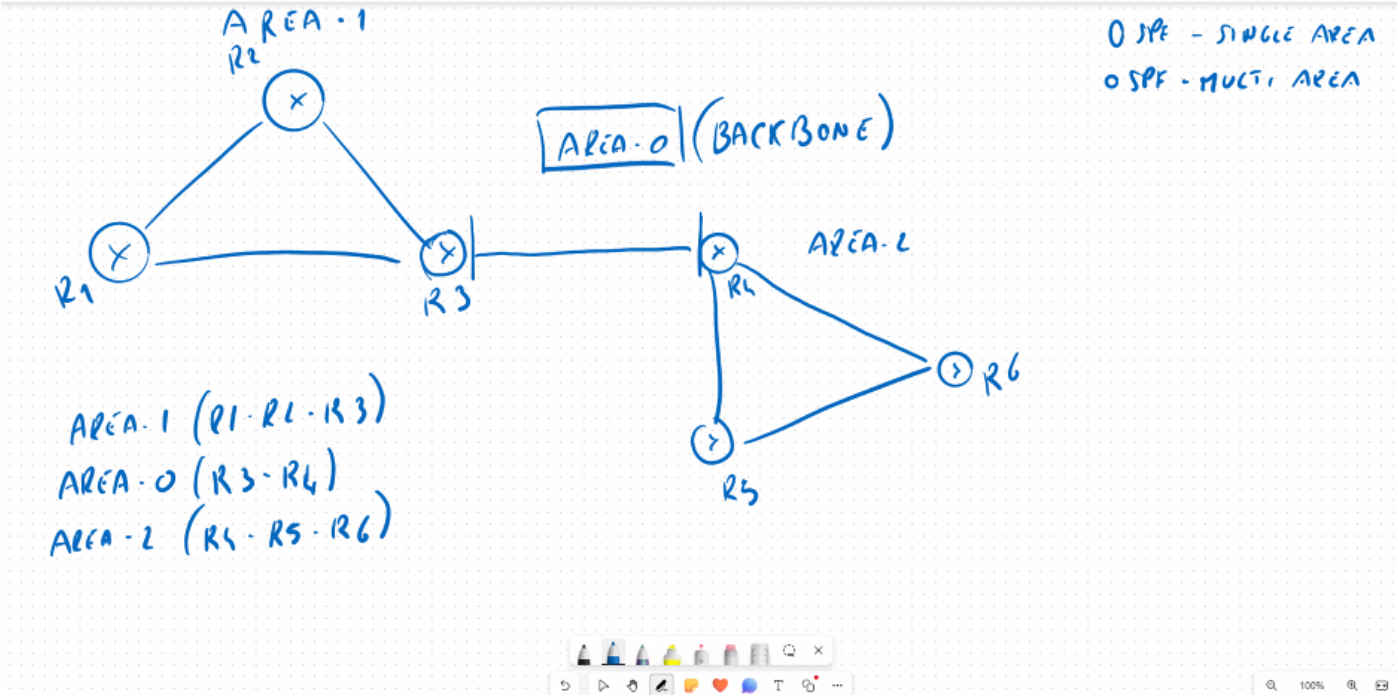
OSPF Features and Characteristics

Introduction to OSPF

- OSPF is a link-state routing protocol that was developed as an alternative for the distance vector Routing Information Protocol (RIP). OSPF has significant advantages over RIP in that it offers faster convergence and scales to much larger network implementations.
- OSPF is a link-state routing protocol that uses the concept of areas. A network administrator can divide the routing domain into distinct areas that help control routing update traffic.
  - A link is an interface on a router, a network segment that connects two routers, or a stub network such as an Ethernet LAN that is connected to a single router.
  - Information about the state of a link is known as a link-state. All link-state information includes the network prefix, prefix length, and cost.
- This module covers basic, single-area OSPF implementations and configurations.

OSPF

IGP
- DISTANCE VECTOR: HOP DI DISTANZA VERSO LA DEST.
- LINK-STATE: BANDWIDTH



OSPF Features and Characteristics

Components of OSPF

- All routing protocols share similar components. They all use routing protocol messages to exchange route information. The messages help build data structures, which are then processed using a routing algorithm.
- Routers running OSPF exchange messages to convey routing information using five types of packets:
  - Hello packet → NEIGHBOR TABLE
  - Database description packet → TOPOLOGY TABLE (LSDB)
  - Link-state request packet → RICHIESTE DI INFO MANCANTI PER COMPLETARE LA PROPRIA T.T.
  - Link-state update packet → INVIARE AGG. SULLA TOPOLOGIA
  - Link-state acknowledgment packet → CONFERMA.
- These packets are used to discover neighboring routers and also to exchange routing information to maintain accurate information about the network.

Hello Packet: viene inviato tra router per presentarsi e viene popolata la neighbor table

OSPF Features and Characteristics

Components of OSPF (Cont.)

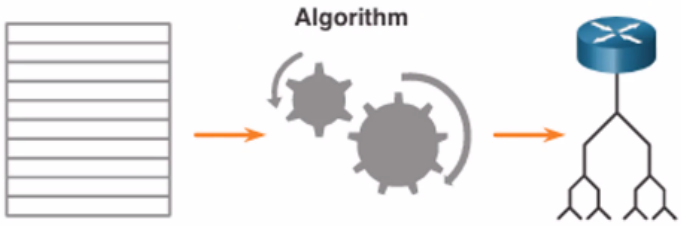
OSPF messages are used to create and maintain three OSPF databases, as follows:

Database	Table	Description
Adjacency Database	Neighbor Table	•List of all neighbor routers to which a router has established bi-directional communication. This table is unique for each router. •Can be viewed using the **`show ip ospf neighbor`** command.
Link-state Database (LSDB)	Topology Table	•Lists information about all other routers in the network. •The database represents the network LSDB. •All routers within an area have identical LSDB. •Can be viewed using the **`show ip ospf database`** command.
Forwarding Database	Routing Table	•List of routes generated when an algorithm is run on the link-state database. •Each router's routing table is unique and contains information on how and where to send packets to other routers. •Can be viewed using the **`show ip route`** command.

OSPF Features and Characteristics

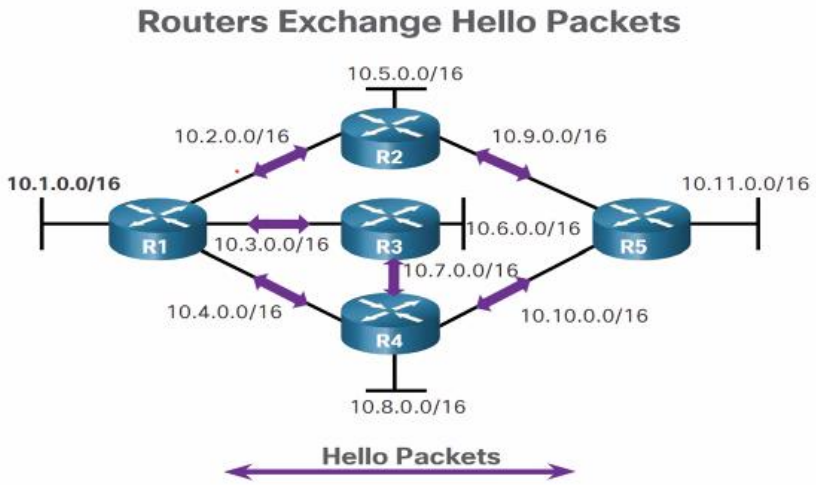
Components of OSPF (Cont.)

- The router builds the topology table using results of calculations based on the Dijkstra shortest-path first (SPF) algorithm. The SPF algorithm is based on the cumulative cost to reach a destination.
- The SPF algorithm creates an SPF tree by placing each router at the root of the tree and calculating the shortest path to each node. The SPF tree is then used to calculate the best routes. OSPF places the best routes into the forwarding database, which is used to make the routing table.



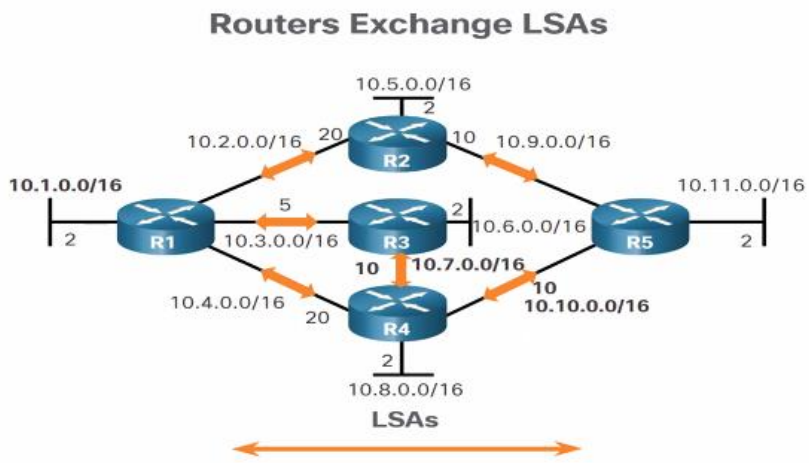
OSPF Features and Characteristics

Establish Neighbor Adjacencies



OSPF Features and Characteristics

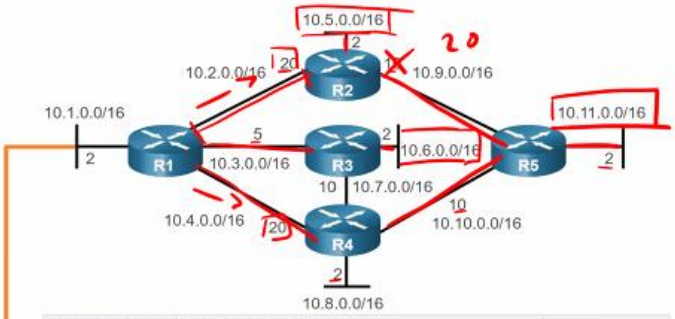
Exchange Link-State Advertisements



OSPF Features and Characteristics

Choose the Best Route

Content of the R1 SPF Tree



Destination	Shortest Path	Cost
10.5.0.0/16	R1→R2	22
10.6.0.0/16	R1→R3	7
10.7.0.0/16	R1→R3	15
10.8.0.0/16	R1→R3→R4	17
10.9.0.0/16	R1→R2	30
10.10.0.0/16	R1→R3→R4	25
10.11.0.0/16	R1→R3→R4→R5	32

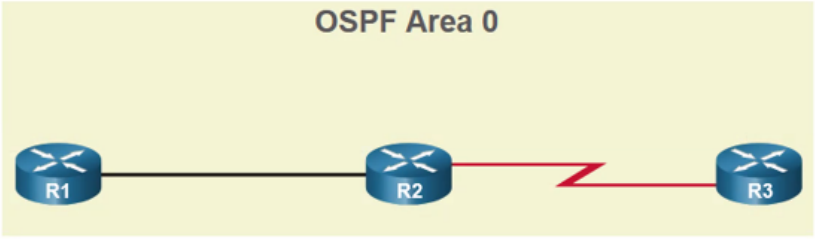
OSPF Features and Characteristics

Single-Area and Multiarea OSPF

To make OSPF more efficient and scalable, OSPF supports hierarchical routing using areas. An OSPF area is a group of routers that share the same link-state information in their LSDBs. OSPF can be implemented in one of two ways, as follows:

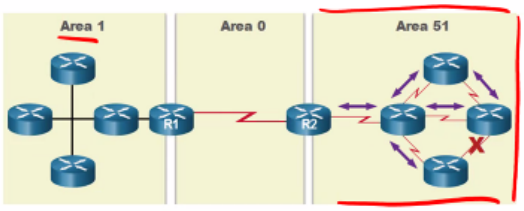
- **Single-Area OSPF** - All routers are in one area. Best practice is to use area 0.
- **Multiarea OSPF** - OSPF is implemented using multiple areas, in a hierarchical fashion. All areas must connect to the backbone area (area 0). Routers interconnecting the areas are referred to as Area Border Routers (ABRs).

The focus of this module is on single-area OSPFv2.



Multiarea OSPF

- The hierarchical-topology design options with multiarea OSPF can offer the following advantages.
  - **Smaller routing tables** - Tables are smaller because there are fewer routing table entries. This is because network addresses can be summarized between areas. Route summarization is not enabled by default.
  - **Reduced link-state update overhead** - Designing multiarea OSPF with smaller areas minimizes processing and memory requirements.
  - **Reduced frequency of SPF calculations** –– Multiarea OSPF localize the impact of a topology change within an area. For instance, it minimizes routing update impact because LSA flooding stops at the area boundary.

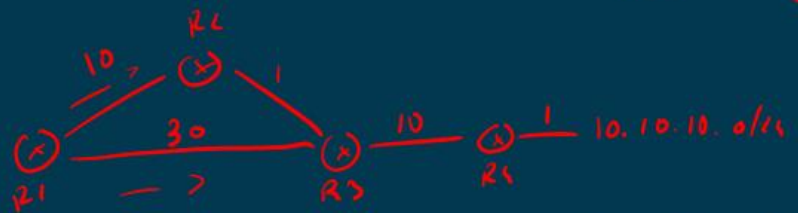


1.2 OSPF Packets

IGP
INTERNAL
GATEWAY
PROTOCOL
→ DIST. VECTOR (HOP DI DISTANZA)
→ LINK-STATE

EGP
EXTERNAL
GATEWAY
PROTOCOL
BGP
→ PATH VECTOR

COSTO = REF. BAND / BAND-LINK



RIP R1 - R2 - R3 - R4
→ R1 - R3 - R4

OSPF → R1 - R2 - R3 - R4 (22)
R1 - R3 - R4 (41)

OSPF Packets

Types of OSPF Packets

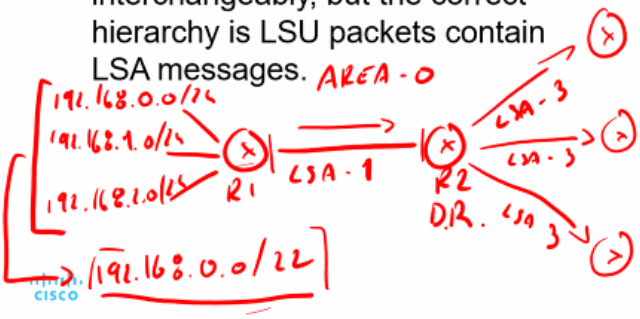
The table summarizes the five different types of Link State Packets (LSPs) used by OSPFv2. OSPFv3 has similar packet types.

Type	Packet Name	Description
1	Hello	Discovers neighbors and builds adjacencies between them
2	Database Description (DBD)	Checks for database synchronization between routers
3	Link-State Request (LSR)	Requests specific link-state records from router to router
4	Link-State Update (LSU)	Sends specifically requested link-state records
5	Link-State Acknowledgment (LSAck)	Acknowledges the other packet types

OSPF Packets

Link-State Updates

- LSUs are also used to forward OSPF routing updates. An LSU packet can contain 11 different types of OSPFv2 LSAs. OSPFv3 renamed several of these LSAs and also contains two additional LSAs.
- LSU and LSA are often used interchangeably, but the correct hierarchy is LSU packets contain LSA messages.



LSUs

Type	Packet Name	Description
1	Hello	Discovers neighbors and builds adjacencies between them
2	DBD	Checks for database synchronization between routers
3	LSR	Requests specific link-state records from router to router
4	LSU	Sends specifically requested link-state records
5	LSAck	Acknowledges the other packet types

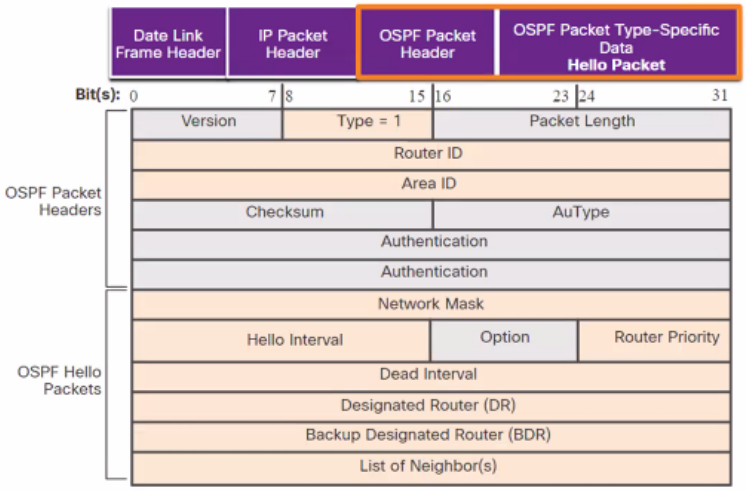
LSAs

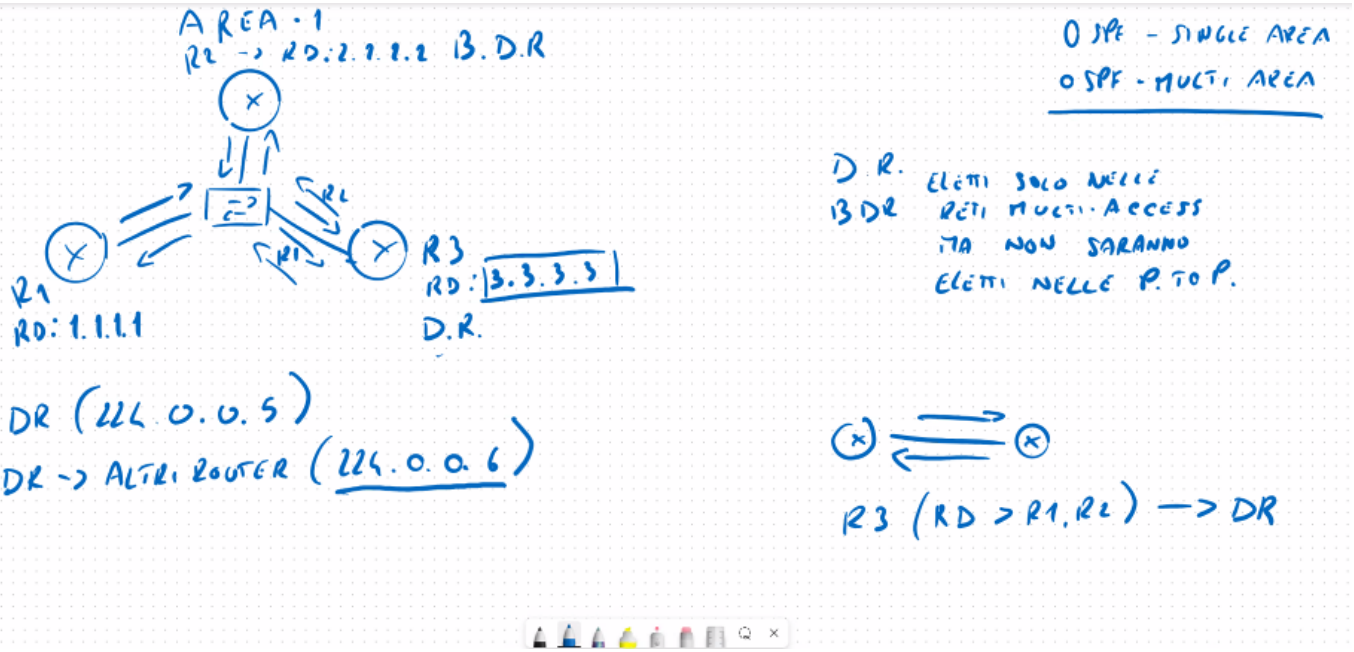
LSA Type	Description
1	Router LSAs
2	Checks for database synchronization between routers
3 or 4	Summary LSAs
5	Autonomous System External LSAs
6	Multicast OSPF LSAs
7	Defined for Not-So-Stubby Areas
8	External Attributes LSA for Border Gateway Patrol (BGPs)

OSPF Packets
Hello Packet

The OSPF Type 1 packet is the Hello packet. Hello packets are used to do the following:

- Discover OSPF neighbors and establish neighbor adjacencies.
- Advertise parameters on which two routers must agree to become neighbors.
- Elect the Designated Router (DR) and Backup Designated Router (BDR) on multiaccess networks like Ethernet. Point-to-point links do not require DR or BDR.





OSPF Operation

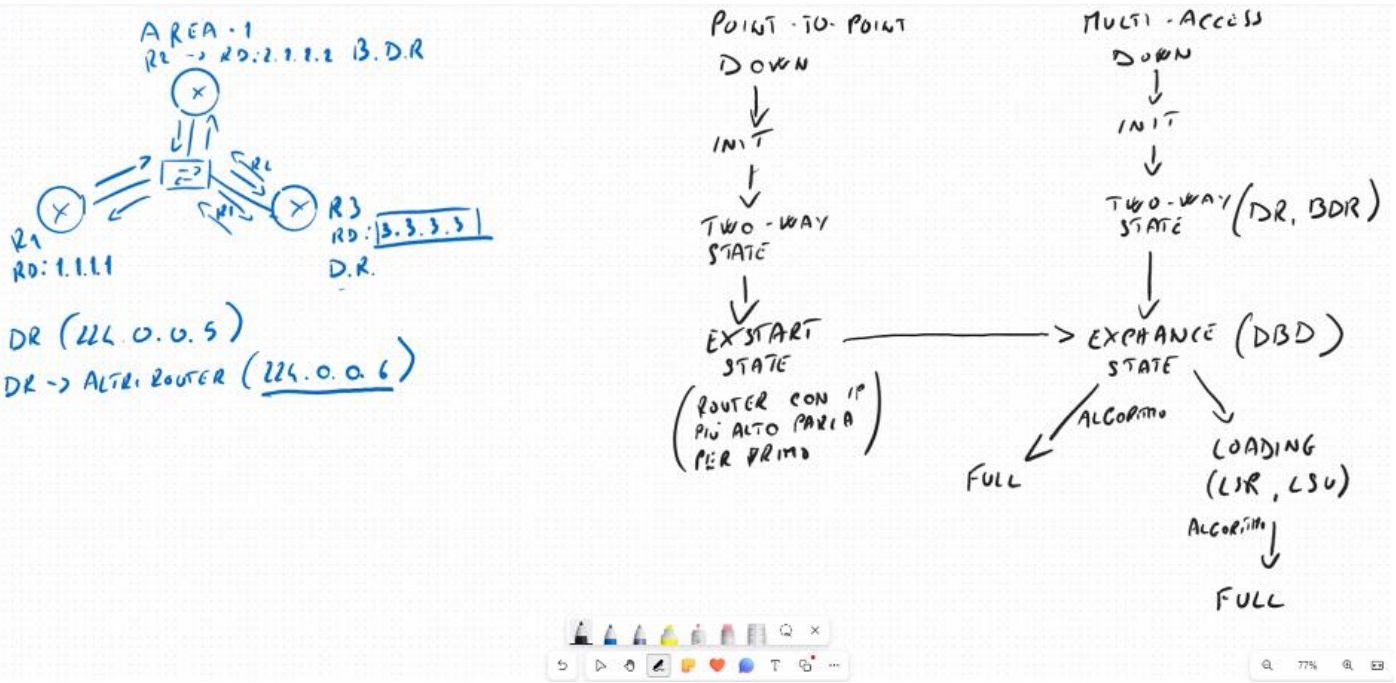
OSPF Operational States (Cont.)

State	Description
ExStart State	On point-to-point networks, the two routers decide which router will initiate the DBD packet exchange and decide upon the initial DBD packet sequence number.
Exchange State	•Routers exchange DBD packets. •If additional router information is required then transition to Loading; otherwise, transition to the Full state.
Loading State	•LSRs and LSUs are used to gain additional route information. •Routes are processed using the SPF algorithm. •Transition to the Full state.
Full State	The link-state database of the router is fully synchronized.

TOPOLOGY TABLE

R1 POINT-TO-POINT R2

S0/0 192.168.10.1 — S0/1 [192.168.10.2] IP > R1



OSPF Operation

Establish Neighbor Adjacencies

- To determine if there is an OSPF neighbor on the link, the router sends a Hello packet that contains its router ID out all OSPF-enabled interfaces. The Hello packet is sent to the reserved All OSPF Routers IPv4 multicast address 224.0.0.5. Only OSPFv2 routers will process these packets.
- The OSPF router ID is used by the OSPF process to uniquely identify each router in the OSPF area. A router ID is a 32-bit number formatted like an IPv4 address and assigned to uniquely identify a router among OSPF peers.
- When a neighboring OSPF-enabled router receives a Hello packet with a router ID that is not within its neighbor list, the receiving router attempts to establish an adjacency with the initiating router.

OSPF Operation

Establish Neighbor Adjacencies (Cont.)

The process routers use to establish adjacency on a multiaccess network:

1	Down to Init State	When OSPFv2 is enabled on the interface, R1 transitions from Down to Init and starts sending OSPFv2 Hellos out of the interface in an attempt to discover neighbors.
2	Init State	When a R2 receives a hello from the previously unknown router R1, it adds R1's router ID to the neighbor list and responds with a Hello packet containing its own router ID.
3	Two-Way State	R1 receives R2's hello and notices that the message contains the R1 router ID in the list of R2's neighbors. R1 adds R2's router ID to the neighbor list and transitions to the Two-Way State. If R1 and R2 are connected with a point-to-point link, they transition to ExStart If R1 and R2 are connected over a common Ethernet network, the DR/BDR election occurs.
4	Elect the DR & BDR	The DR and BDR election occurs, where the router with the highest router ID or highest priority is elected as the DR, and second highest is the BDR

OSPF Operation

Synchronizing OSPF Databases

After the Two-Way state, routers transition to database synchronization states. This is a three step process, as follows:

- Decide first router: The router with the highest router ID sends its DBD first. IPv4 più alto
- Exchange DBDs: As many as needed to convey the database. The other router must acknowledge each DBD with an LSAck packet.
- Send an LSR: Each router compares the DBD information with the local LSDB. If the DBD has more current link information, the router transitions to the loading state.

After all LSRs have been exchanged and satisfied, the routers are considered synchronized and in a full state. Updates (LSUs) are sent:

- When a change is perceived (incremental updates)
- Every 30 minutes

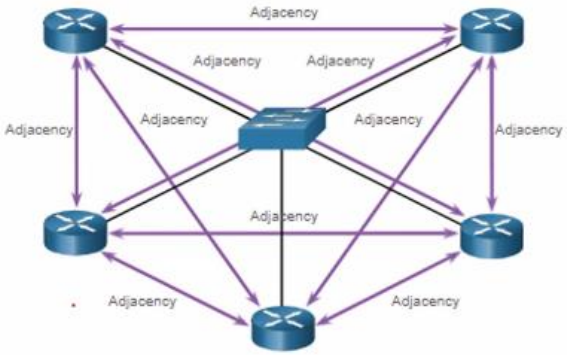
CONFIGURATO AUTOMATICO
R. ID = IPv4 più ALTO

OSPF Operation

The Need for a DR

Multiaccess networks can create two challenges for OSPF regarding the flooding of LSAs, as follows:

- **Creation of multiple adjacencies** - Ethernet networks could potentially interconnect many OSPF routers over a common link. Creating adjacencies with every router would lead to an excessive number of LSAs exchanged between routers on the same network.
- **Extensive flooding of LSAs** - Link-state routers flood their LSAs any time OSPF is initialized, or when there is a change in the topology. This flooding can become excessive.



- Number of Adjacencies = n (n - 1) / 2
- n = number of routers
- Example: 5 (5 - 1) / 2 = 10 adjacencies

LSA Flooding with a DR

- An increase in the number of routers on a multiaccess network also increases the number of LSAs exchanged between the routers. This flooding of LSAs significantly impacts the operation of OSPF.
- If every router in a multiaccess network had to flood and acknowledge all received LSAs to all other routers on that same multiaccess network, the network traffic would become quite chaotic.
- On multiaccess networks, OSPF elects a DR to be the collection and distribution point for LSAs sent and received. A BDR is also elected in case the DR fails. All other routers become DROTHERs. A DROTHER is a router that is neither the DR nor the BDR.
- **Note**: The DR is only used for the dissemination of LSAs. The router will still use the best next-hop router indicated in the routing table for the forwarding of all other packets.

DR 224.0.0.6
BDR
DROTHER 224.0.0.5

