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Sprawozdanie z realizacji laboratorium KRI nr 1
Protokół OSPF

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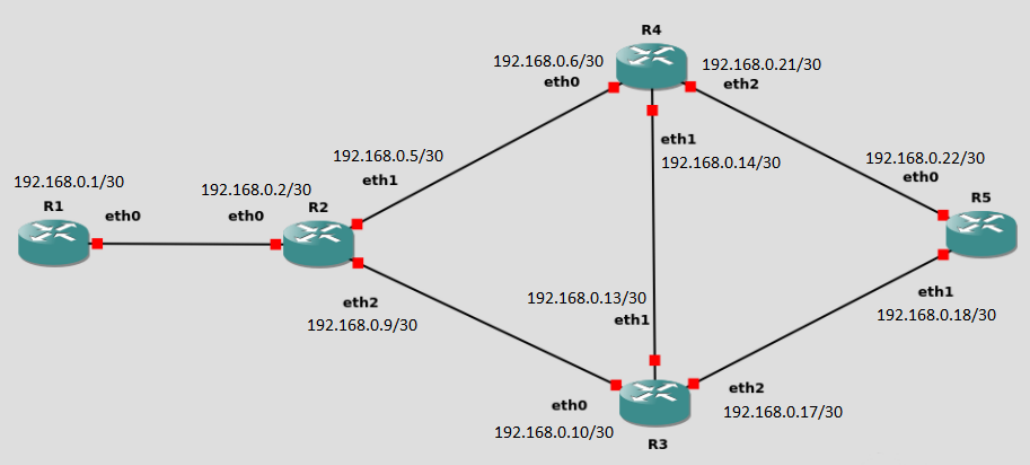
Spis treści

Wstęp

Niniejszy dokument to sprawozdanie z realizacji laboratorium w ramach przedmiotu KRI. Oświadczamy, że ta praca, stanowiąca podstawę do uznania osiągnięcia efektów uczenia się z przedmiotu KRI, została wykonana przez nas samodzielnie.

1. Zadanie A: Konfiguracja urządzeń

Początkiem realizacji laboratorium było skonfigurowanie adresacji IP urządzeń w sieci, którą będziemy badali. Konieczne było zwrócenie uwagi, na to, aby każdy interfejs routera miał unikalny adres IP w podsieci, do której należy. Poniższa grafika obrazuje stworzoną przez nas sieć wraz z naniesionymi adresami.



Rys. 1: Topologia emulowanej sieci

Aby potwierdzić prawidłową konfigurację sprawdziliśmy stworzone połączenia komendą *show ip route*, której wyniki są przedstawione poniżej.

```
R1# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

C>* 192.168.0.0/30 is directly connected, eth0, 00:06:53
```

(a) **R1**

```
R2(config-if)# ex
R2(config)# ex
R2# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

C>* 192.168.0.0/30 is directly connected, eth0, 00:06:34
C>* 192.168.0.4/30 is directly connected, eth1, 00:06:21
C>* 192.168.0.8/30 is directly connected, eth2, 00:06:10
```

(b) **R2**

Rys. 2: Wynik komendy *show ip route*

```
R3# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

C>* 192.168.0.8/30 is directly connected, eth0, 00:05:04
C>* 192.168.0.12/30 is directly connected, eth1, 00:04:53
C>* 192.168.0.16/30 is directly connected, eth2, 00:04:43
```

(a) **R3**

```
R4# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

C>* 192.168.0.4/30 is directly connected, eth0, 00:02:36
C>* 192.168.0.12/30 is directly connected, eth1, 00:02:28
C>* 192.168.0.20/30 is directly connected, eth2, 00:02:19
```

(b) **R4**

Rys. 3: Wynik komendy *show ip route*

```
R5# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

C>* 192.168.0.16/30 is directly connected, eth1, 00:01:11
C>* 192.168.0.20/30 is directly connected, eth0, 00:01:24
```

Rys. 4: Wynik komendy *show ip route* dla **R5**

Pytanie: *Wyjaśnij, jakie adresy znajdują się w tablicach routingu przed włączeniem protokołu routingu w sieci?*

Przed włączeniem protokołu routingu w sieci, tablica routingu zawiera jedynie informacje na temat adresów IP podsieci, w których poszczególne interfejsy routerów się znajdują.

2. Zadanie B: wstępna konfiguracja protokołu OSPF

Skonfigurowaliśmy interfejsy loopback, które będą potem używane jako ID routerów. Ich przypisanie wygląda następująco:

R1	192.168.1.1/32
R2	192.168.1.2/32
R3	192.168.1.3/32
R4	192.168.1.4/32

Po przeprowadzeniu takiej konfiguracji dokonaliśmy weryfikacji przy użyciu komendy *show ip ospf*.

```
R1# show ip ospf
 OSPF Routing Process, Router ID: 192.168.1.1
 Supports only single TOS (TOS0) routes
 This implementation conforms to RFC2328
 RFC1583Compatibility flag is disabled
 OpaqueCapability flag is disabled
 Initial SPF scheduling delay 0 millisec(s)
 Minimum hold time between consecutive SPFs 50 millisec(s)
 Maximum hold time between consecutive SPFs 5000 millisec(s)
 Hold time multiplier is currently 1
 SPF algorithm last executed 32.309s ago
 Last SPF duration 387 usecs
 SPF timer is inactive
 LSA minimum interval 5000 msecs
 LSA minimum arrival 1000 msecs
 Write Multiplier set to 20
 Refresh timer 10 secs
 Maximum multiple paths(ECMP) supported 64
 Administrative distance 110
 Number of external LSA 0. Checksum Sum 0x00000000
 Number of opaque AS LSA 0. Checksum Sum 0x00000000
 Number of areas attached to this router: 1
 Area ID: 0.0.0.0 (Backbone)
   Number of interfaces in this area: Total: 1, Active: 1
   Number of fully adjacent neighbors in this area: 1
   Area has no authentication
   SPF algorithm executed 31 times
   Number of LSA 12
   Number of router LSA 5. Checksum Sum 0x00035109
   Number of network LSA 7. Checksum Sum 0x0002dff9
   Number of summary LSA 0. Checksum Sum 0x00000000
   Number of ASBR summary LSA 0. Checksum Sum 0x00000000
   Number of NSSA LSA 0. Checksum Sum 0x00000000
   Number of opaque link LSA 0. Checksum Sum 0x00000000
   Number of opaque area LSA 0. Checksum Sum 0x00000000
```

(a) Tabela OSPF dla **R1**

```
R2# show ip ospf
 OSPF Routing Process, Router ID: 192.168.1.2
 Supports only single TOS (TOS0) routes
 This implementation conforms to RFC2328
 RFC1583Compatibility flag is disabled
 OpaqueCapability flag is disabled
 Initial SPF scheduling delay 0 millisec(s)
 Minimum hold time between consecutive SPFs 50 millisec(s)
 Maximum hold time between consecutive SPFs 5000 millisec(s)
 Hold time multiplier is currently 2
 SPF algorithm last executed 11m13s ago
 Last SPF duration 336 usecs
 SPF timer is inactive
 LSA minimum interval 5000 msecs
 LSA minimum arrival 1000 msecs
 Write Multiplier set to 20
 Refresh timer 10 secs
 Maximum multiple paths(ECMP) supported 64
 Administrative distance 110
 Number of external LSA 0. Checksum Sum 0x00000000
 Number of opaque AS LSA 0. Checksum Sum 0x00000000
 Number of areas attached to this router: 1
 Area ID: 0.0.0.0 (Backbone)
   Number of interfaces in this area: Total: 3, Active: 3
   Number of fully adjacent neighbors in this area: 3
   Area has no authentication
   SPF algorithm executed 31 times
   Number of LSA 11
   Number of router LSA 5. Checksum Sum 0x00035109
   Number of network LSA 6. Checksum Sum 0x0002af0a
   Number of summary LSA 0. Checksum Sum 0x00000000
   Number of ASBR summary LSA 0. Checksum Sum 0x00000000
   Number of NSSA LSA 0. Checksum Sum 0x00000000
   Number of opaque link LSA 0. Checksum Sum 0x00000000
   Number of opaque area LSA 0. Checksum Sum 0x00000000
```

(b) Tabela OSPF dla **R2**

```
R3# show ip ospf
 OSPF Routing Process, Router ID: 192.168.1.3
 Supports only single TOS (TOS0) routes
 This implementation conforms to RFC2328
 RFC1583Compatibility flag is disabled
 OpaqueCapability flag is disabled
 Initial SPF scheduling delay 0 millisec(s)
 Minimum hold time between consecutive SPFs 50 millisec(s)
 Maximum hold time between consecutive SPFs 5000 millisec(s)
 Hold time multiplier is currently 2
 SPF algorithm last executed 12m13s ago
 Last SPF duration 108 usecs
 SPF timer is inactive
 LSA minimum interval 5000 msecs
 LSA minimum arrival 1000 msecs
 Write Multiplier set to 20
 Refresh timer 10 secs
 Maximum multiple paths(ECMP) supported 64
 Administrative distance 110
 Number of external LSA 0. Checksum Sum 0x00000000
 Number of opaque AS LSA 0. Checksum Sum 0x00000000
 Number of areas attached to this router: 1
 Area ID: 0.0.0.0 (Backbone)
   Number of interfaces in this area: Total: 3, Active: 3
   Number of fully adjacent neighbors in this area: 3
   Area has no authentication
   SPF algorithm executed 29 times
   Number of LSA 11
   Number of router LSA 5. Checksum Sum 0x00035109
   Number of network LSA 6. Checksum Sum 0x0002af0a
   Number of summary LSA 0. Checksum Sum 0x00000000
   Number of ASBR summary LSA 0. Checksum Sum 0x00000000
   Number of NSSA LSA 0. Checksum Sum 0x00000000
   Number of opaque link LSA 0. Checksum Sum 0x00000000
   Number of opaque area LSA 0. Checksum Sum 0x00000000
```

(a) Tabela OSPF dla **R3**

```
R4# show ip ospf
 OSPF Routing Process, Router ID: 192.168.1.4
 Supports only single TOS (TOS0) routes
 This implementation conforms to RFC2328
 RFC1583Compatibility flag is disabled
 OpaqueCapability flag is disabled
 Initial SPF scheduling delay 0 millisec(s)
 Minimum hold time between consecutive SPFs 50 millisec(s)
 Maximum hold time between consecutive SPFs 5000 millisec(s)
 Hold time multiplier is currently 2
 SPF algorithm last executed 13m12s ago
 Last SPF duration 326 usecs
 SPF timer is inactive
 LSA minimum interval 5000 msecs
 LSA minimum arrival 1000 msecs
 Write Multiplier set to 20
 Refresh timer 10 secs
 Maximum multiple paths(ECMP) supported 64
 Administrative distance 110
 Number of external LSA 0. Checksum Sum 0x00000000
 Number of opaque AS LSA 0. Checksum Sum 0x00000000
 Number of areas attached to this router: 1
 Area ID: 0.0.0.0 (Backbone)
   Number of interfaces in this area: Total: 3, Active: 3
   Number of fully adjacent neighbors in this area: 3
   Area has no authentication
   SPF algorithm executed 24 times
   Number of LSA 11
   Number of router LSA 5. Checksum Sum 0x00035109
   Number of network LSA 6. Checksum Sum 0x0002af0a
   Number of summary LSA 0. Checksum Sum 0x00000000
   Number of ASBR summary LSA 0. Checksum Sum 0x00000000
   Number of NSSA LSA 0. Checksum Sum 0x00000000
   Number of opaque link LSA 0. Checksum Sum 0x00000000
   Number of opaque area LSA 0. Checksum Sum 0x00000000
```

(b) Tabela OSPF dla **R4**

```
R5# show ip ospf
 OSPF Routing Process, Router ID: 192.168.1.5
 Supports only single TOS (TOS0) routes
 This implementation conforms to RFC2328
 RFC1583Compatibility flag is disabled
 OpaqueCapability flag is disabled
 Initial SPF scheduling delay 0 millisec(s)
 Minimum hold time between consecutive SPFs 50 millisec(s)
 Maximum hold time between consecutive SPFs 5000 millisec(s)
 Hold time multiplier is currently 2
 SPF algorithm last executed 14m06s ago
 Last SPF duration 415 usecs
 SPF timer is inactive
 LSA minimum interval 5000 msecs
 LSA minimum arrival 1000 msecs
 Write Multiplier set to 20
 Refresh timer 10 secs
 Maximum multiple paths(ECMP) supported 64
 Administrative distance 110
 Number of external LSA 0. Checksum Sum 0x00000000
 Number of opaque AS LSA 0. Checksum Sum 0x00000000
 Number of areas attached to this router: 1
 Area ID: 0.0.0.0 (Backbone)
   Number of interfaces in this area: Total: 2, Active: 2
   Number of fully adjacent neighbors in this area: 2
   Area has no authentication
   SPF algorithm executed 20 times
   Number of LSA 11
   Number of router LSA 5. Checksum Sum 0x00035109
   Number of network LSA 6. Checksum Sum 0x0002af0a
   Number of summary LSA 0. Checksum Sum 0x00000000
   Number of ASBR summary LSA 0. Checksum Sum 0x00000000
   Number of NSSA LSA 0. Checksum Sum 0x00000000
   Number of opaque link LSA 0. Checksum Sum 0x00000000
   Number of opaque area LSA 0. Checksum Sum 0x00000000
```

Rys. 7: Tabela OSPF dla **R5**

```
R1# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O   192.168.0.0/30 [110/10] is directly connected, eth0, weight 1, 00:01:00
C>* 192.168.0.0/30 is directly connected, eth0, 00:57:41
O>* 192.168.0.4/30 [110/20] via 192.168.0.2, eth0, weight 1, 00:00:46
O>* 192.168.0.8/30 [110/20] via 192.168.0.2, eth0, weight 1, 00:00:46
O>* 192.168.0.12/30 [110/30] via 192.168.0.2, eth0, weight 1, 00:00:46
O>* 192.168.0.16/30 [110/30] via 192.168.0.2, eth0, weight 1, 00:00:46
O>* 192.168.0.20/30 [110/30] via 192.168.0.2, eth0, weight 1, 00:00:46
C>* 192.168.1.1/32 is directly connected, lo, 00:51:08
```

(a) **R1**

```
R2# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O   192.168.0.0/30 [110/10] is directly connected, eth0, weight 1, 00:48:37
C>* 192.168.0.0/30 is directly connected, eth0, 01:07:57
O   192.168.0.4/30 [110/10] is directly connected, eth1, weight 1, 00:48:31
C>* 192.168.0.4/30 is directly connected, eth1, 01:07:44
O   192.168.0.8/30 [110/10] is directly connected, eth2, weight 1, 00:48:26
C>* 192.168.0.8/30 is directly connected, eth2, 01:07:33
O>* 192.168.0.12/30 [110/20] via 192.168.0.6, eth1, weight 1, 00:46:56
  *                          via 192.168.0.10, eth2, weight 1, 00:46:56
O>* 192.168.0.16/30 [110/20] via 192.168.0.10, eth2, weight 1, 00:47:43
O>* 192.168.0.20/30 [110/20] via 192.168.0.6, eth1, weight 1, 00:46:56
C>* 192.168.1.2/32 is directly connected, lo, 01:07:18
```

(b) **R2**

Rys. 8: Tablica routingu po rozgłoszeniu sieci w protokole OSPF

```
R3# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O>* 192.168.0.0/30 [110/20] via 192.168.0.9, eth0, weight 1, 00:48:15
O>* 192.168.0.4/30 [110/20] via 192.168.0.9, eth0, weight 1, 00:47:35
  *                         via 192.168.0.14, eth1, weight 1, 00:47:35
O   192.168.0.8/30 [110/10] is directly connected, eth0, weight 1, 00:48:25
C>* 192.168.0.8/30 is directly connected, eth0, 01:06:47
O   192.168.0.12/30 [110/10] is directly connected, eth1, weight 1, 00:48:29
C>* 192.168.0.12/30 is directly connected, eth1, 01:06:36
O   192.168.0.16/30 [110/10] is directly connected, eth2, weight 1, 00:48:22
C>* 192.168.0.16/30 is directly connected, eth2, 01:06:26
O>* 192.168.0.20/30 [110/20] via 192.168.0.14, eth1, weight 1, 00:46:55
  *                          via 192.168.0.18, eth2, weight 1, 00:46:55
C>* 192.168.1.3/32 is directly connected, lo, 01:06:11
```

(a) **R3**

```
R4# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O>* 192.168.0.0/30 [110/20] via 192.168.0.5, eth0, weight 1, 00:48:38
O   192.168.0.4/30 [110/10] is directly connected, eth0, weight 1, 00:48:39
C>* 192.168.0.4/30 is directly connected, eth0, 01:05:25
O>* 192.168.0.8/30 [110/20] via 192.168.0.5, eth0, weight 1, 00:48:38
  *                         via 192.168.0.13, eth1, weight 1, 00:48:38
O   192.168.0.12/30 [110/10] is directly connected, eth1, weight 1, 00:48:40
C>* 192.168.0.12/30 is directly connected, eth1, 01:05:17
O>* 192.168.0.16/30 [110/20] via 192.168.0.13, eth1, weight 1, 00:47:46
  *                          via 192.168.0.22, eth2, weight 1, 00:47:46
O   192.168.0.20/30 [110/10] is directly connected, eth2, weight 1, 00:48:34
C>* 192.168.0.20/30 is directly connected, eth2, 01:05:08
C>* 192.168.1.4/32 is directly connected, lo, 01:04:54
```

(b) **R4**

Rys. 9: Tablica routingu po rozgłoszeniu sieci w protokole OSPF

```
R5# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O>* 192.168.0.0/30 [110/30] via 192.168.0.17, eth1, weight 1, 00:48:43
  *                         via 192.168.0.21, eth0, weight 1, 00:48:43
O>* 192.168.0.4/30 [110/20] via 192.168.0.21, eth0, weight 1, 00:48:43
O>* 192.168.0.8/30 [110/20] via 192.168.0.17, eth1, weight 1, 00:48:48
O>* 192.168.0.12/30 [110/20] via 192.168.0.17, eth1, weight 1, 00:48:43
  *                          via 192.168.0.21, eth0, weight 1, 00:48:43
O   192.168.0.16/30 [110/10] is directly connected, eth1, weight 1, 00:48:55
C>* 192.168.0.16/30 is directly connected, eth1, 01:04:59
O   192.168.0.20/30 [110/10] is directly connected, eth0, weight 1, 00:48:54
C>* 192.168.0.20/30 is directly connected, eth0, 01:05:12
C>* 192.168.1.5/32 is directly connected, lo, 01:04:13
```

Rys. 10: Tablica routingu po rozgłoszeniu sieci w protokole OSPF dla **R5**

3. Zadanie C: Baza danych OSPF

Łącza **R2-R3**, **R2-R4**, **R4-R5** i **R3-R5** ustawiliśmy na połączenia *point-to-point*, co doprowadziło do uzyskania następującego stanu **R5**.

```
R5# show ip ospf database

       OSPF Router with ID (192.168.1.5)

                Router Link States (Area 0.0.0.0)

Link ID         ADV Router      Age  Seq#       CkSum  Link count
192.168.1.1     192.168.1.1     1835 0x80000016 0x3950 1
192.168.1.2     192.168.1.2      471 0x8000002d 0xc69c 4
192.168.1.3     192.168.1.3      565 0x8000002c 0x2b18 5
192.168.1.4     192.168.1.4      564 0x8000002c 0x62dd 5
192.168.1.5     192.168.1.5      558 0x8000001d 0xa596 4

                Net Link States (Area 0.0.0.0)

Link ID         ADV Router      Age  Seq#       CkSum
192.168.0.1     192.168.1.1     1836 0x80000004 0x8b21
192.168.0.14    192.168.1.4       53 0x80000004 0x2771

                Summary Link States (Area 0.0.0.0)

Link ID         ADV Router      Age  Seq#       CkSum  Route
192.168.0.0     192.168.1.2       26 0x80000003 0xe895 192.168.0.0/30
```

Rys. 11: Wynik *show ip ospf database* dla **R5**

```
R5# show ip ospf database router

       OSPF Router with ID (192.168.1.5)


                Router Link States (Area 0.0.0.0)

  LS age: 229
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  Flags: 0x0
  LS Type: router-LSA
  Link State ID: 192.168.1.1
  Advertising Router: 192.168.1.1
  LS Seq Number: 80000016
  Checksum: 0x3950
  Length: 36

   Number of Links: 1

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 192.168.0.1
     (Link Data) Router Interface address: 192.168.0.1
      Number of TOS metrics: 0
       TOS 0 Metric: 10


  LS age: 230
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  Flags: 0x0
  LS Type: router-LSA
  Link State ID: 192.168.1.2
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000024
  Checksum: 0xec91
  Length: 84

   Number of Links: 5

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 192.168.0.1
     (Link Data) Router Interface address: 192.168.0.2
      Number of TOS metrics: 0
       TOS 0 Metric: 10

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.1.4
     (Link Data) Router Interface address: 192.168.0.5
      Number of TOS metrics: 0
       TOS 0 Metric: 10

    Link connected to: Stub Network
     (Link ID) Net: 192.168.0.4
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metric: 10

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.1.3
     (Link Data) Router Interface address: 192.168.0.9
      Number of TOS metrics: 0
       TOS 0 Metric: 10
```

Rys. 12: Wynik *show ip ospf database router* dla **R5** (cz. 1)

```
   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.8
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 10


LS age: 146
Options: 0x2  : *|-|-|-|-|-|E|-
LS Flags: 0x6
Flags: 0x0
LS Type: router-LSA
Link State ID: 192.168.1.3
Advertising Router: 192.168.1.3
LS Seq Number: 80000028
Checksum: 0x3314
Length: 84

 Number of Links: 5

   Link connected to: another Router (point-to-point)
    (Link ID) Neighboring Router ID: 192.168.1.2
    (Link Data) Router Interface address: 192.168.0.10
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.8
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: a Transit Network
    (Link ID) Designated Router address: 192.168.0.14
    (Link Data) Router Interface address: 192.168.0.13
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: another Router (point-to-point)
    (Link ID) Neighboring Router ID: 192.168.1.5
    (Link Data) Router Interface address: 192.168.0.17
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.16
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 10


LS age: 149
Options: 0x2  : *|-|-|-|-|-|E|-
LS Flags: 0x6
Flags: 0x0
LS Type: router-LSA
Link State ID: 192.168.1.4
Advertising Router: 192.168.1.4
LS Seq Number: 80000028
Checksum: 0x6ad9
Length: 84
```

Rys. 13: Wynik *show ip ospf database router* dla **R5** (cz. 2)

```
 Number of Links: 5

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.1.2
   (Link Data) Router Interface address: 192.168.0.6
    Number of TOS metrics: 0
     TOS 0 Metric: 10

  Link connected to: Stub Network
   (Link ID) Net: 192.168.0.4
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metric: 10

  Link connected to: a Transit Network
   (Link ID) Designated Router address: 192.168.0.14
   (Link Data) Router Interface address: 192.168.0.14
    Number of TOS metrics: 0
     TOS 0 Metric: 10

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.1.5
   (Link Data) Router Interface address: 192.168.0.21
    Number of TOS metrics: 0
     TOS 0 Metric: 10

  Link connected to: Stub Network
   (Link ID) Net: 192.168.0.20
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metric: 10


LS age: 172
Options: 0x2  : *|-|-|-|-|-|E|-
LS Flags: 0x3
Flags: 0x0
LS Type: router-LSA
Link State ID: 192.168.1.5
Advertising Router: 192.168.1.5
LS Seq Number: 80000019
Checksum: 0xad92
Length: 72

 Number of Links: 4

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.1.3
   (Link Data) Router Interface address: 192.168.0.18
    Number of TOS metrics: 0
     TOS 0 Metric: 10

  Link connected to: Stub Network
   (Link ID) Net: 192.168.0.16
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metric: 10

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.1.4
   (Link Data) Router Interface address: 192.168.0.22
    Number of TOS metrics: 0
     TOS 0 Metric: 10

  Link connected to: Stub Network
   (Link ID) Net: 192.168.0.20
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metric: 10
```

Rys. 14: Wynik *show ip ospf database router* dla **R5** (cz. 3)

```
R5# show ip ospf database network

       OSPF Router with ID (192.168.1.5)


                Net Link States (Area 0.0.0.0)

  LS age: 566
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: network-LSA
  Link State ID: 192.168.0.1 (address of Designated Router)
  Advertising Router: 192.168.1.1
  LS Seq Number: 80000004
  Checksum: 0x8b21
  Length: 32

  Network Mask: /30
        Attached Router: 192.168.1.1

        Attached Router: 192.168.1.2

  LS age: 482
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: network-LSA
  Link State ID: 192.168.0.14 (address of Designated Router)
  Advertising Router: 192.168.1.4
  LS Seq Number: 80000003
  Checksum: 0x2970
  Length: 32

  Network Mask: /30
        Attached Router: 192.168.1.3

        Attached Router: 192.168.1.4
```

Rys. 15: Wynik *show ip ospf database network* dla **R5**

3.1. Pytania

Dlaczego w OSPF LSDB jest dokładnie 5 LSA routera i 2 LSA sieci? W obszarze OSPF znajduje się 5 routerów, dlatego w OSPF LSDB jest dokładnie 5 LSA routera. 2 LSA sieci wynikają z faktu, że mają związek z dwoma sieciami, czyli dwoma routerami DR, które znajdują się w obszarze OSPF.

Wyjaśnij łącza routera R3 zgłoszone w jego LSA: Router R3 ma 6 zgłoszonych łączy w jego LSA, są to:

1. Łącze do routera **R2** typu *point-to-point* na interfejsie o adresie **192.168.0.10** (R3 eth0)
2. Łącze do *Stub Network* - jest to wewnętrzna sieć nie biorąca udziału w rozgłaszaniu OSPF
3. Łącze do sieci tranzytowej z routerem DR (*192.168.0.13)*
4. Łącze do **R5** typu *point-to-point* na interfejsie o adresie **192.168.0.17** (R3 eth2)
5. Łącze do *Stub Network*
6. Łącze do *Stub Network*, wewnętrznej sieci **R3**

Które routery zostały wybrane jako DR? Zostały wybrane routery **R1** i **R5**. Stało się tak, ponieważ router DR, to ten, który ma w danej sieci najniższy Router ID (w naszym przypadku to adres loopback).

W jaki sposób router R5 może wykryć topologię sieci na podstawie informacji z bazy LSDB? Router R5 może wykryć topologię sieci, dzięki wymianie LSA z innymi routerami. Na podstawie LSA tworzona jest baza LSDB, a następnie aktualizowana przy zmianach w sieci, czemu towarzyszy wyznaczanie optymalnych ścieżek przy użyciu algorytmu SPF.

4. Zadanie D: OSPF multi area

W tej części laboratorium zmieniliśmy przypisanie routerów **R1** i **R2** do nowego obszaru sieci (*area 1*).

```
R1# show ip ospf database

       OSPF Router with ID (192.168.1.1)

                Router Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum  Link count
192.168.1.1     192.168.1.1       1 0x80000006 0x6335 1
192.168.1.2     192.168.1.2       7 0x80000006 0xe81b 1

                Net Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum
192.168.0.2     192.168.1.2       2 0x80000008 0x7333

                Summary Link States (Area 0.0.0.1)

Link ID         ADV Router      Age  Seq#       CkSum  Route
192.168.0.4     192.168.1.2     452 0x80000001 0xc4b7 192.168.0.4/30
192.168.0.8     192.168.1.2     452 0x80000001 0x9cdb 192.168.0.8/30
192.168.0.12    192.168.1.2     452 0x80000001 0xd891 192.168.0.12/30
192.168.0.16    192.168.1.2     452 0x80000001 0xb0b5 192.168.0.16/30
192.168.0.20    192.168.1.2     452 0x80000001 0x88d9 192.168.0.20/30
```

(a) **R1**

```
R5# show ip ospf database

       OSPF Router with ID (192.168.1.5)

                Router Link States (Area 0.0.0.0)

Link ID         ADV Router      Age  Seq#       CkSum  Link count
192.168.1.1     192.168.1.1    1835 0x80000016 0x3950 1
192.168.1.2     192.168.1.2     471 0x8000002d 0xc69c 4
192.168.1.3     192.168.1.3     565 0x8000002c 0x2b18 5
192.168.1.4     192.168.1.4     564 0x8000002c 0x62dd 5
192.168.1.5     192.168.1.5     558 0x8000001d 0xa596 4

                Net Link States (Area 0.0.0.0)

Link ID         ADV Router      Age  Seq#       CkSum
192.168.0.1     192.168.1.1    1836 0x80000004 0x8b21
192.168.0.14    192.168.1.4      53 0x80000004 0x2771

                Summary Link States (Area 0.0.0.0)

Link ID         ADV Router      Age  Seq#       CkSum  Route
192.168.0.0     192.168.1.2      26 0x80000003 0xe895 192.168.0.0/30
```

(b) **R5**

Rys. 16: Wynik *show ip ospf database*

Zaobserwowane zmiany to: Router Link States zawiera jedynie dwa wpisy dotyczące routerów w area 1 (R1 i R2), wpis w Net Link Status został rozgłoszony przez **R2**, ponieważ to on właśnie stał się DR w **area 1**. W sekcji Summary Link States możemy zobaczyć informację o sieciach, które nie są w obrębie tego samego obszaru. W przypadku **R5** jest to tylko sieć **192.168.0.0/30**, ponieważ znajduje się ona w **area 1**.

```
R5# show ip ospf database summary

       OSPF Router with ID (192.168.1.5)


                Summary Link States (Area 0.0.0.0)

  LS age: 255
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: summary-LSA
  Link State ID: 192.168.0.0 (summary Network Number)
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000003
  Checksum: 0xe895
  Length: 28

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

Rys. 17: Wynik *show ip ospf database summary* dla **R5**

```
R1# show ip ospf database summary

       OSPF Router with ID (192.168.1.1)


                Summary Link States (Area 0.0.0.1)

  LS age: 650
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: summary-LSA
  Link State ID: 192.168.0.4 (summary Network Number)
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000001
  Checksum: 0xc4b7
  Length: 28

  Network Mask: /30
        TOS: 0  Metric: 10

  LS age: 650
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: summary-LSA
  Link State ID: 192.168.0.8 (summary Network Number)
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000001
  Checksum: 0x9cdb
  Length: 28

  Network Mask: /30
        TOS: 0  Metric: 10

  LS age: 650
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: summary-LSA
  Link State ID: 192.168.0.12 (summary Network Number)
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000001
  Checksum: 0xd891
  Length: 28

  Network Mask: /30
        TOS: 0  Metric: 20

  LS age: 650
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: summary-LSA
  Link State ID: 192.168.0.16 (summary Network Number)
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000001
  Checksum: 0xb0b5
  Length: 28

  Network Mask: /30
        TOS: 0  Metric: 20

  LS age: 650
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: summary-LSA
  Link State ID: 192.168.0.20 (summary Network Number)
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000001
  Checksum: 0x88d9
  Length: 28

  Network Mask: /30
        TOS: 0  Metric: 20
```

Rys. 18: Wynik *show ip ospf database summary* dla **R1**

Wynik komendy wykonanej na **R5** jest zgodny z oczekiwaniami. W **area 0**, to **R2** jest DR. W *summary LSA* routery widzą sieci rozgłaszane przez ABR (nienależące do ich obszaru). **R5** wykrywa jedną taką sieć, **R1** z kolei pięć. Z *summary LSA* możemy odczytać adresy tych sieci oraz to, przez który router są rozgłaszane. W naszym przypadku to zadanie wykonuje **R2**. Powyższe informacje służą też do wyznaczania optymalnej trasy dla docelowego adresu.

```
R1# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O   192.168.0.0/30 [110/10] is directly connected, eth0, weight 1, 00:07:05
C>* 192.168.0.0/30 is directly connected, eth0, 02:08:30
O>* 192.168.0.4/30 [110/20] via 192.168.0.2, eth0, weight 1, 00:06:55
O>* 192.168.0.8/30 [110/20] via 192.168.0.2, eth0, weight 1, 00:06:55
O>* 192.168.0.12/30 [110/30] via 192.168.0.2, eth0, weight 1, 00:06:55
O>* 192.168.0.16/30 [110/30] via 192.168.0.2, eth0, weight 1, 00:06:55
O>* 192.168.0.20/30 [110/30] via 192.168.0.2, eth0, weight 1, 00:06:55
C>* 192.168.1.1/32 is directly connected, lo, 02:01:57
```

(a) **R1**

```
R2# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O   192.168.0.0/30 [110/10] is directly connected, eth0, weight 1, 00:07:47
C>* 192.168.0.0/30 is directly connected, eth0, 02:08:47
O   192.168.0.4/30 [110/10] is directly connected, eth1, weight 1, 01:49:21
C>* 192.168.0.4/30 is directly connected, eth1, 02:08:34
O   192.168.0.8/30 [110/10] is directly connected, eth2, weight 1, 01:49:16
C>* 192.168.0.8/30 is directly connected, eth2, 02:08:23
O>* 192.168.0.12/30 [110/20] via 192.168.0.6, eth1, weight 1, 00:36:26
  *                          via 192.168.0.10, eth2, weight 1, 00:36:26
O>* 192.168.0.16/30 [110/20] via 192.168.0.10, eth2, weight 1, 00:47:30
O>* 192.168.0.20/30 [110/20] via 192.168.0.6, eth1, weight 1, 00:47:10
C>* 192.168.1.2/32 is directly connected, lo, 02:08:08
```

(b) **R2**

Rys. 19: Wynik *show ip route*

```
R3# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O>* 192.168.0.0/30 [110/20] via 192.168.0.9, eth0, weight 1, 00:08:58
O>* 192.168.0.4/30 [110/20] via 192.168.0.9, eth0, weight 1, 00:37:43
  *                         via 192.168.0.14, eth1, weight 1, 00:37:43
O   192.168.0.8/30 [110/10] is directly connected, eth0, weight 1, 00:49:42
C>* 192.168.0.8/30 is directly connected, eth0, 02:08:15
O   192.168.0.12/30 [110/10] is directly connected, eth1, weight 1, 00:37:51
C>* 192.168.0.12/30 is directly connected, eth1, 02:08:04
O   192.168.0.16/30 [110/10] is directly connected, eth2, weight 1, 01:49:50
C>* 192.168.0.16/30 is directly connected, eth2, 02:07:54
O>* 192.168.0.20/30 [110/20] via 192.168.0.14, eth1, weight 1, 00:17:58
  *                          via 192.168.0.18, eth2, weight 1, 00:17:58
C>* 192.168.1.3/32 is directly connected, lo, 02:07:39
```

(a) **R3**

```
R4# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O>* 192.168.0.0/30 [110/20] via 192.168.0.5, eth0, weight 1, 00:08:20
O   192.168.0.4/30 [110/10] is directly connected, eth0, weight 1, 00:48:20
C>* 192.168.0.4/30 is directly connected, eth0, 02:05:16
O>* 192.168.0.8/30 [110/20] via 192.168.0.5, eth0, weight 1, 00:37:14
  *                         via 192.168.0.13, eth1, weight 1, 00:37:14
O   192.168.0.12/30 [110/10] is directly connected, eth1, weight 1, 00:49:00
C>* 192.168.0.12/30 is directly connected, eth1, 02:05:08
O>* 192.168.0.16/30 [110/20] via 192.168.0.13, eth1, weight 1, 00:17:10
  *                          via 192.168.0.22, eth2, weight 1, 00:17:10
O   192.168.0.20/30 [110/10] is directly connected, eth2, weight 1, 01:48:25
C>* 192.168.0.20/30 is directly connected, eth2, 02:04:59
C>* 192.168.1.4/32 is directly connected, lo, 02:04:45
```

(b) **R4**

Rys. 20: Wynik *show ip route*

```
R5# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O>* 192.168.0.0/30 [110/30] via 192.168.0.17, eth1, weight 1, 00:48:43
  *                         via 192.168.0.21, eth0, weight 1, 00:48:43
O>* 192.168.0.4/30 [110/20] via 192.168.0.21, eth0, weight 1, 00:48:43
O>* 192.168.0.8/30 [110/20] via 192.168.0.17, eth1, weight 1, 00:48:48
O>* 192.168.0.12/30 [110/20] via 192.168.0.17, eth1, weight 1, 00:48:43
  *                          via 192.168.0.21, eth0, weight 1, 00:48:43
O   192.168.0.16/30 [110/10] is directly connected, eth1, weight 1, 00:48:55
C>* 192.168.0.16/30 is directly connected, eth1, 01:04:59
O   192.168.0.20/30 [110/10] is directly connected, eth0, weight 1, 00:48:54
C>* 192.168.0.20/30 is directly connected, eth0, 01:05:12
C>* 192.168.1.5/32 is directly connected, lo, 01:04:13
```

Rys. 21: Wynik *show ip route* dla **R5**

```
R1# show running-config
Building configuration...

Current configuration:
!
frr version 8.3.1_git
frr defaults traditional
hostname R1
no ipv6 forwarding
!
interface eth0
 ip address 192.168.0.1/30
exit
!
interface lo
 ip address 192.168.1.1/32
exit
!
router rip
 network 192.168.0.0/30
 version 2
exit
!
router ospf
exit
!
end
```

(a) **R1**

```
R2# show running-config
Building configuration...

Current configuration:
!
frr version 8.3.1_git
frr defaults traditional
hostname R2
no ipv6 forwarding
!
interface eth0
 ip address 192.168.0.2/30
exit
!
interface eth1
 ip address 192.168.0.5/30
 ip ospf cost 100
 ip ospf network point-to-point
exit
!
interface eth2
 ip address 192.168.0.9/30
 ip ospf network point-to-point
exit
!
interface lo
 ip address 192.168.1.2/32
exit
!
interface eht1
 ip ospf cost 100
exit
!
router rip
 default-metric 2
 network 192.168.0.0/30
 redistribute ospf
 redistribute connected
 version 2
exit
!
router ospf
 redistribute connected
 redistribute rip
 network 192.168.0.4/30 area 0
 network 192.168.0.8/30 area 0
 default-metric 100
exit
!
end
```

(b) **R2**

Rys. 22: Wynik *show running-config*

5. Zadanie E: Koszt połączeń OSPF

W tej części laboratorium korzystaliśmy z narzędzi:

Ping - które zwraca takie informacje jak ilość pokonanych węzłów, czas dotarcia do adresu docelowego pakietu oraz statystyki dotyczące czasu podróży (min/max/avg)

Traceroute - które zwraca informacje o pokonanych przez pakiet adresach w trakcie drogi do adresu docelowego.

```
R4# ping 192.168.0.1
PING 192.168.0.1 (192.168.0.1): 56 data bytes
64 bytes from 192.168.0.1: seq=0 ttl=63 time=0.173 ms
64 bytes from 192.168.0.1: seq=1 ttl=63 time=0.236 ms
64 bytes from 192.168.0.1: seq=2 ttl=63 time=0.187 ms
^C
--- 192.168.0.1 ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 0.173/0.198/0.236 ms
```

Rys. 23: Wynik *ping* z **R4** na **R1**

Użycie komendy **ping** pozwoliło nam na potwierdzenie, czy komunikacja między routerami **R1** i **R4** jest faktycznie możliwa. Poza tym otrzymaliśmy dzięki niej nieco informacji o samym połączeniu na przykład takie jak: ilość węzłów, które są po drodze (ttl), najkrótszy, najdłuższy oraz średni czas, jaki zajęło pakietom dotarcie do adresu docelowego.

```
R4# traceroute 192.168.0.1
traceroute to 192.168.0.1 (192.168.0.1), 30 hops max, 46 byte packets
 1  192.168.0.5 (192.168.0.5)  0.007 ms  0.033 ms  0.013 ms
 2  192.168.0.1 (192.168.0.1)  0.013 ms  0.037 ms  0.012 ms
R4# 2023/04/01 17:22:55 [PHJDC-499N2][EC 100663314] STARVATION: task vtysh_rl_read (563eb4b76a83) ran for 10015ms (cpu time 0ms)
```

Rys. 24: Wynik *traceroute* z **R4** na **R1**

Dzięki komendzie **traceroute** wiemy, że pakiet musiał przejść przez **R4** i **R1**. Wiemy, że domyślnie koszt połączenia jest obliczany dla bandwidth równego 100Gbps. Podzielenie tej wartości przez faktyczną, możemy potwierdzić, że koszt połączenia jest zgodny z oczekiwanym.

```
R1# show ip ospf interface
eth0 is up
  ifindex 40, MTU 1500 bytes, BW 10000 Mbit <UP,BROADCAST,RUNNING,MULTICAST>
  Internet Address 192.168.0.1/30, Broadcast 192.168.0.3, Area 0.0.0.1
  MTU mismatch detection: enabled
  Router ID 192.168.1.1, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State Backup, Priority 1
  Designated Router (ID) 192.168.1.2 Interface Address 192.168.0.2/30
  Backup Designated Router (ID) 192.168.1.1, Interface Address 192.168.0.1
  Saved Network-LSA sequence number 0x80000006
  Multicast group memberships: OSPFAllRouters OSPFDesignatedRouters
  Timer intervals configured, Hello 10s, Dead 40s, Wait 40s, Retransmit 5
    Hello due in 4.336s
  Neighbor Count is 1, Adjacent neighbor count is 1
```

(a) **R1**

```
eth1 is up
  ifindex 44, MTU 1500 bytes, BW 10000 Mbit <UP,BROADCAST,RUNNING,MULTICAST>
  Internet Address 192.168.0.5/30, Broadcast 192.168.0.7, Area 0.0.0.0
  MTU mismatch detection: enabled
  Router ID 192.168.1.2, Network Type POINTOPOINT, Cost: 10
  Transmit Delay is 1 sec, State Point-To-Point, Priority 1
  No backup designated router on this network
  Saved Network-LSA sequence number 0x80000003
  Multicast group memberships: OSPFAllRouters
  Timer intervals configured, Hello 10s, Dead 40s, Wait 40s, Retransmit 5
    Hello due in 8.018s
  Neighbor Count is 1, Adjacent neighbor count is 1
```

(b) **R2**

Rys. 25: Wynik *show ip ospf interface*

```
eth1 is up
  ifindex 44, MTU 1500 bytes, BW 10000 Mbit <UP,BROADCAST,RUNNING,MULTICAST>
  Internet Address 192.168.0.5/30, Broadcast 192.168.0.7, Area 0.0.0.0
  MTU mismatch detection: enabled
  Router ID 192.168.1.2, Network Type POINTOPOINT, Cost: 100
  Transmit Delay is 1 sec, State Point-To-Point, Priority 1
  No backup designated router on this network
  Saved Network-LSA sequence number 0x80000003
  Multicast group memberships: OSPFAllRouters
  Timer intervals configured, Hello 10s, Dead 40s, Wait 40s, Retransmit 5
    Hello due in 2.251s
  Neighbor Count is 1, Adjacent neighbor count is 1
```

Rys. 26: Wynik *show ip ospf interface* dla **R2** po zwiększeniu kosztu

```
R4# ping 192.168.0.1
PING 192.168.0.1 (192.168.0.1): 56 data bytes
64 bytes from 192.168.0.1: seq=0 ttl=62 time=0.192 ms
64 bytes from 192.168.0.1: seq=1 ttl=62 time=0.161 ms
64 bytes from 192.168.0.1: seq=2 ttl=62 time=0.197 ms
64 bytes from 192.168.0.1: seq=3 ttl=62 time=0.151 ms
64 bytes from 192.168.0.1: seq=4 ttl=62 time=0.116 ms
^C
--- 192.168.0.1 ping statistics ---
5 packets transmitted, 5 packets received, 0% packet loss
round-trip min/avg/max = 0.116/0.163/0.197 ms
```

Rys. 27: Wynik *ping* z **R4** na **R1** po zwiększeniu kosztu

```
R4# traceroute 192.168.0.1
traceroute to 192.168.0.1 (192.168.0.1), 30 hops max, 46 byte packets
 1  192.168.0.13 (192.168.0.13)  0.009 ms  0.019 ms  0.006 ms
 2  192.168.0.9 (192.168.0.9)  0.005 ms  0.017 ms  0.005 ms
 3  192.168.0.1 (192.168.0.1)  0.005 ms  0.035 ms  0.013 ms
R4# 2023/04/01 17:50:01 [PHJDC-499N2][EC 100663314] STARVATION: task vtysh_rl_read (563eb4b76a83) ran for 15020ms (cpu time 0ms)
```

Rys. 28: Wynik *ping* z **R4** na **R1** po zwiększeniu kosztu

Możemy zaobserwować, że teraz pakiet pokonał drogę **R4, R3, R2**. Stało się tak, ponieważ na skutek podniesienia kosztu łącza, poprzednia trasa nie była już optymalna. Na tym przykładzie można zaobserwować jak szybko protokół radzi sobie ze zmianami w sieci.

6. Zadanie F: Redystrybucja routingu

```
R1# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

C>* 192.168.0.0/30 is directly connected, eth0, 03:14:48
R>* 192.168.0.4/30 [120/2] via 192.168.0.2, eth0, weight 1, 00:00:19
R>* 192.168.0.8/30 [120/2] via 192.168.0.2, eth0, weight 1, 00:00:14
R>* 192.168.0.12/30 [120/2] via 192.168.0.2, eth0, weight 1, 00:00:24
R>* 192.168.0.16/30 [120/2] via 192.168.0.2, eth0, weight 1, 00:00:22
R>* 192.168.0.20/30 [120/2] via 192.168.0.2, eth0, weight 1, 00:00:22
C>* 192.168.1.1/32 is directly connected, lo, 03:08:15
R>* 192.168.1.2/32 [120/2] via 192.168.0.2, eth0, weight 1, 00:00:14
```

Rys. 29: Wynik *show ip route* dla **R1**

```
R5# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

O>* 192.168.0.0/30 [110/30] via 192.168.0.17, eth1, weight 1, 00:05:31
  *                         via 192.168.0.21, eth0, weight 1, 00:05:31
O>* 192.168.0.4/30 [110/20] via 192.168.0.21, eth0, weight 1, 00:14:26
O>* 192.168.0.8/30 [110/20] via 192.168.0.17, eth1, weight 1, 00:14:31
O>* 192.168.0.12/30 [110/20] via 192.168.0.17, eth1, weight 1, 00:14:26
  *                          via 192.168.0.21, eth0, weight 1, 00:14:26
O   192.168.0.16/30 [110/10] is directly connected, eth1, weight 1, 00:14:39
C>* 192.168.0.16/30 is directly connected, eth1, 02:01:07
O   192.168.0.20/30 [110/10] is directly connected, eth0, weight 1, 00:14:39
C>* 192.168.0.20/30 is directly connected, eth0, 02:01:20
C>* 192.168.1.5/32 is directly connected, lo, 02:00:21
```

Rys. 30: Wynik *show ip route* dla **R5**

```
R1# show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
      (n) - normal, (s) - static, (d) - default, (r) - redistribute,
      (i) - interface

     Network            Next Hop         Metric From            Tag Time
C(i) 192.168.0.0/30     0.0.0.0               1 self              0
R(n) 192.168.0.4/30     192.168.0.2           2 192.168.0.2       0 02:55
R(n) 192.168.0.8/30     192.168.0.2           2 192.168.0.2       0 02:55
R(n) 192.168.0.12/30    192.168.0.2           3 192.168.0.2       0 02:55
R(n) 192.168.0.16/30    192.168.0.2           3 192.168.0.2       0 02:55
R(n) 192.168.0.20/30    192.168.0.2           3 192.168.0.2       0 02:55
R(n) 192.168.1.2/32     192.168.0.2           2 192.168.0.2       0 02:55
```

Rys. 31: Wynik *show ip rip* dla **R1**

```
R5# show ip ospf database

       OSPF Router with ID (192.168.1.5)

                Router Link States (Area 0.0.0.0)

Link ID         ADV Router      Age  Seq#       CkSum  Link count
192.168.1.2    192.168.1.2      326 0x80000032 0xb0f7 4
192.168.1.3    192.168.1.3        7 0x8000002f 0x251b 5
192.168.1.4    192.168.1.4      734 0x8000002f 0x4d3b 5
192.168.1.5    192.168.1.5       54 0x80000020 0x9f99 4

                Net Link States (Area 0.0.0.0)

Link ID         ADV Router      Age  Seq#       CkSum
192.168.0.14   192.168.1.4     1284 0x80000006 0x2373

                AS External Link States

Link ID         ADV Router      Age  Seq#       CkSum  Route
192.168.0.0    192.168.1.2      318 0x80000001 0xebaf E2 192.168.0.0/30 [0x0]
192.168.1.2    192.168.1.2      318 0x80000001 0xdeb6 E2 192.168.1.2/32 [0x0]
```

Rys. 32: Wynik *show ip ospf database* dla **R5**

```
R5# show ip ospf database external

       OSPF Router with ID (192.168.1.5)

                AS External Link States

  LS age: 375
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: AS-external-LSA
  Link State ID: 192.168.0.0 (External Network Number)
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000001
  Checksum: 0xebaf
  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

  LS age: 375
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  LS Type: AS-external-LSA
  Link State ID: 192.168.1.2 (External Network Number)
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000001
  Checksum: 0xdeb6
  Length: 36

  Network Mask: /32
        Metric Type: 2 (Larger than any link state path)
        TOS: 0
        Metric: 100
        Forward Address: 0.0.0.0
        External Route Tag: 0
```

Rys. 33: Wynik *show ip ospf database external* dla **R5**

Wyłączyłyśmy OSPF na **R1** i skonfigurowałyśmy **R1-R2** w taki sposób, aby wymiana informacji routingowych miała miejsce przy użyciu protokołu RIP. Rozgłaszaną siecią jest **192.168.0.0**, ponieważ sieć ta nie należy do domeny OSPF. Metryka tego łącza wynosi **100**.

```
R5# show ip ospf database router

       OSPF Router with ID (192.168.1.5)


                Router Link States (Area 0.0.0.0)

  LS age: 451
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  Flags: 0x2 : ASBR
  LS Type: router-LSA
  Link State ID: 192.168.1.2
  Advertising Router: 192.168.1.2
  LS Seq Number: 80000032
  Checksum: 0xb0f7
  Length: 72

   Number of Links: 4

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.1.4
     (Link Data) Router Interface address: 192.168.0.5
      Number of TOS metrics: 0
       TOS 0 Metric: 100

    Link connected to: Stub Network
     (Link ID) Net: 192.168.0.4
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metric: 100

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.1.3
     (Link Data) Router Interface address: 192.168.0.9
      Number of TOS metrics: 0
       TOS 0 Metric: 10

    Link connected to: Stub Network
     (Link ID) Net: 192.168.0.8
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metric: 10


  LS age: 132
  Options: 0x2  : *|-|-|-|-|-|E|-
  LS Flags: 0x6
  Flags: 0x0
  LS Type: router-LSA
  Link State ID: 192.168.1.3
  Advertising Router: 192.168.1.3
  LS Seq Number: 8000002f
  Checksum: 0x251b
  Length: 84
```

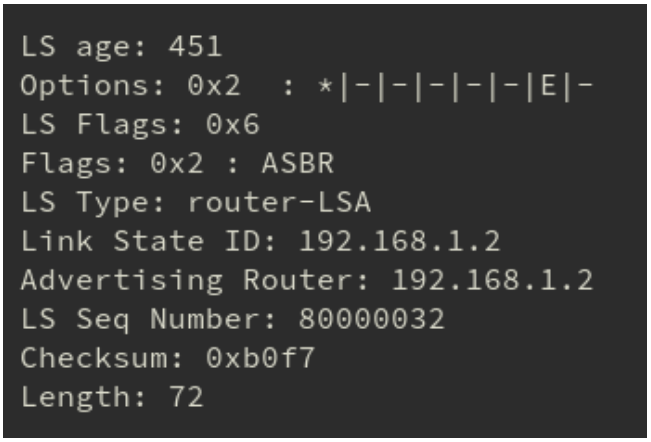
Rys. 34: Wynik *show ip ospf database router* dla **R5** (cz. 1)

```
  Number of Links: 5

   Link connected to: another Router (point-to-point)
    (Link ID) Neighboring Router ID: 192.168.1.2
    (Link Data) Router Interface address: 192.168.0.10
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.8
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: a Transit Network
    (Link ID) Designated Router address: 192.168.0.14
    (Link Data) Router Interface address: 192.168.0.13
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: another Router (point-to-point)
    (Link ID) Neighboring Router ID: 192.168.1.5
    (Link Data) Router Interface address: 192.168.0.17
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.16
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 10


LS age: 859
Options: 0x2  : *|-|-|-|-|-|E|-
LS Flags: 0x6
Flags: 0x0
LS Type: router-LSA
Link State ID: 192.168.1.4
Advertising Router: 192.168.1.4
LS Seq Number: 8000002f
Checksum: 0x4d3b
Length: 84

 Number of Links: 5

   Link connected to: another Router (point-to-point)
    (Link ID) Neighboring Router ID: 192.168.1.2
    (Link Data) Router Interface address: 192.168.0.6
     Number of TOS metrics: 0
      TOS 0 Metric: 100

   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.4
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 100
```

Rys. 35: Wynik *show ip ospf database router* dla **R5** (cz. 2)

```
   Link connected to: a Transit Network
    (Link ID) Designated Router address: 192.168.0.14
    (Link Data) Router Interface address: 192.168.0.14
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: another Router (point-to-point)
    (Link ID) Neighboring Router ID: 192.168.1.5
    (Link Data) Router Interface address: 192.168.0.21
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.20
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 10


LS age: 179
Options: 0x2  : *|-|-|-|-|-|E|-
LS Flags: 0x3
Flags: 0x0
LS Type: router-LSA
Link State ID: 192.168.1.5
Advertising Router: 192.168.1.5
LS Seq Number: 80000020
Checksum: 0x9f99
Length: 72

 Number of Links: 4

   Link connected to: another Router (point-to-point)
    (Link ID) Neighboring Router ID: 192.168.1.3
    (Link Data) Router Interface address: 192.168.0.18
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.16
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: another Router (point-to-point)
    (Link ID) Neighboring Router ID: 192.168.1.4
    (Link Data) Router Interface address: 192.168.0.22
     Number of TOS metrics: 0
      TOS 0 Metric: 10

   Link connected to: Stub Network
    (Link ID) Net: 192.168.0.20
    (Link Data) Network Mask: 255.255.255.252
     Number of TOS metrics: 0
      TOS 0 Metric: 10
```

Rys. 36: Wynik *show ip ospf database router* dla **R5** (cz. 3)



Rys. 37: ASBR Router - **R2**

ID routera ASBR: **192.168.1.2**.