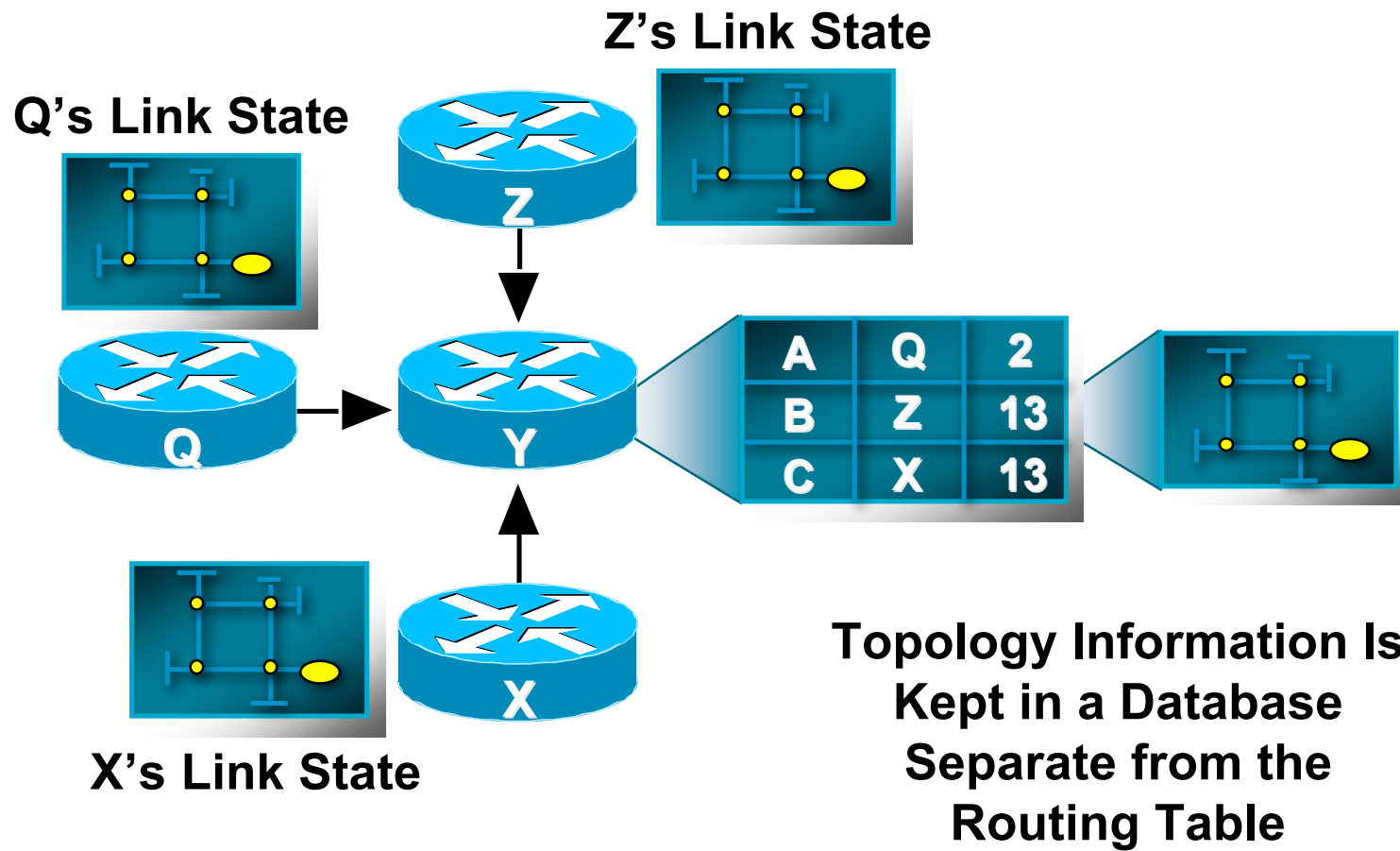# Introduction to OSPF

ISP/IXP Workshops

OSPF

- **Open Shortest Path First**

- **Link state or SPF technology**

- **Developed by OSPF working group of IETF (RFC 1247)**

- **Designed for TCP/IP Internet environment**

- **Fast convergence**

- **Variable-length subnet masks**

- **Discontiguous subnets**

- **No periodic updates**

- **Route authentication**

- **OSPF standard described in RFC2328**

Link State

Z's Link State

Q's Link State

A	Q	2
B	Z	13
C	X	13

X's 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**
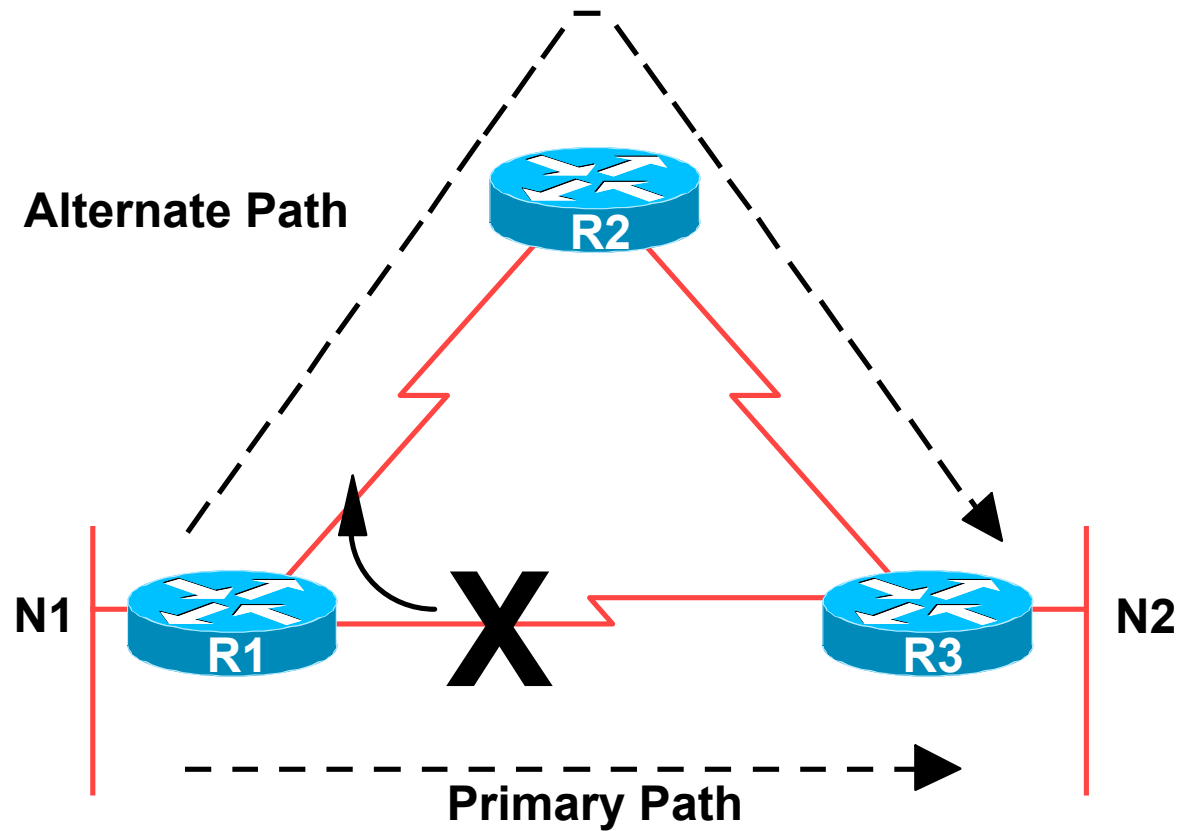
  New LSPs flooded

  All routers recompute routing tables

Low Bandwidth Utilisation
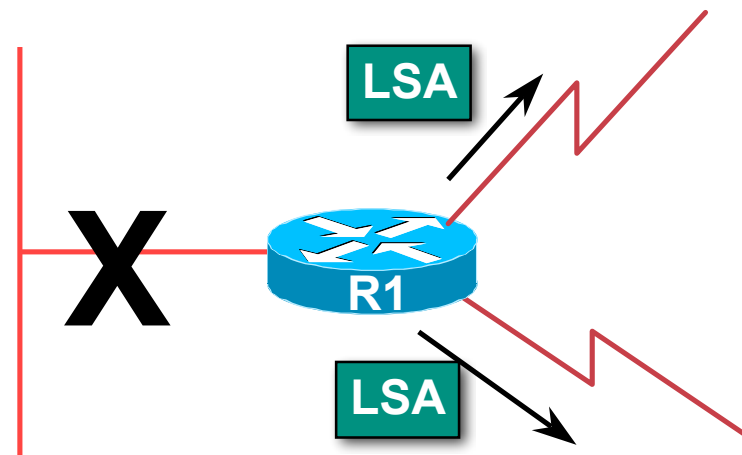
- **Only changes propagated**

- **Multicast on multi-access broadcast networks**

Fast Convergence

- ## Detection Plus LSA/SPF

Alternate Path

R2

R1

N1

X

R3

N2

Primary Path
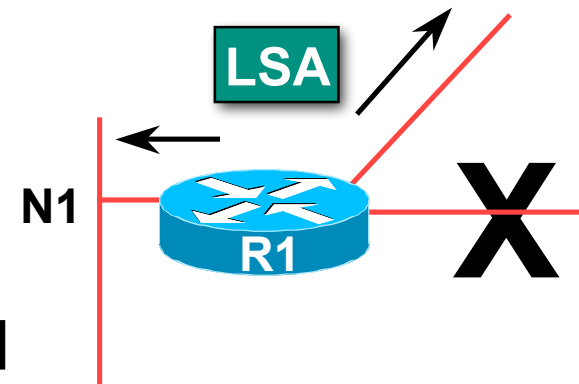
Fast Convergence

- **Finding a new route**

  LSA flooded throughout area

  Acknowledgement based

  Topology database synchronised

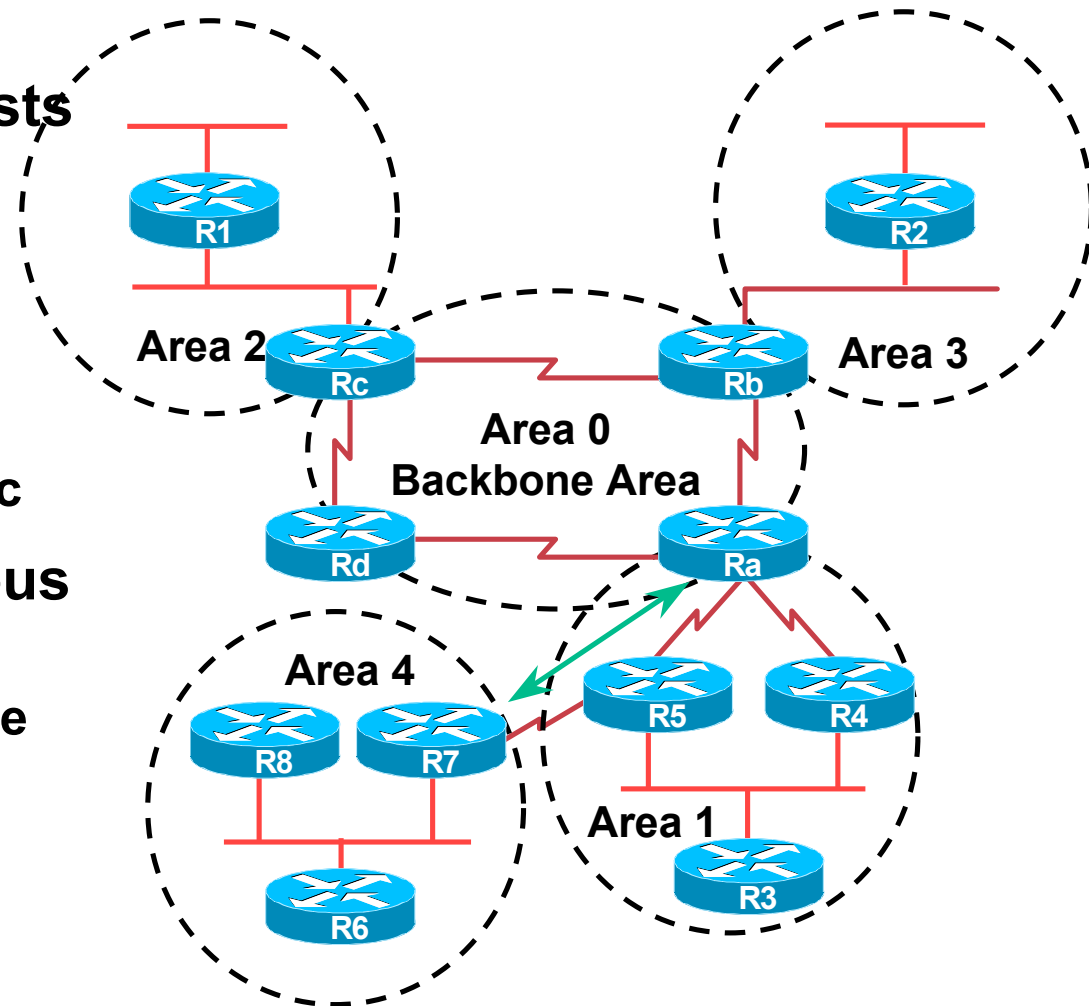 **Each router derives routing table to destination networks**

LSA

N1

R1

X

IP Multicast for Sending/Receiving Updates

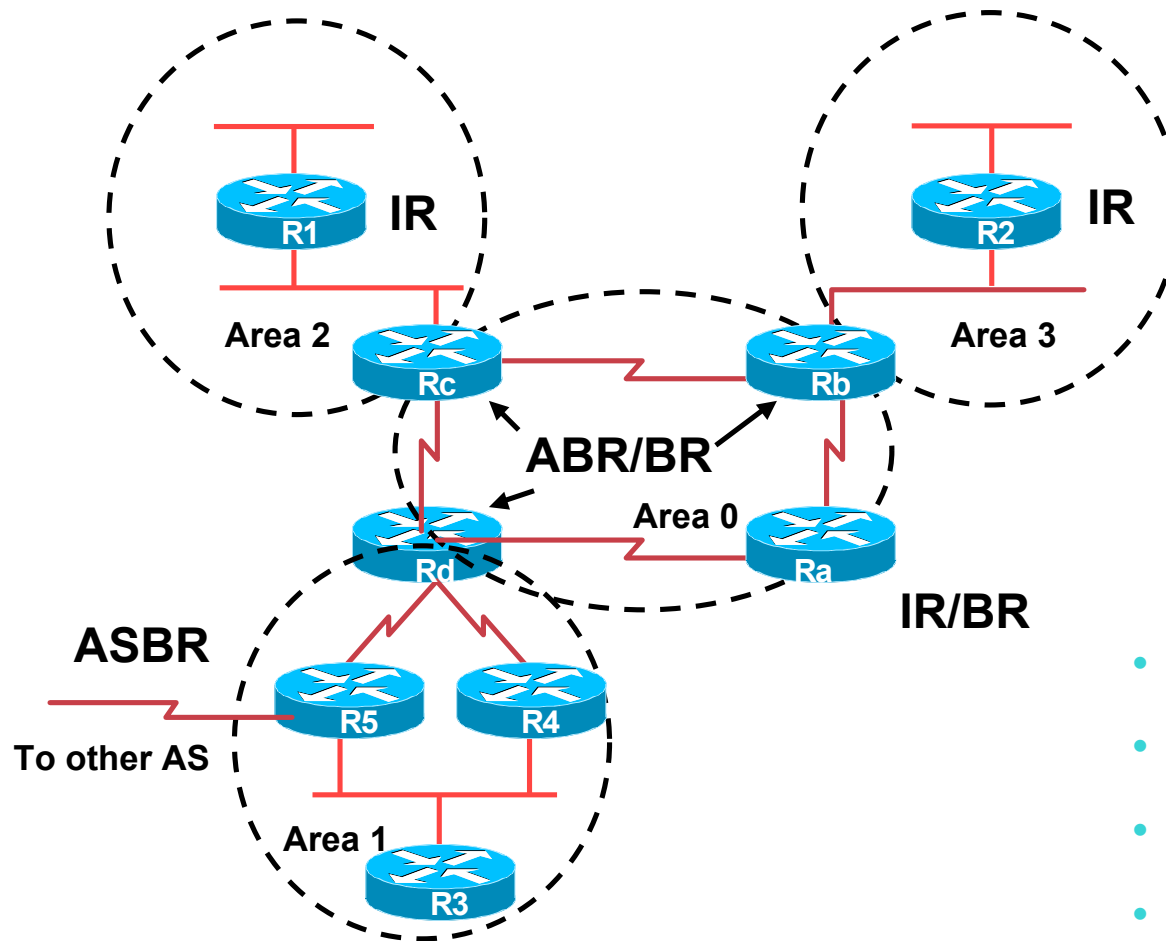- ## Broadcast networks

  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)

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**

Area 2

Area 3

Area 0
Backbone Area

Area 4

Area 1

R1 R2 Rc Rb Rd Ra R5 R4 R8 R7 R3 R6

Classification of Routers

IR

R1

IR

R2

Area 2

Area 3

Rc

Rb

ABR/BR
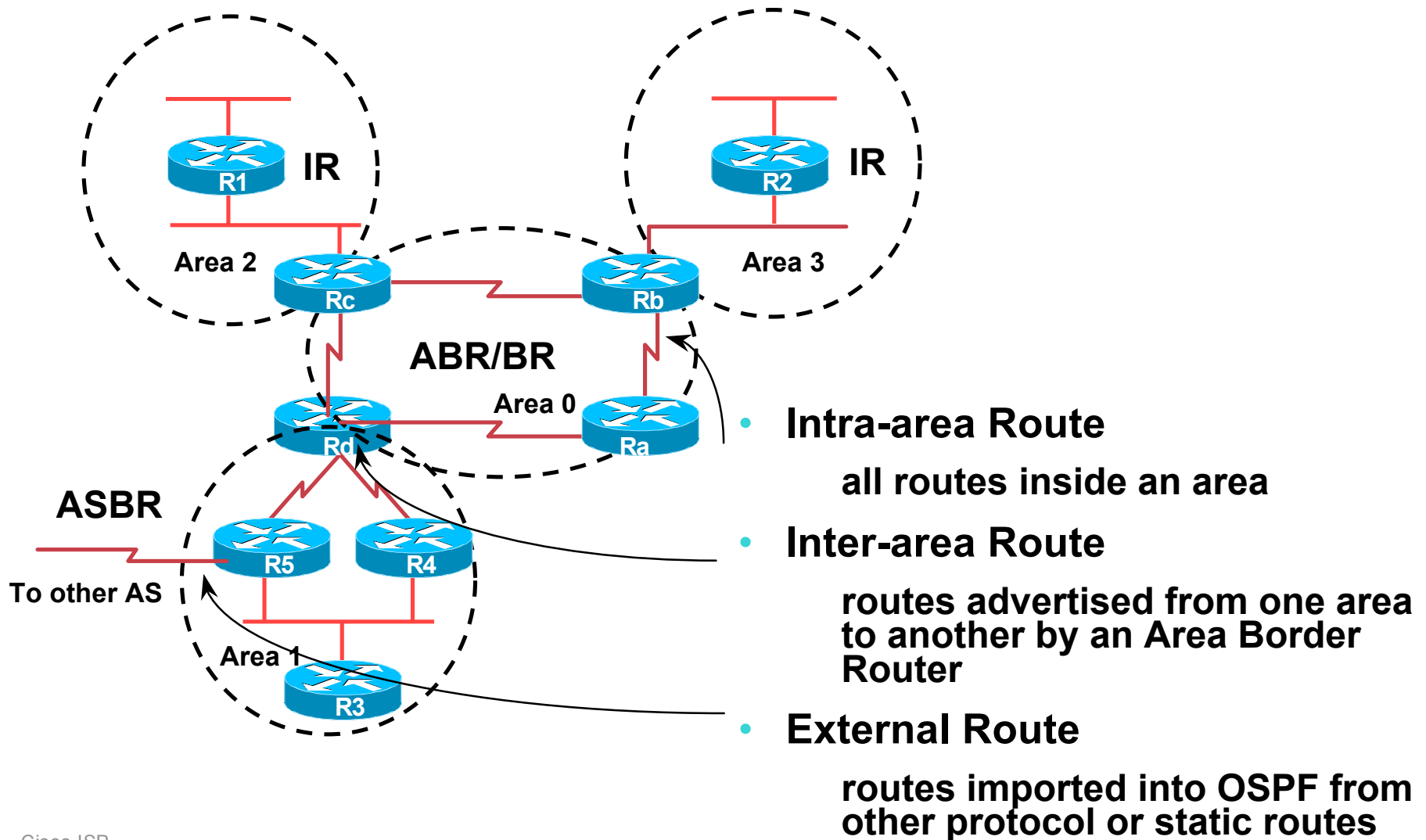
Area 0

Rd

Ra

ASBR

IR/BR

R5

R4

To other AS

Area 1

R3

- **Internal Router (IR)**

- **Area Border Router (ABR)**

- **Backbone Router (BR)**

- **Autonomous System Border Router (ASBR)**

OSPF Route Types

IR

R1

IR

R2

Area 2

Area 3

Rc

Rb

ABR/BR

Area 0

Rd

Ra

ASBR

R5

R4

To other AS

Area 1

R3

- **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

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

R2

FDDI Dual Ring

Backbone Area 0

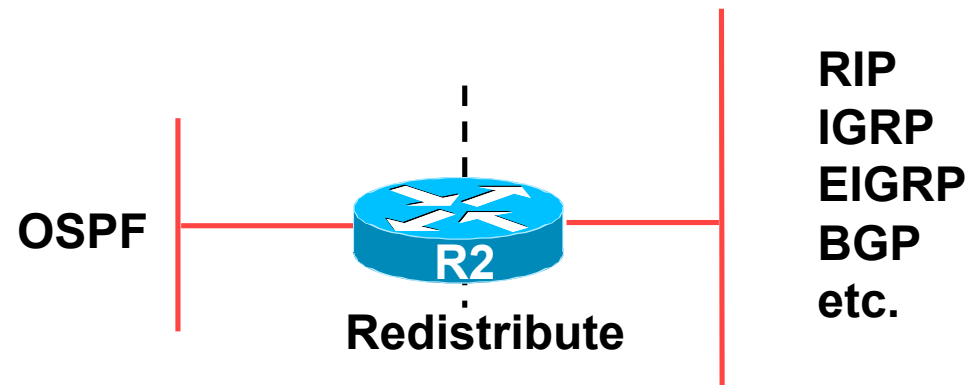**(ABR)**

R1

Area 1

1.A 1.B 1.C
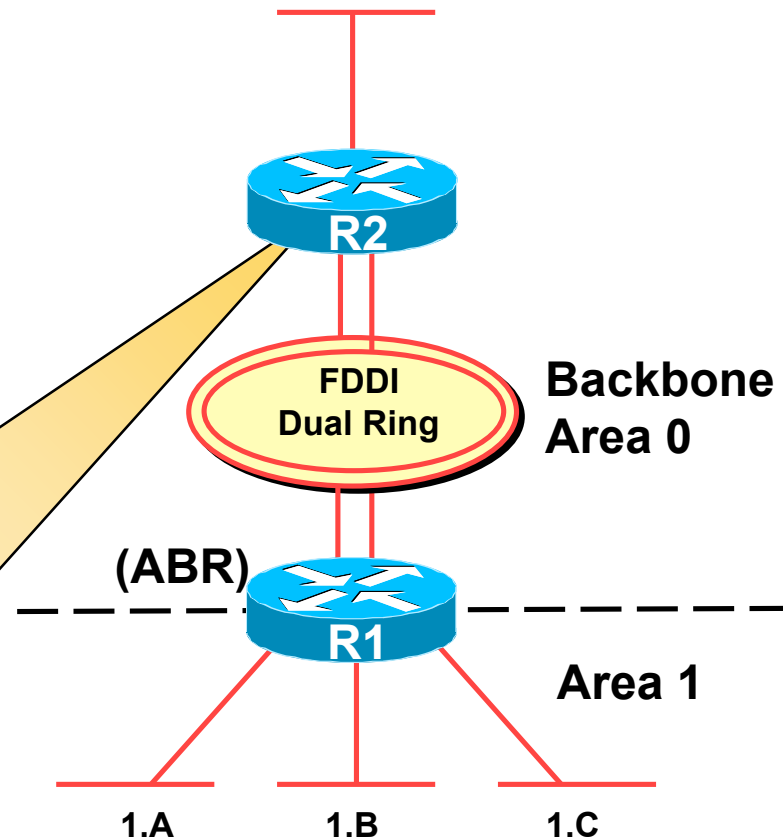
External Routes

- **Prefixes which are redistributed into OSPF from other protocols**

- **Flooded unaltered throughout the AS**

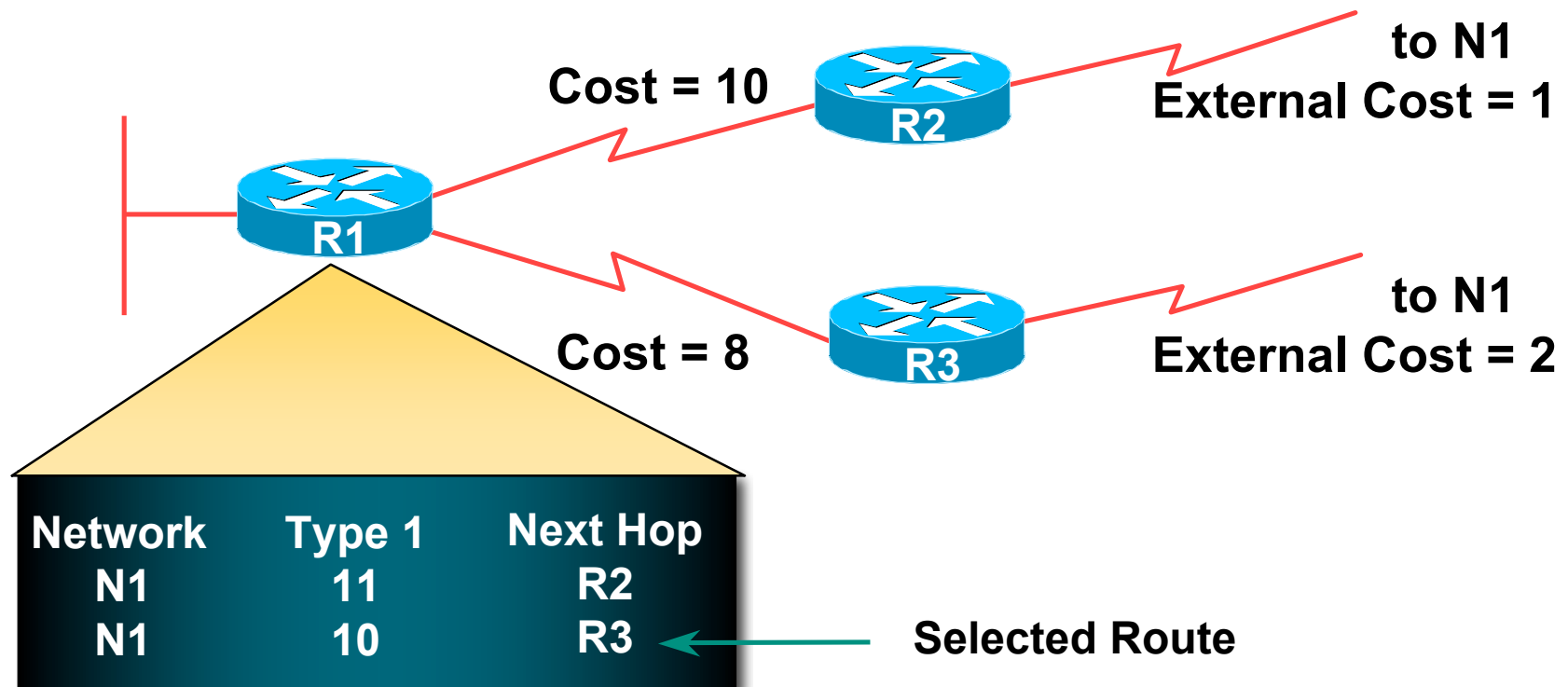- **OSPF supports two types of external metrics**

  Type 1 external metrics
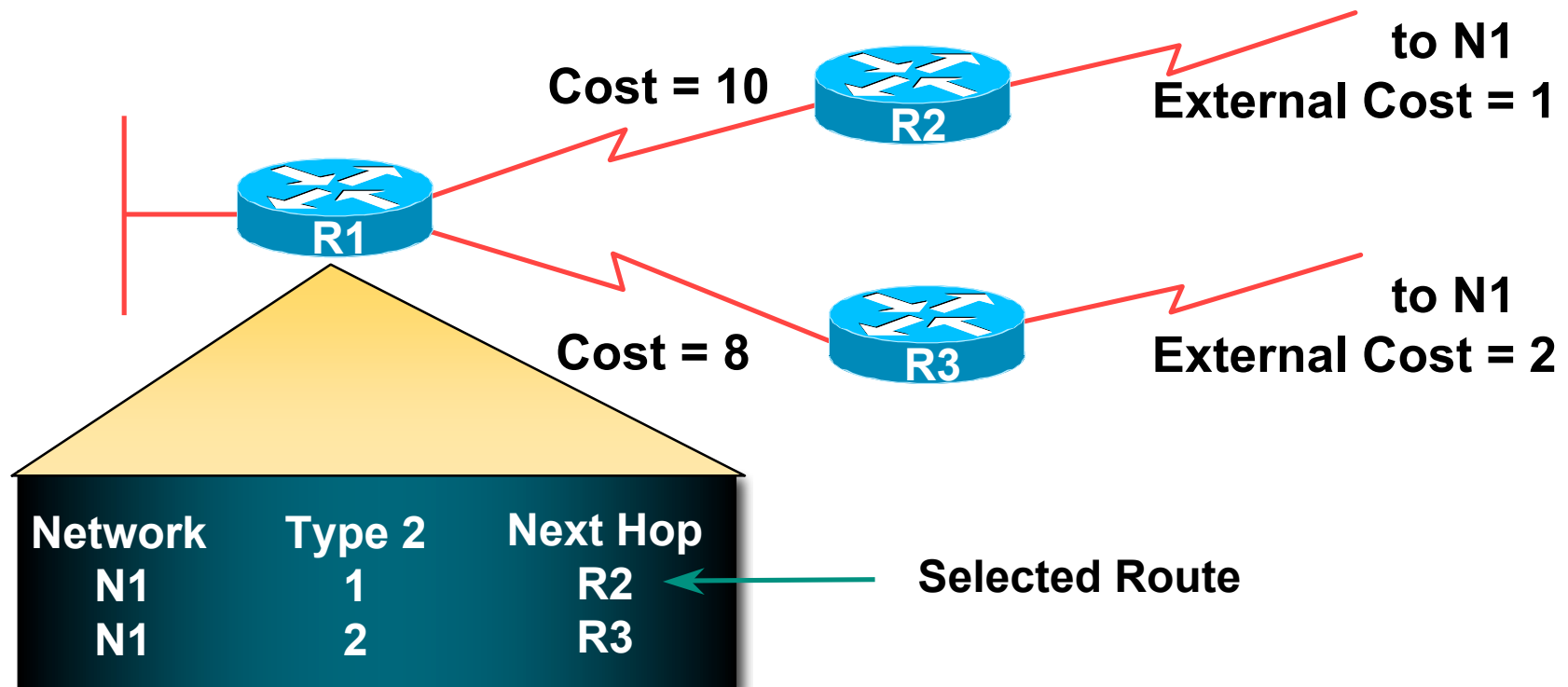
  Type 2 external metrics (Default)

OSPF

R2

Redistribute

RIP
IGRP
EIGRP
BGP
etc.

External Routes

- **Type 1 external metric: metrics are added to the summarised internal link cost**

Cost = 10

R2

to N1
External Cost = 1

R1

Cost = 8

R3

to N1
External Cost = 2

Network	Type 1	Next Hop
N1	11	R2
N1	10	R3

← **Selected Route**

External Routes

- **Type 2 external metric: metrics are compared without adding to the internal link cost**

Cost = 10

R2

to N1
External Cost = 1

R1

Cost = 8

R3

to N1
External Cost = 2

Network	Type 2	Next Hop
N1	1	R2
N1	2	R3

Selected Route

# 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**

Protocol Functionality

- **Bringing up adjacencies**
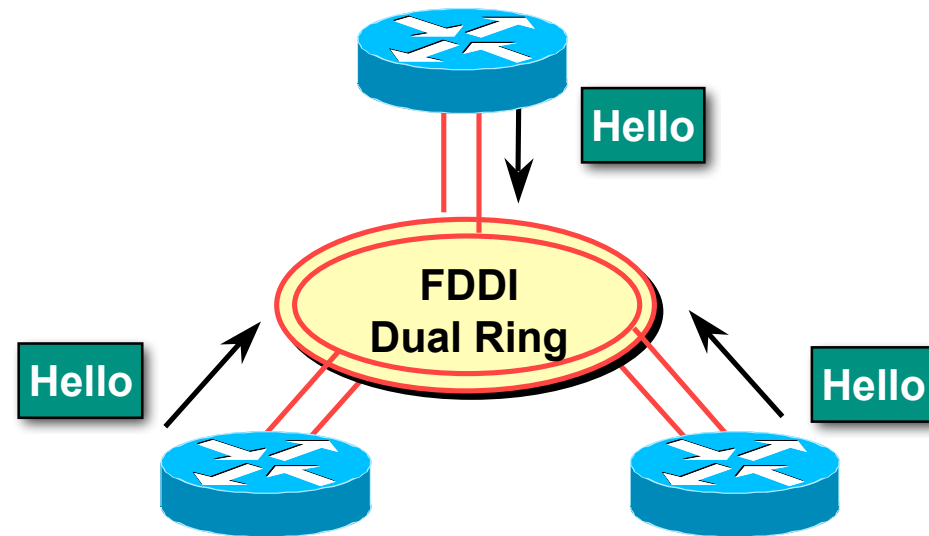
- **LSA types**

- **Area classification**

The Hello Protocol

- **Responsible for establishing and maintaining neighbour relationships**

- **Elects designated router on multi-access networks**
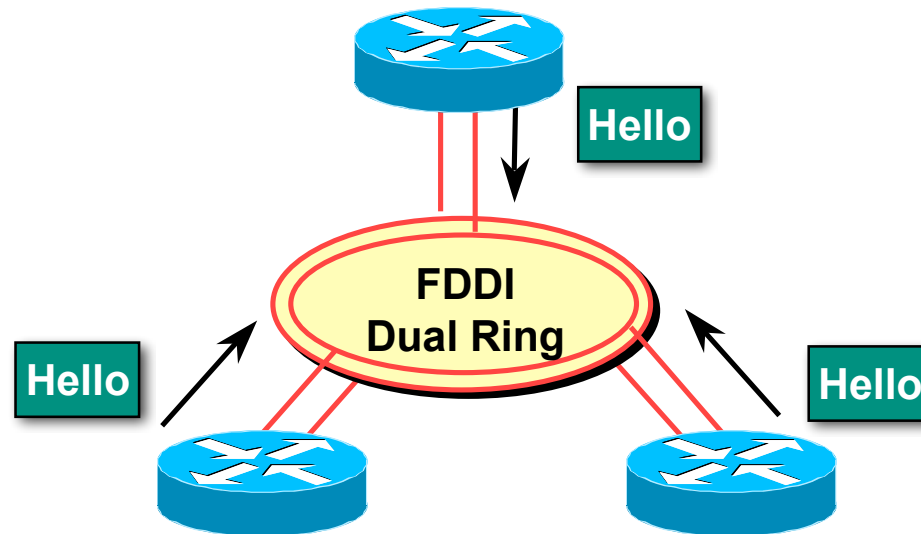
The Hello Packet

- **Router priority**

- **Hello interval**

- **Router dead interval**

- **Network mask**

- **Options: T-bit, E-bit**

- **List of neighbours**

FDDI Dual Ring

Hello

Hello
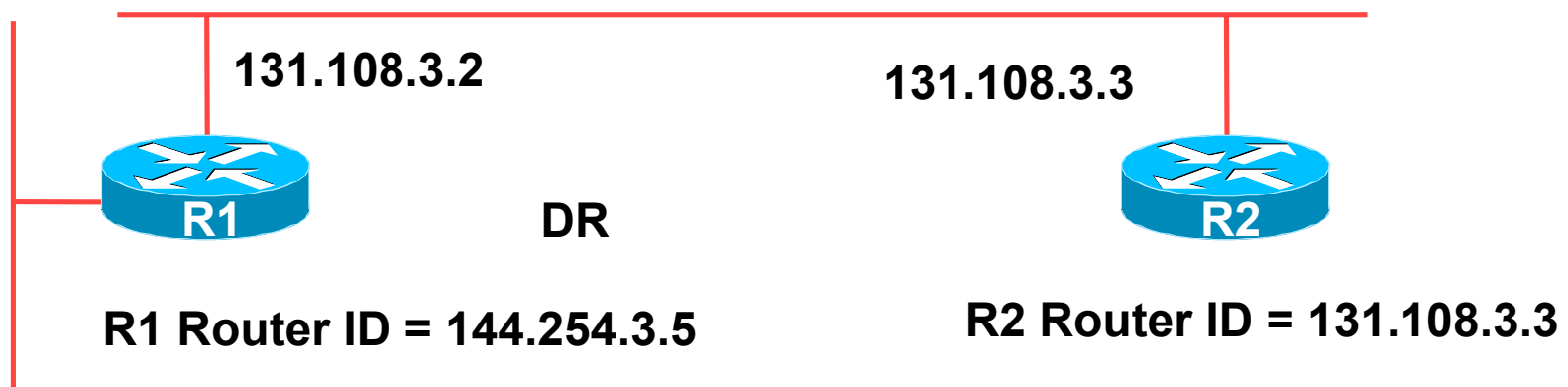
Hello

Designated Router

- **There is ONE designated router per multi-access network**

  Generates network link advertisements

  Assists in database synchronization

Designated Router

Backup Designated Router

Designated Router

Backup Designated Router
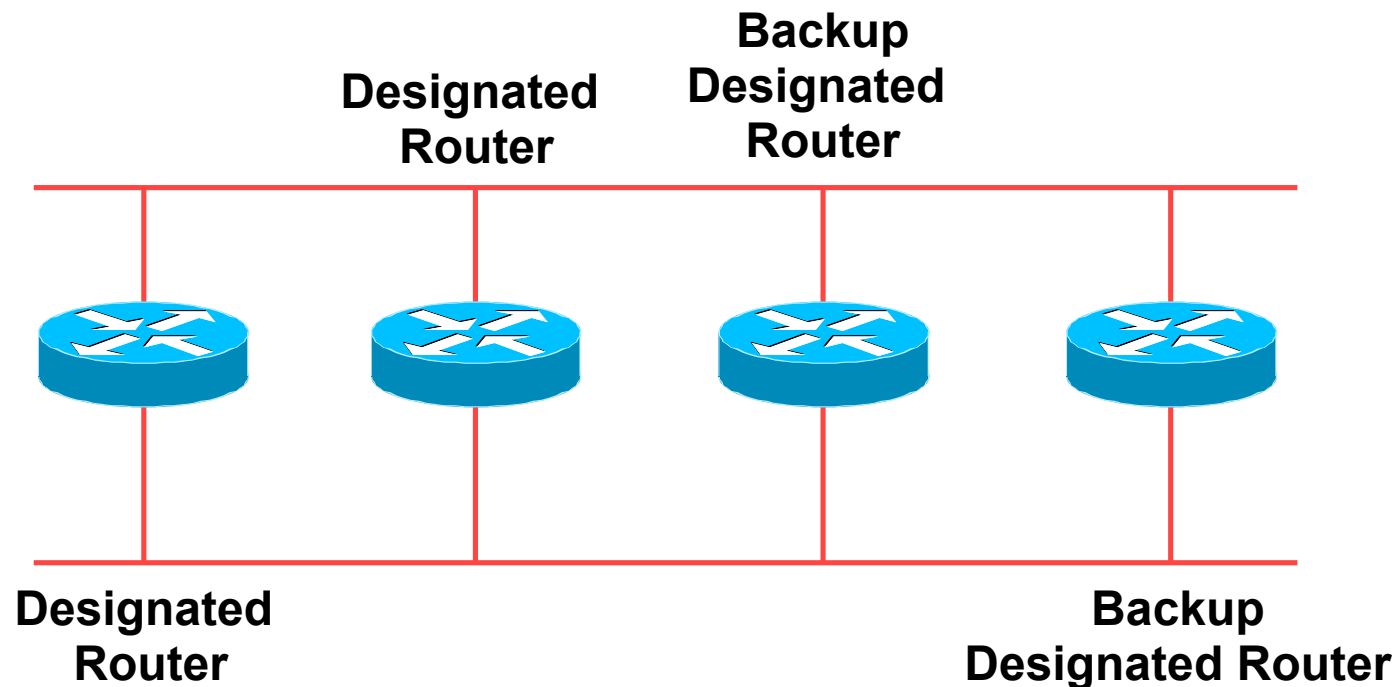
Designated Router by Priority

- **Configured priority (per interface)**

- **Else determined by highest router ID**

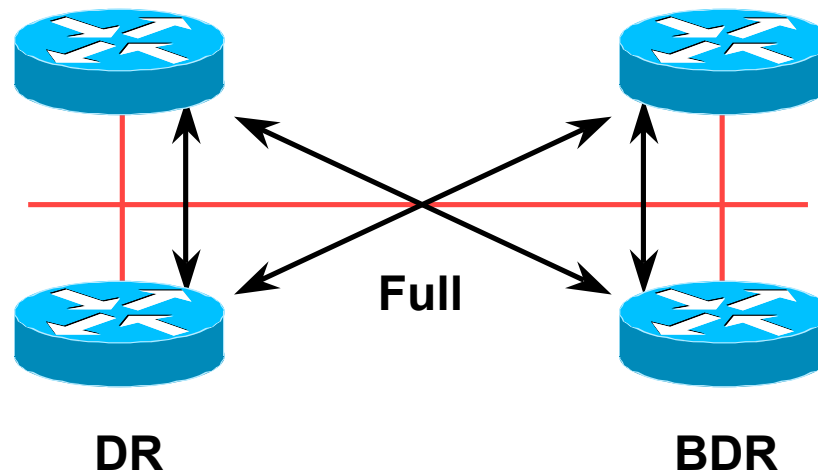   **Router ID is the loopback interface address, if configured, otherwise the highest IP address**

131.108.3.2

131.108.3.3

R1

DR

R2

R1 Router ID = 144.254.3.5

R2 Router ID = 131.108.3.3

144.254.3.5

Neighbouring States

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

Full

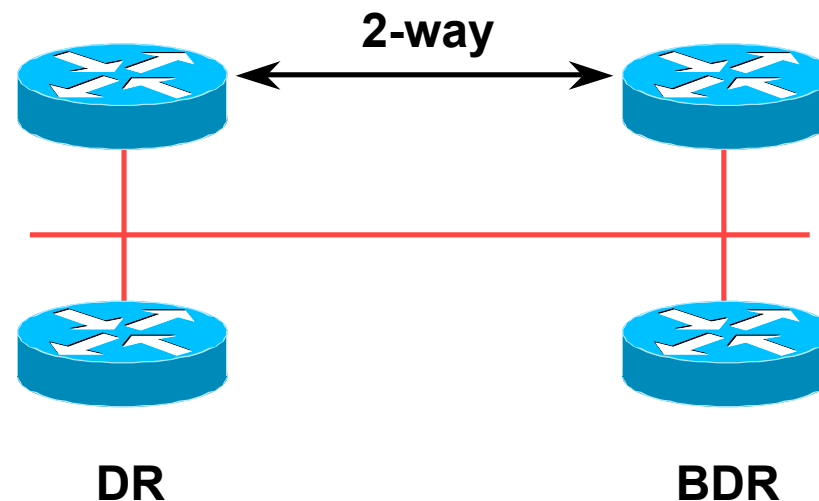**DR**

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**

- **The router itself is the backup designated router**

- **The neighbouring router is the designated router**

- **The neighbouring router is the backup designated router**

LSAs Propagate Along Adjacencies

DR   BDR
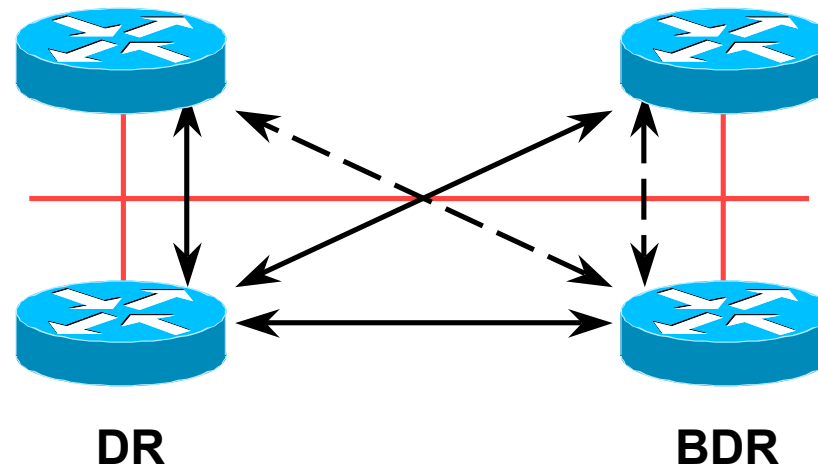
- **LSAs acknowledged along adjacencies**

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

- **Four distinct type of LSAs**

Type 1 :	**Router LSA**
Type 2 :	**Network LSA**
Type 3 and 4:	**Summary LSA**
Type 5 and 7:	**External LSA**

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**
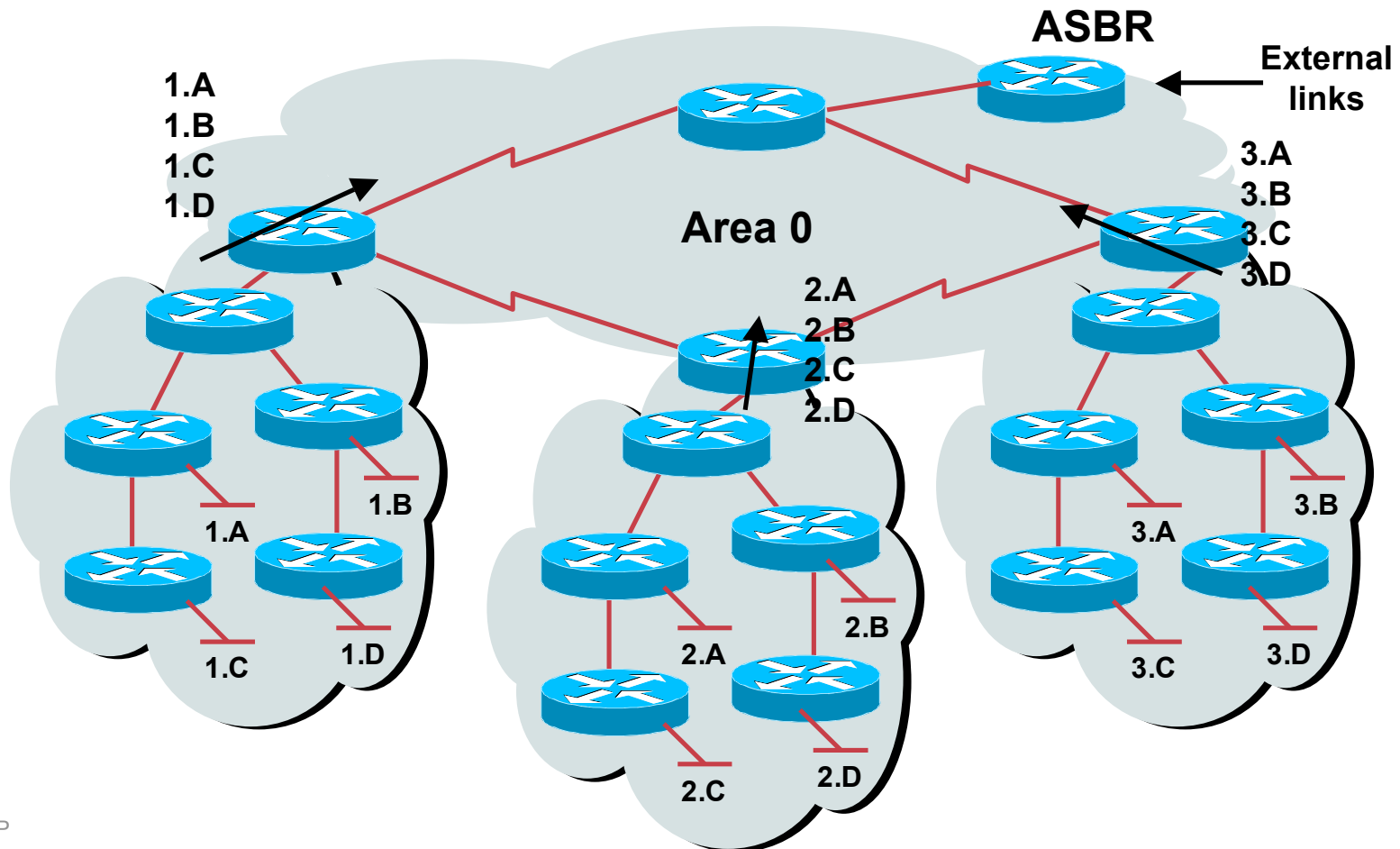
Summary LSA (Type 3 and 4)

- **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)**
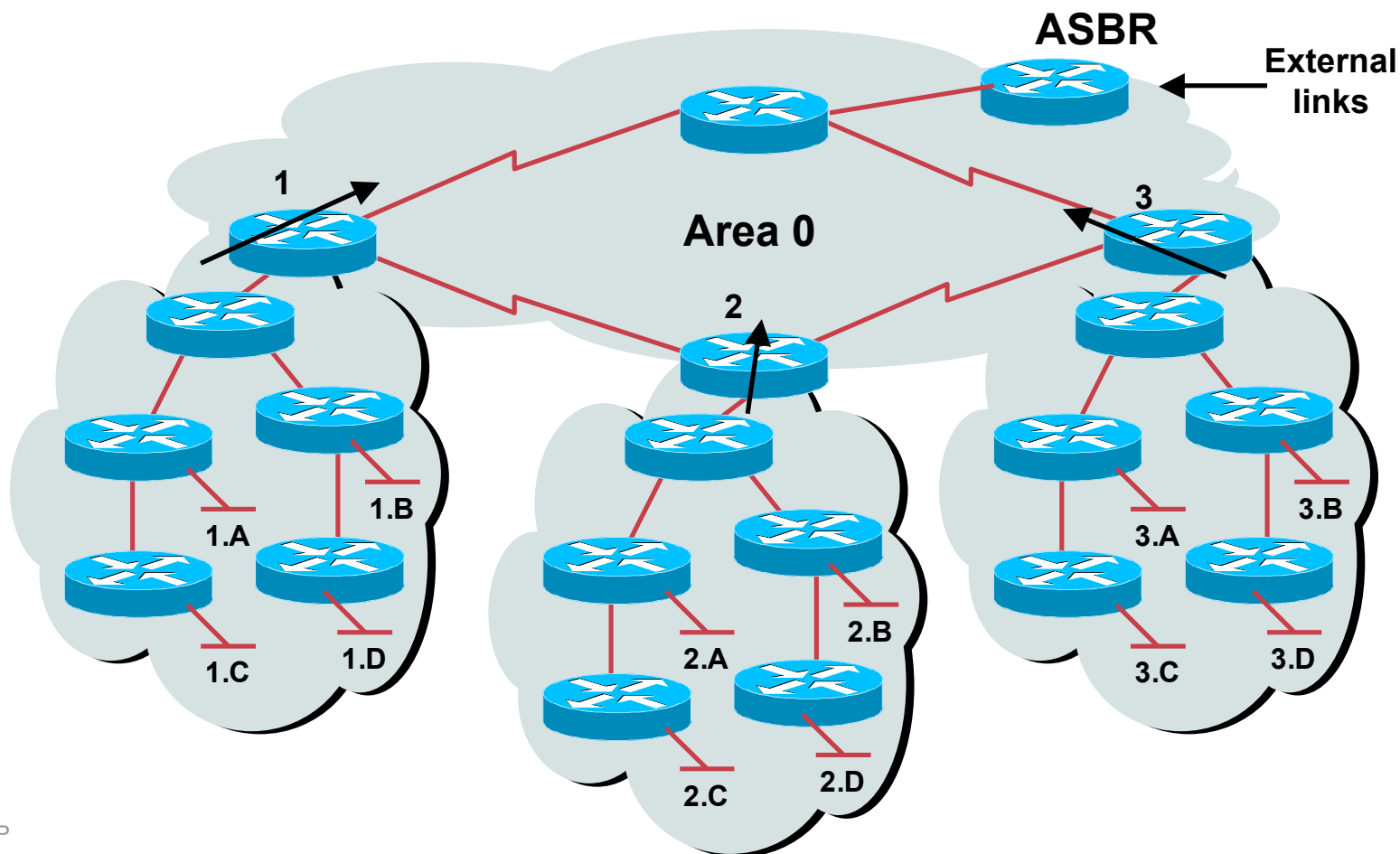
No Summarisation

- **Specific Link LSA advertised out of each area**

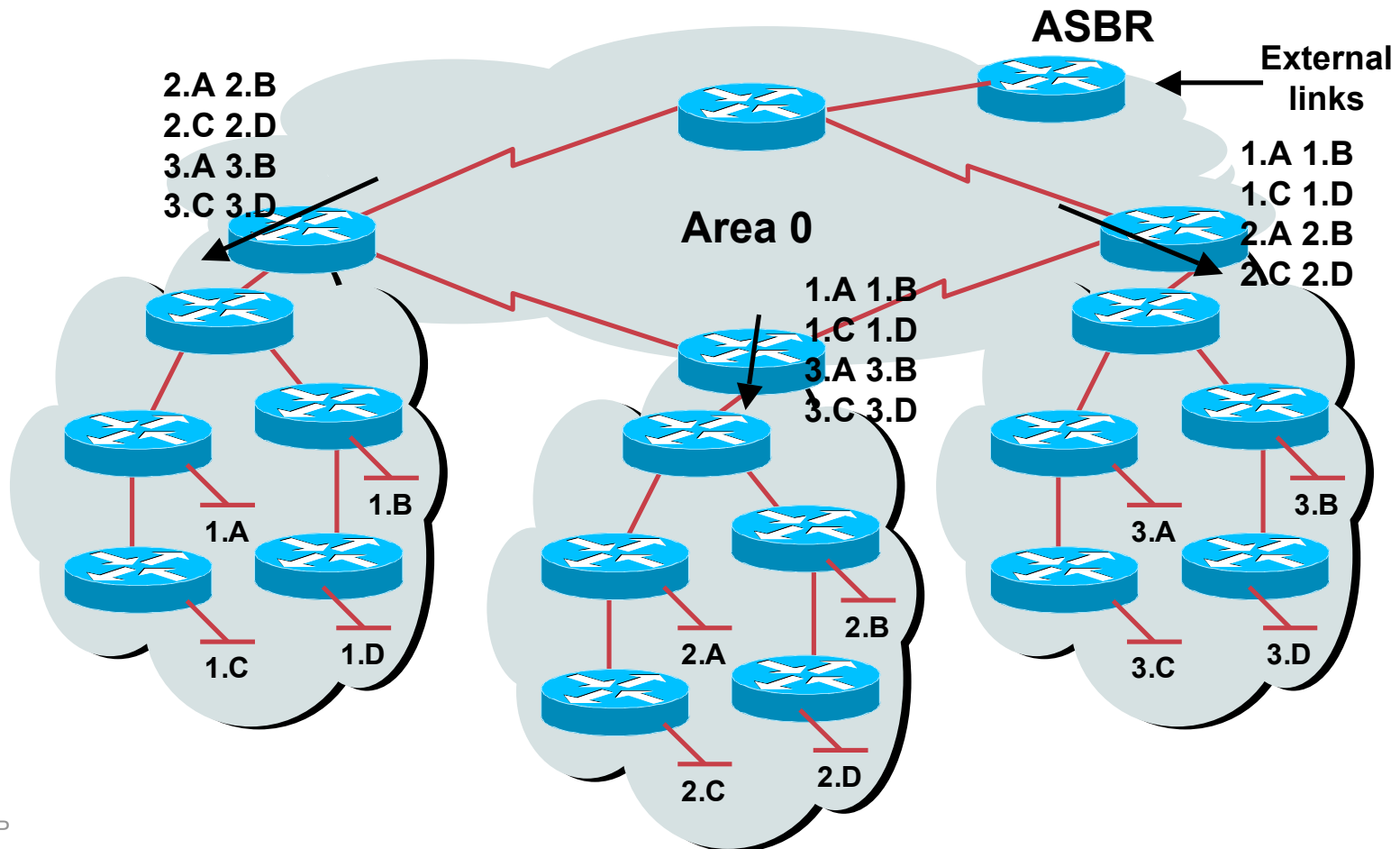- **Link state changes propagated out of each area**

ASBR

External links

1.A
1.B
1.C
1.D

3.A
3.B
3.C
3.D

Area 0

2.A
2.B
2.C
2.D

1.B

1.A

1.C

1.D

2.B

2.A

3.B

3.A

3.C

3.D

2.C

2.D

With Summarisation

- **Only summary LSA advertised out of each area**

- **Link state changes do not propagate out of the area**

ASBR

**External links**

Area 0

1

2

3

1.A 1.B 1.C 1.D

2.A 2.B 2.C 2.D

3.A 3.B 3.C 3.D

No Summarisation

- **Specific Link LSA advertised in to each area**

- **Link state changes propagated in to each area**

ASBR

External links

2.A 2.B
2.C 2.D
3.A 3.B
3.C 3.D

1.A 1.B
1.C 1.D
2.A 2.B
2.C 2.D

Area 0

1.A 1.B
1.C 1.D
3.A 3.B
3.C 3.D

1.A
1.B
1.C
1.D

2.A
2.B
2.C
2.D

3.A
3.B
3.C
3.D

With Summarisation

- **Only summary link LSA advertised in to each area**

- **Link state changes do not propagate in to each area**

ASBR

External links

2
3

1
2

Area 0

1
3

1.A   1.B
1.C   1.D

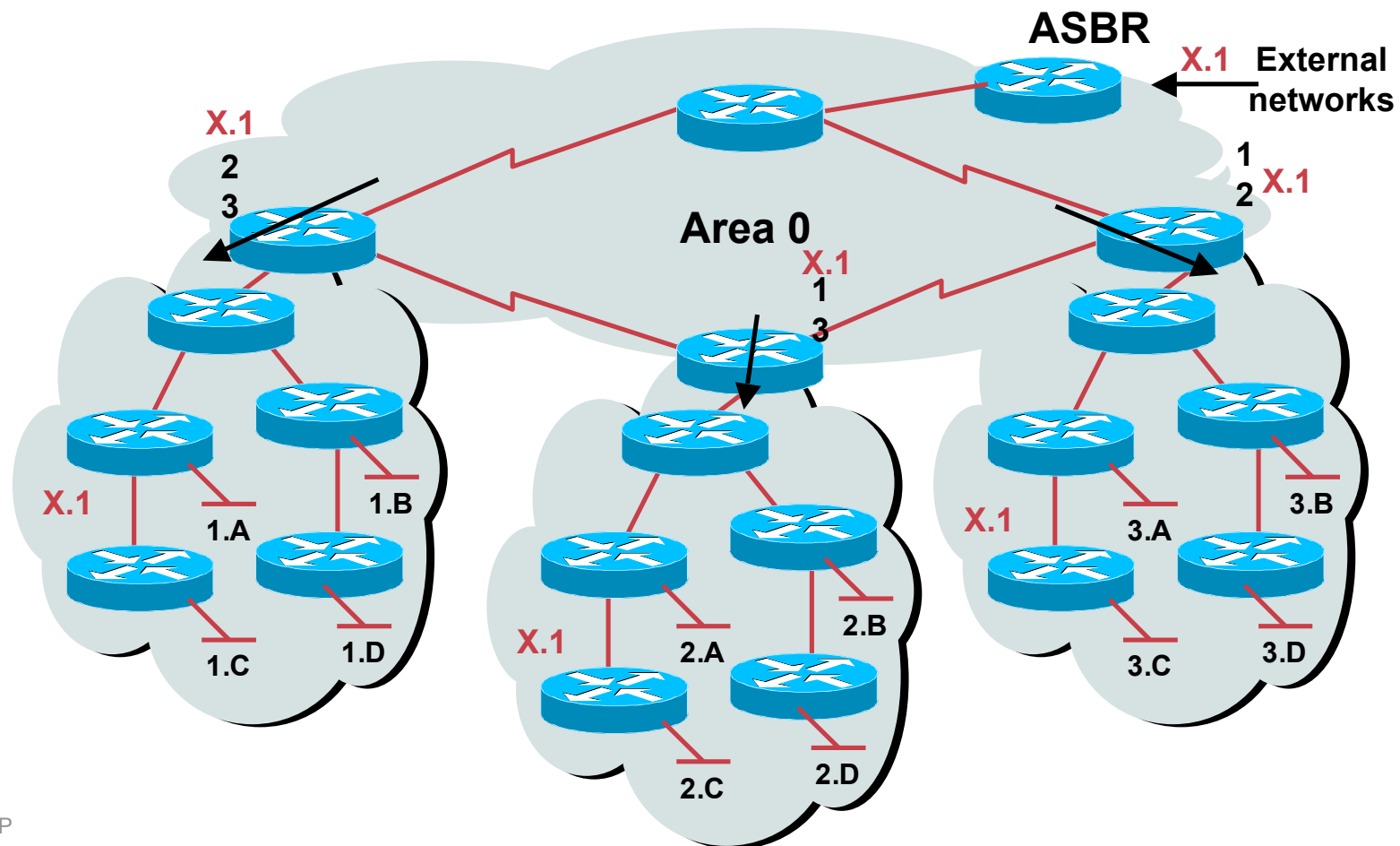2.A   2.B
2.C   2.D

3.A   3.B
3.C   3.D
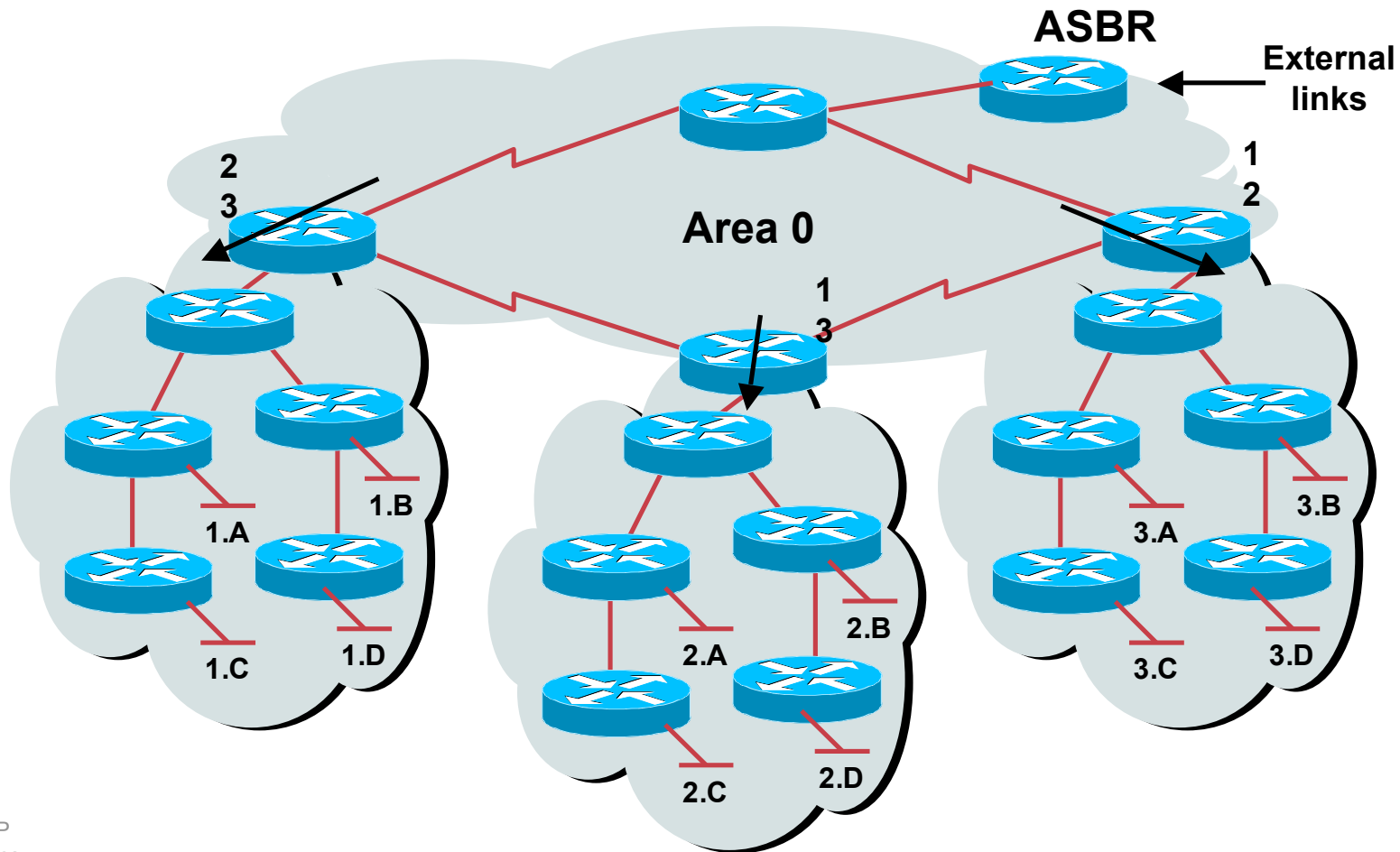
Types of Areas

- **Regular**

- **Stub**
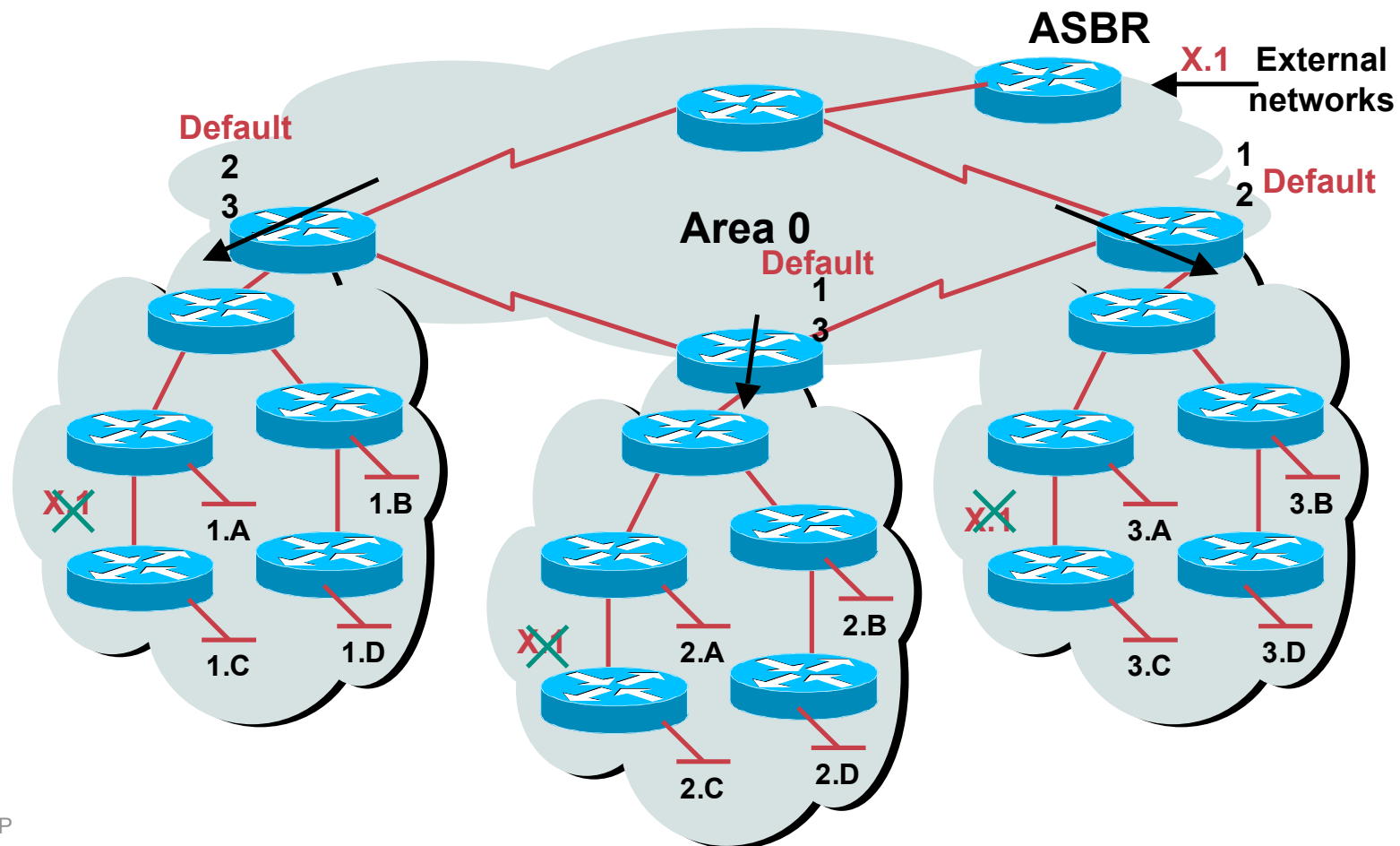
- **Totally Stubby**

- **Not-So-Stubby**

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**
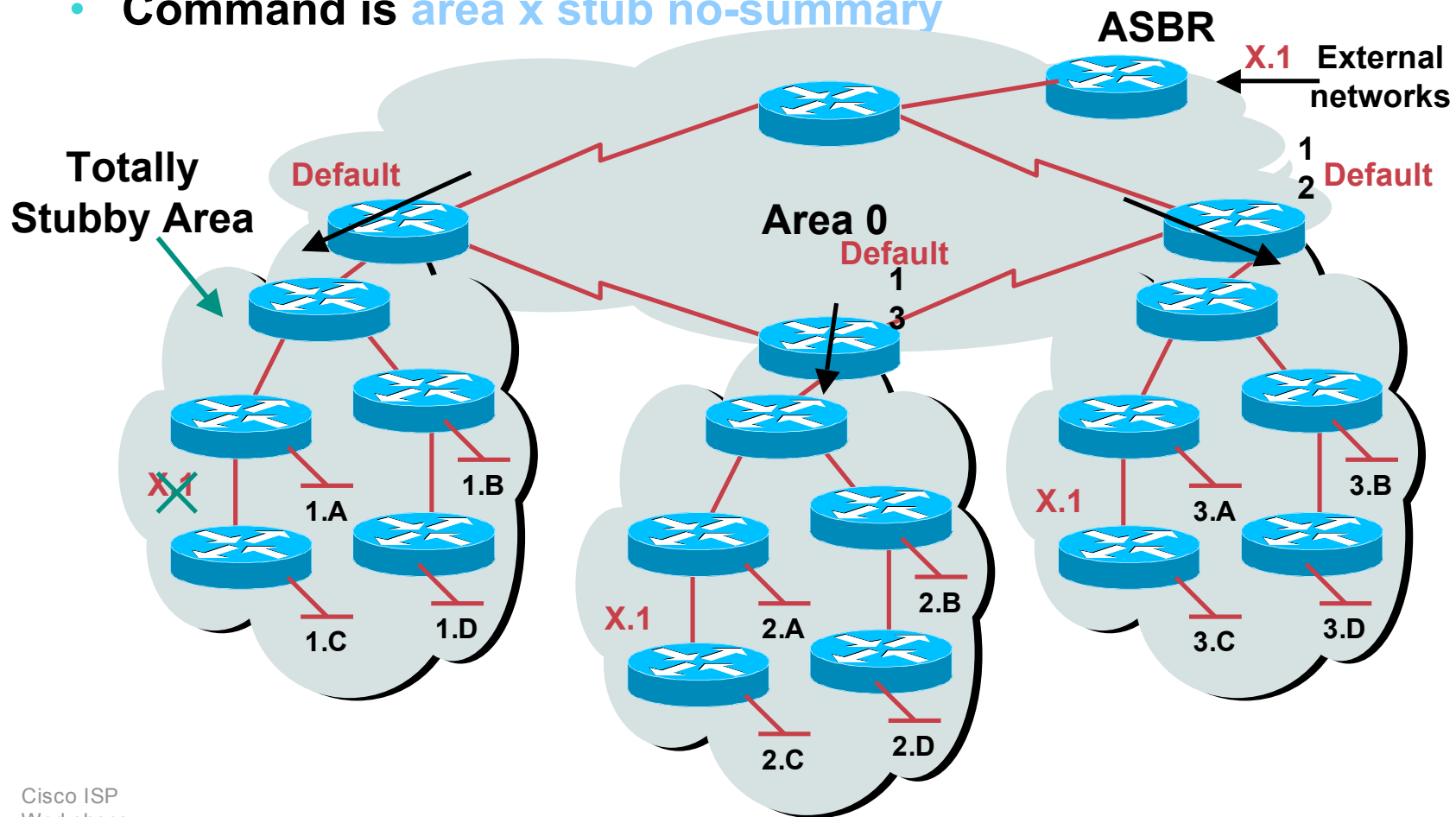
Normal Stub Area

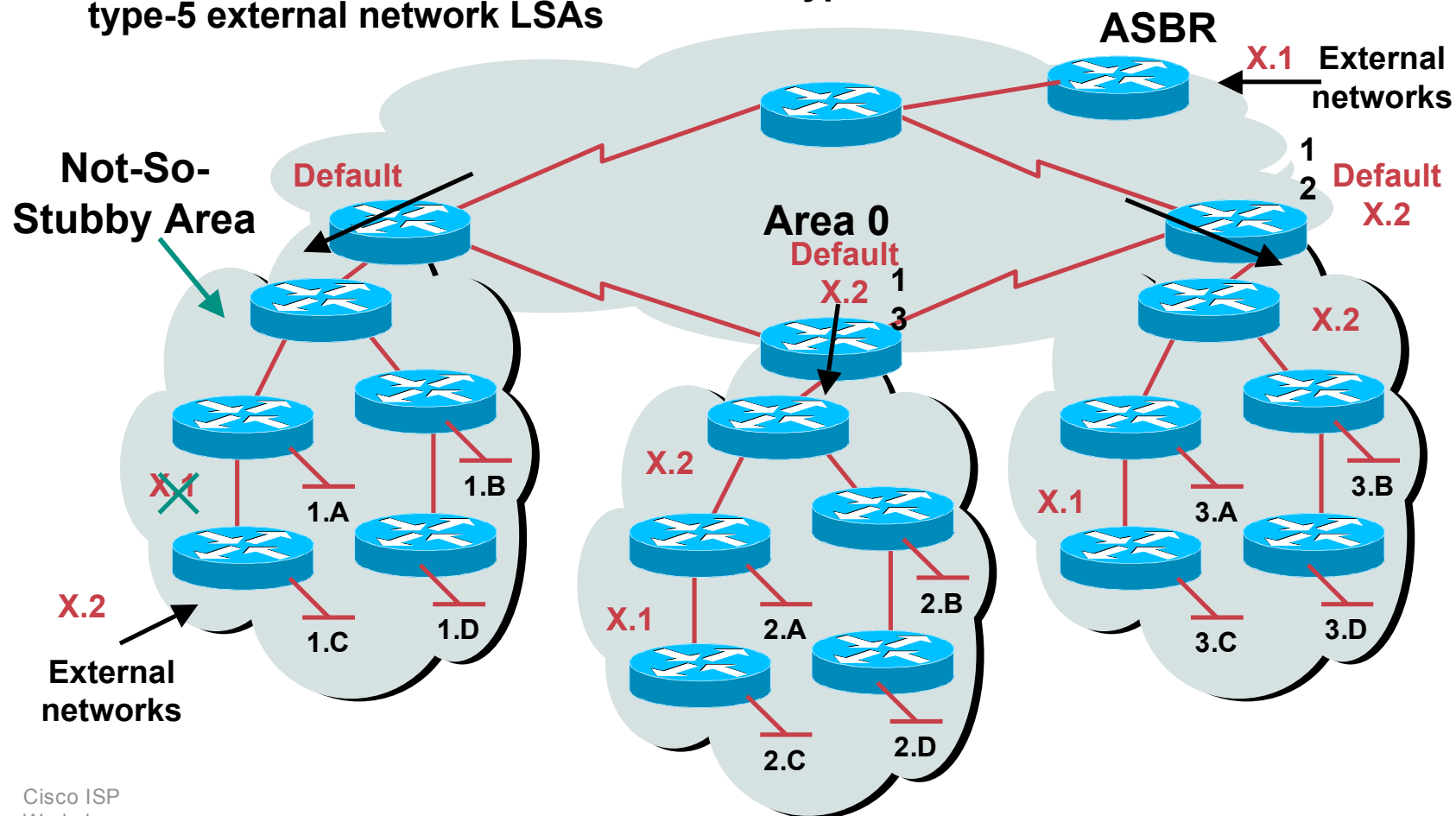- **Summary networks, default route injected**
- **Command is area x stub**

Totally Stubby Area

- **Only a default route injected**

    Default path to closest area border router

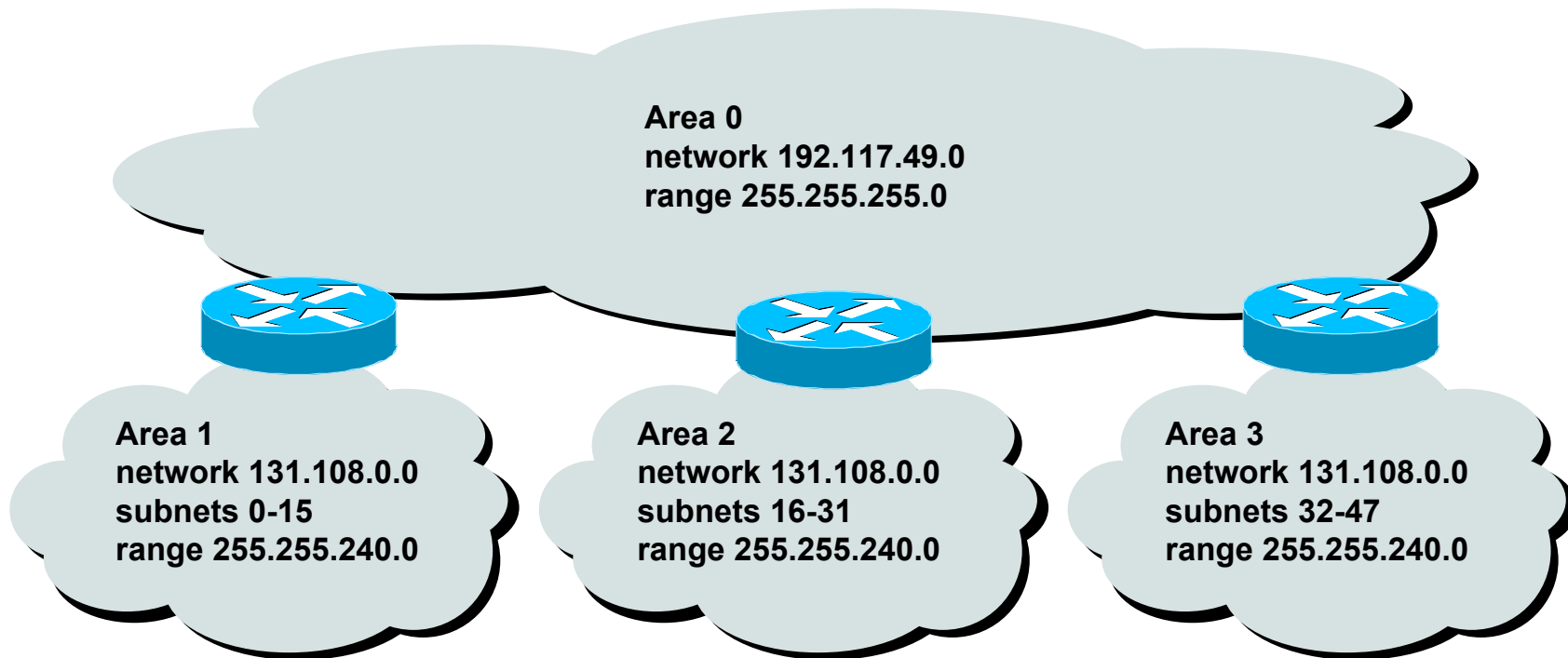- **Command is area x stub no-summary**

39

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**

Addressing for Areas

Area 0
network 192.117.49.0
range 255.255.255.0

Area 1
network 131.108.0.0
subnets 0-15
range 255.255.240.0

Area 2
network 131.108.0.0
subnets 16-31
range 255.255.240.0

Area 3
network 131.108.0.0
subnets 32-47
range 255.255.240.0

Assign contiguous ranges of subnets per area to facilitate summarisation

Summary

- **Scalable OSPF Network Design**

  Area hierarchy

  Stub areas

  Contiguous addressing

  Route summarisation

Introduction to OSPF

ISP/IXP Workshops