

iu-ne-lab-04-Iskander_Nafikov

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- **Hostname:** lenovo

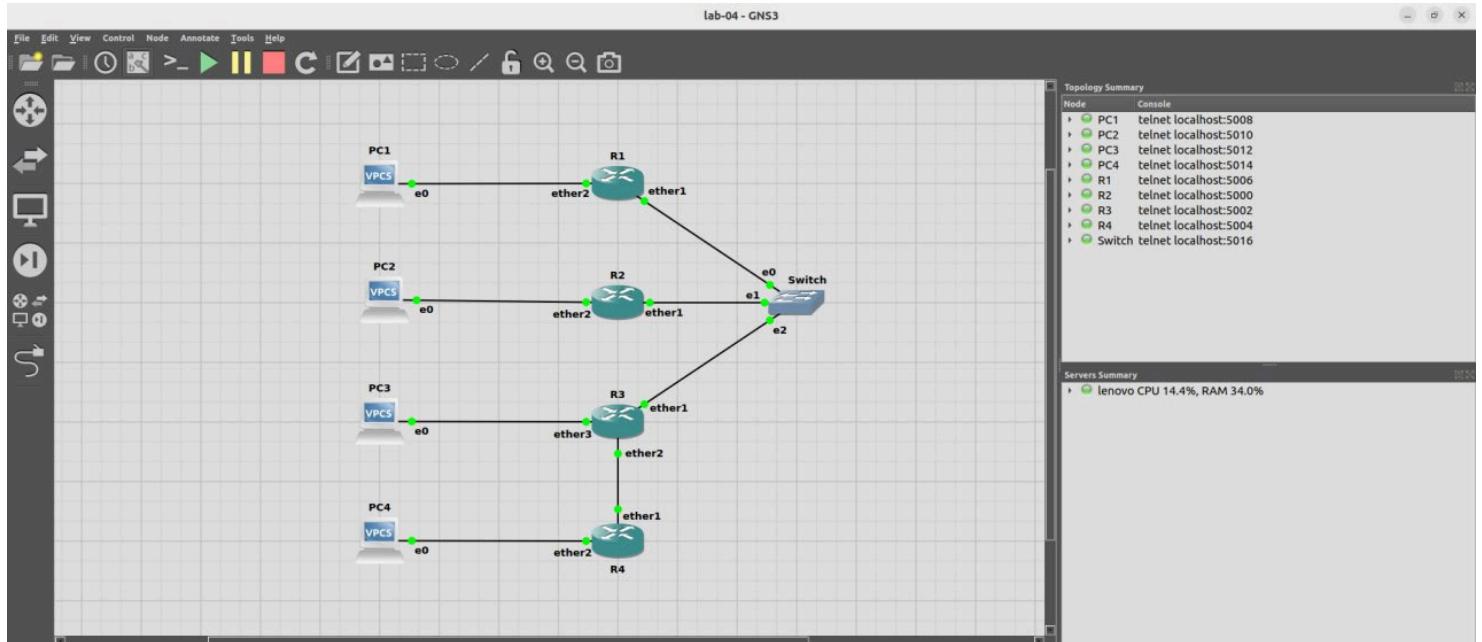
Task 1 - Prepare your network topology

1. In the GNS3 project, select and install a virtual routing solution that you would like to use: Mikrotik (recommended), Pfsense, vyos and so on.

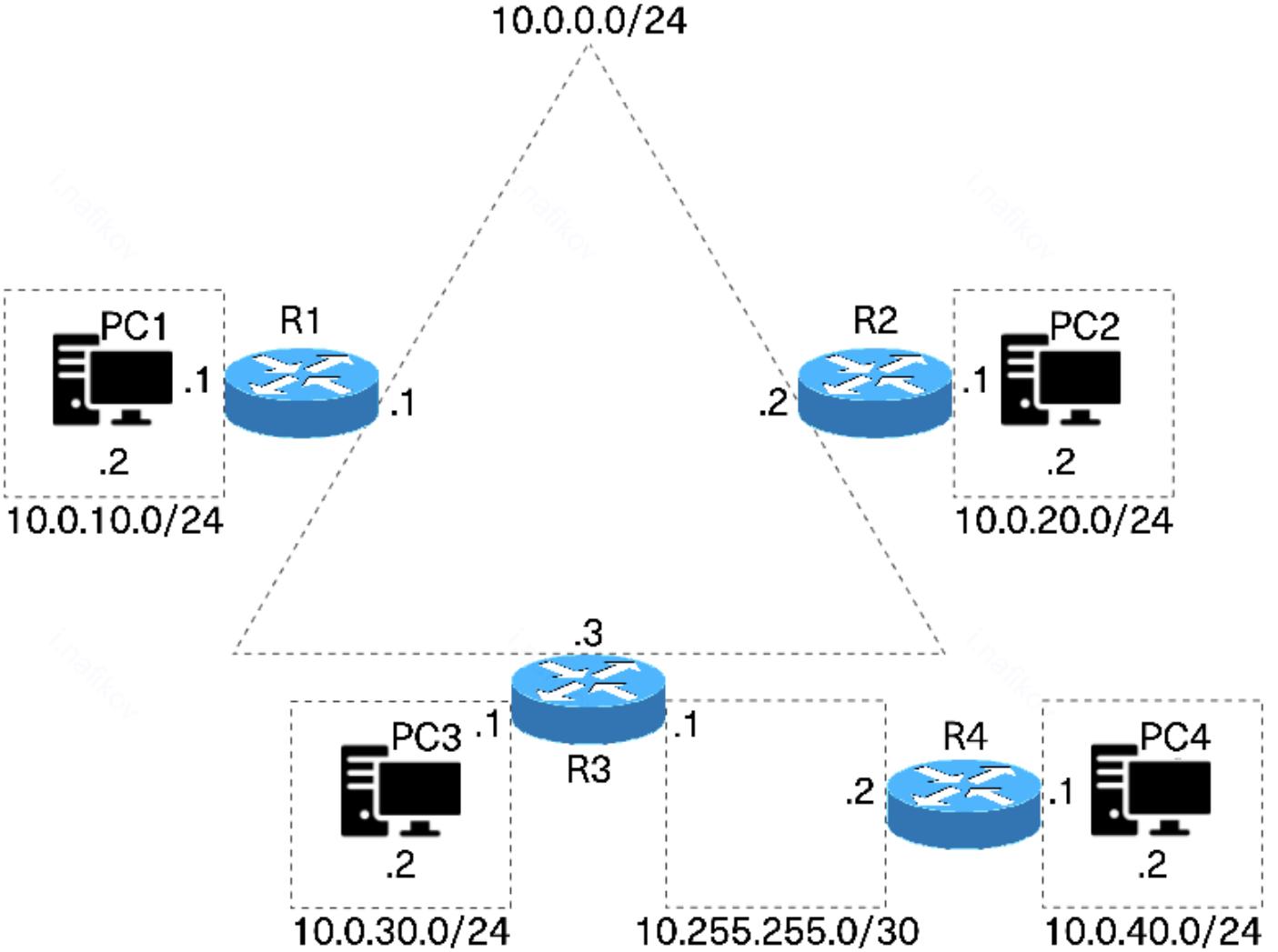
I decided to use Mikrotik as recommended - Mikrotik CHR 7.16

2. Prepare a simple network consisting of at least 3 routers, each one of them has a different subnet, and they should be able to reach each other (for example by a switch/router in the middle or a bus topology). Do not write a static routes between different networks.

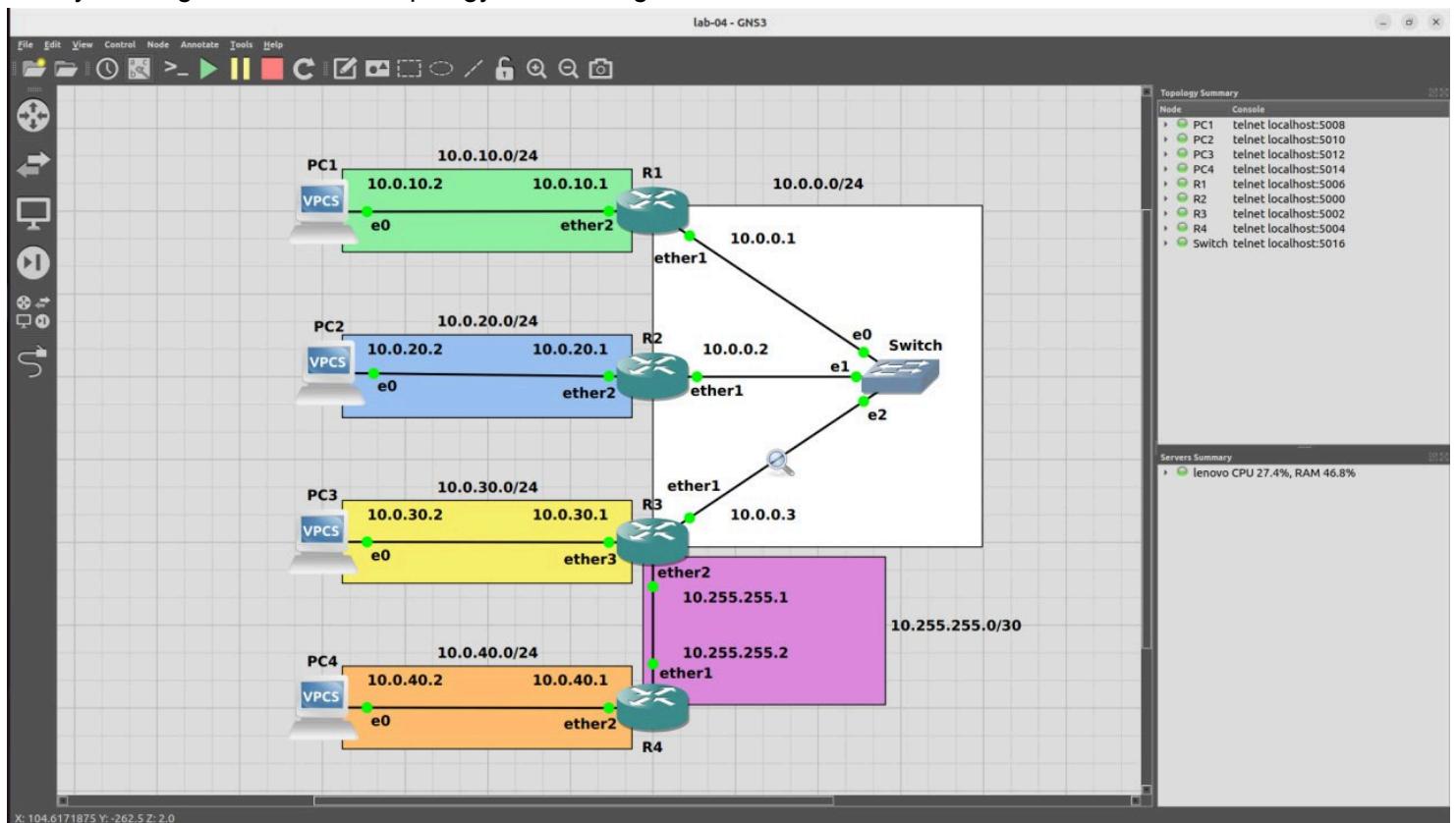
- I prepared my topology as it was suggested:



- However, to prepare it more accurately I was recommended to draw a network scheme before starting the lab. So, I decided to draw the scheme



- Finally, I configured the whole topology as following:



- So now routers can reach each other and the PC node inside their own LAN, but cannot reach others' routers LANs.

```

[admin@MikroTik] > ip address print
Flags: S - SLAVE
Columns: ADDRESS, NETWORK, INTERFACE
# -- ADDRESS      NETWORK      INTERFACE
;; pc1
0 10.0.10.1/24  10.0.10.0  bridge1
;; switch
1 S 10.0.0.1/24  10.0.0.0   ether1
[admin@MikroTik] > ping 10.0.10.2
SEQ HOST
0 10.0.10.2
1 10.0.10.2
sent=2 received=2 packet-loss=0% min-rtt=938us avg-rtt=956us max-rtt=975us
[admin@MikroTik] > ping 10.0.0.2
SEQ HOST
0 10.0.0.2
1 10.0.0.2
sent=2 received=2 packet-loss=0% min-rtt=1ms134us avg-rtt=1ms232us max-rtt=1ms331us
[admin@MikroTik] > ping 10.0.20.2
SEQ HOST
0
1
sent=2 received=0 packet-loss=100%
[admin@MikroTik] >

```

- The similar was applied to PC nodes: we can reach the router, but no other routers or PCs

```

PC3> show ip
NAME      : PC3[1]
IP/MASK   : 10.0.30.2/24
GATEWAY   : 10.0.30.1
DNS       :
MAC       : 00:50:79:66:68:02
LPORT     : 10044
RHOST:PORT: 127.0.0.1:10045
MTU       : 1500

PC3> ping 10.0.30.1
84 bytes from 10.0.30.1 icmp_seq=1 ttl=64 time=0.826 ms
^C
PC3> ping 10.0.20.1
*10.0.30.1 icmp_seq=1 ttl=64 time=0.899 ms (ICMP type:3, code:0, Destination network unreachable)
^C
PC3>
PC3>
PC3>
PC3>
PC3>
PC3>
PC3>

```

So far, I configured my topology without static or dynamic routing with only having direct connections between the routers.

Task 2 - OSPF Learning & Configuring

- Deploy OSPF in your chosen network topology.

Afterwards, I started deploying OSPF in my topology. Actually, since I had started using IPv4 I used OSPFv2.

- Below is the example of configuring OSPF for the router R1 -- ether1 interface

- First, I added **OSPF-instance** (`ospf-instance-1`) with the **router-id** = `1.1.1.1`, **OSPF-area** (`ospf-area-1 - 0.0.0.0`) and **OSPF-interface** (`ether1 - 10.0.0.1/24`).

```

[admin@MikroTik] > routing/ospf
[admin@MikroTik] /routing/ospf> instance/print
Flags: X - disabled, I - inactive
[admin@MikroTik] /routing/ospf> instance add
comment:0x902 domain-id 224.0.0.1 mpls-te-address 224.0.0.1 mpls-te-area 224.0.0.1
copy-from:7734 domain-tag 224.0.0.1 mpls-te-area 224.0.0.1
disabled 0x0001 in-filter-chain 224.0.0.1 name
[admin@MikroTik] /routing/ospf> instance add router-id=1.1.1.1
[admin@MikroTik] /routing/ospf> instance print
Flags: X - disabled, I - inactive
0 name="ospf-instance-1" version=2 vrf=main router-id=1.1.1.1
[admin@MikroTik] /routing/ospf> area print
Flags: X - disabled, I - inactive, D - dynamic; T - transit-capable
[admin@MikroTik] /routing/ospf> area add instance=ospf-instance-1
[admin@MikroTik] /routing/ospf> area print
Flags: X - disabled, I - inactive, D - dynamic; T - transit-capable
0 name="ospf-area-1" instance=ospf-instance-1 area-id=0.0.0.0 type=default
[admin@MikroTik] /routing/ospf> interface-template/add in
instance-id interfaces
[admin@MikroTik] /routing/ospf> interface-template/add interfaces=ether
ether1 ether2 ether3
[admin@MikroTik] /routing/ospf> interface-template/add interfaces=ether1
area: ospf-area-1
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.1%ether1 area=ospf-area-1 state=waiting network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.1%ether1 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.1%ether1 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>
[admin@MikroTik] /routing/ospf>

```

- What is noticeable above is that router's state changed from waiting to dr after 40s (== dead-interval) which means that the router was selected as Designated Router inside the OSPF network where there is only one the same router 😊
- Also, with the help of Wireshark we can see that after adding the interface (ether1) to the OSPF the router started sending OSPF Hello packets broadcasting it (Destination == 224.0.0.5) over this interface.

* [R1 ether1 to Switch Ethernet0]						
No.	Time	Source	Destination	Protocol	Length Info	
25	52.354434	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
26	52.379222	10.0.0.1	224.0.0.22	IGMPv3	54 Membership Report / Join group 224.0.0.5 for any sources	
27	52.778661	10.0.0.1	224.0.0.22	IGMPv3	54 Membership Report / Join group 224.0.0.5 for any sources	
36	62.354932	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
37	72.355734	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
42	82.365991	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
51	92.354136	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
52	92.379370	10.0.0.1	224.0.0.22	IGMPv3	54 Membership Report / Join group 224.0.0.6 for any sources	
53	93.429522	10.0.0.1	224.0.0.22	IGMPv3	54 Membership Report / Join group 224.0.0.6 for any sources	
54	102.356117	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
59	112.366128	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
68	122.376167	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
69	132.380717	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	
74	142.390722	10.0.0.1	224.0.0.5	OSPF	78 Hello Packet	

2. Okay, then my task was to deploy OSPF to the router R2 -- ether1 interface

- I repeated the same actions for the R2 setting its router-id = 2.2.2.2

```

R2
iskanred@leno... x iskanred@leno... x R1 x R2 x R3 x R4 x PC1 x PC2 x PC3 x PC4 x
[admin@MikroTik] > routing ospf
[admin@MikroTik] /routing/ospf> instance add rout
router-id routing-table
[admin@MikroTik] /routing/ospf> instance add router-id=2.2.2.2
[admin@MikroTik] /routing/ospf> area add instance=ospf-instance-1 10.0.0.0/24
[admin@MikroTik] /routing/ospf> interface-template add area=ospf-area-1 interfaces=ether1
[admin@MikroTik] /routing/ospf> interface print ether2
Flags: D - dynamic
0 D address=10.0.0.2%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.1 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s

```

- And we immediately see that R2 got updates from R1 becoming bdr while R1 kept being the Designated Router

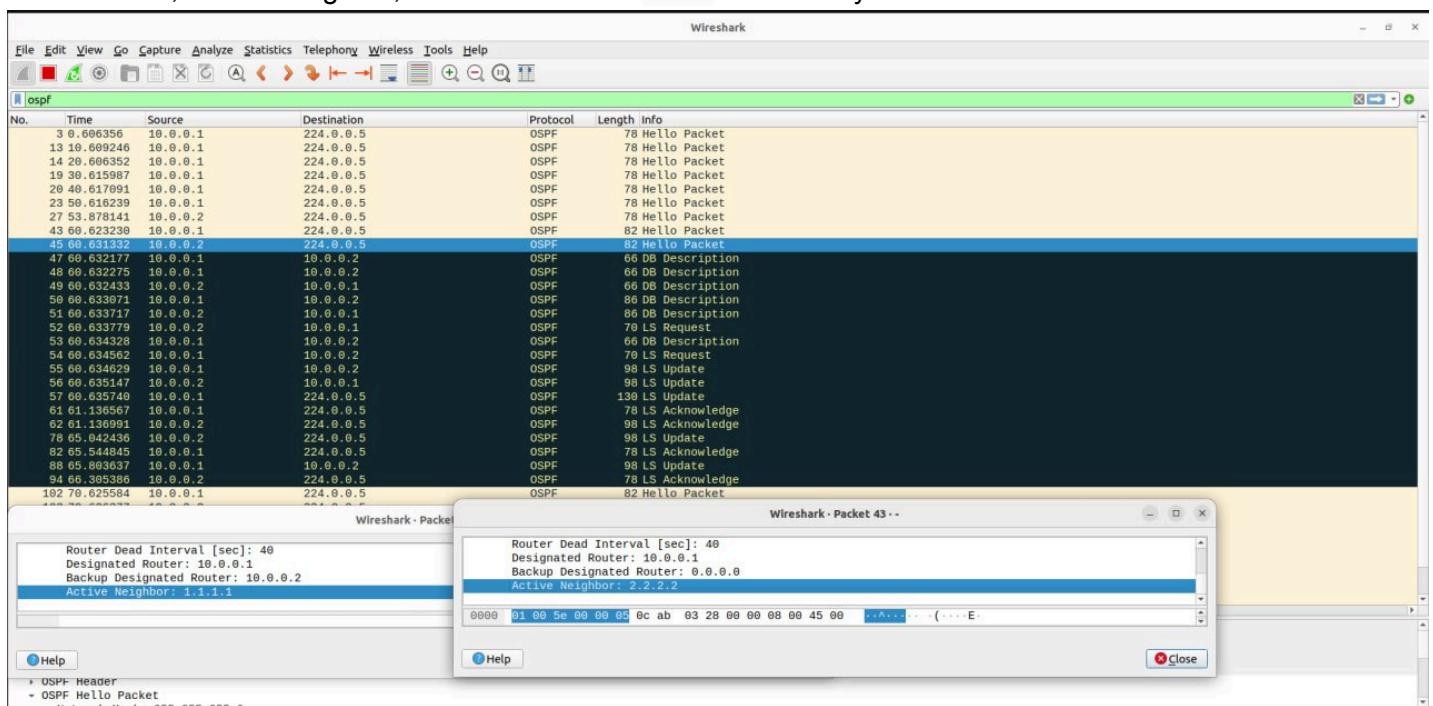
```

[admin@MikroTik] /routing/ospf> interface print ether2
Flags: D - dynamic
0 D address=10.0.0.2%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.1 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s

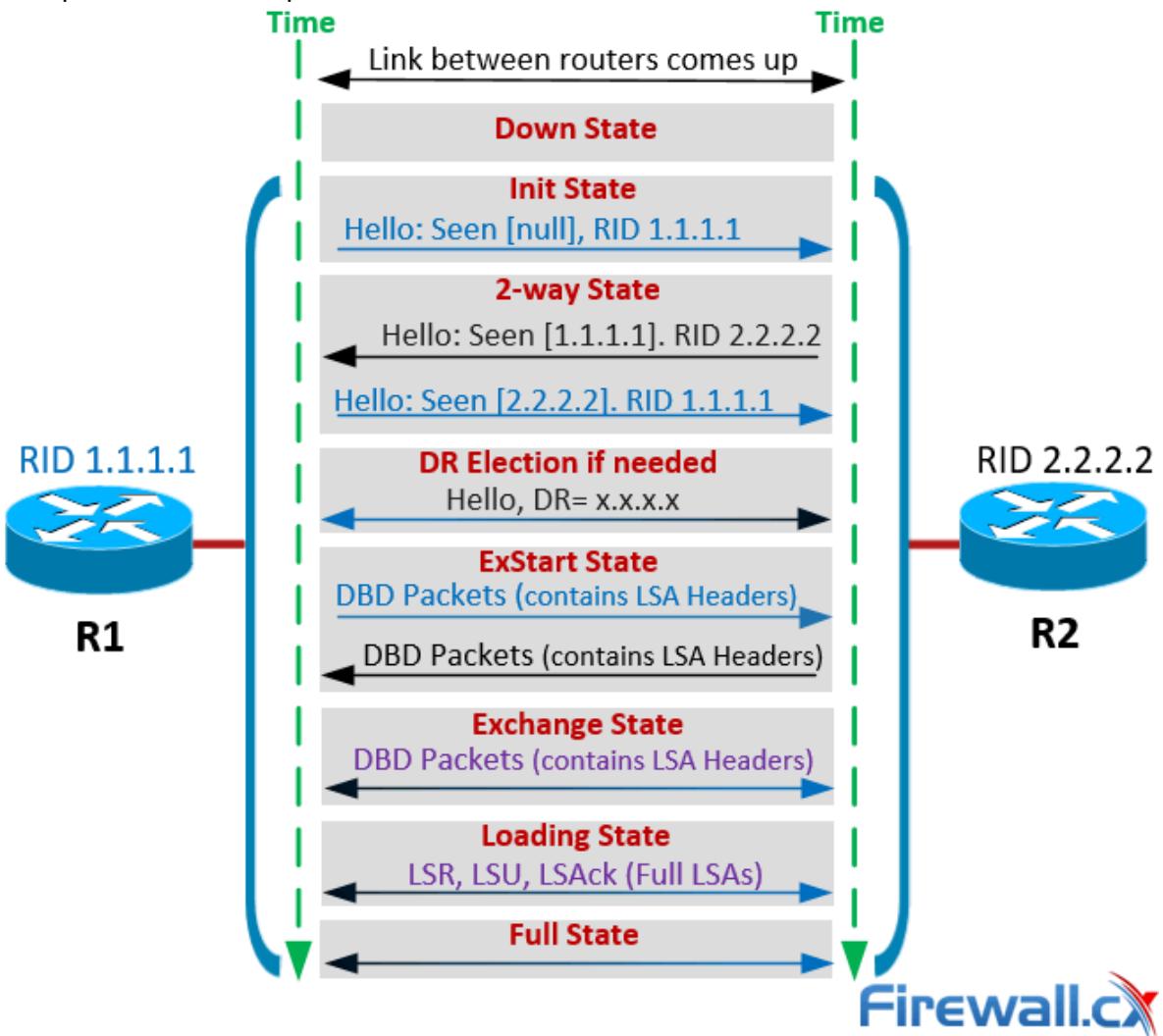
```

- Ant it's easy to notice from the perspective of Wireshark. Both routers sent information about their neighbours in Hello packets and started exchanging their LSA summary in DB Description packets. Then, they requested

absent LSAs, acknowledged it, and moved to the FULL state finally.



- This process can be represented in such a [state machine](#)



- Now we can check R2 node's neighbour table and LSDB

```
[admin@mikrotik] > routing ospf
[admin@mikrotik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.1 priority=128 router-id=1.1.1.1 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
    state-changes=6 adjacency=9m42s timeout=39s
[admin@mikrotik] /routing/ospf> lsa print
Flags: S - self-originated, F - flushing, W - wraparound; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 type="router" originator=1.1.1.1 id=1.1.1.1 sequence=0x80000004 age=585 checksum=0x48E9
    body=
    options=E
    type=network id=10.0.0.1 data=10.0.0.1 metric=1

1 SD instance=ospf-instance-1 area=ospf-area-1 type="router" originator=2.2.2.2 id=2.2.2.2 sequence=0x80000003 age=574 checksum=0xC1E
    body=
    options=E
    type=network id=10.0.0.1 data=10.0.0.2 metric=1

2 D instance=ospf-instance-1 area=ospf-area-1 type="network" originator=1.1.1.1 id=10.0.0.1 sequence=0x80000001 age=585 checksum=0x5DE1
    body=
    netmask=255.255.255.0
    |router-id=1.1.1.1
    |router-id=2.2.2.2
```

- We see that it was updated and we actually see that our neighbour is R1 with the Full state. What is more, we can see an LSA with type 2 Network which means that in this particular subnet there are only 2 routers right now. Let's check neighbour table and LSDB of the router R1

- The same is applied here. However if we check the routing tables on both of the routers, we see the same direct connected networks

```
R1
ikanred@leno... x iskanred@leno... x R1 x R2 x R3 x R4 x PC1 x PC2 x PC3 x PC4 x

[admin@MikroTik] /rooting/ospf> /ip route print
Flags: D - DYNAMIC; A - ACTIVE; C - CONNECT
Columns: DST-ADDRESS, GATEWAY, DISTANCE
      DST-ADDRESS      GATEWAY      DISTANCE
DAC 10.0.0.0/24  ether1          0
DAC 10.0.10.0/24 ether2          0
```



```
R2
ikanred@leno... x iskanred@leno... x R1 x R2 x R3 x R4 x PC1 x PC2 x PC3 x PC4 x

[admin@MikroTik] /rooting/ospf> /ip route print
Flags: D - DYNAMIC; A - ACTIVE; C - CONNECT
Columns: DST-ADDRESS, GATEWAY, DISTANCE
      DST-ADDRESS      GATEWAY      DISTANCE
DAC 10.0.0.0/24  ether1          0
DAC 10.0.20.0/24 ether2          0
```

- To advertise other subnets, we need to deploy OSPF to all the routers' interfaces

3. Let's deploy OSPF to R1 -- ether2 and R2 -- ether2

- First, let's just add interfaces to the OSPF domain

- R1

```

R1
iskanred@leno... x iskanred@leno... x R1 x R2 x R3 x R4 x PC1 x PC2 x PC3 x PC4 x
[admin@MikroTik] /routing/ospf> interface-template add
area 1 comment disabled networks length info priority use-bfd
auth 11.27.0008 copy-from r1
auth 27.02.02 cost 0.2 hello-interval passive 216 5678 retransmit-interval 128 vlink-neighbor-id
auth-id 27.02.02 instance-id 2 place-before 128 Device-ID MikroTik Port-ID ether1
auth-key dead-interval interfaces prefix-list type vlink-transit-area
[admin@MikroTik] /routing/ospf> interface-template add interfaces=ether2
area: ospf-area-1 255.255.255.255
Flags: D - dynamic
0 D address=10.0.0.1%ether1 area=ospf-area-1 state=dr network-type=broadcast bdr=10.0.0.2 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.0.10.1%ether2 area=ospf-area-1 state=waiting network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s

```

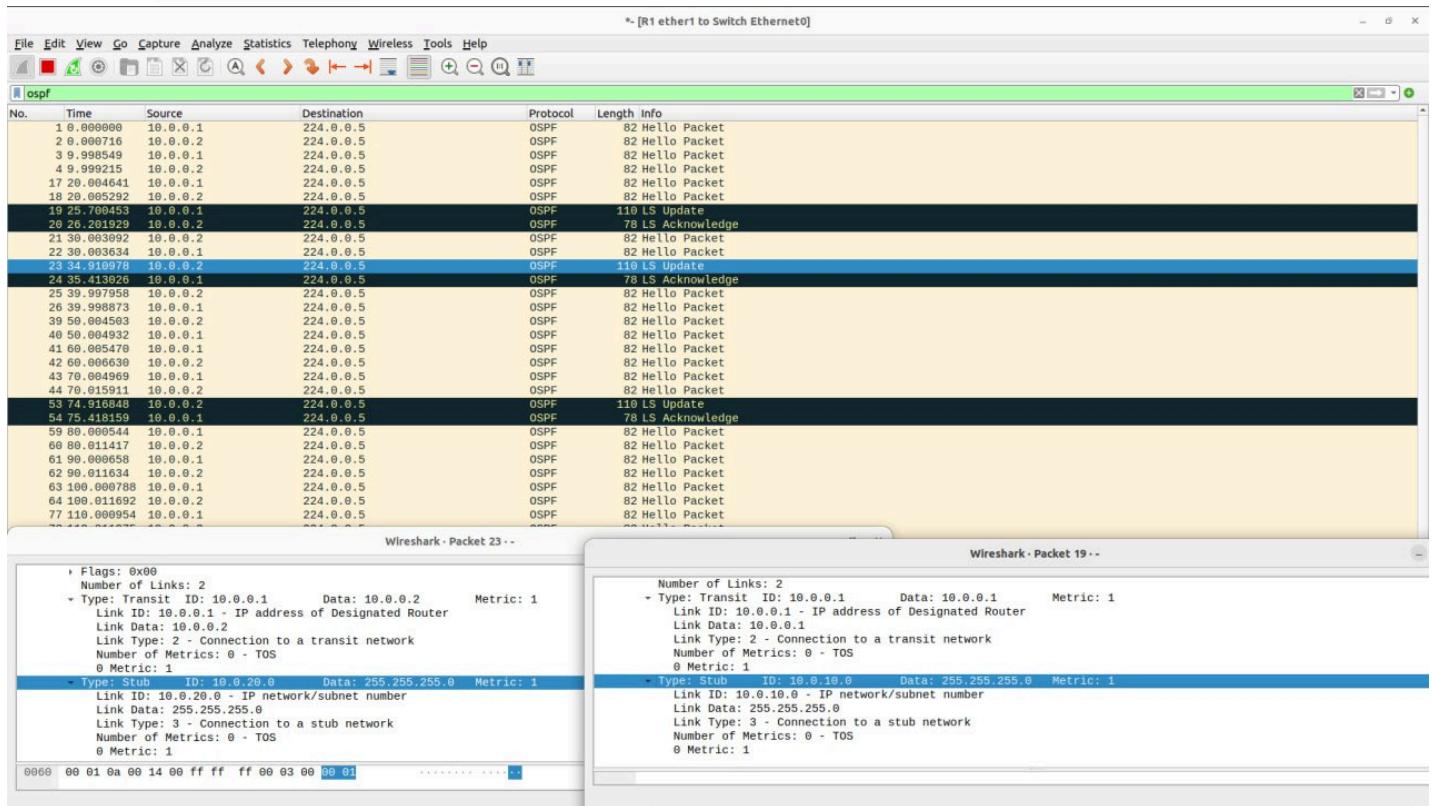
- R2

```

R2
iskanred@leno... x iskanred@leno... x R1 x R2 x R3 x R4 x PC1 x PC2 x PC3 x PC4 x
[admin@MikroTik] /routing/ospf> interface-template add interfaces=ether2 area=ospf-area-1
[admin@MikroTik] /routing/ospf>
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.2%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.1 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.0.20.1%ether2 area=ospf-area-1 state=waiting network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s

```

- Afterwards, we notice that routers sent updates to their common subnet and advertised their own subnets with the help of LS Update/Ack



- Finally, we can see that the routing tables were updated and we can ping PC2 from R1 and PC1 from R2

- R1

```

R1
iskanred@leno... x iskanred@leno... x R1 x R2 x R3 x R4 x PC1 x PC2 x PC3 x PC4 x
[admin@MikroTik] /routing/ospf> /ip route print
Flags: D - DYNAMIC; A - ACTIVE; c - CONNECT, o - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
      DST-ADDRESS GATEWAY PC1 DISTANCE 10.0/24
DAc 10.0.0.0/24 ether1 10.0.10.2 0 10.0.10.1 R1 10.0.0/24
DAc 10.0.10.0/24 ether2 10.0.20.2 0 10.0.20.1 R1 10.0.0/24
DAO 10.0.20.0/24 10.0.0.2%ether1 110 ether2 10.0.0.1 10.0.0/24
[admin@MikroTik] /routing/ospf> /ping 10.0.20.2
SEQ HOST SIZE TTL TIME ether1 STATUS
0 10.0.20.2 56 63 2ms491us
1 10.0.20.2 56 63 1ms819us
sent=2 received=2 packet-loss=0% min-rtt=1ms819us avg-rtt=2ms155us max-rtt=2ms491us

```

- R2

```
[admin@MikroTik] /routing/ospf> /ip route print
Flags: D - DYNAMIC; A - ACTIVE; C - CONNECT, O - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
      DST-ADDRESS GATEWAY PC1 DISTANCE 10.0/24
D[ac] 10.0.0.0/24 ether1 10.0.10.2 0 10.0.10.1 | R1 | 10.0.0.0/24
D[ao] 10.0.10.0/24 10.0.0.1%ether1 110
D[ac] 10.0.20.0/24 ether2 e0 0 ether2 10.0.0.1
[admin@MikroTik] /routing/ospf> /ping 10.0.10.2
SEQ HOST SIZE TTL TIME ether1 STATUS
  0 10.0.10.2 56 63 2ms488us
  1 10.0.10.2 56 63 1ms518us
sent=2 received=2 packet-loss=0% min-rtt=1ms518us avg-rtt=2ms3us max-rtt=2ms488us
```

- We could notice that Distance = 110 is exactly the OSPF's administrative distance

- And of course PC1 can reach R2 and PC2

```
PC1> show ip
NAME : PC1[1]
IP/MASK : 10.0.10.2/24 PC1 10.0.10.0/24
GATEWAY : 10.0.10.1
DNS :
MAC : 00:50:79:66:68:00
LPORT : 10040
RHOST:PORT : 127.0.0.1:10041
MTU : 1500

PC1> ping 10.0.20.2
PC2 10.0.20.0/24
84 bytes from 10.0.20.2 icmp_seq=1 ttl=63 time=1.477 ms
^C
PC1> ping 10.0.20.2
84 bytes from 10.0.20.2 icmp_seq=1 ttl=62 time=3.299 ms
^C
```

- Meanwhile PC2 can reach R1 and PC1

```
PC2> show ip
NAME : PC2[1]
IP/MASK : 10.0.20.2/24 PC1 10.0.10.0/24
GATEWAY : 10.0.20.1
DNS :
MAC : 00:50:79:66:68:01
LPORT : 10042
RHOST:PORT : 127.0.0.1:10043
MTU : 1500

PC2> ping 10.0.0.1
PC2 10.0.20.0/24
84 bytes from 10.0.0.1 icmp_seq=1 ttl=63 time=1.853 ms
^C
PC2> ping 10.0.10.2
84 bytes from 10.0.10.2 icmp_seq=1 ttl=62 time=2.385 ms
^C
```

- R1's and R2's LSDBs were updated and synchronised

- R1 LSDB

```
[admin@MikroTik] /routing/ospf> lsa print
Flags: S - self-originated, F - flushing, W - wraparound; D - dynamic
  0 SD instance=ospf-instance-1 area=ospf-area-1 type="router" originator=1.1.1.1 id=1.1.1.1 sequence=0x80000006 age=610 checksum=0x63A7
    body=
      options=E
      type=network id=10.0.0.1 data=10.0.0.1 metric=1
      type=stub id=10.0.10.0 data=255.255.255.0 metric=1
  1 D instance=ospf-instance-1 area=ospf-area-1 type="router" originator=2.2.2.2 id=2.2.2.2 sequence=0x80000005 age=567 checksum=0xF9FE
    body=
      options=E
      type=network id=10.0.0.1 data=10.0.0.2 metric=1
      type=stub id=10.0.20.0 data=255.255.255.0 metric=1
  2 SD instance=ospf-instance-1 area=ospf-area-1 type="network" originator=1.1.1.1 id=10.0.0.1 sequence=0x80000002 age=119 checksum=0x5BE2
    body=
      netmask=255.255.255.0
      router-id=1.1.1.1
      router-id=2.2.2.2
```

- R2 LSDB

```

[admin@MikroTik] /routing/ospf> lsa print
Flags: S - self-originated, F - flushing, W - wraparound; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 type="router" originator=1.1.1.1 id=1.1.1.1 sequence=0x80000006 age=1070 checksum=0x63A7
    body=
        options=E
        type=network id=10.0.0.1 data=10.0.0.1 metric=1
        type=stub id=10.0.10.0 data=255.255.255.0 metric=1

1 SD instance=ospf-instance-1 area=ospf-area-1 type="router" originator=2.2.2.2 id=2.2.2.2 sequence=0x80000005 age=1014 checksum=0xF9FE
    body=
        options=E
        type=network id=10.0.0.1 data=10.0.0.2 metric=1
        type=stub id=10.0.20.0 data=255.255.255.0 metric=1

2 D instance=ospf-instance-1 area=ospf-area-1 type="network" originator=1.1.1.1 id=10.0.0.1 sequence=0x80000002 age=580 checksum=0x5BE2
    body=
        netmask=255.255.0
        router-id=1.1.1.1
        router-id=2.2.2.2

```

4. Finally, we can deploy OSPF in the same way for all the other routers and its interfaces

- After doing it, we can see for example R3 router's neighbour table. (Notice also that I added 3 interfaces of R3 using 1 template `10.0.0.0/8`).

```

[admin@MikroTik] /routing/ospf> instance add router-id=3.3.3.3
[admin@MikroTik] /routing/ospf> area add instance=ospf-instance-1
[admin@MikroTik] /routing/ospf> interface-template add area=ospf-area-1 networks=10.0.0.0/8
[admin@MikroTik] /routing/ospf> interface print/24
Flags: D - dynamic
0 D address=10.0.0.3%ether1 area=ospf-area-1 state=waiting network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.255.255.1%ether2 area=ospf-area-1 state=bdr network-type=broadcast dr=10.255.255.2 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
2 D address=10.0.30.1%ether3 area=ospf-area-1 state=waiting network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.1 priority=128 router-id=1.1.1.1 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
state-changes=5 adjacency=2m52s timeout=38s
1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.2 priority=128 router-id=2.2.2.2 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
state-changes=6 adjacency=2m52s timeout=38s
2 D instance=ospf-instance-1 area=ospf-area-1 address=10.255.255.2 priority=128 router-id=4.4.4.4 dr=10.255.255.2 bdr=10.255.255.1
state="Full" state-changes=6 adjacency=2m57s timeout=33s

```

- LSDB

```

[admin@MikroTik] /routing/ospf> lsa print
Flags: S - self-originated, F - flushing, W - wraparound; D - dynamic
0 SD instance=ospf-instance-1 area=ospf-area-1 type="router" originator=1.1.1.1 id=1.1.1.1 sequence=0x80000007 age=866 checksum=0x61A8
    body=
        options=E
        type=network id=10.0.10.0/24
        type=stub id=10.0.10.0 data=255.255.255.0 metric=1

1 D instance=ospf-instance-1 area=ospf-area-1 type="router" originator=2.2.2.2 id=2.2.2.2 sequence=0x80000006 age=739 checksum=0xF7FF
    body=
        options=E
        type=network id=10.0.0.1 data=10.0.0.2 metric=1
        type=stub id=10.0.20.0 data=255.255.255.0 metric=1

2 D instance=ospf-instance-1 area=ospf-area-1 type="router" originator=3.3.3.3 id=3.3.3.3 sequence=0x80000005 age=122 checksum=0xFEBC
    body=
        options=E
        type=network id=10.0.0.1 data=10.0.0.3 metric=1
        type=network id=10.255.255.2 data=10.255.255.1 metric=1
        type=stub id=10.0.30.0 data=255.255.255.0 metric=1

3 D instance=ospf-instance-1 area=ospf-area-1 type="router" originator=4.4.4.4 id=4.4.4.4 sequence=0x80000005 age=159 checksum=0x11C2
    body=
        options=E
        type=network id=10.255.255.2 data=10.255.255.2 metric=1
        type=stub id=10.0.40.0 data=255.255.255.0 metric=1

4 SD instance=ospf-instance-1 area=ospf-area-1 type="network" originator=1.1.1.1 id=10.0.0.1 sequence=0x80000004 age=147 checksum=0x2606
    body=
        netmask=255.255.255.0
        router-id=1.1.1.1
        router-id=2.2.2.2
        router-id=3.3.3.3

5 D instance=ospf-instance-1 area=ospf-area-1 type="network" originator=4.4.4.4 id=10.255.255.2 sequence=0x80000001 age=158
    body=
        netmask=255.255.255.252
        router-id=3.3.3.3
        router-id=4.4.4.4

```

- Or R4's routing table

```

[admin@MikroTik] /routing/ospf> interface-template add area=ospf-area-1 networks=10.0.0.0/8
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
  0 D address=10.255.255.2%ether1 area=ospf-area-1 state=waiting network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
  1 D address=10.0.40.1%ether2 area=ospf-area-1 state=waiting network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
  0 area=ospf-area-1 instance-id=0 networks=10.0.0.0/8 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> /ip route print
Flags: D - DYNAMIC; A - ACTIVE; C - CONNECT, O - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
      DST-ADDRESS      GATEWAY      DISTANCE
DAo 10.0.0.0/24 10.255.255.1%ether1    110
DAo 10.0.10.0/24 10.255.255.1%ether1    110
DAo 10.0.20.0/24 10.255.255.1%ether1    110
DAo 10.0.30.0/24 10.255.255.1%ether1    110
DAc 10.0.40.0/24  ether2            0
DAC 10.255.255.0/30 ether1            0
  
```

2. Which interface you will select as the OSPF router ID and why?

- **Loopback interface:** following best practices, the best choice is to configure loopback Interface on a router. The highest loopback interface's IP address is selected as Router ID by default. This is because loopback interfaces are **always up** and do **not depend on physical interfaces**, providing constant **availability** and **stability**.
- **Highest non-loopback interface IP:** If a loopback interface is not configured, OSPF will automatically select the highest IP address on any of the **active** interfaces as the Router ID.
- **Explicit configuration:** In addition, it is always possible to configure Router ID manually. It may help to avoid relying on the automatic selection and to prevent collisions.

In my case, I configured it manually and set it in the following way:

1. R1 - 1.1.1.1
2. R2 - 2.2.2.2
3. R3 - 3.3.3.3
4. R4 - 4.4.4.4

3. What is the difference between advertising all the networks VS manual advertising (per interface or per subnet)? Which one is better?

⚠ Note: In this exercise and further router R5 exists in my topology because I started doing it after I completed Task 3 where I explained why and how I had added it

Generally, manual advertising is better. In addition, one can manually configure advertising all the networks ($0.0.0.0/0$). However, I believe that anyway administrators should be as specific as possible configuring the wildcard which will be applied to all the interfaces on which IP address matches the mask.

For example, other networks can be connected to a router but these networks may use not OSPF protocol (RIP, BGP, etc.) or this network may lay in a different OSPF domain - in other words may lay in a different Autonomy. In such a case a redistribution of routes can be configured, while the router should become **ASBR**.

What is more, in Mikrotik example specifically, we can only configure a cost and other parameters with the help of `interface-template` which can include many interfaces.

However, if an administrator is sure that there will be no other autonomies, than it may be more convenient to configure advertising all the networks.

For instance, I configured R3 and R4 routers using the mask (10.0.0.0/8) while R1 and R2 was configured by interfaces ether1 and ether2 separately:

- R1

```
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 interfaces=ether1 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
1 area=ospf-area-1 interfaces=ether2 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.1%ether1 area=ospf-area-1 state=dr network-type=broadcast bdr=10.0.0.2 cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.0.10.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
```

- R2

```
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 interfaces=ether1 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
1 area=ospf-area-1 interfaces=ether2 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.2%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.1 cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.0.20.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
```

- R3

```
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 instance-id=0 networks=10.0.0.0/8 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.3%ether1 area=ospf-area-1 state=dr-other network-type=broadcast dr=10.0.0.1 bdr=10.0.0.2 cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.255.255.1%ether2 area=ospf-area-1 state=bdr network-type=broadcast dr=10.255.255.2 cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
2 D address=10.0.30.1%ether3 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
```

- R4

```
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 instance-id=0 networks=10.0.0.0/8 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.255.255.2%ether1 area=ospf-area-1 state=dr network-type=broadcast bdr=10.255.255.1 cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.0.40.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
```

4. If you have a static route in a router, how can you let your OSPF neighbors know about it?
Approve and show it on practice

- Let's change the link between R3 and R4 to be not an OSPF

- From the perspective of R3

```

[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.3%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.5 cost=1 priority=128 use-bfd=no
  retransmit-interval=5s transmit-delay=ls hello-interval=10s dead-interval=40s
  ether2 10.0.0.1
1 D address=10.255.255.1%ether2 area=ospf-area-1 state=bdr network-type=broadcast dr=10.255.255.2 cost=1 priority=128 use-bfd=no
  retransmit-interval=5s transmit-delay=ls hello-interval=10s dead-interval=40s
  ether3 10.0.0.1
2 D address=10.0.30.1%ether3 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
  transmit-delay=ls hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 instance-id=0 networks=10.0.0.0/8 type=broadcast retransmit-interval=5s transmit-delay=ls hello-interval=10s
  dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.3%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.5 cost=1 priority=128 use-bfd=no
  retransmit-interval=5s transmit-delay=ls hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>

```

- With not forgetting to return 10.0.30.0/24 network to keep connectivity to the PC3

```

[admin@MikroTik] /routing/ospf> interface-template add networks=10.0.30.0/24 area=ospf-area-1
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.3%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.5 cost=1 priority=128 use-bfd=no
  retransmit-interval=5s transmit-delay=ls hello-interval=10s dead-interval=40s
1 D address=10.0.30.1%ether3 area=ospf-area-1 state=waiting network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
  transmit-delay=ls hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>

```

- And the same from the perspective of R4

```

[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.255.255.2%ether1 area=ospf-area-1 state=dr network-type=broadcast bdr=10.255.255.1 cost=1 priority=128 use-bfd=no
  retransmit-interval=5s transmit-delay=ls hello-interval=10s dead-interval=40s
1 D address=10.0.40.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
  transmit-delay=ls hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 instance-id=0 networks=10.0.0.0/8 type=broadcast retransmit-interval=5s transmit-delay=ls hello-interval=10s
  dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface-template set 0 network=10.0.40.0/24
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.40.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
  transmit-delay=ls hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>

```

- Then, let's configure the static route from the R3 to 10.0.40.0/24 through the R4

```

[admin@MikroTik] /routing/ospf> /ip route print
Flags: D - DYNAMIC; A - ACTIVE; c - CONNECT, o - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
#  DST-ADDRESS      GATEWAY      DISTANCE
DAc 10.0.0.0/24    ether1        0
DAo 10.0.10.0/24   10.0.0.1%ether1 110
DAo 10.0.20.0/24   10.0.0.2%ether1 110
DAc 10.0.30.0/24   ether3        0
DAC 10.255.255.0/30 ether2        0
[admin@MikroTik] /routing/ospf> /ping 10.0.40.2
SEQ HOST          SIZE TTL TIME          STATUS
0 10.0.40.2      56 63 1ms690us no route to host
1 10.0.40.2      56 63 1ms642us no route to host
sent=2 received=0 packet-loss=100%
[admin@MikroTik] /routing/ospf> /ip route add dst-address=10.0.40.0/24 gateway=10.255.255.2
[admin@MikroTik] /routing/ospf> /ip route print
Flags: D - DYNAMIC; A - ACTIVE; c - CONNECT, s - STATIC, o - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
#  DST-ADDRESS      GATEWAY      DISTANCE
DAc 10.0.0.0/24    ether1        0
DAo 10.0.10.0/24   10.0.0.1%ether1 110
DAo 10.0.20.0/24   10.0.0.2%ether1 110
DAc 10.0.30.0/24   ether3        0
0  As 10.0.40.0/24 10.255.255.2 1
DAC 10.255.255.0/30 ether2        0
[admin@MikroTik] /routing/ospf> /ping 10.0.40.2
SEQ HOST          SIZE TTL TIME          STATUS
0 10.0.40.2      56 63 1ms690us
1 10.0.40.2      56 63 1ms642us
sent=2 received=2 packet-loss=0% min-rtt=1ms642us avg-rtt=1ms666us max-rtt=1ms690us
[admin@MikroTik] /routing/ospf>

```

- However, we still cannot reach `10.0.40.0/24` from the other routers such as `R2` because they have no suitable route in their routing tables

```
[admin@mikrotik] > ping 10.0.40.2
SEQ HOST SIZE TTL TIME STATUS
No. Time Source Destination Protocol Length Info
0 0.000 122.73.8.10.0.0.3 224.0.0.5 OSPPF 90 Hello
1 0.050 122.25.77.10.0.0.2 224.0.0.5 OSPPF 90 Hello
sent=2 received=0 packet-loss=100%
[admin@mikrotik] > ip route print
Flags: D - DYNAMIC; A - ACTIVE; c - CONNECT, o - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
DST-ADDRESS GATEWAY DISTANCE
DAc 10.0.0.0/24 ether1 224.0.0.5 0 OSPF
DAO 10.0.10.0/24 10.0.0.1%ether1 110 OSPF
DAC 10.0.20.0/24 ether2 224.0.0.5 0 OSPF
DAO 10.0.30.0/24 10.0.0.3%ether1 110 OSPF
[admin@mikrotik] >
```

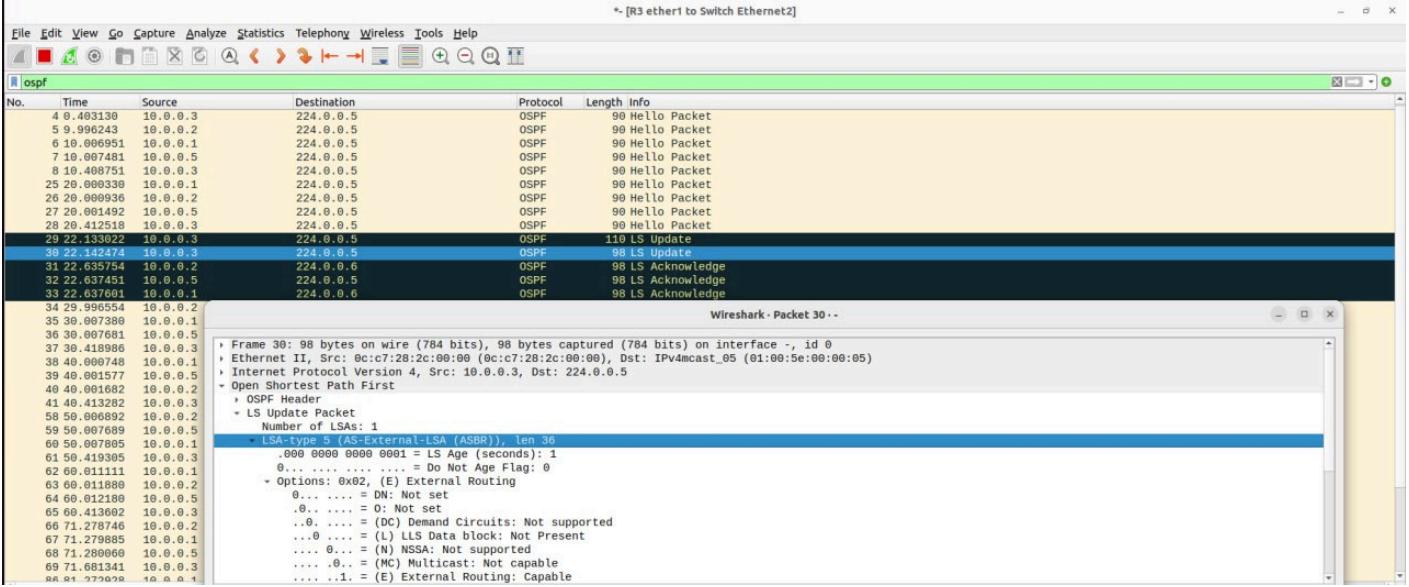
- So now, let's make R3 an ASBR.

- We can just add `redistribute static` flag with the value `static` to our OSPF instance on the router R3 to make it an ASBR for this particular OSPF domain redistributing its static routes as type 5: External LSAs throughout the whole domain

```
[admin@mikrotik] /routing/ospf> instance print  
Flags: X - disabled, I - inactive  
0 name='ospf-instance-1' version=2 vrf=main router-id=3.3.3.3  
[admin@mikrotik] /routing/ospf> instance set 0 redistribute=static
```

- We can immediately see this LSDB update requests initiated by R3

The Wireshark interface displays network traffic for interface R3 ether1 to Switch Ethernets2. The packet list shows OSPF Hello Packets (Type 1) and LS Update packets (Type 5). The details pane shows the internal structure of the OSPF packets, including LSA headers and link state information. The bytes pane shows the raw hex and ASCII data of the packets.



- As we see these requests contain exactly the information that R3 became an ASBR for this OSPF domain and this particular area, and new external Autonomous System, which is marked as LSA-type 5.
- Therefore, now we can actually make sure that this LSA exists in the LSDB

```
[admin@MikroTik] > routing ospf lsa print where type=external
Flags: S - self-originated, F - flushing, W - wraparound; D - dynamic
0 D instance=ospf-instance-1 type="external" originator=3.3.3.3 id=10.0.40.0 sequence=0x80000001 age=606 checksum=0xD241 body=
    options=E
    netmask=255.255.255.0
    forwarding-address=0.0.0.0
    metric=1 type=1
    route-tag=0
[admin@MikroTik] >
```

- Although now we can reach the 10.0.40.0/24 from our OSPF domain it was not enough and we got only timeouts

```
[admin@MikroTik] > ping 10.0.40.2
SEQ HOST SIZE TTL TIME STATUS
0 10.0.40.2 sent=1 received=0 packet-loss=100% timeout
[admin@MikroTik] >
```

- They occurred because packets now can be easily routed outside the OSPF domain, but R4 knows nothing about how to route them back.

- So, let's also add a static route from R4 to our OSPF domain through R3

```
[admin@MikroTik] > ping 10.0.0.3
SEQ HOST SIZE TTL TIME STATUS
0 10.0.0.3 sent=2 received=0 packet-loss=100%
[admin@MikroTik] > ip route print 10.0.10.1
Flags: D - DYNAMIC; A - ACTIVE; C - CONNECT
Columns: DST-ADDRESS, GATEWAY, DISTANCE
#   DST-ADDRESS      GATEWAY      DISTANCE
DAc 10.0.40.0/24  ether2        0
DAc 10.255.255.0/30 ether1       0
[admin@MikroTik] > ip route add dst-address=10.0.0.0/8 gateway=10.255.255.1
[admin@MikroTik] > ip route print
Flags: D - DYNAMIC; A - ACTIVE; C - CONNECT, s - STATIC
Columns: DST-ADDRESS, GATEWAY, DISTANCE
#   DST-ADDRESS      GATEWAY      DISTANCE
0 As 10.0.0.0/8     10.255.255.1  1
DAc 10.0.40.0/24   ether2        0
DAc 10.255.255.0/30 ether1       0
[admin@MikroTik] > ping 10.0.0.3
SEQ HOST SIZE TTL TIME STATUS
0 10.0.0.3 sent=2 received=2 packet-loss=0% min-rtt=788us avg-rtt=896us max-rtt=1ms5us
[admin@MikroTik] >
```

- Notice that I have added `10.0.0.0/8` which is enough to ensure the coverage of the current addresses in the whole topology. A key point here is route precedence rules (packets go through the link which is specified as the most specific over all the routing table entries) keep the connectivity with `10.0.40.0/24` - and, thus, with PC4

The screenshot shows the Winbox interface with several windows open:

- Windows:**
 - [admin@MikroTik] > ping 10.0.30.2
 - [admin@MikroTik] > ping 10.0.40.2
 - [admin@MikroTik] >
 - [admin@MikroTik] >
- Network Topology:**
 - Routers: R1, R2, R3, R4, R5.
 - Hosts: PC1, PC2, PC3, PC4.
 - Switches: Switch.
 - IP Subnets: 10.0.0.0/24, 10.0.20.0/24, 10.0.30.0/24, 10.0.40.0/24.
 - Link Details: e0, e1, e2, e3, ether1, ether2, ether3.
- Server Summary:**
 - lenovo CPU 17.2%, RAM 49.6%

- Finally, me made it possible to reach another Autonomous System that uses static routing from our OSPF domain

The screenshot shows the Winbox interface with several windows open:

- Windows:**
 - [admin@MikroTik] > ping 10.0.40.2
 - [admin@MikroTik] > tool traceroute 10.0.40.2.10.0.1
 - [admin@MikroTik] >
- Network Topology:**
 - Routers: R1, R2, R3, R4, R5.
 - Hosts: PC1, PC2, PC3, PC4.
 - Switches: Switch.
 - Link Details: e0, ether1, ether2, ether3.
- Table:**

#	ADDRESS	LOSS	SENT	LAST	AVG	BEST	WORST	STD-DEV
1	10.0.0.3	0%	4	1.1ms	1	0.8	1.1	0.1
2	10.255.255.2	0%	4	1.7ms	1.7	1.5	1.7	0.1
3	10.0.40.2	0%	4	2.2ms	2.2	1.8	2.5	0.2

5. Enable OSPF with authentication between the neighbors and verify it

I decided to enable OSPF authentication based on the simple plain-text password transmission inside the OSPF Hello packets' header

- First, I enabled the authentication on R1

- We can see there are 3 R1's neighbours. Also, other routers' subnets are reachable

```
[admin@MikroTik] /routing/ospf> ip route print where ospf
Flags: D - DYNAMIC; A - ACTIVE; o - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
  DST-ADDRESS      GATEWAY      DISTANCE
DAO 10.0.20.0/24 10.0.0.2%ether1    110
DAO 10.0.30.0/24 10.0.0.3%ether1    110
DAO 10.0.40.0/24 10.0.0.3%ether1    110
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
  0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.2 priority=128 router-id=2.2.2.2 dr=10.0.0.5 bdr=10.0.0.3 state="TwoWay"
    state-changes=4 timeout=39s
  1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.3 priority=128 router-id=3.3.3.3 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
    state-changes=7 adjacency=42m42s timeout=39s
  2 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
    state-changes=7 adjacency=42m42s timeout=39s
[admin@MikroTik] /routing/ospf> ping 10.0.30.2
SEQ HOST                               SIZE TTL TIME STATUS
  0 10.0.30.2                         56  63 3ms2us 0 Hello Packet
  1 10.0.30.2                         56  63 2ms34us 0 Hello Packet
sent=2 received=2 packet-loss=0% min-rtt=2ms34us avg-rtt=2ms518us max-rtt=3ms2us
[admin@MikroTik] /routing/ospf>
```

- I set up the password password for the interface ether1 which goes to the subnet 10.0.0.0/24 where other routers are located also. The interesting part here is that it became DR inside its own authenticated multicast link.

```
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
  0 area=ospf-area-1 interfaces=ether1 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s
    dead-interval=40s priority=128 cost=1
  1 area=ospf-area-1 interfaces=ether2 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s
    dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface-template set 0 auth=simple auth-id=1 auth-key=password
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
  0 area=ospf-area-1 interfaces=ether1 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s
    dead-interval=40s priority=128 cost=1 auth=simple auth-key="password" auth-id=1
  1 area=ospf-area-1 interfaces=ether2 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s
    dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
  0 D address=10.0.0.1%ether1 area=ospf-area-1 state=dr-other network-type=broadcast dr=10.0.0.5 bdr=10.0.0.3 cost=1 priority=128 use-bfd=no
    retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
  1 D address=10.0.10.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
    transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
  0 D address=10.0.0.1%ether1 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
    transmit-delay=1s hello-interval=10s dead-interval=40s
  1 D address=10.0.10.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
    transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>
```

- And we can see the updates in Wireshark. R1 had sent its auth data inside the OSPF Hello packet's header

The Wireshark screenshot displays a series of OSPF Hello packets sent from R1. The timeline shows the sequence of packets, and the details pane provides a breakdown of the OSPF Hello Packet structure, including the OSPF Header and the OSPF Hello Packet itself. Red arrows point to the OSPF Header and the OSPF Hello Packet in the details pane, highlighting the authentication fields.

- Next, we can see that router R1 "lost" all its neighbours, while other routers "lost" him as a neighbour.

```
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.3 priority=128 router-id=3.3.3.3 dr=10.0.0.5 bdr=10.0.0.3 state="Full" host:5008
    state-changes=6 adjacency=26s timeout=34s
1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.5 bdr=10.0.0.3 state="Full" host:5006
    state-changes=6 adjacency=26s timeout=34s
[admin@MikroTik] /routing/ospf>
```

- What is more, since there is no router who can become a neighbour to R1, it lost the reachability to other routers and vice a versa

R1:

SEQ	HOST	SIZE	TTL	TIME	STATUS
0					no route to host
1					no route to host

R2:

SEQ	HOST	SIZE	TTL	TIME	STATUS
0					no route to host
1					no route to host

- Okay, now let's configure authentication with the same password on R2

- We can see there are 2 R1's neighbours. Also, these routers' subnets are reachable

```
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.3 priority=128 router-id=3.3.3.3 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
    state-changes=6 adjacency=5m16s timeout=35s
1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
    state-changes=6 adjacency=5m16s timeout=35s
[admin@MikroTik] /routing/ospf> /ping 10.0.30.2
SEQ HOST SIZE TTL TIME STATUS
0 10.0.30.2 56 63 2ms510us Hello Packet
1 10.0.30.2 56 63 1ms897us Hello Packet
sent=2 received=2 packet-loss=0% min-rtt=1ms897us avg-rtt=2ms293us max-rtt=2ms510us
[admin@MikroTik] /routing/ospf>
```

- I set up the password `password` for the interface `ether1` which goes to the subnet `10.0.0.0/24` where other routers are located also. The interesting part here is that it became `BDR` inside its authenticated

multicast link, while DR remained the same - R1.

```
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 interfaces=ether1 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1

1 area=ospf-area-1 interfaces=ether2 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface-template set 0 auth=simple auth-id=1 auth-key=password
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 interfaces=ether1 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1 auth=simple auth-key="password" auth-id=1
1 area=ospf-area-1 interfaces=ether2 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.1 priority=128 router-id=1.1.1.1 dr=10.0.0.1 bdr=0.0.0.0 state="TwoWay" state-changes=2 timeout=36s
1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.3 priority=128 router-id=3.3.3.3 dr=10.0.0.5 bdr=10.0.0.3 state="Full" state-changes=6 adjacency=6m55s timeout=6s
2 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.5 bdr=10.0.0.3 state="Full" state-changes=6 adjacency=6m55s timeout=6s
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.2%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.1 cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.0.20.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>
```

- We can also see the updates in Wireshark.

No.	Time	Source	Destination	Protocol	Length	Info
115	161.007180	10.0.0.3	224.0.0.5	OSPF	86	Hello Packet
116	161.0086608	10.0.0.1	224.0.0.5	OSPF	78	Hello Packet
117	161.0085458	10.0.0.5	224.0.0.5	OSPF	80	Hello Packet
118	161.009362	10.0.0.2	224.0.0.5	OSPF	86	Hello Packet
119	161.009121	10.0.0.3	224.0.0.5	OSPF	86	Hello Packet
120	161.074660	10.0.0.4	224.0.0.5	OSPF	78	Hello Packet
137	121.095581	10.0.0.3	224.0.0.5	OSPF	86	Hello Packet
138	121.096287	10.0.0.2	224.0.0.5	OSPF	86	Hello Packet
139	121.096624	10.0.0.5	224.0.0.5	OSPF	86	Hello Packet
140	121.068152	10.0.0.1	224.0.0.5	OSPF	78	Hello Packet
141	131.091022	10.0.0.5	224.0.0.5	OSPF	86	Hello Packet
142	131.091762	10.0.0.2	224.0.0.5	OSPF	86	Hello Packet
143	131.182751	10.0.0.3	224.0.0.5	OSPF	86	Hello Packet
144	131.074162	10.0.0.1	224.0.0.5	OSPF	78	Hello Packet
145	141.093930	10.0.0.2	224.0.0.5	OSPF	86	Hello Packet
146	141.094966	10.0.0.5	224.0.0.5	OSPF	86	Hello Packet
147	141.095167	10.0.0.3	224.0.0.5	OSPF	86	Hello Packet
148	141.0876771	10.0.0.1	224.0.0.5	OSPF	82	Hello Packet
165	151.092861	10.0.0.2	224.0.0.5	OSPF	90	Hello Packet
166	151.094530	10.0.0.5	224.0.0.5	OSPF	86	Hello Packet
168	151.094816	10.0.0.3	224.0.0.5	OSPF	86	Hello Packet
170	151.097459	10.0.0.1	10.0.0.2	OSPF	66	DB Description
171	151.0876747	10.0.0.1	224.0.0.5	OSPF	82	Hello Packet
172	156.097552	10.0.0.1	10.0.0.2	OSPF	66	DB Description
173	161.090020	10.0.0.2	224.0.0.5	OSPF	90	Hello Packet
174	161.090059	10.0.0.5	224.0.0.5	OSPF	86	Hello Packet
175	161.101160	10.0.0.1	10.0.0.2	OSPF	66	DB Description
176	161.181337	10.0.0.3	224.0.0.5	OSPF	86	Hello Packet
177	161.182915	10.0.0.1	224.0.0.5	OSPF	82	Hello Packet

- Now, we can see that R1 and R2 became neighbours, while other routers "lost" them both.

```
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.2 priority=128 router-id=2.2.2.2 dr=10.0.0.1 bdr=10.0.0.2 state="Full" state-changes=6 adjacency=3m38s timeout=32s
[admin@MikroTik] /routing/ospf>
```

```

[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.1 priority=128 router-id=1.1.1.1 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
state-changes=6 adjacency=3m42s timeout=38s
[admin@MikroTik] /routing/ospf>

```

```

R3
[admin@MikroTik] > routing ospf neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
state-changes=6 adjacency=11m55s timeout=36s
[admin@MikroTik] >

```

- And of course now we can reach both the routers from each other

```

[admin@MikroTik] > ip route print
Flags: D - DYNAMIC; A - ACTIVE; c - CONNECT, o - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
  DST-ADDRESS GATEWAY DISTANCE
DAc 10.0.0.0/24 ether1 0
DAc 10.0.10.0/24 ether2 10.0.0.24
DAO 10.0.20.0/24 10.0.0.2%ether1 10.0.10.1 R1
[admin@MikroTik] > ping 10.0.20.2
SEQ HOST SIZE TTL TIME STATUS
  0 10.0.20.2 56 63 2ms417us
  1 10.0.20.2 56 63 1ms761us
sent=2 received=2 packet-loss=0% min-rtt=1ms761us avg-rtt=2ms89us max-rtt=2ms417us
[admin@MikroTik] >

```

```

[admin@MikroTik] > ip route print
Flags: D - DYNAMIC; A - ACTIVE; c - CONNECT, o - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
  DST-ADDRESS GATEWAY DISTANCE
DAc 10.0.0.0/24 ether1 0
DAO 10.0.10.0/24 10.0.0.1%ether1 10.0.10.1 R1
DAc 10.0.20.0/24 ether2 10.0.10.2 0
[admin@MikroTik] > ping 10.0.10.2
SEQ HOST SIZE TTL TIME STATUS
  0 10.0.10.2 56 63 2ms243us
  1 10.0.10.2 56 63 1ms679us
  2 10.0.10.2 56 63 1ms667us
  3 10.0.10.2 56 63 1ms636us
sent=4 received=4 packet-loss=0% min-rtt=1ms636us avg-rtt=1ms806us max-rtt=2ms243us
[admin@MikroTik] >

```

Task 3 - OSPF Verification

- How can you check if you have a full adjacency with your router neighbor?

- I can check it looking at neighbour's state. Let's see at the R3 example:

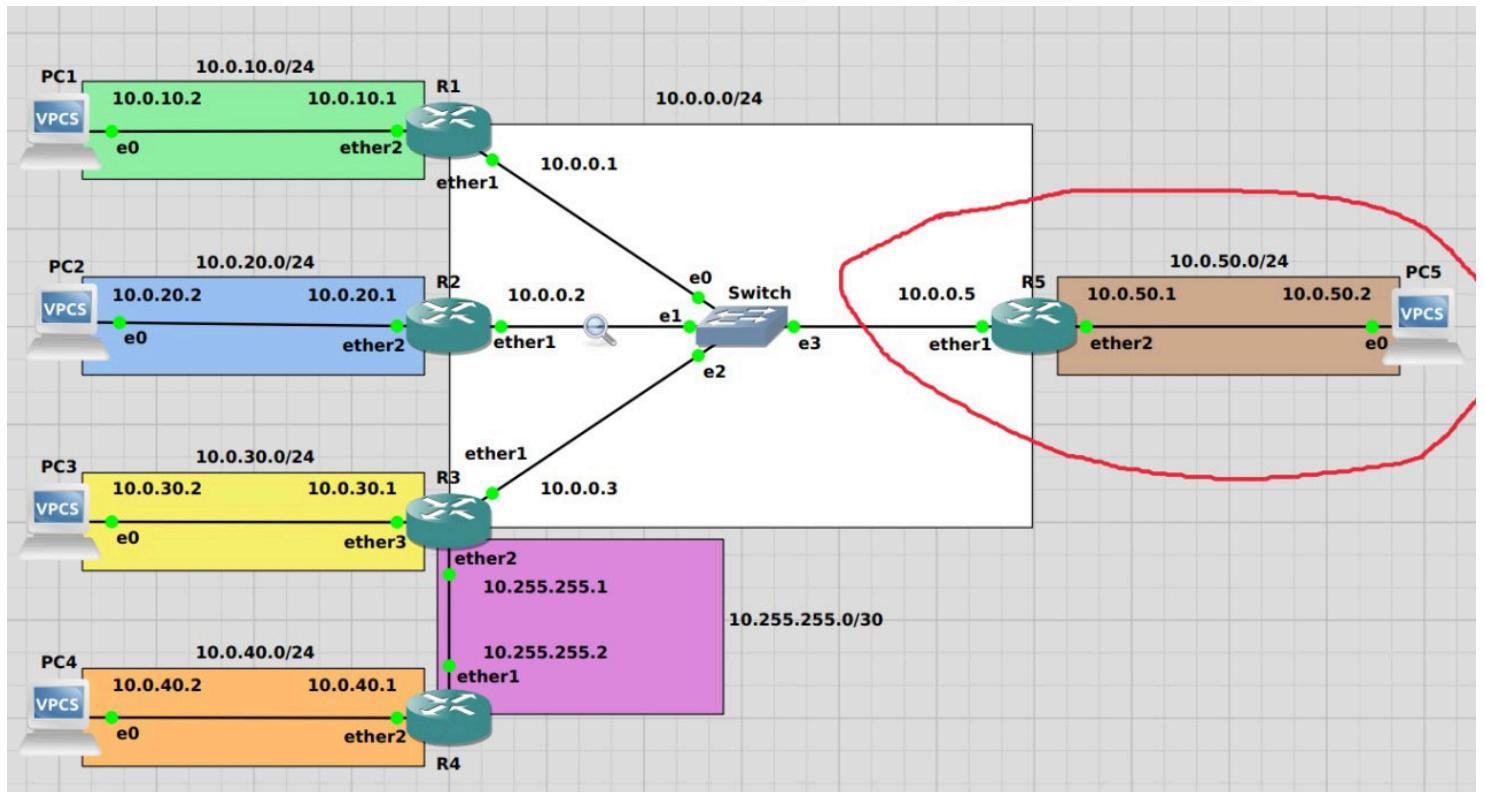
```

[admin@MikroTik] /routing/ospf> neighbor print proplist=address,router-id,state
Flags: V - virtual; D - dynamic
0 D address=10.0.0.1 router-id=1.1.1.1 state="Full"
1 D address=10.0.0.2 router-id=2.2.2.2 state="Full"
2 D address=10.255.255.2 router-id=4.4.4.4 state="Full"
[admin@MikroTik] /routing/ospf> neighbor print proplist=address,router-id,state where router-id=4.4.4.4
Flags: V - virtual; D - dynamic
2 D address=10.255.255.2 router-id=4.4.4.4 state="Full"
[admin@MikroTik] /routing/ospf>

```

- I mentioned the state machine and possible state values above in the Task 2

- To make it more demonstrative, I added another one router R5 (router-id= 5.5.5.5) and PC PC5



- Then, I deployed OSPF to both R5's interfaces
- After all we can see that R3 has the same neighbours in FULL state: R1, R2 in 10.0.0.0/24, and R4 in 10.255.255.0/30. But where is R5?

```
R3
[admin@mikrotik] /routing/ospf> neighbor print where state=Full
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.1 priority=128 router-id=1.1.1.1 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
    state-changes=6 adjacency=3m47s timeout=33s
1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.2 priority=128 router-id=2.2.2.2 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
    state-changes=6 adjacency=3m47s timeout=33s
3 D instance=ospf-instance-1 area=ospf-area-1 address=10.255.255.2 priority=128 router-id=4.4.4.4 dr=10.255.255.2 bdr=10.255.255.1
    state="Full" state-changes=6 adjacency=3m9s timeout=31s
```

- And R5 has indeed TwoWay state from the R3's perspective.

```
R3
[admin@mikrotik] /routing/ospf> neighbor print where router-id=5.5.5.5
Flags: V - virtual; D - dynamic
2 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.1 bdr=10.0.0.2 state="TwoWay"
    state-changes=2 timeout=37s
```

- This happened because R5 and R3 do not need to synchronise LSDB between each other. For this purpose they both have DR and BDR routers, R1 and R2 correspondingly

- 2. How can you check in the routing table which networks did you receive from your neighbors?**
- Since we receive all the updates for LSDB from our neighbours (and to be precise from DR or BDR) we can only check that entries of the routing table were generated by OSPF:

```
R5
[admin@mikrotik] /ip/route> print where ospf
Flags: D - DYNAMIC; A - ACTIVE; o - OSPF
Columns: DST-ADDRESS, GATEWAY, DISTANCE
D Ao 10.0.10.0/24 10.0.0.1%ether1 110
D Ao 10.0.20.0/24 10.0.0.2%ether1 110
D Ao 10.0.30.0/24 10.0.0.3%ether1 110
D Ao 10.0.40.0/24 10.0.0.3%ether1 110
D Ao 10.255.255.0/30 10.0.0.3%ether1 110
```

- Another way which is actually more detailed is to use `routing/route/` instead

```
[admin@MikroTik] > routing route print where ospf
Flags: A - ACTIVE; o - OSPF
Columns: DST-ADDRESS, GATEWAY, AFI, DISTANCE, SCOPE, TARGET-SCOPE, IMMEDIATE-GW
  DST-ADDRESS      GATEWAY      AFI DISTANCE SCOPE TARGET-SCOPE IMMEDIATE-GW
Ao 10.0.20.0/24  10.0.0.2ether1 ip4    110     20          10 10.0.0.2ether1
Ao 10.0.30.0/24  10.0.0.3ether1 ip4    110     20          10 10.0.0.3ether1
Ao 10.0.40.0/24  10.0.0.3ether1 ip4    110     20          10 10.0.0.3ether1
Ao 10.0.50.0/24  10.0.0.5ether1 ip4    110     20 0.0.0.0/24 10 10.0.0.5ether1
Ao 10.255.255.0/30 10.0.0.3ether1 ip4    110     20          10 10.0.0.3ether1
[admin@MikroTik] >
```

The terminal shows the output of the `routing route print where ospf` command. It lists five routes for OSPF areas. The network diagram on the right shows a central switch connected to R1, R2, R3, R4, and R5. Each router is connected to a PC (PC1-PC5) via an interface labeled `ether1`. The switch is also connected to R5 via `ether1`.

3. Use traceroute to verify that you have a full OSPF network.

- I didn't get what does it mean to "have a full OSPF network", so I just performed traceroute from R1 to every subnet

```
[admin@MikroTik] > tool traceroute 10.0.10.2
Columns: ADDRESS, LOSS, SENT, LAST, AVG, BEST, WORST, STD-DEV
# ADDRESS LOSS SENT LAST AVG BEST WORST STD-DEV
1 10.0.10.2 0% 1 0.8ms 0.8 0.8 0.8 0

[admin@MikroTik] > tool traceroute 10.0.20.2
Columns: ADDRESS, LOSS, SENT, LAST, AVG, BEST, WORST, STD-DEV
# ADDRESS LOSS SENT LAST AVG BEST WORST STD-DEV
1 10.0.2 0% 1 1.3ms 1.3 1.3 1.3 0
2 10.0.20.2 0% 1 1.4ms 1.4 1.4 1.4 0

[admin@MikroTik] > tool traceroute 10.0.30.2
Columns: ADDRESS, LOSS, SENT, LAST, AVG, BEST, WORST, STD-DEV
# ADDRESS LOSS SENT LAST AVG BEST WORST STD-DEV
1 10.0.3 0% 1 1.2ms 1.2 1.2 1.2 0
2 10.0.30.2 0% 1 1.5ms 1.5 1.5 1.5 0

[admin@MikroTik] > tool traceroute 10.0.40.2
Columns: ADDRESS, LOSS, SENT, LAST, AVG, BEST, WORST, STD-DEV
# ADDRESS LOSS SENT LAST AVG BEST WORST STD-DEV
1 10.0.0.3 0% 1 1.2ms 1.2 1.2 1.2 0
2 10.255.255.2 0% 1 1.7ms 1.7 1.7 1.7 0
3 10.0.40.2 0% 1 2ms 2 2 2 0

[admin@MikroTik] > tool traceroute 10.0.50.2
Columns: ADDRESS, LOSS, SENT, LAST, AVG, BEST, WORST, STD-DEV
# ADDRESS LOSS SENT LAST AVG BEST WORST STD-DEV
1 10.0.0.5 0% 1 1.3ms 1.3 1.3 1.3 0
2 10.0.50.2 0% 1 2.7ms 2.7 2.7 2.7 0
```

The terminal shows five traceroute commands from R1 to subnets 10.0.10.2, 10.0.20.2, 10.0.30.2, 10.0.40.2, and 10.0.50.2. The network diagram on the right shows R1, R2, R3, R4, and R5 connected to PCs and a central switch. The switch is connected to R5 via `ether1`.

4. Which router is selected as DR and which one is BDR ?

It really depends on the subnet we are considering, or to be more precise, **Multicast Link**.

- For example, in the `10.0.0.0/24` R1 was selected as DR and R2 as BDR

- R1

```
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
  0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.2 priority=128 router-id=2.2.2.2 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
    state-changes=7 adjacency=37m30s timeout=40s
  1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.3 priority=128 router-id=3.3.3.3 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
    state-changes=6 adjacency=36m30s timeout=38s
  2 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
    state-changes=6 adjacency=36m30s timeout=38s
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
  0 D address=10.0.0.1%ether1 area=ospf-area-1 state=dr network-type=broadcast bdr=10.0.0.2 cost=1 priority=128 use-bfd=no
    retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
  1 D address=10.0.10.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
    transmit-delay=1s hello-interval=10s dead-interval=40s
```

The terminal shows the output of `/routing/ospf> neighbor print` and `/routing/ospf> interface print` for R1. The `neighbor print` command lists three neighbors (R2, R3, R5) with their DR and BDR roles highlighted. The `interface print` command lists two interfaces: `ether1` (selected as DR) and `ether2` (selected as DR). The network diagram on the right shows R1, R2, R3, R4, and R5 connected to PCs and a central switch. The switch is connected to R5 via `ether1`.

- R2

```
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.1 priority=128 router-id=1.1.1.1 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
state-changes=6 adjacency=37m48s timeout=32s
1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.3 priority=128 router-id=3.3.3.3 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
state-changes=6 adjacency=36m48s timeout=31s
2 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.1 bdr=10.0.0.2 state="Full"
state-changes=6 adjacency=36m48s timeout=31s
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.2%ether1 area=ospf-area-1 state=bdr network-type=broadcast dr=10.0.0.1 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.0.20.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>
```

- However, inside the 10.255.255.0/30 R4 was selected as DR and R3 as BDR

```
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.255.255.1 priority=128 router-id=3.3.3.3 dr=10.255.255.2 bdr=10.255.255.1
state="Full" state-changes=6 adjacency=46m51s timeout=30s
[admin@MikroTik] /routing/ospf> interface print where address=10.255.255.2%ether1
Flags: D - dynamic
0 D address=10.255.255.2%ether1 area=ospf-area-1 state=dr network-type=broadcast bdr=10.255.255.1 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>
```

- Actually, there always an election process between routers in the same Multicast Link.

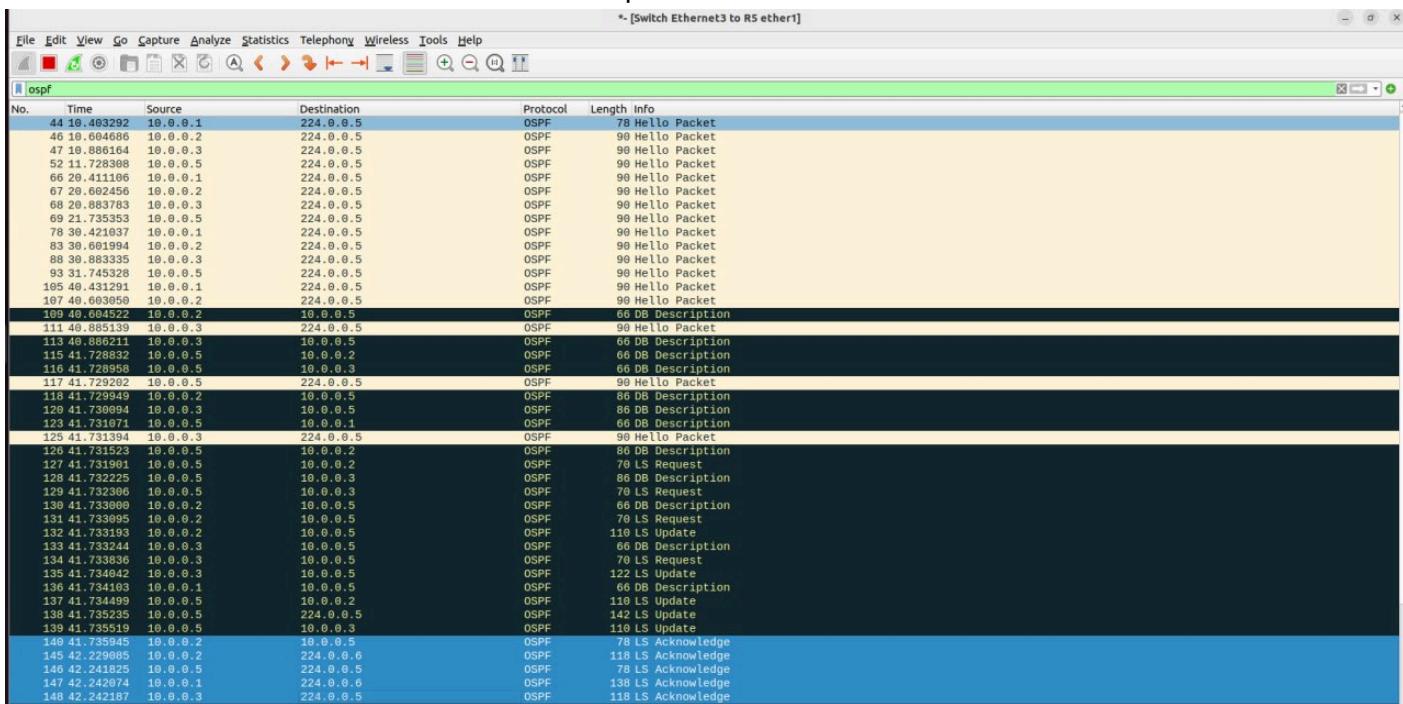
1. Routers check if there are already a DR or BDR elected in their network. If yes, then they just accept it.
 2. If no, routers elect one of them with the **highest priority** as a DR.
 3. If all the priorities are identical, then to break the tie the **highest router-id** is used.
 4. The same election process is applied for BDR after DR is elected.
- So, that's why in the 10.0.0.0/24 R1 and R2 was DR and BDR correspondingly -- they were enabled first one by one, therefore, other routers just accepted that during exchanging Hello packets.
 - However, if I restart my topology, I will get R5 (router-id= 5.5.5.5) as DR and R3 as BDR (router-id= 3.3.3.3) because all the routers have the same priority = 128 by default, but the highest router-ids belong to R5 and R4
 - R1 now in state dr-other in the 10.0.0.0/24 and among other things it is proven that is has TwoWay adjacency state with R2 since thee both are not DR or BDR

```
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.2 priority=128 router-id=2.2.2.2 dr=10.0.0.5 bdr=10.0.0.3 state="TwoWay"
state-changes=2 timeout=38s
1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.3 priority=128 router-id=3.3.3.3 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
state-changes=6 adjacency=4m51s timeout=39s
10.0.0.2 10.0.0.1 10.0.0.0/24
2 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.5 priority=128 router-id=5.5.5.5 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
state-changes=6 adjacency=4m46s timeout=39s
[admin@MikroTik] /routing/ospf> interface print where address="10.0.0.1%ether1"
Flags: D - dynamic
0 D address=10.0.0.1%ether1 area=ospf-area-1 state=dr-other network-type=broadcast dr=10.0.0.5 bdr=10.0.0.3 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>
```

- R5 now is DR and it has Full adjacency with each router in the 10.0.0.0/24

```
[admin@MikroTik] /routing/ospf> neighbor print
Flags: V - virtual; D - dynamic
0 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.1 priority=128 router-id=1.1.1.1 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
state-changes=6 adjacency=3m10s timeout=33s
1 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.2 priority=128 router-id=2.2.2.2 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
state-changes=6 adjacency=3m15s timeout=34s
10.0.0.2 10.0.0.1 10.0.0.0/24
2 D instance=ospf-instance-1 area=ospf-area-1 address=10.0.0.3 priority=128 router-id=3.3.3.3 dr=10.0.0.5 bdr=10.0.0.3 state="Full"
state-changes=6 adjacency=3m15s timeout=35s
[admin@MikroTik] /routing/ospf> interface print where address="10.0.0.5%ether1"
Flags: D - dynamic
0 D address=10.0.0.5%ether1 area=ospf-area-1 state=dr network-type=broadcast bdr=10.0.0.3 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf>
```

- And in Wireshark we can see the actual election process.



- What is interesting here is that R1 and R2 send LS Ack packets to 224.0.0.6 that is the Multicast IP address for OSPF group containing DR and BDR routers only.
- At the same time, both R3 and R3 send LS Ack to 224.0.0.5 that is Multicast IP address for OSPF group containing all the routers in a current Multicast Link.

5. Check what is the cost for each network that has been received by OSPF in the routing table.

- Let's check OSPF path cost which is called precisely `ospf.metric` on R1

```

R1
iskanred@...: ~
iskanred@...: ~
[admin@mikrotik] > routing route print proplist=dst-address,gateway,afi,ospf.metric,immediate-gw where ospf
Flags: A - ACTIVE; o - OSPF
Columns: DST-ADDRESS, GATEWAY, AFI, OSPF.METRIC, IMMEDIATE-GW
DST-ADDRESS GATEWAY AFI OSPF.METRIC IMMEDIATE-GW
Ao 10.0.20.0/24 10.0.0.2%ether1 ip4 2 10.0.0.2%ether1
Ao 10.0.30.0/24 10.0.0.3%ether1 ip4 2 10.0.0.3%ether1
Ao 10.0.40.0/24 10.0.0.3%ether1 ip4 3 10.0.0.3%ether1
Ao 10.0.50.0/24 10.0.0.5%ether1 ip4 2 10.0.0.5%ether1
Ao 10.255.255.0/30 10.0.0.3%ether1 ip4 2 10.0.0.3%ether1
[admin@mikrotik] >

```

- By default, each link has a link with an OSPF cost = 1 in Mikrotik devices. Therefore, the cost from R1 to R4's subnet is 3 while others have only 4. In such a case cost are identical to the hops count. Since R4 is separated from other routers by R3, the cost of path to it is 3 which is really R1 -> R3 -> R4
- Now, let's check this metric from R5 to R4

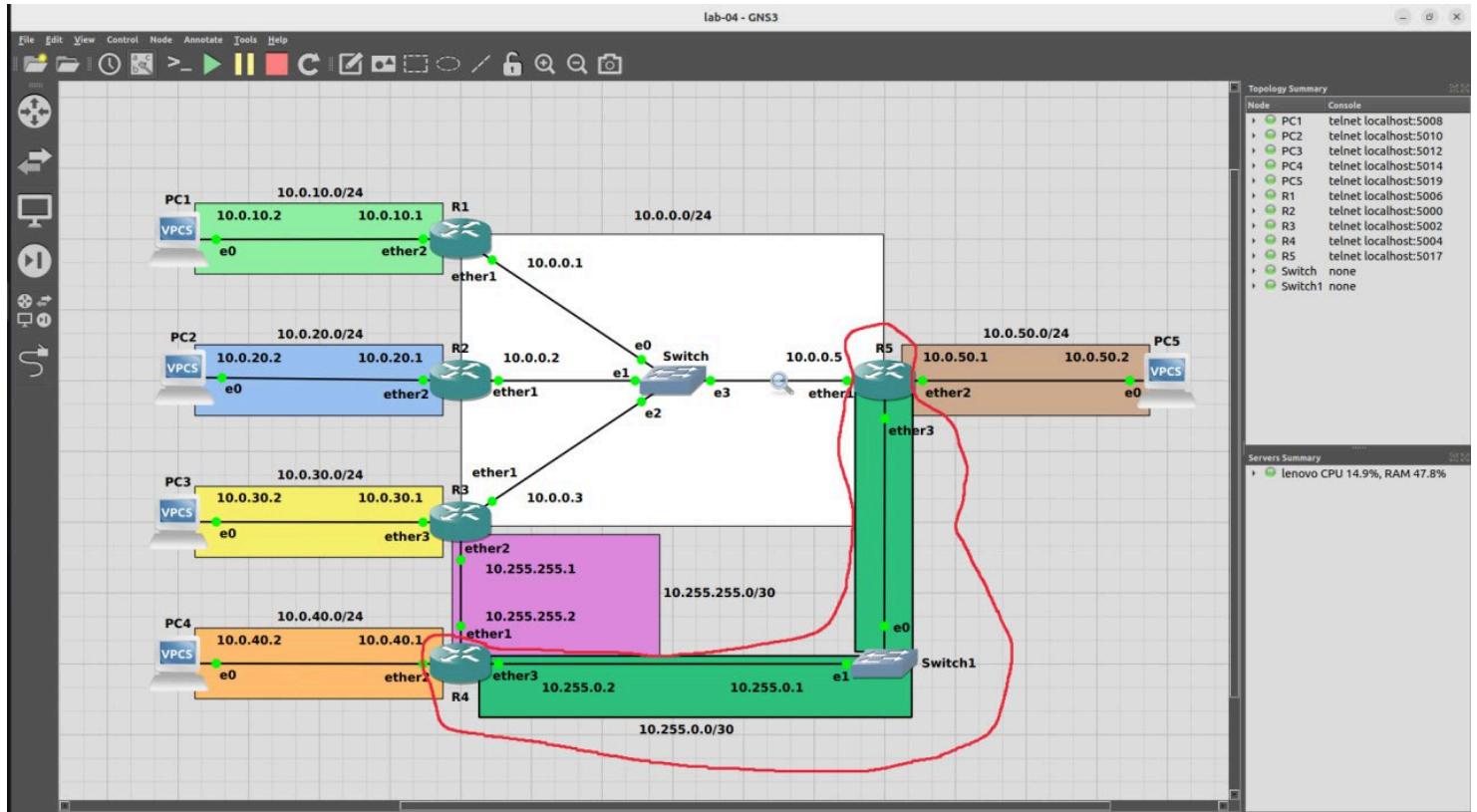
```

R5
iskanred@...: ~
iskanred@...: ~
[admin@mikrotik] > routing route print proplist=dst-address,gateway,afi,distance,ospf.metric,immediate-gw where ospf and dst-address=10.0.40.0/24
Flags: A - ACTIVE; o - OSPF
Columns: DST-ADDRESS, GATEWAY, AFI, DISTANCE, OSPF.METRIC, IMMEDIATE-GW
DST-ADDRESS GATEWAY AFI DISTANCE OSPF.METRIC IMMEDIATE-GW
Ao 10.0.40.0/24 10.0.0.3%ether1 ip4 110 3 10.0.0.3%ether1
[admin@mikrotik] > 10.0.10.0/24

```

- We can see that the cost to R4's subnet 10.0.40.0/24 is exactly the same, which equals to 3

- Now let's add another change to my topology:



- We can see LSDB updates in Wireshark

Capturing from - [Switch Ethernet3 to R5 ether1]						
No.	Time	Source	Destination	Protocol	Length	Info
588	599.162583	10.0.0.5	224.0.0.5	OSPF	90	Hello Packet
589	599.163795	10.0.0.3	224.0.0.5	OSPF	90	Hello Packet
590	599.163946	10.0.0.1	224.0.0.5	OSPF	90	Hello Packet
591	599.164056	10.0.0.2	224.0.0.5	OSPF	90	Hello Packet
592	600.162654	10.0.0.5	224.0.0.5	OSPF	90	Hello Packet
593	600.163796	10.0.0.3	224.0.0.5	OSPF	90	Hello Packet
594	600.163954	10.0.0.2	224.0.0.5	OSPF	90	Hello Packet
595	600.164039	10.0.0.1	224.0.0.5	OSPF	90	Hello Packet
612	619.162739	10.0.0.5	224.0.0.5	OSPF	90	Hello Packet
613	619.163869	10.0.0.2	224.0.0.5	OSPF	90	Hello Packet
614	619.164029	10.0.0.1	224.0.0.5	OSPF	90	Hello Packet
615	619.164140	10.0.0.3	224.0.0.5	OSPF	90	Hello Packet
616	615.592567	10.0.0.3	224.0.0.5	OSPF	122	LS Update
617	616.095478	10.0.0.5	224.0.0.5	OSPF	78	LS Acknowledge
618	616.095624	10.0.0.2	224.0.0.6	OSPF	78	LS Acknowledge
619	616.095699	10.0.0.1	224.0.0.6	OSPF	78	LS Acknowledge
620	620.158456	10.0.0.5	224.0.0.5	OSPF	90	Hello Packet
621	620.159567	10.0.0.1	224.0.0.5	OSPF	90	Hello Packet
622	620.212307	10.0.0.3	224.0.0.5	OSPF	90	Hello Packet
623	620.212492	10.0.0.2	224.0.0.5	OSPF	90	Hello Packet
624	622.999112	10.0.0.3	224.0.0.5	OSPF	122	LS Update
625	623.002670	10.0.0.5	224.0.0.5	OSPF	122	LS Update
626	623.002249	10.0.0.5	224.0.0.5	OSPF	94	LS Update
627	623.502781	10.0.0.5	224.0.0.5	OSPF	78	LS Acknowledge
628	623.504847	10.0.0.3	224.0.0.5	OSPF	98	LS Acknowledge
629	623.504994	10.0.0.2	224.0.0.6	OSPF	118	LS Acknowledge
630	623.505111	10.0.0.1	224.0.0.6	OSPF	118	LS Acknowledge
631	628.188740	10.0.0.3	224.0.0.5	OSPF	122	LS Update
632	628.188938	10.0.0.5	224.0.0.5	OSPF	122	LS Update
633	628.680651	10.0.0.2	224.0.0.6	OSPF	78	LS Acknowledge
634	628.694654	10.0.0.1	224.0.0.6	OSPF	78	LS Acknowledge
635	628.694846	10.0.0.3	224.0.0.5	OSPF	78	LS Acknowledge
636	630.158896	10.0.0.5	224.0.0.5	OSPF	90	Hello Packet

- And let's check the ospf.metric for the path from R5 to R4

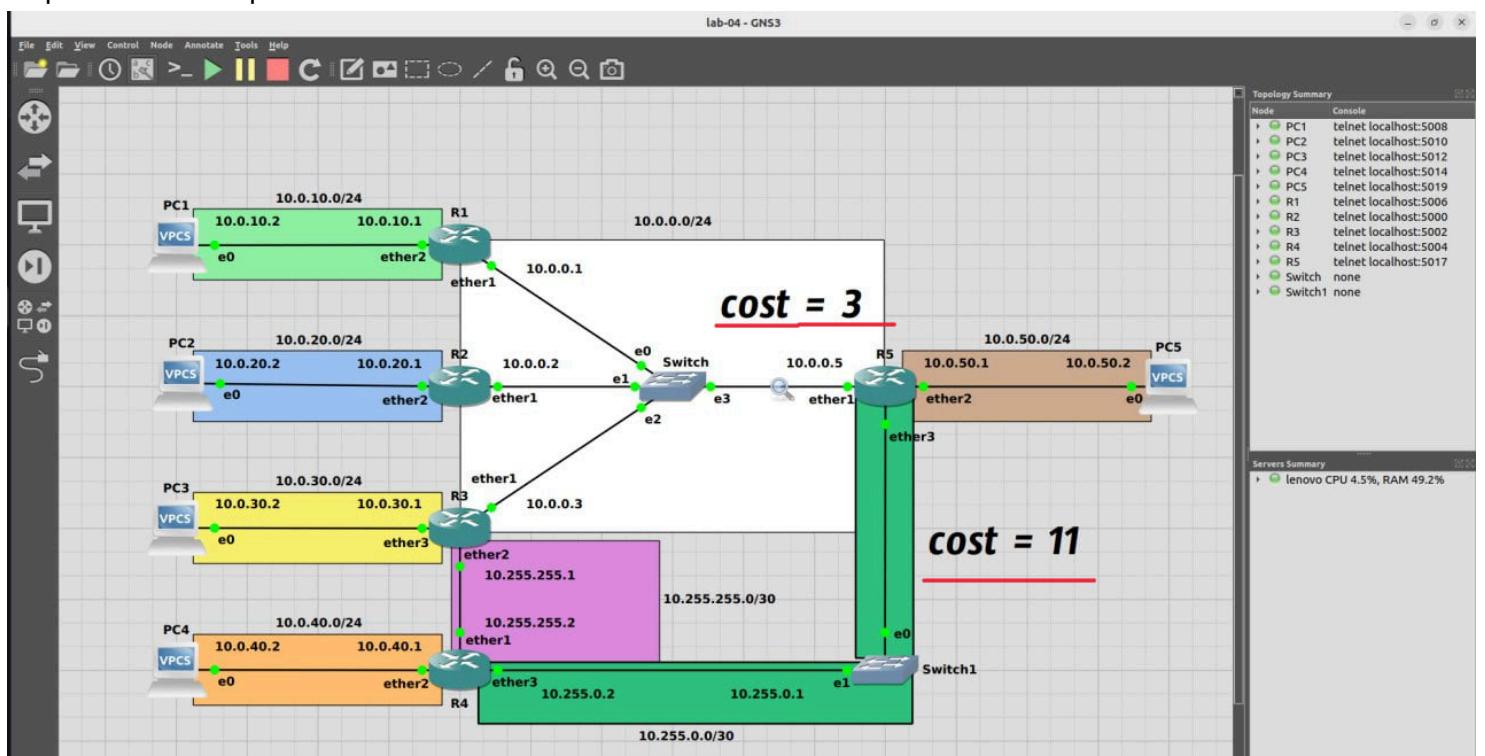
```
R5
iskanred@...: ~ iskanred@...: ~ R1 X R2 X R3 X R4 X R5 X PC1 X PC2 X PC3 X PC4 X PC5 X
[admin@MikroTik] > routing route print proplist=dst-address,gateway,afi,distance,ospf.metric,immediate-gw where ospf and dst-address=10.0.40.0/24
Flags: A - ACTIVE; o - OSPF
Columns: DST-ADDRESS, GATEWAY, AFI, DISTANCE, OSPF.METRIC, IMMEDIATE-GW
DST-ADDRESS GATEWAY AFI DISTANCE OSPF.METRIC IMMEDIATE-GW
Ao 10.0.40.0/24 10.255.0.2%ether3 ip4 110 2 10.255.0.2%ether3
[admin@MikroTik] >
```

- Now we see that it equals to 2 because hops count now is 2: R5 -> R4

- But what if change cost to 10 instead of 1 for the interface on R5 for the link R5 -- R4

```
[admin@MikroTik] /routing/ospf> interface-template print
Flags: X - disabled, I - inactive
0 area=ospf-area-1 interfaces=ether1 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s
dead-interval=40s priority=128 cost=1
1 area=ospf-area-1 interfaces=ether2 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s
dead-interval=40s priority=128 cost=1
2 area=ospf-area-1 interfaces=ether3 instance-id=0 type=broadcast retransmit-interval=5s transmit-delay=1s hello-interval=10s
dead-interval=40s priority=128 cost=1
[admin@MikroTik] /routing/ospf> interface-template set numbers=2 cost=10
[admin@MikroTik] /routing/ospf> interface print
Flags: D - dynamic
0 D address=10.0.0.5%ether1 area=ospf-area-1 state=dr network-type=broadcast bdr=10.0.0.3 cost=1 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
1 D address=10.0.50.1%ether2 area=ospf-area-1 state=dr network-type=broadcast cost=1 priority=128 use-bfd=no retransmit-interval=5s
transmit-delay=1s hello-interval=10s dead-interval=40s
2 D address=10.255.0.1%ether3 area=ospf-area-1 state=dr network-type=broadcast bdr=10.255.0.2 cost=10 priority=128 use-bfd=no
retransmit-interval=5s transmit-delay=1s hello-interval=10s dead-interval=40s
[admin@MikroTik] /routing/ospf> ./././routing route print proplist=dst-address,gateway,afi,distance,ospf.metric,immediate-gw where ospf and d
st-address=10.0.40.0/24
Flags: A - ACTIVE; o - OSPF
Columns: DST-ADDRESS, GATEWAY, AFI, DISTANCE, OSPF.METRIC, IMMEDIATE-GW
DST-ADDRESS GATEWAY AFI DISTANCE OSPF.METRIC IMMEDIATE-GW
Ao 10.0.40.0/24 10.0.0.3%ether1 ip4 110 3 10.0.0.3%ether1
[admin@MikroTik] /routing/ospf>
```

- We see that now `ospf.metric` equals to 3 for the path between R5 and R5. This is because OSPF helped R5 to help more efficient path with the less cost



- The path from R5 to R4 that lays through the Switch 1 costs 11 in total. However, the most efficient path lays through the Swtich and R3 which costs 3 in total. OSPF protocol uses Dijkstra's algorithm for the purpose of selecting the route.

References

- <https://help.mikrotik.com/docs/spaces/ROS/pages/9863229/OSPF#OSPF-PropertyReference>
- <https://www.practicalnetworking.net/stand-alone/ospf-training-course-free-m1/>

- <https://www.firewall.cx/networking/routing-protocols/ospf-adjacency-neighbor-states-forming-process.html>