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OSPF P1

OSPF	○ Link-state r-protocol dev as replacement for RIP ▪ RIP: Acceptable in early days: Hop count as only metric: Not good ▪ Hop count: Doesn't scale well; especially w/multiple paths of varying speeds ○ Faster convergence/scales ○ Classless: Uses concept of areas for scalability

Evolution of OSPF: OSPFv2: IPv4: OSPFv3: IPv6

OSPF	▪ **Began 1987**: IETF OSPF Working Group: **1989:** OSPFv1: RFC 1131 2 implementations: 1. 1 to run on routers 2. 1 to run on UNIX workstations: Became UNIX process: GATED ○ **1991:** OSPFv2: RFC 1247: John Moy ▪ Improvements: Classless by design: Supports VLSM/CIDR ○ **1998:** OSPFv2 updated: RFC 2328: Remains current RFC for OSPF ○ **1999**: OSPFv3 for IPv6: RFC 2740 ▪ OSPF for IPv6: John Moy, Rob Coltun, Dennis Ferguson ○ **2008**: OSPFv3 updated: RFC 5340
IS-IS	**At same time OSPF introduced:** • ISO worked on link-state r-protocol: IS-IS • IETF chose OSPF as recommended IGP

Other Features

Scalable	Works well in small/large network sizes: • Routers can be grouped in areas to support hierarchical sys
Secure	Supports Message Digest 5 (MD5) authentication • Enabled? Only accept encrypted updates from peers w/same pre-shared passwd
AD	Default AD of 110: Preferred over IS-IS/RIP

3 main components of OSPF:

- **Data Structures: OSPF creates/maintains 3 db's**

Contain list of neighboring routers to exchange r-info w/kept/maintained in RAM

Adjacency DB	Creates neighbor table
Link-state DB	LSDB: Creates topology table
Fwding DB	Creates r-table

2. **R-Protocol Msgs:** Exchanges msgs to convey r-info using 5 packet types

Used to discover neighbor routers/maintain accurate info

1.Hello	**2.** DB description	**3.** Link-state request	**4.** Link-state update	**5.** Link-state Acknowledgement

3. **Algorithm:** CPU processes neighbor/topology tables using Dijkstra's SPF alg: Based on cost to reach destination

- Creates SPF tree by placing each router at root of tree/calc shortest path to each
- OSPF places best routes into fwding db: Used to make r-table

show ospf neighbor List neighbor routers
show ospf database View LSDB
show ip route

Link-State Operation: To maintain r-info: OSPF routers complete the following for convergence:

- **Establish Neighbor Adjacencies:**

    1. Must recognize each other on network before they can share info
    2. OSPF-enabled sends Hello packets out all OSPF-enabled ints to determine if neighbors present on links
    3. If neighbor present: Router attempts to establish neighbor adjacency

- **Exchange Link-State Advertisements:**

    1. After adjacencies established: Exchange LSAs: Link-State Advertisements
    2. LSAs contain state/cost of each directly connected link
    3. Routers flood LSAs to adjacent neighbors
    4. Adjacent neighbors receiving LSA flood it to other directly connected neighbors
    5. Done until all routers in area have all LSAs

- **Build Topology Table:**

    1. After LSAs received: OSPF-enabled routers build topology table: LSDB based on them
    2. DB holds all info about topology

- **Execute SPF Alg:**

    1. Execution of the SPF algorithm: SPF algorithm creates SPF tree
    2. From SPF tree: Best paths inserted into table: Decisions made on table entries

Single-Area/Multiarea OSPF: To make more efficient/scalable: OSPF supports hierarchical routing using areas
OSPF area: A group of routers that share the same link-state info in LSDBs
OSPF Implemented 1 of 2 ways:

1. **Single-Area OSPF:** All routers are in 1 area: Backbone area [area 0]
2. **Multiarea OSPF:** Multiple areas in hierarchal fashion. All areas must connect to backbone area [area 0]

ABR: Area Border Routers: All interconnecting areas

- OSPF: Can split an AS: Autonomous Sys into smaller areas: Support for hierarchical routing

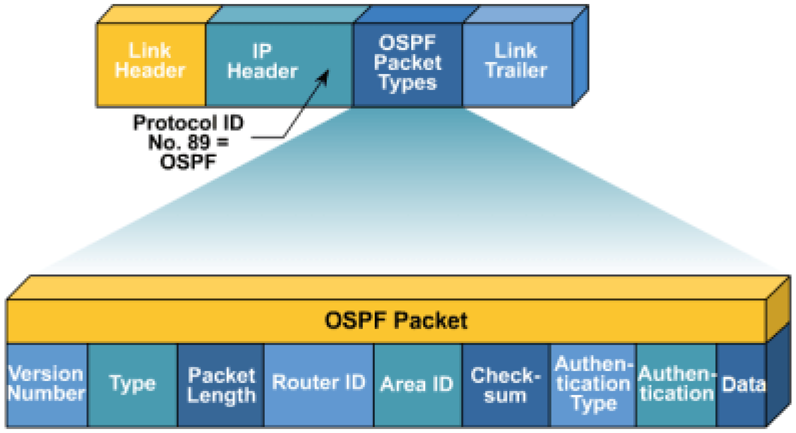
Hierarchical routing: Occurs between areas [interarea]

- Processor intensive ops kept w/in area
- Topology changes to other areas in distance vector: Only update tables: Don't need to rerun SPF alg

Multiarea OSPF advantages:

Smaller Tables	Less table entries b/c addresses can be summarized between areas • Default: Route summarization not enabled
Less LS update overhead	Min processing/mem reqs
Less SPF calcs	Impact of topology change w/in 1 area • Example: Min update impact b/c LSA flooding stops at area boundary

Encapsulating OSPF Messages: Msgs transmitted over eth0 link contain the following info:



Data Link Ethernet Frame Header	ID's destination multicast MAC
IP Packet Header	ID's IPv4 protocol field 89: Indicates OSPF packet • ID's 1 of 2 OSPF multicast addresses 224.0.0.5 | 224.0.0.6
OSPF Packet Header	ID's OSPF Packet Type/Router ID/Area ID
OSPF Packet Type Specific Data	Contains OSPF packet type info • Content differs depending on packet type

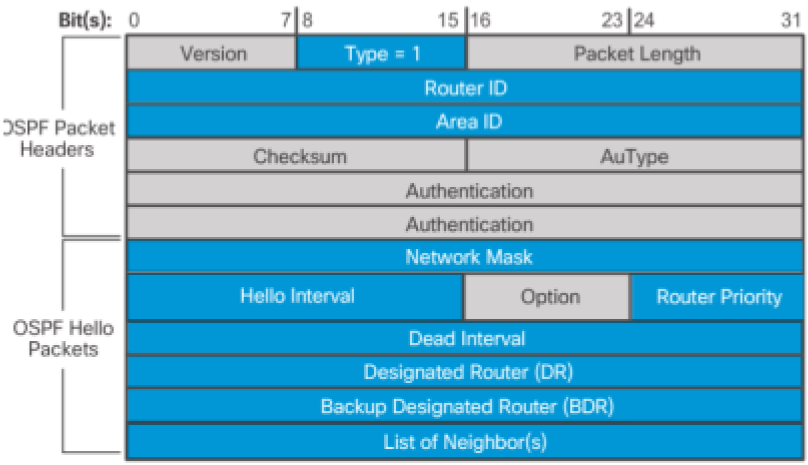
Types of OSPF Packets: OSPF uses link-state packets (LSPs) to establish/maintain neighbor adjacencies/exchange updates

Type 1: Hello	Establishes/maintains adjacency w/other OSPF routers
Type 2: DB Description	**DBD**: Contains abbreviated list of sending router's LSDB • Used by receiving routers to check against local LSDB • LSDB must be identical on all link-state routers w/in area to make SPF tree
Type 3: L-S Request	**LSR:** Receiving routers: Request more info about any entry in DBD by sending LSR
Type 4: L-S Update	**LSU:** Used to reply to LSRs/announce new info • LSUs contain 7 diff types of LSAs
Type 5: L-S Acknowledgment	**LSAck**: When LSU received: Router sends LSAck to confirm receipt • Data field empty • Acknowledges other packet types

Hello Packet: OSPF Type 1
Used to:

1. Discover neighbors/establish adjacencies
2. Advertise on which 2 routers agree to become neighbors
3. Elect DR: Designated Router/BDR: Backup Designated Router on multiaccess networks (Eth0/Frame Relay)
    1. Point-to-point links: No DR/BDR

Type	ID's packet type • 1 = Hello | 2 = DBD | 3 = LSR | 4 = LSU | 5 = LSAck
Router ID	32bit value: Decimal: ID's originating router
Area ID	Area packet originated
Network Mask	Subnet mask associated w/sending int
Hello Interval	Frequency router sends Hello packets [seconds] • Default multiaccess: 10 seconds • Timer must be same on neighbors: Or no adjacency
Router Priority	Used in DR/BDR election • Default is 1: Can be manually altered 0-255 • Higher value = More chance router becomes DR on link
Dead Interval	Time to hear neighbor before declaring out of service [seconds] • Default: Dead Interval = 4x Hello interval • Timer must be same on neighbors: Or no adjacency
DR	Designated Router: Router ID of DR
BDR	Backup Designated Router: Router ID of BDR
List of Neighbors	Router IDs of all adjacent routers



Hello Packet Intervals:
Transmitted to multicast 224.0.0.5 IPv4 | FF02::5 IPv6
- 10 seconds: Default: Multiaccess/Point-to-point
- 30 seconds: Default: Non-broadcast multiaccess: Frame Relay

Dead Interval: If expires before routers receive a Hello packet, OSPF removes neighbor from LSDB
- Router floods LSDB w/info about down neighbor out all OSPF-enabled ints

Cisco uses a default of 4x Hello interval:
- 40 seconds: Default: Multiaccess/Point-to-point
- 120 seconds: Default: NBMA networks: Frame Relay

Link-State Updates	**1. Type 2 DBD:** Initial exchange: Abbreviated list of sending r-LSDB: Receivers check against local LSDB **2. Type 3 LSR:** Used by receivers to request more info about entry in DBD **3. Type 4 LSU:** Used to reply to LSR packet 1. LSUs also fwd OSPF updates 2. They can have 11 diff types of OSPFv2 LSAs: OSPFv3 renamed 7 + has 2 extras

Difference between LSU/LSA: LSU contains 1/more LSAs | LSA's contain route info for destination networks

OSPF Operational States
When OSPF router initially connects, it attempts to:

Create adjacencies	Exchange r-info	Calc best routes	Reach convergence

Progresses through 7 states while attempting to reach convergence:

1. Down	2. Init	3. Two-Way	4. ExStart	5. Exchange	6. Loading	7. Full state

Establish Neighbor Adjacencies
When OSPF enabled on int: Router must determine if another neighbor on link
- R-fwds Hello packet that contains r-ID out all OSPF-enabled ints
- R-ID used by OSPF process to ID each router in area

Router ID: An IP assigned to ID specific r-among OSPF peers
When neighbor receives Hello packet with r-ID not in its list: Receiving r-attempts to establish adjacency
2-Way state depends on type of inter-connection bet adjacent routers:
- If 2 adjacent neighbors are interconnected over point-to-point link: They transition from 2-Way to db sync phase
- If interconnected over common Eth0: A DR/BDR must be elected

DR/BDR: Why is DR/BDR election necessary?
Multiaccess networks can create two challenges for OSPF regarding flooding of LSAs:

Creation of multiple adjacencies	○ Eth0 could potentially interconnect many OSPF r-over common link

	○ Creating adjacencies w/every router is unnecessary/undesirable ○ Would lead to lots of LSAs between routers on same network
Extensive flooding of LSAs	○ Link-state r-flood LSAs any time OSPF initialized/change in topology ○ Can become excessive

Formula: For any # of routers (n) on a multiaccess network, there are n (n – 1) / 2 adjacencies

Synchronizing Db's

After 2-Way state: Routers transition to db synchronization states

- The 4 types of packets are used during process of exchanging/synchronizing LSDBs

ExStart	Master/slave relationship created between each router/adjacent DR/BDR • Router with higher r-ID acts as master
Exchange	Master/slave routers exchange 1/more DBD packets DBD packet includes: Info about LSA entry header: Appears in router's LSDB • Entries can be about a link/or network Each LSA entry header includes info about: • Link-state type | Address of advertising router | Cost | Sequence # • Router uses sequence # to determine newness of received link-state info

As long as neighbors continue receiving Hello packets: Transmitted LSAs remain in topology db

After topological db's synced: Updates (LSUs) sent to neighbors when:

Change is perceived	Every 30 min