MINISTERSTVO ŠKOLSTVA, VEDY, VÝSKUMU A ŠPORTU SLOVENSKEJ REPUBLIKY

Advanced Single Area a Multiarea OSPF

SN (ccna3) – Chapter 9, 10 CCNA, v6

Katedra informačných sietí

Fakulta riadenia a informatiky, ŽU

KIS FRI UNIZA - Vytvorené v rámci projektu KEGA 011STU - 4/2017

V dnešnej prezentácii

- Link state smerovacie protokoly
- OSPFv3
- Pokročilé Single-Area OPSF
- Prečo sa používa multiarea OSPF
- Typy LSA štruktúr
- Konfigurácia multiarea OSPFv2
- Sumarizácia ciest
- Overenie a diagnostika

OSPFv3

OSPFv3 - Podobnosti s OSPFv2

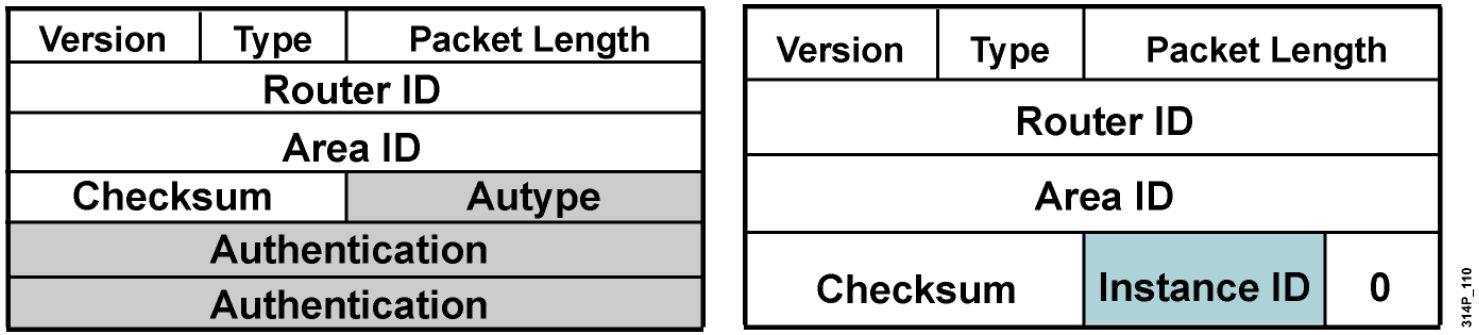
- OSPFv3 je verzia OSPF pre IPv6 (RFC 2740):
  - Vychádza z OSPFv2 + rozšírenia
  - Distribuuje IPv6 prefixy
  - Beží priamo nad IPv6
- OSPFv3 & v2 je možné v sieti prevádzkovať súčasne
  - Sú však úplne nezávislé a každá si spravuje vlastnú databázu
- OSPFv3 používa rovnaké základné typy paketov:
  - Hello
  - Database description (DBD)
  - Link state request (LSR)
  - Link state update (LSU)
  - Link state acknowledgement (LSAck)

OSPFv3 - Podobnosti s OSPFv2

- Mechanizmus zisťovania susedov a tvorby neighborhood/adjacency sú identické
- OSPFv3 má rovnaké typy paketov, niektoré však zmenili formát

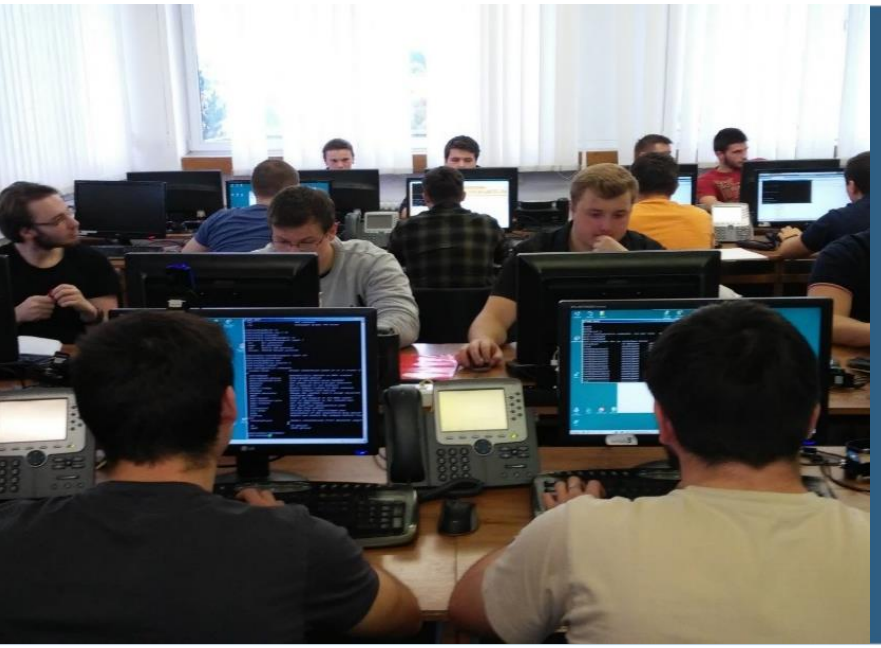
Packet Type	Description
1	Hello
2	Database Description
3	Link State Request
4	Link State Update
5	Link State Acknowledgement

- Všetky OSPFv3 pakety majú 16B hlavičku namiesto 24B hlavičky v OSPFv2



Rozdiely medzi OSPFv2 a OSPFv3

- Na identifikáciu suseda sa používa unicast link-local adresa
- Použité multicastové adresy
  - FF02::5 – Všetky OSPFv3 routery na segmente (link-local scope)
  - FF02::6 – Všetky DR/BDR routery na segmente (link-local scope)
- Zmena v spôsobe používania adries
  - IPv6 adresy sa nenachádzajú v hlavičkách OSPF paketov (súčasť payload)
  - Router LSA (LSA1) a network LSA (LSA2) neobsahujú IPv6 adresy
    - Tie sú v nových LSA8 (link) a LSA9 (intra-area prefixes)
  - Router ID, area ID a link-state ID zostávajú 32-bitové
  - DR a BDR sú identifikované podľa ich Router ID, nie podľa ich IPv6 adresy
- Bezpečnosť
  - OSPFv3 využíva IPSec hlavičky AH a ESP pre autentifikáciu
  - Samotné OSPFv3 neobsahuje nijaký mechanizmus pre autentifikáciu



Základná konfigurácia OSPFv3

Konfigurácia OSPFv3

- OSPFv3 príkazy sú v mnohom podobné tým v OSPFv2
  - Zámena kľúčového slova **ip** za **ipv6**
- OSPFv3 sa zásadne konfiguruje na rozhraniach
  - Príkaz network už neplatí a využíva sa spôsob konfigurácie priamo na rozhraní
    - Podobne ako v novších IOS pre OSPFv2, resp. IS-IS
    - Namiesto slova „ip“ sa používa „ipv6”
      - `ipv6 ospf PID AREA`
- Konfiguračná sekcia pre OSPFv3 (arey, autentifikácia, Router ID...)
  - Samostatný kontext: `ipv6 router ospf process-id`
  - Väčšina známych príkazov z OSPFv2 sa používa rovnako, resp. primerane vzhľadom na zmenu formátu adresy
  - napr. sumarizácia príkazmi area range, summary-prefix, nastavenie typov arey, redistribúcia, atď...
    - Summary route má Cost najvyšší zo sumarizovaných
      - oproti Cisco OSPFv2 – tam je najmenší

Povolenie a spustenie OSPFv3 procesu

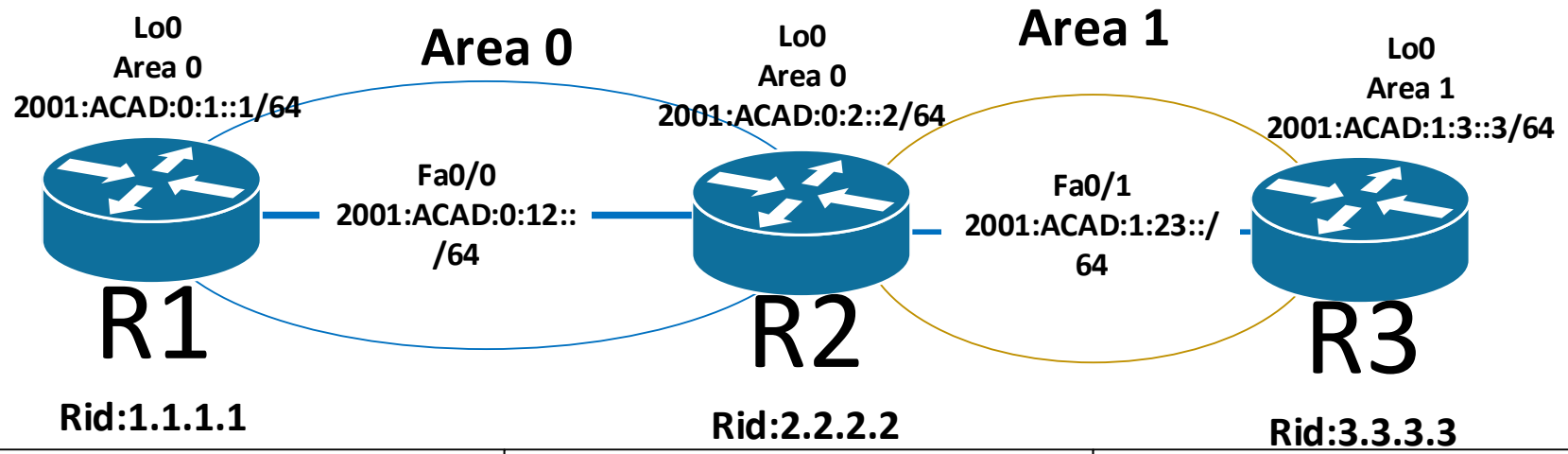
- Voliteľný príkaz

```
Router(config)#
ipv6 router ospf process-id
```

- *process-id* jednoznačne identifikuje OSPFv3 proces lokálny smerovaču

```
R1(config)# ipv6 router ospf 10
R1(config-rtr)#?
  area                   OSPF area parameters
  auto-cost              Calculate OSPF interface cost according to bandwidth
  default                Set a command to its defaults
  default-information    Distribution of default information
  default-metric         Set metric of redistributed routes
  discard-route          Enable or disable discard-route installation
  distance               Administrative distance
  distribute-list        Filter networks in routing updates
  ignore                 Do not complain about specific event
  log-adjacency-changes  Log changes in adjacency state
  maximum-paths          Forward packets over multiple paths
  passive-interface      Suppress routing updates on an interface
  process-min-time       Percentage of quantum to be used before releasing CPU
  redistribute           Redistribute IPv6 prefixes from another routing protocol
  router-id              router-id for this OSPF process
  summary-prefix         Configure IPv6 summary prefix
  timers                 Adjust routing timers
```

OSPFv3 – konfiguračný príklad




```
ipv6 unicast-routing
ipv6 router ospf 1
      router-id 1.1.1.1
int fa 0/0
      no sh
      ipv6 add 2001:acad:12::1/64
      ipv6 add fe80::1 link-local
      ipv6 ospf 1 area 0
int lo 0
      ipv6 add 2001:acad:1::1/64
      ipv6 add fe80::1 link-local
      ipv6 ospf 1 area 0
```

```
unicast-routing
ipv6 router ospf 1
      router-id 2.2.2.2
int fa 0/0
      no sh
      ipv6 add 2001:acad:12::2/64
      ipv6 add fe80::2 link-local
      ipv6 ospf 1 area 0
int lo 0
      ipv6 add 2001:acad:2::2/64
      ipv6 add fe80::2 link-local
      ipv6 ospf 1 area 0
Int fa 0/1
      no sh
      ipv6 add 2001:acad:23::2/64
      ipv6 add fe80::2 link-local
      ipv6 ospf 1 area 1
```

```
ipv6 unicast-routing
ipv6 router ospf 1
      router-id 3.3.3.3
int fa 0/1
      no sh
      ipv6 add 2001:acad:23::3/64
      ipv6 add fe80::3 link-local
      ipv6 ospf 1 area 1
int lo 0
      ipv6 add 2001:acad:3::3/64
      ipv6 add fe80::3 link-local
      ipv6 ospf 1 area 1
```

Ladenie OSPF

Identifikátor smerovača – Router ID

- Na mnohých miestach OSPF protokolu je smerovač identifikovaný unikátnym číslom – tzv. *Router ID* (RID)
  - V LSDB sa RID využíva v tele mnohých LSA (autor alebo obsah)
- Voľba RID pre smerovač:
  - RID špecifikované v konfigurácii OSPF procesu
    - príkazom `router-id`
  - Najvyššia IP adresa spomedzi všetkých aktívnych Loopback rozhraní s IP adresou
  - Najvyššia IP adresa spomedzi všetkých aktívnych rozhraní
- RID sa vyberá v momente spustenia OSPF procesu
  - Ak nie je možné vybrať RID, router sa bude sťažovať
- Pre stabilitu sa odporúča používať
  - buď príkaz `router-id` alebo
  - Loopback ako RID (alebo oboje)
    - Vhodné aj smerovať (manažment, testing apod.)

Príkaz OSPF router-id

Router(config-router)#

```
router-id A.B.C.D
```

- Tento príkaz sa používa v kontexte príkazu router ospf
  - Pre OSPFv2: **router ospf *process-id***
  - Pre OSPFv3: **ipv6 router ospf process-id**
- Ako RID je použiteľná ľubovoľná 32-bitová hodnota v tvare IP adresy
- Ak sa príkaz použije v čase, keď už bežiaci OSPF proces má zvolené RID, zmena sa prejaví
  - až po reštarte routera alebo
  - po ručnom reštarte OSPF procesu cez
    - **clear ip ospf process / clear ipv6 ospf process**

```
Router(config)# router ospf 1
Router(config-router)# router-id 172.16.1.1
Router# clear ip ospf process
Router(config)# ipv6 router ospf 1
Router(config-router)# router-id 172.16.1.1
Router# clear ipv6 ospf process
```

Ovplyvnenie voľby DR a BDR – nastavenie priority

- Nastavenie špecifickej priority rozhraniu smerovača.

Router(config-if)#

```
ip ospf priority number
```

```
ipv6 ospf priority number
```

- Rozhranie smerovača môže mať nastavenú prioritu v rozsahu 0 - 255:
  - 0 = DROTHER - Router cannot be a DR
  - 1 = Favorable - Default for all routers
  - 255 = Very favorable - Ensures at least of a tie.
- Priorita by mala byť nastavená pred samotnou voľbou
- Zobrazenie nastavenej priority a iných kľúčových údajov
  - **`show ip ospf interface`**
  - **`show ipv6 ospf interface`**

OSPF Passive-Interface

- Zabraňuje zasielaniu OSPF updatov cez dané rozhranie

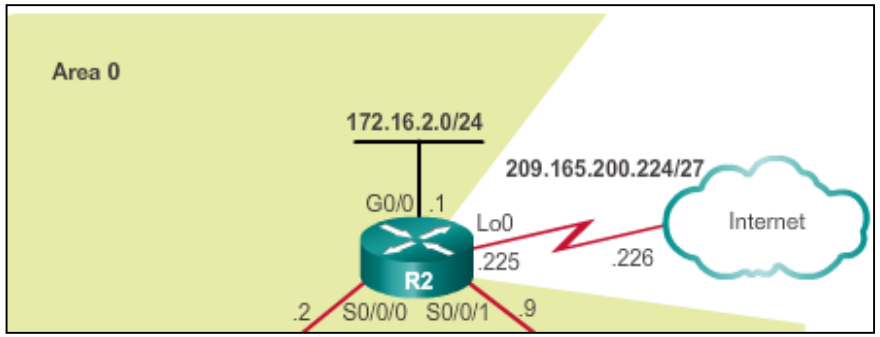
Router(config-router)#

```
passive-interface type number [default]
```

- Voľba **`default`** nastaví všetky rozhrania ako pasívne
  - Dané rozhranie musíme potom explicitne povoliť
    - **`no passive-interface type number`**
- Z pohľadu OSPF:
  - Špecifikované rozhranie sa javí ako stub network
  - Cez rozhranie nie sú prijaté ani posielané updates
  - Zabráni formovaniu susedského vzťahu
  - Ale info o sieti sa posiela

IPv4 default route v OSPFv2

- Posielanie default route v OSPF je možné zabezpečiť iba `príkazom default-information originate`
  - Typ siete v smerovacej tabuľke bude: O E2
  - Router, na ktorom je tento príkaz zadaný, bude rozposielať default route len vtedy, ak ju už sám má v smerovacej tabuľke (rozdiel oproti RIP)
    - Napr. vytvorenú staticky - `ip route 0.0.0.0 0.0.0.0 OUT_INT NEXT_HOP`
  - Nepovinný parameter always sa používa, ak chceme, aby router posielal default route vždy
- Do OSPF nie je možné default route redistribuovať!




```
R2# show ip route | begin Gateway

Gateway of last resort is 209.165.200.226 to network 0.0.0.0

S* 0.0.0.0/0 [1/0] via 209.165.200.226, Loopback0
   172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
O  172.16.1.0/24 [110/65] via 172.16.3.1, 00:01:44,
   Serial0/0/0
C  172.16.2.0/24 is directly connected, GigabitEthernet0/0
L  172.16.2.1/32 is directly connected, GigabitEthernet0/0
C  172.16.3.0/30 is directly connected, Serial0/0/0
L  172.16.3.2/32 is directly connected, Serial0/0/0
O  192.168.1.0/24 [110/65] via 192.168.10.10, 00:01:12,
   Serial0/0/1
   192.168.10.0/24 is variably subnetted, 3 subnets, 2
    masks
O  192.168.10.4/30 [110/128] via 192.168.10.10, 00:01:12,
   Serial0/0/1
            [110/128] via 172.16.3.1, 00:01:12, Serial0/0/0
C  192.168.10.8/30 is directly connected, Serial0/0/1
L  192.168.10.9/32 is directly connected, Serial0/0/1
   209.165.200.0/24 is variably subnetted, 2 subnets, 2
    masks
C  209.165.200.224/30 is directly connected, Loopback0
L  209.165.200.225/32 is directly connected, Loopback0
R2#
```

IPv6 default route v OSPFv3

- Posielanie default route v OSPFv3 pre IPv6 je temer idetické s OSPFv2
  - Smerovač ktorý redistribuuje default route ju musí mať v smerovacej tabuľke
    - Napr. vytvorenú staticky - `ipv6 route ::/0 {ipv6-address | exit-intf}`
    - Inak def. route nebude preposielaná
  - Preposielanie je možné zabezpečiť tiež iba príkazom `default-information originate`
  - Typ siete v smerovacej tabuľke bude: O E2

```
R2# show ipv6 route static
IPv6 Routing Table - default - 12 entries
Codes:C -Connected, L - Local, S - Static, U - Per-user Static route
      B -BGP, R - RIP, H - NHRP, I1 - ISIS L1
      I2 -ISIS L2, IA - ISIS interarea, IS-ISIS summary,D-EIGRP
      EX -EIGRP external, ND-ND Default,NDp-ND Prefix,
      DCE-Destination, NDr -Redirect, O - OSPF Intra,OI-OSPF Inter
      OE1-OSPF ext 1, OE2 -OSPF ext 2, ON1 - OSPF NSSA ext 1
      ON2 - OSPF NSSA ext 2
S   ::/0 [1/0]
     via 2001:DB8:FEED:1::2, Loopback0
R2#
```

Príkaz default-information originate

- Rozposielanie externej default cesty do OSPF.

Router(config-router)#

```
default-information originate [always] [metric metric-value]
[metric-type type-value] [route-map map-name]
```

Parameter	Description
always	(Optional) Specifies that OSPF always advertises the default route regardless of whether the router has a default route in the routing table.
metric *metric-value*	(Optional) A metric used for generating the default route. If you omit a value and do not specify a value using the default-metric router configuration command, the default metric value is 1. Cisco IOS Software documentation indicates that the default metric value is 10; testing shows that it is actually 1.
metric-type *type-value*	(Optional) The external link type that is associated with the default route that is advertised into the OSPF routing domain. It can be one of the following values: 1—Type 1 external route 2—Type 2 external route. The default is type 2 external route (indicated by O*E2 in the routing table).
route-map *map-name*	(Optional) Specifies that the routing process generates the default route if the route map is satisfied.

Zmena časovačov pre OSPFv2

- Časovače musia byť na linke rovnaké
  - inak sa nevytvorí susedský vzťah
- Dead zvyčajne štyri krát dlhší ako hello (pri zmene hello sa nastavuje automaticky)

```
Router(config-if)# ip ospf hello-interval seconds
```

```
Router(config-if)# ip ospf dead-interval seconds
```

Verifying the OSPF Intervals on R1

```
R1# show ip ospf interface serial 0/0/0 | include Timer
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
Retransmit 5
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
Retransmit 5
  Timer intervals configured, Hello 10, Dead 40, Wait 40,
Retransmit 5
R1#
```

Verifying OSPF Timer Activity

```
R1# show ip ospf neighbor

Neighbor ID  Pri  State     Dead Time   Address         Interface
3.3.3.3        0  FULL/-    00:00:35    192.168.10.6    Serial0/0/1
2.2.2.2        0  FULL/-    00:00:33    172.16.3.2      Serial0/0/0
R1#
```

Zmena časovačov pre OSPFv3

- Ako pri IPv4
  - Časovače musia byť na linke rovnaké
    - inak sa nevytvorí susedský vzťah
  - Dead zvyčajne štyri krát dlhší ako hello (pri zmene hello sa nastavuje automaticky)

```
Router(config-if)# ipv6 ospf hello-interval seconds
```

```
Router(config-if)# ipv6 ospf dead-interval seconds
```

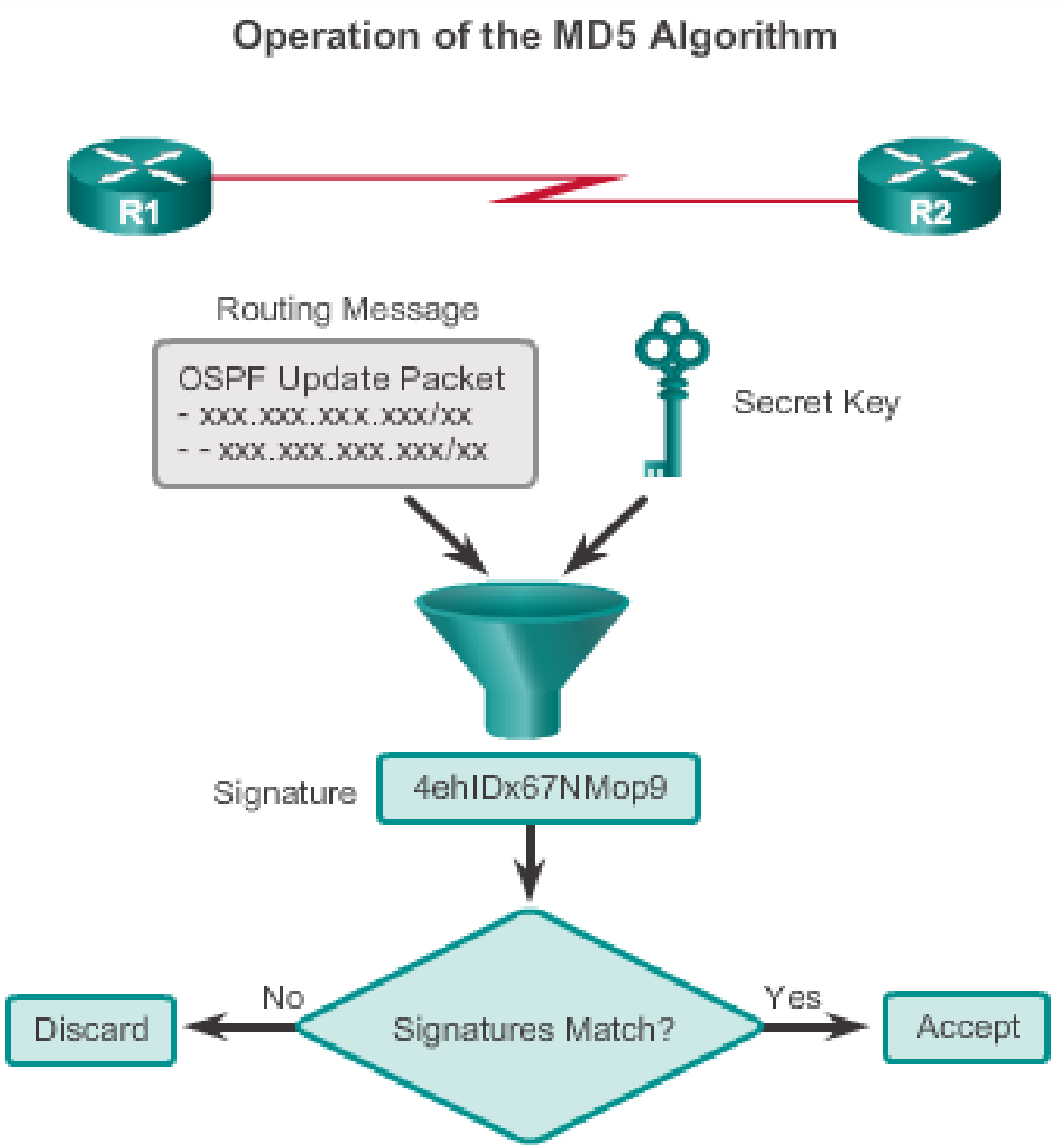
```
R1(config)# interface serial 0/0/0
R1(config-if)# ipv6 ospf hello-interval 5
R1(config-if)# ipv6 ospf dead-interval 20
R1(config-if)# end
R1#
*Apr 10 15:03:51.175: %OSPFv3-5-ADJCHG: Process 10, Nbr
2.2.2.2 on Serial0/0/0 from FULL to DOWN, Neighbor Down:
Dead timer expired
R1#
```

Autentifikácia v OSPF

Zabezpečenie smerovacích updates

- Pri zapnutej autentifikácii smerovač overuje zdroj od ktorého dostáva update
- Autentifikačné heslo musí byť zhodné na oboch stranách
- OSPF podporuje tri typy autentifikácie:
  - **Null** – žiadna autentifikácia.
  - **Simple password authentication** – heslo je poslané ako plain text, neodporúča sa (outdated method).
  - **MD5 authentication** – odporúčaná forma, heslo sa neposiela, posiela sa MD5 hash vypočítaný z hesla

Počítanie MD5



Konfigurácia tzv. Simple Password Authentication (plaintext)

```
Router(config-if)#
ip ospf authentication-key password
```

- Na rozhraní nastaví heslo pre plaintext

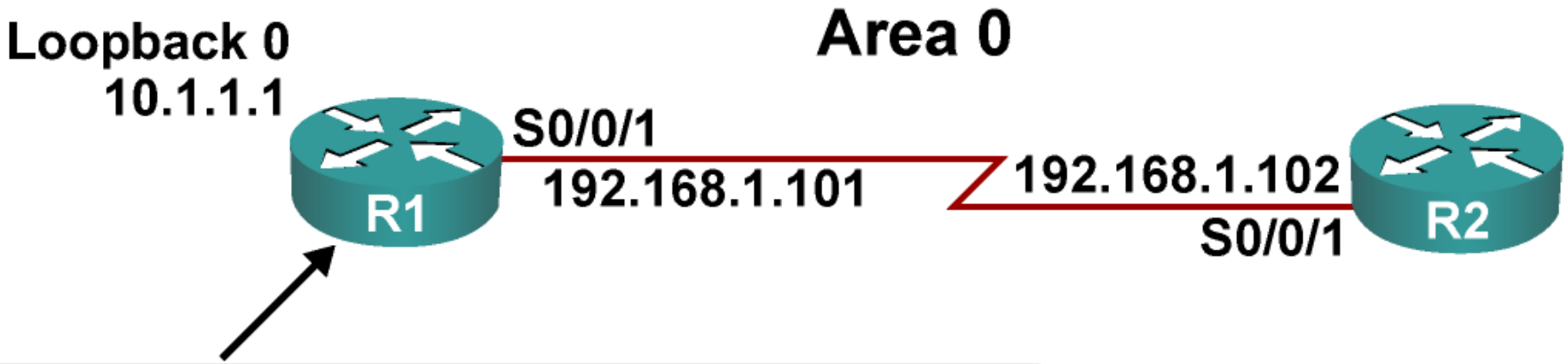
```
Router(config-router)#
area area-id authentication
```

- Definuje druh autentifikácie pre oblasť (v tomto prípade plaintext)

```
Router(config-if)#
ip ospf authentication [null]
```

- Prepíše druh autentifikácie na konkrétnom rozhraní (bez argumentu aktivuje plaintext, argument `null` deaktivuje autentifikáciu)

Príklad konfigurácie plaintext autentifikácie




```
<output omitted>
interface Loopback0
 ip address 10.1.1.1. 255.255.255.0

<output omitted>
interface Serial0/0/1
 ip address 192.168.1.101 255.255.255.224
 ip ospf authentication
 ip ospf authetication-key plainpas

<output omitted>
router ospf 10
 log-adjacency-changes
 network 10.1.1.1 0.0.0.0 area 0
 network 192.168.1.0 0.0.0.255 area 0
```

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Konfigurácia MD5 autentifikácie

```
Router(config-if)#
ip ospf message-digest-key key-id md5 key
```

- Vytvorí kľúč so zadaným ID a heslom
  - Kľúče susedov sa musia zhodovať v ID i hesle
  - Ak je na rozhraní kľúčov viac, pre odosielanie sa používa naposledy pridaný (alebo všetky, ak sú na segmente routery s rôznymi kľúčmi), pre prijatie sa akceptuje ktorýkoľvek

```
Router(config-router)#
area area-id authentication message-digest
```

- Definuje druh autentifikácie pre oblasť (v tomto prípade MD5)

```
Router(config-if)#
ip ospf authentication {message-digest | null}
```

- Prepíše druh autentifikácie na konkrétnom rozhraní (argument `message-digest` aktivuje MD5, argument `null` deaktivuje autentifikáciu)

OSPF MD5 autentifikácia - per area – príklad 1

```
R1(config)# router ospf 10
R1(config-router)# area 0 authentication message-digest
R1(config-router)# exit
R1(config)#
*Apr  8 09:58:09.899: %OSPF-5-ADJCHG: Process 10, Nbr 2.2.2.2
on Serial0/0/0 from FULL to DOWN, Neighbor Down: Dead timer
expired
R1(config)#
*Apr  8 09:58:28.627: %OSPF-5-ADJCHG: Process 10, Nbr 3.3.3.3
on Serial0/0/1 from FULL to DOWN, Neighbor Down: Dead timer
expired
R1(config)#
R1(config)# interface GigabitEthernet 0/0
R1(config-if)# ip ospf message-digest-key 1 md5 CISCO-123
R1(config-if)# exit
R1(config)#
R1(config)# interface Serial 0/0/0
R1(config-if)# ip ospf message-digest-key 1 md5 CISCO-123
R1(config-if)# exit
R1(config)#
R1(config)# interface Serial 0/0/1
R1(config-if)# ip ospf message-digest-key 1 md5 CISCO-123
R1(config-if)#
```

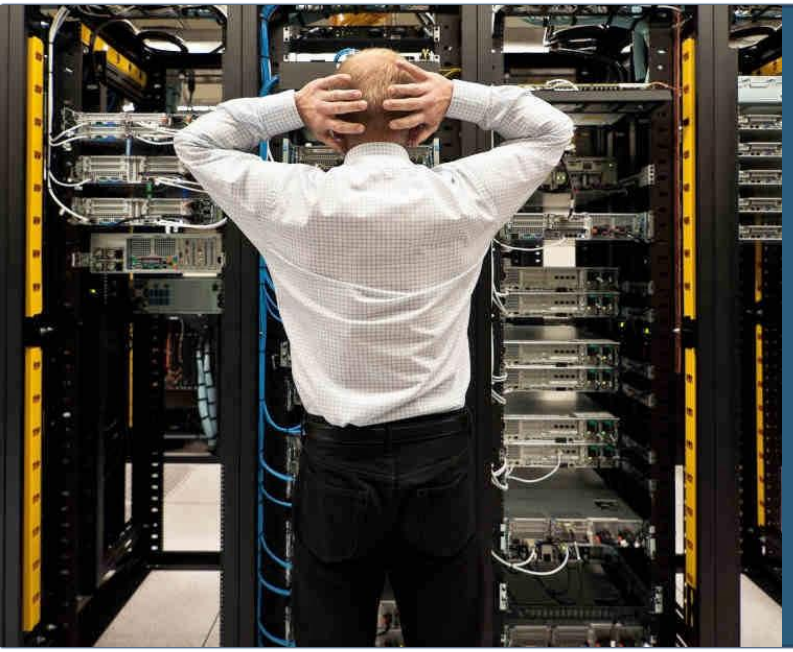
continued

OSPF MD5 autentifikácie – per interface – príklad 2

```
R1(config)# interface GigabitEthernet 0/0
R1(config-if)# ip ospf message-digest-key 1 md5 CISCO-123
R1(config-if)# ip ospf authentication message-digest
R1(config-if)# exit
R1(config)#
R1(config)# interface Serial 0/0/0
R1(config-if)# ip ospf message-digest-key 1 md5 CISCO-123
R1(config-if)# ip ospf authentication message-digest
R1(config-if)# exit
R1(config)#
R1(config)# interface Serial 0/0/1
R1(config-if)# ip ospf message-digest-key 1 md5 CISCO-123
R1(config-if)# ip ospf authentication message-digest
R1(config-if)# exit
R1(config)#
*Apr  8 10:20:10.647: %OSPF-5-ADJCHG: Process 10, Nbr 2.2.2.2
on Serial0/0/0 from FULL to DOWN, Neighbor Down: Dead timer
expired
R1(config)#
*Apr  8 10:20:50.007: %OSPF-5-ADJCHG: Process 10, Nbr 3.3.3.3
on Serial0/0/1 from FULL to DOWN, Neighbor Down: Dead timer
expired
R1(config)#
```

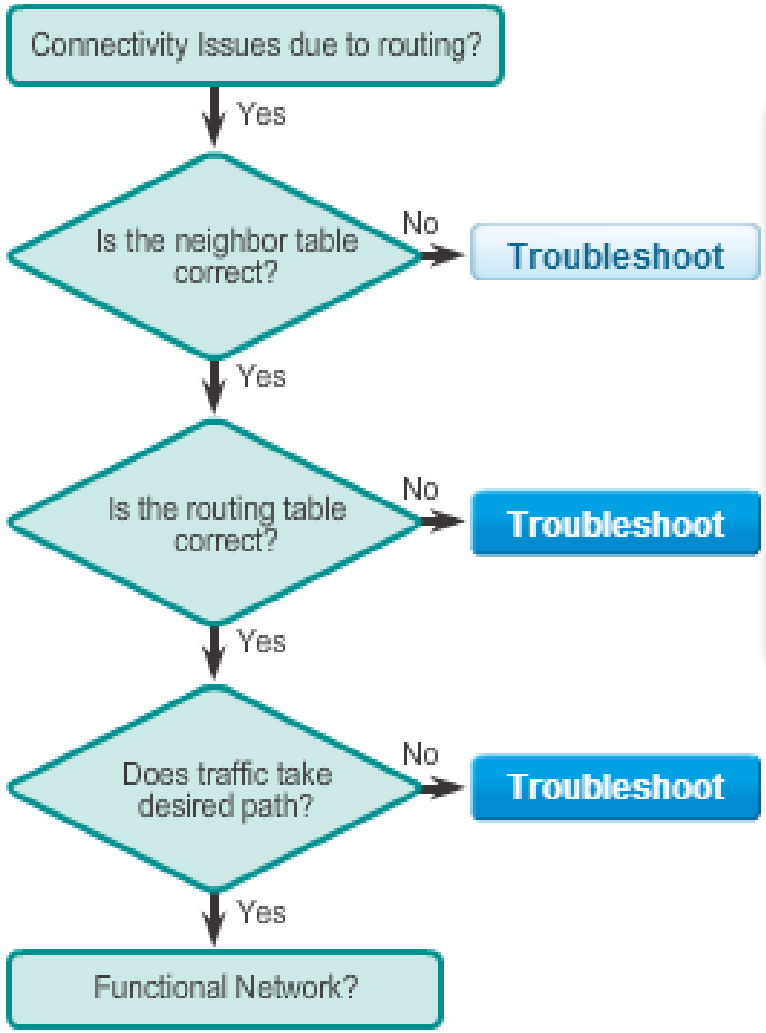
Autentifikácia v OSPFv3

- NA CCNA zatiaľ brať ako fakt, že využíva vstavané IPSec v IPv6



Overenie a diagnostika OSPF

Postup pri diagnostike OSPF



Troubleshoot

- Are the interfaces operational?
- Are the interfaces enabled for OSPF?
- Does the OSPF area match?
- Is there an interface that is configured as passive?

Show commands

```
show ip ospf neighbors
show ip interface brief
show ip ospf interface
```

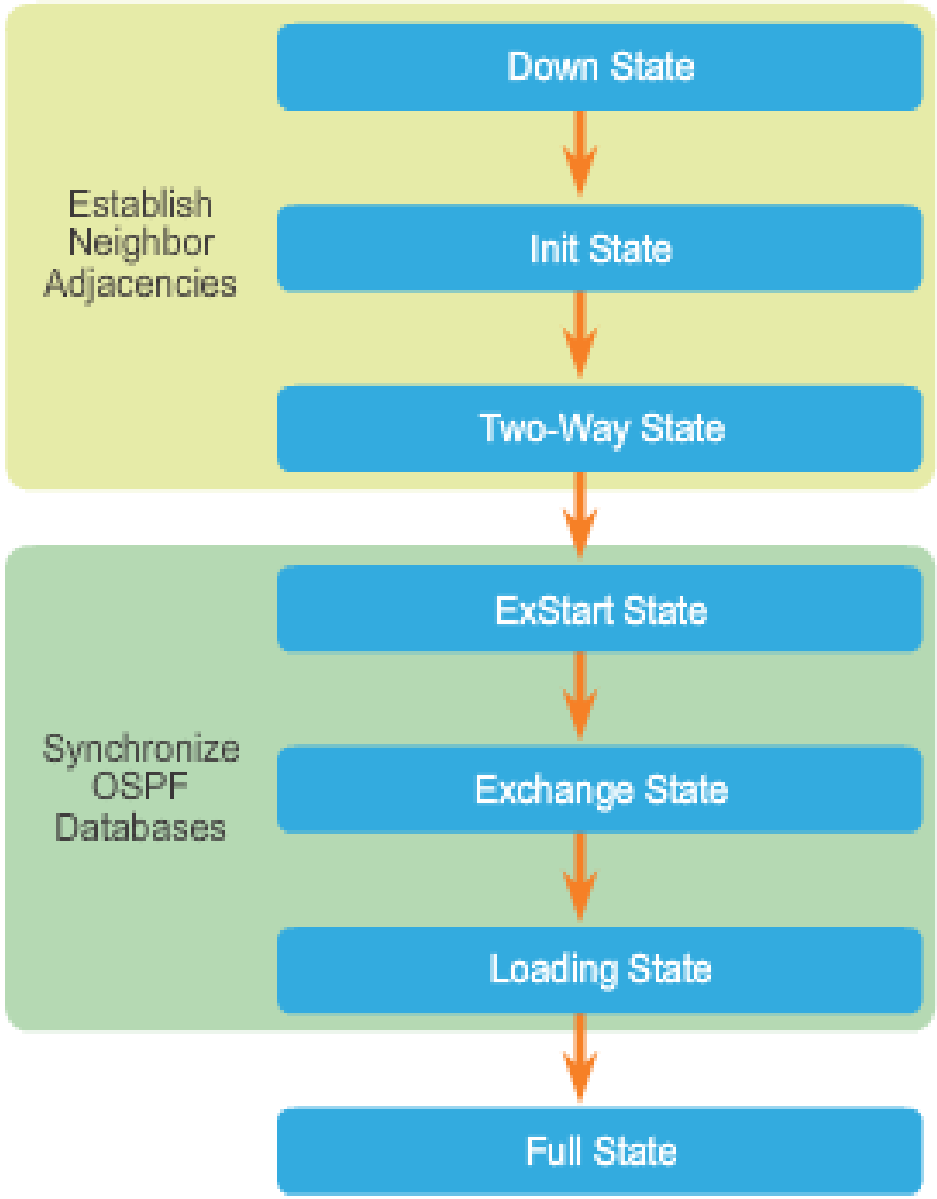
Budovanie OSPF Adjacency vzťahu

OSPF adjacencies will not form if:

- The interfaces are not on the same network.
- OSPF network types do not match.
- OSPF Hello or Dead Timers do not match.
- Interface to neighbor is incorrectly configured as passive.
- There is a missing or incorrect OSPF `network` command.
- Authentication is misconfigured.
- Each interface must be properly addressed and in the "up and up" condition.

Prechody cez OSPF stavy

Smerovač by mal ostať buď v Two Way alebo až vo Full

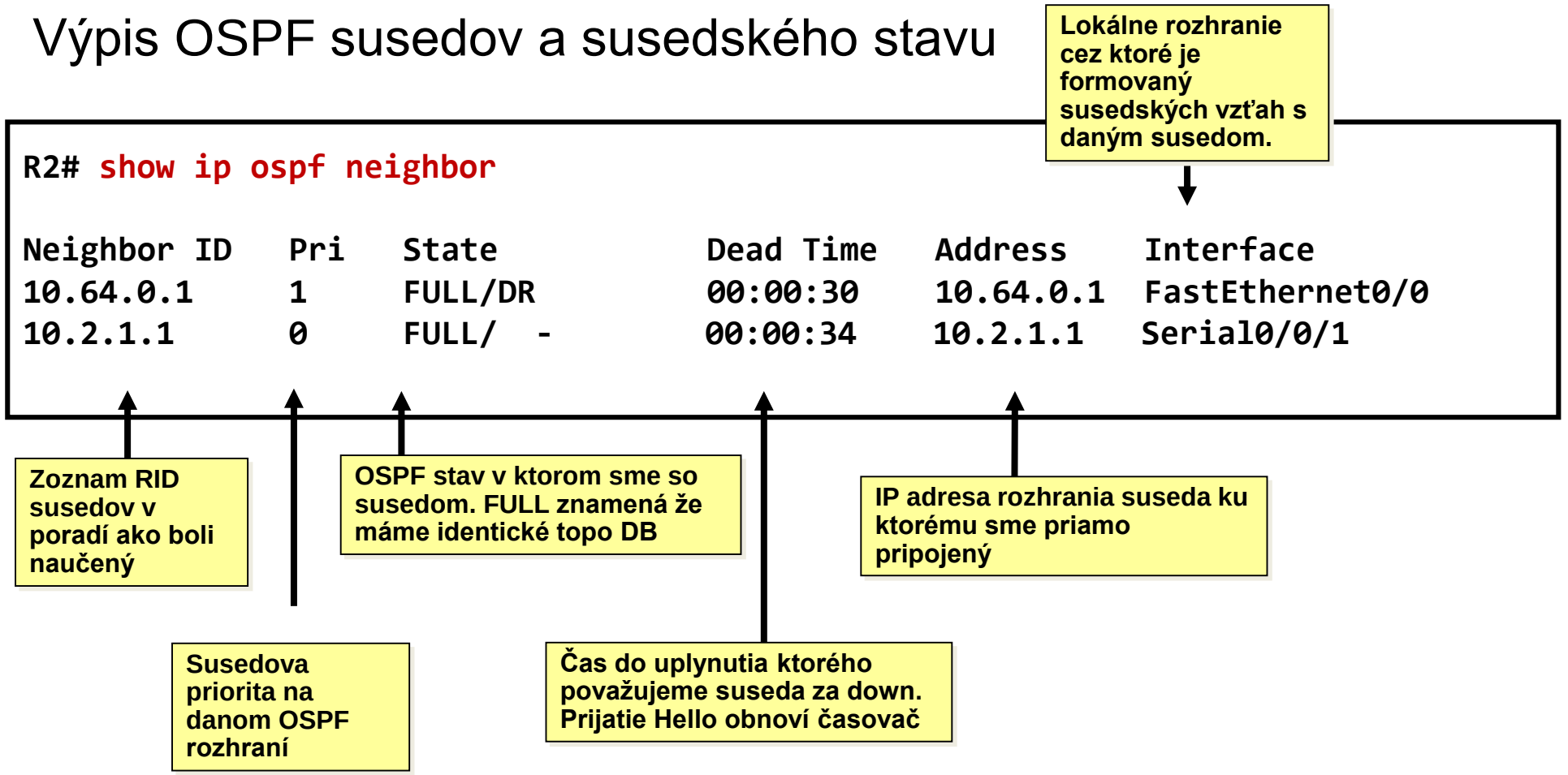


Overenie OSPFv2

Command	Description
`show ip protocols`	Displays OSPF process ID, router ID, networks router is advertising & administrative distance
`show ip ospf neighbors`	Displays OSPF neighbor relationships.
`show ip ospf neighbors detail`	
`show ip route`	Displays the routing table.
`show ip ospf interface`	Displays hello interval and dead interval
`show ip ospf`	Displays OSPF process ID, router ID, OSPF area information & the last time SPF algorithm calculated
`debug ip ospf`	Adjacency, packet, events...

show ip ospf neighbors

Výpis OSPF susedov a susedského stavu



Document ID: 13688 What Does the show ip ospf neighbor Command Reveal?
http://www.cisco.com/en/US/tech/tk365/technologies_tech_note09186a0080094a85.shtml

show ip ospf interface brief

```
R1# sh ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo1          1     0               10.1.1.1/24        1     LOOP  0/0
Fa0/0        1     0               10.1.200.1/24      1     BDR   1/1
Se0/0        1     0               10.1.100.1/24      1562  P2P   1/1
```

show ip ospf interface

```
R1# show ip ospf interface fastEthernet 0/0
FastEthernet0/0 is up, line protocol is up
  Internet Address 10.64.0.1/24, Area 0
  Process ID 1, Router ID 10.64.0.1, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DROTHER, Priority 0
  Designated Router (ID) 10.64.0.2, Interface address 10.64.0.2
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:04
  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 4
  Last flood scan time is 0 msec, maximum is 4 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.64.0.2 (Designated Router)
  Suppress hello for 0 neighbor(s)
```

Document ID: 13689 What Does the show ip ospf interface Command Reveal??
http://www.cisco.com/en/US/partner/tech/tk365/technologies_tech_note09186a0080094056.shtml

Výpis smerovacích ciest naučených cez OSPF.

show ip route ospf

```
R1# show ip route ospf
10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
O IA    10.2.1.0/24 [110/782] via 10.64.0.2, 00:03:05, FastEthernet0/0
R1#
```

show ip ospf

```
R2# show ip ospf
Routing Process “ospf 50” with ID 10.64.0.2
<output omitted>
Area BACKBONE(0)
        Area has no authentication
        SPF algorithm last executed 00:01:25.028 ago
        SPF algorithm executed 7 times
<output omitted>
    Area 1
        Number of interfaces in this area is 1
        Area has no authentication
        SPF algorithm last executed 00:00:54.636 ago
        SPF algorithm executed 3 times
 <output omitted>
R2#
```

show ip protocols

```
R1# show ip protocols
Routing Protocol is “ospf 1”
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 10.64.0.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    10.0.0.0 0.255.255.255 area 0
  Reference bandwidth unit is 100 mbps
<output omitted>
```

Diagnostika susedských vzťahov

```
RouterA# debug ip ospf adj
OSPF: Interface Serial0/0/0.1 going Up
OSPF: Build router LSA for area 0, router ID 192.168.1.1, seq 0x80000023
OSPF: Rcv DBD from 192.168.1.2 on Serial0/0/0.1 seq 0xCF0 opt 0x52 flag 0x7 len 32 mtu 1500
state INIT
OSPF: 2 Way Communication to 192.168.1.2 on Serial0/0/0.1, state 2WAY
OSPF: Send DBD to 192.168.1.2 on Serial0/0/0.1 seq 0xF4D opt 0x52 flag 0x7 len 32
OSPF: NBR Negotiation Done. We are the SLAVE
OSPF: Send DBD to 192.168.1.2 on Serial0/0/0.1 seq 0xCF0 opt 0x52 flag 0x2 len 132
OSPF: Rcv DBD from 192.168.1.2 on Serial0/0/0.1 seq 0xCF1 opt 0x52 flag 0x3 len 132 mtu
1500 state EXCHANGE
OSPF: Send DBD to 192.168.1.2 on Serial0/0/0.1 seq 0xCF1 opt 0x52 flag 0x0 len 32
OSPF: Database request to 192.168.1.2
OSPF: sent LS REQ packet to 192.168.1.2, length 12
OSPF: Rcv DBD from 192.168.1.2 on Serial0/0/0.1 seq 0xCF2 opt 0x52 flag 0x1 len 32 mtu 1500
state EXCHANGE
OSPF: Exchange Done with 192.168.1.2 on Serial0/0/0.1
OSPF: Send DBD to 192.168.1.2 on Serial0/0/0.1 seq 0xCF2 opt 0x52 flag 0x0 len 32
OSPF: Synchronized with 192.168.1.2 on Serial0/0/0.1, state FULL
%OSPF-5-ADJCHG: Process 100, Nbr 192.168.1.2 on Serial0/0/0.1 from LOADING to FULL, Loading
Done
OSPF: Build router LSA for area 0, router ID 192.168.1.1, seq 0x80000024
```

Diagnostika susedských vzťahov – voľba DR/BDR

```
OSPF: Interface FastEthernet0/0 going Up
OSPF: Build router LSA for area 0, router ID 192.168.1.1,seq 0x80000008
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
OSPF: 2 Way Communication to 172.16.1.1 on FastEthernet0/0, state 2WAY
OSPF: end of Wait on interface FastEthernet0/0
OSPF: DR/BDR election on FastEthernet0/0
OSPF: Elect BDR 192.168.1.1
OSPF: Elect DR 192.168.1.1
OSPF: Elect BDR 172.16.1.1
OSPF: Elect DR 192.168.1.1
DR: 192.168.1.1 (Id) BDR: 172.16.1.1 (Id)
OSPF: Send DBD to 172.16.1.1 on FastEthernet0/0 seq 0xDCE opt 0x52 flag 0x7 len 32
OSPF: No full nbrs to build Net Lsa for interface FastEthernet0/0
OSPF: Neighbor change Event on interface FastEthernet0/0
OSPF: DR/BDR election on FastEthernet0/0
OSPF: Elect BDR 172.16.1.1
OSPF: Elect DR 192.168.1.1
DR: 192.168.1.1 (Id) BDR: 172.16.1.1 (Id)
OSPF: Neighbor change Event on interface FastEthernet0/0
OSPF: DR/BDR election on FastEthernet0/0
OSPF: Elect BDR 172.16.1.1
OSPF: Elect DR 192.168.1.1
DR: 192.168.1.1 (Id) BDR: 172.16.1.1 (Id)
OSPF: Rcv DBD from 172.16.1.1 on FastEthernet0/0 seq 0x14B 7 opt 0x52 flag 0x7 len 32 mtu 1500 state EXSTART
OSPF: First DBD and we are not SLAVE-if)#
OSPF: Send DBD to 172.16.1.1 on FastEthernet0/0 seq 0xDCE opt 0x52 flag 0x7 len 32
OSPF: Retransmitting DBD to 172.16.1.1 on FastEthernet0/0[1]
OSPF: Rcv DBD from 172.16.1.1 on FastEthernet0/0 seq 0xDCE opt 0x52 flag 0x2 len 152 mtu 1500 state EXSTART
OSPF: NBR Negotiation Done. We are the MASTER
OSPF: Send DBD to 172.16.1.1 on FastEthernet0/0 seq 0xDCF opt 0x52 flag 0x3 len 132
OSPF: Database request to 172.16.1.1
OSPF: sent LS REQ packet to 172.16.1.1, length 24
OSPF: Rcv DBD from 172.16.1.1 on FastEthernet0/0 seq 0xDCF opt 0x52 flag 0x0 len 32 mtu 1500 state EXCHANGE
OSPF: Send DBD to 172.16.1.1 on FastEthernet0/0 seq 0xDD0 opt 0x52 flag 0x1 len 32
OSPF: No full nbrs to build Net Lsa for interface FastEthernet0/0
OSPF: Build network LSA for FastEthernet0/0, router ID 192.168.1.1
OSPF: Build network LSA for FastEthernet0/0, router ID 192.168.1.1
OSPF: Rcv DBD from 172.16.1.1 on FastEthernet0/0 seq 0xDD0 opt 0x52 flag 0x0 len 32 mtu 1500 state EXCHANGE
OSPF: Exchange Done with 172.16.1.1 on FastEthernet0/0
OSPF: Synchronized with 172.16.1.1 on FastEthernet0/0, state FULL
%OSPF-5-ADJCHG: Process 100, Nbr 172.16.1.1 on FastEthernet0/0 from LOADING to FULL, Loading Done
OSPF: Build router LSA for area 0, router ID 192.168.1.1, seq 0x80000009
OSPF: Build network LSA for FastEthernet0/0, router ID 192.168.1.1
```

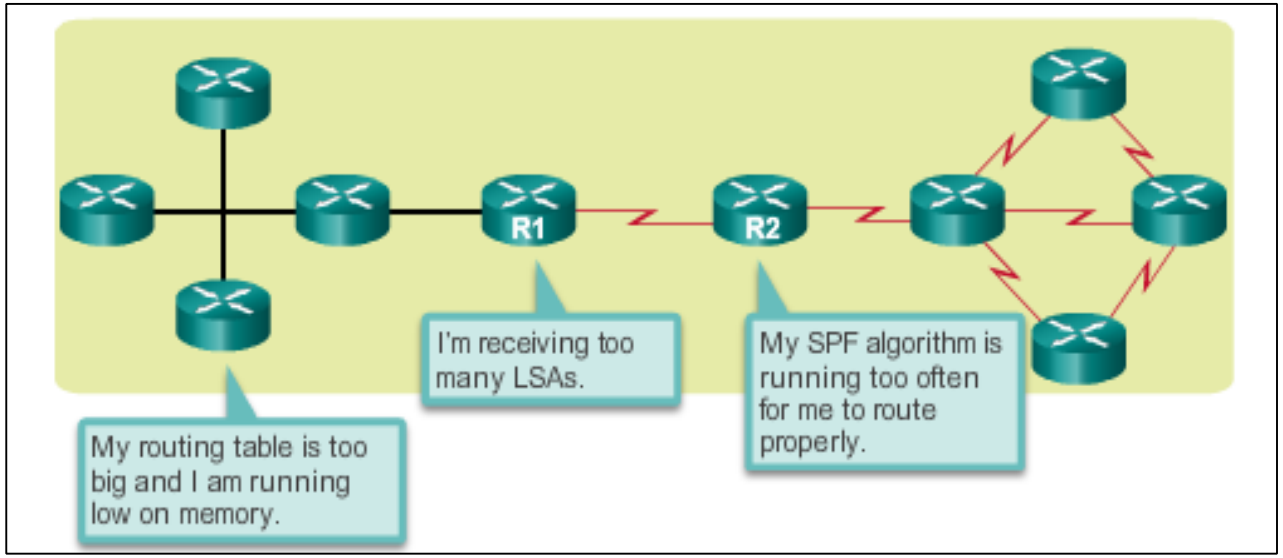
Overenie OSPFv3

- show ipv6 protocols
- show ipv6 ospf neighbor
- show ipv6 ospf interface
- show ipv6 ospf
- show ipv6 route ospf
- clear ipv6 ospf [process-id] process

Multiarea OSPF

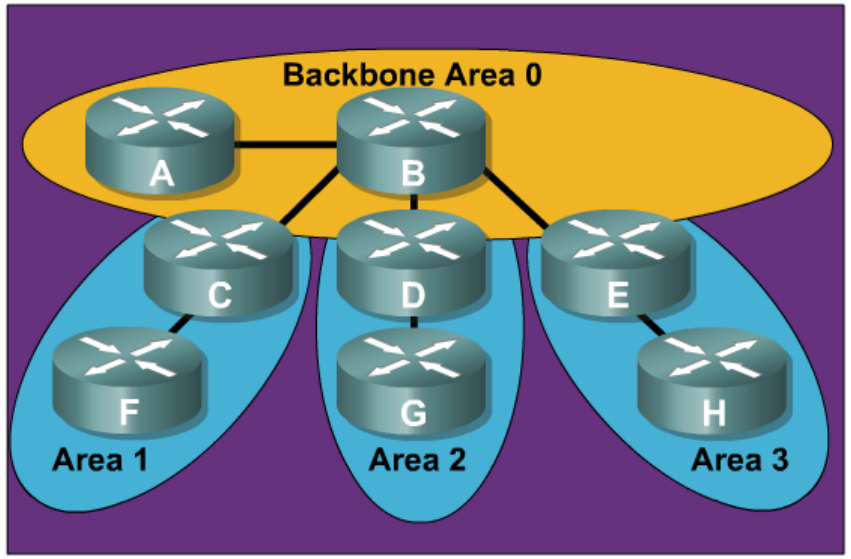
Single-Area OSPF

- **Oblasť (area)**
  - Množina sietí a smerovačov, ktoré poznajú vlastnú topológiu, ale ktoré nepoznajú topológiu zostávajúcej časti autonómneho systému
- Ak máme len jednú oblasť a tá sa stane veľká => musíme riešiť
  - Veľké smerovacie tabuľky (no summarization by default)
  - Veľké link-state database (LSDB)
  - Časté prepočty SPF algoritmu
- Záver: Single-area OSPF vhodné do menších sietí

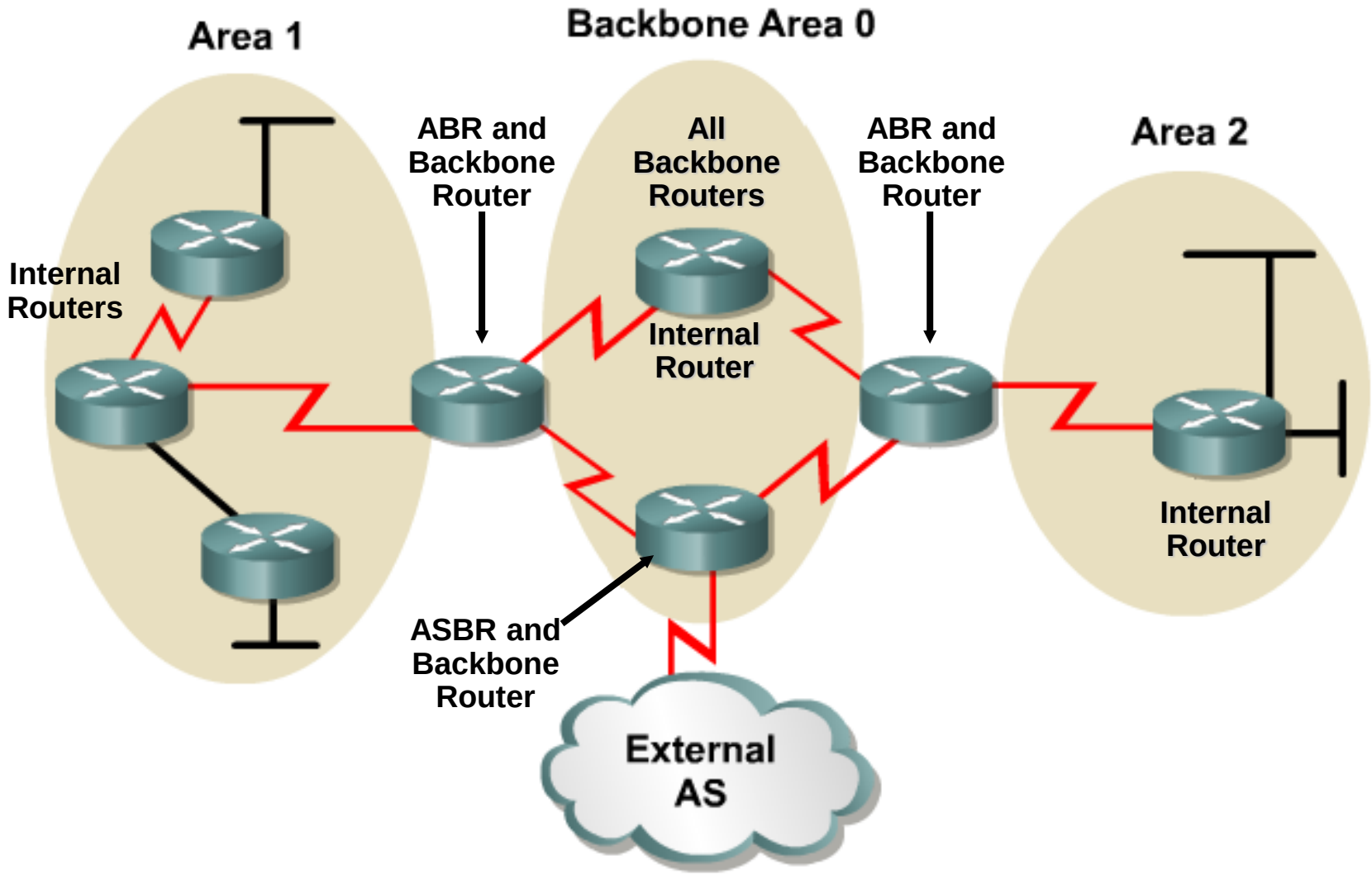


Viaceré oblasti - multiarea

- Možnosť použiť viaceré oblasti
- **Oblasť (area)**
  - Vytvorená za účelom pamäťovej a procesnej optimalizácie
  - Množina sietí a smerovačov, ktoré poznajú vlastnú topológiu, ale ktoré nepoznajú topológiu zostávajúcej časti autonómneho systému
  - Oblasť je identifikovaná 4B číslom
  - Každá oblasť musí byť fyzicky spojená s oblasťou 0 (backbone)
    - Dvojúrovňová hierarchia
  - Hranice oblastí sú **na smerovačoch** (nie na linkách!)
- **Oblasť**
  - Optimalizuje počet smerovacích položiek
  - Lokalizuje dopad zmien topológie
  - Lokalizuje LSA flooding
- **OSPF má dve úrovne oblastí**
  - Backbone
  - Regulárnu (štandardnú)



Typy OSPF smerovačov

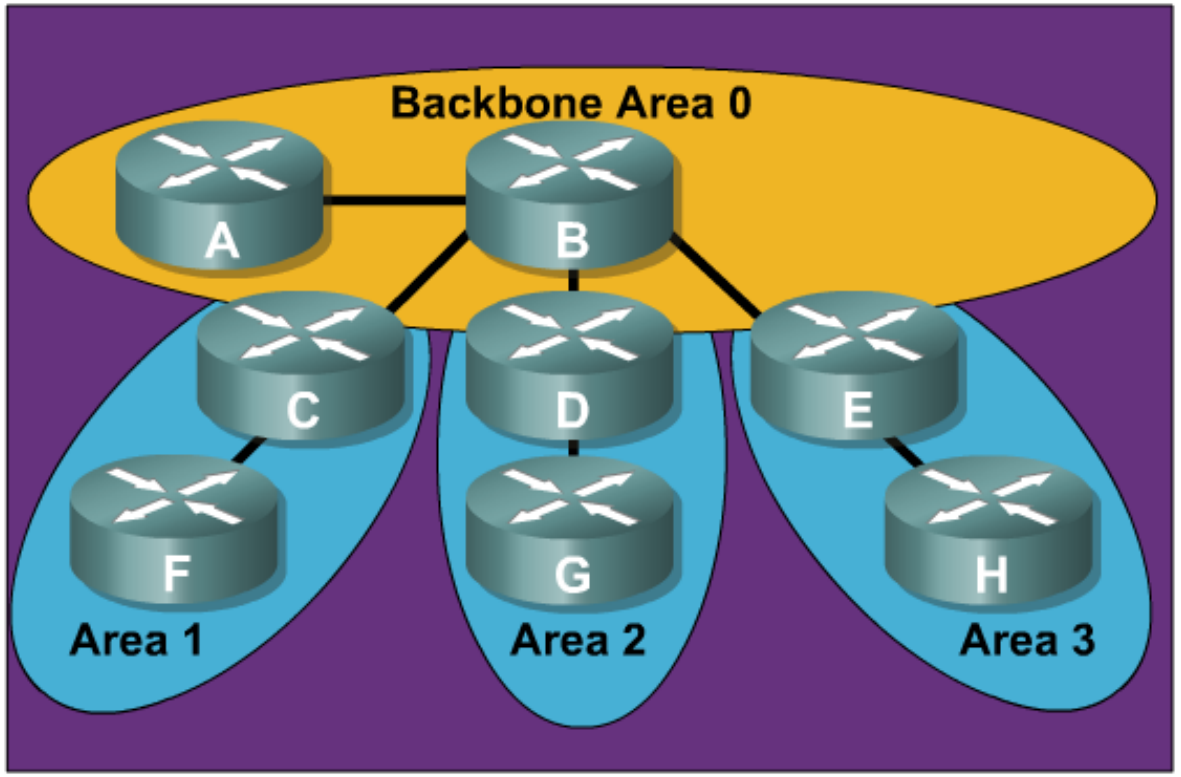


Typy OPSF smerovačov

- Internal router
  - Smerovač, ktorý má všetky svoje rozhrania v tej istej oblasti
  - Všetky interné smerovače majú rovnakú LSDB
- Backbone router
  - Smerovač pripojený aspoň jedným zo svojich rozhraní do backbone area 0
  - Môže byť Internal, ABR, ASBR
- Area Border Router (ABR)
  - Smerovač na rozhraní medzi viacerými oblasťami
    - V OSPF musí každý ABR byť členom oblasti 0 (chrbtice)
  - ABR plní funkcie pre šírenie, filtrovanie a sumarizáciu informácií preposielaných medzi oblasťami
- Autonomous System Boundary Router (ASBR)
  - Smerovač na rozhraní medzi autonómnym systémom a vonkajším svetom
  - ASBR plní funkcie pre import, filtrovanie a sumarizáciu informácií do OSPF zvonku autonómneho systému

Typy OSPF smerovačov

- Smerovače A, B, C, D a E sú backbone smerovače
  - Backbone routers make up Area 0.
- Smerovače C, D a E sú Area Border Routers (ABRs).
  - ABR pripájajú iné oblasti na backbone
- Smerovače A, B, F, G, a H sú internal routers
  - Sú vo vnútri danej oblasti všetkými rozhraniami
  - Neprepájajú iné oblasti



LSA a ich typy – popis topológie

Typy Link State Advertisement (LSA) štruktúr

- LSA sú základné stavebné bloky LSDB
  - Individuálne LSA tvoria záznamy v LSDB
  - Spolu tvoria topologickú DB

LSA Type	Description
1	Router LSAs
2	Network LSAs
3 or 4	Summary LSAs
5	Autonomous System External LSAs
6	Multicast OSPF LSAs
7	Defined for Not-So-Stubby Areas
8	External Attributes LSA for Border Gateway Protocol (BGP)
9, 10, 11	Opaque LSAs

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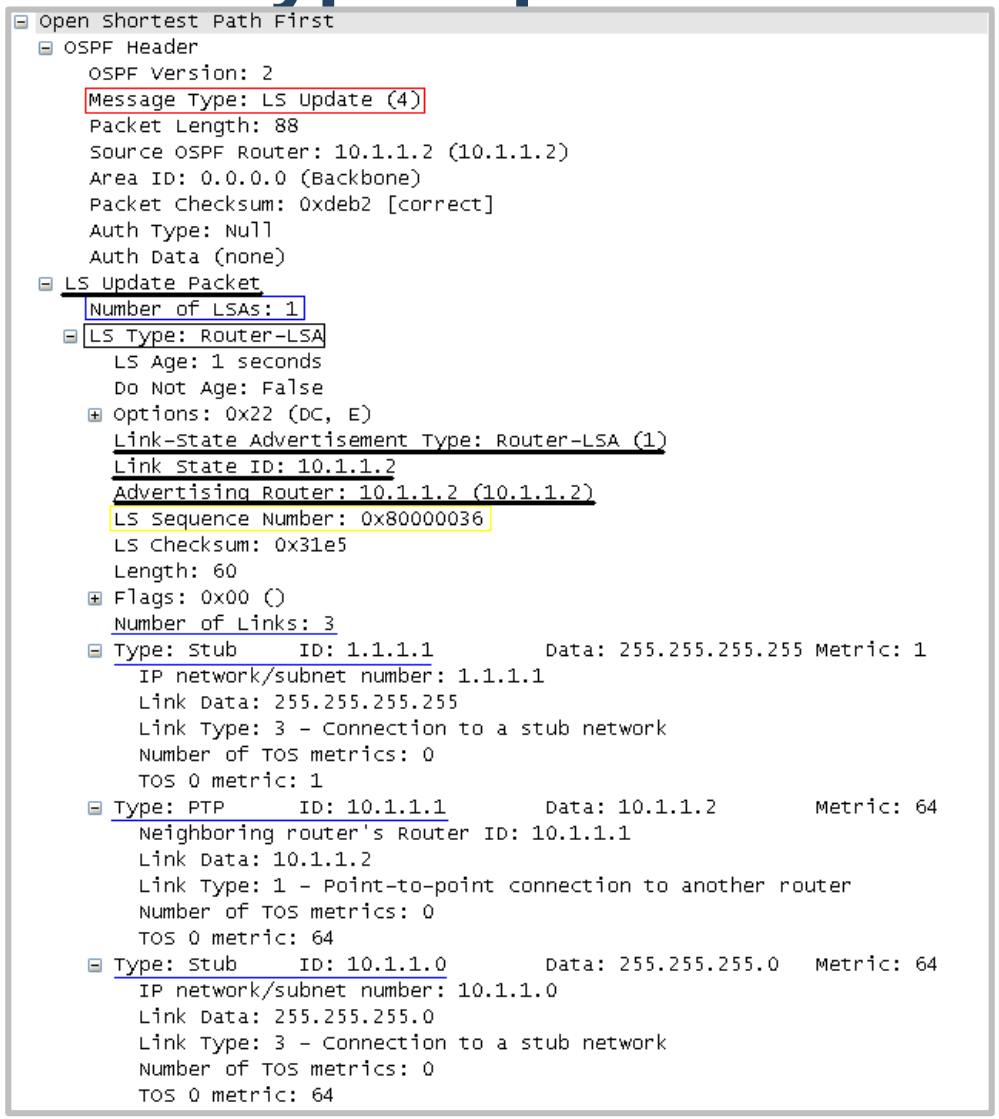
Základné údaje v LSA

- Každé LSA obsahuje hlavičku s nasledujúcimi údajmi
  - Link State Age: Vek LSA v sekundách
  - Options: Bitové príznaky pre rozšírené možnosti OSPF
  - Link State Type: Typ LSA
  - Link State ID (LSID): 4B číslo, ktoré jednoznačne identifikuje toto LSA v databáze
  - Advertising Router: RID routera, ktorý vygeneroval dané LSA
  - LS Sequence Number: Sekvenčné číslo LSA
  - LS Checksum, Length: Kontrolný súčet a veľkosť LSA

LSA Type 1: Router LSA

- Každý router v oblasti sám za seba vygeneruje jedno LSA1
  - LSA1 obsahuje zoznam rozhraní smerovača s ich popisom (sh ip ospf database router self-originate)
- LSA1 sa rozposiela do celej oblasti, neprechádza však cez ABR do iných oblastí
- Link State ID: RID routera, ktorý LSA1 vygeneroval
- LSA1 obsahuje jedno alebo viac polí Link ID (LID) , ktoré indikujú, k čomu je daný router pripojený a akým spôsobom
  - LID ukazuje na LSID ďalšieho objektu, s ktorým je router spojený
  - + Link Data
- Smerovacia položka = **O**

LSA Type 1 paket




```
R1# show ip ospf database router 10.1.1.2 adv-router 10.1.1.2

            OSPF Router with ID (10.1.1.2) (Process ID 1)

                Router Link States (Area 0)

   LS age: 748
   Options: (No TOS-capability, DC)
   LS Type: Router Links
   Link State ID: 10.1.1.2
   Advertising Router: 10.1.1.2
   LS Seq Number: 80000036
   Checksum: 0x31E5
   Length: 60
   Number of Links: 3


     Link connected to: a Stub Network
      (Link ID) Network/subnet number: 1.1.1.1
      (Link Data) Network Mask: 255.255.255.255
        Number of TOS metrics: 0
        TOS 0 Metrics: 1

     Link connected to: another Router (point-to-point)
      (Link ID) Neighboring Router ID: 10.1.1.1
      (Link Data) Router Interface address: 10.1.1.2
        Number of TOS metrics: 0
        TOS 0 Metrics: 64

      Link connected to: a Stub Network
       (Link ID) Network/subnet number: 10.1.1.0
       (Link Data) Network Mask: 255.255.255.0
         Number of TOS metrics: 0
```

Dve LSA za linku (prepoj na suseda) a sieť

LSA Type 2: Network LSA

- Generované DR routerom pre každú tranzitnú multiaccess sieť
  - Obsahuje zoznam RID všetkých smerovačov pripojených k danej sieti
- LSA2 sa rozposiela do celej oblasti, neprechádza však cez ABR do iných oblastí
- Link State ID: IP adresa DR v danej sieti
  - Na toto pole sa odvoláva pole Link ID v LSA1 typu tranzit všetkých členských routerov
- Smerovacia položka = **O**

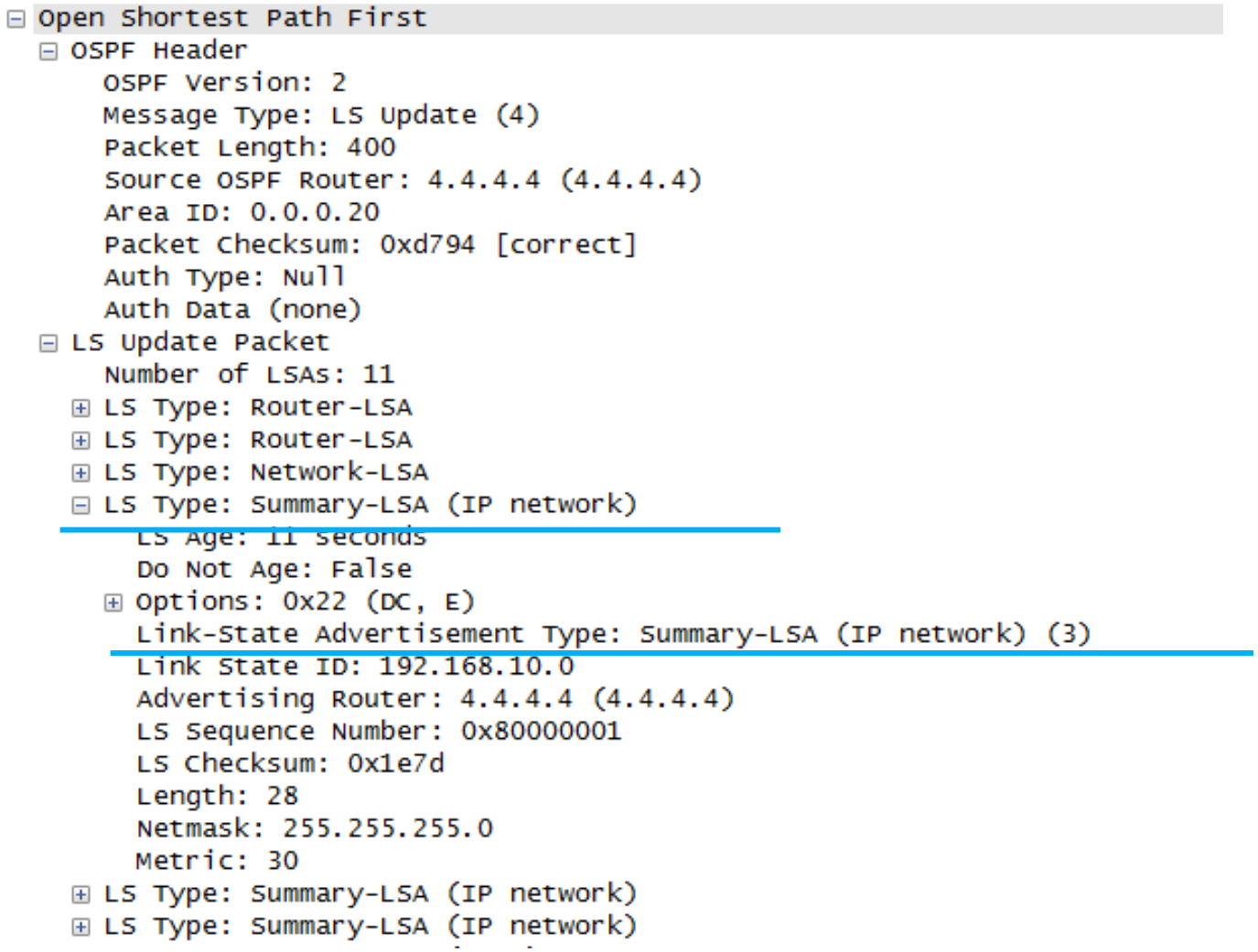
LSA Type 2 paket

```
Open Shortest Path First
  OSPF Header
      OSPF Version: 2
      Message Type: LS Update (4)
      Packet Length: 60
      Source OSPF Router: 5.5.5.5 (5.5.5.5)
      Area ID: 0.0.0.20
      Packet Checksum: 0x1462 [correct]
      Auth Type: Null
      Auth Data (none)
  LS Update Packet
      Number of LSAs: 1
    LS Type: Network-LSA
        LS Age: 3600 seconds
        Do Not Age: False
      Options: 0x22 (DC, E)
          0... .... = DN: DN-bit is NOT set
          .0.. .... = O: O-bit is NOT set
          ..1. .... = DC: Demand Circuits are supported
          ...0 .... = L: The packet does NOT contain LLS data block
          .... 0... = NP: NSSA is NOT supported
          .... .0.. = MC: NOT Multicast Capable
          .... ..1. = E: External Routing Capability
          .... ...0 = MT: NO Multi-Topology Routing
        Link-State Advertisement Type: Network-LSA (2)
        Link State ID: 10.0.20.2
        Advertising Router: 5.5.5.5 (5.5.5.5)
        LS Sequence Number: 0x80000002
        LS Checksum: 0xf4ee
        Length: 32
        Netmask: 255.255.255.252
        Attached Router: 5.5.5.5
        Attached Router: 4.4.4.4
```

LSA Type 3: Summary LSA (IP network)

- LSA3 generuje ABR za príslušnú oblasť do iných oblastí
  - LSA3 obsahujú (potenciálne sumarizovaný) zoznam IP sietí v danej oblasti, avšak bez dodatočnej topologickej informácie (efektívne distance-vector)
  - Bez sumarizácie LSA3 obsahujú jednoducho zoznam IP sietí v danej oblasti
    - By default sa nerobí sumarizácia, je ju potrebné nastaviť konfiguračne
  - Pre oznámenú každú sieť sa generuje jedno LSA3
- LSA3 sa za normálnych okolností rozposielajú do celého autonómneho systému, teda do všetkých oblastí
- Link State ID: IP adresa samotnej ohlasovanej podsiete, maska + cost je obsiahnutý v ďalšom poli správy
- Smerovacia položka = **O IA**

LSA Type 3 paket



LSA Type 4: Summary LSA (ASBR)

- LSA4 generuje ABR za príslušnú oblasť
  - V LSA4 sa prenáša informácia o existencii (ak existuje) ASBR v danej oblasti
- LSA4 sa za normálnych okolností rozposielajú do celého autonómneho systému, teda do všetkých oblastí
- Link-state ID: RID príslušného ASBR

LSA Type 1 s E bitom (ASBR)

```
Open Shortest Path First
  OSPF Header
  LS Update Packet
      Number of LSAs: 1
    LS Type: Router-LSA
        LS Age: 1 seconds
        Do Not Age: False
      Options: 0x22 (DC, E)
          0... .... = DN: DN-bit is NOT set
          .0.. .... = O: O-bit is NOT set
          ..1. .... = DC: Demand Circuits are supported
          ...0 .... = L: The packet does NOT contain LLS data block
          .... 0... = NP: NSSA is NOT supported
          .... .0.. = MC: NOT Multicast Capable
          .... ..1. = E: External Routing Capability
          .... ...0 = MT: NO Multi-Topology Routing
        Link-State Advertisement Type: Router-LSA (1)
        Link State ID: 5.5.5.5
        Advertising Router: 5.5.5.5 (5.5.5.5)
        LS Sequence Number: 0x80000005
        LS Checksum: 0x0a40
        Length: 48
      Flags: 0x00
        Number of Links: 2
      Type: Stub      ID: 192.168.20.0    Data: 255.255.255.0   Metric: 10
      Type: Stub      ID: 10.0.20.0       Data: 255.255.255.252 Metric: 10
```

LSA Type 4 paket

```
Open Shortest Path First
  OSPF Header
      OSPF Version: 2
      Message Type: LS Update (4)
      Packet Length: 400
      Source OSPF Router: 4.4.4.4 (4.4.4.4)
      Area ID: 0.0.0.20
      Packet Checksum: 0xd794 [correct]
      Auth Type: Null
      Auth Data (none)
  LS Update Packet
      Number of LSAs: 11
    LS Type: Router-LSA
    LS Type: Router-LSA
    LS Type: Network-LSA
    LS Type: Summary-LSA (IP network)
    LS Type: Summary-LSA (IP network)
    LS Type: Summary-LSA (IP network)
    LS Type: Summary-LSA (ASBR)
        LS Age: 11 seconds
        Do Not Age: False
      Options: 0x22 (DC, E)
        Link-State Advertisement Type: Summary-LSA (ASBR) (4)
        Link State ID: 5.5.5.5
        Advertising Router: 4.4.4.4 (4.4.4.4)
        LS Sequence Number: 0x80000001
        LS Checksum: 0x6fa0
        Length: 28
        Netmask: 0.0.0.0
        Metric: 20
```

LSA Type 5: External LSA

- LSA5 generuje ASBR
  - V LSA5 sa prenášajú informácie o vonkajších sieťach, t.j. sieťach mimo nášho autonómneho systému
  - Pre každú externú sieť sa generuje jedno LSA5
- Link State ID: IP adresa vonkajšej siete
  - By default sa nerobí sumarizácia
  - Jej implementácia je na zváženie, je ju potrebné nastaviť konfiguračne
  - Smerovacia položka = **O E1 or O E2** tzv. metric-type

LSA Type 5 paket

```
⊟ Open Shortest Path First
  ⊟ OSPF Header
      OSPF Version: 2
      Message Type: LS Update (4)
      Packet Length: 400
      Source OSPF Router: 4.4.4.4 (4.4.4.4)
      Area ID: 0.0.0.20
      Packet Checksum: 0xd794 [correct]
      Auth Type: Null
      Auth Data (none)
  ⊟ LS Update Packet
      Number of LSAs: 11
    ⊞ LS Type: Router-LSA
    ⊞ LS Type: Router-LSA
    ⊞ LS Type: Network-LSA
    ⊞ LS Type: Summary-LSA (IP network)
    ⊞ LS Type: Summary-LSA (IP network)
    ⊞ LS Type: Summary-LSA (IP network)
    ⊞ LS Type: Summary-LSA (ASBR)
    ⊟ LS Type: AS-External-LSA (ASBR)
        LS Age: 197 seconds
        Do Not Age: False
      ⊞ Options: 0x20 (DC)
        Link-State Advertisement Type: AS-External-LSA (ASBR) (5)
        Link State ID: 172.16.3.0
        Advertising Router: 2.2.2.2 (2.2.2.2)
        LS Sequence Number: 0x80000001
        LS Checksum: 0x2860
        Length: 36
        Netmask: 255.255.255.0
        External Type: Type 2 (metric is larger than any other link state path)
        Metric: 100
        Forwarding Address: 0.0.0.0
        External Route Tag: 0
```

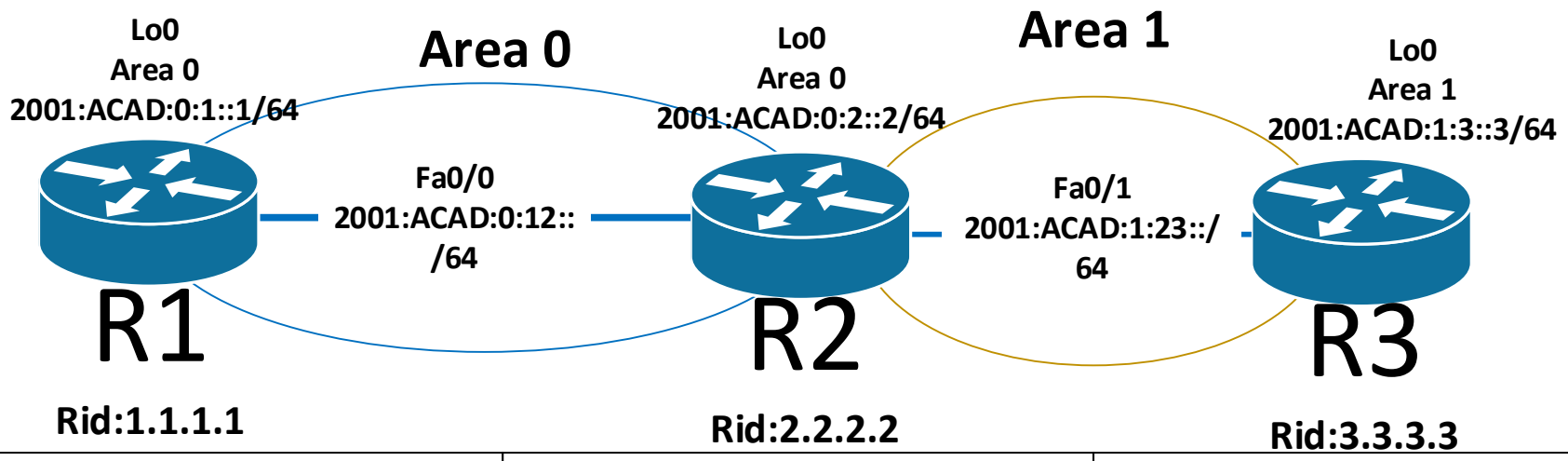
Prehľad LSA v OSPFv3

LSA Name	LS Type code	Flooding scope	LSA Function code
Router LSA	0x2001	Area scope	1
Network LSA	0x2002	Area scope	2
Inter-Area-Prefix-LSA	0x2003	Area scope	3
Inter-Area-Router-LSA	0x2004	Area scope	4
AS-External-LSA	0x4005	AS scope	5
Group-membership-LSA	0x2006	Area scope	6
Type-7-LSA	0x2007	Area scope	7
Link-LSA	0x0008	Link-local scope	8
Intra-Area-Prefix-LSA	0x2009	Area scope	9

Premenované

Nové

OSPF v3




```
ipv6 unicast-routing
ipv6 router ospf 1
      router-id 1.1.1.1
int fa 0/0
      no sh
      ipv6 add 2001:acad:12::1/64
      ipv6 add fe80::1 link-local
      ipv6 ospf 1 area 0
int lo 0
      ipv6 add 2001:acad:1::1/64
      ipv6 add fe80::1 link-local
      ipv6 ospf 1 area 0
```

```
unicast-routing
ipv6 router ospf 1
      router-id 2.2.2.2
int fa 0/0
      no sh
      ipv6 add 2001:acad:12::2/64
      ipv6 add fe80::2 link-local
      ipv6 ospf 1 area 0
int lo 0
      ipv6 add 2001:acad:2::2/64
      ipv6 add fe80::2 link-local
      ipv6 ospf 1 area 0
Int fa 0/1
      no sh
      ipv6 add 2001:acad:23::2/64
      ipv6 add fe80::2 link-local
      ipv6 ospf 1 area 1
```

```
ipv6 unicast-routing
ipv6 router ospf 1
      router-id 3.3.3.3
int fa 0/1
      no sh
      ipv6 add 2001:acad:23::3/64
      ipv6 add fe80::3 link-local
      ipv6 ospf 1 area 1
int lo 0
      ipv6 add 2001:acad:3::3/64
      ipv6 add fe80::3 link-local
      ipv6 ospf 1 area 1
```

OSPFv3 LSA typy – použitie show príkazov

```
LSA1  sh ipv6 ospf database router
LSA2  sh ipv6 ospf database network
LSA3  sh ipv6 ospf database inter-area prefix
LSA4  sh ipv6 ospf database inter-area router
LSA5  sh ipv6 ospf database external
LSA8  sh ipv ospf database link
LSA9  sh ipv ospf database prefix
```

Inter-Area Prefix LSA – LSA 3

- Describes the destination outside the area but still in the AS
- Summary is created for one area, which is flooded out in all other areas
- Originated by an ABR
- Only intra-area routes are advertised into the backbone
- Link State ID simply serves to distinguish inter-area-prefix-LSAs originated by the same router
- Link-local addresses must never be advertised in inter-area- prefix-LSAs

Link LSA – LSA 8

- A link LSA
  - validity per link
  - Link local scope flooding on the link with which they are associated
- Provide router link local addresses of specified link
- List all IPv6 prefixes attached to the link
- Assert a collection of option bit for the Router-LSA

LSA8 – link local scope

```
R1#sh ipv ospf database link self-originate

            OSPFv3 Router with ID (1.1.1.1) (Process ID 1)

                Link (Type-8) Link States (Area 0)

  LS age: 661
  Options: (V6-Bit E-Bit R-bit DC-Bit)
  LS Type: Link-LSA (Interface: FastEthernet0/0)
  Link State ID: 4 (Interface ID)
  Advertising Router: 1.1.1.1
  LS Seq Number: 80000001
  Checksum: 0x4171
  Length: 56
  Router Priority: 1
  Link Local Address: FE80::1
  Number of Prefixes: 1
  Prefix Address: 2001:ACAD:12::
  Prefix Length: 64, Options: None
```

Intra Area Prefix (LSA9)

- Zoznam prefixov sietí per router
- Odvolávka na Link ID v LSA1/2

Intra Area Prefix (LSA9)

```
R1#sh ipv ospf database prefix self-originate

           OSPFv3 Router with ID (1.1.1.1) (Process ID 1)

               Intra Area Prefix Link States (Area 0)

  Routing Bit Set on this LSA
  LS age: 731
  LS Type: Intra-Area-Prefix-LSA
  Link State ID: 0
  Advertising Router: 1.1.1.1
  LS Seq Number: 80000003
  Checksum: 0xAD47
  Length: 52
  Referenced LSA Type: 2001
  Referenced Link State ID: 0
  Referenced Advertising Router: 1.1.1.1
  Number of Prefixes: 1
  Prefix Address: 2001:ACAD:1::1
  Prefix Length: 128, Options: LA , Metric: 0

  Routing Bit Set on this LSA
  LS age: 731
  LS Type: Intra-Area-Prefix-LSA
  Link State ID: 4096
  Advertising Router: 1.1.1.1
  LS Seq Number: 80000001
  Checksum: 0xB269
  Length: 44
  Referenced LSA Type: 2002
  Referenced Link State ID: 4
  Referenced Advertising Router: 1.1.1.1
  Number of Prefixes: 1
  Prefix Address: 2001:ACAD:12::
  Prefix Length: 64, Options: None, Metric: 0
```

Interpretácia OSPF LSDB a OSPF smerovacieho procesu

Obsah OSPF databázy – význam stĺpcov

```
RouterA# show ip ospf database
      OSPF Router with ID (10.0.0.11) (Process ID 1)

                Router Link States (Area 0)
Link ID         ADV Router      Age         Seq#       Checksum Link count
10.0.0.11       10.0.0.11       548         0x80000002 0x00401A 1
10.0.0.12       10.0.0.12       549         0x80000004 0x003A1B 1
100.100.100.100 100.100.100.100 548         0x800002D7 0x00EEA9 2

                Net Link States (Area 0)
Link ID         ADV Router      Age         Seq#       Checksum
172.31.1.3      100.100.100.100 549         0x80000001 0x004EC9

                Summary Net Link States (Area 0)
Link ID         ADV Router      Age         Seq#       Checksum
10.1.0.0        10.0.0.11       654         0x80000001 0x00FB11
10.1.0.0        10.0.0.12       601         0x80000001 0x00F516
<output omitted>
```

LSA1

LSA2

LSA3

Pozor, stĺpec sa volá Link ID,
ale v skutočnosti zobrazuje Link State ID

Voľby výpisu OSPF topo DB - show ip ospf database ?

```
R1# sh ip ospf database ?
  adv-router         Advertising Router link states
  asbr-summary       ASBR summary link states
  database-summary   Summary of database
  external           External link states
  network            Network link states
  nssa-external      NSSA External link states
  opaque-area        Opaque Area link states
  opaque-as          Opaque AS link states
  opaque-link        Opaque Link-Local link states
  router             Router link states
  self-originate     Self-originated link states
  summary            Network summary link states
  |                  Output modifiers
  <cr>
```

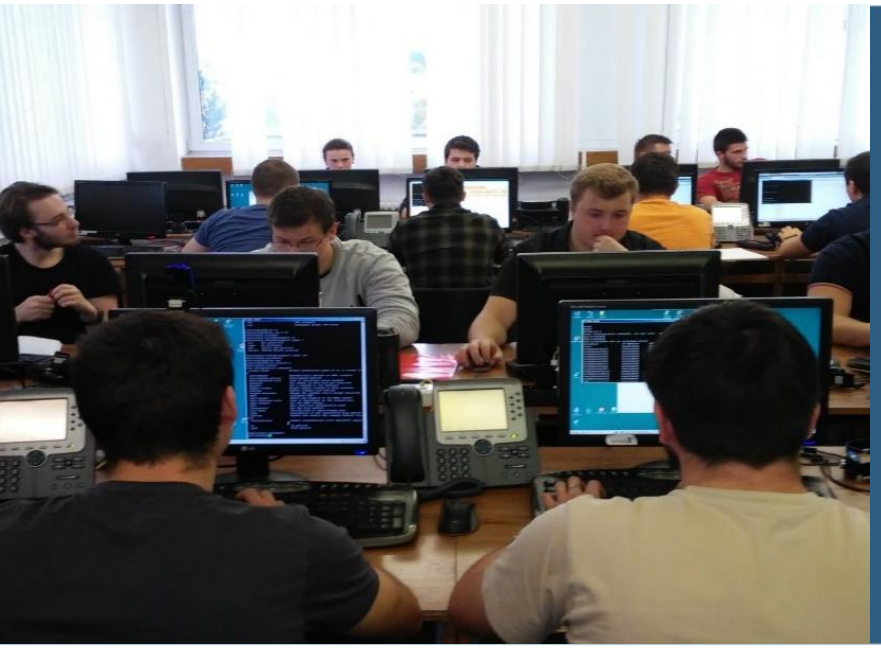
- Dobré na prezeranie jednotlivých LSA záznamov

OSPFv2 LSA typy – použitie show príkazov

```
LSA1  sh ip ospf database router
LSA2  sh ip ospf database network
LSA3  sh ip ospf database summary
LSA4  sh ip ospf database summary abr
LSA5  sh ip ospf database external
LSA7  sh ip ospf database nssa-external
```

Show ip ospf database router (LSA1)

```
R1# show ip ospf database router 10.1.1.2 adv-router 10.1.1.2

            OSPF Router with ID (10.1.1.2) (Process ID 1)

                Router Link States (Area 0)

  LS age: 748
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 10.1.1.2
  Advertising Router: 10.1.1.2
  LS Seq Number: 80000036
  Checksum: 0x31E5
  Length: 60
  Number of Links: 3

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 1.1.1.1
     (Link Data) Network Mask: 255.255.255.255
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 10.1.1.1
     (Link Data) Router Interface address: 10.1.1.2
      Number of TOS metrics: 0
       TOS 0 Metrics: 64

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 10.1.1.0
     (Link Data) Network Mask: 255.255.255.0
      Number of TOS metrics: 0
```



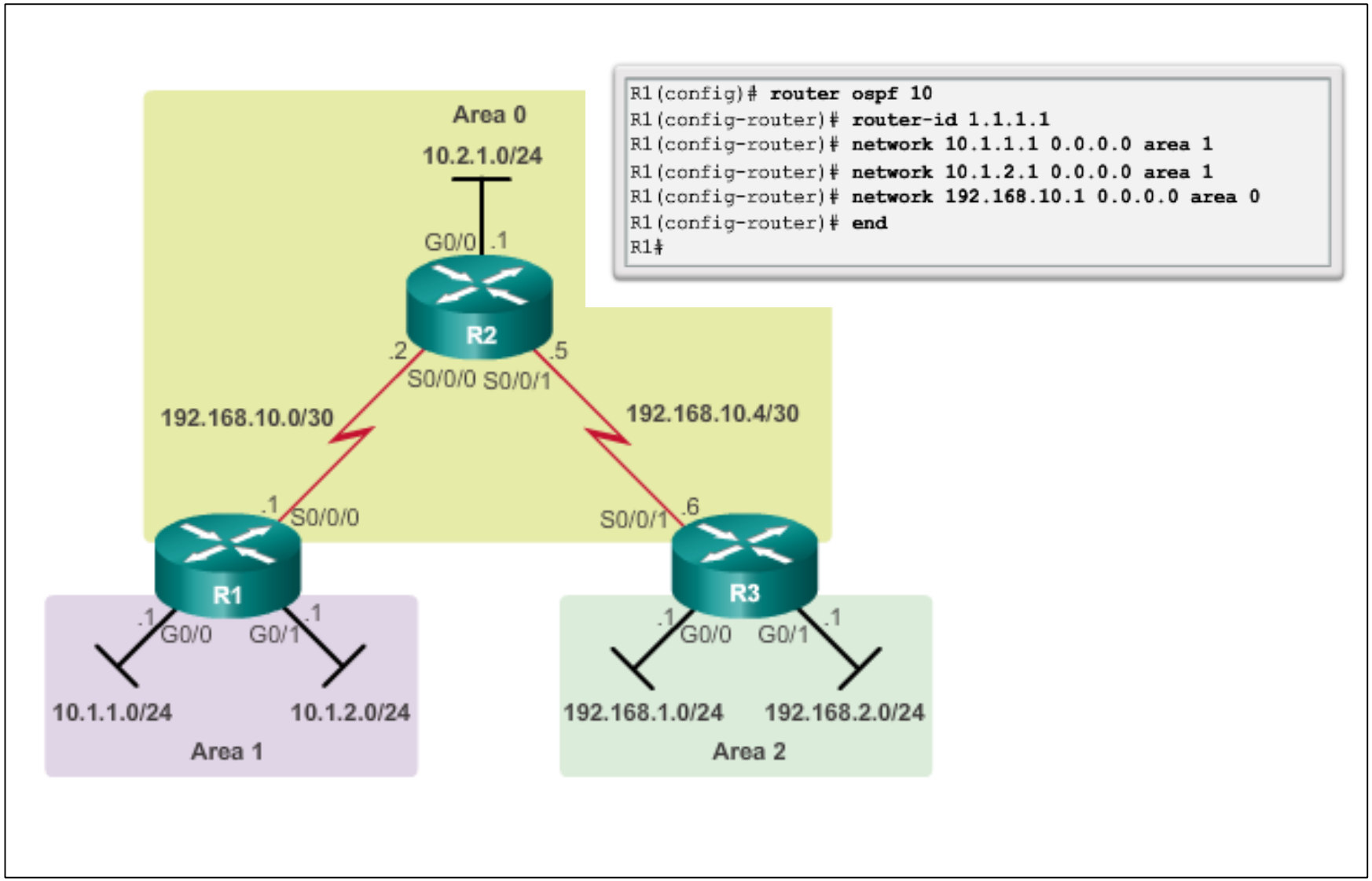
Konfigurácia multiarea OSPF

Implementačný plán multiarea OSPF

Implementation Plan Steps

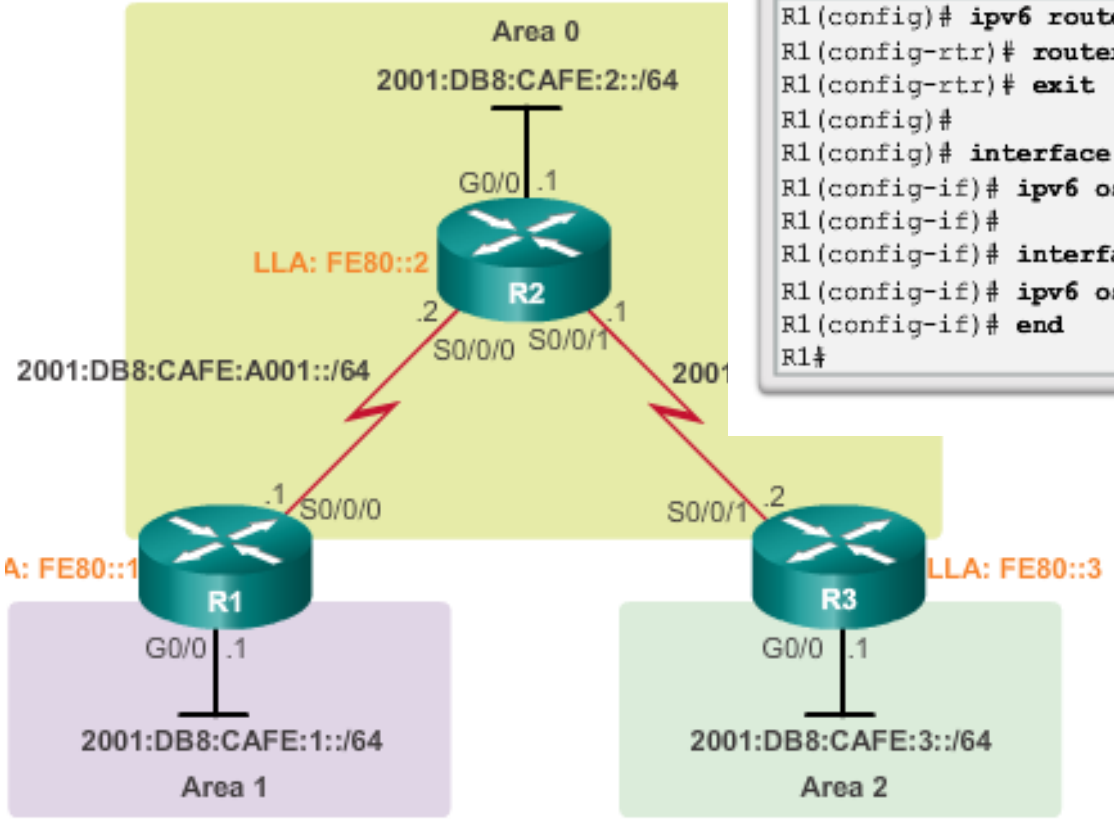
1. Gather the network requirements and parameters.
2. Define the OSPF parameters.
3. Configure OSPF.
4. Verify OSPF.

Príklad




```
R1(config)# router ospf 10
R1(config-router)# router-id 1.1.1.1
R1(config-router)# network 10.1.1.1 0.0.0.0 area 1
R1(config-router)# network 10.1.2.1 0.0.0.0 area 1
R1(config-router)# network 192.168.10.1 0.0.0.0 area 0
R1(config-router)# end
R1#
```

Konfigurácia Multiarea OSPFv3




```
R1(config)# ipv6 router ospf 10
R1(config-rtr)# router-id 1.1.1.1
R1(config-rtr)# exit
R1(config)#
R1(config)# interface GigabitEthernet 0/0
R1(config-if)# ipv6 ospf 10 area 1
R1(config-if)#
R1(config-if)# interface Serial0/0/0
R1(config-if)# ipv6 ospf 10 area 0
R1(config-if)# end
R1#
```

Smerovacia tabuľka v OSPF – external routes

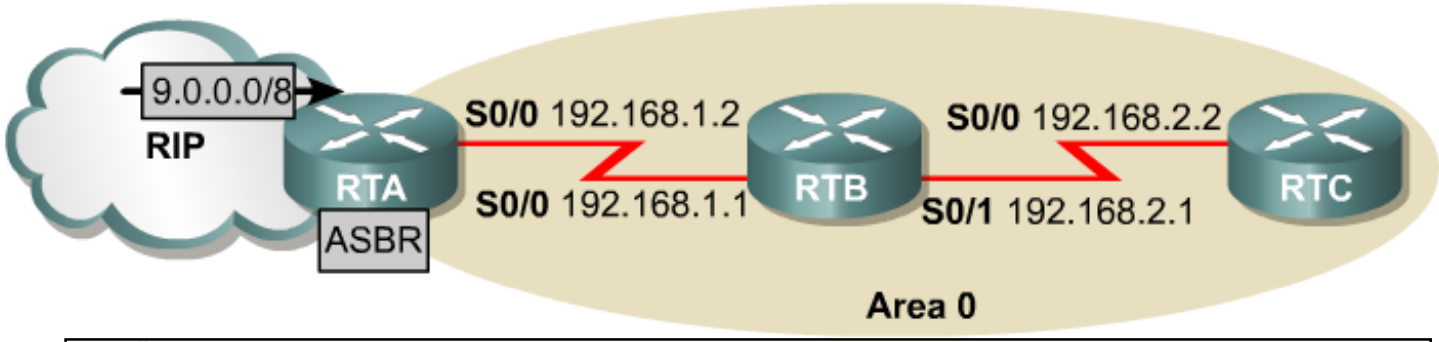
Smerovacia tabuľka v OSPF

Route Designator	Description	
O	OSPF intra-area (router LSA) and network LSA	• Networks from within the router's area. Advertised by way of router LSAs and network LSAs.
O IA	OSPF interarea (summary LSA)	• Networks from outside the router's area but within the OSPF AS. Advertised by way of summary LSAs.
O E1	Type 1 external routes	• Networks from outside the router's AS, advertised by way of external LSAs.
O E2	Type 2 external routes	• Networks from outside the router's AS, advertised by way of external LSAs.

```
R1# show ip route
<output omitted>
Gateway of last resort is not set
172.31.0.0/24 is subnetted, 2 subnets
O IA 172.31.2.0 [110/1563] via 10.1.1.1, 00:12:35, FastEthernet0/0
O IA 172.31.1.0 [110/782] via 10.1.1.1, 00:12:35, FastEthernet0/0
10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C 10.200.200.13/32 is directly connected, Loopback0
C 10.1.3.0/24 is directly connected, Serial0/0/0
O 10.1.2.0/24 [110/782] via 10.1.3.4, 00:12:35, Serial0/0/0
C 10.1.1.0/24 is directly connected, FastEthernet0/0
O 10.1.0.0/24 [110/782] via 10.1.1.1, 00:12:37, FastEthernet0/0
O E2 10.254.0.0/24 [110/50] via 10.1.1.1, 00:12:37, FastEthernet0/0
```

E2 Routes

```
RTB#show ip route
<output omitted>
O E2 9.0.0.0/8 [110/20] via 192.168.1.2, 00:00:07, Serial0/0
C    192.168.1.0/24 is directly connected, Serial0/0
C    192.168.2.0/24 is directly connected, Serial0/1
```

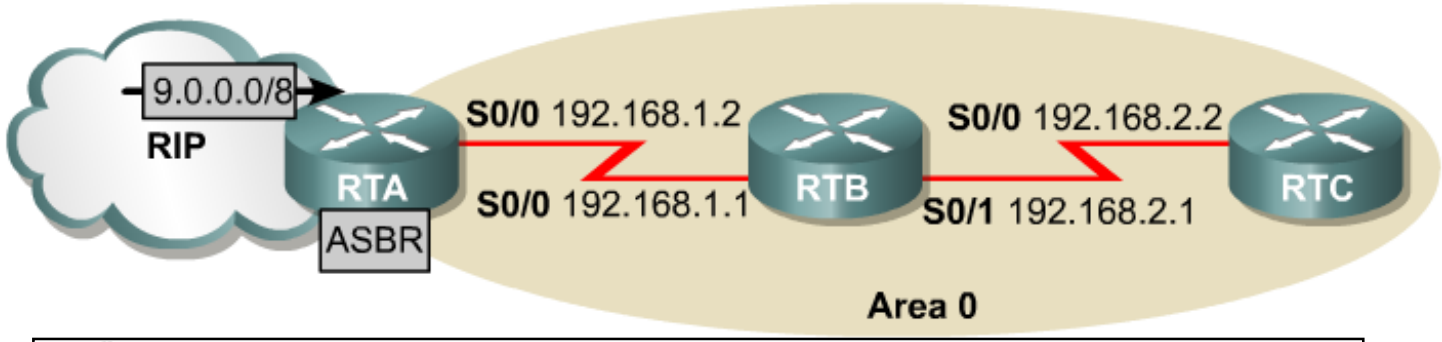



```
RTC#show ip route
<output omitted>
O E2 9.0.0.0/8 [110/20] via 192.168.2.1, 00:00:46, Serial0/0
O    192.168.1.0/24 [110/1171] via 192.168.2.1, 00:03:09, Serial0/0
C    192.168.2.0/24 is directly connected, Serial0/0
```

- By default, RTA uses a Type 2 metrics to send external routing information.
- RTB will receive the external RIP routes, including 9.0.0.0/8 from RTA.
- When RTB forwards this route, the metric for the external route remains the same (in this case, 20).

E1 Routes

```
RTB#show ip route
<output omitted>
O E1 9.0.0.0/8 [110/410] via 192.168.1.2, 00:00:05, Serial0/0
C    192.168.1.0/24 is directly connected, Serial0/0
C    192.168.2.0/24 is directly connected, Serial0/1
```



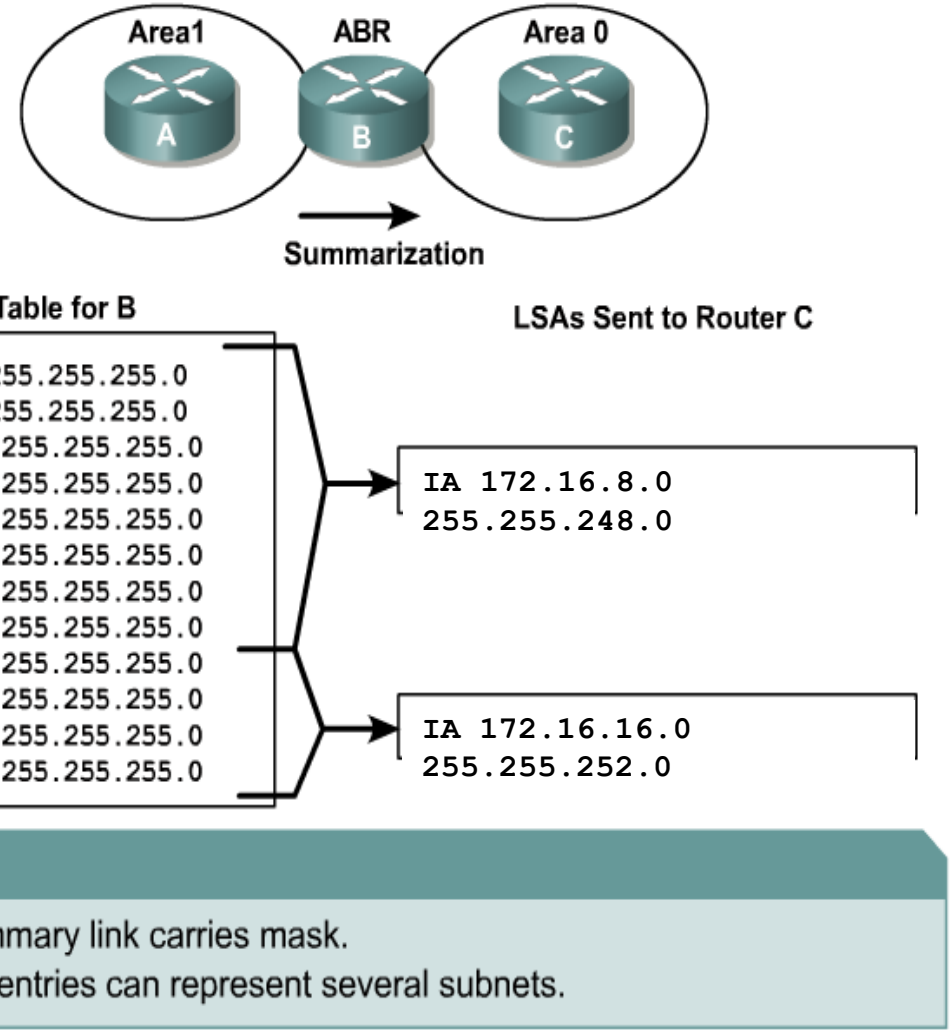

```
RTC#show ip route
<output omitted>
O E1 9.0.0.0/8 [110/1191] via 192.168.2.1, 00:00:47, Serial0/0
O    192.168.1.0/24 [110/1171] via 192.168.2.1, 00:04:50, Serial0/0
C    192.168.2.0/24 is directly connected, Serial0/0
```

- If RTA is configured to use a Type 1 metric with external routes, OSPF will increment the metric value of the external route according to its standard cost algorithm.

Sumarizácia v OSPF

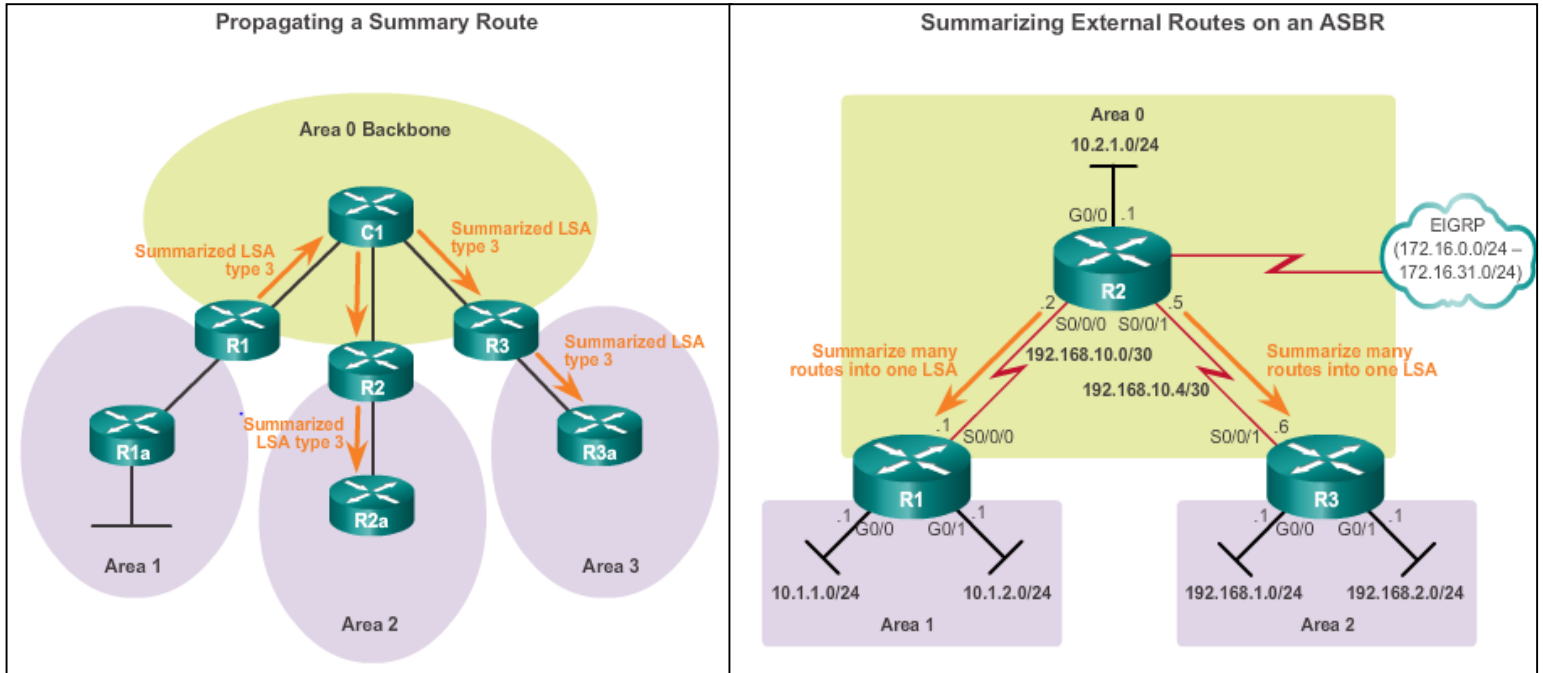
Sumarizovanie sietí

- Sumarizovanie = vyjadrenie viacerých sietí v jednom LSA
- Sumarizovanie priamo ovplyvňuje BW, pamäť a CPU smerovačov potrebných na beh OSPF procesu a držanie DB
- Nepriamo ovplyvňuje:
  - Ak zlyhá linka siete ktorá je sumarizovaná, alebo často mení stav (flapping), topo zmena sa do iných oblasti neprenáša
  - Tým zabraňujeme neustálemu prepočítavaniu OSPF procesu
- Predpokladom dobrej sumarizácie je samozrejme kontinuálny blok adries



Typy sumarizovania v OSPF

- V OSPF sa nezávisle od seba konfigurujú dva druhy sumarizácií
  - Sumarizácia sietí v oblastiach (interarea)
    - Zmysel len na ABR, ktorý vytvára Type LSA 3 z LSA1 a 2 pre inter area LSU
  - Sumarizácia externých sietí získaných redistribúciou (External route)
    - Zmysel len na ASBR, ktorý vytvára Type LSA 5
  - Na interných smerovačoch môžem sumarizovať len cesty vkladané do routing table, nie LSDB položky



Sumarizovanie sietí v oblastiach

- Sumarizácia sietí v oblastiach sa zásadne konfiguruje na príslušných ABR, a to príkazom

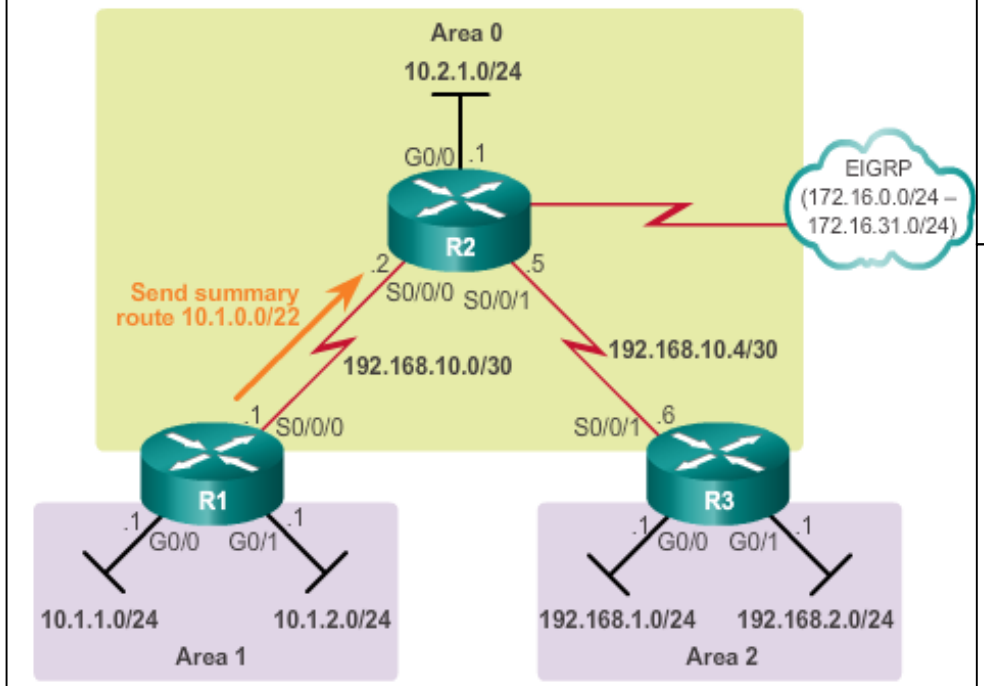
```
Router(config-router)#area area-id range SIEŤ MASKA [not-advertise |
advertise] [cost COST]
```

  - area-id: oblasť, ktorá obsahuje sumarizované siete
  - not-advertise: daná pokrývajúca sieť a jej komponenty sa neprepošlú do ostatných oblastí (budú skryté)
  - advertise: rozsah sa bude preposielať ako Lsa 3
  - cost: cena pre sumarizovanú cestu. Defaultne nastavená na najnižšiu cenu z cien sumarizovaných ciest
- Príkaz je možné opakovane použiť a sumarizovať na rôzne siete podľa potreby

Príklad pre Inter-Area sumarizáciu

```
R1(config)# router ospf 1
R1(config-router)# network 192.168.10.0 0.0.0.3 area 0
R1(config-router)# network 10.1.1.0 0.0.0.255 area 1
R1(config-router)# network 10.1.2.0 0.0.0.255 area 1
R1(config-router)# area 1 range 10.1.0.0 255.255.224.0
```

Summarizing Interarea Routes on ABRs



Verify the R3 Routing Table Before Summarization

```
R3# show ip route ospf | begin Gateway
Gateway of last resort is not set

      10.0.0.0/24 is subnetted, 3 subnets
O IA     10.1.1.0 [110/1295] via 192.168.10.5, 00:27:14, Serial0/0/1
O IA     10.1.2.0 [110/1295] via 192.168.10.5, 00:27:14, Serial0/0/1
O        10.2.1.0 [110/648] via 192.168.10.5, 00:27:57,  Serial0/0/1
      192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
O        192.168.10.0/30 [110/1294] via 192.168.10.5, 00:27:57,
         Serial0/0/1
R3#
```

```
R3# show ip route ospf | begin Gateway
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O IA     10.1.0.0/22 [110/1295] via 192.168.10.5, 00:00:06,
Serial0/0/1
O        10.2.1.0/24 [110/648] via 192.168.10.5, 00:29:23,
Serial0/0/1
      192.168.10.0/24 is variably subnetted, 3 subnets, 2
masks
O        192.168.10.0/30 [110/1294] via 192.168.10.5,
00:29:23, Serial0/0/1
R3#
```

Overenie OSPF

Overenie Multiarea OSPF

```
! Používajú sa tie isté príkazy ako pri single area!
show ip ospf neighbor
show ip ospf
show ip ospf interface
show ip protocols
show ip ospf interface brief
show ip route ospf
show ip ospf database
```

Note: Pre OSPFv3, `ip` nahraď `ipv6`.

MINISTERSTVO ŠKOLSTVA, VEDY, VÝSKUMU A ŠPORTU SLOVENSKEJ REPUBLIKY

Ďakujem za pozornosť!

Ohodnoť našu CNA na google:

- https://goo.gl/maps/BAnFvQKYCBpffcEX7

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