Introduction to OSPF

ISP/IXP Workshops
OSPF

- Dynamic Routing Protocol
- Link State technology
- Runs over IP, protocol 89
- Designed by IETF for TCP/IP
- Supports VLSM
- Multi-vendor
- Fast rerouting
• Minimises routing protocol traffic
• Low bandwidth requirements
• Supports different types of areas
• Route summarisation and authentication
• Cisco’s implementation is fully compliant with the specification OSPF v2.
Link State

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

Q’s Link State

Z’s Link State

X’s Link State

A  Q  2
B  Z  13
C  X  13
Link State Routing

- Neighbour discovery
- Constructing an LSP
- Distribute LSP
- 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
Optimal Path Utilisation

The optimal path is determined by the sum of the interface costs.

Cost = 1  Cost = 1

N2  N3
FDDI Dual Ring  FDDI Dual Ring

N1  R1

Cost = 10

N5

Cost = 10

N4

R2

R3

R4
Fast Convergence

- Detection Plus LSA/SPF
Fast Convergence

• Finding a new route

  LSA flooded throughout area

  Acknowledgement based

  Topology database synchronised

  Each router derives routing table to destination networks
Utilises IP Multicast for Sending/Receiving Updates

- **Broadcast networks**
  
  DR and BDR $\rightarrow$ AllISPFRouters (224.0.0.5)
  
  All other routers $\rightarrow$ AllIDRRouters (224.0.0.6)

- **Hello packets sent to AllISPFRouters**
  
  (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

<table>
<thead>
<tr>
<th>Network</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R1</td>
</tr>
<tr>
<td>1.A</td>
<td>R1</td>
</tr>
<tr>
<td>1.B</td>
<td>R1</td>
</tr>
<tr>
<td>1.C</td>
<td>R1</td>
</tr>
</tbody>
</table>
External Routes

- Redistributed into OSPF
- 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

<table>
<thead>
<tr>
<th>Network</th>
<th>Type 1</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>11</td>
<td>R2</td>
</tr>
<tr>
<td>N1</td>
<td>10</td>
<td>R3</td>
</tr>
</tbody>
</table>

Cost = 8

Cost = 10

Cost = 10

Selected Route

to N1
External Cost = 1
to N1
External Cost = 2
External Routes

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

<table>
<thead>
<tr>
<th>Network</th>
<th>Type 2</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>1</td>
<td>R2</td>
</tr>
<tr>
<td>N1</td>
<td>2</td>
<td>R3</td>
</tr>
</tbody>
</table>
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

• One per multi-access network

Generates network links 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

R1 Router ID = 144.254.3.5

R2 Router ID = 131.108.3.3
Neighbouring States

- **2-way**

  Router sees itself in other Hello packets

  DR selected from neighbours in state

  2-way or greater
• **Full**

  Routers are fully adjacent
  Databases synchronised
  Relationship to DR and BDR
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

- 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

- Five 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 intra-area routes are advertised into the backbone
- Type 4 is the information about the ASBR
External LSA (Type 5)

- 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
- Specific link LSA advertised out
- Link state changes propagate out
Summarised: Summary Links

- Only summary LSA advertised out
- Link state changes do not propagate
Not Summarised: Specific Links

- Specific link LSA advertised in
- Link state changes propagate in
• Only summary LSA advertised in
• Link state changes do not propagate
From area 1’s viewpoint

- Summary networks from other areas injected
- External networks injected, for example network X.1
Normal Stub Area

From area 1’s viewpoint

- Summary networks from other areas injected
- Default network injected into the area - represents external links
- Default path to closest area border router
- Define all routers in the area as stub

**area x stub** command
Totally Stubby Area

From area 1’s viewpoint

• Only a default network is injected into the area
  Represents external networks and all inter-area routes
• Default path to closest area border router
• Define all routers in the area as totally stubby

area x stub no-summary command

External Networks

ASBR

X.1

1,2

Default 2&3

1,3

1.A

1.B

1.D

1.C

2.A

2.B

2.D

2.C

3.A

3.B

3.D

3.C

X.1

X.1
Not-So-Stubby Area

- Capable of importing external 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

Area 0
network 192.117.49.0
range 255.255.255.0

Area 1
network 131.108.0.0
subnets 17-31
range 255.255.240.0

Area 2
network 131.108.0.0
subnets 33-47
range 255.255.240.0

Area 3
network 131.108.0.0
subnets 49-63
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
ROUTER OSPF <pid#x>
REDISTRIBUTE {protocol} <as#y>
  <metric>
  <metric-type (1 or 2)
  <tag>
  <subnets>
Router Sub-commands

- NETWORK <n.n.n.n> <mask> AREA <area-id>
- AREA <area-id> STUB {no-summary}
- AREA <area-id> AUTHENTICATION
- AREA <area-id> DEFAULT_COST <cost>
- AREA <area-id> VIRTUAL-LINK <router-id>...
- AREA <area-id> RANGE <address mask>
Interface Subcommands

- IP OSPF COST <cost>
- IP OSPF PRIORITY <8-bit-number>
- IP OSPF HELLO-INTERVAL <number-of-seconds>
- IP OSPF DEAD-INTERVAL <number-of-seconds>
- IP OSPF AUTHENTICATION-KEY <8-bytes-of-password>