

IPv6 Routing Protocols



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Trainer

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- Πάνω από 70 trainings , 800+ μαθητές

IPv6 Basics



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Why IPv6 ?

- Οι διαθέσιμες διευθύνσεις IPv4 εξαντλούνται
- Διασύνδεση από άκρο σε άκρο
- Μειωμένη πολυπλοκότητα δικτύου
- Ασφάλεια

IPv6

- Το IPv6 αποτελείται από 8 πεδία με μήκος 16 bits
- Γραπτή σε δεκαεξαδικούς αριθμούς
- Διαχωρίζεται με colon ":"
- 2001:0db8:0be0:75a1:0000:0000:0000:0001

Compare IPv4 - IPv6

	IPv4	IPv6
Address space	32 bits	128 bits
Possible addresses	2^{32}	2^{128}
Address format	192.0.2.1	2001:db8:3:4:5:6:7:8
Header length	20 bytes	40 bytes
Header fields	14	8
	Δεκαδικό 0-9	Δεκαεξαδικό 0-9, A-F
IPsec	προαιρετικό	Υποχρεωτικό

Address Notation

- 2001:0db8:0be0:75a2:0000:0000:0000:0001
- Τα αρχικά μηδενικά μπορούν να διαγραφούν
 - 2001:db8:be0:75a2:0:0:0:1
- Τα διαδοχικά πεδία των μηδενικών μπορούν να αντικατασταθούν με “:”
 - 2001:db8:be0:75a2::1

Address Notation

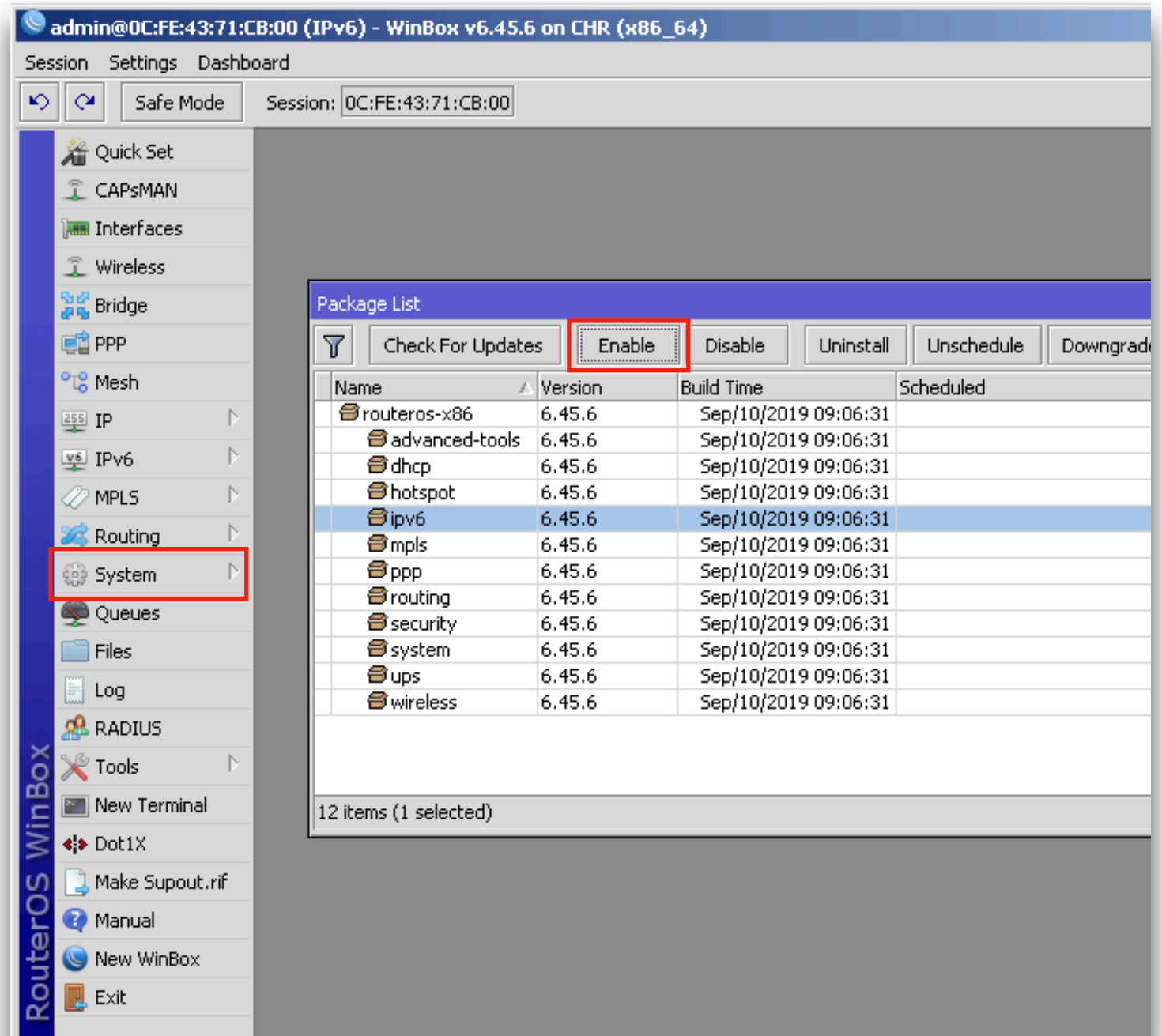
- 2001:0db8:0000:0000:0010:0000:0000:0001
- Αν υπάρχουν πολλά διαδοχικά πεδία με μηδενικά, μόνο ένα μπορεί να αντικατασταθεί
- 2001:db8::10:0:0:1 ή 2001:db8:0:0:10::1 (Η ίδια διεύθυνση IP. Και οι δύο είναι έγκυρες αλλά προτείνεται η πρώτη)

RouterOS και IPv6

- Ενεργοποίηση πρωτοκόλλου ipv6

/system package enable ipv6

/system reboot



Subnetting

2001:0db8:0be0:	75a2:	0000:0000:0000:0001
Routing prefix: 48 bits	Subnet:16	65536 x /64
2001:0db8:0be0:7	5a2:	0000:0000:0000:0001
Routing prefix: 52 bits	Subnet:12	4096 x /64
2001:0db8:0be0:75	a2:	0000:0000:0000:0001
Routing prefix: 56 bits	Subnet:8	256 x /64
2001:0db8:0be0:75a	2:	0000:0000:0000:0001
Routing prefix: 60 bits	Subnet:4	16 x /64

Address Types

Type	Range
Link Local	fe80::/10
Global unicast	2000::/3
Multicast	ff00::/8
Unique local	fc00::/7

Unique Local Address

- Δε χρησιμοποιείται ποτέ στο Internet
- fc00::/7 prefix έχει δεσμευτεί για ULA
- Διαιρείται σε fc00::/8 και fd00::/8
- Το fd00::/8 μέχρι στιγμής είναι το μόνο prefix που χρησιμοποιείται

EUI-64

- 64-bit extended unique identifier (EUI)
- Παράγεται από την 48-bit MAC address
- 00:0c:29:0c:47:d5
- + ff:fe
- 00:0c:29:ff:fe:0c:47:d5

Modified EUI-64

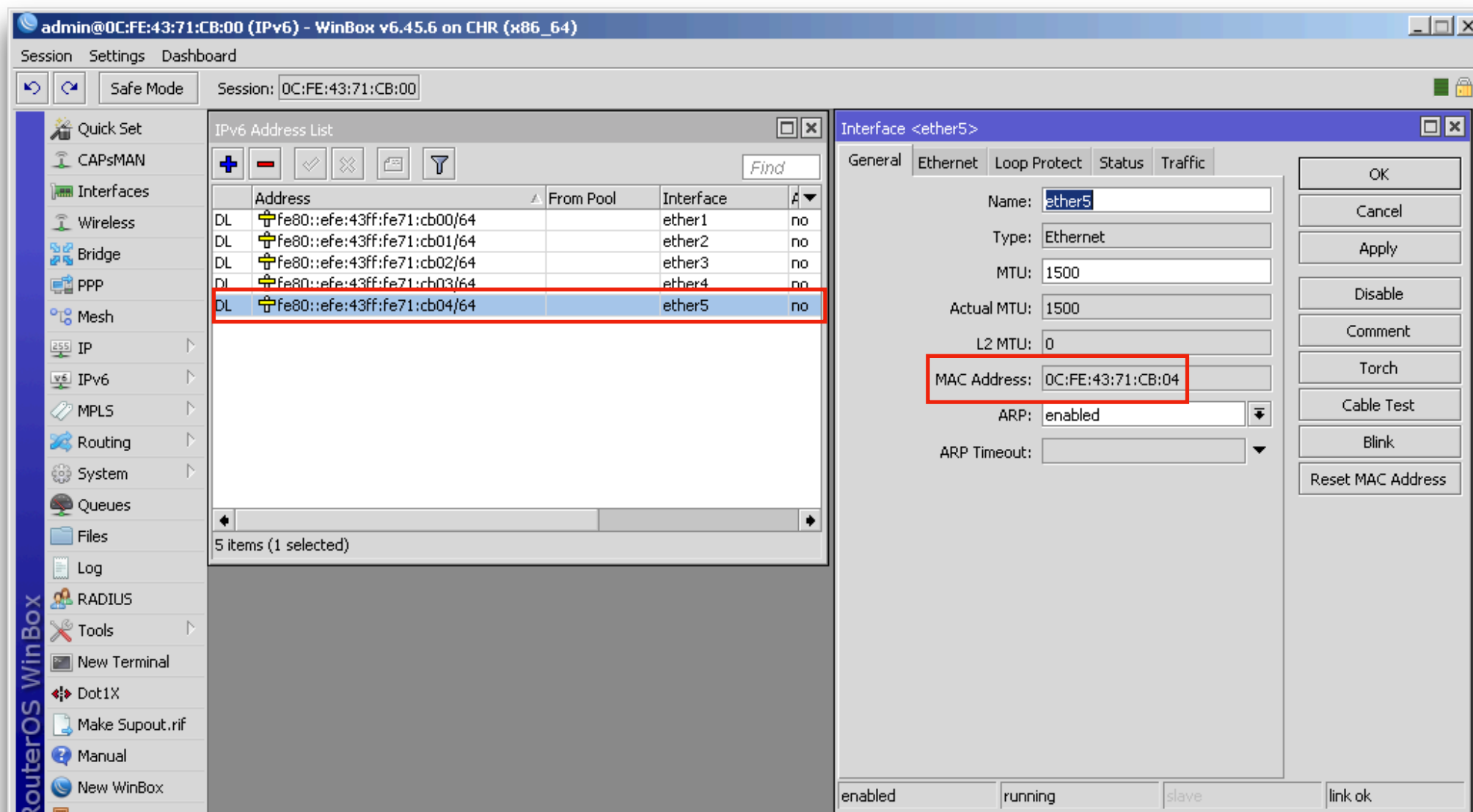
- Χρησιμοποιείται στο stateless address auto configuration (SLAAC)
- Το έβδομο bit από αριστερά (Universal/Local) πρέπει να αντιστραφεί
 - 00 (L) → 02 (U)
 - 02:0c:29:ff:fe:0c:47:d5

Modified EUI-64

- IPv6 prefix
 - 2001:db8:be0:75a2::/64
- Το τροποποιημένο EUI-64 από τη MAC address
 - 02:0c:29:ff:fe:0c:47:d5
- Αποτέλεσμα
 - 2001:db8:be0:75a2:020c:29ff:fe0c:47d5

Link Local Address

- **fe80::/64** + Interface ID (Modified EUI-64)
- Αντίστοιχη με το **169.254.0.0/16** σε IPv4



IPv6 Static Routing



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IPv6 Subnetting

- 2001:db8::1/120
- Μέγιστο μήκος IPv6 = **128bit**
- Μήκος πεδίου = **16bit**
- 2001:db8:0000:0000:0000:0000:0000:**0000** (**16bit**)
 - ffff:ffff:ffff:ffff:ffff:ffff:ffff:**0000**
 - ffff:ffff:ffff:ffff:ffff:ffff:ffff:**0001**
 - ffff:ffff:ffff:ffff:ffff:ffff:ffff:**ffff**

IPv6 Subnetting

- 2001:db8:0000:0000:0000:0000:0000:00**00** (**8bit**)
 - ffff:ffff:ffff:ffff:ffff:ffff:ffff:ff00
 - IPV6 Range
 - 2001:db8::**0**/120 -2001:db8::**FF**/120
 - 2001:db8::**100**/120 -2001:db8::**1FF**/120
 - 2001:db8::**200**/120 -2001:db8::**2FF**/120

IPv6 Address (Routers)

R1

```
/ipv6 address
```

```
add address=2001:db8::1/120 advertise=no interface=ether5  
add address=2001:db8::202/120 advertise=no interface=ether2  
add address=2001:db8::a01/120 advertise=no interface=ether4
```

R2

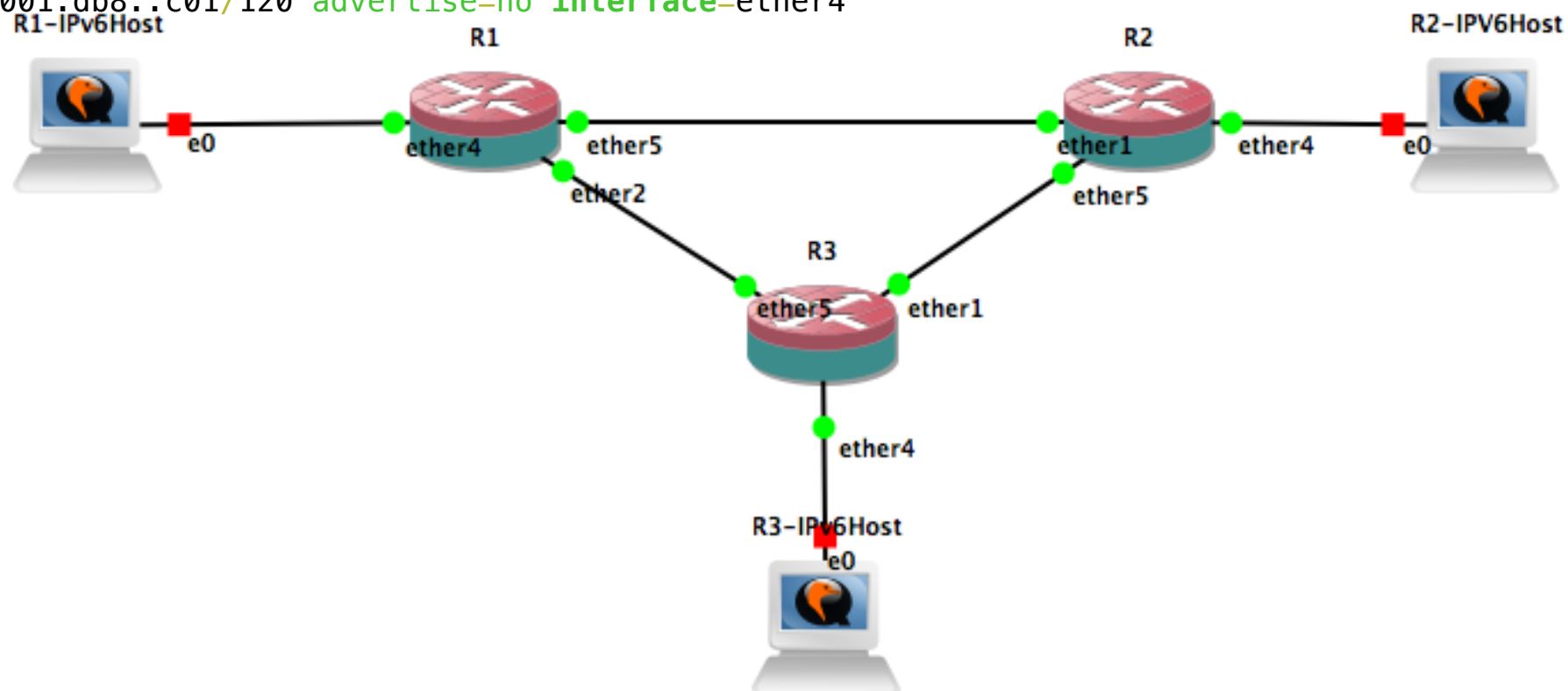
```
/ipv6 address
```

```
add address=2001:db8::2/120 advertise=no interface=ether1  
add address=2001:db8::101/120 advertise=no interface=ether5  
add address=2001:db8::b01/120 advertise=no interface=ether4
```

R3

```
/ipv6 address
```

```
add address=2001:db8::102/120 advertise=no interface=ether1  
add address=2001:db8::201/120 advertise=no interface=ether5  
add address=2001:db8::c01/120 advertise=no interface=ether4
```



IPv6 Address (R1)

IPv6 Address <2001:db8::1/120>

Address: 2001:db8::1/120

From Pool:

Interface: ether5

☐ EUI64
☐ Advertise
☐ No DAD

OK
Cancel
Apply
Disable
Comment
Copy
Remove

enabled Global

to R2

IPv6 Address <2001:db8::202/120>

Address: 2001:db8::202/120

From Pool:

Interface: ether2

☐ EUI64
☐ Advertise
☐ No DAD

OK
Cancel
Apply
Disable
Comment
Copy
Remove

enabled Global

to R3

IPv6 Address <2001:db8::a01/120>

Address: 2001:db8::a01/120

From Pool:

Interface: ether4

☐ EUI64
☐ Advertise
☐ No DAD

OK
Cancel
Apply
Disable
Comment
Copy
Remove

enabled Global

to IPv6Host

IPv6 ping (R1)

```
R1 — telnet 172.16.202.129 5013 — 82x18
[[admin@R1] > ping 2001:db8::2
SEQ HOST                                SIZE TTL TIME  STATUS
0 2001:db8::2                          56 255 0ms  echo reply
1 2001:db8::2                          56 255 0ms  echo reply
2 2001:db8::2                          56 255 0ms  echo reply
3 2001:db8::2                          56 255 0ms  echo reply
4 2001:db8::2                          56 255 0ms  echo reply
5 2001:db8::2                          56 255 0ms  echo reply
sent=6 received=6 packet-loss=0% min-rtt=0ms avg-rtt=0ms max-rtt=0ms

[admin@R1] > 
```

R1 to R2

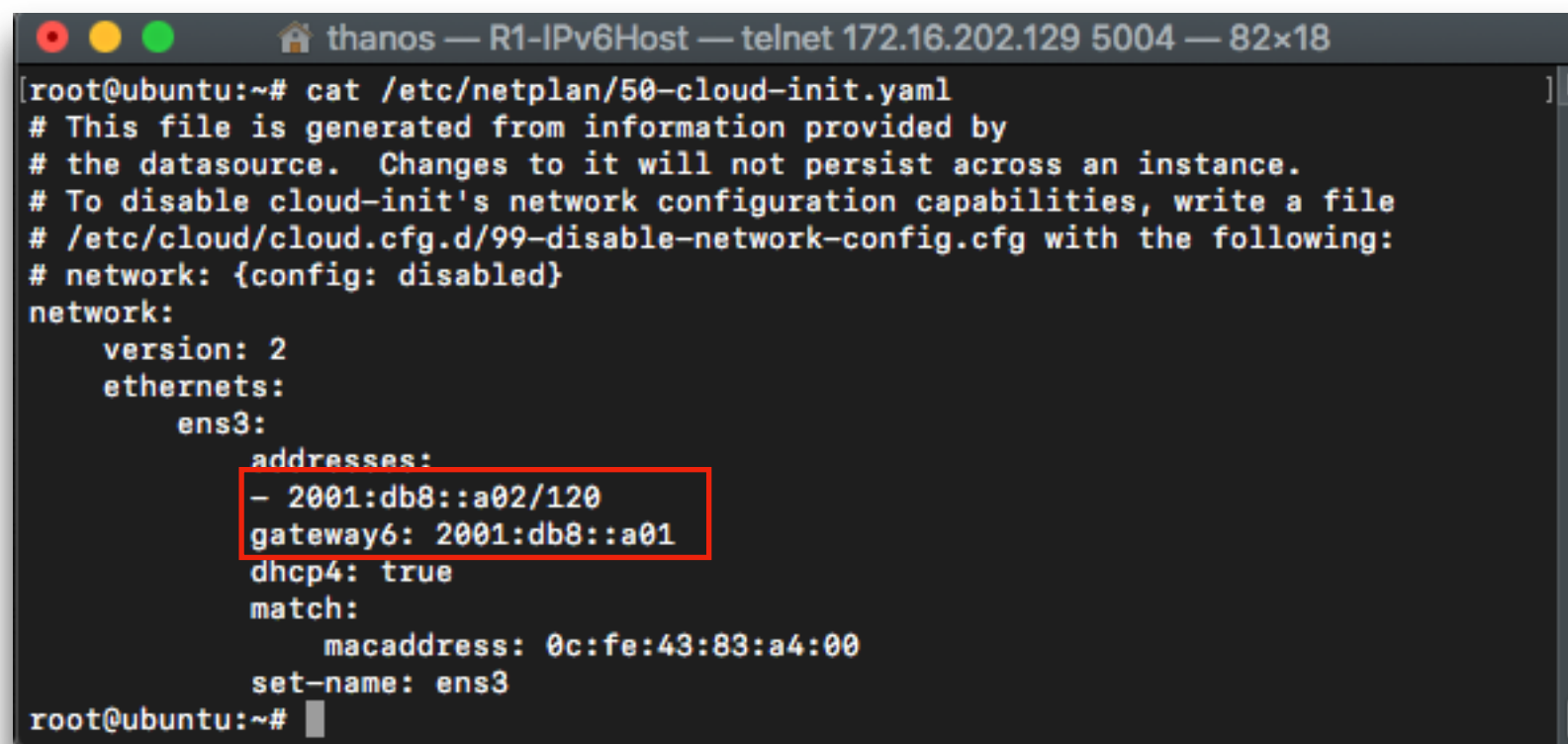
```
R1 — telnet 172.16.202.129 5013 — 82x18
[[admin@R1] > ping 2001:db8::201
SEQ HOST                                SIZE TTL TIME  STATUS
0 2001:db8::201                        56 64 0ms  echo reply
1 2001:db8::201                        56 64 0ms  echo reply
2 2001:db8::201                        56 64 0ms  echo reply
3 2001:db8::201                        56 64 0ms  echo reply
4 2001:db8::201                        56 64 0ms  echo reply
5 2001:db8::201                        56 255 0ms  echo reply
sent=6 received=6 packet-loss=0% min-rtt=0ms avg-rtt=0ms max-rtt=0ms

[admin@R1] > 
```

R1 to R3

IPv6 Address (Hosts)

- Για το συγκεκριμένο παράδειγμα έχει χρησιμοποιηθεί η διανομή Ubuntu Cloud Guests 18.04 και στατική διεύθυνση IPv6 με χρήση του Netplan
- **R1-IPv6Host : 2001:db8::a02/120**
- **R2-IPv6Host : 2001:db8::b02/120**
- **R3-IPv6Host : 2001:db8::c02/120**



A terminal window titled "thanos — R1-IPv6Host — telnet 172.16.202.129 5004 — 82x18". The prompt is [root@ubuntu:~#. The user has entered the command cat /etc/netplan/50-cloud-init.yaml. The output shows a Netplan configuration file. The configuration includes a comment about the file being generated from cloud-init, instructions on how to disable network configuration, and a network configuration block for ens3. The network configuration specifies version 2, an ethernet interface ens3 with a list of addresses containing 2001:db8::a02/120, a gateway6 of 2001:db8::a01, dhcp4 set to true, a match block with macaddress 0c:fe:43:83:a4:00, and set-name ens3. The terminal ends with the prompt root@ubuntu:~#.

```
[root@ubuntu:~# cat /etc/netplan/50-cloud-init.yaml
# This file is generated from information provided by
# the datasource. Changes to it will not persist across an instance.
# To disable cloud-init's network configuration capabilities, write a file
# /etc/cloud/cloud.cfg.d/99-disable-network-config.cfg with the following:
# network: {config: disabled}
network:
  version: 2
  ethernets:
    ens3:
      addresses:
        - 2001:db8::a02/120
      gateway6: 2001:db8::a01
      dhcp4: true
      match:
        macaddress: 0c:fe:43:83:a4:00
      set-name: ens3
root@ubuntu:~#
```


IPv6 Static Route

R1

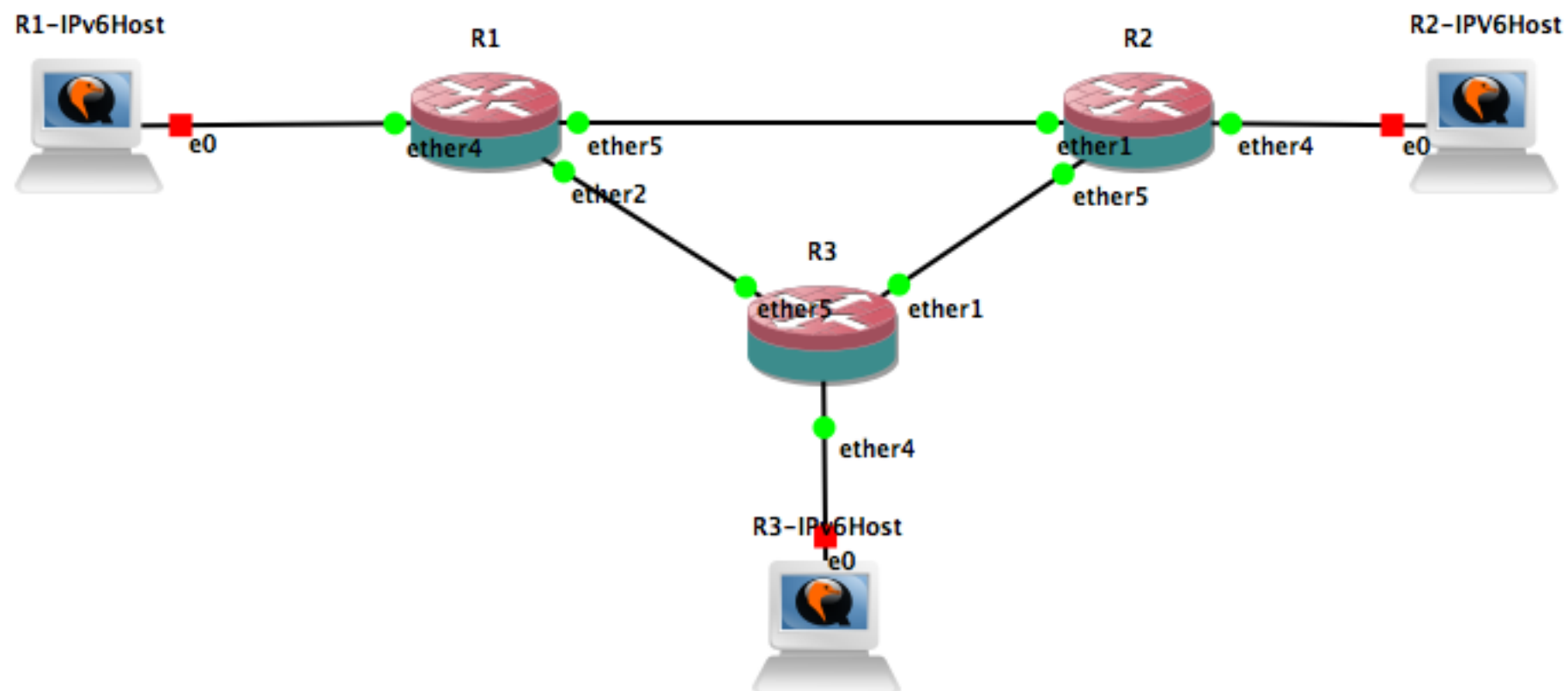
```
/ipv6 route  
add distance=1 dst-address=2001:db8::b00/120 gateway=2001:db8::2  
add distance=1 dst-address=2001:db8::c00/120 gateway=2001:db8::201
```

R2

```
/ipv6 route  
add distance=1 dst-address=2001:db8::a00/120 gateway=2001:db8::1  
add distance=1 dst-address=2001:db8::c00/120 gateway=2001:db8::102
```

R3

```
/ipv6 route  
add distance=1 dst-address=2001:db8::a00/120 gateway=2001:db8::202  
add distance=1 dst-address=2001:db8::b00/120 gateway=2001:db8::101
```



IPv6 Static Route (R1)

IPv6 Route <2001:db8::b00/120>

General Attributes

Dst. Address: 2001:db8::b00/120

Gateway: 2001:db8::2 reachable ether5

Check Gateway: ☐

Type: unicast

Distance: 1

Scope: 30

Target Scope: 10

Received From:

enabled active static

R1 > R2

IPv6 Route <2001:db8::c00/120>

General Attributes

Dst. Address: 2001:db8::c00/120

Gateway: 2001:db8::201 reachable ether2

Check Gateway: ☐

Type: unicast

Distance: 1

Scope: 30

Target Scope: 10

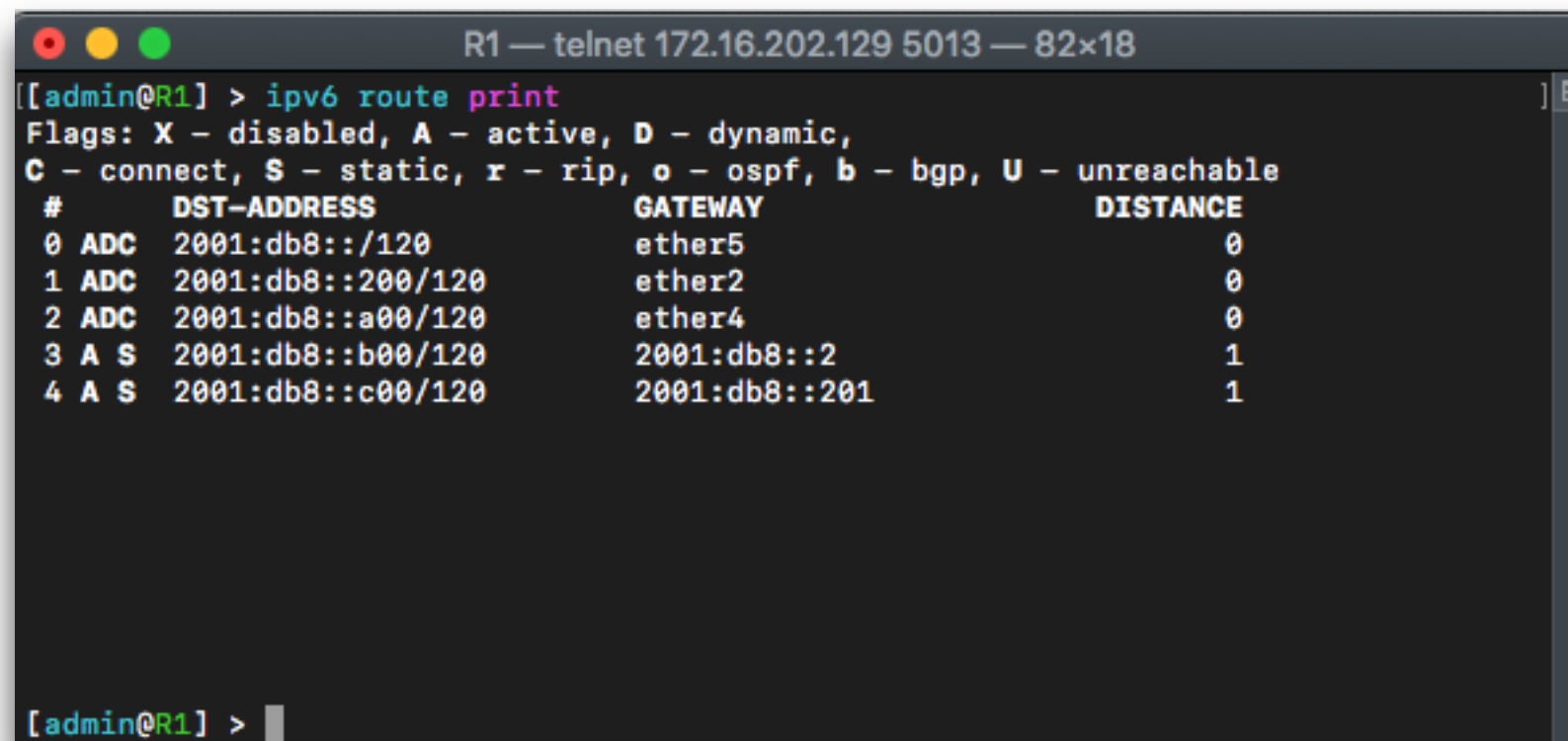
Received From:

enabled active static

R1 > R3

IPv6 Static Route (R1)

/ipv6 route print



A terminal window titled "R1 — telnet 172.16.202.129 5013 — 82x18" displays the output of the command `[[admin@R1] > ipv6 route print]`. The output shows a list of IPv6 routes with their flags, destination addresses, gateways, and distances. The flags are explained as: X - disabled, A - active, D - dynamic, C - connect, S - static, r - rip, o - ospf, b - bgp, U - unreachable.

#	Flags	DST-ADDRESS	GATEWAY	DISTANCE
0	ADC	2001:db8::/120	ether5	0
1	ADC	2001:db8::200/120	ether2	0
2	ADC	2001:db8::a00/120	ether4	0
3	A S	2001:db8::b00/120	2001:db8::2	1
4	A S	2001:db8::c00/120	2001:db8::201	1

The terminal prompt `[[admin@R1] >` is visible at the bottom.

Traceroute (R1)

```
R1 — telnet 172.16.202.129 5013 — 82x18
[admin@R1] > tool traceroute address=2001:db8::b02
# ADDRESS      LOSS SENT  LAST    AVG    BEST  WORST
1 2001:db8::2    0%   5    0.5ms   0.5    0.4    0.7
2 2001:db8::b02  0%   5    0.7ms   1.1    0.7    2.7
```

to R2-IPv6Host

```
R1 — telnet 172.16.202.129 5013 — 82x18
[admin@R1] > tool traceroute address=2001:db8::c02
# ADDRESS      LOSS SENT  LAST    AVG    BEST  WORST
1 2001:db8::201  0%   5    0.3ms   0.4    0.3    0.5
2 2001:db8::c02  0%   5    0.6ms   1      0.5    2.3
```

to R3-IPv6Host

IPv6 Dynamic Routing Protocols



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IPv6 Dynamic Routing

- Το RouterOS υποστηρίζει τα εξής δυναμικά πρωτόκολλα δρομολόγησης για το IPv6 :
 - **OSPF**
 - **BGP**
 - **RIP**

OSPFv2 vs OSPFv3

Οι ελάχιστες ρυθμίσεις για ενεργοποίηση του πρωτοκόλλου σε IPv4 και IPv6

Δυναμικό πρωτόκολλο	OSPFv2	OSPFv3
Υποστηρίζει	IPv4	IPv6
Για την ενεργοποίηση πρέπει να ρυθμιστεί	Network	Interface
Router-ID	Αυτόματα χρησιμοποιεί την μικρότερη IP από ένα ενεργό interface	Πρέπει να οριστεί χειροκίνητα και παραμένει σε 32bit IPv4 Format

OSPFv3

- Οι βασικές αρχές λειτουργίας του **OSPFv3** παραμένουν οι ίδιες
 - Designated Routers Elections (**DR-BDR**)
 - Υποστήριξη περιοχών (**Backbone - Area Type**)
 - Υπολογισμοί για το Short Path First (**SPF**)
 - Αλγόριθμος Flooding

Router-ID

- Πάντα χρησιμοποιούμε static IP για το router-ID και από ένα interface που είναι πάντα **R**unning
- Το RouterOS δεν έχει loopback interface
- Δημιουργούμε ένα bridge interface και του βάζουμε IP

Router-ID

R1

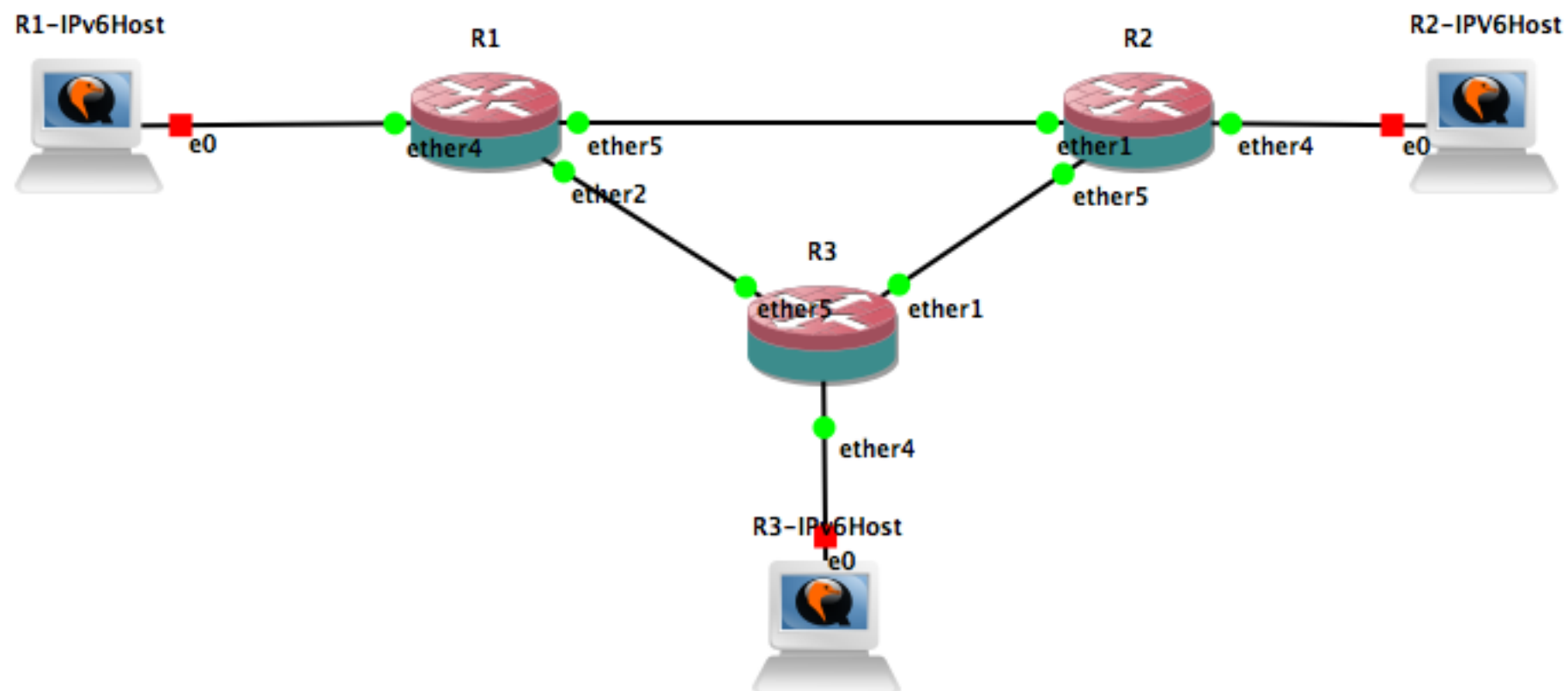
```
/interface bridge add name=loopback  
/ip address add interface=loopback address=10.0.0.1/32
```

R2

```
/interface bridge add name=loopback  
/ip address add interface=loopback address=10.0.0.2/32
```

R3

```
/interface bridge add name=loopback  
/ip address add interface=loopback address=10.0.0.3/32
```



Ενεργοποίηση OSPFv3

R1

```
/routing ospf-v3 instance
set [ find default=yes ] redistribute-connected=as-type-1 router-id=10.0.0.1
/routing ospf-v3 interface
add area=backbone interface=loopback
add area=backbone interface=ether2
add area=backbone interface=ether5
/ipv6 route remove [find static]
```

R2

```
/routing ospf-v3 instance
set [ find default=yes ] redistribute-connected=as-type-1 router-id=10.0.0.2
/routing ospf-v3 interface
add area=backbone interface=loopback
add area=backbone interface=ether1
add area=backbone interface=ether5
/ipv6 route remove [find static]
```

R3

```
/routing ospf-v3 instance
set [ find default=yes ] redistribute-connected=as-type-1 router-id=10.0.0.3
/routing ospf-v3 interface
add area=backbone interface=loopback
add area=backbone interface=ether1
add area=backbone interface=ether5
/ipv6 route remove [find static]
```

Ενεργοποίηση OSPFv3 (R1)

OSPFv3

Interfaces Instances Areas Area Ranges Virtual Links Neighbors NBMA Neighbors LSA Routes ...

+ - ✓ ✗ 🔍 Find

Area	Interface	Cost	Priority	Network Type	Instance	Neig...	State
backb...	loopback	10	1	default	default	0	designated r...
backb...	ether2	10	1	default	default	0	designated r...
backb...	ether5	10	1	default	default	0	designated r...

3 items

OSPFv3

Interfaces Instances Areas Area Ranges Virtual Links Neighbors NBMA Neighbors LSA Routes ...

+ - ✓ ✗ 🔍 Find

Name	Router ID	Redistribute Connected Routes	Running
* default	10.0.0.1	as type 1	yes

1 item

OSPFv3

Area Ranges Virtual Links Neighbors NBMA Neighbors LSA Routes AS Border Routers OSPFv3 Routers ...

🔍 Find

Instance	Router ID	Address	Interface	State Changes
default	10.0.0.3	fe80::efe:43...	ether2	5
default	10.0.0.2	fe80::efe:43...	ether5	4

2 items

'Ελεγχος OSPFv3

```
R1 — telnet 172.16.202.129 5013 — 80x15
[admin@R1] > routing ospf-v3 neighbor print
0 instance=default router-id=10.0.0.3 address=fe80::efe:43ff:fe4:604
  interface=ether2 priority=1 dr=10.0.0.1 backup-dr=10.0.0.3 state="Full"
  state-changes=5 ls-retransmits=0 ls-requests=0 db-summaries=0
  adjacency=6m5s

1 instance=default router-id=10.0.0.2 address=fe80::efe:43ff:fea7:1e00
  interface=ether5 priority=1 dr=10.0.0.1 backup-dr=10.0.0.2 state="Full"
  state-changes=4 ls-retransmits=0 ls-requests=0 db-summaries=0
  adjacency=6m24s

[admin@R1] >
```

```
thanos — R2 — telnet 172.16.202.129 5016 — 80x15
[admin@R2] > routing ospf-v3 neighbor print
0 instance=default router-id=10.0.0.3 address=fe80::efe:43ff:fe4:600
  interface=ether5 priority=1 dr=10.0.0.3 backup-dr=10.0.0.2 state="Full"
  state-changes=6 ls-retransmits=0 ls-requests=0 db-summaries=0
  adjacency=7m7s

1 instance=default router-id=10.0.0.1 address=fe80::efe:43ff:fe71:cb04
  interface=ether1 priority=1 dr=10.0.0.1 backup-dr=10.0.0.2 state="Full"
  state-changes=5 ls-retransmits=0 ls-requests=0 db-summaries=0
  adjacency=7m56s

[admin@R2] >
```

```
thanos — R3 — telnet 172.16.202.129 5018 — 80x15
[admin@R3] > routing ospf-v3 neighbor print
0 instance=default router-id=10.0.0.1 address=fe80::efe:43ff:fe71:cb01
  interface=ether5 priority=1 dr=10.0.0.1 backup-dr=10.0.0.3 state="Full"
  state-changes=5 ls-retransmits=0 ls-requests=0 db-summaries=0
  adjacency=7m56s

1 instance=default router-id=10.0.0.2 address=fe80::efe:43ff:fea7:1e04
  interface=ether1 priority=1 dr=10.0.0.3 backup-dr=10.0.0.2 state="Full"
  state-changes=5 ls-retransmits=0 ls-requests=0 db-summaries=0
  adjacency=7m26s

[admin@R3] >
```

'Ελεγχος OSPFv3 (R1)

```
R1 — telnet 172.16.202.129 5013 — 82x18
[admin@R1] > tool traceroute address=2001:db8::b02
# ADDRESS      LOSS SENT  LAST      AVG      BEST     WORST
1 2001:db8::2    0%    5    0.5ms    0.5     0.4     0.7
2 2001:db8::b02  0%    5    0.7ms    1.1     0.7     2.7
```

to R2-IPv6Host

```
R1 — telnet 172.16.202.129 5013 — 82x18
[admin@R1] > tool traceroute address=2001:db8::c02
# ADDRESS      LOSS SENT  LAST      AVG      BEST     WORST
1 2001:db8::201  0%    5    0.3ms    0.4     0.3     0.5
2 2001:db8::c02  0%    5    0.6ms    1       0.5     2.3
```

to R3-IPv6Host

Q/A



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