## Slide 1

**Introduction to OSPF**

**ISP/IXP Workshops**

## Slide 2

## OSPF

- **O**pen **S**hortest **P**ath **F**irst
- **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**

## Slide 3

## Link State



Z's Link State

Q's Link State

| A | Q | 2 |
| B | Z | 13 |
| C | X | 13 |

**Topology Information Is Kept in a Database Separate from the Routing Table**
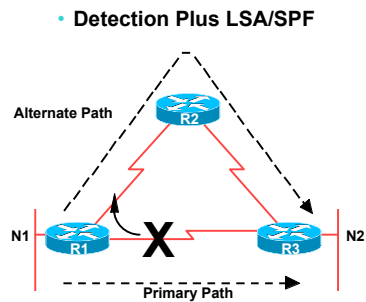
X's Link State

## Slide 4
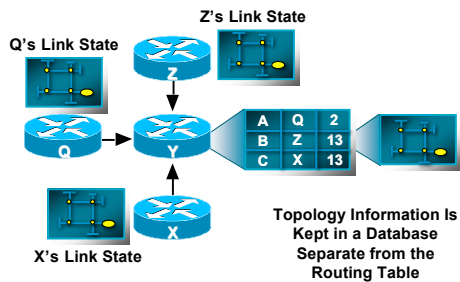
## Link State Routing

- **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**

## Slide 5

## Low Bandwidth Utilisation



LSA

X    R1

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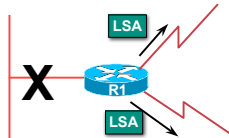
- **Only changes propagated**
- **Multicast on multi-access broadcast networks**

## Slide 6

## Fast Convergence

- **Detection Plus LSA/SPF**



Alternate Path

R2

N1    R1    X    R3    N2

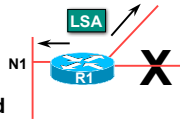**Primary Path**

## Fast Convergence

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

## 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

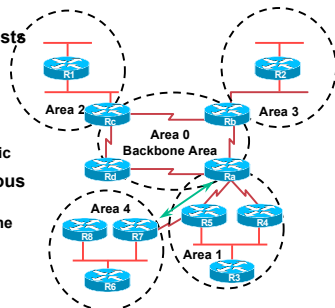- **Group of contiguous hosts and networks**
- **Per area topological database**
  - Invisible outside the area
  - Reduction in routing traffic
- **Backbone area contiguous**
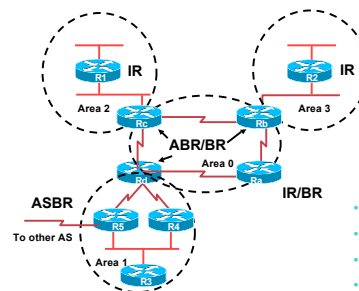  - All other areas must be connected to the backbone
- **Virtual Links**

## Classification of Routers

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

## OSPF Route Types
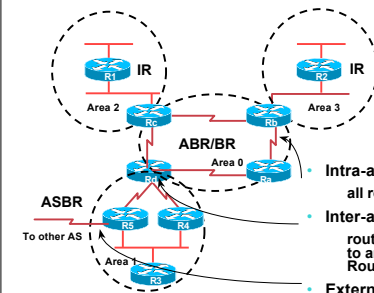
- **Intra-area Route**
  - all routes inside an area
- **Inter-area Route**
  - routes advertised from one area to another by an Area Border Router
- **External Route**
  - routes imported into OSPF from other protocol or static routes

## 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 |
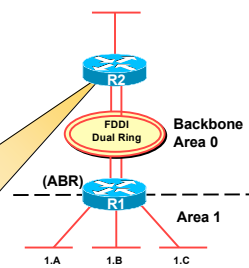
## External Routes

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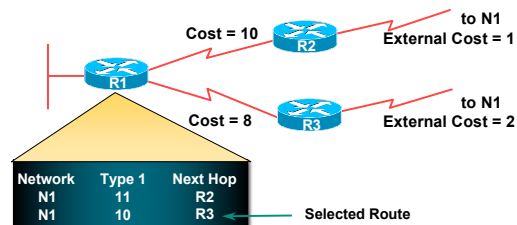  - Type 1 external metrics
  - Type 2 external metrics (Default)

OSPF ── R2 ── RIP
IGRP
EIGRP
BGP
etc.

**Redistribute**

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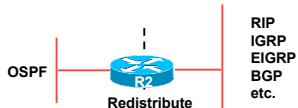
## External Routes

- **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 ←

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## 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 ←

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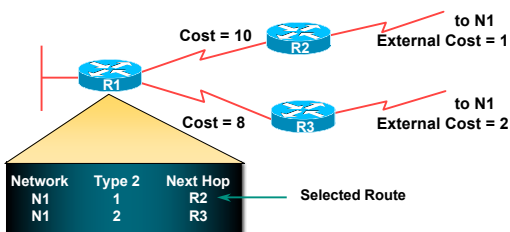
## Topology/Link State Database

- **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**
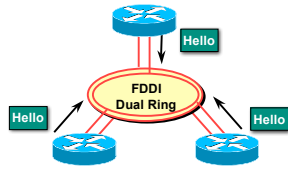- **Elects designated router on multi-access networks**

Hello

FDDI Dual Ring

Hello        Hello
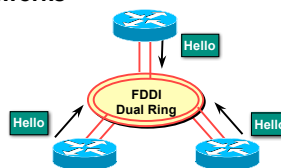
## The Hello Packet

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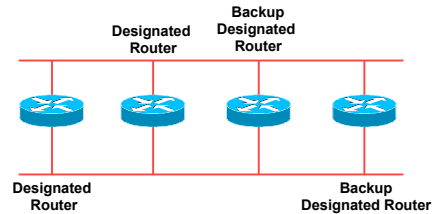- **Options: T-bit, E-bit**
- **List of neighbours**

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## Designated Router

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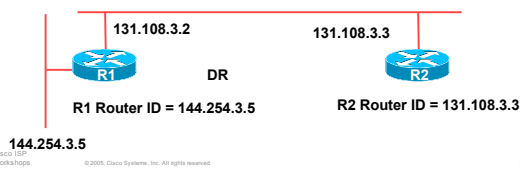  - **Assists in database synchronization**

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## Designated Router by Priority

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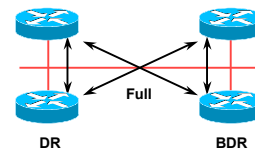  - **Router ID is the loopback interface address, if configured, otherwise the highest IP address**

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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**
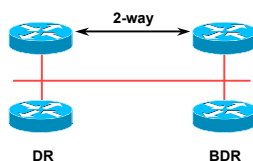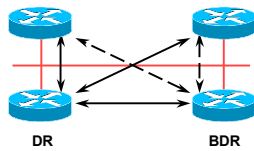
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## When to Become Adjacent

- **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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*4*

## 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**
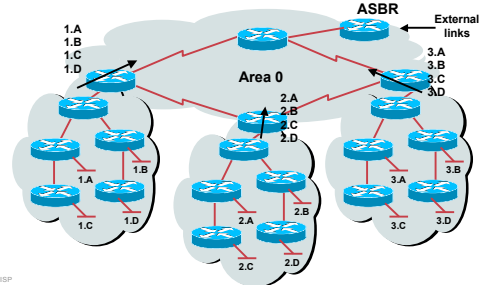- **(Type 7 LSAs used to describe external LSA for one specific OSPF area type)**

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## No Summarisation

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

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## With Summarisation

- **Only summary LSA advertised out of each area**
- **Link state changes do not propagate out of the area**
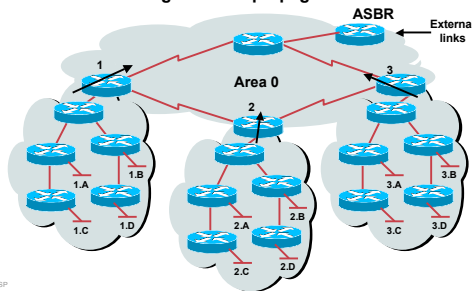
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## No Summarisation
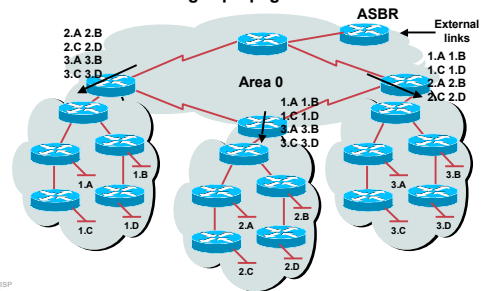
- **Specific Link LSA advertised in to each area**
- **Link state changes propagated in to each area**

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## With Summarisation

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

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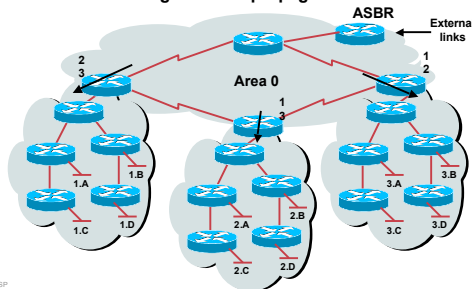
## Types of Areas

- **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
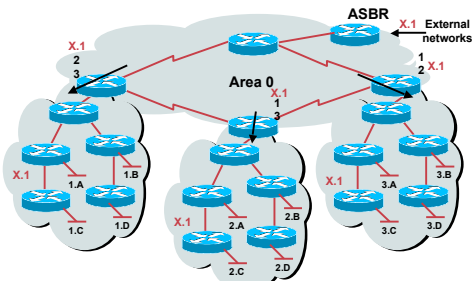
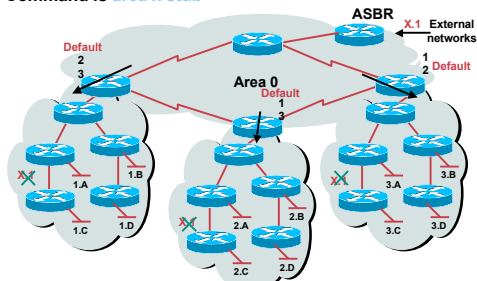## Normal Stub Area

- 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
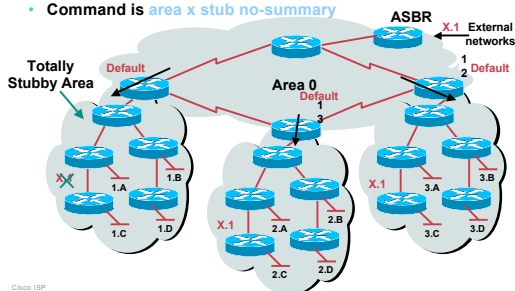
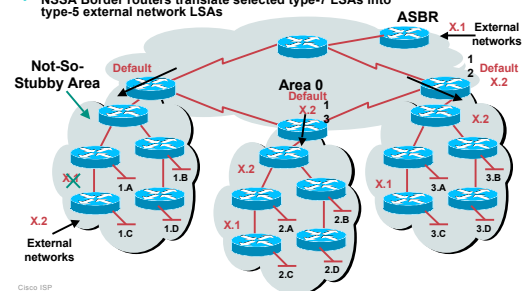## Not-So-Stubby Area

- 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
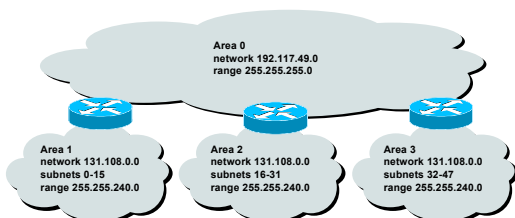
## Addressing for Areas



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**

Cisco ISP
Workshops

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