

# LABORATORY 7

The main goal of the exercise is getting knowledge about a basic configuration of OSPF routing protocol in typical segmented network where segments were divided into subnets through VLSM.

## OSPF Routing Protocol.

Open Shortest Path First (OSPF) is an Interior Gateway Protocol (IGP) standardized by the Internet Engineering Task Force (IETF) and commonly used in large Enterprise networks. OSPF is a link-state routing protocol providing fast convergence and excellent scalability. Like all link-state protocols, OSPF is very efficient in its use of network bandwidth.

## OSPF operation.

For routing purposes, OSPF uses area conception. Every router has the full database of link states for each area. In the OSPF network you can assign any number to area from 0 to 65535. One area has to have number 0 assigned.

NOTE: In the OSPF network including many areas, every area must be connected to the area which has the number 0 assigned. This "0 area" is also called a skeletal area.

Interior gateway protocol:

1. Reacts fast to the network changes.
2. Sends updates only after network changes approaches
3. Sends updates cyclically (Network state refreshing).
4. Uses hello mechanism to define neighbours availability.

In practice it means that every OSPF router sends hello packets to track the states of near routers. Every router uses also LSA (link-state advertisements) to track the states of every router in the supported network area.

## OSPF protocol configuration.

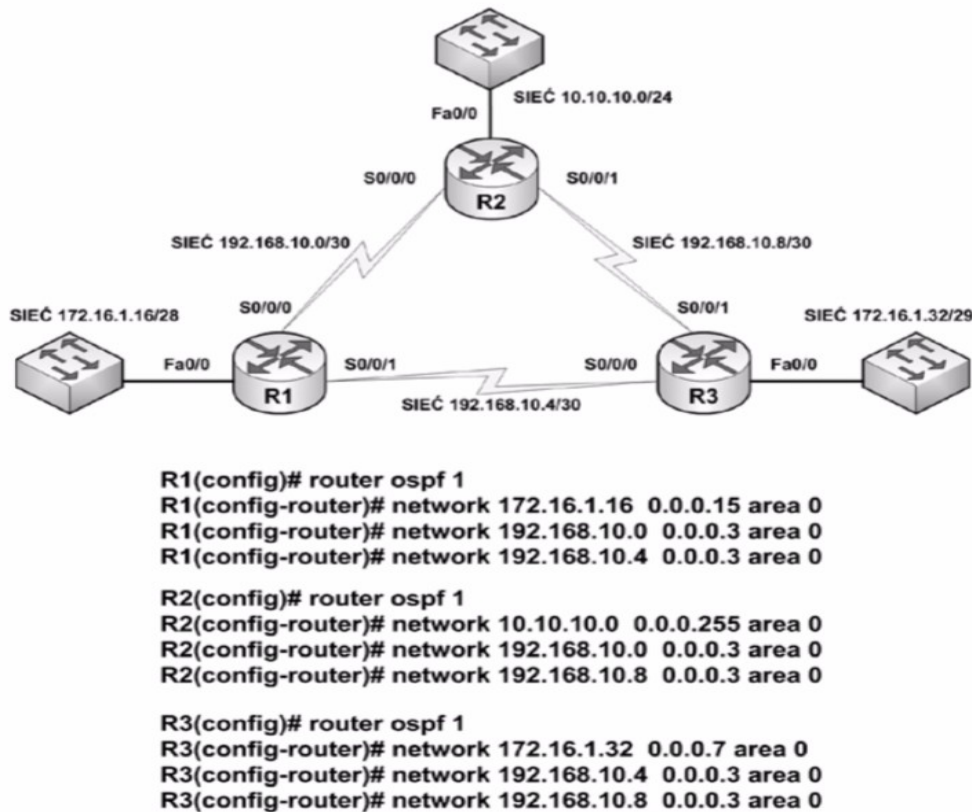
OSPF configuration requires activation of the OSPF routing process on the router and providing network addresses, areas information. Addresses are configured through wildcard masks, not the subnet mask.

To get the wildcard mask you have to subtract the subnet mask from the 255.255.255.255 address e.g.:

```
255.255.255.255
-255.255.255.252    ==> 0.0.0.3
```

NOTE: Check this also: <http://www.dslreports.com/faq/15216>

Area identifiers must be written as full numbers or in decimal notation. Exemplary configuration of the OSPF protocol is shown by the image below:



A. To turn on the OSPF routing, following command must be used:

**Router(config)#router ospf <process\_id>**

Process identifier is a number used to identify the OSPF routing process on the router. Many OSPF routing processes may be launched on the same router in the same time. Number from 1 to 65535 may be used. Most of the network administrators use the same identifier in the whole autonomous system, but it is not necessary. Launching more than one OSPF process is rarely used – only if it is necessary.

B. In the OSPF networks are announced by:

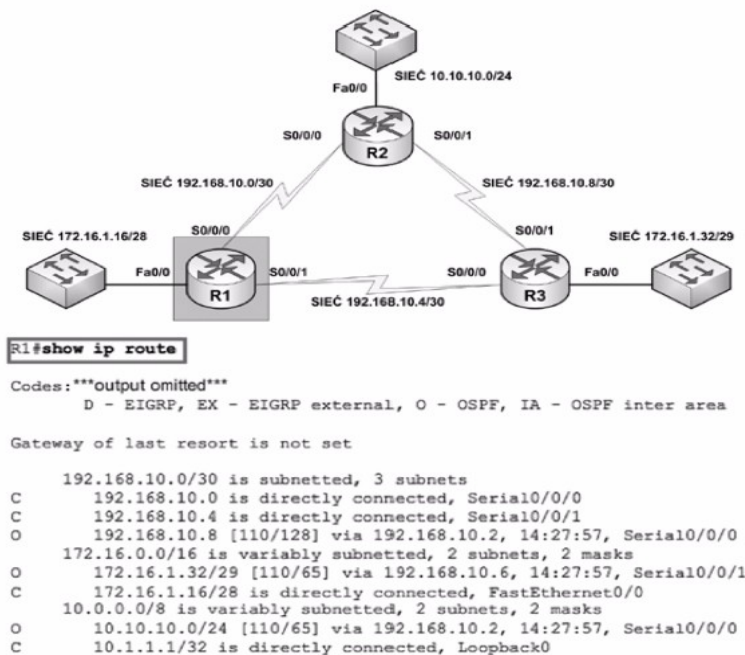
**Router(config-router)#network <address> <opposite mask> area <area\_id>**

Every network has to be connected to the area it belongs. Network address may be the address of the whole network, subnetwork or interface address. Opposite mask represents a pool of host addresses which are supported in the segment.

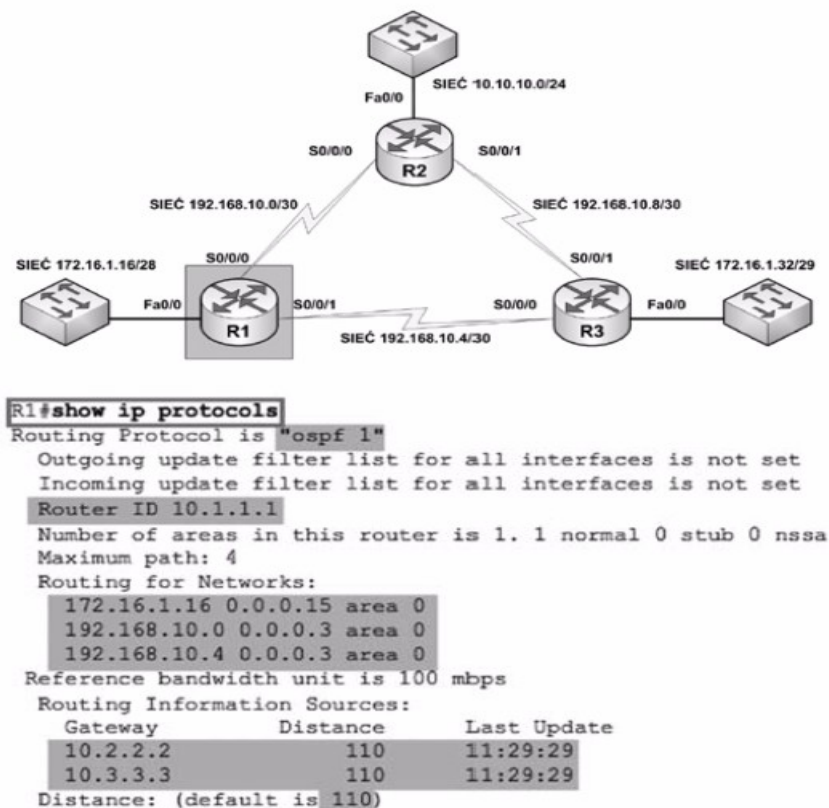
**OSPF protocol configuration verifying.**

A. Command **show ip route** is used to check if the OSPF protocol sends and receives informations about routes. Letter "O" at the begining of every entry means that the

source of information about the route is dynamic OSPF link state routing protocol.



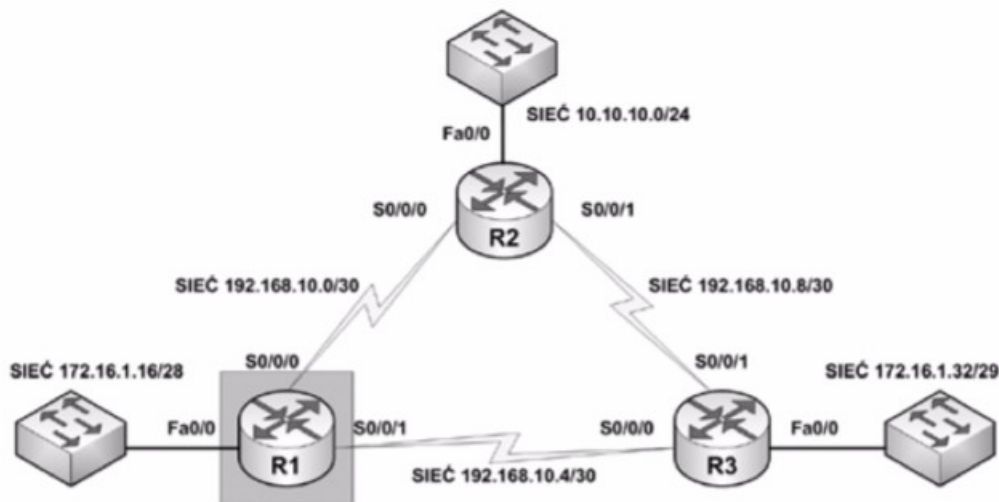
B. Command `show ip protocols` is used to check the current router identifier. Besides the command allows to check the networks broadcasted by the router, neighbours which are used to receive the updates by the router and default administrative distance (110 for OSPF protocol).



C. Command `show ip ospf` is used to check the current router identifier. Besides it displays the informations about the OSPF area and a time of the last execution of the SPF algorithm.

```
R1#show ip ospf
***output omitted***
Routing Process "ospf 1" with ID 10.1.1.1
Start time: 00:00:19.540, Time elapsed: 11:31:15.776
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
Supports area transit capability
Router is not originating router-LSAs with maximum metric
Initial SPF schedule delay 5000 msecs
Minimum hold time between two consecutive SPF calculations 10000 msecs
Maximum wait time between two consecutive SPF calculations 10000 msecs
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msecs
Area BACKBONE(0)
    Number of interfaces in this area is 3
    Area has no authentication
    SPF algorithm last executed 11:30:31.628 ago
    SPF algorithm executed 5 times
    Area ranges are
```

D. The fastest way to check the hello interval and inoperative time is to use the command `show ip ospf interface`. These intervals are in OSPF hello packets exchanged between neighbouring routers. OSPF protocol may have different hello intervals and inoperative times on different interfaces but if routers have to become neighbours their intervals and times must be identical.



```
R1#show ip ospf interface serial 0/0/0
```

```
Serial0/0/0 is up, line protocol is up
Internet Address 192.168.10.1/30, Area 0
Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 64
Transmit Delay is 1 sec, State POINT_TO_POINT,
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  oob-resync timeout 40
  Hello due in 00:00:07
Supports Link-local Signaling (LLS)
Index 2/2, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 4 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 10.2.2.2
Suppress hello for 0 neighbor(s)
```

E. Another useful commands:

|                              |   |
|------------------------------|---|
| show ip ospf neighbor detail | Detailed neighbours list, priorities, states  |
| show ip ospf database        | Displays database, router id, OPSF process id. Using keywords may display different databases (more at <a href="http://www.cisco.com">www.cisco.com</a> ) |
| debug ip ospf events         | Reportig every OSPF events  |
| debug ip ospf adj            | Reporting events about OSPF adherence   |

### Default OSPF route preaching.

OSPF routing ensures that there are loop-free paths to all networks in the domain. To achieve network outside your domain, OSPF must know about the network, or must have a default route. A practical solution is to add a default route to the OSPF router

connected to the external network. This route may be redistributed among all routers located in the autonomous system through normal OSPF updates. The configured default route is used by the router to create a gateway of last resort. Syntax of the configuration of static default route uses the network address of 0.0.0.0 and a subnet mask of 0.0.0.0:

```
Router(config)#ip route 0.0.0.0 0.0.0.0 <interface | jump address>  
Router(config-router)#default-information originate
```

### Configuration of the OSPF parameters.

NOTE: It is recommended that loopback interfaces have been used on all routers that are running OSPF. Loopback interface should be configured with the address of the 32-bit subnet mask equal to 255.255.255.255. This 32-bit subnet mask is called a host mask because it determines network consisting of a single host. When OSPF needs to advertise a loopback network, always announce it as a route to the 32-bit mask host.

E.G.:

```
! Create the loopback 0 interface  
Sydney3(config)#interface loopback 0  
Sydney3(config-if)#ip address 192.168.31.33  
255.255.255.255  
Sydney3(config-if)#exit  
! Remove loopback 0 interface  
Sydney3(config)#no interface loopback 0  
Sydney3(config)#  
01:47:27: %LINK-5-CHANGED: Interface Loopback0, changed  
state to administratively down
```

### Modifying the cost of OSPF.

For proper operation of OSPF, it is important to set interface bandwidth properly.

```
Router(config)#interface serial 0/0  
Router(config-if)#bandwidth 64
```

**The default bandwidth of serial interfaces is Cisco routers is 1.544 Mbit / s or 1544 kbit / s**

**The default expense attributed to link 100 Mb / s is the lowest cost value equal to 1.**

NOTE: In the event of a network of 100 Mb / s and Gigabit Ethernet, these default cost, unless changed, may result in less effective choice path.



To change the default bandwidth reference, use the following command:

```
Router(config-router)#auto-cost <reference-bandwidth mbps>
```

You may also change the cost assigned to the interface:

```
Router(config-if)#ip ospf cost <liczba>
```

### OSPF clock configuration.

To be able to exchange information, OSPF routers must use the same value of time between hello packets and the time of retention within a given network segment. By default, the hold time is four times greater than the time between Hello packets. This means that the router can make four attempts to send Hello packet before it is considered off (dead). The values of the clocks can be changed by the network administrator. Justification for changing the clocks can only improve the network performance OSPF. You should just change the value of the clocks to correspond to the values on adjacent routers. To configure the interval Hello packets and the hold time, use the following commands:

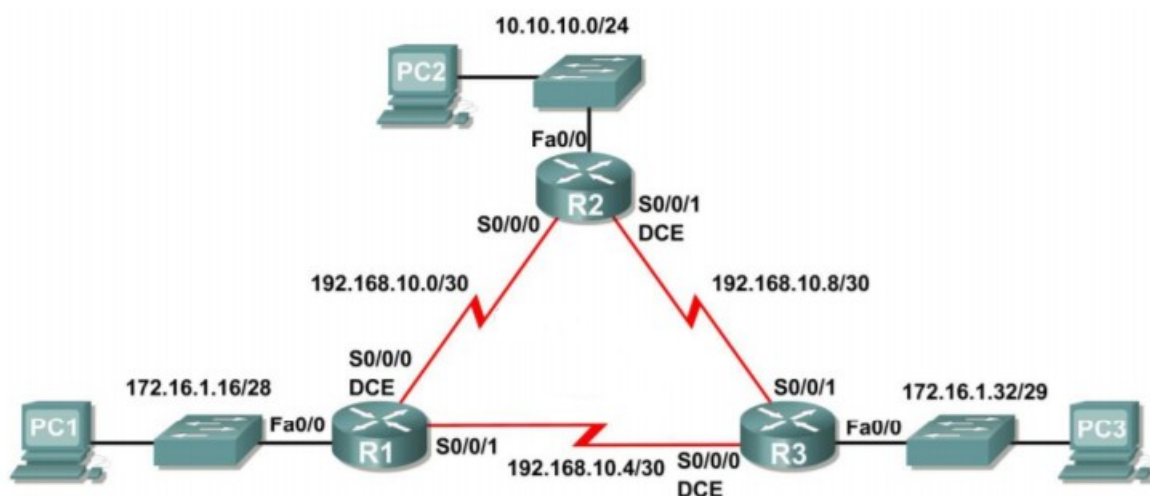
```
Router(config-if)#ip ospf <hello-interval seconds>
```

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

## EXERCISE

NOTE: The report must set out all the elements (questions, commands) highlighted in red.

### Topology Diagram



**NOTE: Names given to routers treat as examples and in the exercise use include names and types of the used routers (skip setting vlans on S1 and S2).**

**Addressing Table**

| Device | Interface | IP Address    | Subnet Mask     | Default Gateway |
|--------|-----------|---------------|-----------------|-----------------|
| R1     | Fa0/0     | 172.16.1.17   | 255.255.255.240 | N/A             |
|        | S0/0/0    | 192.168.10.1  | 255.255.255.252 | N/A             |
|        | S0/0/1    | 192.168.10.5  | 255.255.255.252 | N/A             |
| R2     | Fa0/0     | 10.10.10.1    | 255.255.255.0   | N/A             |
|        | S0/0/0    | 192.168.10.2  | 255.255.255.252 | N/A             |
|        | S0/0/1    | 192.168.10.9  | 255.255.255.252 | N/A             |
| R3     | Fa0/0     | 172.16.1.33   | 255.255.255.248 | N/A             |
|        | S0/0/0    | 192.168.10.6  | 255.255.255.252 | N/A             |
|        | S0/0/1    | 192.168.10.10 | 255.255.255.252 | N/A             |
| PC1    | NIC       | 172.16.1.20   | 255.255.255.240 | 172.16.1.17     |
| PC2    | NIC       | 10.10.10.10   | 255.255.255.0   | 10.10.10.1      |
| PC3    | NIC       | 172.16.1.35   | 255.255.255.248 | 172.16.1.33     |

## 1. Serial and Ethernet interfaces configuration.

A. Configure interfaces on R1, R2, R3 (table above).

B. Verify ip addresses of the interfaces (use `show ip interface brief`) **result of the command for R1, R2, R3 add to the report**

C. Configure Ethernet interfaces on PC1, PC2, PC3 (table above), check the configuration (command `ping`)

## 2. OSPF configuration on R1.

A. Turning on OSPF.

```
R1(config)#router ospf 1
```

B. Configure `network` command for LAN.

```
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
```

C. Configure router to broadcast 192.168.10.0/30 added to Serial0/0/0 interface.

```
R1(config-router)#network 192.168.10.0 0.0.0.3 area 0
```



D. Configure router to broadcast 192.168.10.4/30 added to Serial0/0/1 interface.

```
R1(config-router)#network 192.168.10.4 0.0.0.3 area 0
```

### 3. OSPF configuration on R2, R3.

A. Turning on OSPF on R2.

```
R2(config)#router ospf 1
```

B. Configure router to broadcast LAN 10.10.10.0/24 in the OSPF updates.

```
R2(config-router)#network 10.10.10.0 0.0.0.255 area 0
```

C. Configure router to broadcast 192.168.10.0/30 added to Serial0/0/0 interface.

```
R2(config-router)#network 192.168.10.0 0.0.0.3 area 0
```

```
00:07:27:      %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on  
Serial0/0/0 from EXCHANGE to FULL, Exchange Done
```

NOTE: Message shown above appears when the network serial link between R1 and R2 is added to the OSPF configuration of a neighborhood relationship with another OSPF router has been established.

D. Configure router to broadcast 192.168.10.8/30 added to Serial1/0/0 interface.

```
R2(config-router)#network 192.168.10.8 0.0.0.3 area 0
```

E. Configure OSPF on R3. Use `router ospf` and `network`. Process ID set to 1. Configure router to broadcast 3 connected networks.

```
R3(config)#router ospf 1
```

```
R3(config-router)#network 172.16.1.32 0.0.0.7 area 0
```

```
R3(config-router)#network 192.168.10.4 0.0.0.3 area 0
```

```
R2(config-router)#
```

```
00:17:46: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on  
Serial0/0/0 from LOADING to FULL, Loading Done
```

```
R3(config-router)#network 192.168.10.8 0.0.0.3 area 0
```

```
R3(config-router)#
```

```
00:18:01: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.9 on  
Serial0/0/1 from EXCHANGE to FULL, Exchange Done
```

#### 4. Router ID configuration.

OSPF router ID is used to uniquely identify each router in the OSPF routing domain. If no router ID or loopback interface has not been configured on the three routers, router ID for each of them will be determined by the highest IP address of the active interface. By using the command diagnostic protocol (OSPF router on each other), specify the ID of the router R1, R2 and R3 router. **Put the results of chosen commands in the report with selected Router ID.**

#### 5. Checking the OSPF.

A. On R1 use `show ip ospf neighbor` to display informations about R2 and R3. You should be able to find neighbour ID, IP of every adjacent interface and interface which R1 uses to guess a neighbour. **Put the command result in the report, explain "Pri" and "State" columns.**

B. use `show ip protocols` on R1. **Put the result for this command used on R2, explain "normal", "stub", "nssa" in:**

```
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
```

C. **Display routing table on R1. Put it in the report, select routes broadcasted by OSPF.**

D. **Select OSPF cost to reach 10.10.10.0/24 on the table from C.**

#### 6. Setting OSPF parameters.

A. Use `show interfaces serial0/0/0` on R1. **Put the result in the report with bandwidth selected.**

B. Use bandwidth to change the bandwidth on serial interfaces of R1 and R2 on 64 kb/s

R1:

```
R1(config)#interface serial0/0/0
R1(config-if)#bandwidth 64
R1(config)#interface serial0/0/1
R1(config-if)#bandwidth 64
```

R2:

```
R2(config)#interface serial0/0/0
R2(config-if)#bandwidth 64
R2(config)#interface serial0/0/1
```

```
R2(config-if)#bandwidth 64
```

Use `show ip ospf interface` on R1 to check the costs of serial links. Put the result in the report, select costs for both links. What do these costs depend on? Explain.

C. Use `ip ospf cost` to change the bandwidth of R3 on 1562.

```
R3(config)#interface serial0/0/0
R3(config-if)#ip ospf cost 1562
R3(config)#interface serial0/0/1
R3(config-if)#ip ospf cost 1562
```

Use a command which allows to verify if the costs were changed. Put it in the report.

## 7. Default route redistribution in OSPF.

A. Make a loopback interface on R1 which will simulate link to ISP.

```
R1(config)#interface loopback1
R1(config-if)#ip address 172.30.1.1 255.255.255.252
```

B. Configure static default route on R1. Use an address of loopback interface.

```
R1(config)#ip route 0.0.0.0 0.0.0.0 loopback1
```

Use `default-information originate` to add the default route to OSPF updates, which are sent from R1.

```
R1(config)#router ospf 1
R1(config-router)#default-information originate
```

Display routing table for R1 which confirms the default route propagation. Put it in the report.

## 8. OSPF clock setting.

A. Use `show ip ospf neighbor` on R1 to check the dead time.

```
R1#show ip ospf neighbor
```

| Neighbor ID | Pri | State  | Dead Time | Address      |
|-------------|-----|--------|-----------|--------------|
| Interface   |     |        |           |              |
| 10.2.2.2    | 0   | FULL/- | 00:00:34  | 192.168.10.2 |
| Serial0/0/0 |     |        |           |              |
| 10.3.3.3    | 0   | FULL/- | 00:00:34  | 192.168.10.6 |
| Serial0/0/1 |     |        |           |              |

B. OSPF dead and hello intervals may be modified by using `ip ospf hello-interval` and `ip ospf dead-interval`. Set hello interval on 5 seconds and dead interval on 20 seconds on R1 interface Serial0/0/0

```
R1(config)#interface serial0/0/0
R1(config-if)#ip ospf hello-interval 5
R1(config-if)#ip ospf dead-interval 20
```

C. Modify clocks on R2 serial0/0/0 to match them to R1 interface

```
R2(config)#interface serial0/0/0
R2(config-if)#ip ospf hello-interval 5
R2(config-if)#ip ospf dead-interval 20
```

Display the result of using `show ip ospf interface serial0/0/0`. Select the place which confirms the change on intervals configuration. Put it in the report.

Take notice of a dead time on serial0/0/0. It is much shorter (counting starts at 20 not 40). Link serial0/0/1 works with default intervals. **Should we change the intervals on the second interface of let them be? Explain.**

## Question 1-B

### R1

```
R1#show ip interface brief
Interface      IP-Address      OK? Method Status      Protocol
GigabitEthernet0/0  172.16.1.17    YES manual up          up
GigabitEthernet0/1  unassigned      YES unset  administratively down down
GigabitEthernet0/2  unassigned      YES unset  administratively down down
Serial0/3/0        192.168.10.1   YES manual up          up
Serial0/3/1        192.168.10.5   YES manual up          up
Vlan1             unassigned      YES unset  administratively down down
```

### R2

```
R2#show ip interface brief
Interface      IP-Address      OK? Method Status      Protocol
GigabitEthernet0/0  10.10.10.1     YES manual up          up
GigabitEthernet0/1  unassigned      YES unset  administratively down down
GigabitEthernet0/2  unassigned      YES unset  administratively down down
Serial0/3/0        192.168.10.2   YES manual up          up
Serial0/3/1        192.168.10.9   YES manual up          up
Vlan1             unassigned      YES unset  administratively down down
```

### R3

```
R3#show ip interface brief
Interface      IP-Address      OK? Method Status      Protocol
GigabitEthernet0/0  172.16.1.33    YES manual up          up
GigabitEthernet0/1  unassigned      YES unset  administratively down down
GigabitEthernet0/2  unassigned      YES unset  administratively down down
Serial0/3/0        192.168.10.6   YES manual up          up
Serial0/3/1        192.168.10.10  YES manual up          up
Vlan1             unassigned      YES unset  administratively down down
```

## Question 4

### R1

```
R1#show ip ospf
Routing Process "ospf 1" with ID 192.168.10.5
Supports only single TOS(TOS0) routes
Supports opaque LSA
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 3
    Area has no authentication
    SPF algorithm executed 8 times
    Area ranges are
    Number of LSA 3. Checksum Sum 0x01e247
    Number of opaque link LSA 0. Checksum Sum 0x000000
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```



R2

```
R2#show ip ospf
Routing Process "ospf 1" with ID 192.168.10.9
Supports only single TOS(TOS0) routes
Supports opaque LSA
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 3
    Area has no authentication
    SPF algorithm executed 7 times
    Area ranges are
    Number of LSA 3. Checksum Sum 0x01e247
    Number of opaque link LSA 0. Checksum Sum 0x000000
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

R3

```
R3#show ip ospf
Routing Process "ospf 1" with ID 192.168.10.10
Supports only single TOS(TOS0) routes
Supports opaque LSA
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 3
    Area has no authentication
    SPF algorithm executed 4 times
    Area ranges are
    Number of LSA 3. Checksum Sum 0x01e247
    Number of opaque link LSA 0. Checksum Sum 0x000000
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

## Question 5-A

R1

```
R1#show ip ospf neighbor
```

| Neighbor ID   | Pri | State   | Dead Time | Address      | Interface   |
|---------------|-----|---------|-----------|--------------|-------------|
| 192.168.10.9  | 0   | FULL/ - | 00:00:39  | 192.168.10.2 | Serial0/3/0 |
| 192.168.10.10 | 0   | FULL/ - | 00:00:38  | 192.168.10.6 | Serial0/3/1 |

```
R1#
```

The Pri field indicates the priority of the neighbor router. A router with a priority of 0 never becomes a DR or a backup designated router (BDR)

**The State field indicates the functional state of the neighbor router. FULL means the router is fully adjacent with its neighbor.**

## Question 5-B

R1

```
R1#show ip protocols
```

Routing Protocol is "ospf 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 192.168.10.5

Number of areas in this router is 1. 1 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

- 172.16.1.16 0.0.0.15 area 0
- 192.168.10.0 0.0.0.3 area 0
- 192.168.10.4 0.0.0.3 area 0

Routing Information Sources:

| Gateway       | Distance | Last Update |
|---------------|----------|-------------|
| 192.168.10.5  | 110      | 00:04:50    |
| 192.168.10.9  | 110      | 00:04:30    |
| 192.168.10.10 | 110      | 00:04:30    |

Distance: (default is 110)

R2

```
R2#show ip protocols
```

Routing Protocol is "ospf 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 192.168.10.9

Number of areas in this router is 1. 1 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

- 10.10.10.0 0.0.0.255 area 0
- 192.168.10.0 0.0.0.3 area 0
- 192.168.10.8 0.0.0.3 area 0

Routing Information Sources:

| Gateway       | Distance | Last Update |
|---------------|----------|-------------|
| 192.168.10.5  | 110      | 00:05:46    |
| 192.168.10.9  | 110      | 00:05:26    |
| 192.168.10.10 | 110      | 00:05:26    |

Distance: (default is 110)

In a normal OSPF area there are no restrictions; the area can carry all types of routes.

A stub area does not receive routes from other autonomous systems. Routing from the stub area is performed through the default route to the backbone area.

The Not So Stubby Area (NSSA) is a type of stub area that can import external routes, with some limited exceptions.

## Question 5-C

R1

```
R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/24 is subnetted, 1 subnets
O   10.10.10.0/24 [110/65] via 192.168.10.2, 00:07:42, Serial0/3/0
C   172.16.0.0/16 is variably subnetted, 3 subnets, 3 masks
C   172.16.1.16/28 is directly connected, GigabitEthernet0/0
L   172.16.1.17/32 is directly connected, GigabitEthernet0/0
O   172.16.1.32/29 [110/65] via 192.168.10.6, 00:06:50, Serial0/3/1
C   192.168.10.0/24 is variably subnetted, 5 subnets, 2 masks
C   192.168.10.0/30 is directly connected, Serial0/3/0
L   192.168.10.1/32 is directly connected, Serial0/3/0
C   192.168.10.4/30 is directly connected, Serial0/3/1
L   192.168.10.5/32 is directly connected, Serial0/3/1
O   192.168.10.8/30 [110/128] via 192.168.10.2, 00:06:38, Serial0/3/0
    [110/128] via 192.168.10.6, 00:06:38, Serial0/3/1
```

## Question 5-D

R2

```
R2#show ip ospf interface
GigabitEthernet0/0 is up, line protocol is up
Internet address is 10.10.10.1/24, Area 0
Process ID 1, Router ID 192.168.10.9, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State DR, Priority 1
Designated Router (ID) 192.168.10.9, Interface address 10.10.10.1
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:07
Index 1/1, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 0, Adjacent neighbor count is 0
Suppress hello for 0 neighbor(s)
```

## Question 6-A

### R1 Before Change

```
R1#show interfaces serial0/3/0
Serial0/3/0 is up, line protocol is up (connected)
Hardware is HD64570
Internet address is 192.168.10.1/30
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
Encapsulation HDLC, loopback not set, keepalive set (10 sec)
Last input never, output never, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0 (size/max/drops); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
    Conversations 0/0/256 (active/max active/max total)
    Reserved Conversations 0/0 (allocated/max allocated)
    Available Bandwidth 1158 kilobits/sec
5 minute input rate 61 bits/sec, 0 packets/sec
5 minute output rate 68 bits/sec, 0 packets/sec
143 packets input, 10036 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
146 packets output, 10236 bytes, 0 underruns
0 output errors, 0 collisions, 1 interface resets
0 output buffer failures, 0 output buffers swapped out
More...
```

### R1 After Change

```
R1#show interfaces serial0/3/0
Serial0/3/0 is up, line protocol is up (connected)
Hardware is HD64570
Internet address is 192.168.10.1/30
MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
Encapsulation HDLC, loopback not set, keepalive set (10 sec)
Last input never, output never, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0 (size/max/drops); Total output drops: 0
Queueing strategy: weighted fair
Output queue: 0/1000/64/0 (size/max total/threshold/drops)
    Conversations 0/0/256 (active/max active/max total)
    Reserved Conversations 0/0 (allocated/max allocated)
    Available Bandwidth 48 kilobits/sec
5 minute input rate 61 bits/sec, 0 packets/sec
5 minute output rate 62 bits/sec, 0 packets/sec
127 packets input, 8952 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
130 packets output, 9088 bytes, 0 underruns
0 output errors, 0 collisions, 1 interface resets
0 output buffer failures, 0 output buffers swapped out
0 carrier transitions
DCD=up DSR=up DTR=up RTS=up CTS=up
```

## Question 6-B

R1

```
R1#show ip ospf interface
GigabitEthernet0/0 is up, line protocol is up
  Internet address is 172.16.1.17/28, Area 0
  Process ID 1, Router ID 192.168.10.5, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.10.5, Interface address 172.16.1.17
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
Serial0/3/0 is up, line protocol is up
  Internet address is 192.168.10.1/30, Area 0
  Process ID 1, Router ID 192.168.10.5, Network Type POINT-TO-POINT, Cost: 1562
  Transmit Delay is 1 sec, State POINT-TO-POINT, Priority 0
  No designated router on this network
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.10.9
  Suppress hello for 0 neighbor(s)
Serial0/3/1 is up, line protocol is up
  Internet address is 192.168.10.5/30, Area 0
  Process ID 1, Router ID 192.168.10.5, Network Type POINT-TO-POINT, Cost: 1562
  Transmit Delay is 1 sec, State POINT-TO-POINT, Priority 0
  No designated router on this network
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.10.10
  Suppress hello for 0 neighbor(s)
```

Cost depends on bandwidth. For the Serial interfaces, OSPF will use the configured bandwidth, measured in Kbps, to determine the cost.



## Question 6-C

R3

```
R3#show ip ospf interface
```

```
GigabitEthernet0/0 is up, line protocol is up
  Internet address is 172.16.1.33/29, Area 0
  Process ID 1, Router ID 192.168.10.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.10.10, Interface address 172.16.1.33
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:04
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
Serial0/3/0 is up, line protocol is up
  Internet address is 192.168.10.6/30, Area 0
  Process ID 1, Router ID 192.168.10.10, Network Type POINT-TO-POINT, Cost: 1562
  Transmit Delay is 1 sec, State POINT-TO-POINT, Priority 0
  No designated router on this network
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:02
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.10.5
  Suppress hello for 0 neighbor(s)
Serial0/3/1 is up, line protocol is up
  Internet address is 192.168.10.10/30, Area 0
  Process ID 1, Router ID 192.168.10.10, Network Type POINT-TO-POINT, Cost: 1562
  Transmit Delay is 1 sec, State POINT-TO-POINT, Priority 0
  No designated router on this network
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:07
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.10.9
  Suppress hello for 0 neighbor(s)
```

## Question 7-B

R1

```
R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

    10.0.0.0/24 is subnetted, 1 subnets
O       10.10.10.0/24 [110/1563] via 192.168.10.2, 00:04:19, Serial0/3/0
    172.16.0.0/16 is variably subnetted, 3 subnets, 3 masks
C       172.16.1.16/28 is directly connected, GigabitEthernet0/0
L       172.16.1.17/32 is directly connected, GigabitEthernet0/0
O       172.16.1.32/29 [110/1563] via 192.168.10.6, 00:08:37, Serial0/3/1
    172.30.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.30.1.0/30 is directly connected, Loopback1
L       172.30.1.1/32 is directly connected, Loopback1
    192.168.10.0/24 is variably subnetted, 5 subnets, 2 masks
C       192.168.10.0/30 is directly connected, Serial0/3/0
L       192.168.10.1/32 is directly connected, Serial0/3/0
```

## Question 8-C

R1

```
R1#show ip ospf interface serial0/3/0
Serial0/3/0 is up, line protocol is up
Internet address is 192.168.10.1/30, Area 0
Process ID 1, Router ID 192.168.10.5, Network Type POINT-TO-POINT, Cost: 1562
Transmit Delay is 1 sec, State POINT-TO-POINT, Priority 0
No designated router on this network
No backup designated router on this network
Timer intervals configured, Hello 5, Dead 20, Wait 20, Retransmit 5
  Hello due in 00:00:04
Index 2/2, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 192.168.10.9
Suppress hello for 0 neighbor(s)
```

R2

```
R2#show ip ospf interface serial0/3/0
Serial0/3/0 is up, line protocol is up
Internet address is 192.168.10.2/30, Area 0
Process ID 1, Router ID 192.168.10.9, Network Type POINT-TO-POINT, Cost: 1562
Transmit Delay is 1 sec, State POINT-TO-POINT, Priority 0
No designated router on this network
No backup designated router on this network
Timer intervals configured, Hello 5, Dead 20, Wait 20, Retransmit 5
  Hello due in 00:00:03
Index 2/2, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
  Adjacent with neighbor 192.168.10.5
Suppress hello for 0 neighbor(s)
```

**There is no need because they have same cost. But they can be changed its doesn't gonna effect anything.**

## **Conclusion**

**I learned what is the OSPF protocol and how to configure it. Also i learned Dijkstra Algorithm is used from it.**

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