

TD – laboratorium 3

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Schemat adresacji

Tablica 1: Adresacja interfejsów

Router	Interfejs	Adres IP	Podsieć
R1	e0/0	192.168.11.1	192.168.11.0/30
R2	e0/0	192.168.11.2	192.168.11.0/30
	e0/1	192.168.10.1	192.168.10.0/30
	e0/2	192.168.10.5	192.168.10.4/30
R3	e0/0	192.168.10.1	192.168.10.0/30
	e0/2	192.168.10.6	192.168.10.4/30
	e0/3	192.168.10.17	192.168.10.16/30
R4	e0/1	192.168.10.2	192.168.10.0/30
	e0/2	192.168.10.5	192.168.10.4/30
	e0/3	192.168.10.18	192.168.10.16/30
R5	e0/0	192.168.10.2	192.168.10.0/30
	e0/2	192.168.10.6	192.168.10.4/30

Tablica 2: Adresacja interfejsów loopback

Router	Loopback IP
R1	192.168.0.1
R2	192.168.0.2
R3	192.168.0.3
R4	192.168.0.4
R5	192.168.0.5

A Podstawowa konfiguracja urządzenia

W początkowej konfiguracji urządzeń każdemu interfejsowi na każdym routerze przypisano adres IP komendą `ip address <ip address> <mask>` a następnie potwierdzono pomyślne przypisanie komendami `show cdp neighbors` oraz `show ip route`.

Na każdym z routerów wpisów w tablicy trasowania jest tyle, ile skonfigurowanych interfejsów, każdy w innej podsieci. Routery mogą obecnie wysyłać pakiety tylko do bezpośrednio połączonych urządzeń.

Router R1

#show cdp neighbors					
Device ID	Local Intrfce	Holdtme	Capability	Platform	
↪ Port ID					
R2	Eth 0/0	174	R S I	3640	Eth
↪ 0/0					

#show ip route	
Gateway of last resort is not set	
192.168.11.0/30 is subnetted, 1 subnets	
C	192.168.11.0 is directly connected, Ethernet0/0

Router R2

#show cdp neighbors					
Device ID	Local Intrfce	Holdtme	Capability	Platform	
↪ Port ID					
R3	Eth 0/2	171	R S I	3640	Eth
↪ 0/2					
R1	Eth 0/0	169	R S I	3640	Eth
↪ 0/0					
R4	Eth 0/1	177	R S I	3640	Eth
↪ 0/1					

```

#show ip route
Gateway of last resort is not set

    192.168.10.0/30 is subnetted, 2 subnets
C       192.168.10.0 is directly connected, Ethernet0/1
C       192.168.10.4 is directly connected, Ethernet0/2
    192.168.11.0/30 is subnetted, 1 subnets
C       192.168.11.0 is directly connected, Ethernet0/0

```

Router R3

```

#show cdp neighbors

```

Device ID	Local Intrfce	Holdtme	Capability	Platform
↪ Port ID				
R2	Eth 0/2	160	R S I	3640 Eth
↪ 0/2				
R4	Eth 0/3	162	R S I	3640 Eth
↪ 0/3				
R5	Eth 0/0	149	R S I	3640 Eth
↪ 0/0				

```

#show ip route
Gateway of last resort is not set

    192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Ethernet0/0
C       192.168.10.4 is directly connected, Ethernet0/2
C       192.168.10.16 is directly connected, Ethernet0/3

```

Router R4

#show cdp neighbors					
Device ID	Local Intrfce	Holdtme	Capability	Platform	
↪ Port ID					
R2	Eth 0/1	166	R S I	3640	Eth
↪ 0/1					
R3	Eth 0/3	178	R S I	3640	Eth
↪ 0/3					
R5	Eth 0/2	165	R S I	3640	Eth
↪ 0/2					

#show ip route	
Gateway of last resort is not set	
192.168.10.0/30 is subnetted, 3 subnets	
C	192.168.10.0 is directly connected, Ethernet0/1
C	192.168.10.4 is directly connected, Ethernet0/2
C	192.168.10.16 is directly connected, Ethernet0/3

Router R5

#show cdp neighbors					
Device ID	Local Intrfce	Holdtme	Capability	Platform	
↪ Port ID					
R3	Eth 0/0	153	R S I	3640	Eth
↪ 0/0					
R4	Eth 0/2	141	R S I	3640	Eth
↪ 0/2					

#show ip route	
Gateway of last resort is not set	
192.168.10.0/30 is subnetted, 2 subnets	
C	192.168.10.0 is directly connected, Ethernet0/0
C	192.168.10.4 is directly connected, Ethernet0/2

B Wstępna konfiguracja protokołu OSPF

Aby móc wysyłać pakiety IP po sieci, potrzebny jest protokół trasowania taki, jak OSPF. Na razie cała sieć jest w obszarze 0. Należy także skonfigurować interfejsy loopback komendą `ip address <loopback ip> 255.255.255.255` – ich adresy IP będą one użyte przez Cisco IOS jako identyfikatory routerów. Protokół OSPF został skonfigurowany na każdym z routerów komendą `network <prefix> <wildcard-mask> area 0`.

```
Router R1
R1#show ip ospf
Routing Process "ospf 1" with ID 192.168.0.1
Start time: 00:41:12.040, Time elapsed: 00:05:15.920
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 msec
Minimum hold time between two consecutive SPF's 10000 msec
Maximum wait time between two consecutive SPF's 10000 msec
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msec
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msec
Retransmission pacing timer 66 msec
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
Number of areas transit capable is 0
External flood list length 0
  Area BACKBONE(0) (Inactive)
    Number of interfaces in this area is 1
    Area has no authentication
```

```
SPF algorithm last executed 00:00:51.576 ago
SPF algorithm executed 1 times
Area ranges are
Number of LSA 1. Checksum Sum 0x00934F
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
```

```
R1#show ip route
```

```
Codes: 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
       i - IS-IS, su - IS-IS summary, 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
```

```
192.168.11.0/30 is subnetted, 1 subnets
C      192.168.11.0 is directly connected, Ethernet0/0
192.168.0.0/32 is subnetted, 1 subnets
C      192.168.0.1 is directly connected, Loopback0
```

Router R2

```
R2#show ip ospf
Routing Process "ospf 1" with ID 192.168.0.2
Start time: 00:45:37.408, Time elapsed: 00:01:21.024
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 msec
Minimum hold time between two consecutive SPF 10000 msec
Maximum wait time between two consecutive SPF 10000 msec
Incremental-SPF disabled
Minimum LSA interval 5 sec
Minimum LSA arrival 1000 msec
LSA group pacing timer 240 sec
Interface flood pacing timer 33 msec
Retransmission pacing timer 66 msec
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
Number of areas transit capable is 0
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 3
    Area has no authentication
    SPF algorithm last executed 00:00:24.428 ago
    SPF algorithm executed 2 times
    Area ranges are
    Number of LSA 8. Checksum Sum 0x039683
    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#show ip route

```

Codes: 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

```

i - IS-IS, su - IS-IS summary, 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

192.168.10.0/30 is subnetted, 3 subnets
C 192.168.10.0 is directly connected, Ethernet0/1
C 192.168.10.4 is directly connected, Ethernet0/2
O 192.168.10.16 [110/20] via 192.168.10.6, 00:00:30, Ethernet0/2
[110/20] via 192.168.10.2, 00:00:30, Ethernet0/1
192.168.11.0/30 is subnetted, 1 subnets
C 192.168.11.0 is directly connected, Ethernet0/0
192.168.0.0/32 is subnetted, 1 subnets
C 192.168.0.2 is directly connected, Loopback0

Router R3

```
R3#show ip ospf
Routing Process "ospf 1" with ID 192.168.0.3
Start time: 00:38:42.252, Time elapsed: 00:09:31.272
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 msec
Minimum hold time between two consecutive SPF's 10000 msec
Maximum wait time between two consecutive SPF's 10000 msec
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msec
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msec
```



```
Retransmission pacing timer 66 msec
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
Number of areas transit capable is 0
External flood list length 0
```

Area BACKBONE(0)

```
Number of interfaces in this area is 3
Area has no authentication
SPF algorithm last executed 00:00:05.740 ago
SPF algorithm executed 4 times
Area ranges are
Number of LSA 8. Checksum Sum 0x039683
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 1
```

R3#show ip route

```
Codes: 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
       i - IS-IS, su - IS-IS summary, 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

192.168.10.0/30 is subnetted, 3 subnets

C 192.168.10.0 is directly connected, Ethernet0/0

```
C      192.168.10.4 is directly connected, Ethernet0/2
C      192.168.10.16 is directly connected, Ethernet0/3
      192.168.11.0/30 is subnetted, 1 subnets
O      192.168.11.0 [110/20] via 192.168.10.5, 00:00:46, Ethernet0/2
      192.168.0.0/32 is subnetted, 1 subnets
C      192.168.0.3 is directly connected, Loopback0
```

Router R4

```
R4#show ip ospf
Routing Process "ospf 1" with ID 192.168.0.4
Start time: 00:46:28.580, Time elapsed: 00:01:54.936
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 msec
Minimum hold time between two consecutive SPF's 10000 msec
Maximum wait time between two consecutive SPF's 10000 msec
Incremental-SPF disabled
Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msec
LSA group pacing timer 240 secs
Interface flood pacing timer 33 msec
Retransmission pacing timer 66 msec
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
Number of areas transit capable is 0
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 3
    Area has no authentication
```

```
SPF algorithm last executed 00:00:15.408 ago
SPF algorithm executed 4 times
Area ranges are
Number of LSA 8. Checksum Sum 0x039683
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
```

```
R4#show ip route
```

```
Codes: 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
        i - IS-IS, su - IS-IS summary, 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
```

```
192.168.10.0/30 is subnetted, 3 subnets
C      192.168.10.0 is directly connected, Ethernet0/1
C      192.168.10.4 is directly connected, Ethernet0/2
C      192.168.10.16 is directly connected, Ethernet0/3
192.168.11.0/30 is subnetted, 1 subnets
O      192.168.11.0 [110/20] via 192.168.10.1, 00:00:20, Ethernet0/1
192.168.0.0/32 is subnetted, 1 subnets
C      192.168.0.4 is directly connected, Loopback1
```

Router R5

```
R5#show ip ospf
```

```
Routing Process "ospf 1" with ID 192.168.0.5
```

```
Start time: 00:43:30.048, Time elapsed: 00:00:25.140
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 msec
Minimum hold time between two consecutive SPF 10000 msec
Maximum wait time between two consecutive SPF 10000 msec
Incremental-SPF disabled
Minimum LSA interval 5 sec
Minimum LSA arrival 1000 msec
LSA group pacing timer 240 sec
Interface flood pacing timer 33 msec
Retransmission pacing timer 66 msec
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
Number of areas transit capable is 0
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 2
    Area has no authentication
    SPF algorithm last executed 00:00:08.400 ago
    SPF algorithm executed 1 times
    Area ranges are
    Number of LSA 8. Checksum Sum 0x04688C
    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 3
```

```
R5#show ip route
```

```

Codes: 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
       i - IS-IS, su - IS-IS summary, 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

```

192.168.10.0/30 is subnetted, 3 subnets
C      192.168.10.0 is directly connected, Ethernet0/0
C      192.168.10.4 is directly connected, Ethernet0/2
O      192.168.10.16 [110/20] via 192.168.10.5, 00:00:02, Ethernet0/2
           [110/20] via 192.168.10.1, 00:00:02, Ethernet0/0
192.168.0.0/32 is subnetted, 1 subnets
C      192.168.0.5 is directly connected, Loopback0

```

C Baza danych OSPF

Domyślnie wszystkie połączenia między routerami mają skonfigurowany typ broadcastowy, w rzeczywistości są one jednak point-to-point. By uniknąć zbędnego wyznaczania routerów DR i BDR, należy zmienić typ połączenia na odpowiednich interfejsach przy pomocy `ip ospf network point-to-point`. Point-to-point został skonfigurowany na połączeniach R2–R3, R2–R4, R4–R5 i R3–R5.

W bazie danych OSPF znajdują się 5 wiadomości router LSA i 2 wiadomości network LSA. Wiadomości router LSA R5 otrzymuje od każdego routera w obszarze, w tym od samego siebie, dlatego jest ich 5, network LSA wysyłają routery DR, w tym przypadku R1–R2 i R3–R4 nie są połączone point-to-point, dlatego R1 i R3 są routerami DR.

Analizując informacje zwracane przez `show ip ospf database router` można zauważyć, że router R3 (adres loopback 192.168.0.3) jest połączony z samym sobą (adres

192.168.10.17) jako DR oraz z routerami R2 i R5 przez point-to-point.

Router R5

```
R5#show ip ospf database
```

OSPF Router with ID (192.168.0.5) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link ↔ count
192.168.0.1	192.168.0.1	458	0x80000002	0x0084E4	1
192.168.0.2	192.168.0.2	102	0x80000007	0x005BF5	5
192.168.0.3	192.168.0.3	188	0x80000006	0x00AC85	5
192.168.0.4	192.168.0.4	108	0x80000008	0x0076B6	5
192.168.0.5	192.168.0.5	30	0x80000006	0x000649	4

Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.10.17	192.168.0.3	530	0x80000001	0x00B5BC
192.168.11.1	192.168.0.1	458	0x80000001	0x002760

```
R5#show ip ospf database router
```

OSPF Router with ID (192.168.0.5) (Process ID 1)

Router Link States (Area 0)

LS age: 475

Options: (No TOS-capability, DC)

LS Type: Router Links

Link State ID: 192.168.0.1

Advertising Router: 192.168.0.1

LS Seq Number: 80000002

Checksum: 0x84E4

Length: 36

Number of Links: 1

Link connected to: a Transit Network

(Link ID) Designated Router address: 192.168.11.1

(Link Data) Router Interface address: 192.168.11.1

Number of TOS metrics: 0

TOS 0 Metrics: 10

LS age: 119

Options: (No TOS-capability, DC)

LS Type: Router Links

Link State ID: 192.168.0.2

Advertising Router: 192.168.0.2

LS Seq Number: 80000007

Checksum: 0x5BF5

Length: 84

Number of Links: 5

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.3

(Link Data) Router Interface address: 192.168.10.5

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.4

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.4

(Link Data) Router Interface address: 192.168.10.1

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.0

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Transit Network

(Link ID) Designated Router address: 192.168.11.1

(Link Data) Router Interface address: 192.168.11.2

Number of TOS metrics: 0

TOS 0 Metrics: 10

LS age: 238

Options: (No TOS-capability, DC)

LS Type: Router Links

Link State ID: 192.168.0.3

Advertising Router: 192.168.0.3

LS Seq Number: 80000006

Checksum: 0xAC85

Length: 84

Number of Links: 5

Link connected to: a Transit Network

(Link ID) Designated Router address: 192.168.10.17

(Link Data) Router Interface address: 192.168.10.17

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.2

(Link Data) Router Interface address: 192.168.10.6

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.4

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.5

(Link Data) Router Interface address: 192.168.10.1

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.0

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

LS age: 167

Options: (No TOS-capability, DC)

LS Type: Router Links

Link State ID: 192.168.0.4

Advertising Router: 192.168.0.4

LS Seq Number: 80000008

Checksum: 0x76B6

Length: 84

Number of Links: 5

Link connected to: a Transit Network

(Link ID) Designated Router address: 192.168.10.17

(Link Data) Router Interface address: 192.168.10.18

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.5

(Link Data) Router Interface address: 192.168.10.5

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.4

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.2

(Link Data) Router Interface address: 192.168.10.2

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.0

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

LS age: 92

Options: (No TOS-capability, DC)

LS Type: Router Links

Link State ID: 192.168.0.5

Advertising Router: 192.168.0.5

LS Seq Number: 80000006

Checksum: 0x649

Length: 72

Number of Links: 4

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.4

(Link Data) Router Interface address: 192.168.10.6

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.4

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.3

(Link Data) Router Interface address: 192.168.10.2

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.0

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

R5#show ip ospf database network

OSPF Router with ID (192.168.0.5) (Process ID 1)

Net Link States (Area 0)

Routing Bit Set on this LSA

LS age: 622

Options: (No TOS-capability, DC)

LS Type: Network Links

Link State ID: 192.168.10.17 (address of Designated Router)

Advertising Router: 192.168.0.3

LS Seq Number: 80000001

Checksum: 0xB5BC

Length: 32

```
Network Mask: /30
    Attached Router: 192.168.0.3
    Attached Router: 192.168.0.4

Routing Bit Set on this LSA
LS age: 550
Options: (No TOS-capability, DC)
LS Type: Network Links
Link State ID: 192.168.11.1 (address of Designated Router)
Advertising Router: 192.168.0.1
LS Seq Number: 80000001
Checksum: 0x2760
Length: 32
Network Mask: /30
    Attached Router: 192.168.0.1
    Attached Router: 192.168.0.2
```

D Wieloobszarowy OSPF

W celu stworzenia wieloobszarowego OSPF zmieniony zostaje obszar interfejsu R1–R2 na 1 przy użyciu komendy `network <prefix> <wildcard-mask> area 1`. Router R2 jako jedyny posiada interfejsy w obydwóch obszarach, więc staje się routerem ABR. W celu weryfikacji topologii sieci na routerze R1 (obszar 1) i R5 (obszar 0) zostają wykonane `show ip ospf database` i `show ip ospf database summary`.

Na podstawie informacji z wywołania komendy `show ip ospf database` R1 otrzymuje router LSA z R1 i R2, a R5 otrzymuje router LSA z R2, R3, R4, R5. R1 jest dodatkowo połączony przez R2(ABR) z podsieciami obszaru 0, R5 jest połączony przez R2 z podsiecią R1–R2.

Komenda `show ip ospf database summary` pozwala uzyskać więcej informacji na temat summary network LSA – wiadomości uzyskiwanych od routerów ABR, oznaczających podsieci z innego obszaru. Dla R1 są to podsieci 192.168.10.0, 192.168.10.4 i 192.168.10.16, dla R5 jest to 192.168.11.0.

Router R1

R1#show ip ospf database

OSPF Router with ID (192.168.0.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link ↔ count
192.168.0.1	192.168.0.1	154	0x80000002	0x008ED9	1
192.168.0.2	192.168.0.2	155	0x80000002	0x008FD4	1

Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.11.2	192.168.0.2	155	0x80000001	0x001372

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.10.0	192.168.0.2	215	0x80000001	0x00A3B3
192.168.10.4	192.168.0.2	215	0x80000001	0x007BD7
192.168.10.16	192.168.0.2	215	0x80000001	0x0067D5

R1#show ip ospf database summary

OSPF Router with ID (192.168.0.1) (Process ID 1)

Summary Net Link States (Area 1)

Routing Bit Set on this LSA

LS age: 280

Options: (No TOS-capability, DC, Upward)

LS Type: Summary Links(Network)

Link State ID: 192.168.10.0 (summary Network Number)

Advertising Router: 192.168.0.2

LS Seq Number: 80000001

Checksum: 0xA3B3

```
Length: 28
Network Mask: /30
    TOS: 0  Metric: 10

Routing Bit Set on this LSA
LS age: 280
Options: (No TOS-capability, DC, Upward)
LS Type: Summary Links(Network)
Link State ID: 192.168.10.4 (summary Network Number)
Advertising Router: 192.168.0.2
LS Seq Number: 80000001
Checksum: 0x7BD7
Length: 28
Network Mask: /30
    TOS: 0  Metric: 10
```

```
Routing Bit Set on this LSA
LS age: 298
Options: (No TOS-capability, DC, Upward)
LS Type: Summary Links(Network)
Link State ID: 192.168.10.16 (summary Network Number)
Advertising Router: 192.168.0.2
LS Seq Number: 80000001
Checksum: 0x67D5
Length: 28
Network Mask: /30
    TOS: 0  Metric: 20
```

R1# show ip route

```
Codes: 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
       i - IS-IS, su - IS-IS summary, 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

192.168.10.0/30 is subnetted, 3 subnets

O IA 192.168.10.0 [110/20] via 192.168.11.2, 00:04:27, Ethernet0/0

O IA 192.168.10.4 [110/20] via 192.168.11.2, 00:04:27, Ethernet0/0

O IA 192.168.10.16 [110/30] via 192.168.11.2, 00:04:27, Ethernet0/0

192.168.11.0/30 is subnetted, 1 subnets

C 192.168.11.0 is directly connected, Ethernet0/0

192.168.0.0/32 is subnetted, 1 subnets

C 192.168.0.1 is directly connected, Loopback0

Router R5

R5#show ip ospf database summary

OSPF Router with ID (192.168.0.5) (Process ID 1)

Summary Net Link States (Area 0)

Routing Bit Set on this LSA

LS age: 424

Options: (No TOS-capability, DC, Upward)

LS Type: Summary Links(Network)

Link State ID: 192.168.11.0 (summary Network Number)

Advertising Router: 192.168.0.2

LS Seq Number: 80000001

Checksum: 0x98BD

Length: 28

Network Mask: /30

TOS: 0 Metric: 10

R5#

*Mar 1 01:01:55.147: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.0.3 on

↪ Ethernet0/0 from LOADING to FULL, Loading Done

```

R5#
*Mar  1 01:01:58.715: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.0.4 on
↳ Ethernet0/2 from LOADING to FULL, Loading Done
R5#show ip route
Codes: 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
       i - IS-IS, su - IS-IS summary, 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

    192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Ethernet0/0
C       192.168.10.4 is directly connected, Ethernet0/2
O       192.168.10.16 [110/20] via 192.168.10.5, 00:00:49, Ethernet0/2
        [110/20] via 192.168.10.1, 00:00:49, Ethernet0/0
    192.168.11.0/30 is subnetted, 1 subnets
O IA    192.168.11.0 [110/30] via 192.168.10.5, 00:00:49, Ethernet0/2
        [110/30] via 192.168.10.1, 00:00:49, Ethernet0/0
    192.168.0.0/32 is subnetted, 1 subnets
C       192.168.0.5 is directly connected, Loopback0

```

E Koszty łącza OSPF

W celu weryfikacji czy i jakimi ścieżkami routery przesyłają między sobą informacje, z routera R4 spingowany zostaje interfejs e0/0 routera R1 przy użyciu komend `ping <ip-address>` oraz `traceroute <ip-address>`. Pingowanie kończy się sukcesem, dane zostają przesłane.

Ścieżka przesyłu podana przez traceroute zgadza się z topologią sieci – dane przesyłane

są na router R2 (adres 192.168.10.1 dla interfejsu R2–R4), a następnie na R1 (adres 192.168.11.1).

Tablica 3: Koszty połączeń z routera R1

Podsieć	Koszt połączenia
192.168.0.0/32 (loopback)	bezpośrednio połączony
192.168.11.0/30	bezpośrednio połączony
192.168.10.0/30	20
192.168.10.4/30	20
192.168.10.16/30	30

Koszty połączeń zestawione z tablicy (3) wynikają z narzuconej topologii sieci: interfejs e0/0 routera R1 jest skonfigurowany w podsieci 192.168.11.0/30, podsieci 192.168.10.0/30 oraz 192.168.10.4/30 (odpowiednio dla połączeń R2–R4 oraz R2–R3) są dostępne przez dwa przeskoki (każde o metryce 10) a podsieć 192.168.10.16 jest dostępna przez trzy.

Dopóki wszystkie połączenia miały przypisany koszt równy 10, połączenie R2–R4 miało koszt 10 (routery te są bezpośrednio połączone interfejsami e0/1). Po wzroście kosztu tego połączenia routery R2 i R4 zaczęły komunikować się ścieżką o koszcie 20 – poprzez router R3.

Koszt połączenia R2–R4 zostaje ustawiony na obu routerach na 100, zmiana ta jest widoczna w `show ip ospf interface` wywołanym na R2. Ponowne spingowanie R1 z R4 przy pomocy traceroute daje inny rezultat – OSPF wybiera najkrótszą ścieżkę, a ta nie wiedzie teraz przez R2–R4. Zgodnie z topologią sieci najkrótsza ścieżka to teraz R4–R3–R2–R1.

```
Router R4 - #ping 192.168.11.1
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/36/44 ms
```

```
Router R4 - #traceroute 192.168.11.1
Tracing the route to 192.168.11.1
```

```
 1 192.168.10.1 224 msec 228 msec 236 msec
 2 192.168.11.1 780 msec 28 msec 572 msec
```

Router R2 - koszty łączy

R2#show ip ospf interface brief

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs
↪ F/C						
Et0/2	1	0	192.168.10.5/30	10	P2P	1/1
Et0/1	1	0	192.168.10.1/30	10	P2P	1/1
Et0/0	1	1	192.168.11.2/30	10	DR	1/1

Router R2 - koszty łączy po zmianie

R2#show ip ospf interface

Ethernet0/2 is up, line protocol is up

Internet Address 192.168.10.5/30, Area 0

Process ID 1, Router ID 192.168.0.2, Network Type POINT_TO_POINT,

↪ Cost: 10

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 00:00:08

Supports Link-local Signaling (LLS)

Index 3/3, flood queue length 0

Next 0x0(0)/0x0(0)

Last flood scan length is 1, maximum is 2

Last flood scan time is 0 msec, maximum is 4 msec

Neighbor Count is 1, Adjacent neighbor count is 1

Adjacent with neighbor 192.168.0.3

Suppress hello for 0 neighbor(s)

Ethernet0/1 is up, line protocol is up

Internet Address 192.168.10.1/30, Area 0

Process ID 1, Router ID 192.168.0.2, Network Type POINT_TO_POINT,

↪ Cost: 100

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 00:00:02

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 2
Last flood scan time is 0 msec, maximum is 4 msec
Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.0.4
Suppress hello for 0 neighbor(s)
Ethernet0/0 is up, line protocol is up
Internet Address 192.168.11.2/30, Area 1
Process ID 1, Router ID 192.168.0.2, Network Type BROADCAST, Cost: 10
Transmit Delay is 1 sec, State DR, Priority 1
Designated Router (ID) 192.168.0.2, Interface address 192.168.11.2
Backup Designated router (ID) 192.168.0.1, Interface address
    ↪ 192.168.11.1
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:00
Supports Link-local Signaling (LLS)
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 4 msec
Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.0.1 (Backup Designated Router)
Suppress hello for 0 neighbor(s)
```

```
Router R4 - #ping 192.168.11.1
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 64/279/460
    ↪ ms
```

```
Router R4 - #traceroute 192.168.11.1
Tracing the route to 192.168.11.1
```

```
 1 192.168.10.17 816 msec 232 msec 228 msec
 2 192.168.10.5 532 msec 344 msec 476 msec
 3 192.168.11.1 2000 msec 456 msec 384 msec
```

F Redystrybucja tras

Router R1 jest połączony bezpośrednio wyłącznie z R2, uzasadnionym jest zatem zmiana protokołu połączenia R1-R2 z OSPF na RIP. W tym celu OSPF zostaje wyłączony na R1, a RIP zostaje włączony na R1 i R2, na nowo skonfigurowane zostają adresy. Komenda `show ip route` wywołana na R5 wskazuje, że interfejs R1-R2 przestał być interfejsem inter-area. Zgadza się to z wprowadzonymi zmianami, ponieważ R1-R2 nie tworzą teraz obszaru OSPF.

Komenda `show ip ospf database router` pokazuje z kolei, że R2 z ID 192.168.0.2 jest ASBR routerem, na podstawie `show ip ospf database external` wiadomo, że łączy on R5 z siecią 192.168.11.0 (R2 jest Advertising Routerem), co zgadza się z założoną topologią sieci. Metryka dostępu do tej sieci wynosi 100, wynika to z faktu, że na R2 ustawiliśmy default-metric na 100, przy usunięciu R1-R2 z OSPF. Wówczas zaszła zmiana topologii sieci więc trasa do R5 została zredystrybuowana. Przy drugiej zmianie metryki, nie doszło do zmiany w obszarze OSPF, więc metryka dla R5 się nie zmieniła.

```
Router R1 - #show ip route
Gateway of last resort is not set

R    192.168.10.0/24 [120/2] via 192.168.11.2, 00:00:20, Ethernet0/0
    192.168.11.0/30 is subnetted, 1 subnets
C      192.168.11.0 is directly connected, Ethernet0/0
    192.168.0.0/32 is subnetted, 1 subnets
C      192.168.0.1 is directly connected, Loopback0
```

Router R5 - #show ip route

Gateway of last resort is not set

```

    192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Ethernet0/0
C       192.168.10.4 is directly connected, Ethernet0/2
O       192.168.10.16 [110/20] via 192.168.10.5, 00:15:35, Ethernet0/2
        [110/20] via 192.168.10.1, 00:15:35, Ethernet0/0
    192.168.11.0/30 is subnetted, 1 subnets
O       192.168.11.0 [110/30] via 192.168.10.1, 00:15:35, Ethernet0/0
    192.168.0.0/32 is subnetted, 1 subnets
C       192.168.0.5 is directly connected, Loopback0

```

Router R5 - stan końcowy

R5#show ip ospf database

OSPF Router with ID (192.168.0.5) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link ↪ count
192.168.0.2	192.168.0.2	1136	0x80000014	0x007096	5
192.168.0.3	192.168.0.3	1823	0x80000014	0x009A88	5
192.168.0.4	192.168.0.4	42	0x80000014	0x00C2A8	5
192.168.0.5	192.168.0.5	850	0x8000000D	0x00F750	4

Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.10.18	192.168.0.4	42	0x80000004	0x009BD1

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
192.168.11.0	192.168.0.2	341	0x80000001	0x00B5BD	0

```
R5#show ip ospf database external
```

```
OSPF Router with ID (192.168.0.5) (Process ID 1)
```

```
Type-5 AS External Link States
```

```
LS age: 388
```

```
Options: (No TOS-capability, DC)
```

```
LS Type: AS External Link
```

```
Link State ID: 192.168.11.0 (External Network Number )
```

```
Advertising Router: 192.168.0.2
```

```
LS Seq Number: 80000001
```

```
Checksum: 0xB5BD
```

```
Length: 36
```

```
Network Mask: /30
```

```
Metric Type: 2 (Larger than any link state path)
```

```
TOS: 0
```

```
Metric: 100
```

```
Forward Address: 0.0.0.0
```

```
External Route Tag: 0
```

```
R5#show ip ospf database router
```

```
OSPF Router with ID (192.168.0.5) (Process ID 1)
```

```
Router Link States (Area 0)
```

```
Routing Bit Set on this LSA
```

```
LS age: 1198
```

```
Options: (No TOS-capability, DC)
```

```
LS Type: Router Links
```

```
Link State ID: 192.168.0.2
```

```
Advertising Router: 192.168.0.2
```

```
LS Seq Number: 80000014
```

```
Checksum: 0x7096
```

```
Length: 84
```

AS Boundary Router

Number of Links: 5

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.11.0

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.3

(Link Data) Router Interface address: 192.168.10.5

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.4

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)

(Link ID) Neighboring Router ID: 192.168.0.4

(Link Data) Router Interface address: 192.168.10.1

Number of TOS metrics: 0

TOS 0 Metrics: 100

Link connected to: a Stub Network

(Link ID) Network/subnet number: 192.168.10.0

(Link Data) Network Mask: 255.255.255.252

Number of TOS metrics: 0

TOS 0 Metrics: 100