



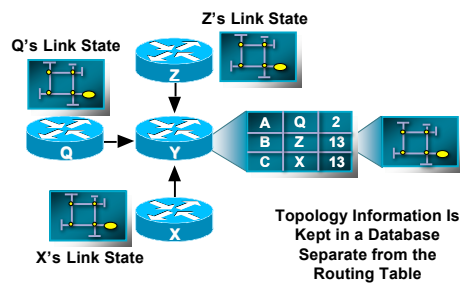
## Introduction to OSPF

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

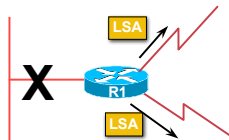
## Link State



## Link State Routing

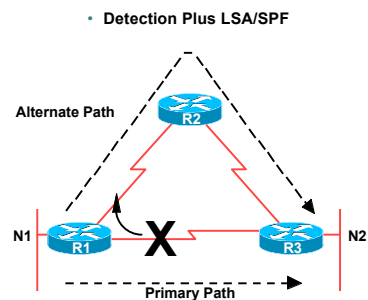
- Neighbour discovery
- Constructing a Link State Packet (LSP)
- Distribute the LSP  
(Link State Announcement – LSA)
- Compute routes
- On network failure  
New LSPs flooded  
All routers recompute routing tables

## Low Bandwidth Utilisation



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

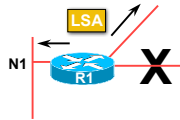
## Fast Convergence



## 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

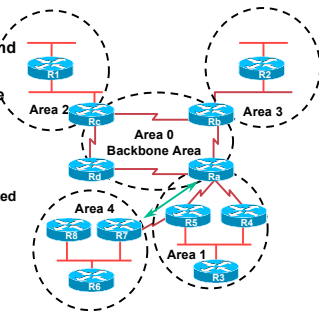
All routers must accept packets sent to AllSPFRouters (224.0.0.5)

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

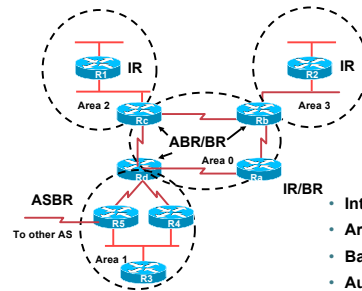
- Hello packets sent to AllSPFRouters (Unicast on point-to-point and virtual links)

## 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

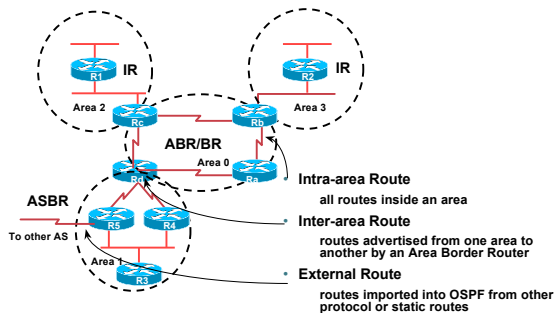


## Classification of Routers



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

## OSPF Route Types



## Inter-Area Route Summarisation

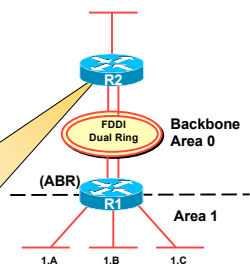
- Prefix or all subnets
- Prefix or all networks
- 'Area range' command

With summarisation

Network	Next Hop
1	R1

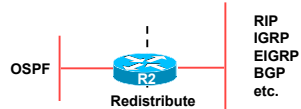
Without summarisation

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



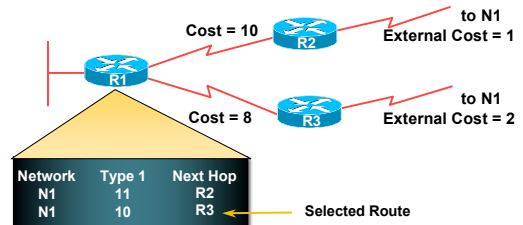
## External Routes

- 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)



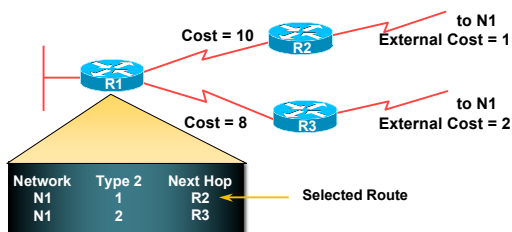
## External Routes

- 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

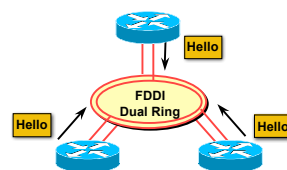
- A router has a separate LS database for each area to which it belongs
- All routers belonging to the same area have identical database
- SPF calculation is performed separately for each area
- LSA flooding is bounded by area

## Protocol Functionality

- Bringing up adjacencies
- LSA types
- Area classification

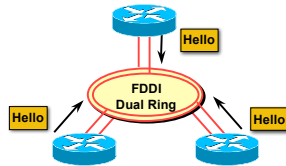
## The Hello Protocol

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



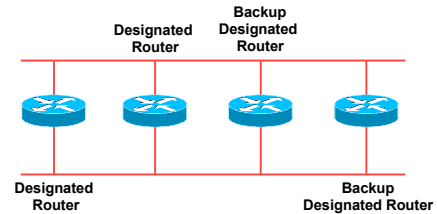
## The Hello Packet

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



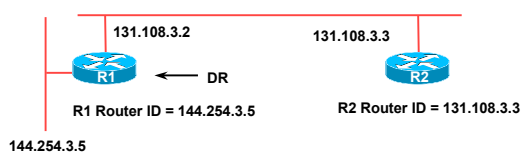
## Designated Router

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



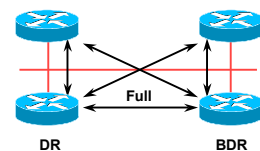
## Designated Router by Priority

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



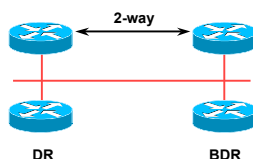
## Neighbouring States

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



## Neighbouring States

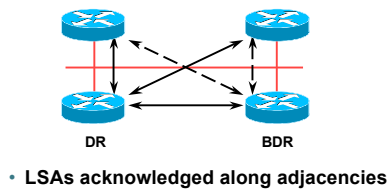
- 2-way
  - Router sees itself in other Hello packets
  - DR selected from neighbours in state 2-way or greater



## When to Become Adjacent

- Underlying network is point to point
- Underlying network type is virtual link
- The router itself is the designated router
- 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



## 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)

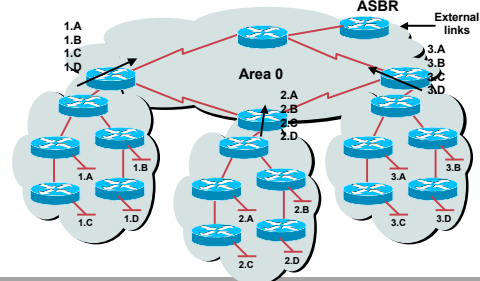
- Describes the destination outside the area but still in the AS
- Flooded throughout a single area
- Originated by an ABR
- Only inter-area routes are advertised into the backbone
- Type 4 is the information about the ASBR

## 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)

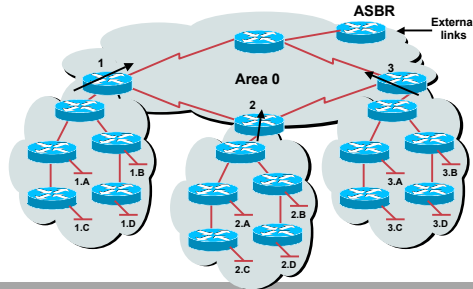
## No Summarisation

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



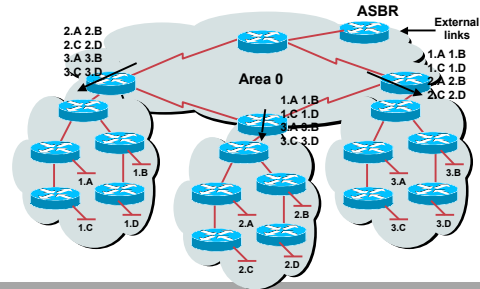
## With Summarisation

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



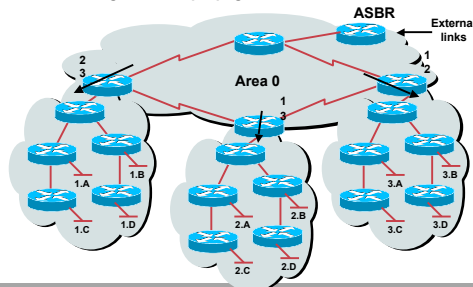
## No Summarisation

- 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

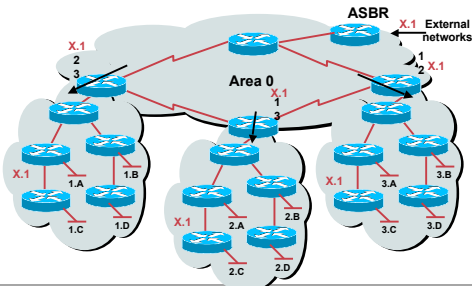


## Types of Areas

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

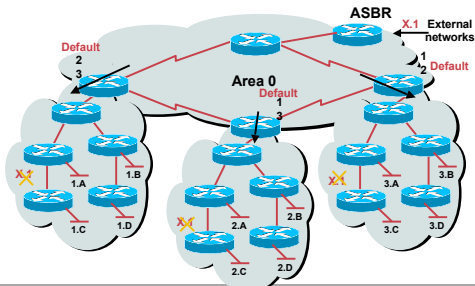
## Regular Area (Not a Stub)

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



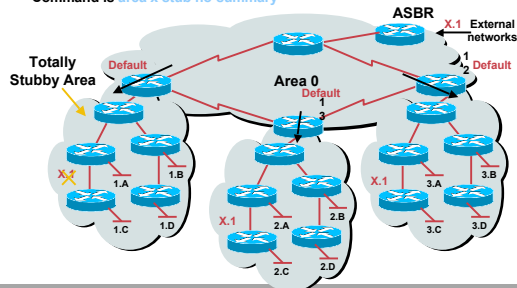
## Normal Stub Area

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



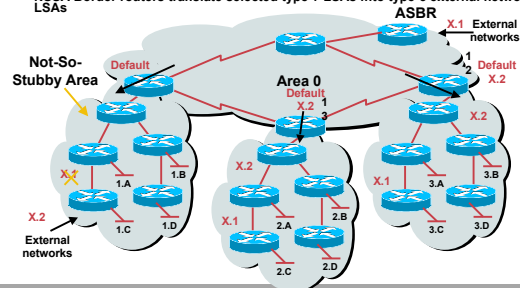
## Totally Stubby Area

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

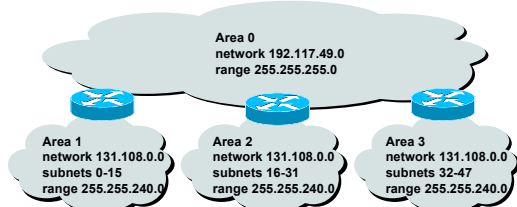


## Not-So-Stubby Area

- 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



## Addressing for Areas



Assign contiguous ranges of subnets per area to facilitate summarisation

## Summary

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



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