Fundamentals Of OSPF (Junos Edition)

◔ What is OSPF?

Open Shortest Path First (OSPF) is a robust, scalable, and widely deployed link-state interior gateway protocol (IGP). Unlike distance-vector protocols (like RIP) which rely on secondhand information, OSPF routers build a complete topological map of the network. Each router independently calculates the shortest path to every destination using Dijkstra's Shortest Path First (SPF) algorithm. This results in faster convergence and more efficient, loop-free routing.

- **Protocol Type:** Link-State IGP
- **Standard:** Open standard (RFC 2328 for OSPFv2)
- **Algorithm:** Dijkstra's SPF Algorithm
- **Metric:** Cost (configurable per-interface value)
- **Route Preference (Junos):** 10 (Internal), 150 (External)

OSPF Packet Types

- **Hello:** Establishes and maintains neighbor relationships.
- **Database Description (DD):** Transfers LSA headers during adjacency formation.
- **Link-State Request (LSR):** Requests specific LSAs from a neighbor.
- **Link-State Update (LSU):** Transmits one or more LSAs to share link-state information.
- **Link-State Acknowledgment (LSAck):** Confirms receipt of Link-State Update packets for reliable flooding.

Forming a Neighbor Adjacency

The Path to Adjacency: OSPF Neighbor States

OSPF routers progress through a series of states. This process ensures that only compatible routers share detailed routing information.

1. Down

The initial state. No Hello packets have been received.

2. Init

A Hello packet has been received, but the local router's ID is not listed in the neighbor's Hello. This means communication is one-way so far.

3. 2-Way

Bidirectional communication is established. On broadcast networks, this is as far as non-DR/BDR routers will go with each other.

4. ExStart

A primary/secondary relationship is established for the LSDB exchange. The router with the higher Router ID becomes the primary.

5. Exchange

Routers exchange Database Descriptor (DBD) packets, which are summaries of their Link-State Databases (LSDBs).

6. Loading

The router sends Link-State Request (LSR) packets for more complete information about any new or outdated LSAs.

7. Full

The LSDBs are fully synchronized. The routers are now fully adjacent.

> **Note on NBMA:** On Non-Broadcast Multi-Access (NBMA) networks, an additional "Attempt" state is used where Hellos are sent to manually configured neighbors before the Init state.

Designated Router (DR) and Backup Designated Router (BDR)

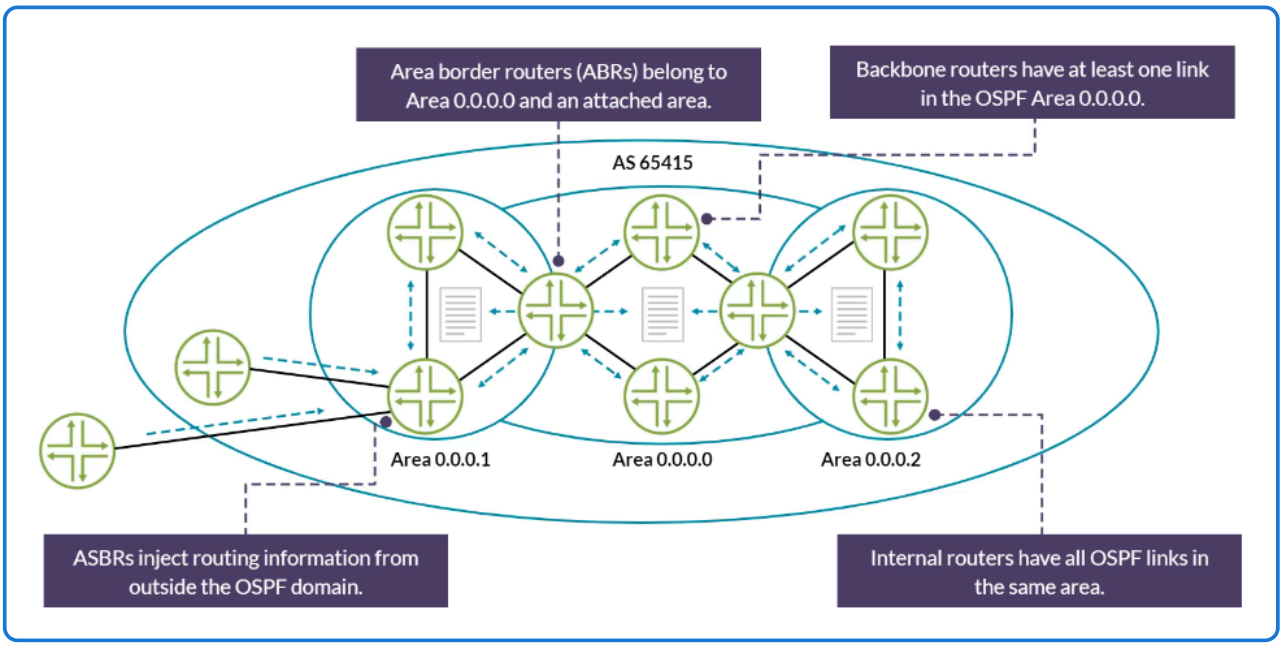
On broadcast media (e.g., Ethernet), OSPF elects a DR to reduce adjacency overhead. The BDR is a standby. This process prevents a full mesh of adjacencies on a LAN segment.

- **Election Criteria:** The router with the highest OSPF priority (1-255) wins. A priority of 0 makes a router ineligible to be a DR. If priorities are tied, the router with the highest Router ID wins.
- **Default Priority:** 128 in Junos. Configurable via `set protocols ospf area 0.0.0.0 interface ge-0/0/0.0 priority 100`.
- **Non-Preemptive:** A DR remains the DR until it fails, even if a router with a higher priority joins the network later.
- **Point-to-Point Links:** For efficiency, configure serial links or dedicated Ethernet links as point-to-point to skip the DR/BDR election process entirely.

```
set protocols ospf area 0.0.0.0 interface ge-0/0/0.0 interface-type p2p
```

■ OSPF Scalability: LSAs, Areas, and Router Roles

OSPF Router Roles



OSPF uses a hierarchical design with different router roles to create a scalable and efficient network.

- **Internal Routers:** Have all of their OSPF-enabled interfaces within the same area. They maintain a detailed LSDB for their area only.
- **Backbone Routers:** Have at least one interface connected to Area 0. All ABRs are backbone routers.
- **Area Border Routers (ABRs):** Connect two or more areas (e.g., Area 1 and Area 0). They are responsible for summarizing routes and advertising them between areas using Type 3 LSAs.
- **Autonomous System Boundary Routers (ASBRs):** Inject routing information from outside the OSPF domain (e.g., from BGP or a static route) into OSPF as Type 5 or Type 7 external LSAs.

LSA Type Overview

LSA Type	Name	Generated By	Flooding Scope
1	Router LSA	All Routers	Within Area
2	Network LSA	Designated Router (DR)	Within Area
3	Summary LSA	ABR	Between Areas
4	ASBR Summary LSA	ABR	To other Areas
5	External LSA	ASBR	All Areas (except Stub)
7	NSSA External LSA	ASBR in NSSA	NSSA Only (ABR translates to Type 5)

Summary of LSAs in Area Types

Different area types exist to control LSA propagation and enhance scalability. Junos supports standard area types and can achieve behavior similar to Cisco's proprietary types through configuration.

Area Type	Type 1/2 (Router/Network)	Type 3 (Summary)	Type 4 (ASBR-Summary)	Type 5 (External)	Generates Type 7	Special Notes
Standard/Backbone	Yes	Yes	Yes	Yes	No	Allows all LSAs.
Stub	Yes	Yes	No	No	No	Blocks Type 4/5. ABR injects a default route.
Stub (no-summaries)	Yes	No	No	No	No	Junos equivalent of Totally Stubby. Blocks Type 3 (except default).
NSSA	Yes	Yes	No	No	Yes	Uses Type 7 LSAs, translated to Type 5 by ABR.
NSSA (no-summaries)	Yes	No	No	No	Yes	Junos equivalent of Totally NSSA. Blocks Type 3 (except default).

💡 **Note on Type 4 LSAs:** These are critical because for a router in Area 1 to use an external route from an ASBR in Area 2, it must first know how to reach that ASBR. The Type 4 LSA provides this reachability information.

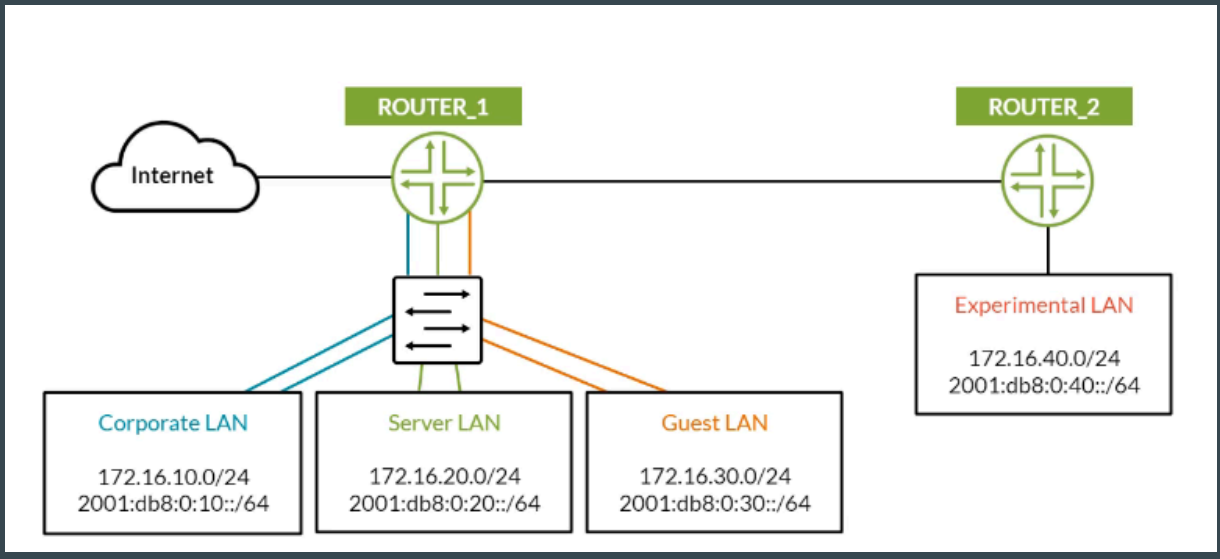
Route Summarization and Virtual Links

Route Summarization: On an ABR, you can aggregate multiple prefixes into a single summary advertisement. This shrinks the LSDB and routing tables in other areas and hides network instability, as individual link flaps within the source area are not advertised beyond the ABR.

```
set protocols ospf area 0.0.0.1 area-range 192.168.0.0/16
```

Virtual Links: Provides a logical tunnel to connect a disconnected area to the backbone (Area 0) through a transit area. A virtual link is a last resort and cannot be configured over stub areas because they block the necessary LSAs.

Configuration Scenario (Junos)



ROUTER_1 advertises its LAN prefixes and a default route to ROUTER_2 in Area 0.

ROUTER_1 Configuration (OSPFv2)

Configure OSPF, advertise LAN prefixes, and export a default route for IPv4.

```
set interfaces ge-0/0/0 unit 0 family inet address 10.1.2.1/30 /* To R2 */
set interfaces ge-0/0/1 unit 0 family inet address 172.16.10.1/24 /* Corporate */
set interfaces ge-0/0/2 unit 0 family inet address 172.16.20.1/24 /* Server */
set interfaces ge-0/0/3 unit 0 family inet address 172.16.30.1/24 /* Guest */
set interfaces ge-0/0/4 unit 0 family inet address 200.0.0.1/30 /* Internet */
set routing-options static route 0.0.0.0/0 next-hop 200.0.0.2
set policy-options policy-statement export-default term 1 from protocol static
set policy-options policy-statement export-default term 1 from route-filter 0.0.0.0/0 exa
set policy-options policy-statement export-default term 1 then accept
set protocols ospf area 0.0.0.0 interface ge-0/0/0.0 interface-type p2p
set protocols ospf area 0.0.0.0 interface ge-0/0/1.0
set protocols ospf area 0.0.0.0 interface ge-0/0/2.0
set protocols ospf area 0.0.0.0 interface ge-0/0/3.0
set protocols ospf export export-default
set routing-options router-id 1.1.1.1
```

ROUTER_1 Configuration (OSPFv3)

Configure OSPFv3 for IPv6 prefixes and export the IPv6 default route.

```
set interfaces ge-0/0/0 unit 0 family inet6 address 2001:db8:0:12::1/64
set interfaces ge-0/0/1 unit 0 family inet6 address 2001:db8:0:10::1/64
set interfaces ge-0/0/2 unit 0 family inet6 address 2001:db8:0:20::1/64
set interfaces ge-0/0/3 unit 0 family inet6 address 2001:db8:0:30::1/64
set interfaces ge-0/0/4 unit 0 family inet6 address 2001:db8:0:100::1/64
```

```
set routing-options rib inet6.0 static route ::/0 next-hop 2001:db8:0:100::2
set policy-options policy-statement export-default term 2 from protocol static
set policy-options policy-statement export-default term 2 from route-filter ::/0 exact
set policy-options policy-statement export-default term 2 then accept
set protocols ospf3 area 0.0.0.0 interface ge-0/0/0.0 interface-type p2p
set protocols ospf3 area 0.0.0.0 interface ge-0/0/1.0
set protocols ospf3 area 0.0.0.0 interface ge-0/0/2.0
set protocols ospf3 area 0.0.0.0 interface ge-0/0/3.0
set protocols ospf3 export export-default
```

ROUTER_2 Configuration

Configure OSPFv2 and OSPFv3 to form adjacencies with ROUTER_1.

```
set interfaces ge-0/0/0 unit 0 family inet address 10.1.2.2/30 /* To R1 */
set interfaces ge-0/0/1 unit 0 family inet address 172.16.40.1/24 /* Experimental */
set protocols ospf area 0.0.0.0 interface ge-0/0/0.0 interface-type p2p
set protocols ospf area 0.0.0.0 interface ge-0/0/1.0
set routing-options router-id 2.2.2.2

set interfaces ge-0/0/0 unit 0 family inet6 address 2001:db8:0:12::2/64
set interfaces ge-0/0/1 unit 0 family inet6 address 2001:db8:0:40::1/64
set protocols ospf3 area 0.0.0.0 interface ge-0/0/0.0 interface-type p2p
set protocols ospf3 area 0.0.0.0 interface ge-0/0/1.0
```

🔍 Verification & Troubleshooting Toolkit (Junos)

Check Neighbor Adjacency (v2 & v3)

Verify OSPF adjacency. Look for **Full**.

```
user@ROUTER_1> show ospf neighbor
Address          Interface              State     ID               Pri  Dead
10.1.2.2         ge-0/0/0.0             Full      2.2.2.2          128    38

user@ROUTER_1> show ospf3 neighbor
ID               Interface              State     Pri  Dead         Address
2.2.2.2          ge-0/0/0.0             Full      128    34         fe80::...
```

Note: OSPFv3 uses link-local addresses (fe80::/10) for neighbor communication, ensuring adjacencies form even without global IPv6 addresses on the link itself.

Verify OSPF Routes (v2 & v3)

Check if ROUTER_1 learns ROUTER_2's Experimental LAN and if ROUTER_2 learns ROUTER_1's LANs.

```
user@ROUTER_1> show route protocol ospf
inet.0: ...
172.16.40.0/24     *[OSPF/10] 00:05:32, metric 2
                      > to 10.1.2.2 via ge-0/0/0.0

user@ROUTER_2> show route protocol ospf
inet.0: ...
172.16.10.0/24     *[OSPF/10] 00:15:10, metric 2
                      > to 10.1.2.1 via ge-0/0/0.0
172.16.20.0/24     *[OSPF/10] 00:15:08, metric 2
                      > to 10.1.2.1 via ge-0/0/0.0
172.16.30.0/24     *[OSPF/10] 00:15:05, metric 2
                      > to 10.1.2.1 via ge-0/0/0.0
0.0.0.0/0          *[OSPF/150] 00:14:50, metric 1, Ext2
                      > to 10.1.2.1 via ge-0/0/0.0
```

OSPF Quick Reference Cheatsheet

OSPF Core Concepts

Packet Types & Protocol

Hello	Discover/maintain neighbors
DD	Summarize LSDB headers
LSR	Request full LSA info
LSU	Flood LSA data
LSAck	Acknowledge LSUs
Protocol #	89 (Not TCP/UDP)
Multicast	224.0.0.5, 224.0.0.6

Quick Facts (Junos)

Preference	10 (Internal), 150 (External)
Router ID	Highest IP unless set
DR Election	Highest Priority (1-255) > Highest Router ID
Default Priority	128
Timers	Hello: 10s, Dead: 40s (P2P/Bcast)

Common Junos Commands

Purpose	Command
Show neighbor state	`show ospf neighbor` / `show ospf3 neighbor`
Show database	`show ospf database` / `show ospf3 database`
Show OSPF routes	`show route protocol ospf` / `show route protocol ospf3`
Show interface state & DR info	`show ospf interface` / `show ospf3 interface`

≣ Glossary of Terms

- **Area:** A logical grouping of routers and links that serves as a boundary for LSA flooding, helping to scale the OSPF domain.
- **ASBR (Autonomous System Boundary Router):** A router that connects the OSPF domain to an external network and injects external routes.
- **ABR (Area Border Router):** A router with interfaces in more than one OSPF area, responsible for summarizing and filtering information between areas.
- **Cost:** The OSPF metric used to determine the best path. Lower total cost is preferred. In Junos, the default cost is 1 for all interfaces.
- **Dijkstra's Algorithm:** The algorithm used by OSPF to calculate the shortest path from a single source to all other destinations in the topology.
- **DR / BDR (Designated Router / Backup DR):** On multi-access networks, a DR is elected to reduce adjacency overhead. The BDR is a hot standby.
- **Interface-Type P2P:** A Junos command to set an interface's OSPF network type to point-to-point, which prevents DR/BDR election and can speed up adjacency formation.
- **LSA (Link-State Advertisement):** A data packet containing information about the local state of a router or network. LSAs are the building blocks of the LSDB.
- **LSDB (Link-State Database):** A collection of all the LSAs known to a router. All routers within a single area have an identical LSDB for that area.
- **MTU Mismatch:** A common issue where two connected interfaces have different Maximum Transmission Unit sizes, which can prevent the OSPF database exchange from completing, stalling the adjacency at the ExStart state.
- **OSPFv2 vs. OSPFv3:** OSPFv2 (RFC 2328) was designed for IPv4. OSPFv3 (RFC 5340) was updated to support IPv6, carrying IPv6 prefixes and using IPv6 for transport.
- **Route Preference:** The Junos equivalent of Administrative Distance. It is used to select the best route when multiple protocols provide a path to the same destination.