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

Topography Information Is Kept in a Database Separate from the Routing Table
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
• 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
Inter-Area Route Summarisation

- Prefix or all subnets
- Prefix or all networks
- ‘Area range’ command
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

External Cost = 1

to N1

Cost = 8

External Cost = 2

to N1

Selected Route
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>

Cost = 10 to N1
External Cost = 1 to N1

Cost = 8
External Cost = 2

Selected Route: R3
Topography/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

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
• 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
• 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
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