Lucerne University of
Applied Sciences and Arts
HOCHSCHULE
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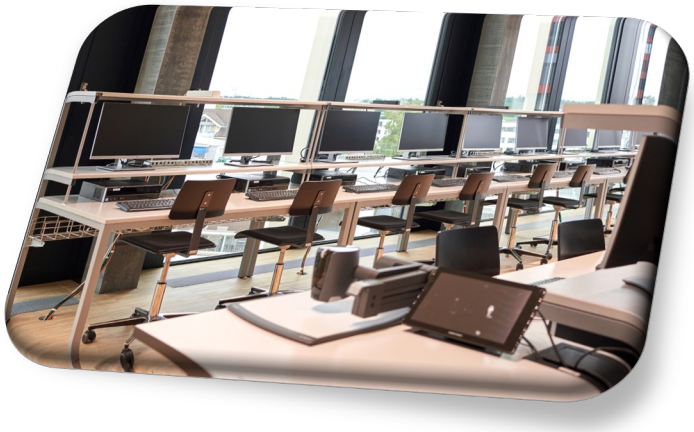
Informatik

Networking III – SW7: OSPFv2



Ausbildung

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FH Zentralschweiz

Today

Time	Topic	Activity Type
ca. 45 min	OSPFv2: Basics	Plenum + Live Quiz
ca. 20 min	OSPF in Practice	Wireshark Guided Lab
ca. 15 min	Pause	
ca. 45 min	OSPFv2: Additional Concepts	Plenum + Live Quiz
ca. 15 min	OSPFv2 To DOs, Q&A & Review; Overview Next Week	Plenum + Individual Review

Introduction to OSPF

- Link-state routing protocol
  - Link
    - Interface on a router
    - Network segment that connects two routers,
    - Stub network, e.g. Ethernet LAN that is connected to a single router
  - Link-state:
    - Network prefix, prefix length, and cost
  - Areas: division of the routing domain to help control routing update traffic
- Alternative for RIP (Routing Information Protocol)
  - Faster convergence
  - Scaling to larger network implementations

OSPF Packets

- Routing protocol messages
  - To exchange route information
  - Build data structures
  - Data structures processed using a routing algorithm

- OSPF Packets used to:
  - discover neighboring routers
  - exchange routing information
  - maintain accurate network information

OSPF Databases & Tables

Database	Table	Description

OSPF Databases & Tables

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 • 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 Process

1. The router gathers information about routers it can (bidirectionally) reach into the **Neighbor Table**

2. The router builds the **Topology Table** with all routers in the OSPF Area

3. The router performs Dijkstra Shortest-Path First (SPF) algorithm on the routers in the **Topology Table**
   - SPF calculates the shortest path to each node

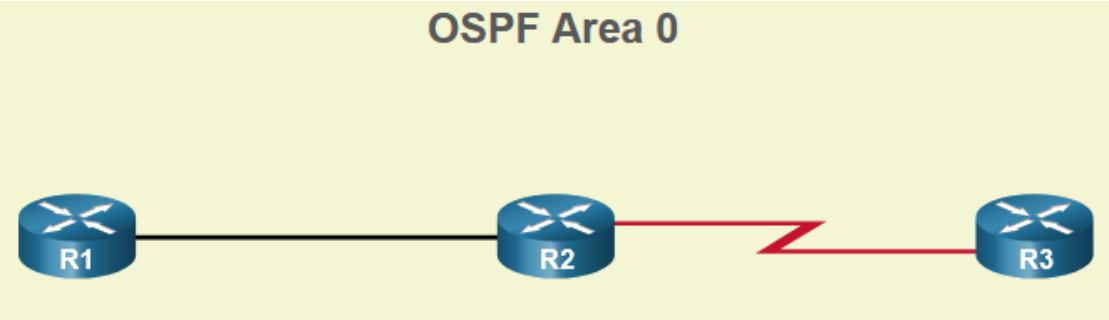
4. OSPF places the best routes into the **forwarding database** (routing table)

Single-Area OSPF

Area: group of routers that share the same link-state information in their LSDBs.

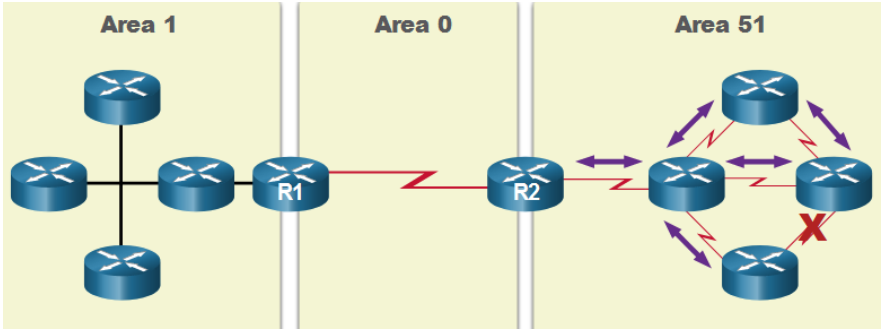
OSPF can be implemented as:

- **Single-Area OSPF** - All routers are in one area. Best practice is to use area 0



- **Multiarea OSPF** ⇨

Multiarea OSPF



- Multiple areas, hierarchical
- All areas must connect to the backbone area (area 0)
- Routers interconnecting the areas: Area Border Routers (ABRs)

- Advantages of multiarea OSPF
  - Smaller routing tables
  - Reduced link-state update overhead
  - Reduced frequency of SPF calculations
    - Topology changes localized within an area
    - LSA flooding stops at the area boundary

OSPFv3

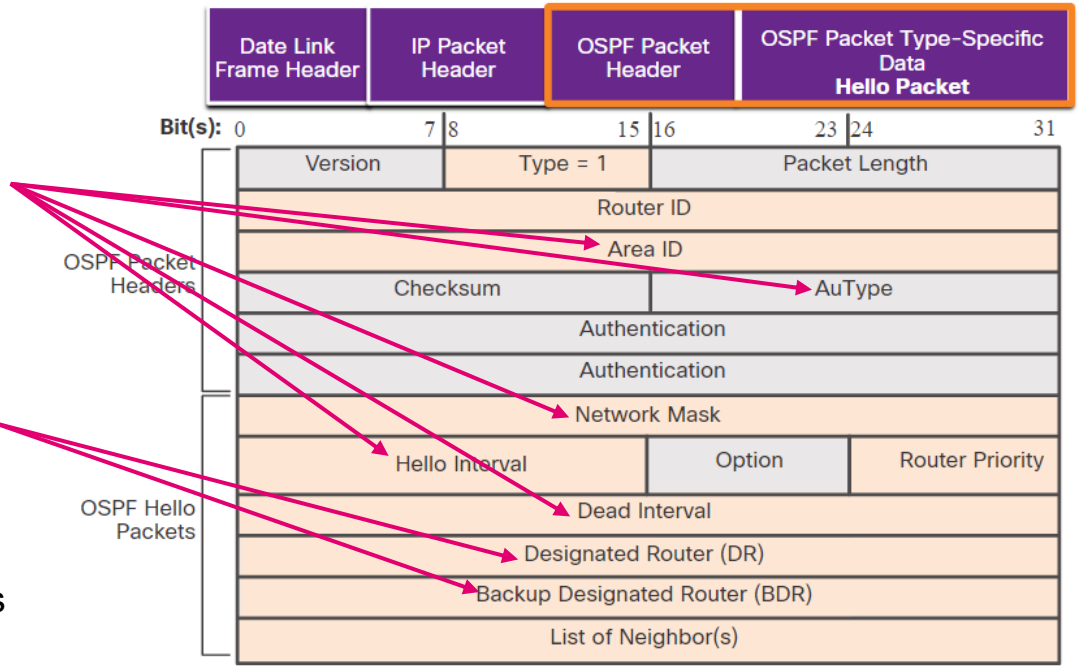
- Exchanges routing information to populate the IPv6 routing table with remote prefixes
- Includes support for both IPv4 and IPv6
  - Address Families feature
- Same functionality as OSPFv2 but uses IPv6 as the network layer transport
- Also uses the SPF algorithm
- Has separate processes from OSPFv2 (runs independently)

Types of OSPF Packets

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

Hello Packet (Type 1)

- 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.
  - Not required in **Point-to-point** links



Link-State Updates (Type 4)

- Include OSPF routing updates
- 11 different types of OSPFv2 Link-State Advertisements (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

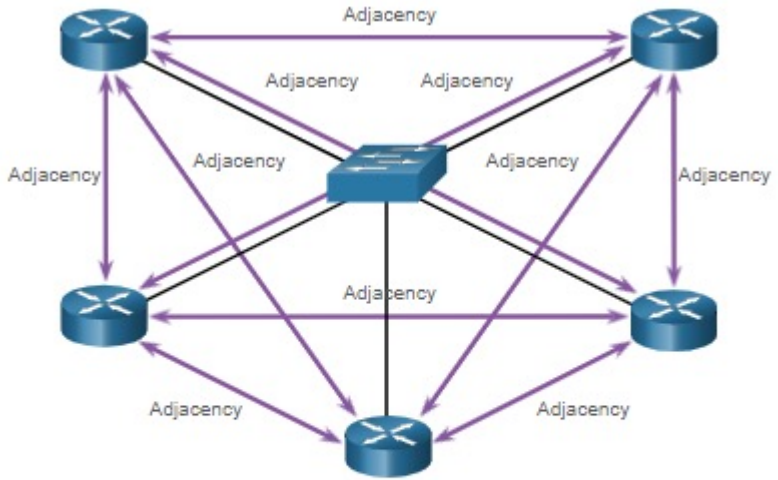
The Need for a Designated Router (DR) in Multi-access Networks

Issues:

- Creation of multiple adjacencies on shared media
- Extensive flooding of LSAs (OSPF init, topology change)

Solution: DR as a **collection and distribution point for LSAs**

- BDR also elected (in case the DR fails)
- All other routers become DROTHER (neither DR nor BDR).
- DR only used for the dissemination of LSAs. It still uses best next-hop router for packet routing



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

OSPF Router Roles

Designated Router (DR)

- Responsible for collecting and distributing LSAs
- Uses multicast address 224.0.0.5 (all OSPF routers)

Backup Designated Router (BDR)

- Listens and maintains a relationship with all other routers
- DR stops producing Hello packets → BDR promotes itself to the DR role

Other Routers (DROTHER)

- All other routers (no DR and not BDR)
- Use the multicast address 224.0.0.6 (all designated routers) to send OSPF packets to the DR and BDR.

OSPF Operational States

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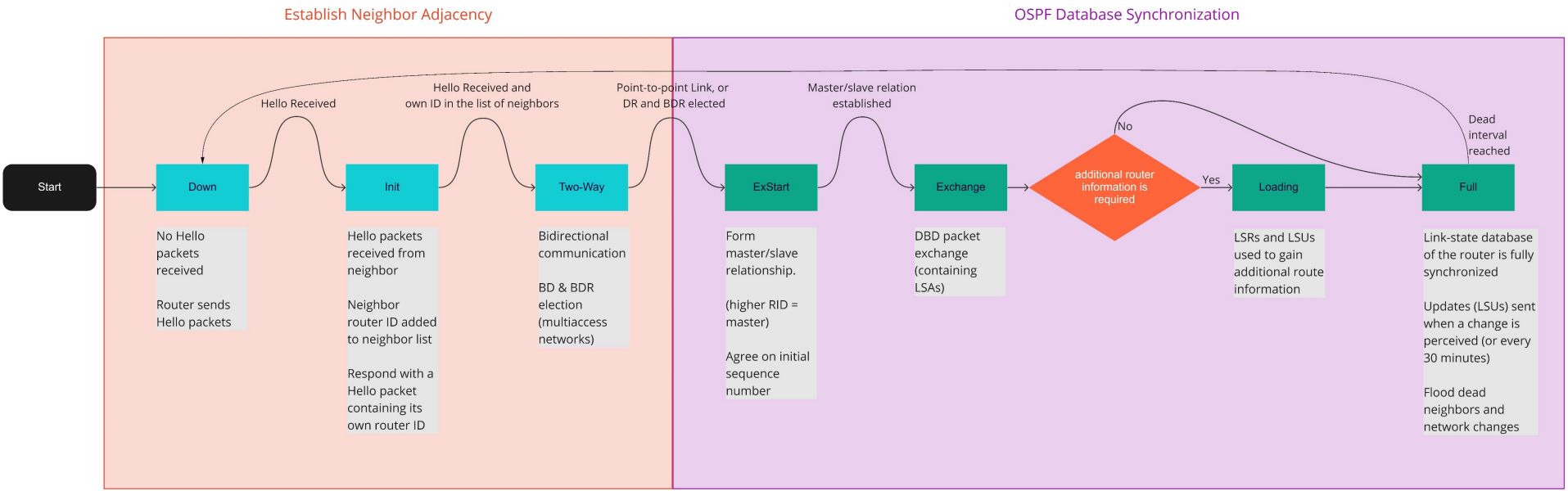

Live Quiz: Mentimeter

https://www.menti.com/al6jzf6zdk7x

www.menti.com Code: **6591 8568**

Mentimeter

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OSPF Wireshark Experiment (1/2)

- Download and open the capture “OSPF.cap” from ILIAS
- How many routers are involved in the OSPF Wireshark trace?
- What is the destination IP address of the Hello Packets?
  - Why?
- What are Priorities of each router?
  - Hint: look for this in: OSPF/OSPF Header/OSPF Hello Packet
- What are the DR and BDR in the initial 12 Hello Packets?
  - Hint: look for this in: OSPF/OSPF Header/OSPF Hello Packet
- What are the selected DR and BDR?
  - Hint: look for this in Frame #19
  - Why? comes later ☺

OSPF Wireshark Experiment (2/2)

- How many **LSA Types** are in the DBD Packet in Frame#18?
- How many **LSAs** are in the DBD Packet in Frame#18?
- How do Frame#23 and Frame#28 relate to each other?
  - Hint: look at the payload of the OSPF Packets

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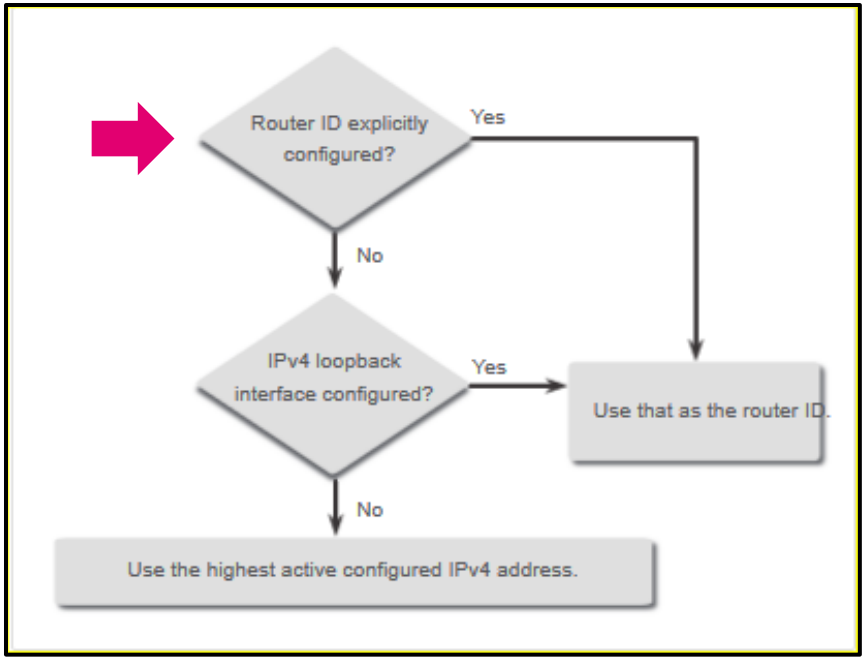
OSPF Router ID

- 32-bit value represented as an IPv4 address
- uniquely identifies an OSPF router
- Router with the highest router ID will be the master in the adjacency ⇒ sends their database descriptor (DBD) packets first (Exchange State)
- Used for the DR and BDR election (Two-Way state)
- Can be
  - Manually defined (admin)
  - automatically assigned (router self)

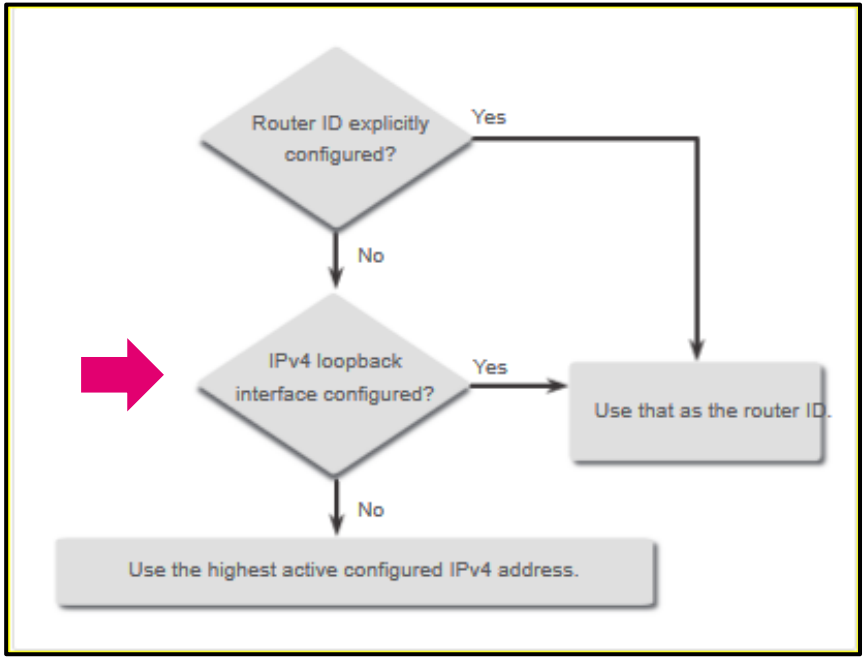


OSPF Router ID

Configuring OSPF

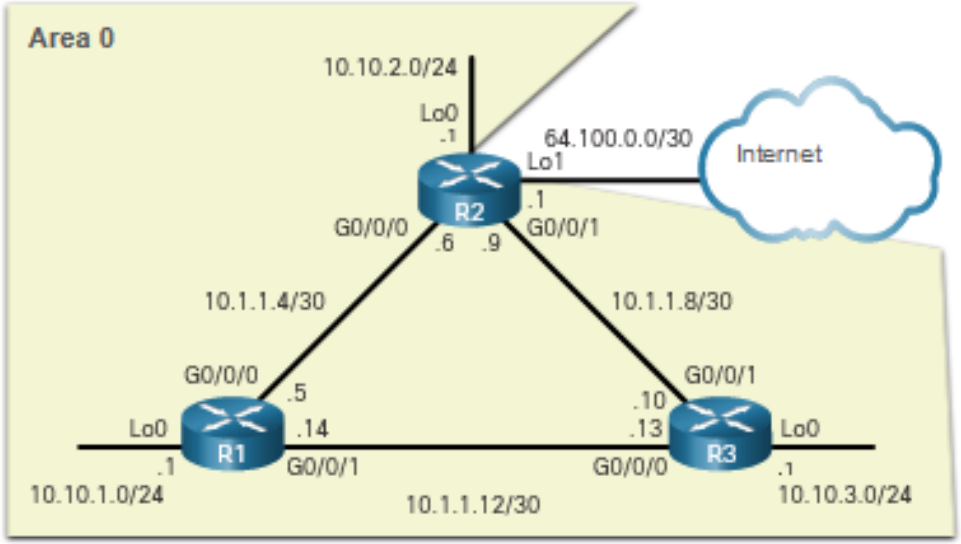
```
R1# show ip protocols | include Router ID
Router ID 10.10.1.1
R1# conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)# router ospf 10
```

Configure a Loopback Interface as the Router ID




```
R1(config-if)# interface Loopback 1
R1(config-if)# ip address 1.1.1.1 255.255.255.255
R1(config-if)# end
R1# show ip protocols | include Router ID
  Router ID 1.1.1.1
R1#
```

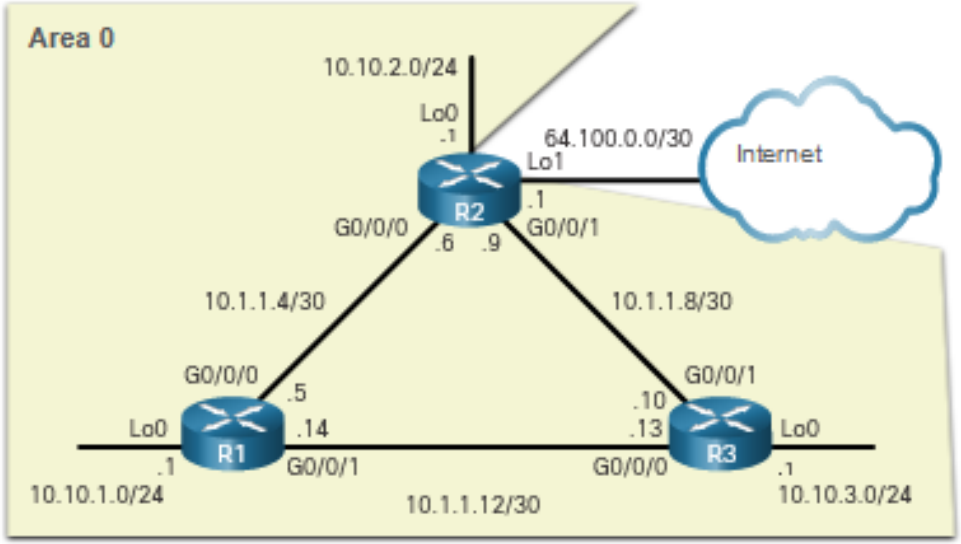
Configure OSPF Using the **network** Command (Option 1)



Option 1. wildcard mask identifies the interface based on the network addresses

```
R1(config)# router ospf 10
R1(config-router)# network 10.10.1.0 0.0.0.255 area 0
R1(config-router)# network 10.1.1.4 0.0.0.3 area 0
R1(config-router)# network 10.1.1.12 0.0.0.3 area 0
R1(config-router)#
```

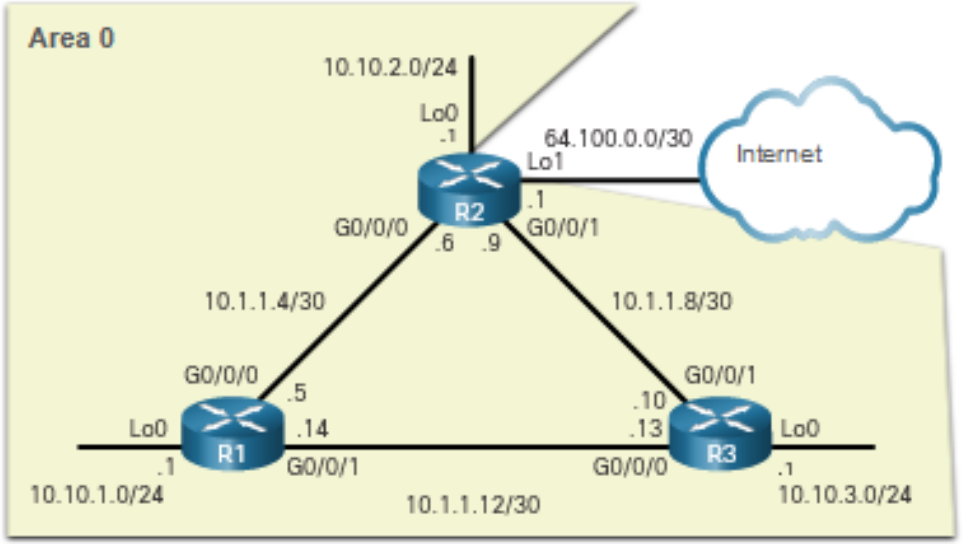
Configure OSPF Using the **network** Command (Option 2)



Option 2. exact interface IPv4 address using a quad zero wildcard mask

```
R1(config)# router ospf 10
R1(config-router)# network 10.10.1.1 0.0.0.0 area 0
R1(config-router)# network 10.1.1.5 0.0.0.0 area 0
R1(config-router)# network 10.1.1.14 0.0.0.0 area 0
R1(config-router)#
```

Configure OSPF Using the ip ospf Command (Option 3)



Option 3. ip ospf command

```
R1(config-router)# interface GigabitEthernet 0/0/0
R1(config-if)# ip ospf 10 area 0
R1(config-if)# interface GigabitEthernet 0/0/1
R1(config-if)# ip ospf 10 area 0
R1(config-if)# interface Loopback 0
R1(config-if)# ip ospf 10 area 0
```

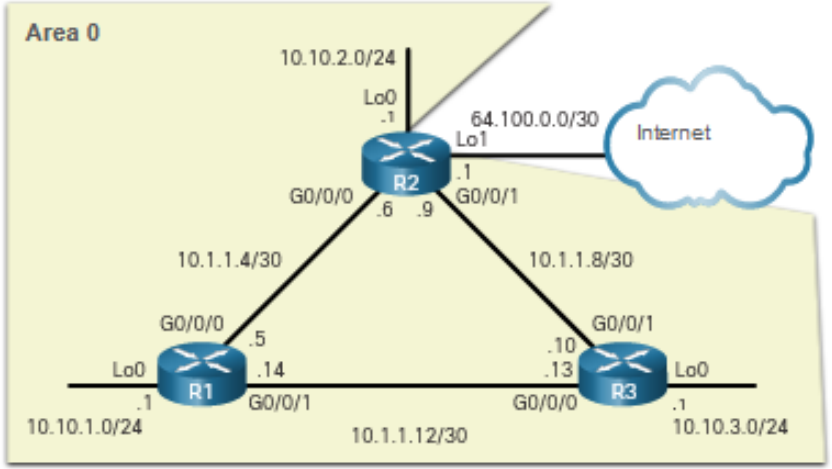
Point-to-Point OSPF Networks

Passive Interface

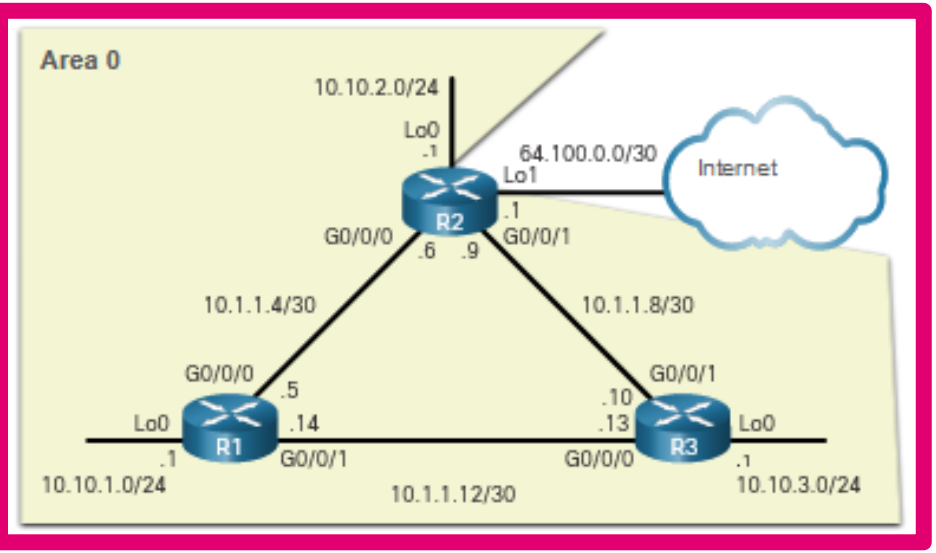
- OSPF messages forwarded on all OSPF-enabled interfaces
  - Only needed on interfaces that are connecting to other OSPF-enabled routers
  - Inefficient!

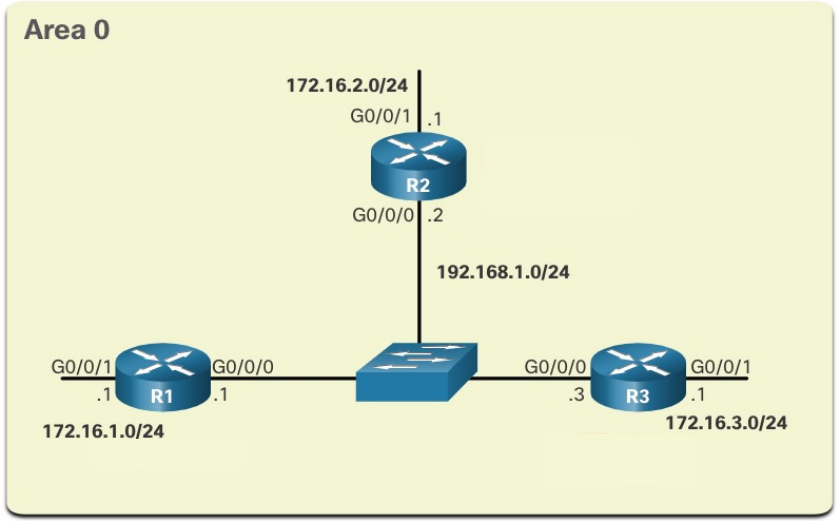
```
R1(config)# router ospf 10
R1(config-router)# passive-interface loopback 0
R1(config-router)# end
```

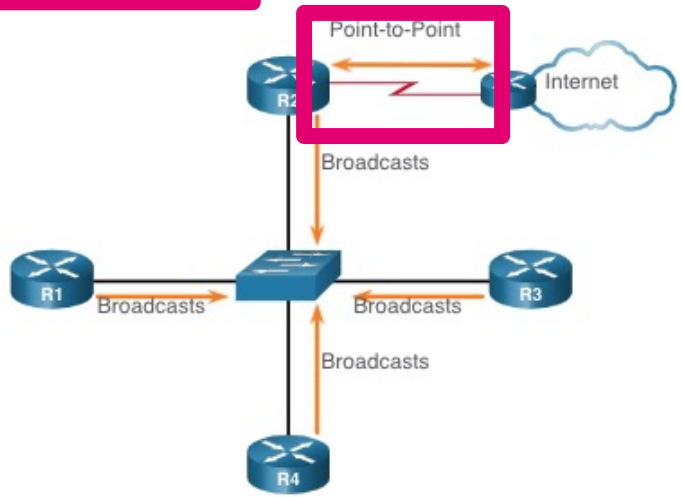
- Defining an interface as passive:
  - Interface no longer used to forward OSPF messages
  - Network attached to the interface still advertised to other OSPF Routers




```
R1# show ip protocols
*** IP Routing is NSF aware ***
(output omitted)
Routing Protocol is "ospf 10"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 1.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
  Routing on Interfaces Configured Explicitly (Area 0):
    Loopback0
    GigabitEthernet0/0/1
    GigabitEthernet0/0/0
  Passive Interface(s):
    Loopback0
  Routing Information Sources:
```

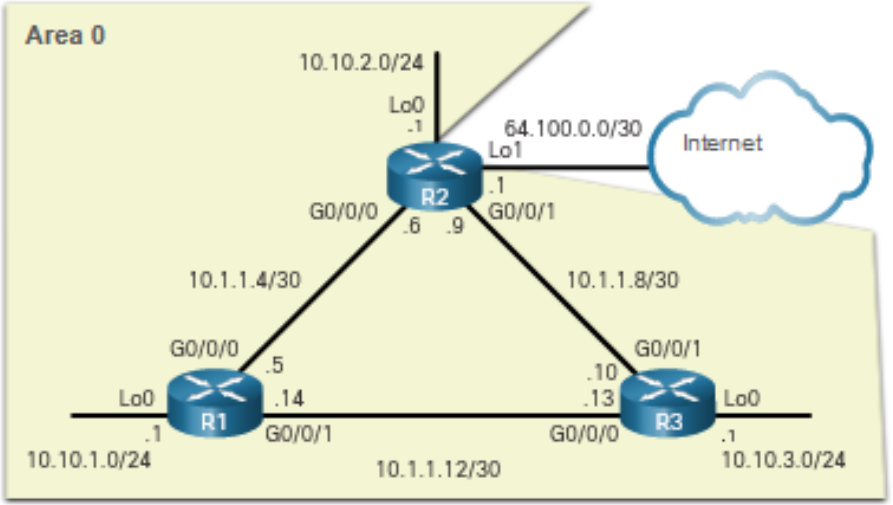


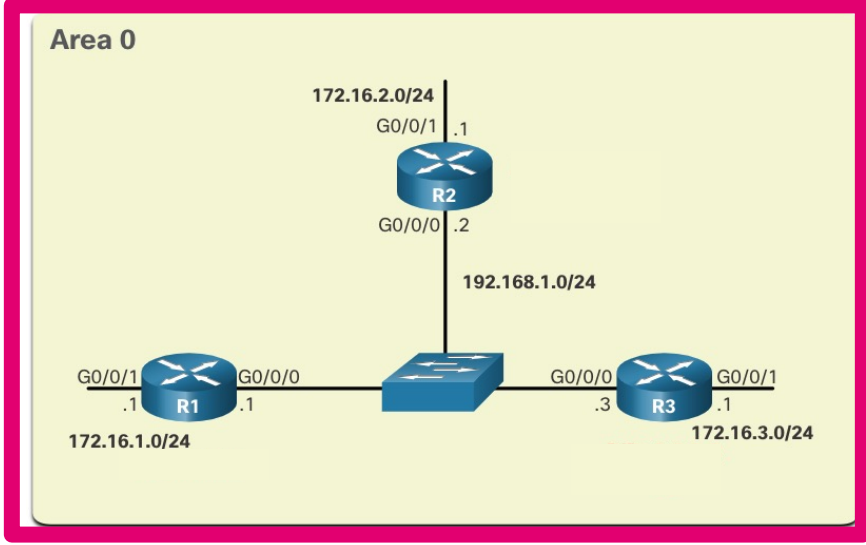


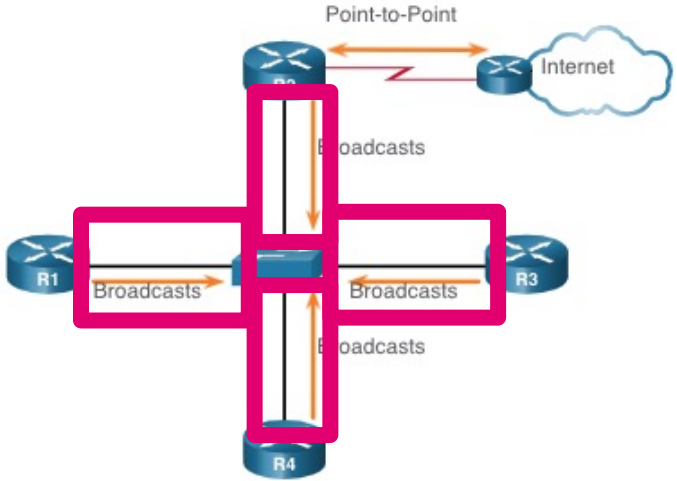


OSPF Point-to-Point Networks (Cont.)

```
R1(config)# interface GigabitEthernet 0/0/0
R1(config-if)# ip ospf network point-to-point
*Jun 6 00:44:05.208: %OSPF-5-ADJCHG: Process 10, Nbr 2.2.2.2 on GigabitEthernet0/0/0 from
FULL to DOWN, Neighbor Down: Interface down or detached
*Jun 6 00:44:05.211: %OSPF-5-ADJCHG: Process 10, Nbr 2.2.2.2 on GigabitEthernet0/0/0 from
LOADING to FULL, Loading Done
R1(config-if)# end
R1# show ip ospf interface GigabitEthernet 0/0/0
GigabitEthernet0/0/0 is up, line protocol is up
  Internet Address 10.1.1.5/30, Area 0, Attached via Interface Enable
  Process ID 10, Router ID 1.1.1.1, Network Type POINT_TO_POINT, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown    Topology Name
```







OSPF Broadcast Networks

```
R1# show ip ospf interface GigabitEthernet 0/0/0
GigabitEthernet0/0/0 is up, line protocol is up
  Internet Address 10.1.1.5/30, Area 0, Attached via Interface Enable
  Process ID 10, Router ID 1.1.1.1, Network Type BROADCAST, Cost: 1
  Topology-MTID    Cost    Disabled    Shutdown    Topology Name
        0           1        no           no          Base
  Enabled by interface config, including secondary ip addresses
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 2.2.2.2, Interface address 10.1.1.6
  Backup Designated router (ID) 1.1.1.1, Interface address 10.1.1.5
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
```

Default DR/BDR Election Process

1. DR ← Router with the highest interface priority
   BDR ← Router with the second highest interface priority

- Priority: [0→255].
- 0: cannot be elected as DR nor BDR.
- 1: default.

2. Interface priorities are equal ⇒
   DR ← Router with the highest router ID
   BDR ← Router with the second highest router ID

- The election process is one-time: when the first router with an OSPF-enabled interface is active
- The addition of a new router does not initiate a new election process
- Possible that a router with a lower router ID becomes the DR (not all routers have booted)

DR Failure and Recovery

After the DR is elected, it remains the DR until the DR fails

- The OSPF process on the DR fails or is stopped
- The multiaccess interface on the DR fails or is shutdown

If the DR fails

- BDR promoted to DR
- Even if another DROTHER with a higher priority or router ID is added to the network after the DR/BDR election.
- BUT after a BDR is promoted to DR: a new BDR election occurs and the DROTHER with the highest priority or router ID is elected as the new BDR

Default DR/BDR Election Process

1. DR ← Router with the highest interface priority
   BDR ← Router with the second highest interface priority

- Priority: [0→255].
- 0: cannot be elected as DR nor BDR.
- 1: default

```
R1(config)# interface GigabitEthernet 0/0/0
R1(config-if)# ip ospf priority 255
R1(config-if)# end
R1# clear ip ospf process
Reset ALL OSPF processes? [no]: y
R1# *Jun 5 03:47:41.563: %OSPF-5-ADJCHG: Process 10, Nbr 2.2.2.2 on GigabitEthernet0/0/0
from FULL to DOWN, Neighbor Down: Interface down or detached
```

Hello Packet Intervals

- OSPFv2 Hello packets
  - to multicast address 224.0.0.5 (all OSPF routers) every 10 seconds (**Hello interval**)
  - not sent on interfaces set to passive by the passive-interface command

- **Dead interval**: period that the router waits to receive a Hello packet before declaring the neighbor down. When it expires:
  - Neighbor removed from its link-state database (LSDB)
  - Router floods the LSDB update out all OSPF-enabled interfaces

- Cisco: Dead interval = 4x Hello interval
  - Changing the Hello interval **AUTOMATICALLY** changes the Dead interval 😒

Modify OSPFv2 Intervals

```
Router(config-if)# ip ospf hello-interval seconds
Router(config-if)# ip ospf dead-interval seconds
```

- Use the **no ip ospf hello-interval** and **no ip ospf dead-interval** commands to reset the intervals to their default

Propagate a Default Static Route in OSPFv2

To propagate a default route, the (edge) router must be configured with:

- A default static route using the **ip route 0.0.0.0 0.0.0.0** [*next-hop-address* | *exit-intf*] command.

- The **default-information originate** router configuration command.

```
R2(config)# interface lo1
R2(config-if)# ip address 64.100.0.1 255.255.255.252
R2(config-if)# exit
```

Verify the Propagated Default Route

```
R2# show ip route | begin Gateway
Gateway of last resort is 0.0.0.0 to network 0.0.0.0
S*     0.0.0.0/0 is directly connected, Loopback1
      10.0.0.0/8 is variably subnetted, 9 subnets, 3 masks
(output omitted)
```

```
R1# show ip route | begin Gateway
Gateway of last resort is 10.1.1.6 to network 0.0.0.0
O*E2  0.0.0.0/0 [110/1] via 10.1.1.6, 00:11:08, GigabitEthernet0/0/0
      10.0.0.0/8 is variably subnetted, 9 subnets, 3 masks
(output omitted)
```

Live Quiz: Mentimeter

https://www.menti.com/al6jzf6zdk7x

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OSPFv2

Today:

- Focused on gaining a high-level understanding
- Covered the most important aspects

Please also have a look in Netacad (not discussed today):

- Verification Commands (2.3.4-5, 2.6)
- Modifying Costs (2.4.1-4)

Strongly recommended:

- Module Exam 1-2 (**Testatbedingung**)
- Module Quiz 1 and 2
- Packet Tracer Activity 2.7.1

Nächste Woche 11.04.2024 (SW8)

- Advanced Routing Lab
- Raum 404
- In Zweier-Gruppen

- Laborprotokoll in ILIAS abzugeben
  - **Testatbedingung**
  - Spätestens 10.12.2023 (am besten sofort nach dem Labor!)