

# Introduction to OSPF

ISP/IXP Workshops

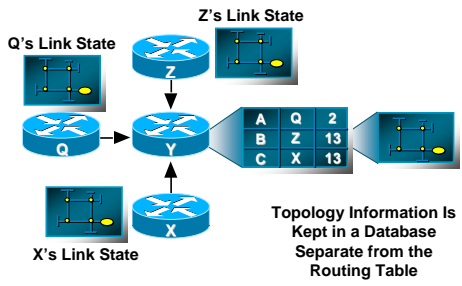
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## OSPF

- **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**

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## Link State



Topology Information Is Kept in a Database Separate from the Routing Table

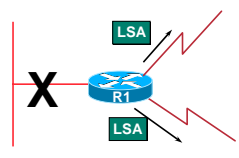
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## Link State Routing

- **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

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## Low Bandwidth Utilisation

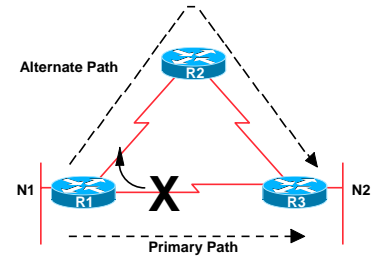


- **Only changes propagated**
- **Multicast on multi-access broadcast networks**

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## Fast Convergence

- **Detection Plus LSA/SPF**



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## Fast Convergence

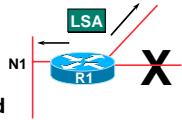
- Finding a new route

LSA flooded throughout area

Acknowledgement based

Topology database synchronised

Each router derives routing table to destination networks



## IP Multicast for Sending/Receiving Updates

- Broadcast networks

All routers must accept packets sent to AllISPF Routers (224.0.0.5)

All DR and BDR routers must accept packets sent to AllID Routers (224.0.0.6)

- Hello packets sent to AllISPF Routers (Unicast on point-to-point and virtual links)

## OSPF Areas

- Group of contiguous hosts and networks

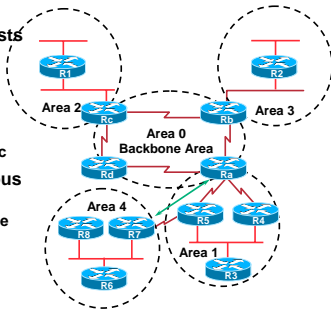
- Per area topological database

Invisible outside the area  
Reduction in routing traffic

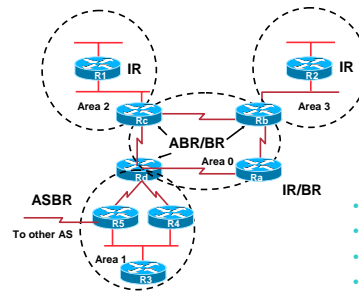
- Backbone area contiguous

All other areas must be connected to the backbone

- Virtual Links

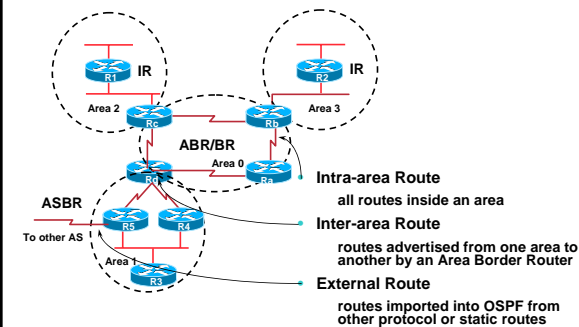


## Classification of Routers



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

## OSPF Route Types



## Inter-Area Route Summarisation

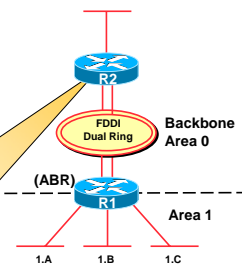
- Prefix or all subnets
- Prefix or all networks
- 'Area range' command

With summarisation

Network	Next Hop
1	R1

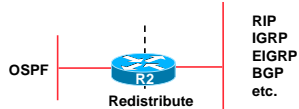
Without summarisation

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



## External Routes

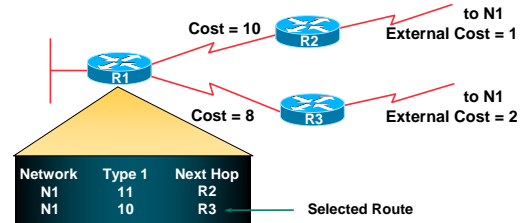
- Prefixes which are redistributed into OSPF from other protocols
- Flooded unaltered throughout the AS
- OSPF supports two types of external metrics
  - Type 1 external metrics
  - Type 2 external metrics (Default)



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## External Routes

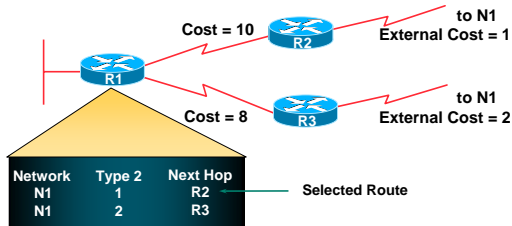
- Type 1 external metric: metrics are added to the summarised internal link cost



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## External Routes

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



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## 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

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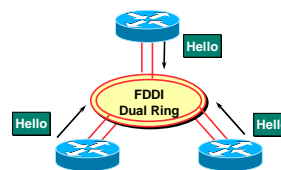
## Protocol Functionality

- Bringing up adjacencies
- LSA types
- Area classification

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## The Hello Protocol

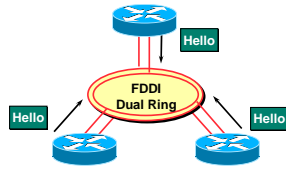
- Responsible for establishing and maintaining neighbour relationships
- Elects designated router on multi-access networks



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## The Hello Packet

- Router priority
- Hello interval
- Router dead interval
- Network mask
- Options: T-bit, E-bit
- List of neighbours

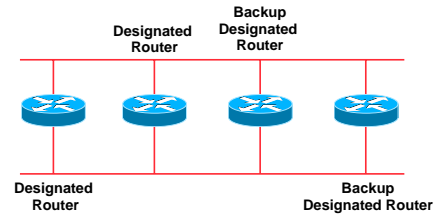


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## Designated Router

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

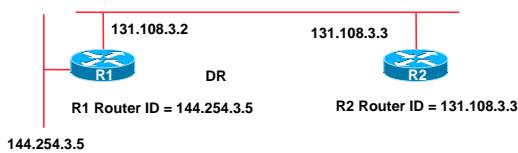


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## Designated Router by Priority

- Configured priority (per interface)
- Else determined by highest router ID  
Router ID is the loopback interface address, if configured, otherwise the highest IP address

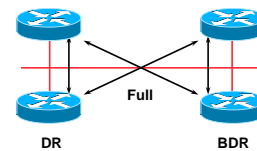


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## Neighbouring States

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

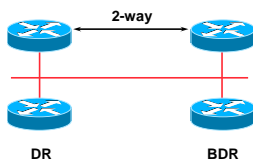


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## Neighbouring States

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



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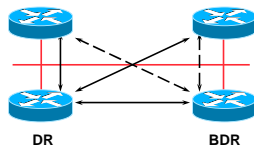
## When to Become Adjacent

- 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

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## LSAs Propagate Along Adjacencies



- LSAs acknowledged along adjacencies

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## 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

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## 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

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## 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

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## 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

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## 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

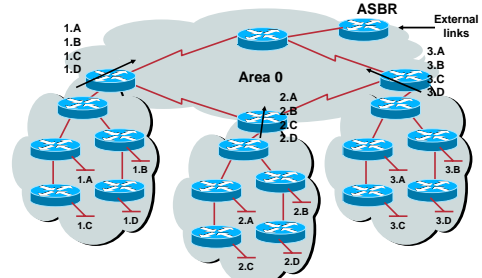
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## External LSA (Type 5 and 7)

- 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)

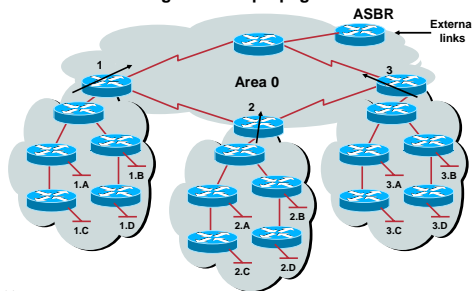
## No Summarisation

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



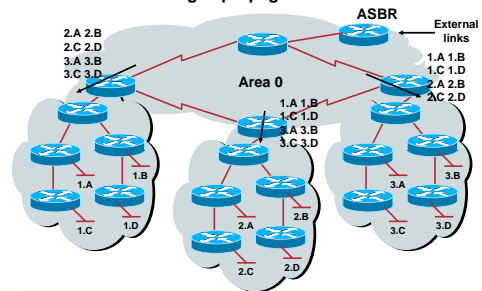
## With Summarisation

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



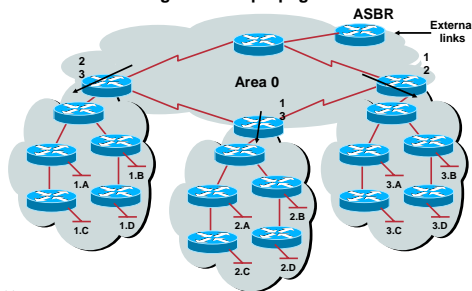
## No Summarisation

- 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

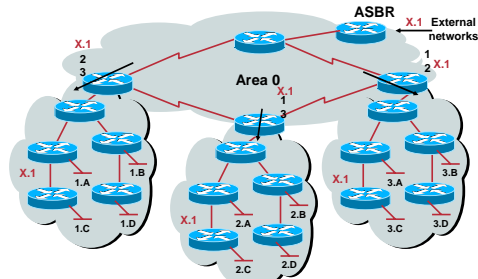


## Types of Areas

- Regular
- Stub
- Totally Stubby
- Not-So-Stubby

## Regular Area (Not a Stub)

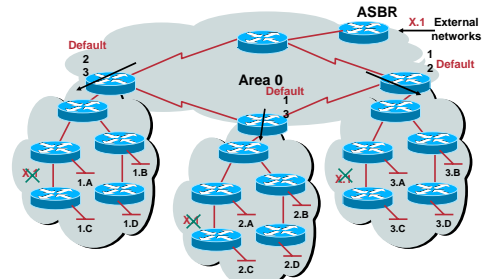
- From Area 1's point of view, summary networks from other areas are injected as are external networks such as X.1



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## Normal Stub Area

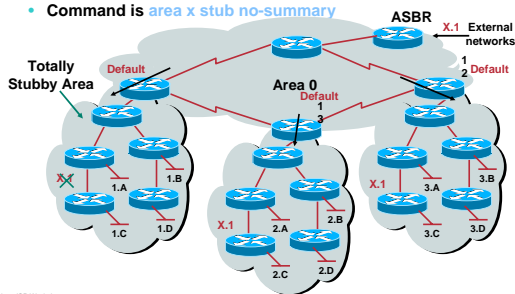
- Summary networks, default route injected
- Command is `area x stub`



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## Totally Stubby Area

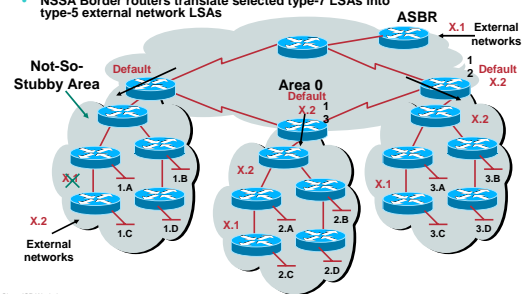
- Only a default route injected
- Default path to closest area border router
- Command is `area x stub no-summary`



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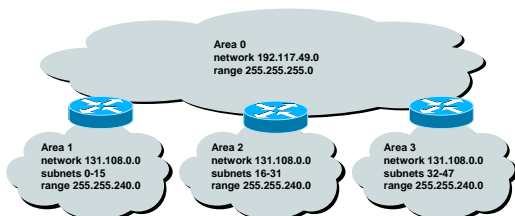
## Not-So-Stubby Area

- 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



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## Addressing for Areas



Assign contiguous ranges of subnets per area to facilitate summarisation

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## Summary

- Scalable OSPF Network Design
  - Area hierarchy
  - Stub areas
  - Contiguous addressing
  - Route summarisation

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# Introduction to OSPF

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