OSPF for IPv6

ISP Workshops

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Acknowledgements

- This material originated from the Cisco ISP/IXP Workshop Programme developed by Philip Smith & Barry Greene

- Use of these materials is encouraged as long as the source is fully acknowledged and this notice remains in place

- Bug fixes and improvements are welcomed
  - Please email workshop (at) bgp4all.com

Philip Smith
Recap: OSPFv2

- April 1998 was the most recent revision (RFC 2328)
- OSPF uses a 2-level hierarchical model
- SPF calculation is performed independently for each area
- Typically faster convergence than DVRPs
- Relatively low, steady state bandwidth requirements
OSPFv3 overview

- OSPF for IPv6
- Based on OSPFv2, with enhancements
- Distributes IPv6 unicast prefixes
- Runs directly over IPv6
- Ships-in-the-night with OSPFv2
- OSPFv3 does **not** carry IPv4 prefixes
  - RFC5838 proposes an extension which adds address family support
OSPFv3 / OSPFv2 Similarities

- Basic packet types
  - Hello, DBD, LSR, LSU, LSA
- Mechanisms for neighbor discovery and adjacency formation
- Interface types
  - P2P, P2MP, Broadcast, NBMA, Virtual
- LSA flooding and aging
- Nearly identical LSA types
OSPFv3 / OSPFv2 Differences

OSPFv3 runs on a Link instead of per IP Subnet

- A link by definition is a medium over which two nodes can communicate at link layer
- In IPv6 multiple IP subnet can be assigned to a link and two nodes in different subnet can communicate at link layer therefore OSPFv3 is running per link instead of per IP subnet
- An Interface connect to a link and multiple interface can be connected to a link
OSPFv3 / OSPFv2 Differences

Support of Multiple Instance per Link

- New field (instance) in OSPF packet header allow running multiple instance per link
- Instance ID should match before packet being accepted
- Useful for traffic separation, multiple areas per link and address families (RFC5838)
Address Semantic Change in LSA

- Router and Network LSA carry only topology information
- Router LSA can be split across multiple LSAs; Link State ID in LSA header is a fragment ID
- Intra area prefix are carried in a new LSA payload called intra-area-prefix-LSAs
- Prefix are carried in payload of inter-area and external LSA
OSPFv3 / OSPFv2 Differences

Generalisation of Flooding Scope

- In OSPFv3 there are three flooding scope for LSAs (link-local scope, area scope, AS scope) and they are coded in LS type explicitly
- In OSPFv2 initially only area and AS wide flooding was defined; later opaque LSAs introduced link local scope as well
OSPFv3 / OSPFv2 Differences

Explicit Handling of Unknown LSA

- The handling of unknown LSA is coded via U-bit in LS type
- When U bit is set, the LSA is flooded with the corresponding flooding scope, as if it was understood
- When U bit is clear, the LSA is flooded with link local scope
- In v2 unknown LSA were discarded
OSPFv3 / OSPFv2 Differences

Authentication is Removed from OSPF

- Authentication in OSPFv3 has been removed
- OSPFv3 relies now on the IPv6 authentication header since OSPFv3 run over IPv6
- Autype and Authentication field in the OSPF packet header therefore have been suppressed
OSPFv3 / OSPFv2 Differences

OSPF Packet format has been changed

- The mask field has been removed from Hello packet
- IPv6 prefix are only present in payload of Link State update packet
OSPFv3 / OSPFv2 Differences

Two New LSAs Have Been Introduced

- **Link-LSA** has a link local flooding scope and has three purposes:
  - The router link local address
  - List all IPv6 prefixes attached to the link
  - Assert a collection of option bit for the Router-LSA

- **Intra-area-prefix-LSA**
  - Used to advertise router’s IPv6 address within the area
Inter-Area Prefix LSA

- Describes the destination outside the area but still in the AS
- Summary is created for one area, which is flooded out in all other areas
- Originated by an ABR
- Only intra-area routes are advertised into the backbone
- Link State ID simply serves to distinguish inter-area-prefix-LSAs originated by the same router
- Link-local addresses must never be advertised in inter-area-prefix-LSAs
# LSA Types

<table>
<thead>
<tr>
<th>LSA Type</th>
<th>LSA Function Code</th>
<th>LSA Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Router-LSA</td>
<td>1</td>
<td>0x2001</td>
</tr>
<tr>
<td>Network-LSA</td>
<td>2</td>
<td>0x2002</td>
</tr>
<tr>
<td>Inter-Area-Prefix-LSA</td>
<td>3</td>
<td>0x2003</td>
</tr>
<tr>
<td>Inter-Area-Router-LSA</td>
<td>4</td>
<td>0x2004</td>
</tr>
<tr>
<td>AS-External-LSA</td>
<td>5</td>
<td>0x4005</td>
</tr>
<tr>
<td>Deprecated</td>
<td>6</td>
<td>0x2006</td>
</tr>
<tr>
<td>NSSA-LSA</td>
<td>7</td>
<td>0x2007</td>
</tr>
<tr>
<td>Link-LSA</td>
<td>8</td>
<td>0x0008</td>
</tr>
<tr>
<td>Intra-Area-Prefix-LSA</td>
<td>9</td>
<td>0x2009</td>
</tr>
</tbody>
</table>

**NEW LSAs**
Configuring OSPFv3 in Cisco IOS

- Similar to OSPFv2
  - Prefixing existing Interface and Exec mode commands with “ipv6”

- Interfaces configured directly
  - Replaces network command
  - (Also available in OSPFv2 from IOS 12.4)

- “Native” IPv6 router mode
  - Not a sub-mode of router ospf
Configuring OSPFv3

- Setting up the OSPFv3 process:
  
  ```
  [no] ipv6 router ospf <process ID>
  ```

- Applying the OSPFv3 process to an interface:
  
  ```
  interface <router-int-name>
  [no] ipv6 ospf <process ID> area <area ID>
  ```

- Configuring summarisation:
  
  ```
  ipv6 router ospf <process ID>
  [no] area <area ID> range <prefix>/<length>
  ```
OSPFv3 exec mode commands

- Exec mode commands:
  - `show ipv6 ospf [<process ID>]`
  - `clear ipv6 ospf [<process ID>]`

- Showing new LSA:
  - `show ipv6 ospf [<process ID>] database link`
  - `show ipv6 ospf [<process ID>] database prefix`
OSPFv3 Authentication

- Configuring authentication per area:
  - SPI value has to be unique per area:
    
    ```
    ipv6 router ospf <process ID>
    area 0 authentication ipsec spi 256 md5 <passwd>
    ```

- Disabling authentication on a specific link when area authentication is activated:

  ```
  interface fastethernet 0/0
  ipv6 ospf authentication null
  ```

- Configuring authentication per interface:
  - SPI value has to be unique per link:

  ```
  interface fastethernet 0/0
  ipv6 ospf authentication ipsec spi 256 md5 <passwd>
  ```
OSPFv3 Debug Commands

- Adjacency is not appearing
  
  ```
  [no] debug ipv6 ospf adj
  [no] debug ipv6 ospf hello
  ```

- SPF is running constantly
  
  ```
  [no] debug ipv6 ospf spf
  [no] debug ipv6 ospf flooding
  [no] debug ipv6 ospf events
  [no] debug ipv6 ospf lsa-generation
  [no] debug ipv6 ospf database-timer
  ```

- General purpose
  
  ```
  [no] debug ipv6 ospf packets
  [no] debug ipv6 ospf retransmission
  [no] debug ipv6 ospf tree
  ```
OSPFv3 Configuration Example

Router1#
interface POS1/1
ipv6 address 2001:db8:FFFF:1::1/64
ipv6 ospf 100 area 0
!
interface POS2/0
ipv6 address 2001:db8:1:1::2/64
ipv6 ospf 100 area 1
ipv6 router ospf 100
  log-adjacency-changes
!

Router2#
interface POS3/0
ipv6 address 2001:db8:1:1::1/64
ipv6 ospf 100 area 1
ipv6 router ospf 100
  log-adjacency-changes
Router2#sh ipv6 ospf int pos 3/0
POS3/0 is up, line protocol is up
  Link Local Address FE80::290:86FF:FE5D:A000, Interface ID 7
  Area 1, Process ID 100, Instance ID 0, Router ID 10.1.1.4
  Network Type POINT_TO_POINT, Cost: 1
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:02
  Index 1/1/1, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 3, maximum is 3
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.1.1.3
  Suppress hello for 0 neighbor(s)
Router2#sh ipv6 ospf neighbor detail
Neighbor 10.1.1.3
  In the area 1 via interface POS3/0
  Neighbor: interface-id 8, link-local address FE80::2D0:FFFF:FE60:DFFF
  Neighbor priority is 1, State is FULL, 12 state changes
  Options is 0x630C34B9
  Dead timer due in 00:00:33
  Neighbor is up for 00:49:32
  Index 1/1/1, retransmission queue length 0, number of retransmission 1
  First 0x0(0)/0x0(0)/0x0(0) Next 0x0(0)/0x0(0)/0x0(0)
  Last retransmission scan length is 2, maximum is 2
  Last retransmission scan time is 0 msec, maximum is 0 msec
Router2#sh ipv6 route
IPv6 Routing Table - 5 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
    U - Per-user Static route
    I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
    O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2

OI  2001:db8:FFFF:1::/64 [110/2]
    via FE80::2D0:FFFF:FE60:DFFF, POS3/0
C   2001:db8:1:1::/64 [0/0]
    via ::, POS3/0
L   2001:db8:1:1::1/128 [0/0]
    via ::, POS3/0
L    FE80::/10 [0/0]
    via ::, Null10
L     FF00::/8 [0/0]
    via ::, Null10
OSPFv3 link troubleshooting

- Next router address in OSPFv3 is a link-local address

  OI 2001:db8:FFFF:1::/64 [110/2]
  via FE80::2D0:FFFF:FE60:DFFF, POS3/0

- How to troubleshoot??
  - SSH to neighbouring router needs extended SSH command, for example:
    ```bash
    ssh FE80::2D0:FFFF:FE60:DFFF /source-int POS3/0
    ```
  - Source interface has to be specified – a router with multiple interfaces has no idea which interface the remote link local address is attached to
Cisco IOS OSPFv3 Database Display

Router2# show ipv6 ospf database

OSPF Router with ID (3.3.3.3) (Process ID 1)

<table>
<thead>
<tr>
<th>Link ID</th>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Checksum</th>
<th>Link count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.1.1.1</td>
<td>2009</td>
<td>0x8000000A 0x2DB1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3.3.3.3</td>
<td>501</td>
<td>0x80000007 0xF3E6</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Net Link States (Area 0)

<table>
<thead>
<tr>
<th>Link ID</th>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1.1.1.1</td>
<td>480</td>
<td>0x80000006 0x3BAD</td>
<td></td>
</tr>
</tbody>
</table>

Inter Area Prefix Link States (Area 0)

<table>
<thead>
<tr>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1.1</td>
<td>1761</td>
<td>0x80000005</td>
<td>2001:db8:2:2::/64</td>
</tr>
<tr>
<td>1.1.1.1</td>
<td>982</td>
<td>0x80000005</td>
<td>2001:db8:2:4::2/128</td>
</tr>
</tbody>
</table>

Link (Type-8) Link States (Area 0)

<table>
<thead>
<tr>
<th>Link ID</th>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Checksum</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>3.3.3.3</td>
<td>245</td>
<td>0x80000006 0xF3DC</td>
<td>Lo0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1.1.1.1</td>
<td>236</td>
<td>0x80000008 0x68F</td>
<td>Fa2/0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3.3.3.3</td>
<td>501</td>
<td>0x80000008 0xE7BC</td>
<td>Fa2/0</td>
<td></td>
</tr>
</tbody>
</table>

Intra Area Prefix Link States (Area 0)

<table>
<thead>
<tr>
<th>Link ID</th>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Checksum</th>
<th>Ref</th>
<th>Fidtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.1.1.1</td>
<td>480</td>
<td>0x80000008 0xD670</td>
<td>0x2001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>107</td>
<td>1.1.1.1</td>
<td>236</td>
<td>0x80000008 0xC05F</td>
<td>0x2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3.3.3.3</td>
<td>245</td>
<td>0x80000006 0x3FF7</td>
<td>0x2001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Cisco IOS OSPFv3 Detailed LSA Display

show ipv6 ospf 1 database inter-area prefix

  LS age: 1714
  LS Type: Inter Area Prefix Links
  Link State ID: 0
  Advertising Router: 1.1.1.1
  LS Seq Number: 80000006
  Checksum: 0x25A0
  Length: 36
  Metric: 1
  Prefix Address: 2001:db8:2:2:
  Prefix Length: 64, Options: None

show ipv6 ospf 1 database link

  LS age: 283
  Options: (IPv6 Router, Transit Router, E-Bit, No Type 7-to-5, DC)
  LS Type: Link-LSA (Interface: Loopback0)
  Link State ID: 11 (Interface ID)
  Advertising Router: 3.3.3.3
  LS Seq Number: 80000007
  Checksum: 0xF1DD
  Length: 60
  Router Priority: 1
  Link Local Address: FE80::205:5FFF:FEAC:1808
  Number of Prefixes: 2
  Prefix Address: 2001:db8:1:3:
  Prefix Length: 64, Options: None
  Prefix Address: 2001:db8:1:3:
  Prefix Length: 64, Options: None
Conclusion

- Based on existing OSPFv2 implementation
- Similar CLI and functionality
OSPF for IPv6

ISP Workshops