### Protocol Header

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Version</td>
<td>8</td>
<td>16</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>Type</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Length</td>
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</tr>
<tr>
<td>Router ID</td>
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<tr>
<td>Area ID</td>
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<tr>
<td>Checksum</td>
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<td>Instance ID</td>
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<tr>
<td>Reserved</td>
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<tr>
<td>Data</td>
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</tbody>
</table>

#### Link State Advertisements

**Router Link (Type 1)**
Lists neighboring routers and the cost to each; flooded within an area

**Network Link (Type 2)**
Generated by a DR; lists all routers on an adjacent segment; flooded within an area

**Network Summary (Type 3)**
Generated by an ABR and advertised among areas

**ASBR Summary (Type 4)**
Injected by an ABR into the backbone to advertise the presence of an ASBR within an area

**External Link (Type 5)**
Generated by an ASBR and flooded throughout the AS to advertise a route external to OSPF

**NSSA External Link (Type 7)**
Generated by an ASBR in a not-so-stubby area; converted into a type 5 LSA by the ABR when leaving the area

#### Router Types

- **Internal Router**
  All interfaces reside within the same area

- **Backbone Router**
  A router with an interface in area 0 (the backbone)

- **Area Border Router (ABR)**
  Connects two or more areas

- **AS Boundary Router (ASBR)**
  Connects to additional routing domains; typically located in the backbone

#### Area Types

- **Standard Area**
  Default OSPF area type

- **Stub Area**
  External link (type 5) LSAs are replaced with a default route

- **Totally Stubby Area**
  Type 3, 4, and 5 LSAs are replaced with a default route

- **Not So Stubby Area (NSSA)**
  A stub area containing an ASBR; type 5 LSAs are converted to type 7 within the area

#### External Route Types

- **E1**
  Cost to the advertising ASBR plus the external cost of the route

- **E2 (Default)**
  Cost of the route as seen by the ASBR

#### Authentication

- **AllSPF Address**
  224.0.0.5

- **AllDR Address**
  224.0.0.6

#### Metric Formula

\[
\text{cost} = \frac{100,000 \text{ Kbps}^*}{\text{link speed}}
\]

* modifiable with `ospf auto-cost reference-bandwidth`

#### Adjacency States

- **1** Down
- **2** Attempt
- **3** Init
- **4** 2-Way
- **5** Exstart
- **6** Exchange
- **7** Loading
- **8** Full

#### DR/BDR Election

- The DR serves as a common point for all adjacencies on a multiaccess segment

- The BDR also maintains adjacencies with all routers in case the DR fails

- Election does not occur on point-to-point or multipoint links

- Default priority (0-255) is 1; highest priority wins; 0 cannot be elected

- DR preemption will not occur unless the current DR is reset

#### Virtual Links

- Tunnel formed to join two areas across an intermediate

- Both end routers must share a common area

- At least one end must reside in area 0

- Cannot traverse stub areas

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**Troubleshooting**

- `show ip [route | protocols]`
- `show ip ospf border-routers`
- `show ip ospf interface`
- `show ip ospf virtual-links`
- `show ip ospf neighbor`
- `debug ip ospf [...]`
### OSPF · PART 2

**Network Types**

<table>
<thead>
<tr>
<th></th>
<th>Nonbroadcast (NBMA)</th>
<th>Multipoint Broadcast</th>
<th>Multipoint Nonbroadcast</th>
<th>Broadcast</th>
<th>Point-to-Point</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DR/BDR Elected</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Neighbor Discovery</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Hello/Dead Timers</strong></td>
<td>30/120</td>
<td>30/120</td>
<td>30/120</td>
<td>10/40</td>
<td>10/40</td>
</tr>
<tr>
<td><strong>Defined By</strong></td>
<td>RFC 2328</td>
<td>RFC 2328</td>
<td>Cisco</td>
<td>Cisco</td>
<td>Cisco</td>
</tr>
<tr>
<td><strong>Supported Topology</strong></td>
<td>Full Mesh</td>
<td>Any</td>
<td>Any</td>
<td>Full Mesh</td>
<td>Point-to-Point</td>
</tr>
</tbody>
</table>

**Configuration Example**

**Router A**

```plaintext
interface Serial0/0
  description WAN Link
  ip address 172.16.34.2 255.255.255.252

interface FastEthernet0/0
  description Area 0
  ip address 192.168.0.1 255.255.255.0

interface Loopback0
  ! Used as router ID
  ip address 10.0.34.1 255.255.255.0

router ospf 100
  ! Advertising the WAN cloud to OSPF
  redistribute static subnets
  network 192.168.0.0 0.0.0.255 area 0

  ! Static route to the WAN cloud
  ip route 172.16.0.0 255.255.192.0 172.16.34.1
```

**Router B**

```plaintext
interface Ethernet0/0
  description Area 0
  ip address 192.168.0.2 255.255.255.0
  ip ospf 100 area 0

interface Ethernet0/1
  description Area 2
  ip address 192.168.2.1 255.255.255.0
  ip ospf 100 area 2

  ! Optional MD5 authentication configured
  ip ospf authentication message-digest
  ip ospf message-digest-key 1 md5 FooBar
  ! Give B priority in DR election
  ip ospf priority 100

interface Ethernet0/2
  description Area 1
  ip address 192.168.1.1 255.255.255.0
  ip ospf 100 area 1

interface Loopback0
  ip address 10.0.34.2 255.255.255.0

router ospf 100
  ! Define area 1 as a stub area
  area 1 stub
  ! Virtual link from area 0 to area 9
  area 2 virtual-link 10.0.34.3
```

**Router C**

```plaintext
interface Ethernet0/0
  description Area 9
  ip address 192.168.9.1 255.255.255.0
  ip ospf 100 area 9

interface Ethernet0/1
  description Area 2
  ip address 192.168.2.2 255.255.255.0
  ip ospf 100 area 2

  ! Optional MD5 authentication configured
  ip ospf authentication message-digest
  ip ospf message-digest-key 1 md5 FooBar
  ! Give C second priority (BDR) in election
  ip ospf priority 50

interface Loopback0
  ip address 10.0.34.3 255.255.255.0

router ospf 100
  ! Define area 9 as a totally stubby area
  area 9 stub no-summary
  ! Virtual link from area 9 to area 0
  area 2 virtual-link 10.0.34.2
```