TD – laboratorium 3

Piotr Rogulski 305867

Szymon Sieradzki 305881

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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 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 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 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
```

```
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 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 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 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 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 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 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
```

```
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 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).

Koszty przesyłu z R1 TBD

Bandwidth R2-R4 TBD

Koszt połączenia R2-R4 zostaje ustawiony 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 - #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
```