

# OSPF areas

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# OSPF Areas

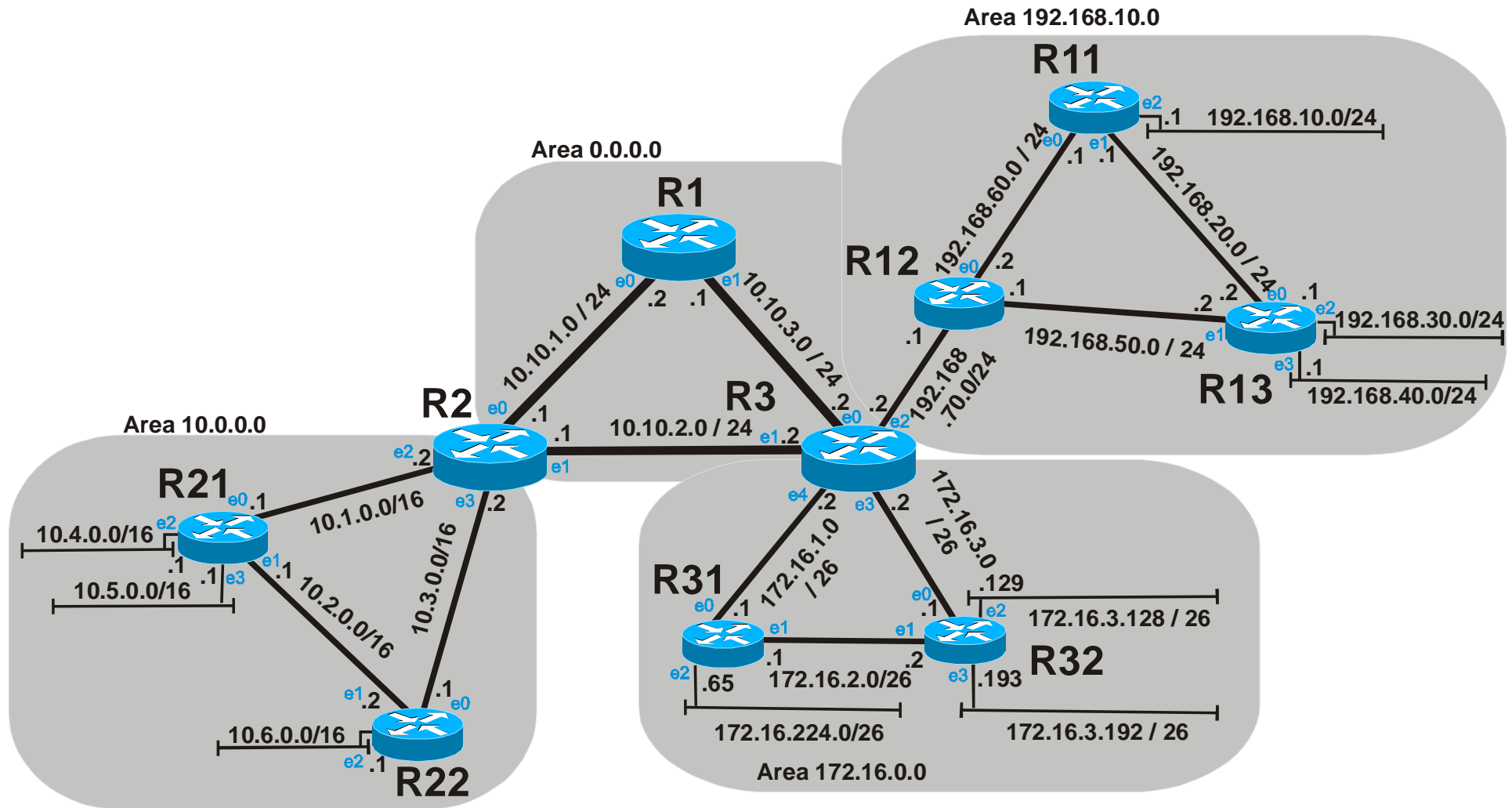
## Obszary OSPF

- Celem zajęć jest szczegółowe poznanie działania protokołu OSPF w sieci składającej się z wielu obszarów OSPF (*multiple area OSPF*).
- W ramach zajęć zostanie utworzone 10 ruterów.
- Rutery będą wstępnie przygotowane do pracy (konfiguracja sieciowa, konfiguracja protokołu OSPF).
- Protokół OSPF będzie obsługiwał cztery obszary.

# Cel ćwiczenia

- Przeanalizować zachowanie protokołu OSPF w scenariuszu z kilkoma obszarami.
- Przeanalizować rolę routerów ABR, w szczególności należy zwrócić uwagę na zawartość sekcji **Summary LSA**, na podstawie oględzin bazy LS Database:
  - w routerze brzegowym
  - w routerze wewnątrzbzobzarowym
- Przeanalizować sposób wyznaczania trasy w relacjach między obszarami przez routery poszczególnych rodzajów (ABR, intra-area). W szczególności zbadać sposób obliczania kosztu trasy jako sumy kosztów. Potwierdzić wyliczenia na podanym przykładzie.
- Zbadać agregację prefiksów (sumaryzację adresów) na routerach ABR. Ocenić wpływ sumaryzacji na koszt do sieci zagregowanej.

# Network topology



# Get a list of OSPF commands

```
ospfd> list
```

```
[...]
```

```
show ip ospf
```

```
show ip ospf border-routers
```

```
show ip ospf database
```

```
show ip ospf database (asbr-summary|external|network|router|summary|nssa-external) (self-originate|)
```

```
show ip ospf database (asbr-summary|external|network|router|summary|nssa-external) A.B.C.D
```

```
show ip ospf database (asbr-summary|external|network|router|summary|nssa-external) A.B.C.D (self-originate|)
```

```
show ip ospf database (asbr-summary|external|network|router|summary|nssa-external) A.B.C.D adv-router A.B.C.D
```

```
show ip ospf database (asbr-summary|external|network|router|summary|nssa-external) adv-router A.B.C.D
```

```
show ip ospf database (asbr-summary|external|network|router|summary|nssa-external|max-age|self-originate)
```

```
show ip ospf interface [INTERFACE]
```

# Jump into privilege mode and see privileged commands

```
ospfd> enable  
Password: root
```

```
ospfd# ?
```

clear	Reset functions
configure	Configuration from vty interface
copy	Copy configuration
debug	Debugging functions (see also 'undebug')
disable	Turn off privileged mode command
end	End current mode and change to enable mode.
exit	Exit current mode and down to previous mode
help	Description of the interactive help system
list	Print command list
no	Negate a command or set its defaults
quit	Exit current mode and down to previous mode

show	Show running system information
------	---------------------------------

terminal	Set terminal line parameters
who	Display who is on vty

write terminal	Write running configuration to memory, network, or terminal
-------------------	--

# View LS database on R11 (Router LSA)

```
R11 ospfd> show ip ospf database
```

```
Router Link States (Area 192.168.10.0)

Link ID          ADV Router      Age  Seq#           CkSum  Link count
192.168.40.1     192.168.40.1   140  0x800000004   0xd696  4
192.168.10.1     192.168.10.1   142  0x800000003   0x47c1  3
192.168.70.1     192.168.70.1   147  0x800000005   0x4780  3
172.16.1.2       172.16.1.2     143  0x800000004   0x93eb  1
```

## ■ Question 1

- Which routers send Router LSAs? What information can we see about them when using the **show ip ospf database** command (page 8)? What detailed information do they reveal when we use the **show ip ospf database router** command?



# View LS database on R11 (Network LSA)

```
R11 ospfd> show ip ospf database
```

```
[ ----- ✕ ----- ]
```

## Net Link States (Area 192.168.10.0)

Link ID	ADV Router	Age	Seq#	CkSum
192.168.20.1	192.168.40.1	147	0x80000001	0xbc34
192.168.50.1	192.168.70.1	148	0x80000001	0x8539
192.168.60.2	192.168.70.1	148	0x80000001	0xa901
192.168.70.1	192.168.70.1	144	0x80000001	0x9df6

## ■ Question 2

- Which routers send Network LSAs? What information can we see about them when using the **show ip ospf database** command (page 10)? What detailed information do they reveal when we use the **show ip ospf database network** command?

# View LS database on R11 (summary LSA)

```
R11 ospfd> show ip ospf database
```

```
[ ----- ✕ ----- ]
```

## Summary Link States (Area 192.168.10.0)

Link ID	ADV Router	Age	Seq#	CkSum	Route
10.1.0.0	172.16.1.2	139	0x80000001	0xa1ea	10.1.0.0/16
10.2.0.0	172.16.1.2	139	0x80000001	0xf987	10.2.0.0/16
10.3.0.0	172.16.1.2	139	0x80000001	0x8901	10.3.0.0/16
10.4.0.0	172.16.1.2	139	0x80000001	0xe19d	10.4.0.0/16
10.5.0.0	172.16.1.2	139	0x80000001	0xd5a8	10.5.0.0/16
10.6.0.0	172.16.1.2	139	0x80000001	0xc9b3	10.6.0.0/16
10.10.1.0	172.16.1.2	139	0x80000001	0x2a58	10.10.1.0/24
10.10.2.0	172.16.1.2	181	0x80000001	0xbad0	10.10.2.0/24
10.10.3.0	172.16.1.2	181	0x80000001	0xafda	10.10.3.0/24
172.16.1.0	172.16.1.2	181	0x80000001	0xbf63	172.16.1.0/26

```
[ ----- ✕ ----- ]
```

### ■ Question 3

- Which routers send Summary LSAs (page 12)? What information can we see about them when using the **show ip ospf database** command (page 10)? What detailed information do they reveal when we use the **show ip ospf database summary** command (page 22)?

### ■ Question 4

- Explain how the Link ID is chosen according to LSA type. Notice the different values of this parameter on pages 8 and 10.

### ■ Question 5

- Explain how the ADV Router is chosen according to LSA type. Notice the different values of this parameter on Pages 8 and 10.

### ■ Question 6

- What do the following parameters represent: Age, Sequence, Link count? (Pages 8 and 10)

# Learn neighbors of R11

```
R11 ospfd> show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	RXmtL	RqstL	DBsmL
192.168.70.1	1	Full/DR	00:00:32	192.168.60.2	eth0:192.168.60.1	0	0	0
192.168.40.1	1	Full/DR	00:00:32	192.168.20.2	eth1:192.168.20.1	0	0	0

```
ospfd>
```

## ■ Question 7

- What can you say about the neighbors of R11?

# Request border routers on R11

```
R11 ospfd> show ip ospf border-routers
```

```
===== OSPF router routing table =====  
R      172.16.1.2          [20] area: 192.168.10.0, ABR  
                                via 192.168.60.2, eth0
```

```
ospfd>
```

## ■ Question 8

- What function does a **border router** have?

# Show content of R11 routing table

```
R11 ospfd> show ip ospf route
```

```
===== OSPF network routing table =====
N IA 10.1.0.0/16          [40] area: 192.168.10.0
                               via 192.168.60.2, eth0
N IA 10.2.0.0/16          [50] area: 192.168.10.0
                               via 192.168.60.2, eth0
N IA 10.3.0.0/16          [40] area: 192.168.10.0
                               via 192.168.60.2, eth0
N IA 10.4.0.0/16          [50] area: 192.168.10.0
                               via 192.168.60.2, eth0
N IA 10.5.0.0/16          [50] area: 192.168.10.0
                               via 192.168.60.2, eth0
N IA 10.6.0.0/16          [50] area: 192.168.10.0
                               via 192.168.60.2, eth0
N IA 10.10.1.0/24         [40] area: 192.168.10.0
                               via 192.168.60.2, eth0
N IA 10.10.2.0/24         [30] area: 192.168.10.0
                               via 192.168.60.2, eth0
[-----X-----]
===== OSPF router routing table =====
R    192.168.70.2          [20] area: 192.168.10.0, ABR
                               via 192.168.60.2, eth0
===== OSPF external routing table =====
```

# See neighbors of R12

```
R12 ospfd> show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.10.1	1	Full/Backup	00:00:34	192.168.60.1	eth0:192.168.60.2
192.168.40.2	1	Full/Backup	00:00:30	192.168.50.2	eth1:192.168.50.1
172.16.1.2	1	Full/Backup	00:00:36	192.168.70.2	eth2:192.168.70.1

```
ospfd>
```

# See border-routers of R12

```
R12 ospfd> show ip ospf border-routers
```

```
===== OSPF router routing table =====  
R      172.16.1.2      [10] area: 192.168.10.0, ABR  
                        via 192.168.70.2, eth2
```



# View LS database on R12

## (Router LSAs)

```
R12 ospfd> show ip ospf database
```

```
Router Link States (Area 192.168.10.0)
```

Link ID	ADV Router	Age	Seq#	CkSum	Link count
192.168.40.1	192.168.40.1	140	0x80000004	0xd696	4
192.168.10.1	192.168.10.1	142	0x80000003	0x47c1	3
192.168.70.1	192.168.70.1	147	0x80000005	0x4780	3
172.16.1.2	172.16.1.2	143	0x80000004	0x93eb	1

# View LS database on R12 (cont.)

## (Network Link LSA and Network Summary LSA)

### Net Link States (Area 192.168.10.0)

Link ID	ADV Router	Age	Seq#	CkSum
192.168.20.1	192.168.40.1	147	0x80000001	0xbc34
192.168.50.1	192.168.70.1	148	0x80000001	0x8539
192.168.60.2	192.168.70.1	148	0x80000001	0xa901
192.168.70.1	192.168.70.1	144	0x80000001	0x9df6

### Summary Link States (Area 192.168.10.0)

Link ID	ADV Router	Age	Seq#	CkSum	Route
10.1.0.0	172.16.1.2	139	0x80000001	0xa1ea	10.1.0.0/16
10.2.0.0	172.16.1.2	139	0x80000001	0xf987	10.2.0.0/16
10.3.0.0	172.16.1.2	139	0x80000001	0x8901	10.3.0.0/16
10.4.0.0	172.16.1.2	139	0x80000001	0xe19d	10.4.0.0/16
10.5.0.0	172.16.1.2	139	0x80000001	0xd5a8	10.5.0.0/16
10.6.0.0	172.16.1.2	139	0x80000001	0xc9b3	10.6.0.0/16
10.10.1.0	172.16.1.2	139	0x80000001	0x2a58	10.10.1.0/24
10.10.2.0	172.16.1.2	181	0x80000001	0xbad0	10.10.2.0/24
10.10.3.0	172.16.1.2	181	0x80000001	0xafda	10.10.3.0/24
172.16.1.0	172.16.1.2	181	0x80000001	0xbf63	172.16.1.0/26

[-----X-----]

## ■ Question 9

- Examine the listings on pages 17, 18 and 19
- Do you notice any difference between R11 and R12 LS databases? Explain why.

# Check neighbors of R21 and R22

```
r21 ospfd# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.3.0.2	1	Full/Backup	00:00:39	10.1.0.2	eth0:10.1.0.1
10.6.0.1	1	Full/DR	00:00:33	10.2.0.2	eth1:10.2.0.1

```
r22 ospfd# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.3.0.2	1	Full/Backup	00:00:35	10.3.0.2	eth0:10.3.0.1
10.5.0.1	1	Full/Backup	00:00:35	10.2.0.1	eth1:10.2.0.2

# Show R11 database for network summary links

```
R11 ospfd> sho ip ospf database summary
```

```
OSPF Router with ID (192.168.60.1)
```

```
Summary Link States (Area 0.0.0.0)
```

```
Summary Link States (Area 10.0.0.0)
```

```
Summary Link States (Area 172.16.0.0)
```

```
Summary Link States (Area  
192.168.10.0)
```

```
LS age: 1664  
Options: 2  
LS Type: summary-LSA  
Link State ID: 10.1.0.0 (summary Network Number)  
Advertising Router: 192.168.70.2  
LS Seq Number: 80000001  
Checksum: 0xalea  
Length: 28  
Network Mask: /16  
TOS: 0 Metric: 20  
LS age: 1534  
Options: 2  
LS Type: summary-LSA  
Link State ID: 10.2.0.0 (summary Network Number)  
Advertising Router: 192.168.70.2  
LS Seq Number: 80000001  
Checksum: 0xf987  
Length: 28  
Network Mask: /16  
TOS: 0 Metric: 30
```

```
LS age: 510  
Options: 2  
LS Type: summary-LSA  
Link State ID: 10.3.0.0 (summary Net.No)  
Advertising Router: 192.168.70.2  
LS Seq Number: 80000002  
Checksum: 0x8702  
Length: 28  
Network Mask: /16  
TOS: 0 Metric: 20  
LS age: 500  
Options: 2  
LS Type: summary-LSA  
Link State ID: 10.6.0.0 (summary Net.No)  
Advertising Router: 192.168.70.2  
LS Seq Number: 80000002  
Checksum: 0xc7b4  
Length: 28  
Network Mask: /16  
TOS: 0 Metric: 30  
LS age: 1674  
Options: 2  
LS Type: summary-LSA  
Link State ID: 10.10.1.0 (summary Net.No)  
Advertising Router: 192.168.70.2  
LS Seq Number: 80000001  
Checksum: 0x2a58  
Length: 28  
Network Mask: /24  
TOS: 0 Metric: 20  
[ ----- X ----- ]
```

```
ospfd >
```

IP Networks

## ■ Question 10

- Consider the Summary LSAs
- What detailed information does the `show ip ospf database summary` command reveal (page 22)?
- What do the following parameters indicate: metric, TOS?

■ **Hint:** The default metric of any link is set to 10

# Show R12 database for network summary links

```
R12 ospfd> sho ip ospf database summary
```

```
OSPF Router with ID (192.168.70.1)
```

```
Summary Link States (Area 0.0.0.0)
```

```
Summary Link States (Area 10.0.0.0)
```

```
Summary Link States (Area 172.16.0.0)
```

```
Summary Link States (Area 192.168.10.0)
```

```
LS age: 1574
Options: 2
LS Type: summary-LSA
Link State ID: 10.1.0.0 (summary Network Number)
Advertising Router: 192.168.70.2
LS Seq Number: 80000001
Checksum: 0xalea
Length: 28
Network Mask: /16
      TOS: 0  Metric: 20
LS age: 1444
Options: 2
LS Type: summary-LSA
Link State ID: 10.2.0.0 (summary Network Number)
Advertising Router: 192.168.70.2
LS Seq Number: 80000001
Checksum: 0xf987
Length: 28
Network Mask: /16
      TOS: 0  Metric: 30
```

```
LS age: 421
Options: 2
LS Type: summary-LSA
Link State ID: 10.3.0.0 (summary Net.No)
Advertising Router: 192.168.70.2
LS Seq Number: 80000002
Checksum: 0x8702
Length: 28
Network Mask: /16
      TOS: 0  Metric: 20
```

```
LS age: 411
Options: 2
LS Type: summary-LSA
Link State ID: 10.6.0.0 (summary Net.No)
Advertising Router: 192.168.70.2
LS Seq Number: 80000002
Checksum: 0xc7b4
Length: 28
Network Mask: /16
      TOS: 0  Metric: 30
```

```
LS age: 1585
Options: 2
LS Type: summary-LSA
Link State ID: 10.10.1.0 (summary Net.No)
Advertising Router: 192.168.70.2
LS Seq Number: 80000001
Checksum: 0x2a58
Length: 28
Network Mask: /24
      TOS: 0  Metric: 20
```

```
[ ----- ✕ ----- ]
```

```
ospfd >
```

IP Networks

## ■ Question 11

- Examine the contents of the OSPF database on R3.
- How does it differ from the ones previously observed?



# Configure ospfd from a terminal

```
ospfd# configure terminal
```

```
ospfd(config)# ?
```

access-list	Add an access list entry
banner	Set banner string
debug	Debugging functions (see also 'undebug')
enable	Modify enable password parameters
end	End current mode and change to enable mode.
exit	Exit current mode and down to previous mode
help	Description of the interactive help system
hostname	Set system's network name
interface	Select an interface to configure
ip	IP information
ipv6	IPv6 information
line	Configure a terminal line
list	Print command list
log	Logging control
no	Negate a command or set its defaults
password	Assign the terminal connection password

```
ospfd(config)#  
  interface eth0
```

# Configure interface eth0 with command line

```
ospfd(config)# interface eth0
```

```
ospfd(config-if)# ?
```

quit	Exit current mode and down to previous mode
route-map	Create route-map or enter route-map command
mod router	Enable a routing process
service	Set up miscellaneous service
show	Show running system information
write	Write running configuration to memory, network, or terminal

# Check what we can configure in a given interface

```
ospfd(config-if)# ospf ?
```

authentication-key	Authentication password (key)
cost	Interface cost
dead-interval	Interval after which a neighbor is declared dead
hello-interval	Time between HELLO packets
message-digest-key	Message digest authentication password (key)
network	Network type
priority	Router priority
retransmit-interval	Time between retransmitting lost link state advertisements
transmit-delay	Link state transmit delay

## ■ Question 12

- Change the cost of a given link to a very high value (e.g. 100)

- `ospfd(config-if)# ospf cost XXX`

- Check that the change has been made in the OSPF database and observe how the optimum route changes (use **traceroute** and **ping -R**)

# Tasks [intra-area routing]

- Analyze the availability of different destinations and analyze the paths taken by the packets, e.g., between R22 and R11. Use **ping -R**, and **traceroute**
- Analyze the routing tables of **intra-area routers** and the **cost** of each path. Explain the observed costs. How does the intra-area router know the path costs to different destinations (even outside of the area)? Where is this information stored?

# Lab Scenario Personalization

- Modify the default scenario in the following way
  - Change the cost of **eth1** on **R3** to **LAB-ID**, where LAB-ID is your personal ID assigned by the lab instructor to create **asymmetric routing**
- **Note well:** from now-on
  - Command-line commands should reflect this change, therefore there can be differences in the outputs shown in the manual

# Reporting

- Please deliver the following items to the UPEL system using your account
  1. A photocopy or a screenshot showing the output of the following commands
    - **ping -R from R22 to R11**
    - **traceroute from R22 to R11**
    - **ping -R from R11 to R22**
    - **traceroute from R11 to R22**

# Tasks [inter-area routing]

- Analyze the contents of the **LS Update** message of type 3 (**Summary LSA**), use **tcpdump** and **wireshark**.
- Set prefix aggregation (**summarization**) for an ABR. What is the distance (cost) to an aggregated prefix? Compare the new cost with the original cost.
- **Add an additional ABR to area 10.0.0.0**, e.g., by converting the R1 role to an ABR (add a new link between routers R21 and R1). Check the correctness of the new ABR. What sort of information appeared in the **LS Database**?



# Wskazówki do zadań [PL version]

- Przeanalizować oraz zanotować osiągalność i przebieg tras w relacjach pomiędzy obszarami (**ping**, **ping -R**, **tracert**), na przykład w relacji R22 → R11.
- Zmienić koszt na jednym z łączy, poprzez które przebiega wybrana trasa tak, aby na tym łączy był realizowany routing asymetryczny, np. można podwyższyć koszt w R3 na interfejsie eth1. Ocenić wpływ tej zmiany na przebieg trasy poprzez analizę raportów z **tracert**.
- Przeglądnąć tablice routingu na routerach wewnątrzobszarowych i ocenić koszty tras. Z czego wynikają takie koszty ? Skąd router wewnątrzobszarowy zna wszystkie składniki kosztu trasy? Gdzie przechowuje informacje pozwalające mu określić całkowity koszt trasy ?
- Jak oblicza koszt najkrótszej trasy do odległej sieci (leżącej w innym obszarze) router brzegowy ABR, a jak router wewnątrzobszarowy ? W oparciu o jakie informacje z lokalnej bazy LS Database zostaje obliczony całkowity koszt ?
- Wychwycić LS Update message typu 3 (**Summary LSA**) podczas dialogu prowadzonego przez routery (użyć **tcpdump** + **Wireshark** na wybranym interfejsie routera). Przeanalizować zawartość komunikatu.
- Wprowadzić drugi ABR dla AREA 10.0.0.0, np. poprzez konwersję R1 na ABR (poprzez dodanie łączy w relacji R21 <--> R1). Sprawdzić poprawność tak zdefiniowanego routera ABR. Jakie nowe informacje pojawiły się w LS Database?