



UNIVERSITY OF ŽILINA
Faculty of Management Science
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MikroTik

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Motivácia



€1400



€40

Agenda

- Predstavenie spoločnosti MikroTik
- Zoznámenie sa s hardvérom
- Predstavenie RouterOS
- CLI na RouterOS



MikroTik

História

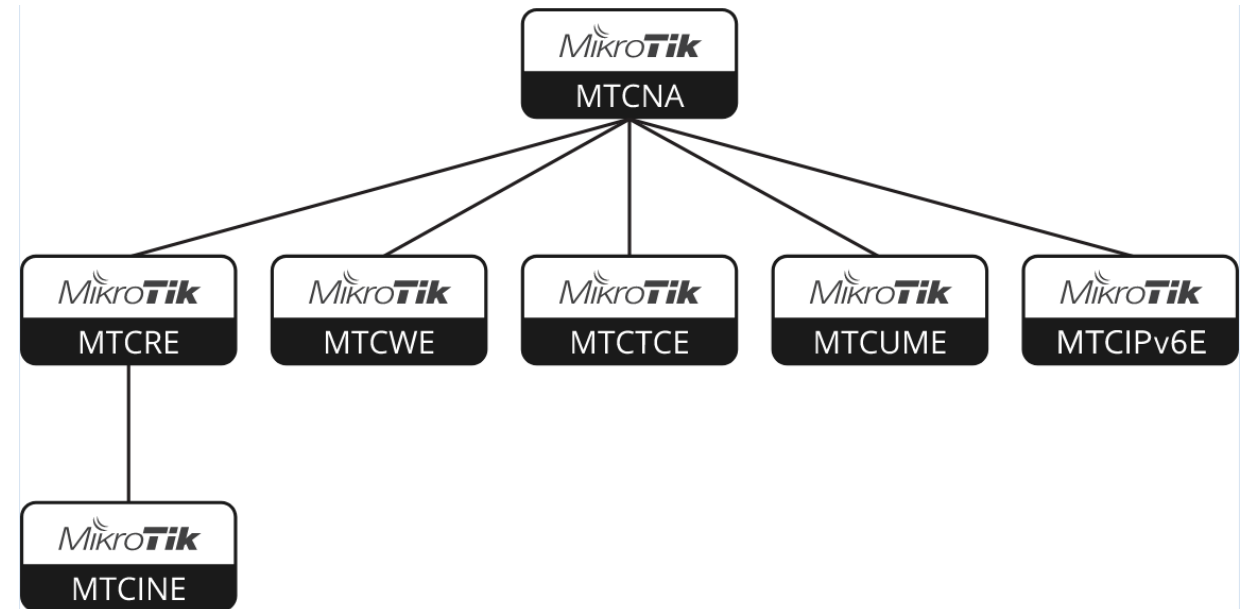
- Založenie v 1996
- Sídlo: Riga, Lotyšsko
- Riešenia pre bezdrôtových ISP
- 1997
 - RouterOS pre routre postavené na Intel (PC) platforme
- 2002
 - vlastné hardvérové riešenia s názvom RouterBOARD

MikroTik



MikroTik akadémia

- Podobné ako Cisco Netacad
- Certifikácie rozdelené do úrovní
- MTCNA
 - Zamerané na základné sieťové technológie
 - Routing, Bridge, DHCP, Firewall, NAT, WiFi, QoS, Tunnel(PPPoE), monitoring
 - Prezentované na RouterOS
 - Nie tak do detailov ako CCNA
- MikroTik akadémia na Uniza
 - Elektrotechnická fakulta



Bezdrôtové zariadenia pre ISP

- Spoje bod-bod
- AP a viacerí klienti
- Samostatné dosky bez obalu
 - RouterBOARD
- Nelicencované pásmo
 - 2,4GHz, 5GHz, 60GHz
- Licencované pásmo
- WiFi, LTE, LoRa
- Využívané lokálnymi ISP:
 - Bluenet, WCOM...



Kombinované zariadenia pre domácnosti

- Domáci bezdrôtový router (router+switch+WiFi)
- 100M/1G porty
- 2,4 alebo 5GHz WiFi
- WiFi AC štandard
- SFP/10G SFP+



- Samostatné WiFi access point
 - Vnútorne aj vonkajšie

- Powerline

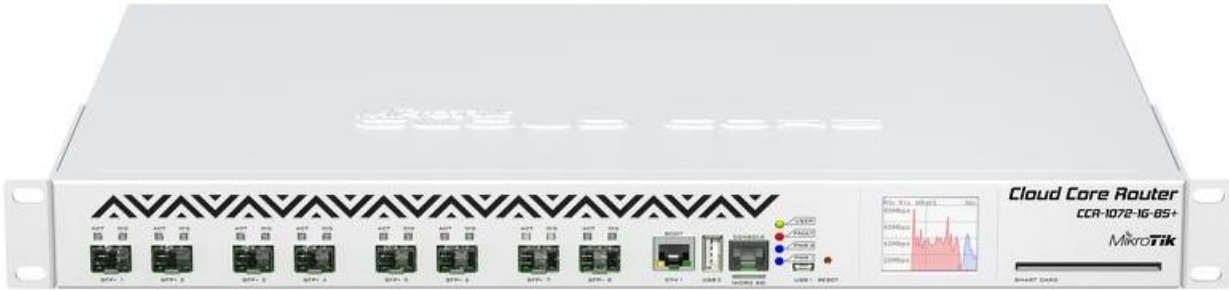
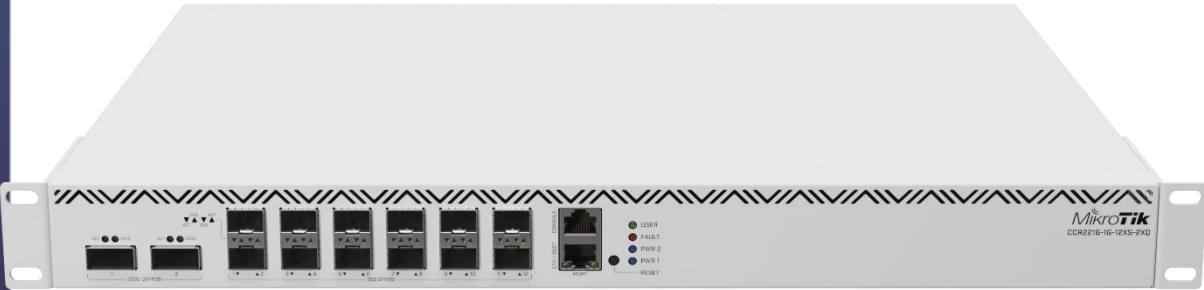
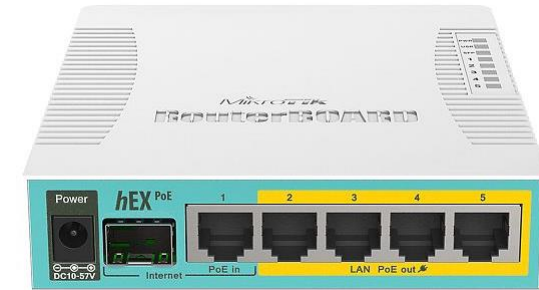
- Mesh AP

- 5G



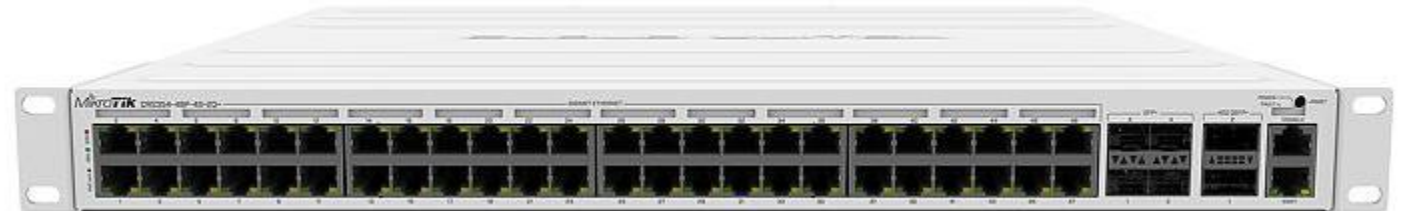
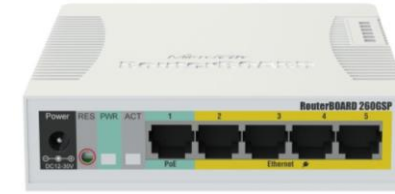
Route

- 5 portové (100M/1GbE) routre aj s PoE pre domácnosti a malé firmy
- Rack modely 1GbE s SFP
- Core routre pre stredné firmy s 10/25/40/100GbE portami s viacerými PSU



Switche

- SwOS aj RouterOS
- 5 portové (100M/1G) routre aj s PoE pre domácnosti a malé firmy
- 24/48 portové 1G rack modely s 10GbE a 40GbE uplinkmi aj s PoE
- reverse POE switche pre ISP
- 4/8/16/24 port 10GbE distribučné switche aj s 40GbE uplinkmi
- 4port 100GbE switch





RouterOS

RouterOS

- Uzavretý OS pre sieťové zariadenia
- Linux kernel v5.6.3 (v7)/v3.3.5 (v6)
- Podpora množstva architektúr:
 - x86, MIPS, TILE, ARM, PPC
- Minimum 32MB RAM
- L2 funkcionálna a šifrovanie (IPSec) akcelerované hardwarom
- L3 akcelerovaná v HW (v7) na niektorých zariadeniach / len na CPU (v6)
- Licencia súčasťou hardware alebo samostatne (x86)
- Licenčné úrovne
 - Level 3 – WiFi klient (nie je AP)
 - Level 4,5,6 – počty VPN tunelov, Hotspot klientov spravovaných AP
- Aktualizácie dostupné počas celej životnosti zariadenia priamo na stránke výrobcu bezplatne
- Cloud Hosted Router (CHR)
 - RouterOS pre virtuálne stroje
 - VirtualBox, KVM, VMWare, Hyper-V, Xen
 - 64bit CPU, 128MB RAM, 128MB HDD
 - Bezplatná verzia obmedzená 1Mbps/interface
 - Všetky funkcie ako klasický RouterOS

Funkcionalita

- Firewall
 - Stavový firewall, NAT, L7 filtering
- Routing
 - Statický, RIPv1/v2, RIPvng, OSPFv2/v3, BGP
 - VRF
- DHCP klient aj server
- QoS, VRRP, NTP, Dynamic DNS, OpenFlow, SNMP, RADIUS
- VPN
 - IPSec, OpenVPN, PPTP, L2TP, 6in4, 6to4
 - MPLS L3VPN, VPLS
- MPLS
- Wireless
 - WiFi 802.11 a/b/g/n/ac
 - proprietárne protokoly Nstreme, NV2
- CDP, SSH, Telnet, ping...
- Dot1X, WireGuard, WXLAN, REST API

WinBox

- Windows GUI utilita na konfiguráciu
- Funguje na Linuxe pod Wine
- GUI rozčlenené logicky podľa CLI príkazov
- Vhodné na oboznámenie sa s RouterOS
- Nie všetky pokročilé funkcie dostupné
- Štandardne na porte 8291
- Podporuje pripojenie na L2

The screenshot shows the WinBox interface for RouterOS configuration. The main window displays the 'Route List' configuration page, which is divided into several sections:

- Session Information:** krisjanis@[fe80::4e5e:cff:fe6:c0ab%3] (3C18-Krisjanis_GW) - WinBox v6.36rc6 on CCR1036-12G-4S (tile)
- Navigation:** Quick Set, CAPsMAN, Interfaces, Wireless, Bridge, PPP, Mesh, IP, IPv6, MPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, LCD, Partition, Make Supout.rif, Manual, New WinBox.
- Main Configuration Area:**
 - Route List:** Includes tabs for Routes, Nexthops, Rules, and VRF. A search bar and filter options are present.
 - Interface List:** A table showing network interfaces with columns for Name, Type, L2 MTU, Tx, Rx, and Tx Packet (p/s).

Name	Type	L2 MTU	Tx	Rx	Tx Packet (p/s)
ether3	Ethernet	1580	0 bps	0 bps	
ether4	Ethernet	1580	0 bps	0 bps	
ether5	Ethernet	1580	0 bps	0 bps	
ether6	Ethernet	1580	0 bps	0 bps	
ether7	Ethernet	1580	0 bps	0 bps	
ether8	Ethernet	1580	0 bps	0 bps	
ether9	Ethernet	1580	0 bps	0 bps	
Local - Slave - crs212Jan					
ether10	Ethernet	1580	0 bps	0 bps	
MT_local					
ether11_GW	Ethernet	1580	152.2 kbps	168.2 kbps	
Local - SW - Slave -> PC					
ether12	Ethernet	1580	363.9 kbps	177.5 kbps	
local	Bridge	1580	363.9 kbps	177.4 kbps	

Webfig

- Web utilita dostupné priamo po pripojení na port 80/443 na zariadenie
- Alternatíva ku WinBox
- Nie je potrebné nič inštalovať
- Funkcionalita oproti CLI obmedzená

RouterOS v6.41.4 (stable)

Quick Set WebFig Terminal

Filter Rules NAT Mangle Raw Service Ports Connections Address Lists Layer7 Protocols Firewall

Add New Reset All Counters

12 items

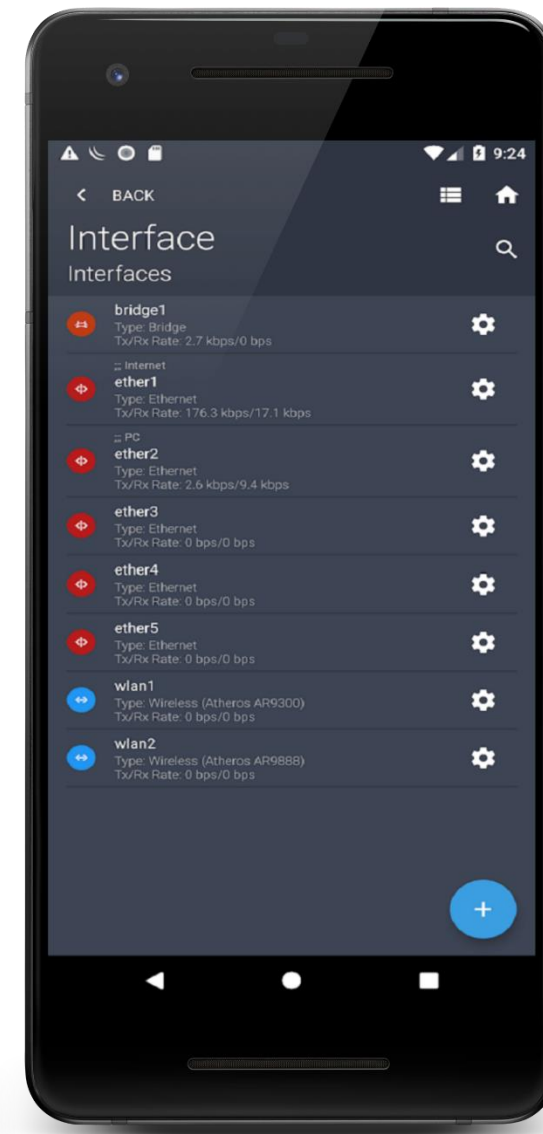
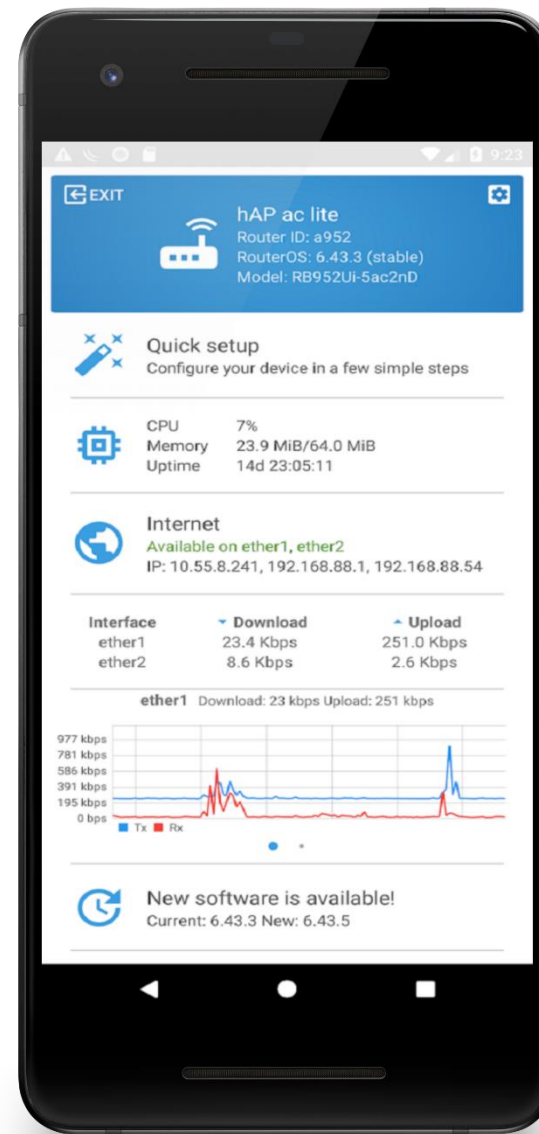
	#	Action	Chain	Src. Address	Dst. Address	Proto...	Src. Port	Dst. Port	Any. Port
- D	0	✓ accept	input			1 (icmp)			
- D	1	✓ accept	input						
- D	2	✓ accept	input						
- D	3	✓ accept	forward						
- D	4	✓ accept	forward						
- D	5	✓ accept	forward	10.0.7.254					
- D	6	✓ accept	forward		10.0.7.254				
- D	7	✗ drop	forward						
;;; wifi nemoze na mng vlan									
- D	8	✗ drop	forward						
;;; wifi nemoze na net vlan									
- D	9	✗ drop	forward						
;;; wifi nemoze na mng private vlan									
- D	10	✗ drop	forward						
;;; net vlana nemoze na private vianu									
- D	11	✗ drop	forward						

MikroTik pre Android a API

- MikroTik Pro
 - Konfiguračný nástroj pre Android
 - Stabilná verzia vyšla po dlhom testovaní v 2019
 - Voľby rozčlenené podobne ako vo WinBox a WebFig

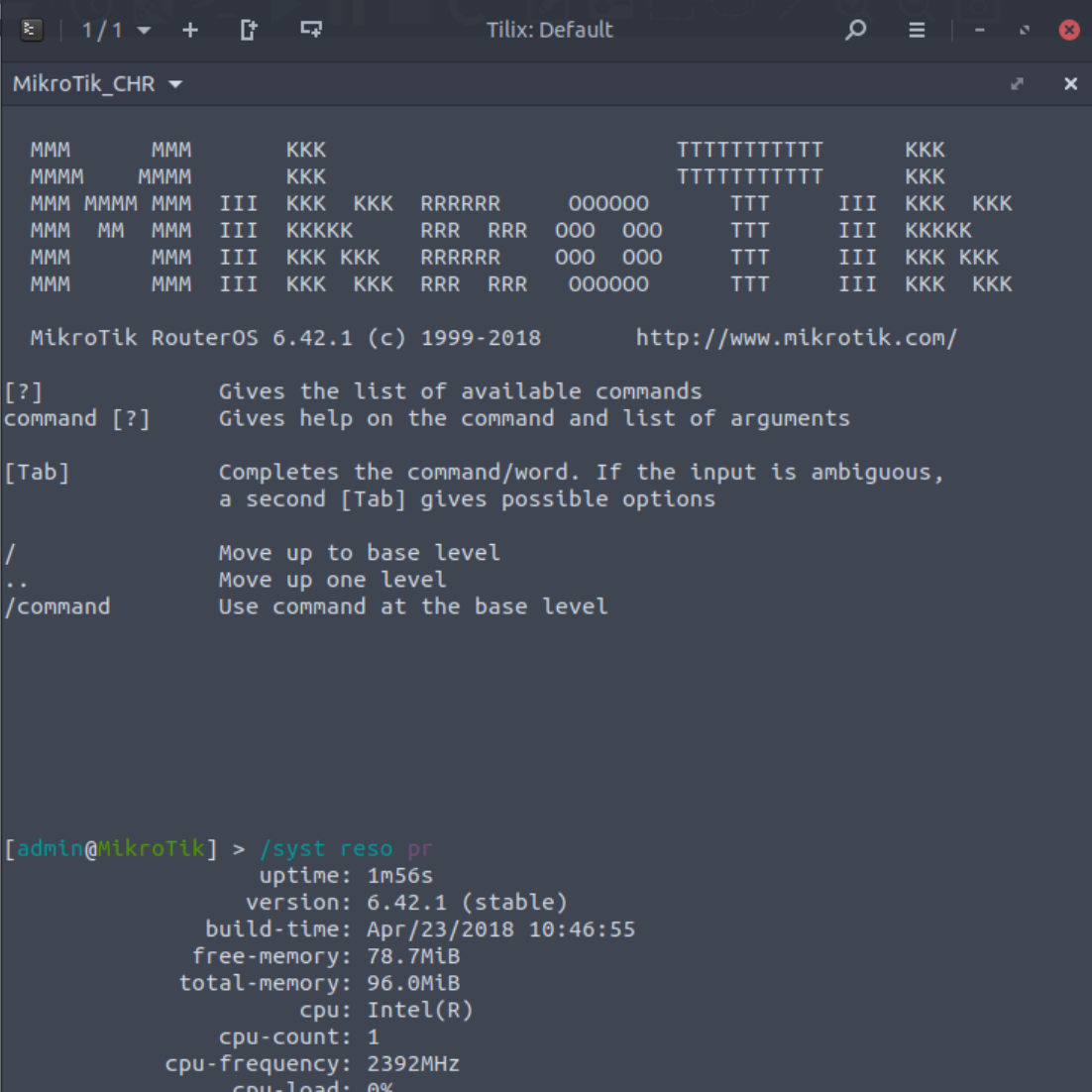
- Proprietárne API
 - Štandardne na portoch 8728 a 8729 (SSL)
 - Dostupné knižnice pre množstvo jazykov
 - Java, Python, Go, PHP...

- REST API
 - Vo verzii 7
 - Štandardne zakázané
 - Dostupné na porte 443
 - Ľahšie ovládateľné ako proprietárne API
 - Nie sú potrebné špeciálne knižnice



CLI

- Dostupná cez SSH, Telnet, WinBox
- Na vyšších modeloch aj RJ45 sériová konzola
- Odporúčané používať namiesto GUI utilít
- Oficiálna dokumentácia sa odkazuje len na CLI



```
Tilix: Default
MikroTik_CHR
MMM      MMM      KKK      TTTTTTTTTT      KKK
MMMM     MMMM     KKK      TTTTTTTTTT      KKK
MMM MMMM  MMM  III  KKK  KKK  RRRRRR   000000   TTT   III  KKK  KKK
MMM  MM  MMM  III  KKKKK  RRR  RRR  000  000   TTT   III  KKKKK
MMM      MMM  III  KKK  KKK  RRRRRR   000  000   TTT   III  KKK  KKK
MMM      MMM  III  KKK  KKK  RRR  RRR   000000   TTT   III  KKK  KKK

MikroTik RouterOS 6.42.1 (c) 1999-2018      http://www.mikrotik.com/

[?]          Gives the list of available commands
command [?]  Gives help on the command and list of arguments

[Tab]        Completes the command/word. If the input is ambiguous,
              a second [Tab] gives possible options

/            Move up to base level
..          Move up one level
/command     Use command at the base level

[admin@MikroTik] > /syst reso pr
              uptime: 1m56s
              version: 6.42.1 (stable)
              build-time: Apr/23/2018 10:46:55
              free-memory: 78.7MiB
              total-memory: 96.0MiB
              cpu: Intel(R)
              cpu-count: 1
              cpu-frequency: 2392MHz
              cpu-load: 0%
```



RouterOS – základná konfigurácia

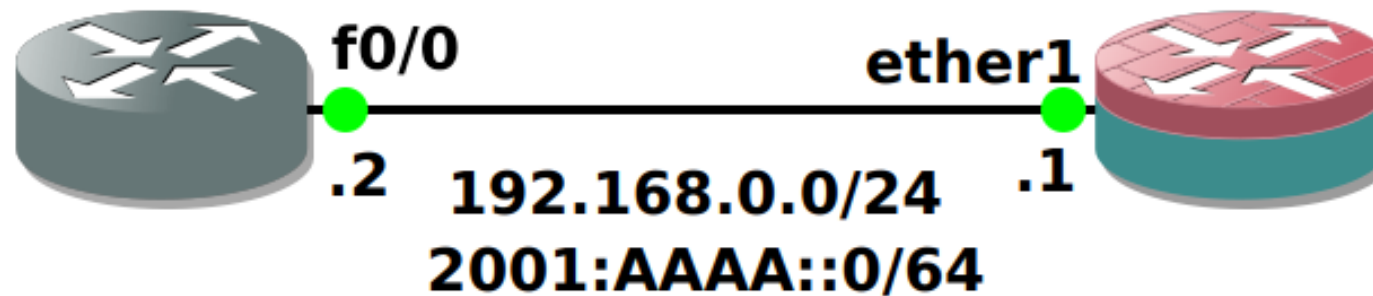
Topológia

- Cisco 7200
 - IOS 15.2(4)M11

- MikroTik CHR
 - RouterOS 7.2.1

Cisco_c7200

MikroTik_CHR



lo0: 192.168.20.2/24
2001:ACAD:20::2/64

lo1: 192.168.21.2/24
2001:ACAD:21::2/64

lo0: 192.168.10.1/24
2001:ABBA:10::1/64

lo1: 192.168.11.1/24
2001:ABBA:11::1/64

Prvé pripojenie

- Pri prvom pripojení je potrebné sa prihlásiť
 - Default je admin, žiadne heslo

```

...
MikroTik 7.2.1 (stable)
MikroTik Login: admin
Password:

  MMMM   MMMM   KKK           TTTTTTTTTTT   KKK
  MMM MMMM MMM III KKK KKK RRRRRR   000000   TTT   III KKK KKK
  MMM MM  MMM III KKKKK   RRR RRR  000 000   TTT   III KKKKK
  MMM     MMM III KKK KKK RRRRRR   000 000   TTT   III KKK KKK
  MMM     MMM III KKK KKK RRR RRR   000000   TTT   III KKK KKK

MikroTik RouterOS 7.2.1 (c) 1999-2022      http://www.mikrotik.com/

[?]          Gives the list of available commands
command [?]  Gives help on the command and list of arguments

[Tab]        Completes the command/word. If the input is ambiguous,
              a second [Tab] gives possible options

/            Move up to base level
..           Move up one level
/command     Use command at the base level

[admin@MikroTik] >

```

CLI

- Na rozdiel od Cisco IOS
 - CLI nie je rozdelené do režimov
 - organizované ako stromová štruktúra
 - Nemá running a startup konfig
 - Zadané príkazy sú okamžite uložené
- /
 - interface
 - bonding
 - bridge
 - ethernet
 - ip
 - address
 - dhcp-server
 - route
 - firewall
 - nat
 - ipv6
 - log
 - routing
 - system
 - package
 - reboot

Pohyb v stromovej štruktúre

- <tab> - dopĺňa príkazy / zobrazuje možné kľúčové slová
- <enter> - vstúpi do úrovne štruktúry / spustenie príkazu
- ? – zobrazí popis príkazu
- .. – o úroveň vyššie
- / - späť do koreňa

```
[admin@MikroTik] > /ip address <tab>
add comment disable edit enable export find print remove set
...
[admin@MikroTik] > /ip ?
.. -- go up to root
address -- Address management
dhcp-client -- DHCP client settings
dhcp-server -- DHCP server settings
firewall -- Firewall management
route -- Route management
...
[admin@MikroTik] > /ip address <enter>
[admin@MikroTik] /ip address> ..
[admin@MikroTik] /ip > ..
[admin@MikroTik] /ip address> /
[admin@MikroTik] >
```

Farby v CLI

- červená – příkaz zle zadaný
- tyrkysová – příkaz správně zadaný/menu stromu
- zelená – parametre příkazu (povinné parametre označené tučným písmom)
- fialová – příkazy v každej úrovni stromu (add, set, enable, export...)

```
[admin@MikroTik] > /ip adress
...
[admin@MikroTik] > /ip add
...
[admin@MikroTik] > /ip address add address=192.168.10.1/24 interface=ether1
...
[admin@MikroTik] > /ip address add <tab>
broadcast comment copy-from disabled netmask network address interface
...
[admin@MikroTik] > /interface <tab>
6to4 ipip ppp-client vlan export
bonding ipipv6 ppp-server vpls find
bridge l2tp-client pppoe-client vrrp monitor-traffic
detect-internet l2tp-server pppoe-server wireless print
eosp list pptp-client blink reset-counters
eospv6 lte pptp-server comment set
ethernet mesh sstp-client disable
gre ovpn-client sstp-server edit
gre6 ovpn-server traffic-eng enable
```


Zobrazenie konfigurácie

- /export – kompletná konfigurácia
- príkaz export v konkrétnej časti stromu – konfigurácia iba časti stromu

```
[admin@MikroTik] > /export
# apr/15/2022 12:46:47 by RouterOS 7.2.1
#
/interface bridge
add name=lo0
/interface ethernet
set [ find default-name=ether2 ] name=ether1
set [ find default-name=ether1 ] name=ether2
/ip address
add address=192.168.20.1/24 interface=lo0 network=192.168.20.0
/ip dhcp-client
add disabled=no interface=ether2
/ipv6 address
add address=fd00::1 interface=lo0
...
[admin@MikroTik] > /ip address export
# may/15/2022 12:51:07 by RouterOS 7.2.1
#
/ip address
add address=192.168.20.1/24 interface=lo0 network=192.168.20.0
```

Zobrazenie používateľov a zmena hesla

- `/user print` – zobrazenie používateľov
- `/user set <meno> password=<heslo>` – zmena hesla
- už nastavené heslo nie je možné zobrazit'

```
[admin@MikroTik] > /user print
Flags: X - disabled
#  NAME                GROUP                ADDRESS                LAST-LOGGED-IN
0  ;;; system default user
   admin                full                 apr/15/2020 11:02:46
[admin@MikroTik] >

...

[admin@MikroTik] > /user set admin password=tazkeheslo
```

Zmena hostname

- `/system identity set name=<hostname>` – zmena hostname

```
[admin@MikroTik] > /system identity print  
name: MikroTik
```

```
...
```

```
[admin@MikroTik] > /system identity set name=RouterMikrotik
```

```
...
```

```
[admin@RouterMikrotik] > /system identity print  
name: RouterMikrotik
```

Zakázanie telnetu + zmena SSH portu

- `/ip service print` – ktoré služby bežia na akých portoch

```
[admin@MikroTik] > /ip service print
Flags: X - disabled, I - invalid
#  NAME      PORT ADDRESS          CERTIFICATE
0  telnet    23
3  ssh      22
...
[admin@MikroTik] > /ip service disable telnet
[admin@MikroTik] > /ip service set ssh port=2222
...

[admin@MikroTik] > /ip service print
Flags: X - disabled, I - invalid
#  NAME      PORT ADDRESS          CERTIFICATE
0  XI telnet  23
1  ftp      21
2  www      80
3  ssh     2222
```



Práca s rozhraniami

Zobrazenie zapnutie a vypnutie rozhraní

- `/interface print` – zobrazenie rozhraní
- `/interface enable <nazov>` – zapnutie rozhrania
- `/interface disable numbers=0,1` – vypnutie rozhraní s indexom 0 a 1

```
[admin@MikroTik] > /interface print
Flags: D - dynamic, X - disabled, R - running, S - slave
#      NAME      TYPE      ACTUAL-MTU  L2MTU
0  R  ether1      ether      1500
1  R  ether2      ether      1500
...
[admin@MikroTik] > /interface disable ether1
[admin@MikroTik] > /interface disable numbers=0,1
[admin@MikroTik] > /interface enable ether2
...
[admin@MikroTik] > /interface print
Flags: D - dynamic, X - disabled, R - running, S - slave
#      NAME      TYPE      ACTUAL-MTU  L2MTU
0  X  ether1      ether      1500
1  R  ether2      ether      1500
```

Loopback rozhranie

- RouterOS nemá samostatné loopback rozhrania
- emulácia funkcionality pridaním bridge rozhrania bez asociovania bridge portov
- `/interface bridge add name=lo0` – vytvorí bridge rozhranie s názvom lo0

```
[admin@MikroTik] > /interface bridge add name=lo0
...
[admin@MikroTik] > /interface print
Flags: D - dynamic, X - disabled, R - running, S - slave
#      NAME      TYPE      ACTUAL-MTU  L2MTU
0  X  ether1      ether      1500
1  R  ether2      ether      1500
2  R  lo0         bridge     1500 65535
...
[admin@MikroTik] > interface bridge print brief
Flags: X - disabled, R - running
#      NAME      MTU  ACTUAL-MTU  L2MTU
0  R  lo0         auto      1500 65535
```

Softvérový prepínač

- na niektorých zariadeniach akcelerovaný hardvérom
- `/interface bridge add name=switch1` – vytvorí switch
- `/interface bridge port add bridge=switch1 interface=ether1` – pridá rozhranie ako port switchu

```
[admin@MikroTik] > /interface bridge add name=switch1
[admin@MikroTik] > /interface bridge port add bridge=switch1 interface=ether1
[admin@MikroTik] > /interface bridge port add bridge=switch1 interface=ether2
...
[admin@MikroTik] > /interface print
Flags: D - dynamic, X - disabled, R - running, S - slave
#      NAME          TYPE          ACTUAL-MTU  L2MTU
0  RS ether1        ether          1500
1  RS ether2        ether          1500
3  R  switch1        bridge         1500 65535
```

Softvérový prepínač - VLANy

- ether1 – trunk port (native VLAN 1)
- ether2 – access port VLAN 20

```
[admin@MikroTik] > /interface bridge add name=switch1 vlan-filtering=yes
[admin@MikroTik] > /interface bridge port add bridge=switch1 interface=ether1
[admin@MikroTik] > /interface bridge port add bridge=switch1 interface=ether2 pvid=20
[admin@MikroTik] > /interface bridge vlan add bridge=switch1 tagged=ether1
untagged=ether2 vlan-ids=20
...
[admin@MikroTik] > /interface bridge vlan print
Flags: X - disabled, D - dynamic
```

#	BRIDGE	VLAN-IDS	CURRENT-TAGGED	CURRENT-UNTAGGED
0	D switch1	1		switch1 ether1
1	switch1	20	ether1	ether2

VLAN rozhrania

- interface fa0/1.<VLAN ID> – na Cisco zariadení (router)
- interface vlan <VLAN ID> – na Cisco zariadení (switch)
- /interface vlan add interface=<rozhranie> vlan-id=<id> – vytvorí vln rozhranie na rozhraní “rozhranie” s VLAN ID “id”

```
[admin@MikroTik] > /interface vlan add interface=ether1 vlan-id=10 name=ether1.10
[admin@MikroTik] > /interface vlan add interface=switch1 vlan-id=20 name=vlan20
...
```

```
[admin@MikroTik] > /interface vlan print
Flags: X - disabled, R - running, S - slave
```

#	NAME	MTU	ARP	VLAN-ID	INTERFACE
0	R ether1.10	1500	enabled	10	ether1
1	R vlan20	1500	enabled	20	switch1

Etherchannel

- `/interface bonding add name=bond0 slaves=ether1,ether2 mode=802.3ad`
 - vytvorí Etherchannel rozhranie s názvom „bond0“
 - zlúči rozhrania „ether1“ a „ether2“
 - režim Etherchannelu je „802.3ad“ (LACP)

```
[admin@MikroTik] > /interface bonding add name=bond0 slaves=ether1,ether2
mode=802.3ad
```

```
...
```

```
[admin@MikroTik] > /interface bonding print
```

```
Flags: X - disabled, R - running
```

```
0 R name="bond0" mtu=1500 mac-address=08:00:27:11:79:8A arp=enabled
  arp-timeout=auto slaves=ether1,ether2 mode=802.3ad primary=none
  link-monitoring=mii arp-interval=100ms arp-ip-targets=""
  mii-interval=100ms down-delay=0ms up-delay=0ms lacp-rate=30secs
  transmit-hash-policy=layer-2 min-links=0
```

CDP

```
[admin@MikroTik] > /ip neighbor print detail
0 interface=ether1 address=192.168.0.2 address4=192.168.0.2
  mac-address=CA:01:23:EF:00:00 identity="Cisco_c7200"
  platform="Cisco 7206VXR"
  version="Cisco IOS Software, 7200 Software (C7200-ADVENTERPRISEK9-M),
    Version 15.2(4)M11, RELEASE SOFTWARE (fc2)\nTechnical Support:
    http://www.cisco.com/techsupport\nCopyright (c) 1986-2016 by Cisco
    Systems, Inc.\nCompiled Sun 16-Oct-16 07:53 by prod_rel_team"
  unpack=none age=27s interface-name="FastEthernet0/0" system-caps=""
  system-caps-enabled=""
```

```
Cisco_c7200#show cdp neighbors detail
-----
Device ID: MikroTik
Entry address(es):
  IP address: 192.168.0.1
Platform: MikroTik, Capabilities: Router
Interface: FastEthernet0/0, Port ID (outgoing port): ether1
Holdtime : 112 sec

Version :
7.2.1 (stable)

advertisement version: 1
```




IPv4 adresácia

Pridanie, odobranie a zobrazenie IPv4 adres na rozhraniach

- `/ip address add address=192.168.11.1/24 interface=lo1` – pridá IP na rozhranie
- `/ip address remove numbers=2` – odobranie položky s indexom 2 s položiek IP adres

```
[admin@MikroTik] > /ip address add address=192.168.11.1/24 interface=lo1
...
[admin@MikroTik] > /ip address print
Flags: X - disabled, I - invalid, D - dynamic
#   ADDRESS           NETWORK           INTERFACE
0   192.168.0.1/24      192.168.0.0       ether1
1   192.168.10.1/24     192.168.10.0      lo0
2   192.168.11.1/24    192.168.11.0      lo1
...
[admin@MikroTik] > /ip address remove numbers=2
[admin@MikroTik] > /ip address remove [find interface=lo0]
...
[admin@MikroTik] > /ip address print
Flags: X - disabled, I - invalid, D - dynamic
#   ADDRESS           NETWORK           INTERFACE
0   192.168.10.1/24     192.168.10.0      lo0
1   192.168.0.1/24     192.168.0.0       ether1
```

Cisco na druhej strane

- Zapnutie rozhrania a nastavenie IPv4 adresy

```
Cisco_c7200(config)#interface FastEthernet0/0  
Cisco_c7200(config-if)#no shutdown  
Cisco_c7200(config-if)#ip address 192.168.0.2 255.255.255.0
```

Overenie

```
[admin@MikroTik] > ping 192.168.0.2 count=4
SEQ HOST                                SIZE TTL TIME  STATUS
  0 192.168.0.2                          56 255 21ms
  1 192.168.0.2                          56 255  9ms
  2 192.168.0.2                          56 255  7ms
  3 192.168.0.2                          56 255  6ms
sent=4 received=4 packet-loss=0% min-rtt=6ms avg-rtt=10ms max-rtt=21ms
```

```
Cisco_c7200#ping 192.168.0.1
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 192.168.0.1, timeout is 2 seconds:
```

```
!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/63/68 ms
```

```
R1#
```

Smerovacia tabuľka RouterOS

```
[admin@MikroTik] > /ip route print  
Flags: X - disabled, A - active, D - dynamic,  
C - connect, S - static, r - rip, b - bgp, o - ospf, m - mme,  
B - blackhole, U - unreachable, P - prohibit
```

#		DST-ADDRESS	PREF-SRC	GATEWAY	DISTANCE
0	ADC	192.168.0.0/24	192.168.0.1	ether1	0
1	ADC	192.168.10.0/24	192.168.10.1	lo0	0
2	ADC	192.168.11.0/24	192.168.11.1	lo1	0

Smerovacia tabuľka Cisco

```
Cisco_c7200#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

Gateway of last resort is not set

```

192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.0.0/24 is directly connected, FastEthernet0/0
L      192.168.0.2/32 is directly connected, FastEthernet0/0
192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.20.0/24 is directly connected, Loopback0
L      192.168.20.2/32 is directly connected, Loopback0
192.168.21.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.21.0/24 is directly connected, Loopback1
L      192.168.21.2/32 is directly connected, Loopback1
```



IPv6 adresácia

Povolenie IPv6 (vo verzii 6)

- IPv6 funkcionálnosť je štandardne vypnutá (vo v7 štandardne zapnutá)
- je potrebné povoliť softvérový balíček ipv6 a reštartovať zariadenie
- /system package print - vypíše dostupné balíčky
- /system package enable ipv6 - povolí IPv6 balíček
- /system reboot - reštartuje zariadenie

```
[admin@MikroTik] > /system package print
Flags: X - disabled
#   NAME                VERSION                SCHEDULED
0   routeros-x86         6.46.5
1   system                6.46.5
2 X ipv6                 6.46.5
...
[admin@MikroTik] > /system package enable ipv6
...
[admin@MikroTik] > /system package print
Flags: X - disabled
#   NAME                VERSION                SCHEDULED
2 X ipv6                 6.46.5                scheduled for enable
...
[admin@MikroTik] > /system reboot
Reboot, yes? [y/N]:
y
system will reboot shortly
```

Nastavenie a overenie IPv6 adres na rozhraniach

```
[admin@MikroTik] > /ipv6 address add address=2001:AAAA::1/64 interface=ether1
[admin@MikroTik] > /ipv6 address add address=2001:ABBA:10::1/64 interface=lo0
[admin@MikroTik] > /ipv6 address add address=2001:ABBA:11::1/64 interface=lo1

...

[admin@MikroTik] > /ipv6 address print
Flags: X - disabled, I - invalid, D - dynamic, G - global, L - link-local
#   ADDRESS                               FROM-... INTERFACE      ADV
0 DL fe80::8450:c9ff:fef0:2edc/64         lo1             no
1 DL fe80::50b2:b8ff:febe:429a/64         lo0             no
2 DL fe80::a00:27ff:fe11:798a/64         ether1          no
3 G 2001:aaaa::1/64                       ether1          yes
4 G 2001:abba:10::1/64                     lo0             yes
5 G 2001:abba:11::1/64                     lo1             yes
```

Cisco na drugej strani

```
Cisco_c7200(config)#ipv6 unicast-routing
Cisco_c7200(config)#ipv6 cef
...
Cisco_c7200(config-if)#interface fastEthernet 0/0
Cisco_c7200(config-if)#ipv6 address 2001:aaaa::2/64
...
Cisco_c7200(config-if)#int loopback 0
Cisco_c7200(config-if)#ipv6 address 2001:acad:20::2/64
...
Cisco_c7200(config-if)#int loopback 1
Cisco_c7200(config-if)#ipv6 address 2001:acad:21::2/64
```

Overenie

```
[admin@MikroTik] > ping 2001:aaaa::2
  SEQ HOST                                SIZE TTL  TIME   STATUS
  0 2001:aaaa::2                          56  64  8ms   echo reply
  1 2001:aaaa::2                          56  64  7ms   echo reply
  2 2001:aaaa::2                          56  64 10ms   echo reply
  3 2001:aaaa::2                          56  64  9ms   echo reply
  4 2001:aaaa::2                          56  64 10ms   echo reply
  5 2001:aaaa::2                          56  64  9ms   echo reply
  6 2001:aaaa::2                          56  64  9ms   echo reply
  7 2001:aaaa::2                          56  64 10ms   echo reply
  8 2001:aaaa::2                          56  64  9ms   echo reply
  9 2001:aaaa::2                          56  64  8ms   echo reply
sent=10 received=10 packet-loss=0% min-rtt=7ms avg-rtt=8ms max-rtt=10ms
```

```
Cisco_c7200#ping 2001:aaaa::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2001:AAAA::1, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/6/8 ms
```

Smerovacia tabuľka IPv6

```
[admin@MikroTik] > /ipv6 route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, o - ospf, b - bgp, U - unreachable
#      DST-ADDRESS      GATEWAY      DISTANCE
0 ADC  2001:aaaa::/64    ether1       0
1 ADC  2001:abba:10::/64  lo0          0
2 ADC  2001:abba:11::/64  lo1          0
```

Smerovacia tabuľka na Cisco

```
Cisco_c7200#show ipv6 route
IPv6 Routing Table - default - 7 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
        B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
        H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
        IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
        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, I - LISP
C 2001:AAAA::/64 [0/0]
  via FastEthernet0/0, directly connected
L 2001:AAAA::2/128 [0/0]
  via FastEthernet0/0, receive
C 2001:ACAD:20::/64 [0/0]
  via Loopback0, directly connected
L 2001:ACAD:20::2/128 [0/0]
  via Loopback0, receive
C 2001:ACAD:21::/64 [0/0]
  via Loopback1, directly connected
L 2001:ACAD:21::2/128 [0/0]
  via Loopback1, receive
L FF00::/8 [0/0]
  via Null0, receive
```



REST API

Povolenie REST API (vo verzii 7)

- Dostupné len cez HTTPs -> štandardne vypnuté -> získať certifikát
- Vytvorte si certifikát certifikačnej authority
- Certifikát podpíšte
- Vytvorte certifikát pre smerovač.
- Certifikát podpíšte certifikačnou autoritou
- Povoľte HTTPS a nastavte mu vygenerovaný certifikát
- Rest API následne dostupné na: <https://IP/rest>

```
[admin@MikroTik] > /certificate add name=LocalCA common-name=LocalCA key-usage=key-  
cert-sign,crl-sign  
[admin@MikroTik] > /certificate sign LocalCA  
[admin@MikroTik] > /certificate add name=REST common-name=192.168.1.10  
[admin@MikroTik] > /certificate sign REST ca=LocalCA  
[admin@MikroTik] > /ip service set www-ssl certificate=REST disabled=no
```



DHCP

DHCP server

- vytvorenie poolu, z ktorého sa budú IP prideliť
- nastavenie gateway a dns servera siete
- zapnutie dhcp servera

```
[admin@MikroTik] > /ip pool add name=dhcp1 ranges=192.168.0.10-192.168.0.20
[admin@MikroTik] > /ip dhcp-server network add address=192.168.0.0/24 gateway=192.168.0.1 dns-server=8.8.8.8
[admin@MikroTik] > /ip dhcp-server add name=dhcp-server1 address-pool=dhcp1 interface=ether1 disabled=no
...
[admin@MikroTik] > /ip dhcp-server print
Flags: D - dynamic, X - disabled, I - invalid
#   NAME           INTERFACE      RELAY          ADDRESS-POOL    LEASE-TIME  ADD-ARP
0   dhcp-s... ether1          dhcp1          dhcp1          10m
[admin@MikroTik] > /ip dhcp-server network print
Flags: D - dynamic
#   ADDRESS          GATEWAY        DNS-SERVER      WINS-SERVER     DOM
0   192.168.0.0/24    192.168.0.1    8.8.8.8
```

DHCP server - overenie

```
[admin@MikroTik] > /ip dhcp-server lease print detail
Flags: X - disabled, R - radius, D - dynamic, B - blocked
 0 D address=192.168.0.20 mac-address=CA:01:23:EF:00:00
   client-id="cisco-ca01.23ef.0000-Fa0/0" address-lists=""
   server=dhcp-server1 dhcp-option="" status=bound expires-after=9m22s
   last-seen=38s active-address=192.168.0.20
   active-mac-address=CA:01:23:EF:00:00
   active-client-id="cisco-ca01.23ef.0000-Fa0/0" active-server=dhcp-server1
   host-name="Cisco_c7200"
```

```
*May  2 21:45:39.951: %DHCP-6-ADDRESS_ASSIGN: Interface FastEthernet0/0 assigned DHCP
address 192.168.0.20, mask 255.255.255.0, hostname Cisco_c7200
```

```
Cisco_c7200#show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.0.20	YES	DHCP	up	up
Loopback0	192.168.20.2	YES	manual	up	up
Loopback1	192.168.21.2	YES	manual	up	up

DHCP klient + overenie

```
[admin@MikroTik] > /ip dhcp-client add interface=ether1 disabled=no
...
[admin@MikroTik] > /ip dhcp-client print
Flags: X - disabled, I - invalid, D - dynamic
#   INTERFACE          USE ADD-DEFAULT-ROUTE STATUS      ADDRESS
0   ether1             yes yes          searching...
```

```
[admin@MikroTik] > /ip dhcp-client print
Flags: X - disabled, I - invalid, D - dynamic
#   INTERFACE          USE ADD-DEFAULT-ROUTE STATUS      ADDRESS
0   ether1             yes yes          bound      192.168.0.1/24
...
[admin@MikroTik] > /ip address print
Flags: X - disabled, I - invalid, D - dynamic
#   ADDRESS            NETWORK          INTERFACE
0   192.168.10.1/24     192.168.10.0    lo0
1   192.168.11.1/24     192.168.11.0    lo1
2 D 192.168.0.1/24     192.168.0.0     ether1
```



NAT

Statický NAT (preklad 1:1)

- vonkajší interface, IP – ether1, fastEthernet0/0, 158.193.152.100
- vnútorný interface, IP – ether2, fastEthernet0/1, 192.168.10.254
- na rozdiel od Cisco, musí byť IP pridaná na vonkajšom rozhraní

```
[admin@MikroTik] > /ip address add address=158.193.152.100/28 interface=ether1
[admin@MikroTik] > /ip firewall nat add chain=srcnat src-address=192.168.10.254
action=src-nat to-addresses=158.193.152.100
[admin@MikroTik] > /ip firewall nat add chain=dstnat dst-address=158.193.152.100
action=dst-nat to-addresses=192.168.10.254
```

```
Cisco_c7200(config)# interface fastEthernet0/0
Cisco_c7200(config-if)# ip nat outside
Cisco_c7200(config)# interface fastEthernet0/1
Cisco_c7200(config-if)# ip nat inside

Cisco_c7200(config)# ip nat inside source static 192.168.10.254 158.193.152.100
```


PNAT overload

- vonkajší interface – ether1, fastEthernet0/0
- vnútorný interface – ether2, fastEthernet0/1
- vnútorná sieť – 192.168.10.0/24

```
[admin@MikroTik] > /ip firewall nat add chain=srcnat src-address=192.168.10.0/24  
action=masquerade out-interface=ether1
```

```
Cisco_c7200(config)# interface fastEthernet0/0  
Cisco_c7200(config-if)# ip nat outside  
Cisco_c7200(config)# interface fastEthernet0/1  
Cisco_c7200(config-if)# ip nat inside  
  
Cisco_c7200(config)# access-list 1 permit ip 192.168.10.0 0.0.0.255 any  
  
Cisco_c7200(config)# ip nat inside source list 1 interface fastEthernet0/0 overload
```

Port forwarding

- vonkajší interface – ether1, fastEthernet0/0
- vnútorný interface – ether2, fastEthernet0/1
- HTTPS server IP – 192.168.10.254/24

```
[admin@MikroTik] > /ip firewall nat add chain=dstnat in-interface=ether1 dst-port=443  
protocol=tcp action=dst-nat to-addresses=192.168.10.254 to-ports=443
```

```
Cisco_c7200(config)# interface fastEthernet0/0  
Cisco_c7200(config-if)# ip nat outside  
Cisco_c7200(config)# interface fastEthernet0/1  
Cisco_c7200(config-if)# ip nat inside
```

```
Cisco_c7200(config)# ip nat inside source static tcp 192.168.10.254 443 interface  
fastEthernet0/0 443
```



PPPoE

PPPoE klient

- vonkajší interface – ether1, fastEthernet0/0
- PPPoE interface – WAN, Dialer1
- nezabudnúť pridať požadovanú formu NATu

```
[admin@MikroTik] > /interface pppoe-client add add-default-route=yes disabled=no
allow=pap,chap interface=ether1 name=WAN password=DSLtazkeHeslo user=MojeMeno
...
[admin@MikroTik] > /ip firewall nat add chain=srcnat src-address=192.168.10.0/24
action=masquerade out-interface=WAN
```

```
Cisco_c7200(config)# interface FastEthernet 0/0
Cisco_c7200(config-if)# no ip address
Cisco_c7200(config-if)# pppoe enable
Cisco_c7200(config-if)# pppoe-client dial-pool-number 1
Cisco_c7200(config-if)# no shut
...
Cisco_c7200(config)# interface Dialer1
Cisco_c7200(config-if)# ip address negotiated
Cisco_c7200(config-if)# ip nat outside
Cisco_c7200(config-if)# encapsulation ppp
Cisco_c7200(config-if)# dialer pool 1
Cisco_c7200(config-if)# ppp authentication chap pap callin
Cisco_c7200(config-if)# ppp pap sent-username MojeMeno password DSLtazkeHeslo
Cisco_c7200(config-if)# ppp chap hostname MojeMeno
Cisco_c7200(config-if)# ppp chap password DSLtazkeHeslo
Cisco_c7200(config-if)# no shut
...
Cisco_c7200(config)# access-list 1 permit ip 192.168.10.0 0.0.0.255 any
Cisco_c7200(config)# ip nat inside source list 1 interface Dialer1 overload
```



Statický routing

Statický routing – IPv4

- dst-address = cieľová sieť
- gateway = next-hop

```
[admin@MikroTik] > /ip route add dst-address=192.168.20.0/24 gateway=192.168.0.2
```

```
[admin@MikroTik] > /ip route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
#       DST-ADDRESS      PREF-SRC      GATEWAY          DISTANCE
0 ADC   192.168.0.0/24    192.168.0.1    ether1           0
1 ADC   192.168.11.0/24   192.168.11.1   lo1              0
2 A S   192.168.20.0/24   192.168.0.2    192.168.0.2     1
```

```
...
[admin@MikroTik] > ping 192.168.20.2
  SEQ HOST                      SIZE TTL TIME   STATUS
  0 192.168.20.2                  56 255 7ms
  1 192.168.20.2                  56 255 8ms
  2 192.168.20.2                  56 255 9ms
  3 192.168.20.2                  56 255 9ms
sent=4 received=4 packet-loss=0% min-rtt=7ms avg-rtt=8ms max-rtt=10ms
```

Statický routing – IPv6

- dst-address = cieľová sieť
- gateway = next-hop

```
[admin@MikroTik] > /ipv6 route add dst-address=2001:acad:20::0/64 gateway=2001:aaaa::2
```

```
[admin@MikroTik] > /ipv6 route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, o - ospf, b - bgp, U - unreachable
#      DST-ADDRESS      GATEWAY      DISTANCE
0 ADC  2001:aaaa::/64    ether1       0
1 ADC  2001:abba:10::/64  lo0          0
2 ADC  2001:abba:11::/64  lo1          0
3 A S  2001:acad:20::/64  2001:aaaa::2 1
```

...

```
[admin@MikroTik] > ping 2001:acad:20::2
```

SEQ	HOST	SIZE	TTL	TIME	STATUS
0	2001:acad:20::2	56	64	20ms	echo reply
1	2001:acad:20::2	56	64	7ms	echo reply
2	2001:acad:20::2	56	64	9ms	echo reply

sent=3 received=3 packet-loss=0% min-rtt=7ms avg-rtt=12ms max-rtt=20ms



OSPFv2 – single area

Pridanie inštancie

- Router ID sa nastavuje pre každú inštanciu zvlášť
- RouterOS obsahuje štandardne vypnutú inštanciu „default“, ktorú nie je možné zmazať
- meno OSPF inštancie je lokálne podobne ako číslo procesu na Cisco routroch

```
[admin@MikroTik] > /routing ospf instance set default router-id=192.168.10.1  
disabled=no
```

```
[admin@MikroTik] > /routing ospf instance print  
Flags: X - disabled, * - default  
0 X* name="default" router-id=0.0.0.0 distribute-default=never  
  redistribute-connected=no redistribute-static=no redistribute-rip=no  
  redistribute-bgp=no redistribute-other-ospf=no metric-default=1  
  metric-connected=20 metric-static=20 metric-rip=20 metric-bgp=auto  
  metric-other-ospf=auto in-filter=ospf-in out-filter=ospf-out
```

```
...  
[admin@MikroTik] > /routing ospf instance print  
Flags: X - disabled, * - default  
0 * name="default" router-id=192.168.10.1 distribute-default=never  
  redistribute-connected=no redistribute-static=no redistribute-rip=no  
  redistribute-bgp=no redistribute-other-ospf=no metric-default=1  
  metric-connected=20 metric-static=20 metric-rip=20 metric-bgp=auto  
  metric-other-ospf=auto in-filter=ospf-in out-filter=ospf-out
```

Pridanie rozhrania

- Rozhranie sa pridá do OSPF pomocou príkazu network
- Oblasť sa identifikuje menom, area 0 (0.0.0.0) má štandardne meno backbone

```
[admin@MikroTik] > /routing ospf network add network=192.168.0.0/24 area=backbone
```

```
[admin@MikroTik] > /routing ospf area print
Flags: X - disabled, I - invalid, * - default
#   NAME                AREA-ID                TYPE    DEFAULT-COST
0  * backbone           0.0.0.0                default
...
[admin@MikroTik] > /routing ospf network print
Flags: X - disabled, I - invalid
#   NETWORK              AREA
0   192.168.0.0/24       backbone
```

Konfigurácia Cisco IOS

```
Cisco_c7200(config)#router ospf 1
Cisco_c7200(config-router)#router-id 192.168.20.1
Cisco_c7200(config-router)#exit

Cisco_c7200(config)#interface FastEthernet0/0
Cisco_c7200(config-if)#ip ospf 1 area 0
Cisco_c7200(config-if)#
```

Overenie rozhraní

```
[admin@MikroTik] > /routing ospf interface print
Flags: X - disabled, I - inactive, D - dynamic, P - passive
#      INTERFACE          COST PRI NETWORK-TYPE  AUT... AUTHENTICATIO...
0 D ether1                10  1 broadcast    none
1 D lo0                   10  1 broadcast    none
```

```
Cisco_c7200#show ip ospf interface brief
Interface    PID   Area          IP Address/Mask    Cost   State  Nbrs  F/C
Lo0          1     0             192.168.20.2/24    1      LOOP  0/0
Fa0/0       1     0             192.168.0.2/24     1      BDR   1/1
```

Overenie susedov

```
[admin@MikroTik] > /routing ospf neighbor print
0 instance=default router-id=192.168.20.1 address=192.168.0.2 interface=ether1
priority=1 dr-address=192.168.0.1 backup-dr-address=192.168.0.2
state="Full" state-changes=5 ls-retransmits=0 ls-requests=0 db-summaries=0
adjacency=5m55s
```

```
Cisco_c7200#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.10.1	1	FULL/DR	00:00:31	192.168.0.1	FastEthernet0/0

Smerovacie tabuľky

```
[admin@MikroTik] > /ip route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
#       DST-ADDRESS      PREF-SRC      GATEWAY      DISTANCE
0 ADC   192.168.0.0/24     192.168.0.1   ether1        0
1 ADC   192.168.10.0/24    192.168.10.0  lo0           0
2 ADC   192.168.11.0/24    192.168.11.1  lo1           0
3 ADo   192.168.20.2/32    192.168.0.2   110
```

```
Cisco_c7200#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C    192.168.0.0/24 is directly connected, FastEthernet0/0
L    192.168.0.2/32 is directly connected, FastEthernet0/0
O    192.168.10.0/24 [110/11] via 192.168.0.1, 00:01:49, FastEthernet0/0
192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C    192.168.20.0/24 is directly connected, Loopback0
L    192.168.20.2/32 is directly connected, Loopback0
192.168.21.0/24 is variably subnetted, 2 subnets, 2 masks
C    192.168.21.0/24 is directly connected, Loopback1
L    192.168.21.2/32 is directly connected, Loopback1
```



OSPFv2 – multi area

Vytvorenie oblasti a pridanie rozhrania

- Vytvoríme oblasť 1
- Do oblasti 1 pridáme lo1 rozhrania

```
[admin@MikroTik] > /routing ospf area add name=area1 area-id=0.0.0.1
...
[admin@MikroTik] > /routing ospf area print
Flags: X - disabled, I - invalid, * - default
#      NAME                AREA-ID      TYPE      DEFAULT-COST
0  *  backbone                0.0.0.0     default
1      area1                0.0.0.1     default
```

```
[admin@MikroTik] > /routing ospf network add network=192.168.11.0/24 area=area1
...
[admin@MikroTik] > /routing ospf network print
Flags: X - disabled, I - invalid
#      NETWORK              AREA
0  192.168.0.0/24         backbone
1  192.168.10.0/24        backbone
2  192.168.11.0/24        area1
```


Overenie rozhraní

```
[admin@MikroTik] > /routing ospf interface print
Flags: X - disabled, I - inactive, D - dynamic, P - passive
#    INTERFACE          COST PRI NETWORK-TYPE  AUT... AUTHENTICATIO...
0 D  ether1              10  1 broadcast    none
1 D  lo0                 10  1 broadcast    none
2 D  lo1                 10  1 broadcast    none
```

```
Cisco_c7200#sh ip ospf interface brief
Interface    PID    Area          IP Address/Mask    Cost    State  Nbrs  F/C
Lo0          1      0             192.168.20.2/24    1      LOOP  0/0
Fa0/0       1      0             192.168.0.2/24     1      BDR   1/1
Lo1         1      1             192.168.21.2/24    1      LOOP  0/0
```

Overenie smerovacej tabuľky

```
[admin@MikroTik] > /ip route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
```

#		DST-ADDRESS	PREF-SRC	GATEWAY	DISTANCE
0	ADC	192.168.0.0/24	192.168.0.1	ether1	0
1	ADC	192.168.10.0/24	192.168.10.0	lo0	0
2	ADC	192.168.11.0/24	192.168.11.1	lo1	0
3	ADo	192.168.20.2/32		192.168.0.2	110
4	ADo	192.168.21.2/32		192.168.0.2	110

```
Cisco_c7200#show ip route
C       192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.0.0/24 is directly connected, FastEthernet0/0
L       192.168.0.2/32 is directly connected, FastEthernet0/0
O       192.168.10.0/24 [110/11] via 192.168.0.1, 00:00:03, FastEthernet0/0
O IA    192.168.11.0/24 [110/11] via 192.168.0.1, 00:00:03, FastEthernet0/0
C       192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.20.0/24 is directly connected, Loopback0
L       192.168.20.2/32 is directly connected, Loopback0
C       192.168.21.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.21.0/24 is directly connected, Loopback1
L       192.168.21.2/32 is directly connected, Loopback1
```



OSPFv2 – databázy

OSPF databáza na RouterOS

```
[admin@MikroTik] > /routing ospf lsa print
AREA          TYPE          ID            ORIGINATOR    SEQUENCE-NU...    AGE
backbone      router        192.168.10.1  192.168.10.1  0x80000005        320
backbone      router        192.168.20.1  192.168.20.1  0x80000005         82
backbone      network       192.168.0.1   192.168.10.1  0x80000002       1031
backbone      summary-n...  192.168.11.0  192.168.10.1  0x80000002        319
backbone      summary-n...  192.168.21.2  192.168.20.1  0x80000002         82
area1         router        192.168.10.1  192.168.10.1  0x80000002        320
area1         summary-n...  192.168.0.0   192.168.10.1  0x80000002        320
area1         summary-n...  192.168.10.0  192.168.10.1  0x80000002        320
area1         summary-n...  192.168.20.2  192.168.10.1  0x80000002        320
area1         summary-n...  192.168.21.2  192.168.10.1  0x80000002       136
...
[admin@MikroTik] > /routing ospf lsa print detail
instance=default area=backbone type=router id=192.168.10.1
  originator=192.168.10.1 sequence-number=0x80000005 age=360 checksum=0x2BCE
  options="E" body=
    flags=BORDER
      link-type=Stub id=192.168.10.0 data=255.255.255.0 metric=10
      link-type=Transit id=192.168.0.1 data=192.168.0.1 metric=10
...
```

OSPF databáza na Cisco IOS

```
Cisco_c7200#show ip ospf database
```

```
OSPF Router with ID (192.168.20.1) (Process ID 1)
```

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

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.10.1	192.168.10.1	412	0x80000005	0x002BCE	2
192.168.20.1	192.168.20.1	173	0x80000005	0x006B5F	2

```
Net Link States (Area 0)
```

Link ID	ADV Router	Age	Seq#	Checksum
192.168.0.1	192.168.10.1	1124	0x80000002	0x009DE9

```
Summary Net Link States (Area 0)
```

Link ID	ADV Router	Age	Seq#	Checksum
192.168.11.0	192.168.10.1	411	0x80000002	0x004A1F
192.168.21.2	192.168.20.1	173	0x80000002	0x0045F6

```
Router Link States (Area 1)
```

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.20.1	192.168.20.1	173	0x80000002	0x002191	1

```
Summary Net Link States (Area 1)
```

Link ID	ADV Router	Age	Seq#	Checksum
192.168.0.0	192.168.20.1	173	0x80000002	0x004112
192.168.10.0	192.168.20.1	173	0x80000002	0x003708
192.168.11.0	192.168.20.1	173	0x80000002	0x002C12
192.168.20.2	192.168.20.1	173	0x80000002	0x0050EC

```
...
```



OSPFv3 – single area

Pridanie inštancie a rozhrania

- na rozdiel od OSPFv2 sa rozhrania pridávajú cez príkaz interface

```
[admin@MikroTik] > /routing ospf-v3 instance set default router-id=192.168.10.1  
disabled=no
```

```
[admin@MikroTik] > /routing ospf-v3 interface add interface=ether1 area=backbone
```

Overenie rozhraní

```
[admin@MikroTik] > /routing ospf-v3 interface print
Flags: X - disabled, I - inactive, D - dynamic, P - passive
#      INTERFACE          AREA                COST  PRIORITY NETWORK-TYPE
0      ether1                backbone            10    1 default
1      lo0                   backbone            10    1 default
```

```
Cisco_c7200#show ipv6 ospf interface brief
Interface    PID   Area      Intf ID   Cost   State  Nbrs  F/C
Lo0          1     0         5         1     LOOP  0/0
Fa0/0       1     0         3         1     BDR   1/1
```


Overenie susedov

```
[admin@MikroTik] > /routing ospf-v3 neighbor print
0 instance=default router-id=192.168.21.2 address=fe80::c801:23ff:feef:0
  interface=ether1 priority=1 dr=192.168.10.1 backup-dr=192.168.21.2
  state="Full" state-changes=5 ls-retransmits=0 ls-requests=0 db-summaries=0
  adjacency=4m58s
```

```
Cisco_c7200#show ipv6 ospf neighbor
```

```
          OSPFv3 Router with ID (192.168.21.2) (Process ID 1)
```

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
192.168.10.1	1	FULL/DR	00:00:35	1	FastEthernet0/0



OSPFv3 – multi area

Vytvorenie oblasti a pridanie rozhrania

- Vytvoríme oblasť 1
- Do oblasti 1 pridáme lo1 rozhrania
- passive – pasívny interface
- network-type – typ rozhrania (broadcast, point-to-point)

```
[admin@MikroTik] > /routing ospf-v3 area add name=area1 area-id=0.0.0.1
...
[admin@MikroTik] > /routing ospf-v3 area print
Flags: X - disabled, I - invalid, * - default
#   NAME          AREA-ID        TYPE        DEFAULT-COST
0  * backbone      0.0.0.0        default
1   area1         0.0.0.1        default
```

```
[admin@MikroTik] > /routing ospf-v3 interface add interface=lo1 area=area1
...
[admin@MikroTik] > /routing ospf-v3 interface add interface=lo1 area=area1
passive=yes
...
[admin@MikroTik] > /routing ospf-v3 interface add interface=lo1 area=area1 network-
type=point-to-point
```

Overenie rozhraní

```
[admin@MikroTik] > /routing ospf-v3 interface print
Flags: X - disabled, I - inactive, D - dynamic, P - passive
#    INTERFACE          AREA                COST PRIORITY NETWORK-TYPE
0    ether1              backbone           10    1 default
1    lo0                 backbone           10    1 default
2    lo1                 area1              10    1 default
```

```
Cisco_c7200#show ipv6 ospf interface brief
Interface    PID    Area          Intf ID    Cost    State Nbrs F/C
Lo0          1     0             5          1     LOOP  0/0
Fa0/0       1     0             3          1     BDR   1/1
```

Overenie smerovacej tabuľky

```
[admin@MikroTik] > /ipv6 route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, o - ospf, b - bgp, U - unreachable
#       DST-ADDRESS          GATEWAY          DISTANCE
0 ADC   2001:aaaa::/64        ether1           0
1 ADC   2001:abba:10::/64     lo0              0
2 ADC   2001:abba:11::/64     lo1              0
3 ADo   2001:acad:21::2/128   fe80::c801:23ff:feef:...
```

```
Cisco_c7200#show ipv6 route
C   2001:AAAA::/64 [0/0]
    via FastEthernet0/0, directly connected
L   2001:AAAA::2/128 [0/0]
    via FastEthernet0/0, receive
O   2001:ABBA:10::/64 [110/11]
    via FE80::A00:27FF:FE11:798A, FastEthernet0/0
C   2001:ACAD:20::/64 [0/0]
    via Loopback0, directly connected
L   2001:ACAD:20::2/128 [0/0]
    via Loopback0, receive
C   2001:ACAD:21::/64 [0/0]
    via Loopback1, directly connected
L   2001:ACAD:21::2/128 [0/0]
    via Loopback1, receive
L   FF00::/8 [0/0]
    via Null0, receive
```



UNIVERSITY OF ŽILINA
Faculty of Management Science
and Informatics

Ďakujem za pozornosť.



Vytvorené v rámci projektu KEGA 026TUKE-4/2021