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

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

Q’s Link State

Z’s Link State

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

X’s 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

- 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
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 AllIDRouters (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

Diagram:
- IR: Internet Router
- ABR/BR: Area Border Router
- ASBR: Autonomous System Border Router
- R1, R2, R3, R4, R5: Routers
- Area 0, Area 1, Area 2, Area 3
- To other AS: connection to another Autonomous System
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>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<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

- 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

<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 = 10 to N1
External Cost = 1 to N1
Cost = 8 to N1
External Cost = 2 to N1
• 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>

Cost = 10 to N1
External Cost = 1

Cost = 8 to N1
External Cost = 2

Selected Route

R1


to N1

R2


to N1

R3


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

R1 Router ID = 144.254.3.5
R2 Router ID = 131.108.3.3
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

- LSAs acknowledged along adjacencies

DR

BDR
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

![OSPF Diagram]

- Area 0
- ASBR
- External links

- 1.A 1.B
- 1.C 1.D
- 2.A 2.B
- 2.C 2.D
- 3.C 3.D

- 2.A 2.B
- 2.C 2.D
- 3.C 3.D

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- 2.A 2.B
- 2.C 2.D

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- 1.B
- 1.C
- 1.D
- 2.A
- 2.B
- 2.C
- 2.D
- 3.A
- 3.B
- 3.C
- 3.D
With Summarisation

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

Diagram showing the connectivity between different areas and networks.
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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