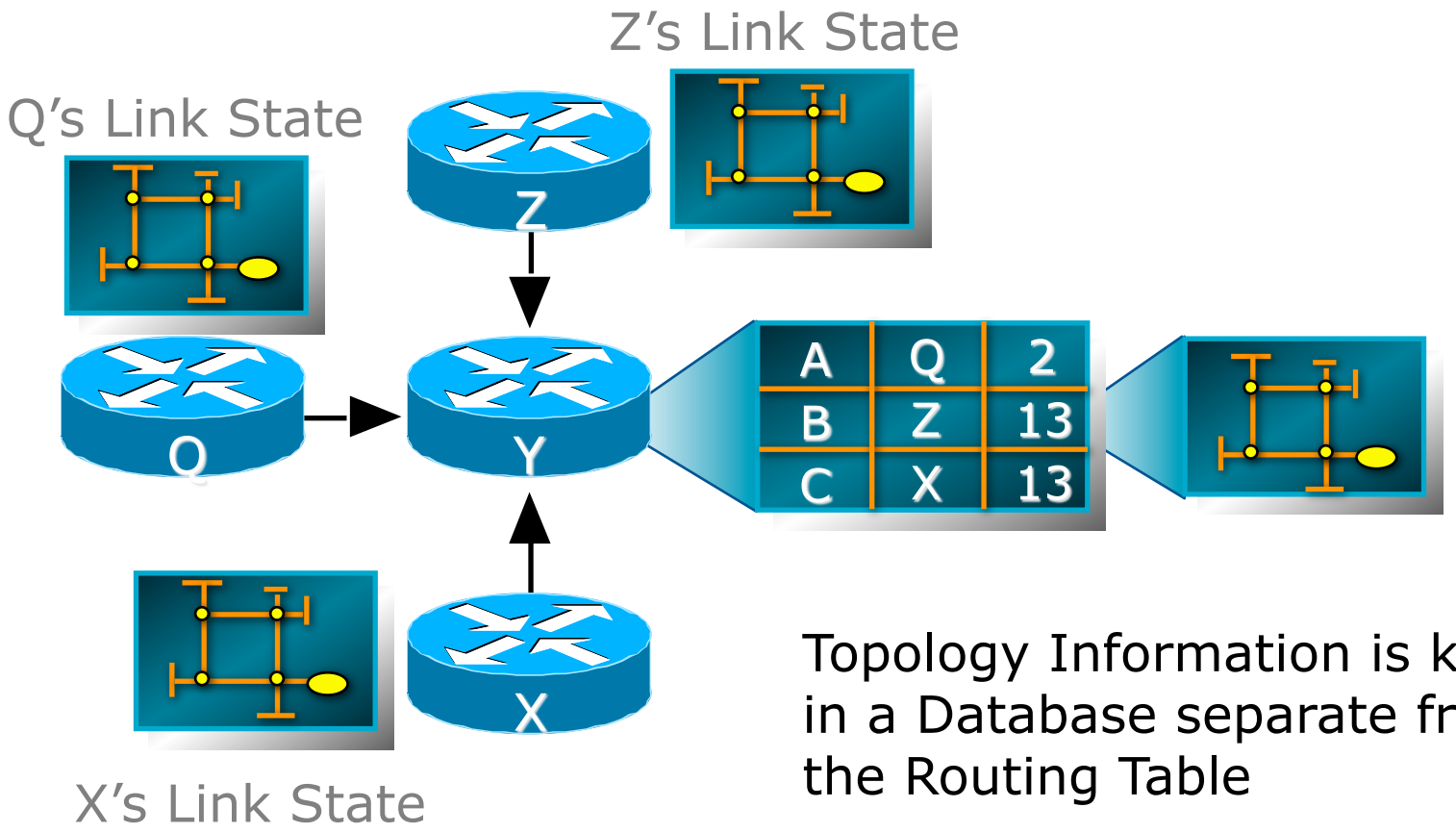
Introduction to OSPF

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

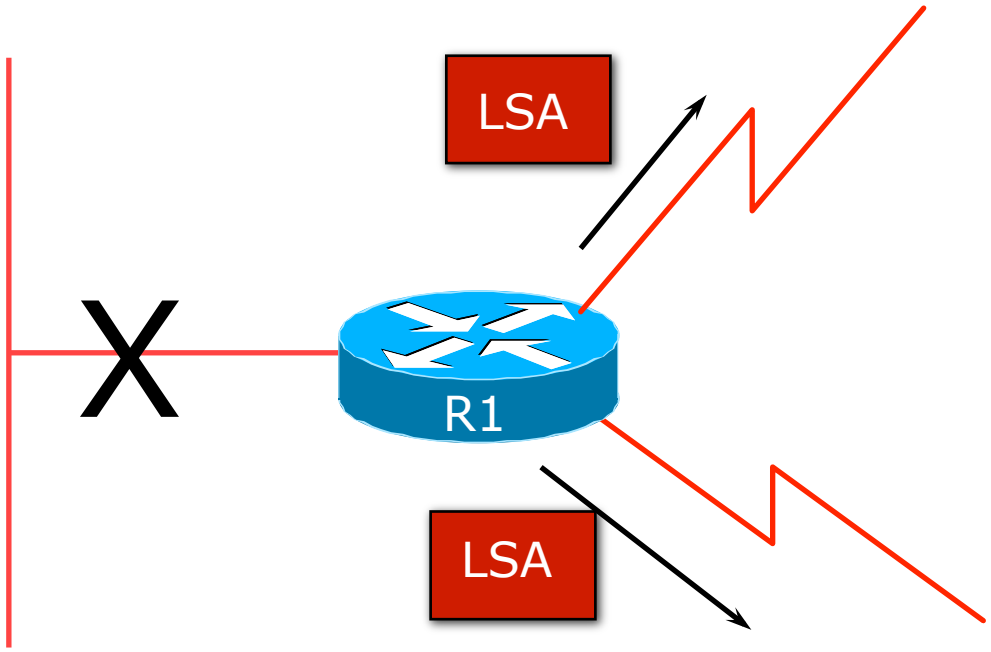


Topology Information is kept in a Database separate from the Routing Table

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 table

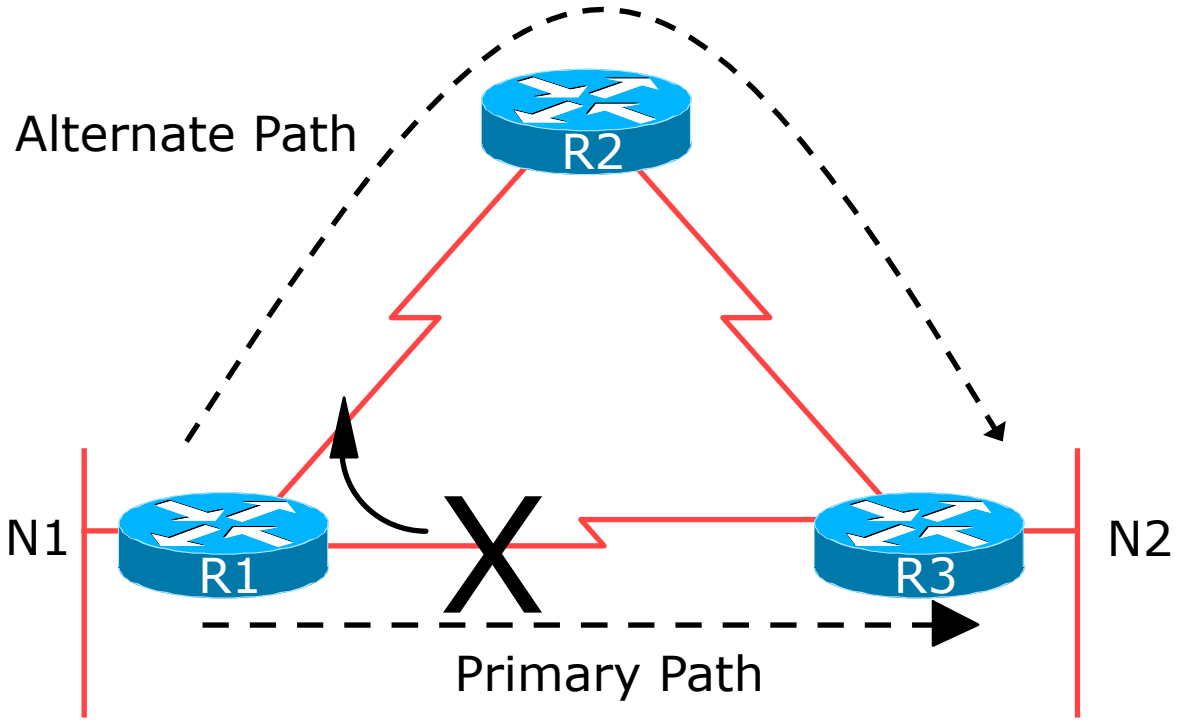
Low Bandwidth Utilisation



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

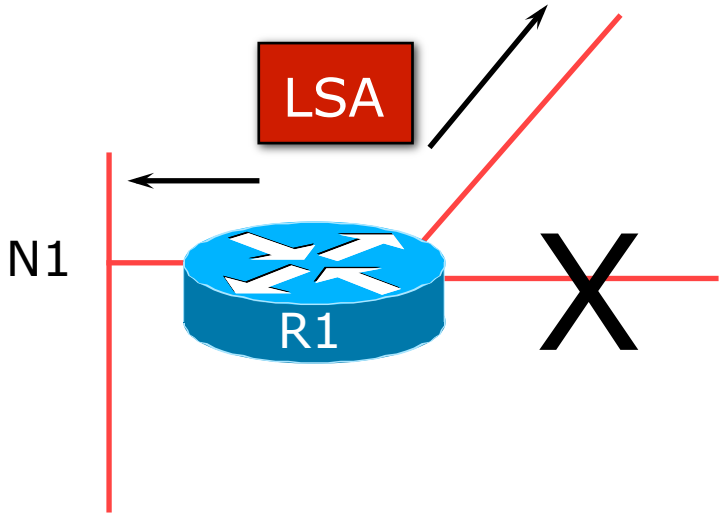
Fast Convergence

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



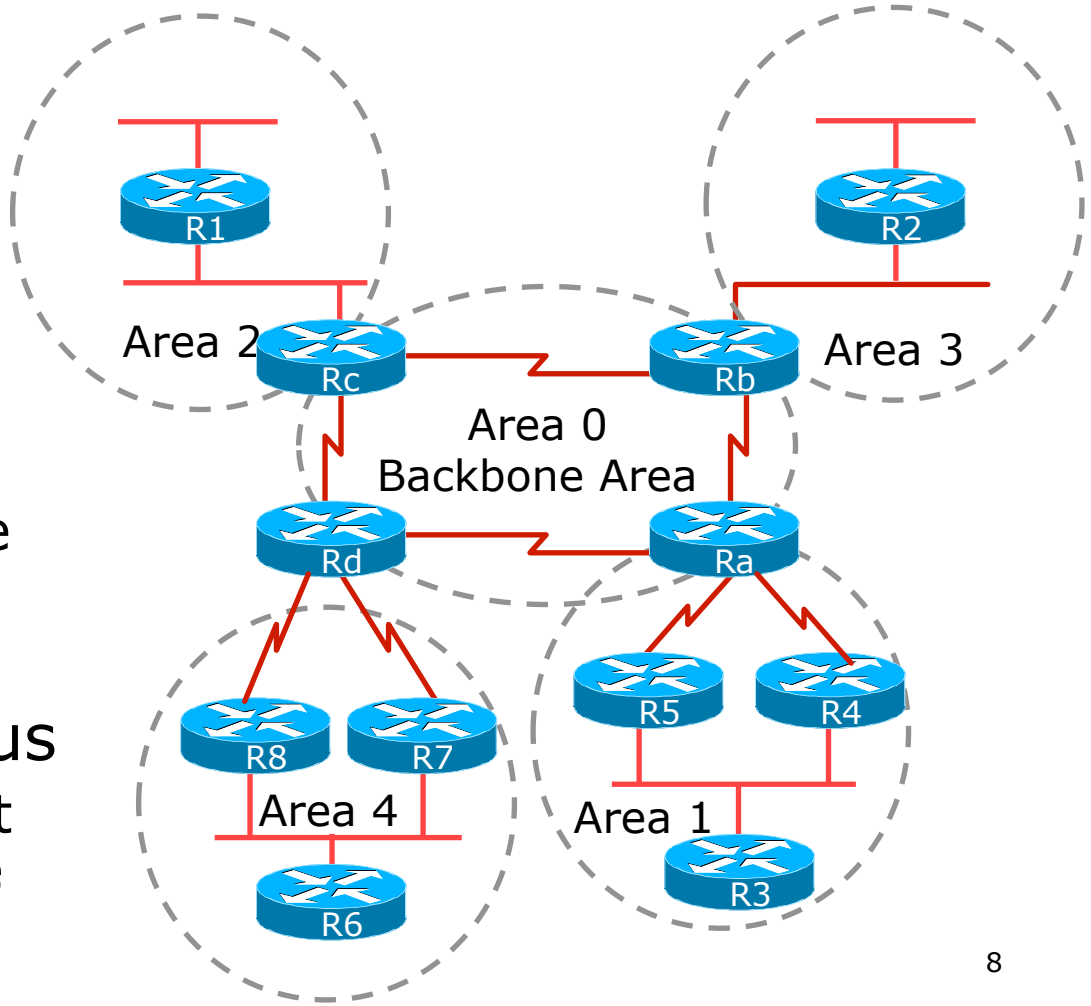
Fast Convergence

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



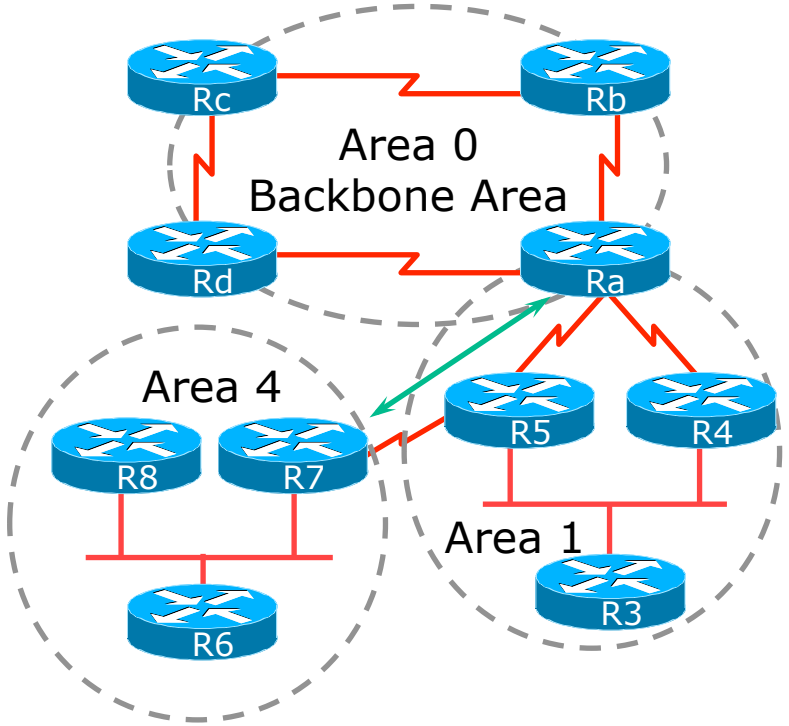
OSPF Areas

- 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

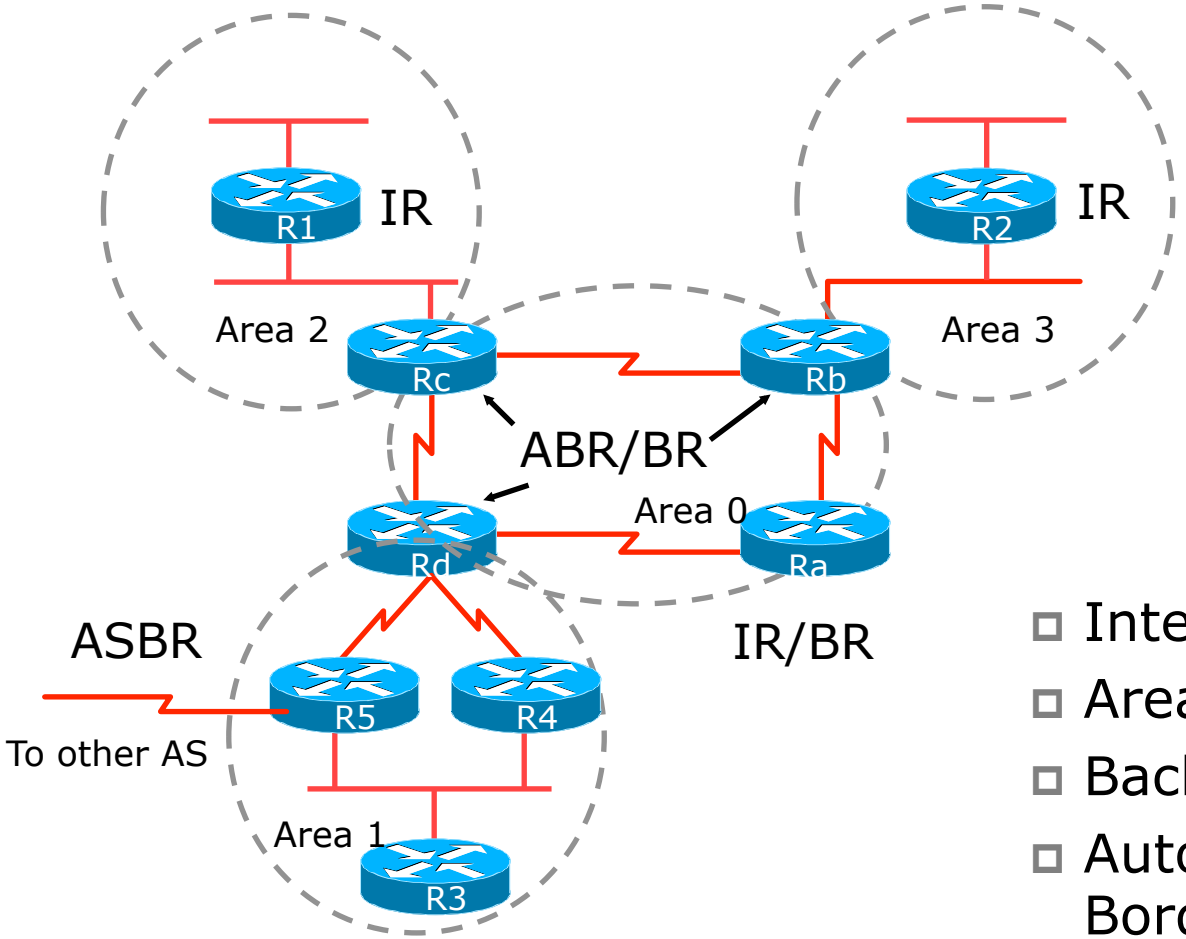


Virtual Links between OSPF Areas

- 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

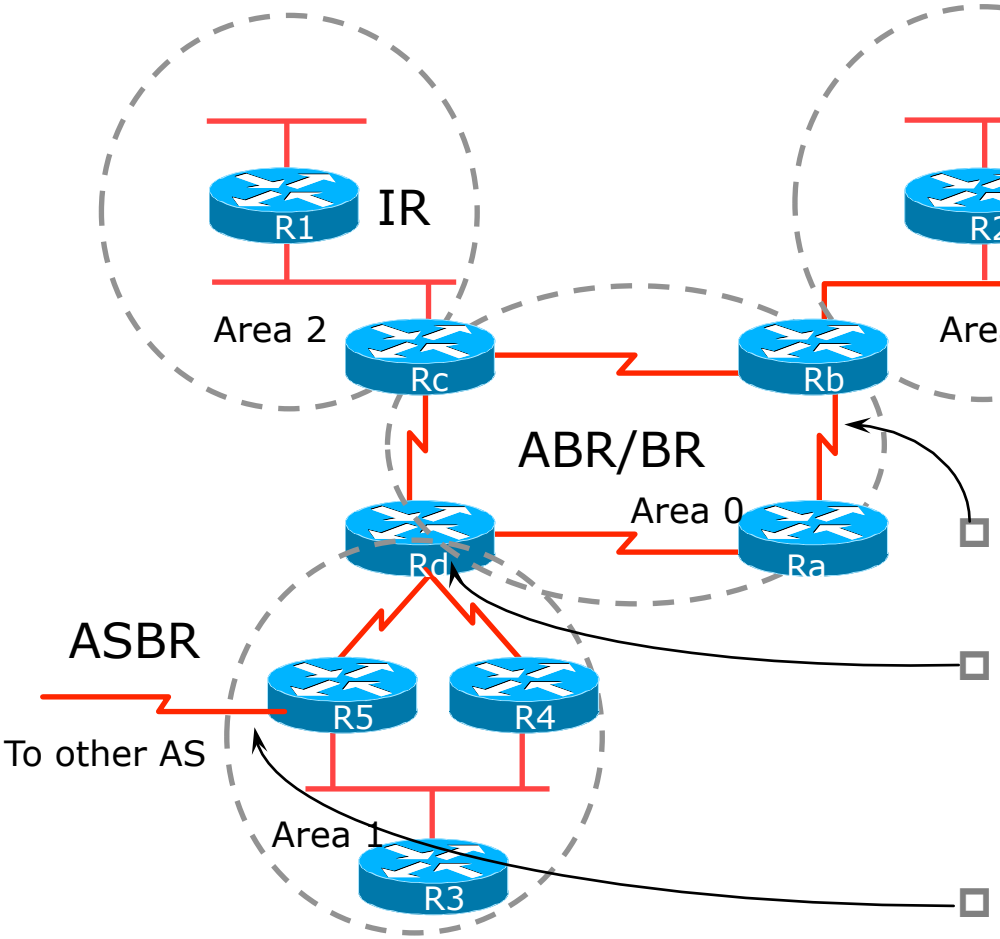


Classification of Routers



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

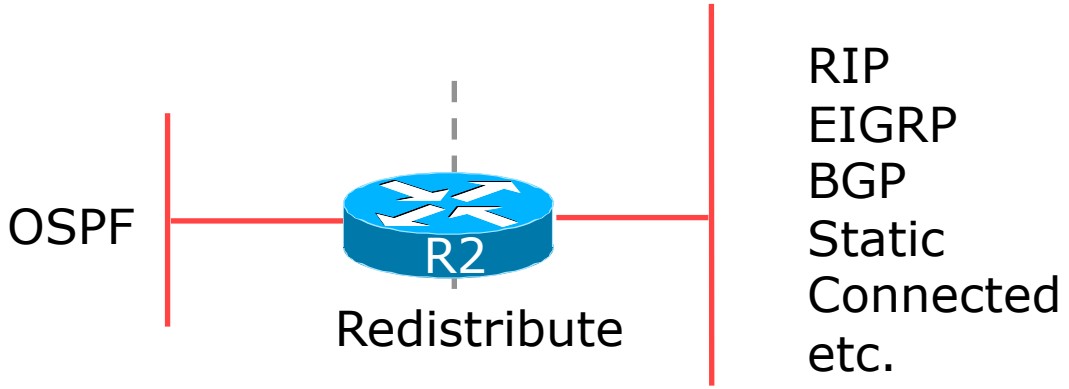
OSPF Route Types



- 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

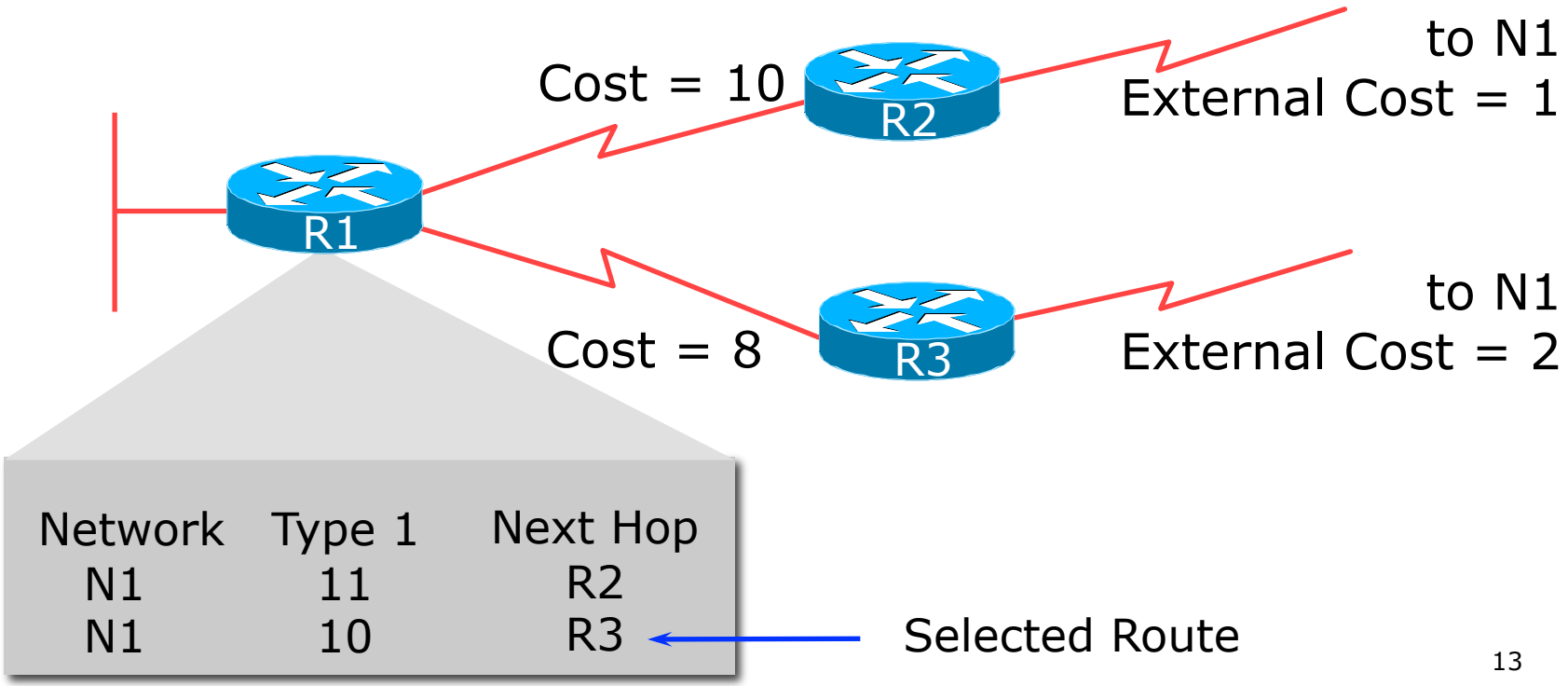
External Routes

- 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)



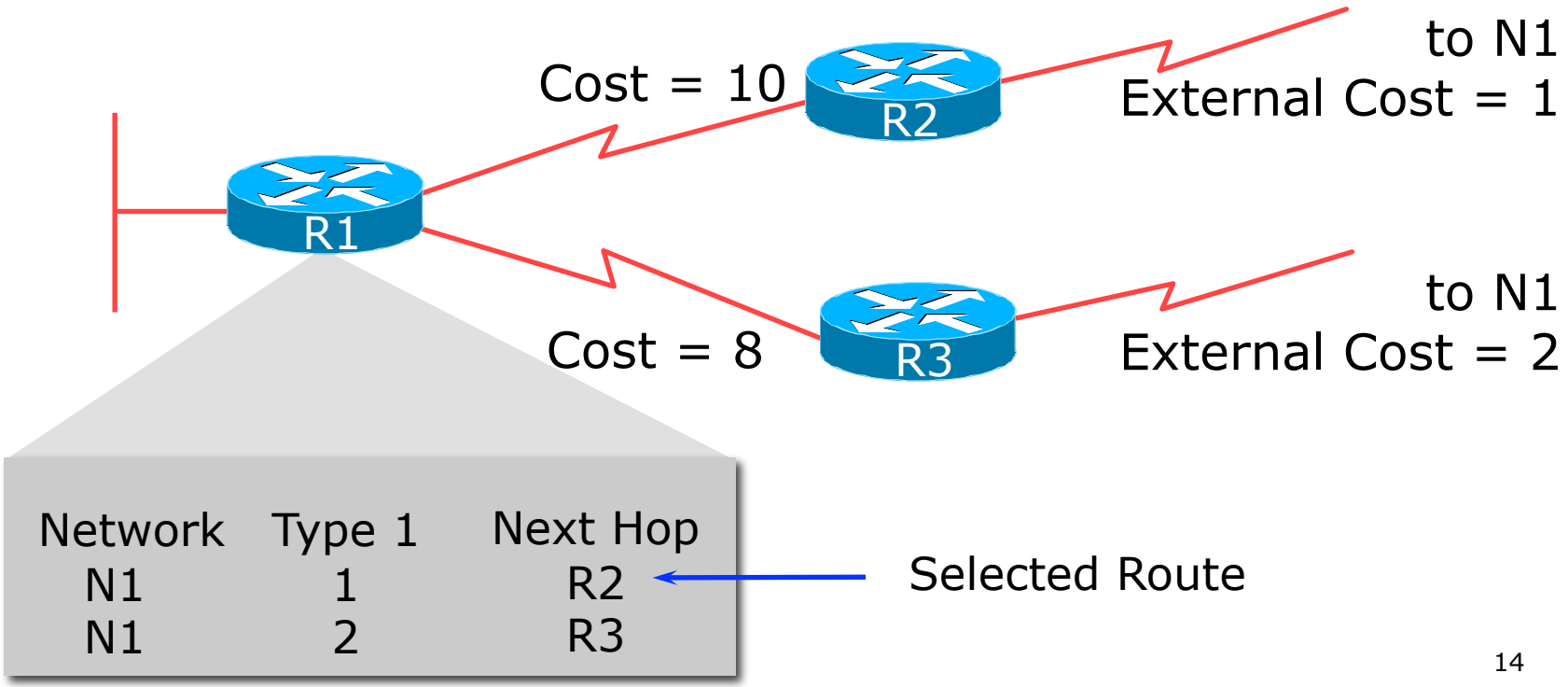
External Routes

- 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

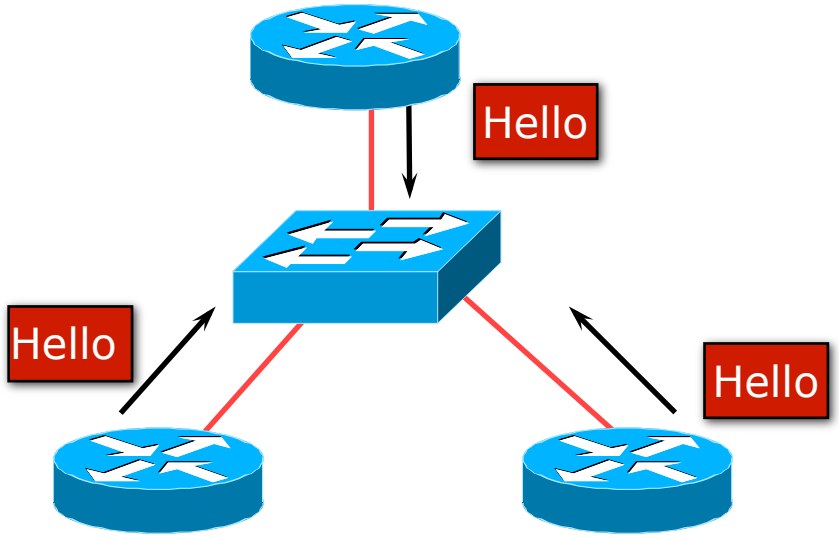


Topology/Link State Database

- 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

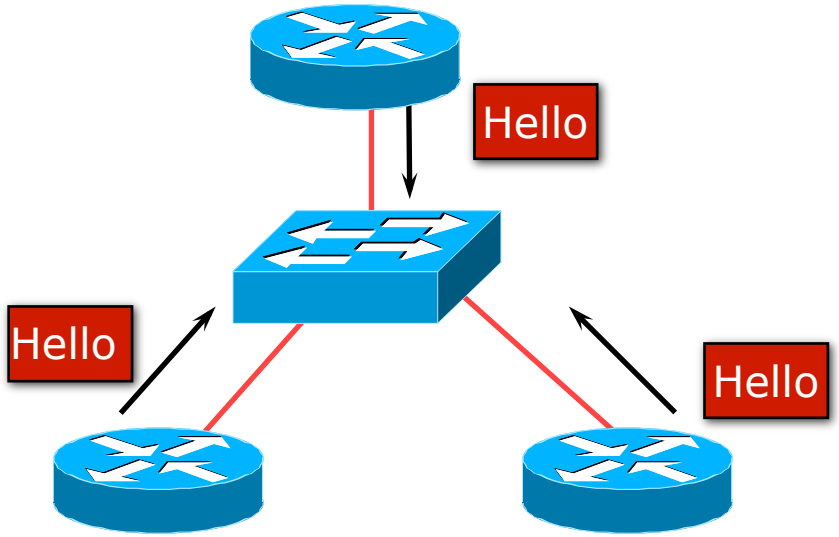
The Hello Protocol

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



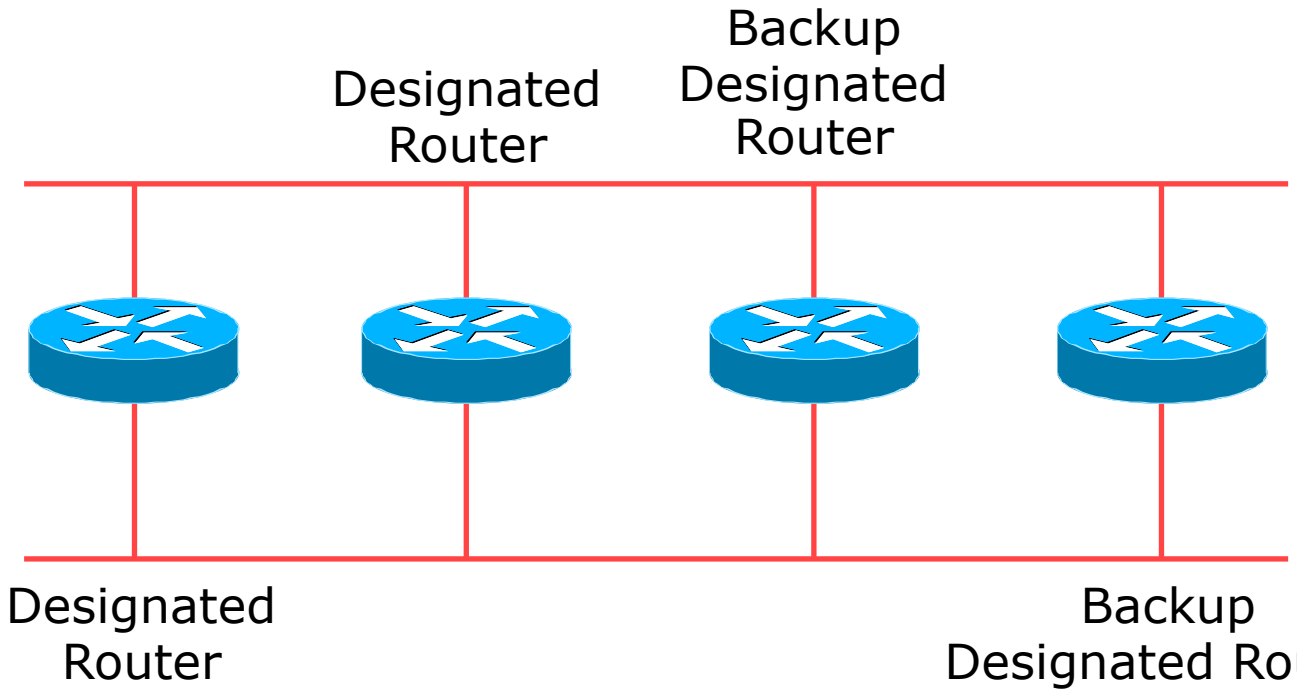
The Hello Packet

- 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)



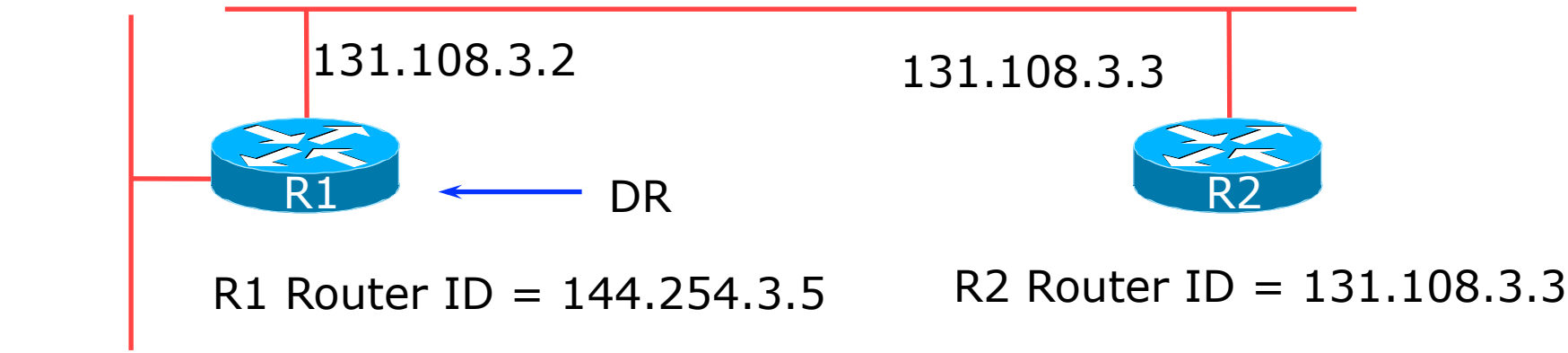
Designated Router

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



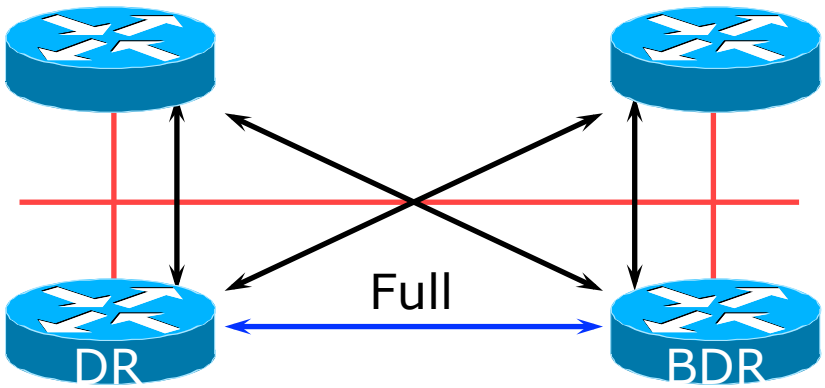
Designated Router by Priority

- 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



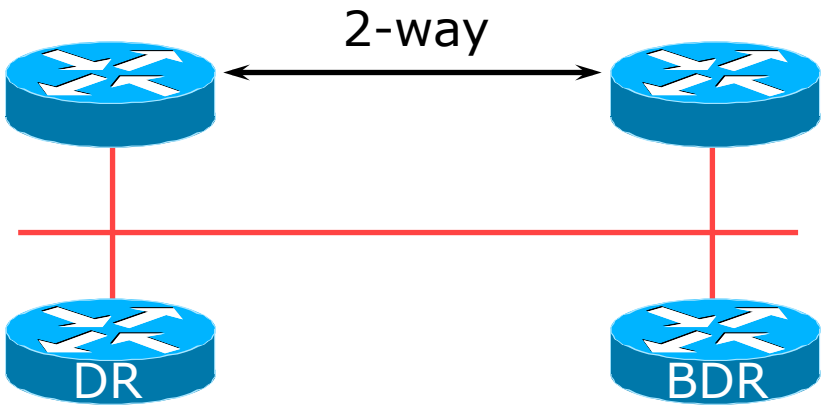
Neighbouring States

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



Neighbouring States

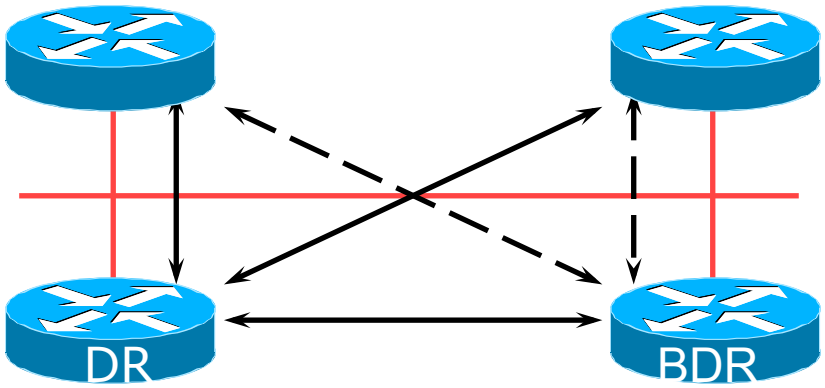
- 2-way
  - Router sees itself in other Hello packets
  - DR selected from neighbours in state 2-way or greater



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

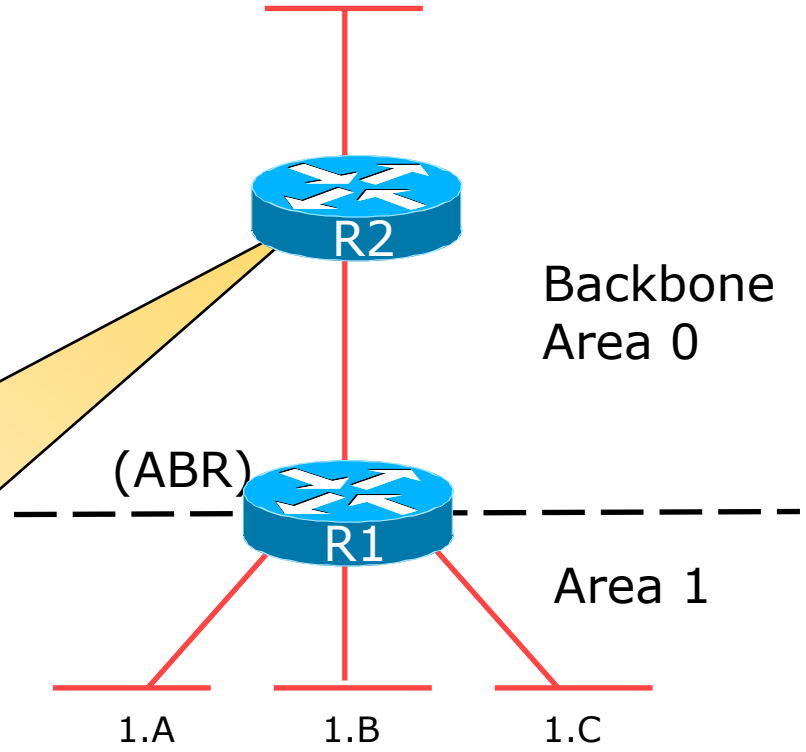
- Prefix or all subnets
- Prefix or all networks
- 'Area range' command

With summarisation

Network	Next Hop
1	R1

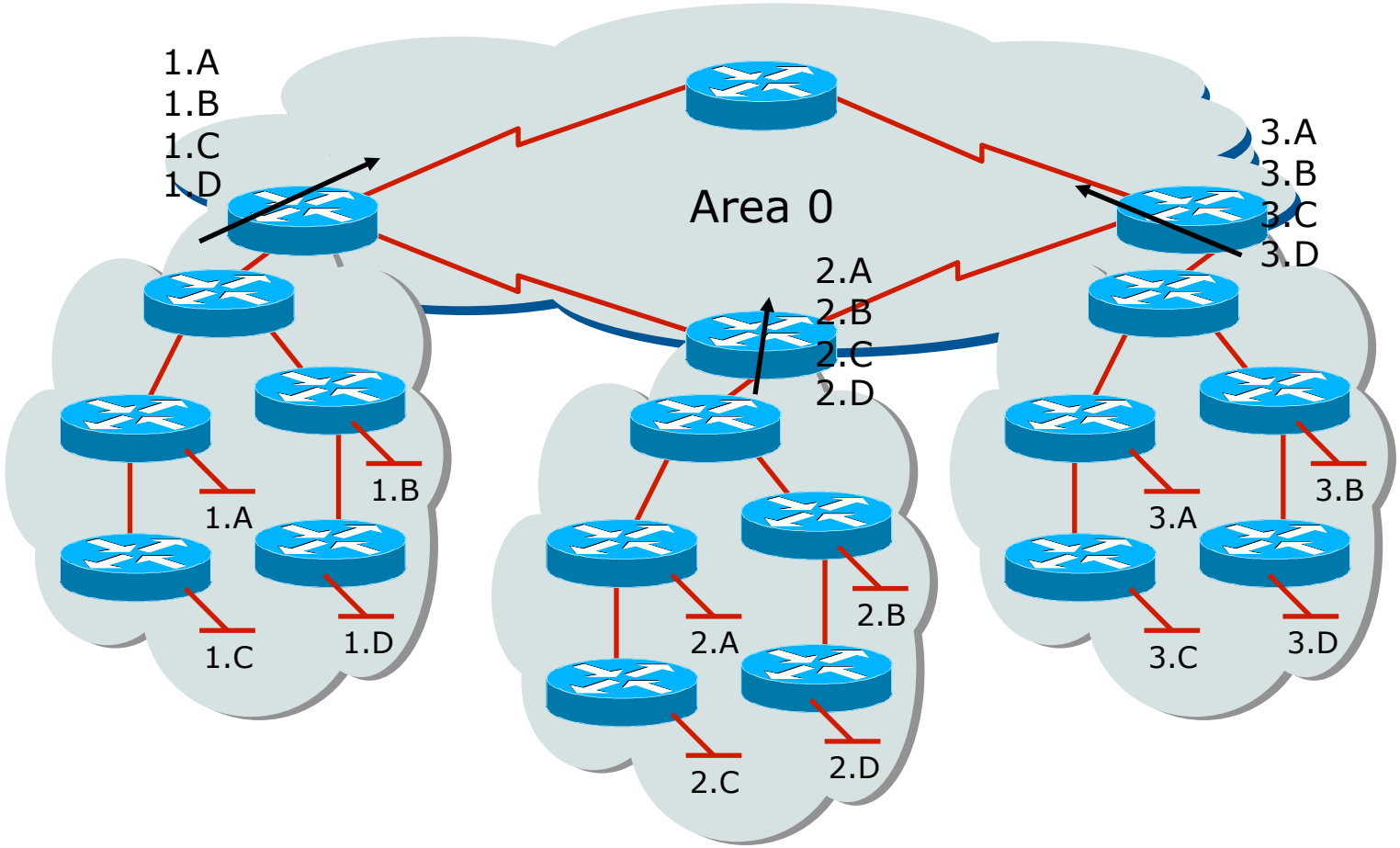
Without summarisation

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



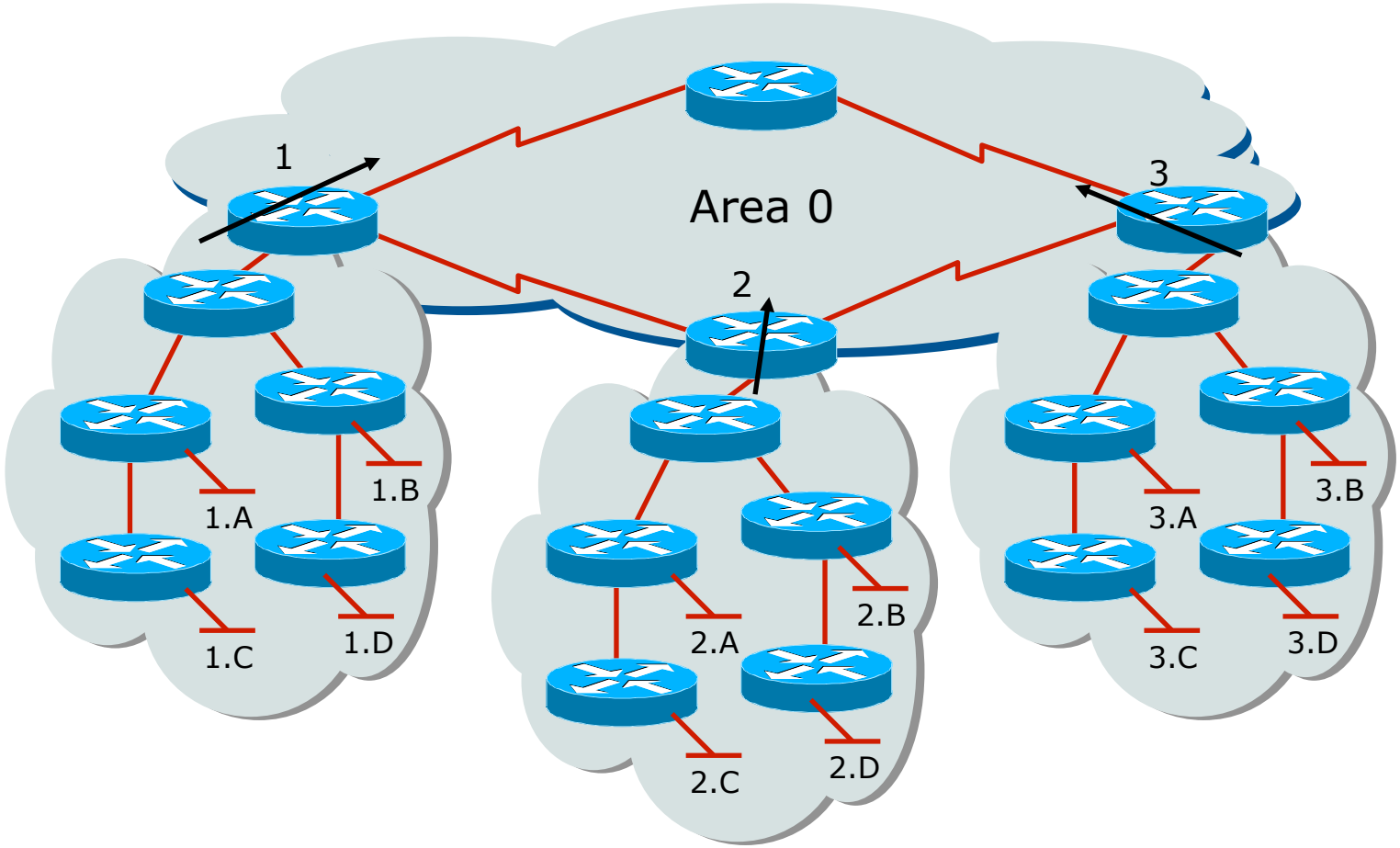
No Summarisation

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



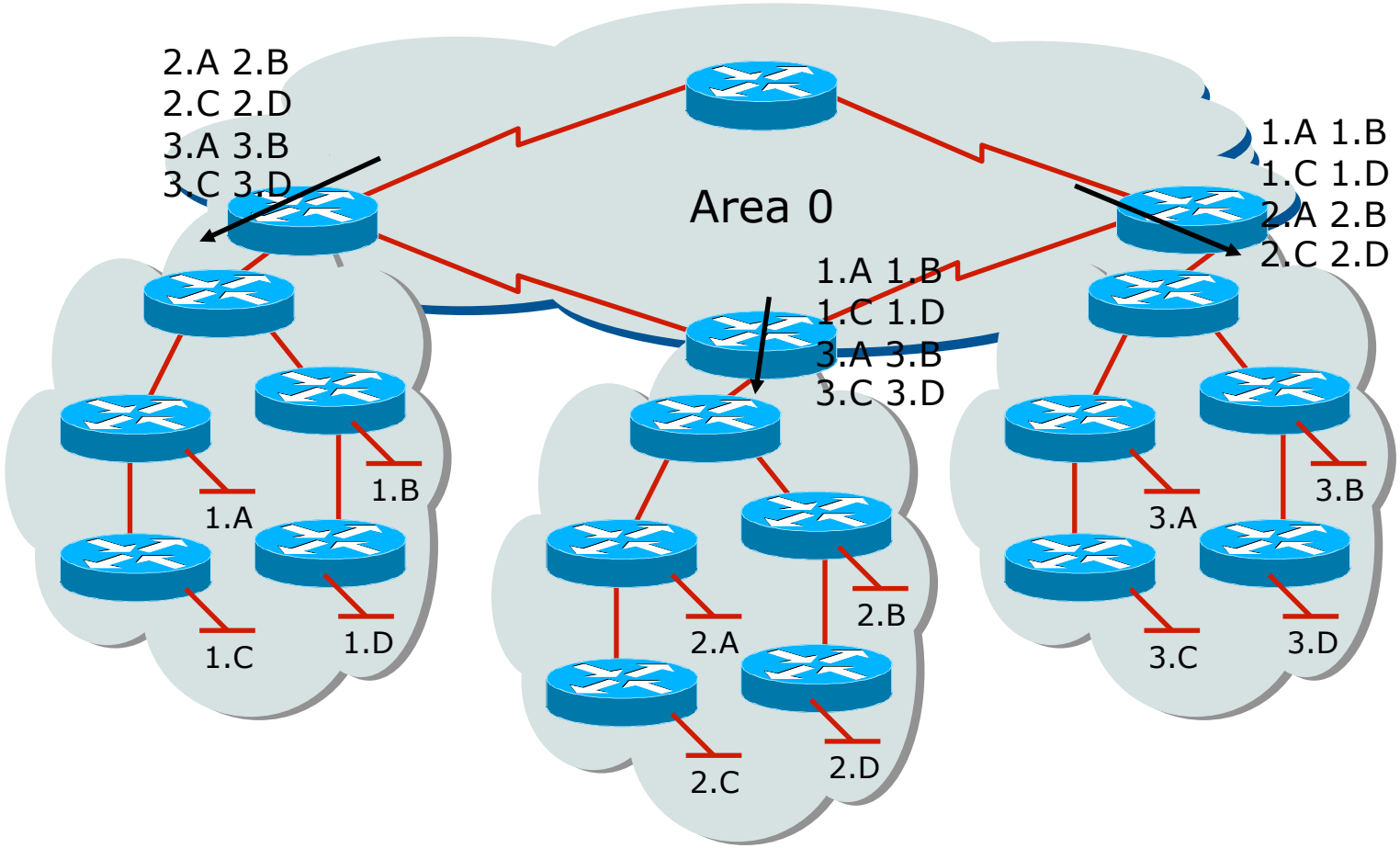
With Summarisation

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



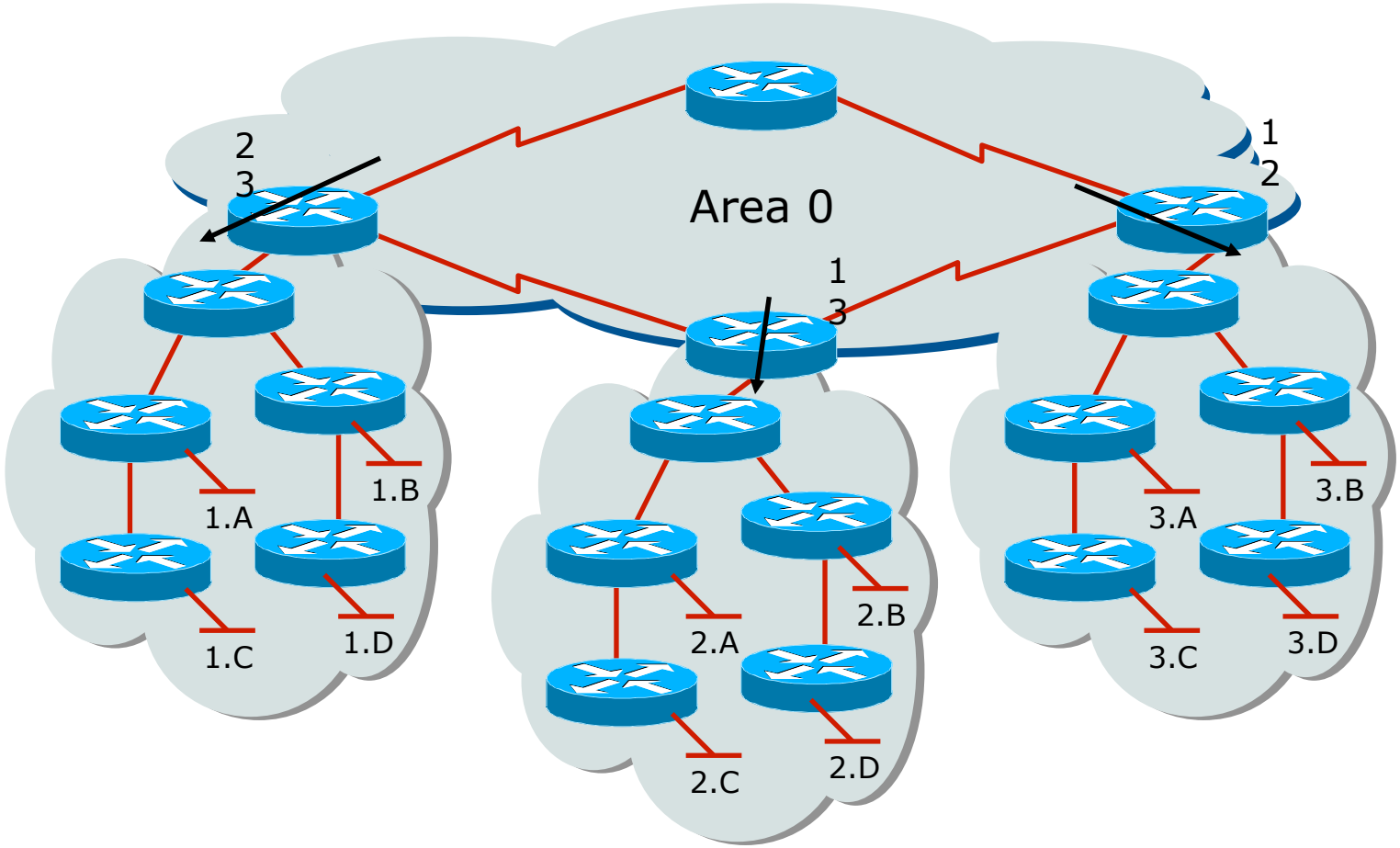
No Summarisation

- 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

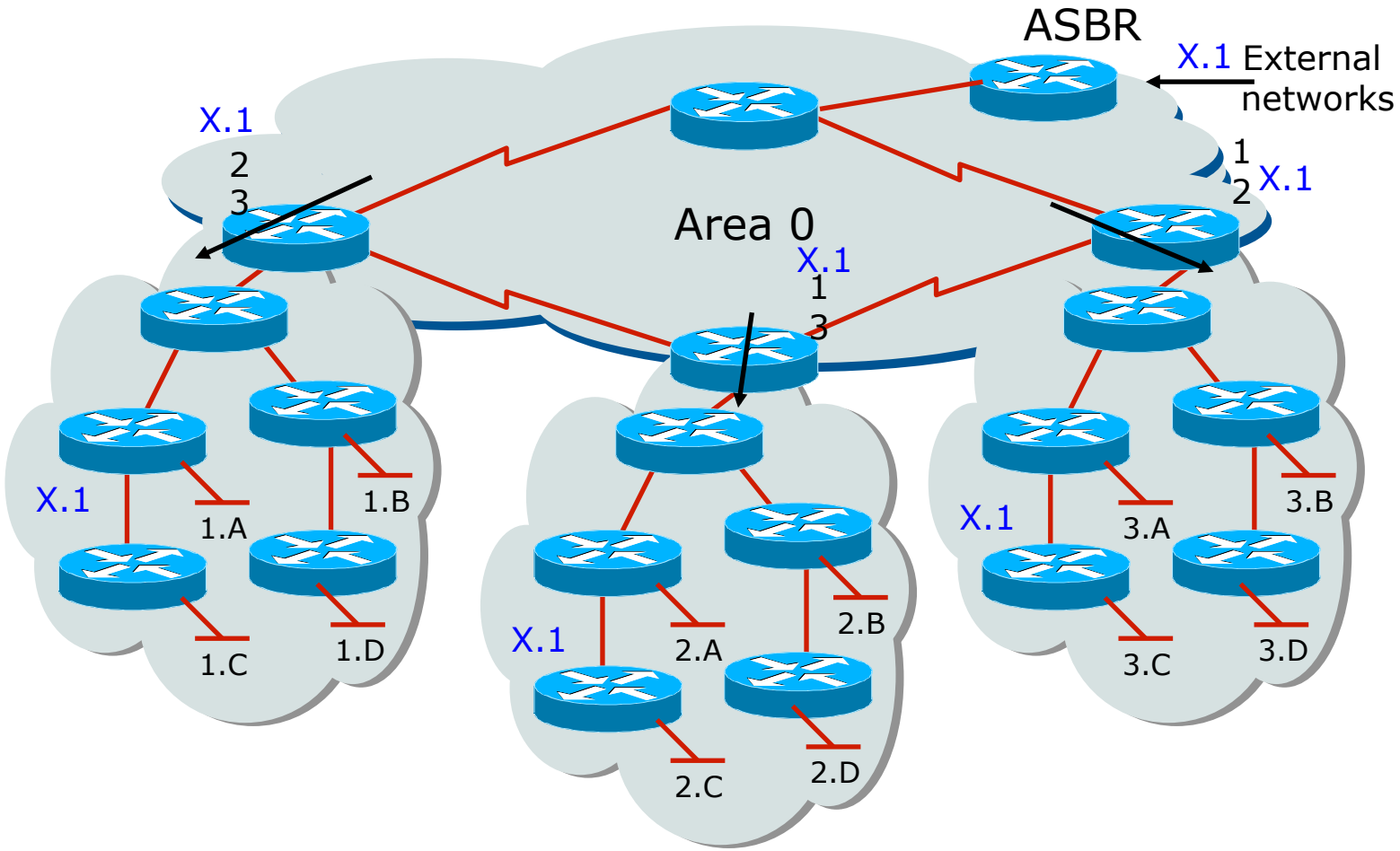


Types of Areas

- 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

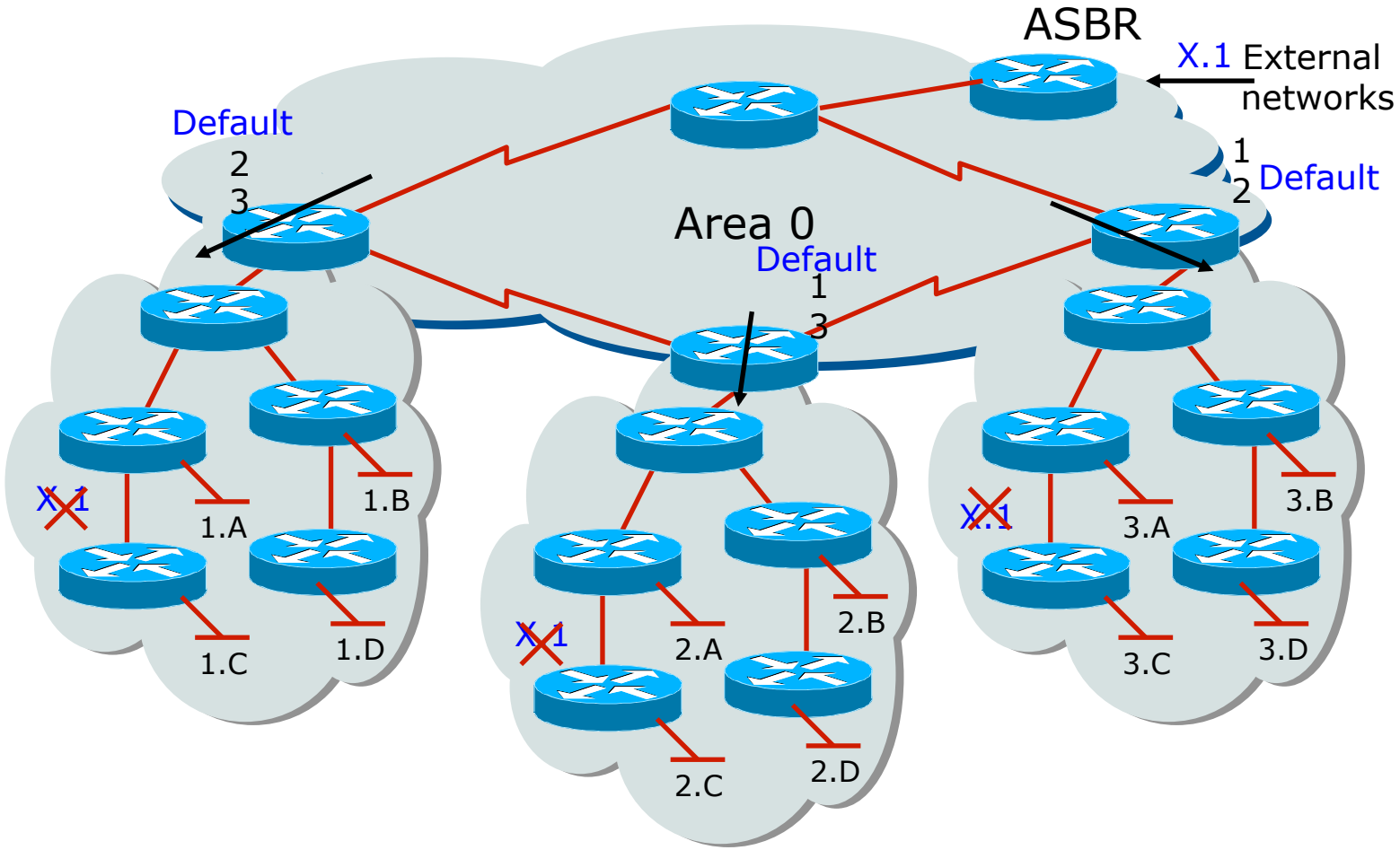
Regular Area (Not a Stub)

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



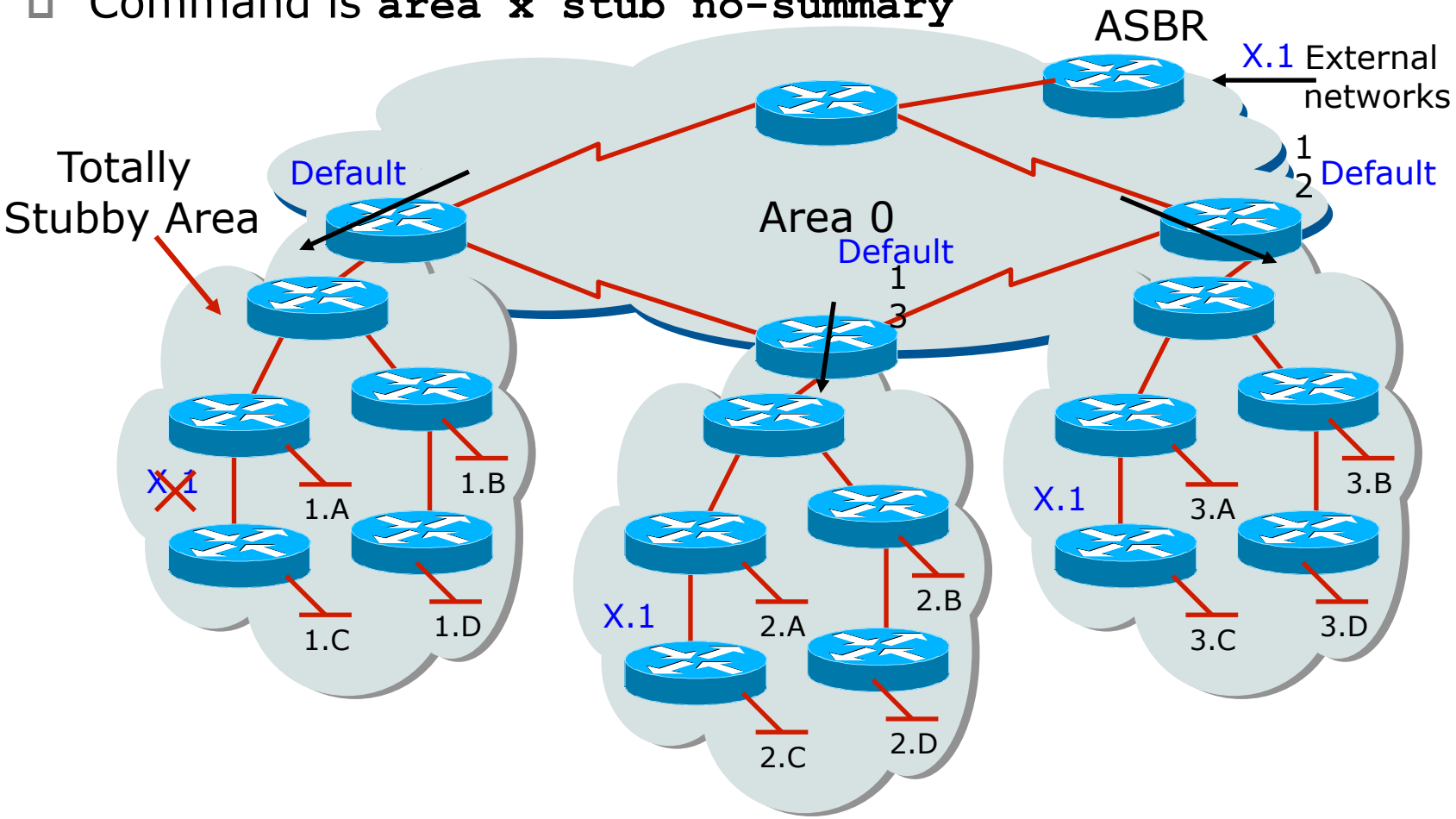
Normal Stub Area

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



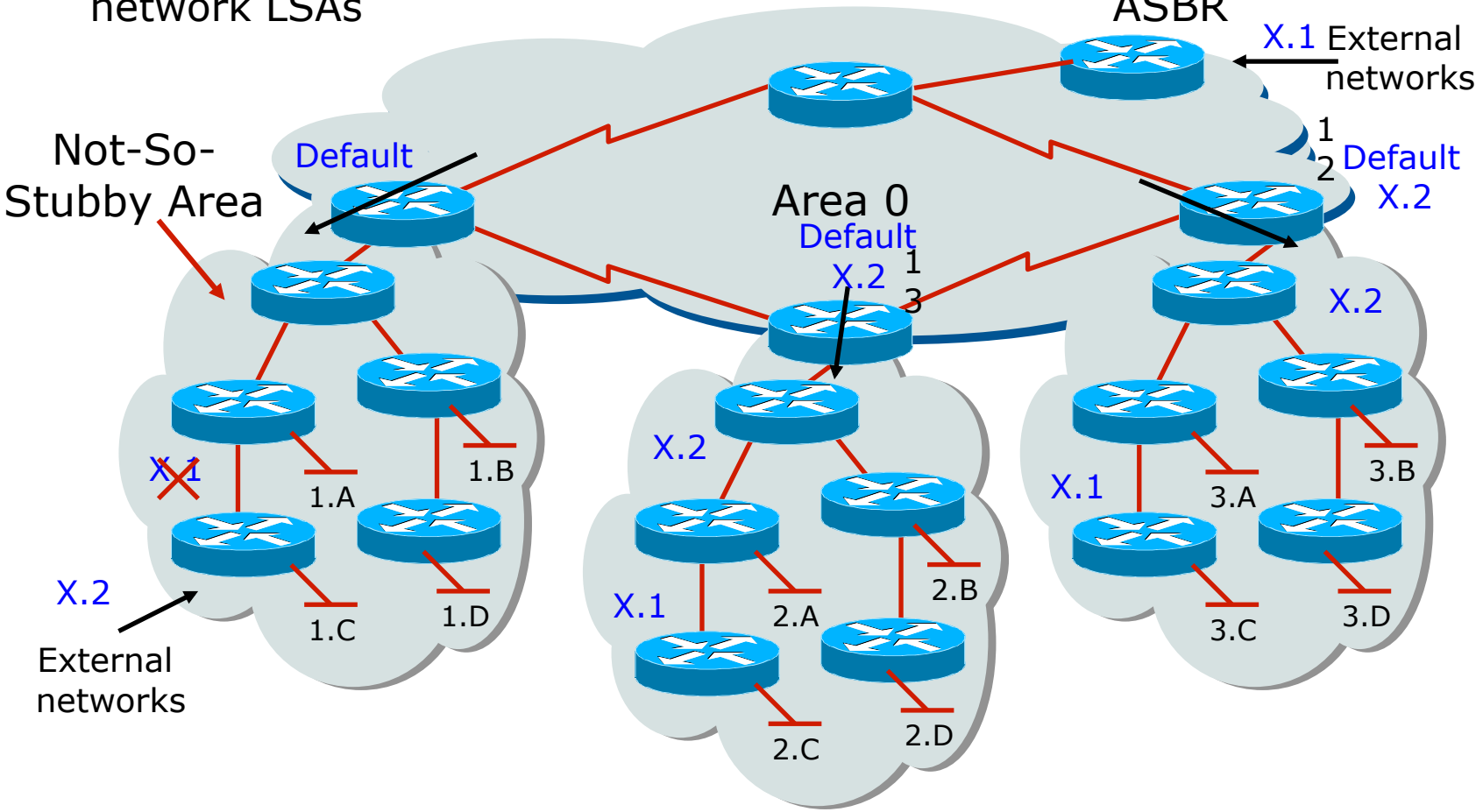
Totally Stubby Area

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



Not-So-Stubby Area

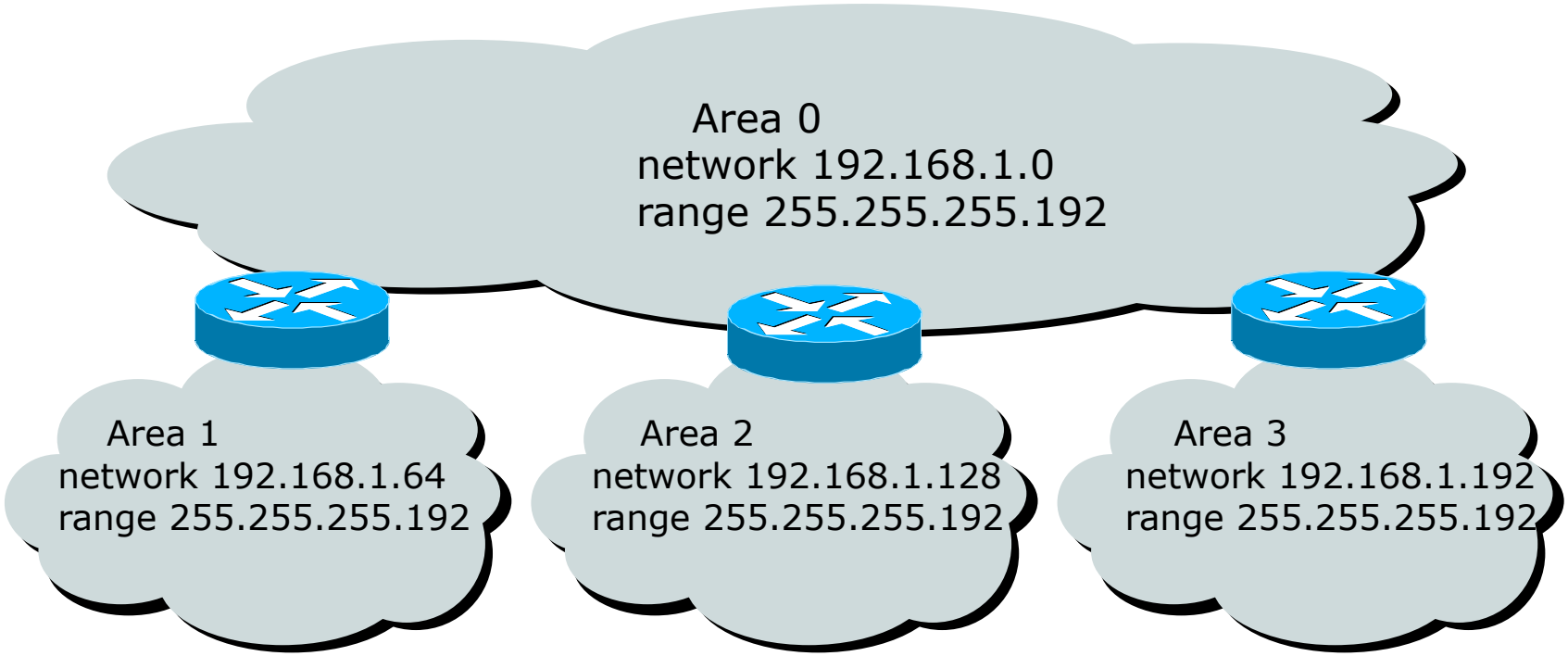
- Capable of importing routes in a limited fashion
- Type-7 LSA's carry external information within an NSSA
- NSSA Border routers translate selected type-7 LSAs into type-5 external network LSAs



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

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