

OSPF

Open Shortest Path First

- Designed for:
 - TCP/IP environment
 - Fast convergence
 - Variable-length subnet masks
 - Discontinuous subnets
 - Incremental updates
 - Route authentication
- Runs on IP, Protocol 89

What is OSPF?

- Open
 - Developed by IETF IGP working group, RFC2328
- SPF
 - Each router floods link-state information through its neighbors to other routers
 - Based on the flooded link-state information, each router maintains a complete link-state database
 - Based on the link-state database, a routing table is constructed using SPF (e.g., Dijkstra's) algorithm

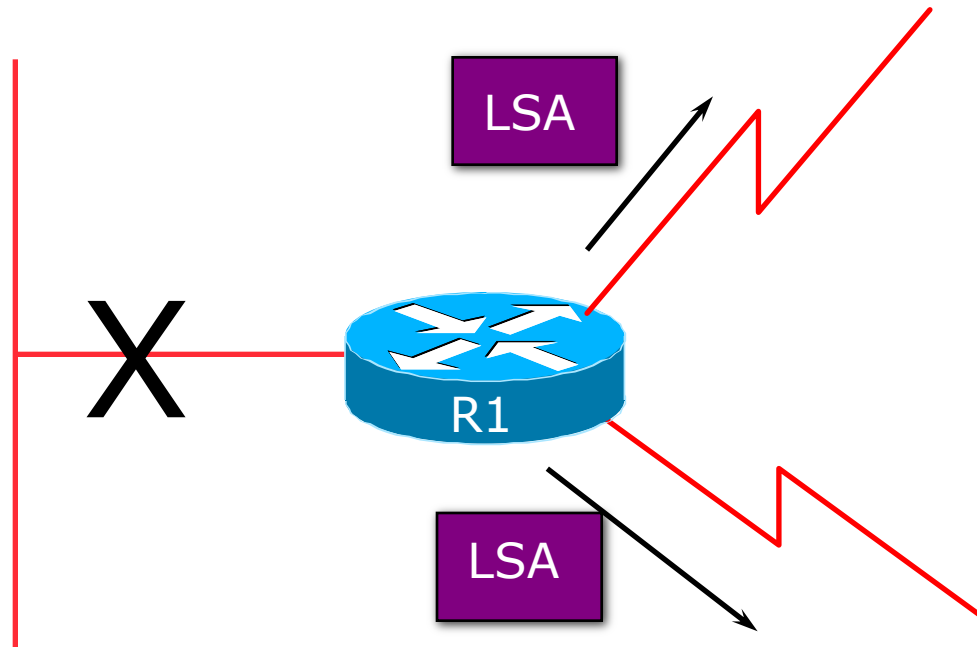
Features of OSPF

- Use flexible metrics instead of only hop count
- Supports variable-length subnetting
- Allows load balancing among equal-cost paths
- Supports multiple routes; one for each IP type of service (ToS)
- Authenticates route exchanges
- Quick convergence
- Uses multicast rather than broadcast of its messages to reduce network load

Comparing OSPF with Distance Vector Routing Protocols

Distance Vector	Link State
• View network topology from neighbors perspective • Adds distance vectors from router to router • Frequent, periodic updates: Slow convergence • Passes copies of routing tables to neighbor routers • Use flat topology	• Gets common view of entire network topology • Calculates the shortest path to other routers • Event-triggered updates: Faster convergence • Passes link-state routing updates to other routers • Allows hierarchical design for large internetworks

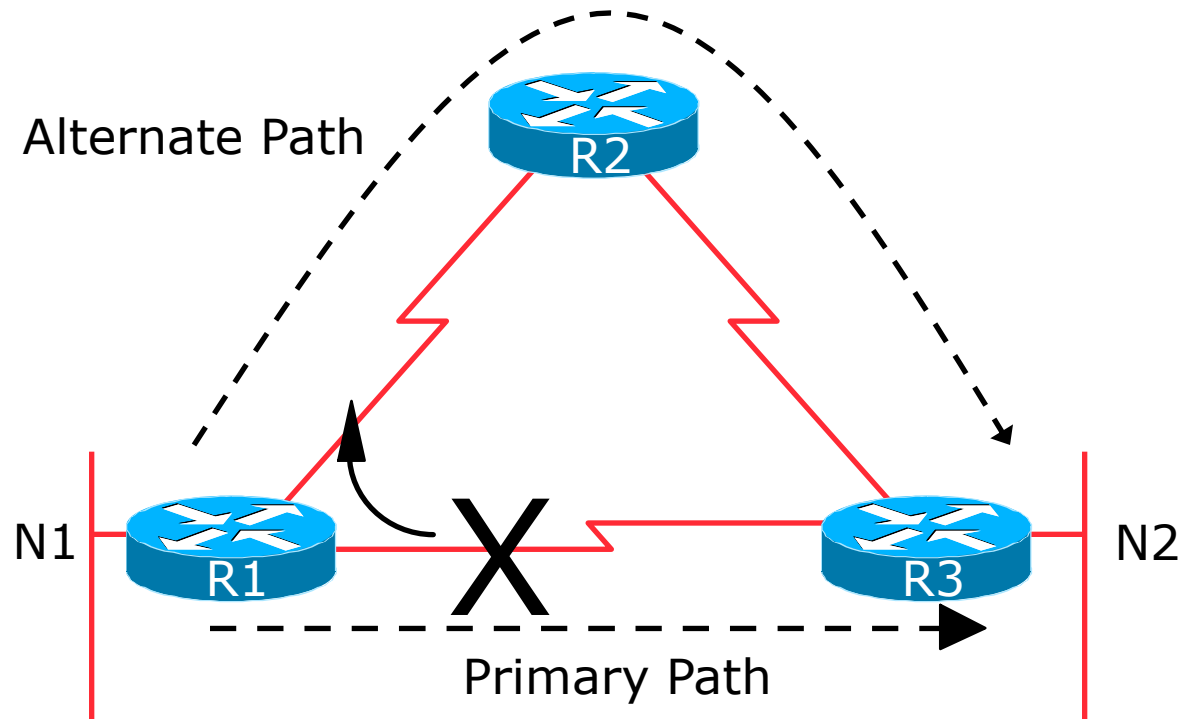
Low Bandwidth Utilisation



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

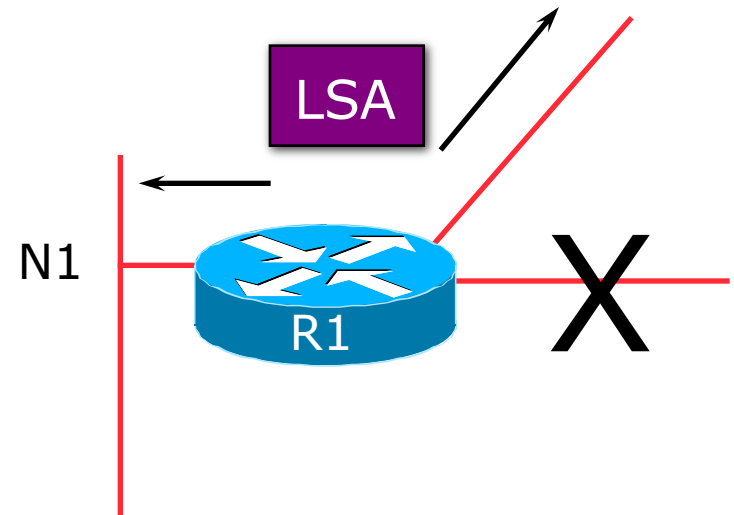
Fast Convergence

- 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



Disadvantage of OSPF

- It require extra CPU to run SPF algorithm
- It requires more RAM to store adjacency topology
- It is more Complex to set up and hard to troubleshoot

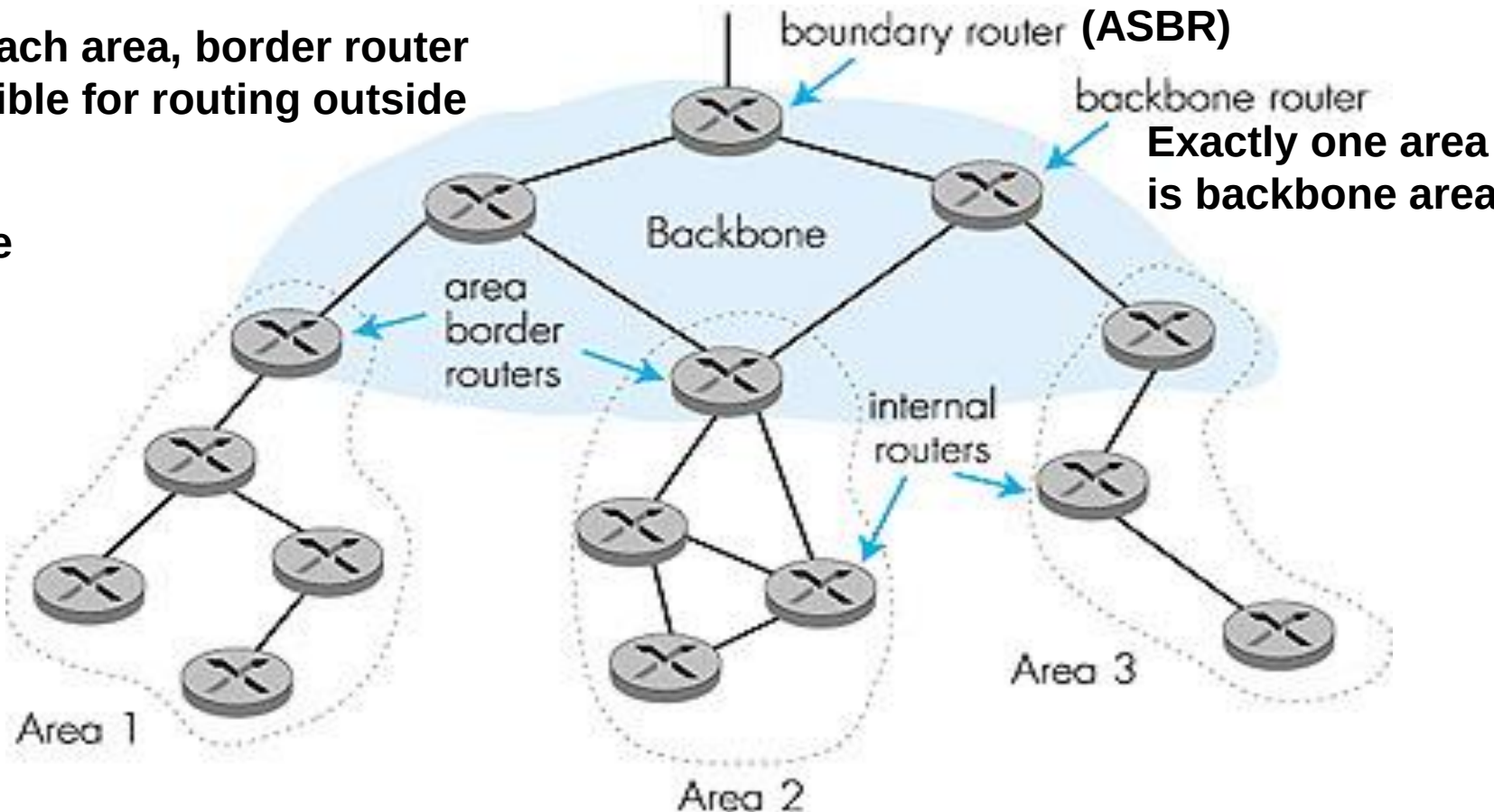
Hierarchical OSPF

- AS is organized as two-level hierarchy
 - AS is partitioned into self-contained areas
 - Areas are interconnected by a backbone area
 - Areas are identified by a 32-bit area ID
 - 0.0.0.0 is reserved for the backbone area
- Four types of routers
 - Internal router, area border router, backbone router, autonomous system boundary router (ASBR)

OSPF AS organized into a 2-level hierarchy

Within each area, border router responsible for routing outside the area

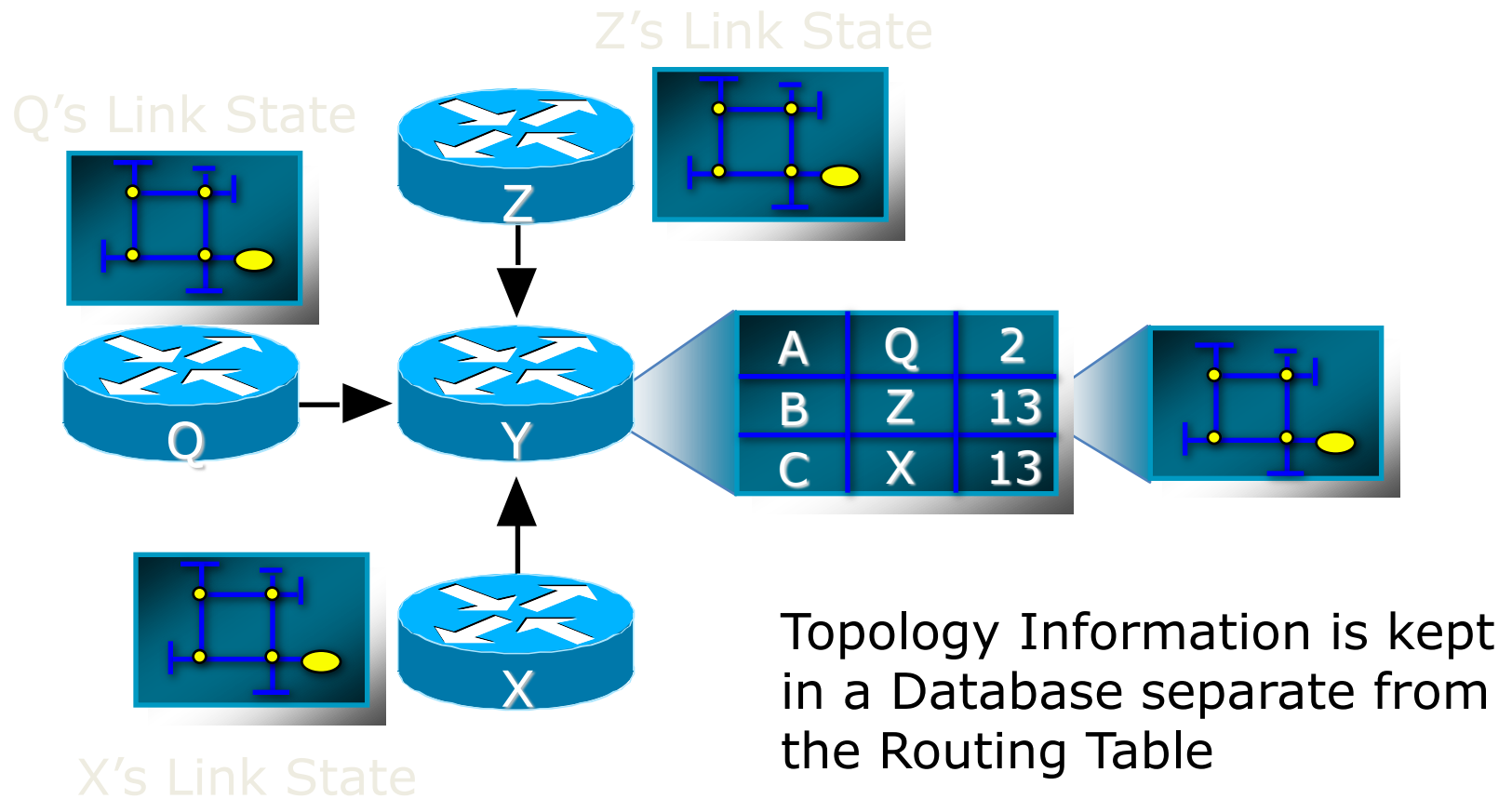
Backbone area contains all area border routers and possibly others



AS- Autonomous System

- Group of Network under a single admin protocol
- Create Boundry for routing protocols
- Used to break large network into smaller network

Link State



Two Level Hierarchy

- Backbone Area

Central Point of the OSPF

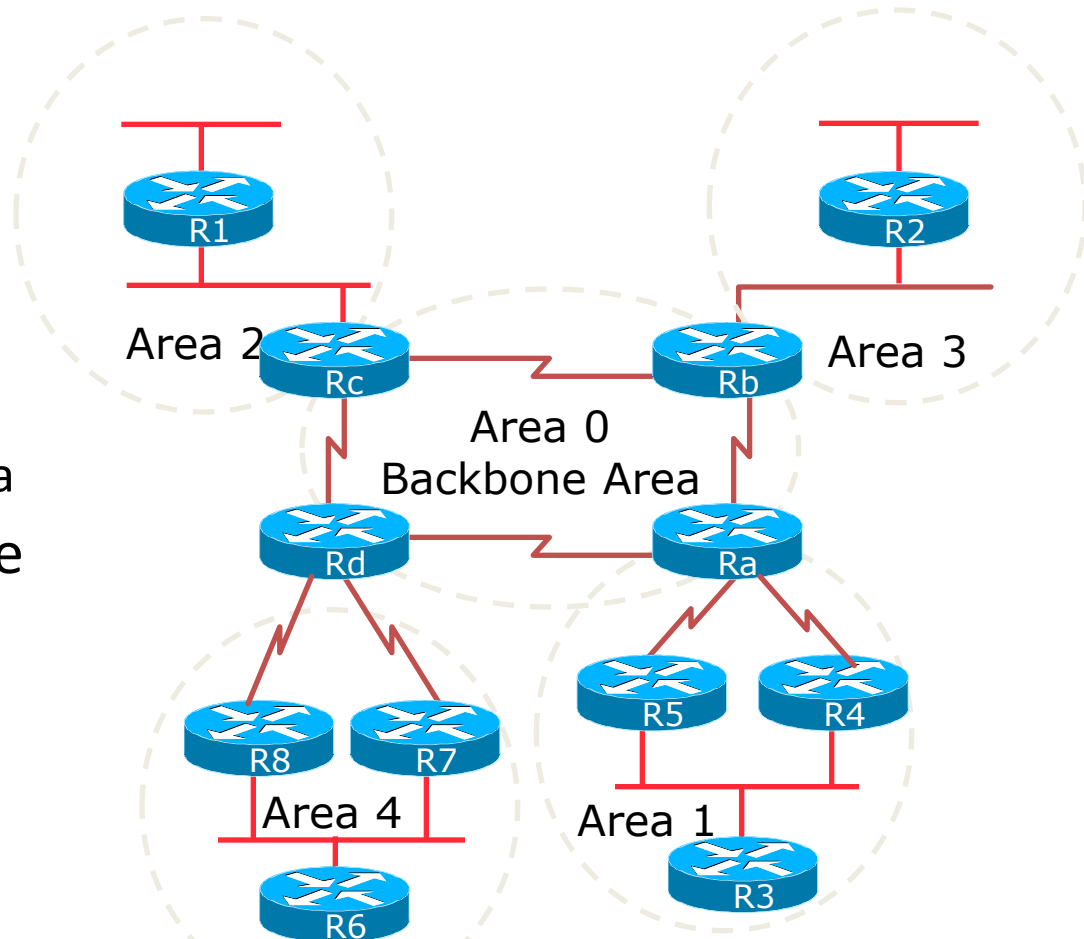
Routers running in this area requires to maintained complete database of entire network

- Area of Backbone

In this area requires to maintained an area specific database

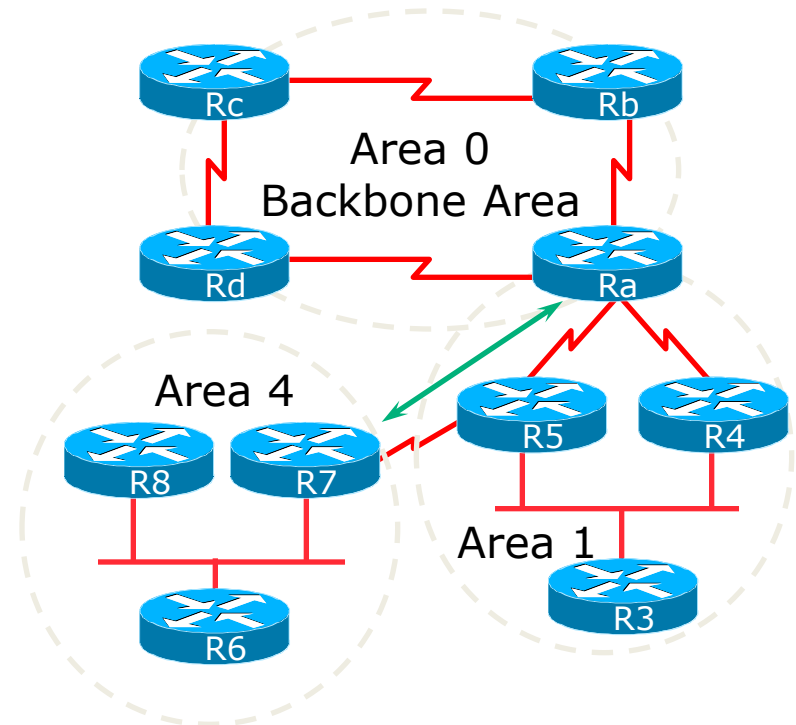
OSPF Areas

- 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

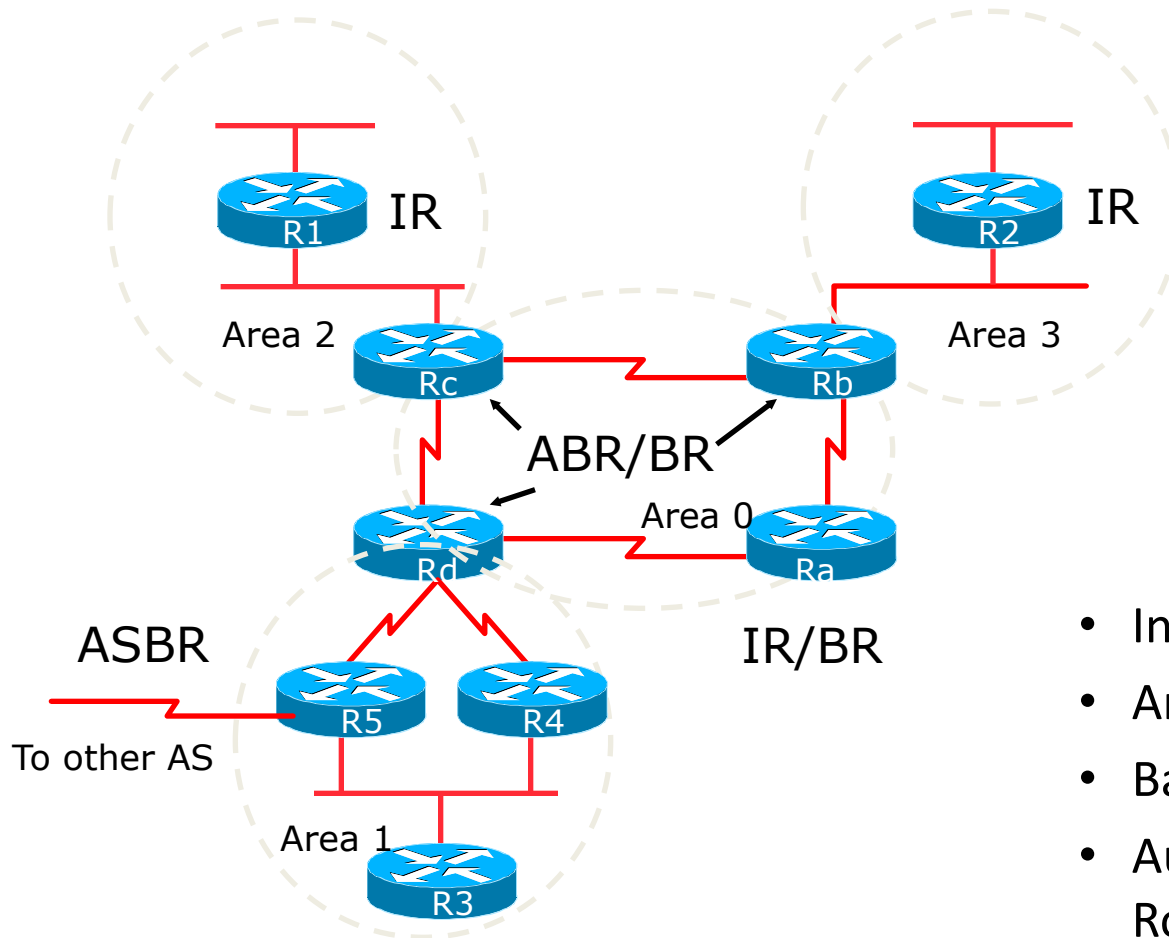


Virtual Links between OSPF Areas

- 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)

ABR- Area Boarder Router

Bridge between backbone and area of backbone

-If minimum interface is in OSPF (area 0) and other interface can be any area

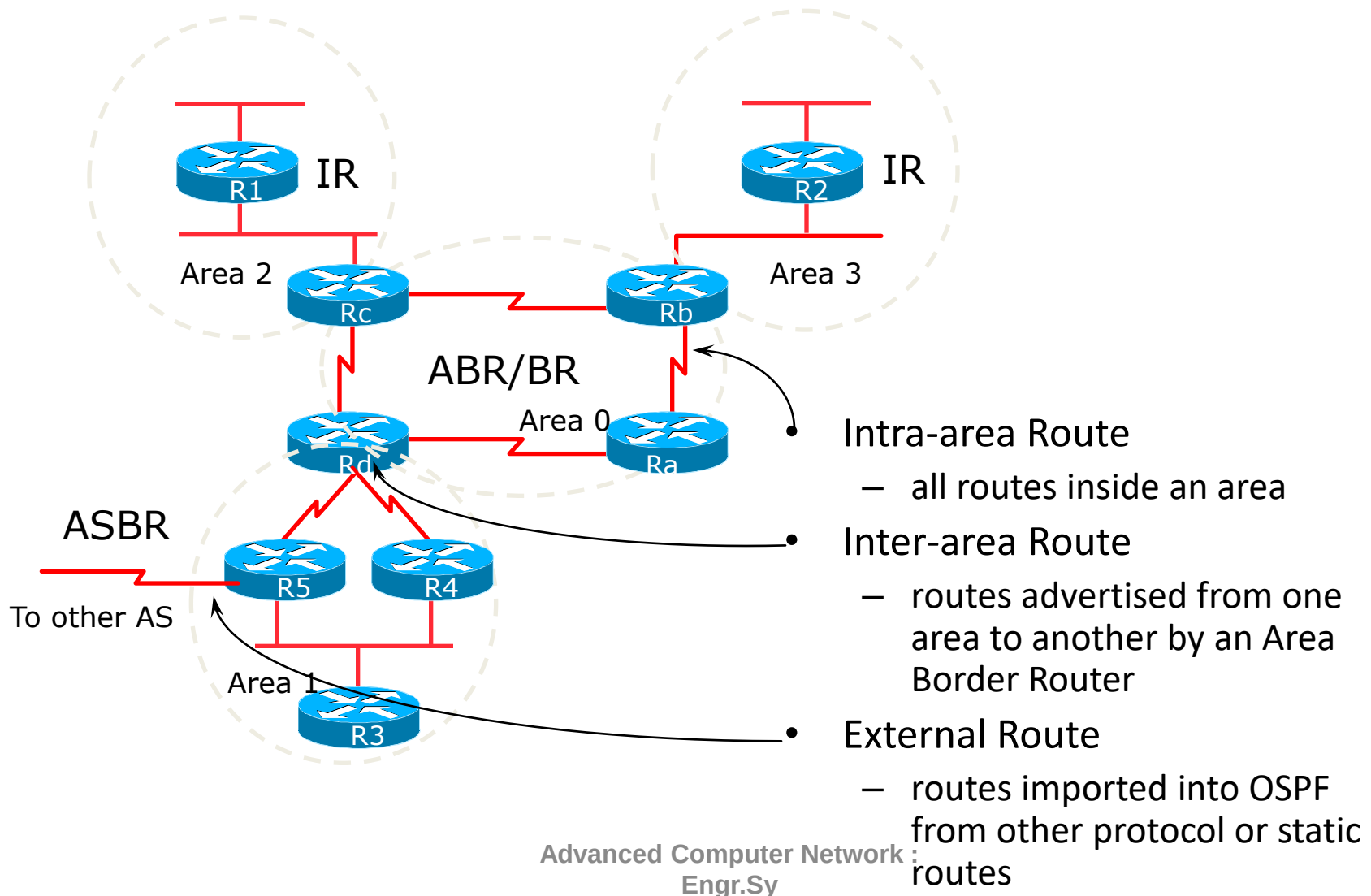
ASBR- Autonomous System Boundary router

If one interface is in OSPF Domain and other interface is in other routing protocols

IR- Internal Router

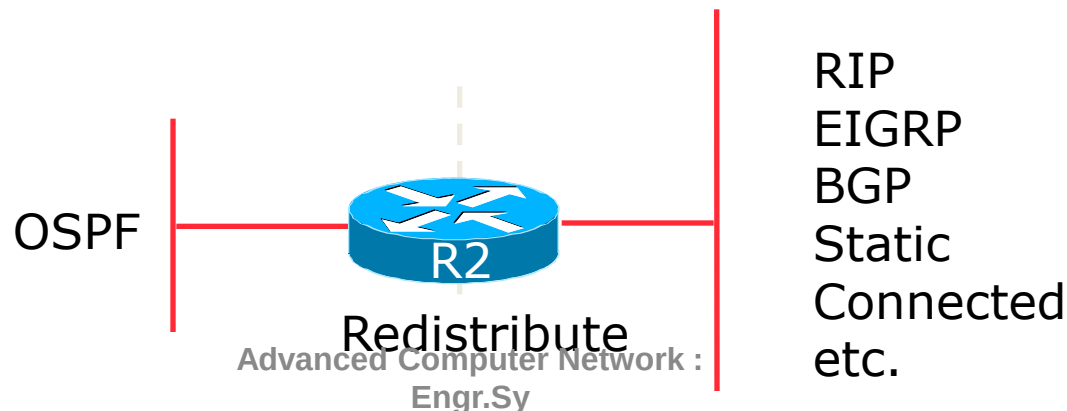
Router running area of backbone, IR only needs to maintain an area centric local database

OSPF Route Types



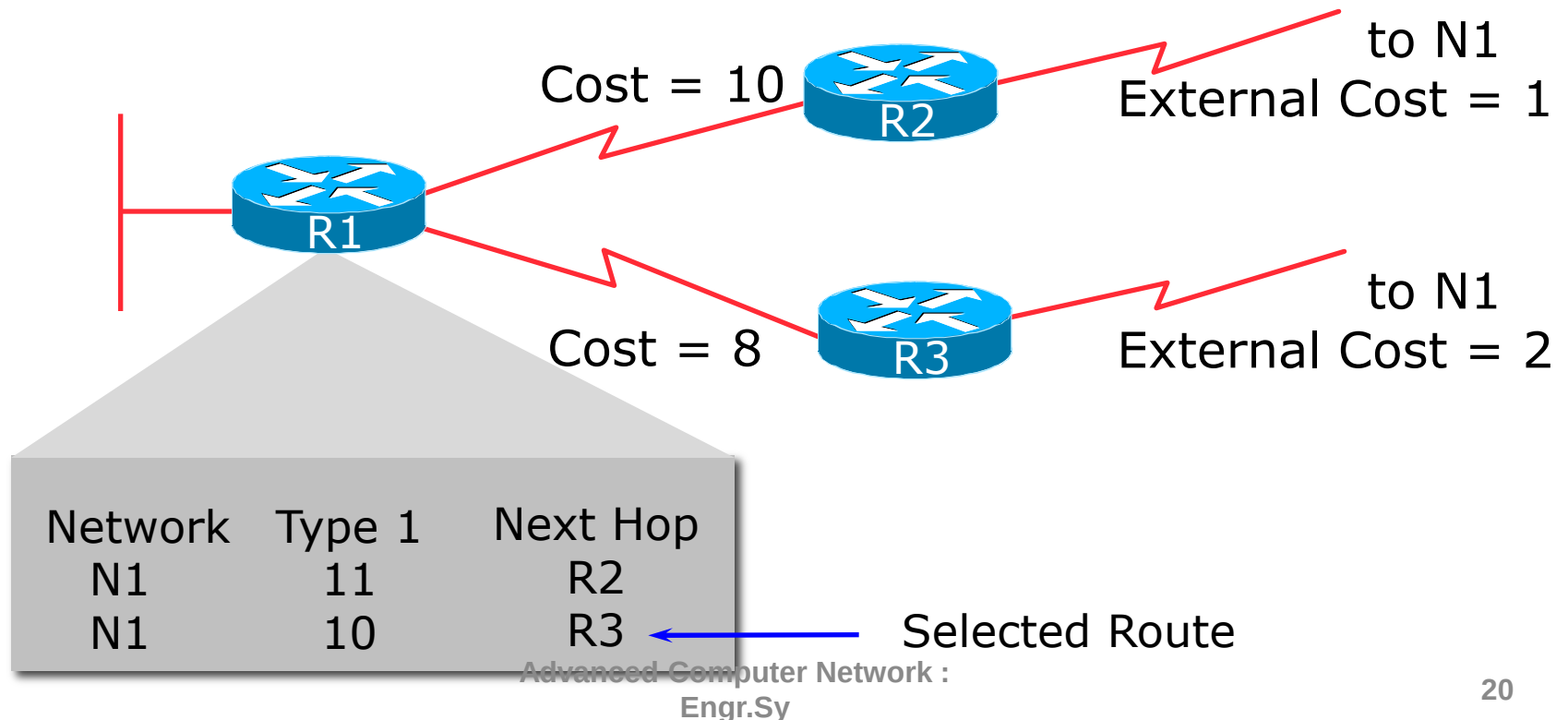
External Routes

- 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)



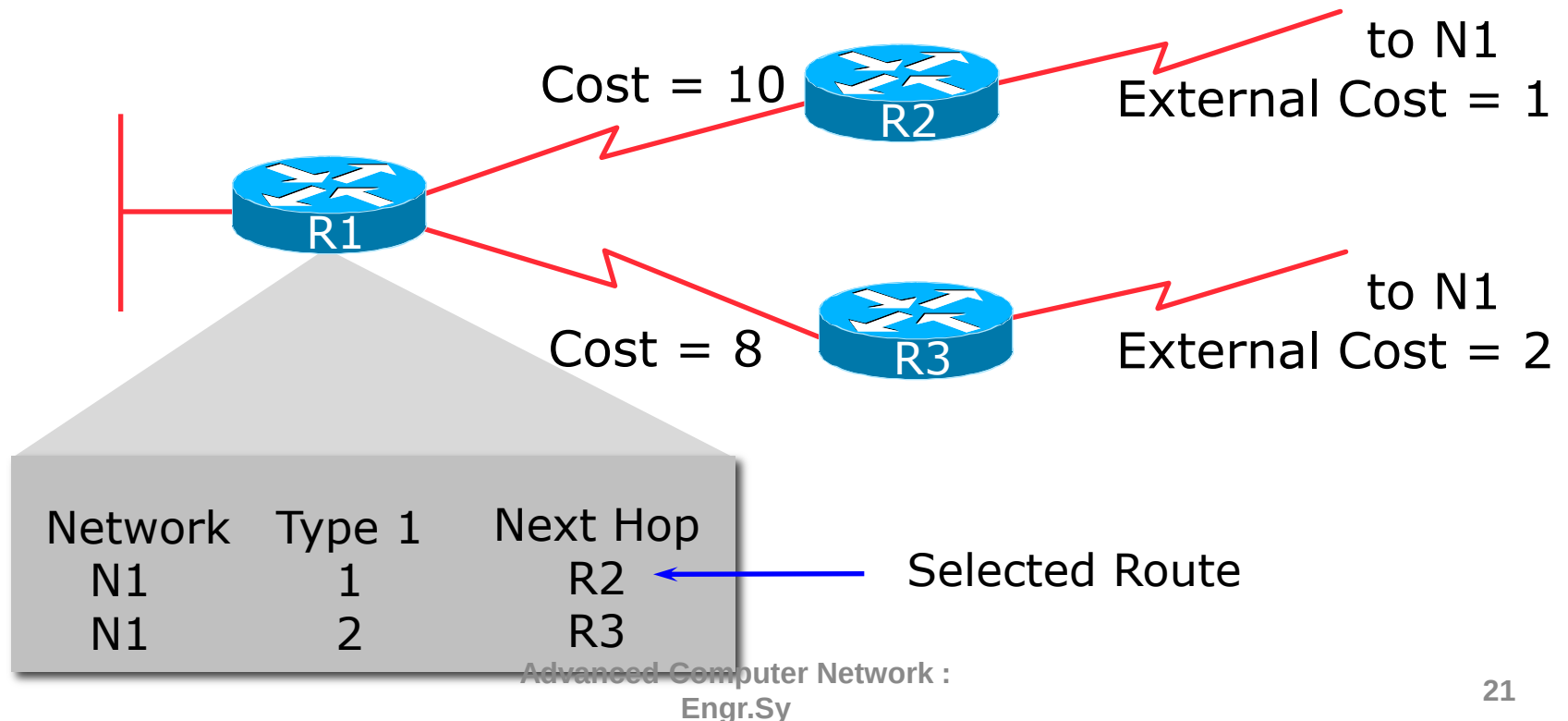
External Routes

- 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



OSPF Metric Cost

- Cost- Inverse Proportional of Bandwidth

Cost = Reference Bandwidth / Interface Bandwidth

Any decimal value should be rounder back in nearest integer

Any value below 1 would be considered as 1 .

Reference Bandwidth- Arbitrary value in OSPF , in Cisco 100 Mbps but other vendors they have its own ref.bandwidth

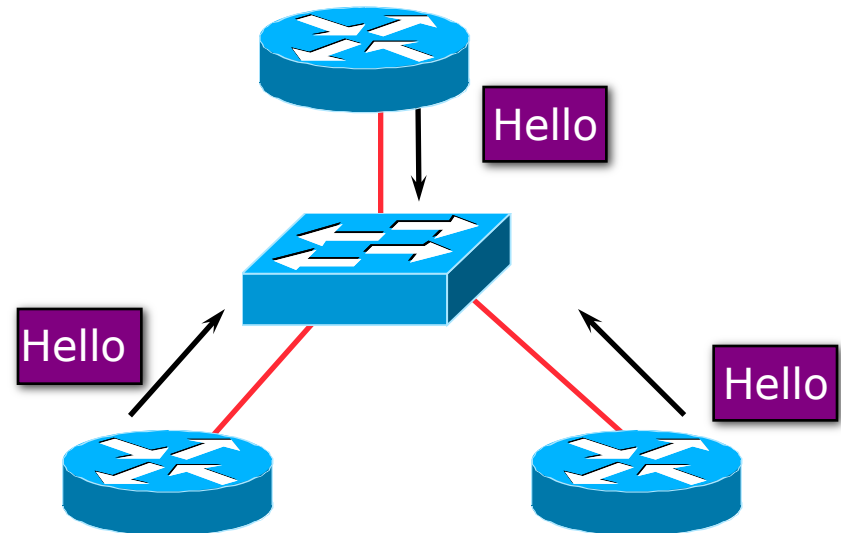
Interface	Bandwidth	Metric Calculation	Cost
Ethernet Link	10 Mbps	$10^8/10 \text{ Mbps}$	10
Fast Ethernet	100 Mbps	$10^8/100 \text{ Mbps}$	1
Serial Link	1544 Kbps	$10^8/1544 \text{ Kbps}$	64

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

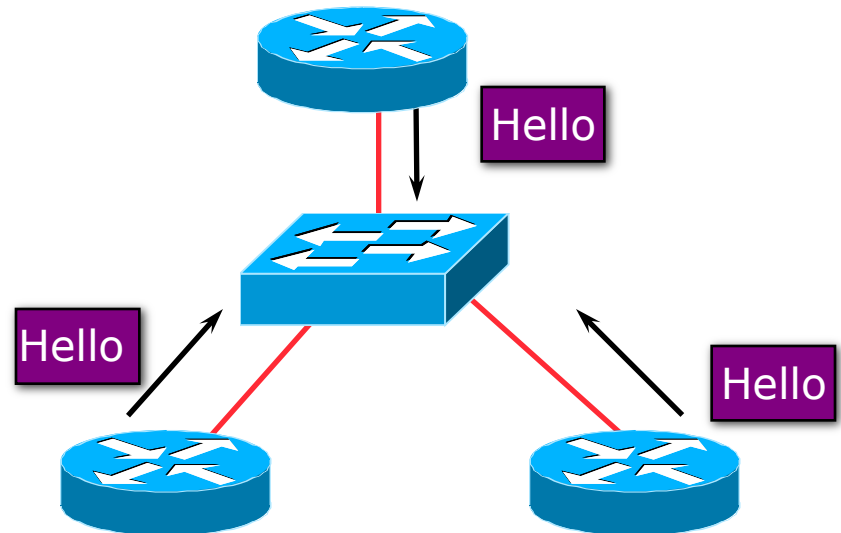
- Responsible for establishing and maintaining neighbour relationships
- Elects designated router on multi-access networks
- Send packets in every 10 seconds in multi segments and every 30s in non Broadcast multi-access



Hello – Used to establish and maintained adjacency with other OSPF routers they are also used to elect designated router and back up designated router

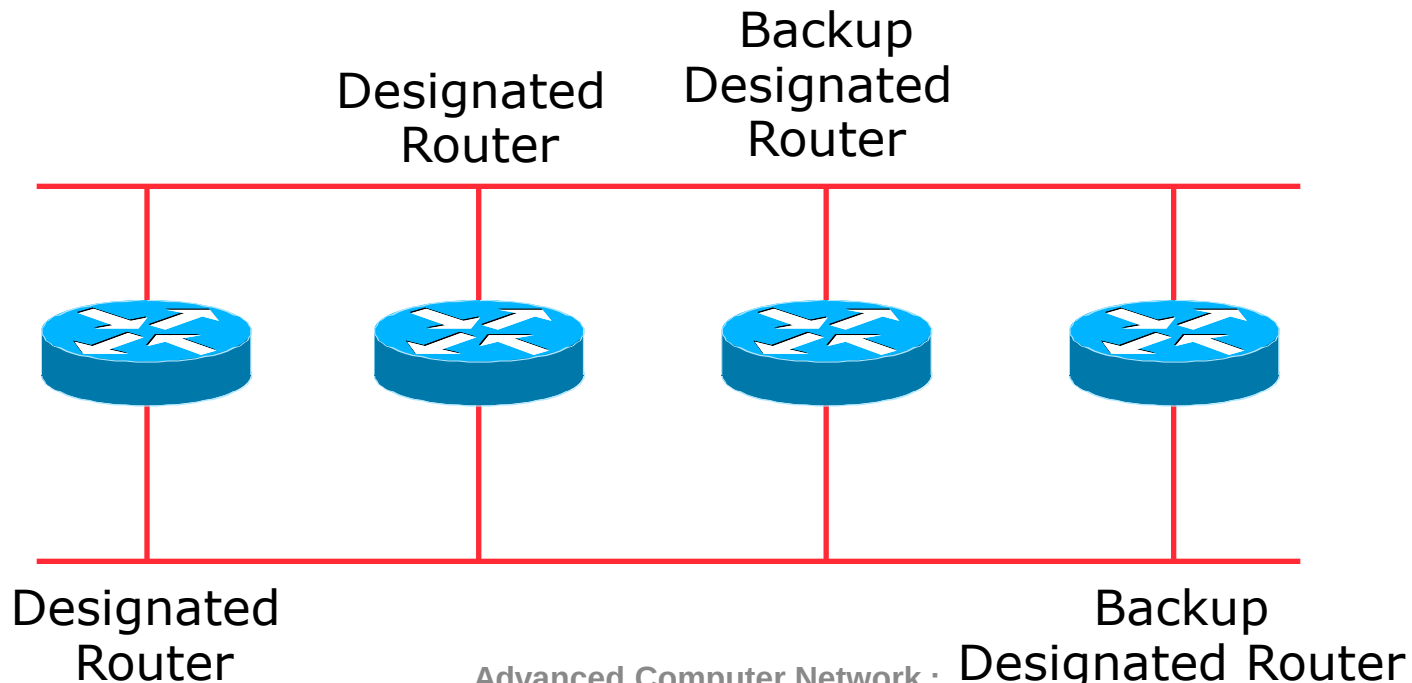
The Hello Packet

- Contains:
 - Router priority
 - Hello interval
 - Router dead interval
 - Network mask
 - List of neighbours
 - DR and BDR



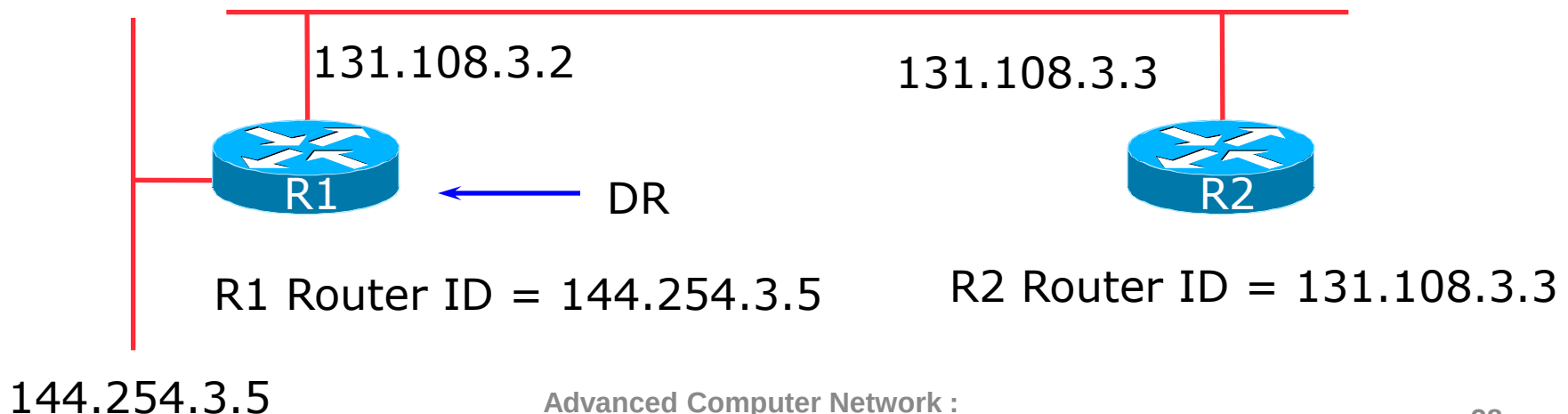
Designated Router

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



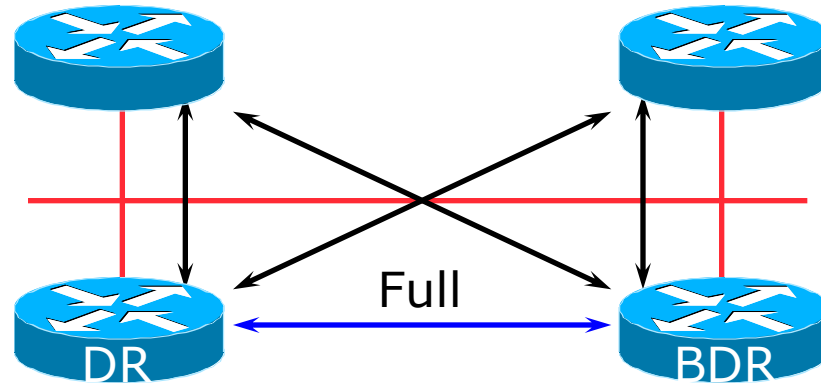
Designated Router by Priority

- 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



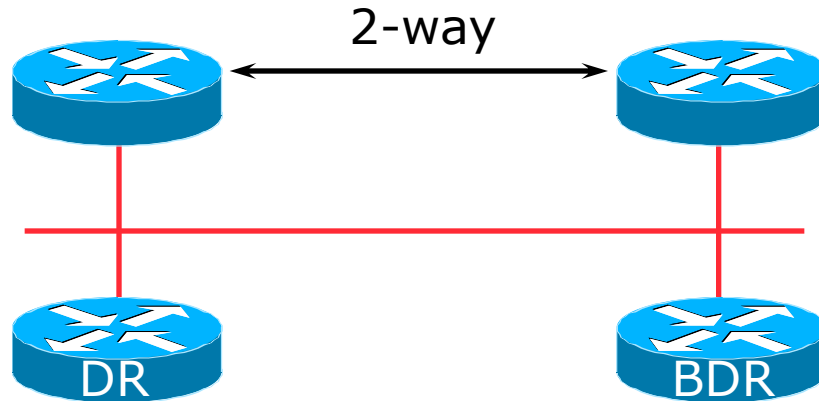
Neighbouring States

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



Neighbouring States

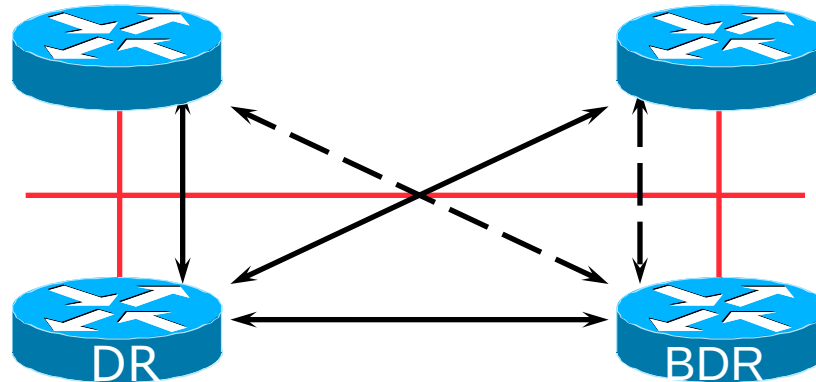
- 2-way
 - Router sees itself in other Hello packets
 - DR selected from neighbours in state 2-way or greater



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)

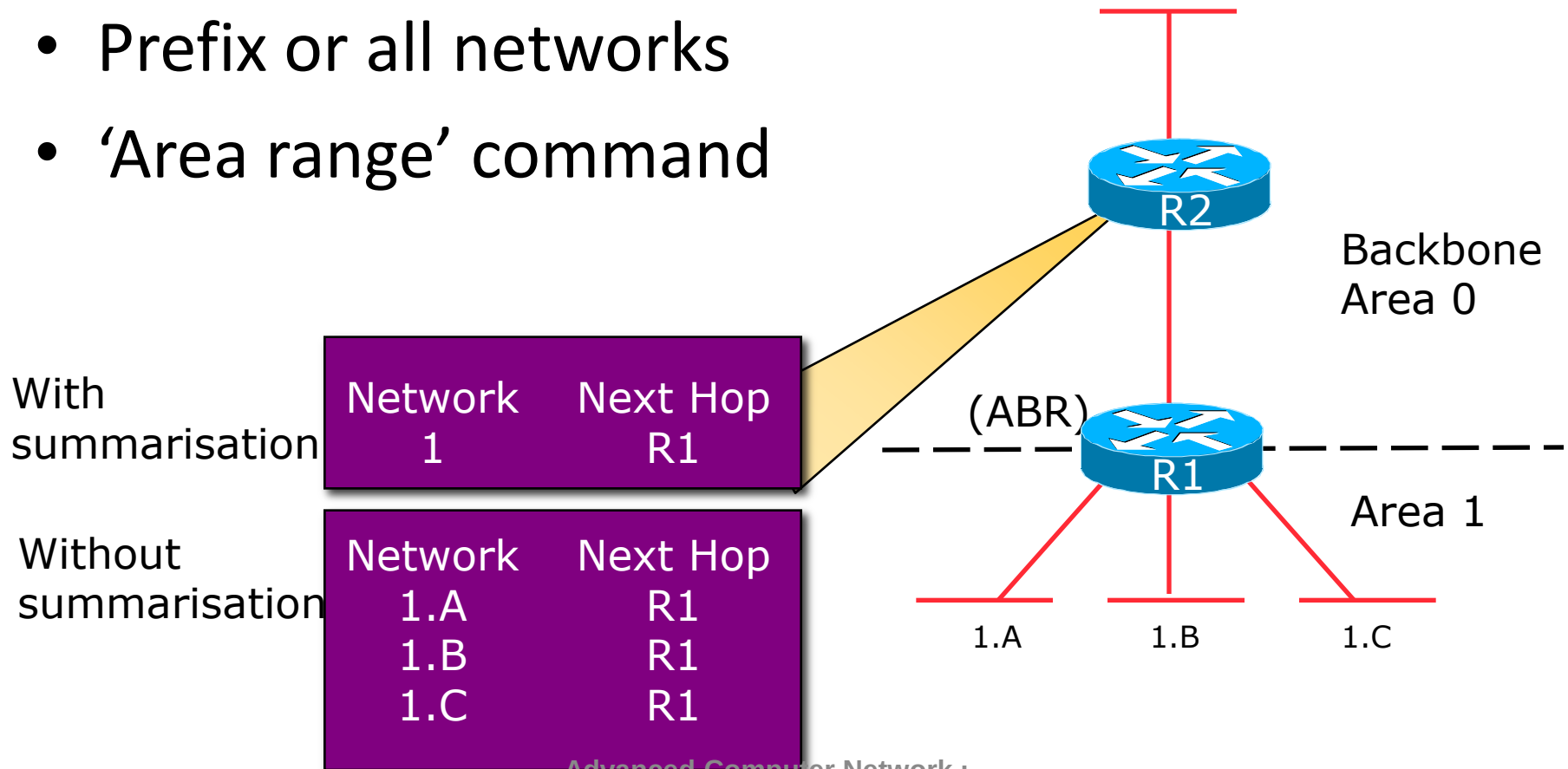
- Describes the destination outside the area but still in the AS
- Flooded throughout a single area
- Originated by an ABR
- Only inter-area routes are advertised into the backbone
- Type 4 is the information about the ASBR

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)

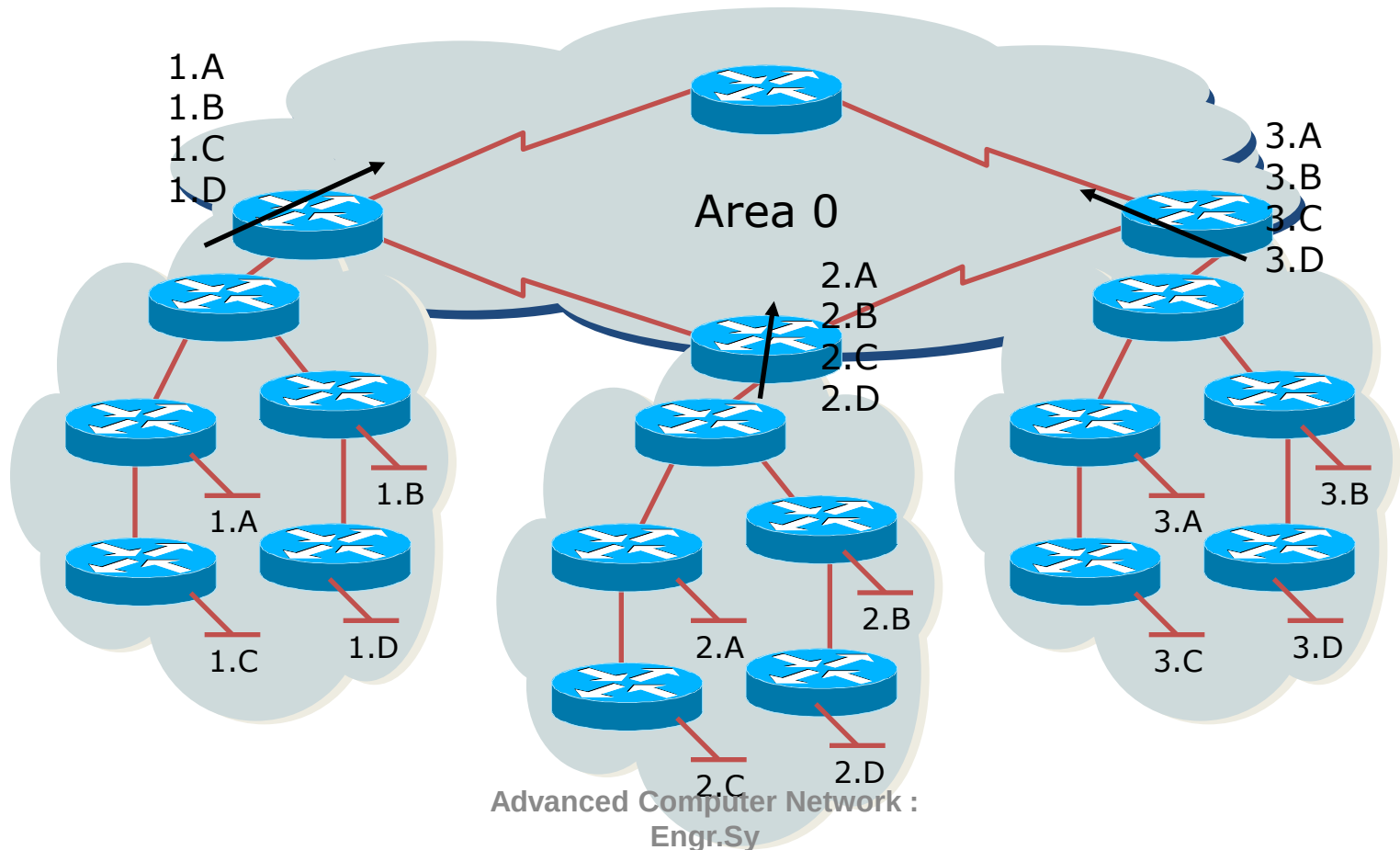
Inter-Area Route Summarisation

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



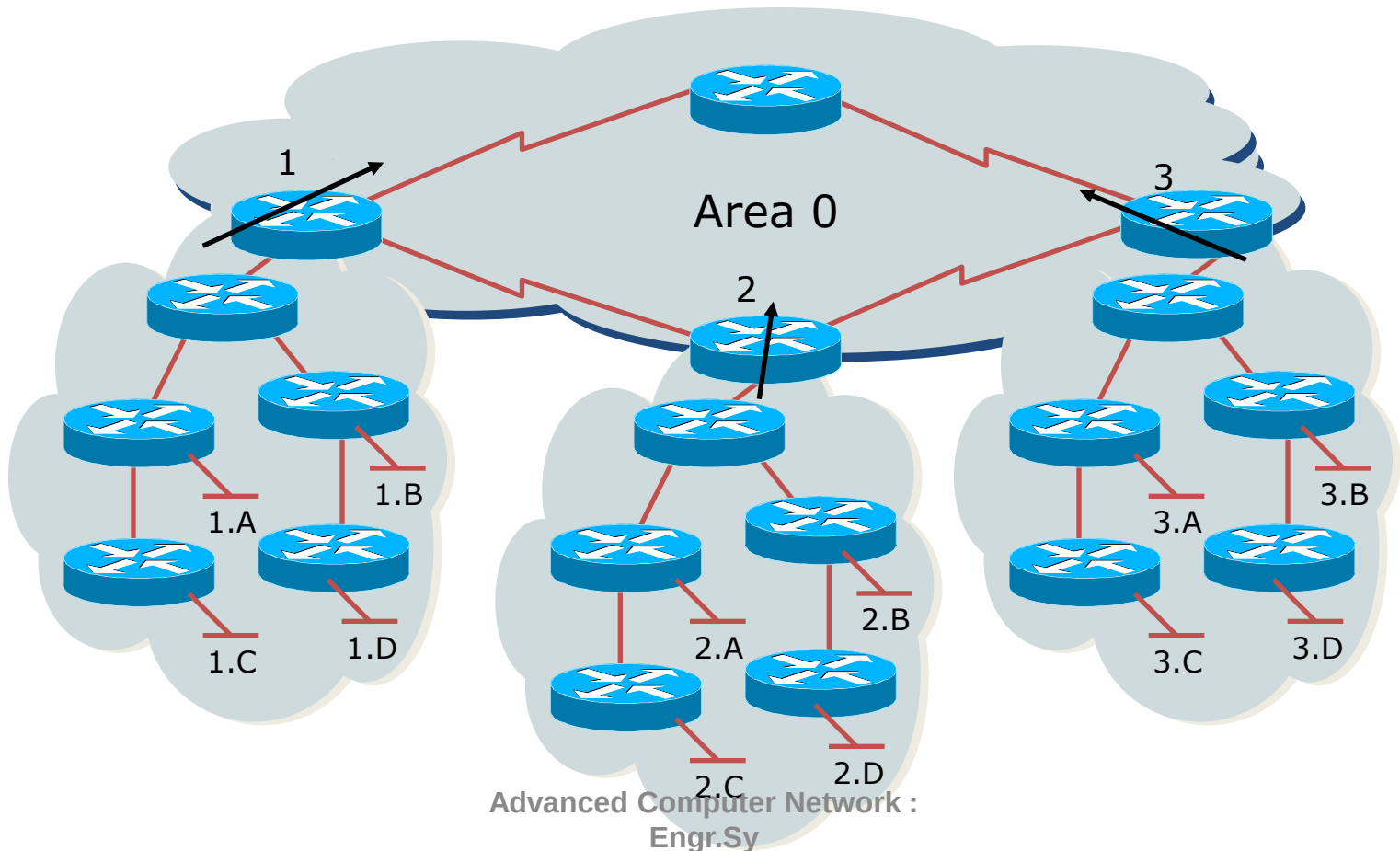
No Summarisation

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



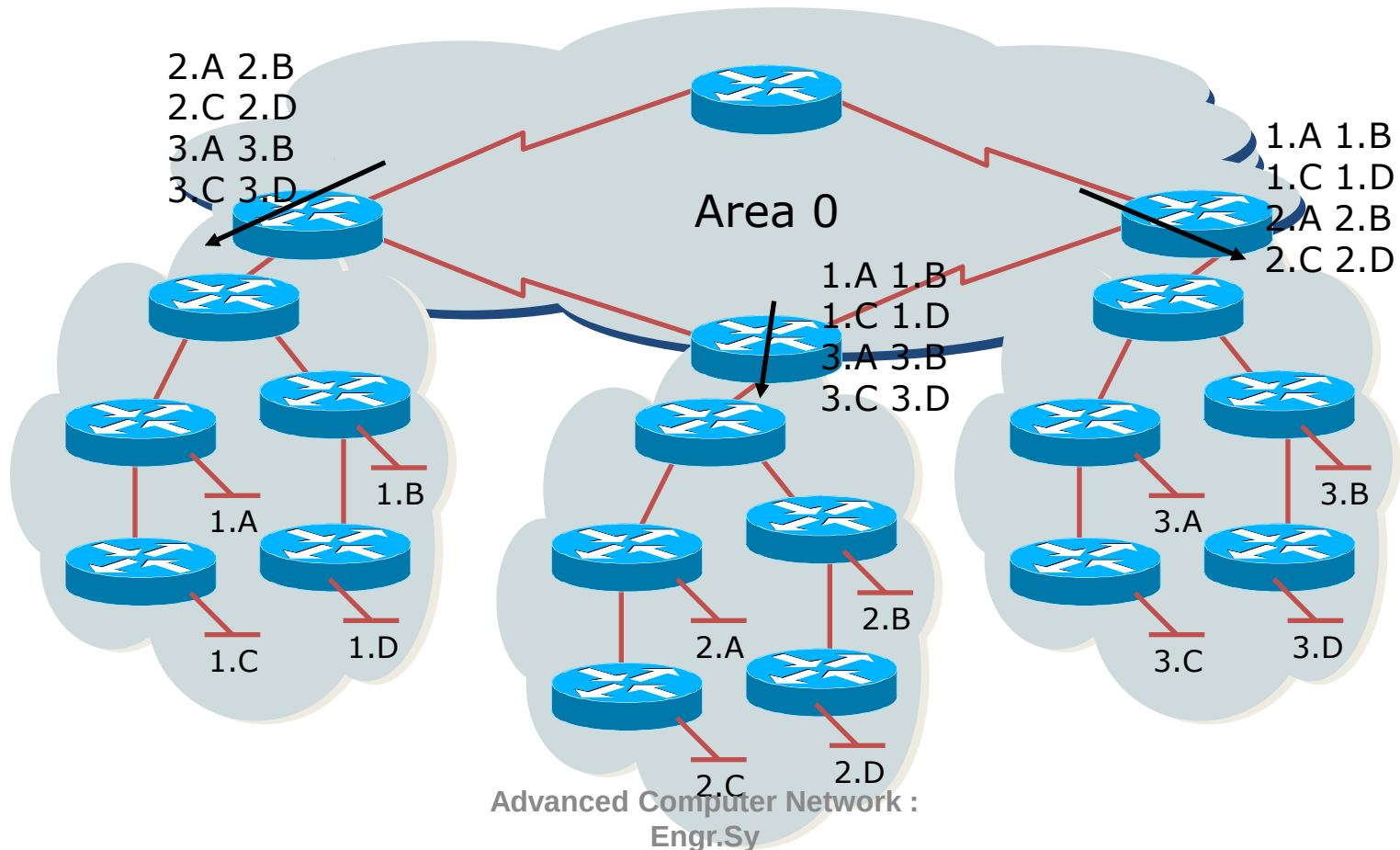
With Summarisation

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



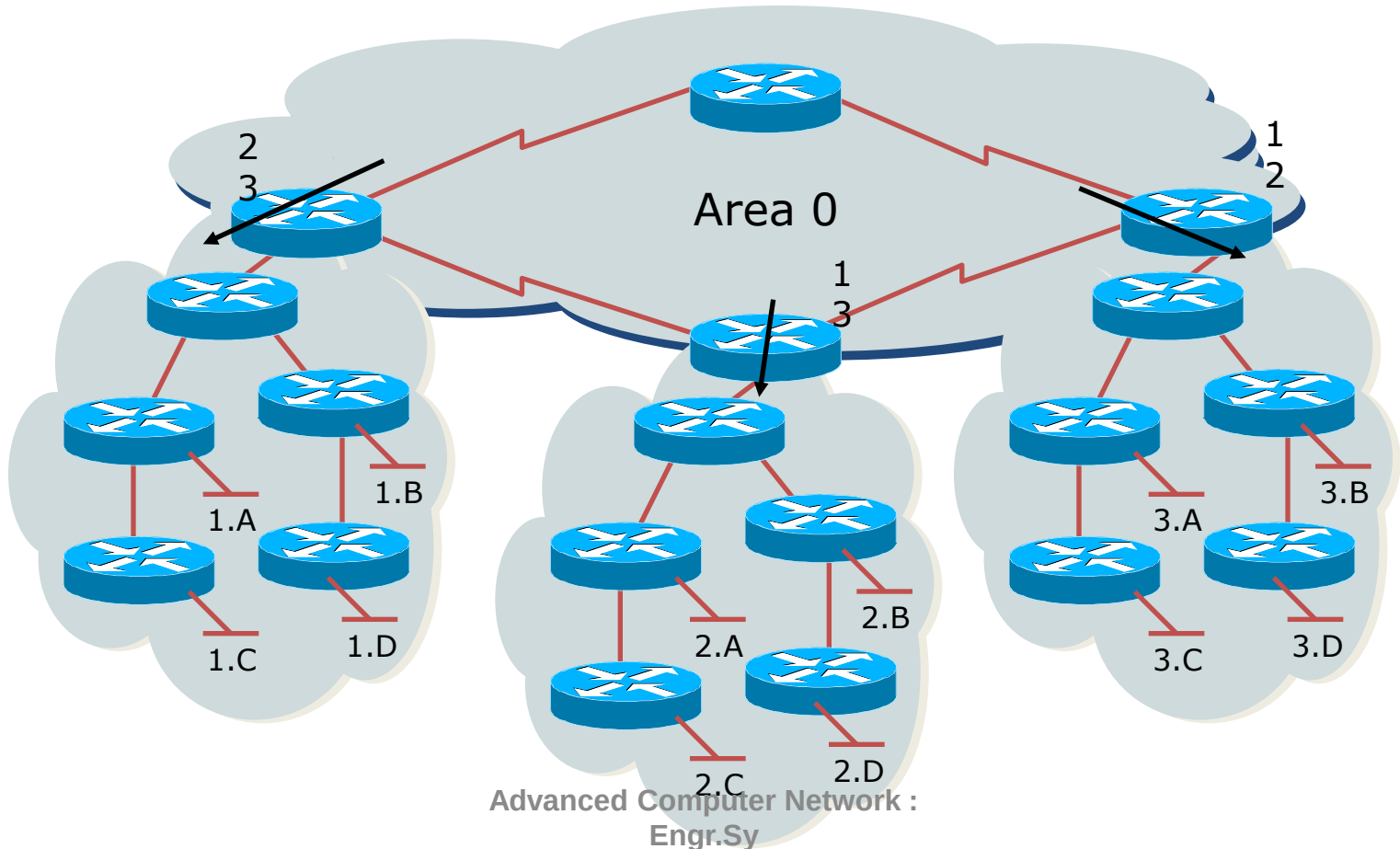
No Summarisation

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



With Summarisation

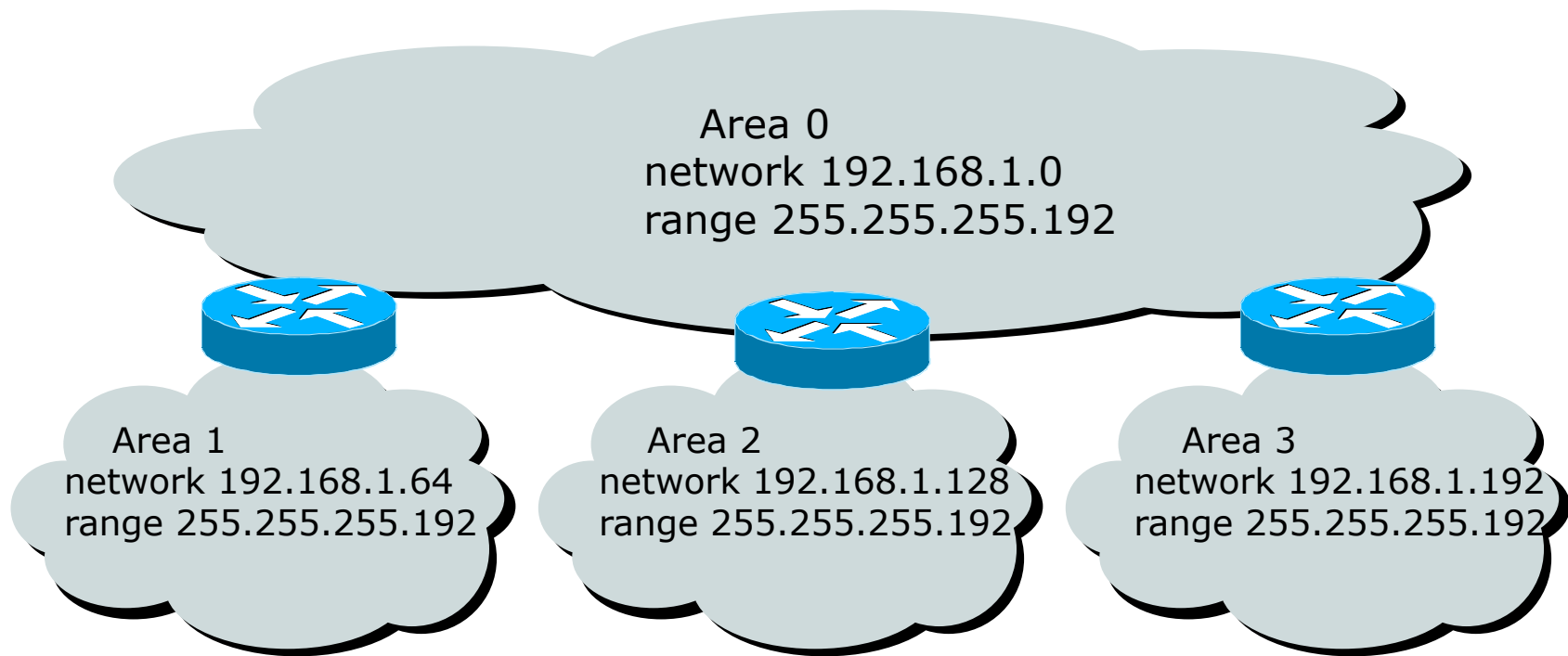
- Only summary link LSA advertised in to each area
- Link state changes do not propagate in to each area



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

OSPF packets

- Five types of OSPF packets
 - Hello(1)
 - Database description(2)
 - Link-State Request(3)/Update(4)/Acknowledgement(5)
- OSPF common header

Version	Type (1-5)	Packet Length
Router ID		
Area ID		
Checksum		Authentication Type
Authentication		
Authentication		

OSPF common header fields

- Version number: 2
- Type: Type of OSPF packet
- Packet length: in bytes, includes OSPF header
- Router ID: 32-bit number assigned to each OSPF running router – uniquely identifies router within AS
- Area ID: any four-byte number (0.0.0.0 reserved for backbone area)
- Checksum: error detection
- Three Authentication related fields: to authenticate OSPF packets

Hello packet

Network mask		
Hello interval	Options	Priority
Dead interval		
Designated router		
Backup designated router		
Neighbor 1		
...		
Neighbor n		

Hello packet fields

- Network mask: Subnet mask of the interface the packet is sent on
- Hello interval: Number of seconds between Hello packets
- Options: optional capabilities supported by the router
- Priority: of the router – used in election of designated router
- Dead interval: Number of seconds before declaring a nonresponding neighbor down
- Designated router/Backup: Every broadcast network with at least two routers has a designated router. This sends network LSAs for the broadcast network. This field is 0.0.0.0 if there is no designated router
- Neighbors: Router ID of each neighbor from whom Hello packets have recently been received

Activity 3 – Lab

