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IPv6 – kako?

(bez suvišnog “zašto?”)

<http://linux.voyager.hr/ipv6/>



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Sličnosti

- IP adresa (kao koncept, izgled je drugačiji)
- Netmask (veći raspon – do /128 umjesto do /32)
- Rute (“ip -6 route show” umjesto “ip -4 route show”)
- Firewall (“ip6tables” umjesto “iptables”)
- Alati (“ping6” ili “ping -6” umjesto “ping”)
- ICMP / ICMPv6 (niti jednog ne kompletno blokirati!! PMTU+)

Različitosti – IP adresa izgled

- IPv4 adrese *uglavnom* dotted-quad decimal
 - 192.0.2.42
 - ali i manje poznate (ping 127.1, ping 3221226026)
- IPv6 (8x16bit hexadecimal, variable length je **vrlo** čest)
 - 2001:0db8:0014:0000:0000:0000:0000:0001
 - 2001:db8:14:0:0:0:0:1
 - 2001:db8:14::1

Različitosti #2

- Interface uvijek ima link-local automatski generiranu adresu (“fe80::”)!
- IP address literal u kombinaciji s portovima ide u uglate zagrade (“127.0.0.1:80” vs. “[::1]:80”)
- ARP & MAC vs. ND & link-local adrese
 - IPv4: arp -n (ili ip -4 neighbour show)
 - IPv6: ip -6 neighbour show (ip n)
- DHCP vs. DHCPv6 vs. SLAAC (IPv6 Stateless Address Auto-configuration; dijelom kao IPv4 169.254.0.0/16 zeroconf), privacy extensions
- IPv6 temporary addresses, DAD (Duplicate Address Detection)

Zablude

- IPv4 NAT je sigurniji
 - (S)NAT je samo stateful firewall + izmjena source adrese.
 - Ono što daje “sigurnost” je statuful firewall (iptables -I INPUT --state ESTABLISHED, RELATED -j ACCEPT) koji radi jednako dobro i bez izmjene source adrese.

IPv6 subnets

- /128 je host (kao /32 na IPv4)
- ::/0 je sav IPv6 (kao 0.0.0.0/0 na IPv4 – ali oprez, kao i tamo to uključuje svašta)
- najmanji upotrebljivi subnet /64 (64bita, a **sav** IPv4 je samo 32 bita!)
- home korisnicima se obično daje /56 ili čak /48

Special addresses

- `::1` (localhost; 127.0.0.1)
- `::` ili `::/0` ili `0::0/0` (kao i `0.0.0.0/0`: “default” cijeli svijet, npr. za rute ili listening IP)
- `ff02::1` (all nodes), `ff02::2` (all routers)
- `fe80::/10` (link-local)
- `fd00::/8` (ULA - unique local address)
- `::ffff:192.0.2.17` (V4MAPPED – API, logs)

Transition tehnologije

- Dual stack (IPv4+IPv6) - najčešće
- NAT64+DNS64 (IPv6 only; NAT na IPv4)
- za test ako nema ništa: 6in4 (protocol 41) - npr. <http://tunnelbroker.net/>
- razne poluradeće (Teredo, 6to4, ..)

Command line #1

- ip -4 address show
 - ip -6 a show scope global
- ip a add 192.0.2.17/24 dev wlan0
 - ip a add 2001:db8:42::17/64 dev wlan0
- route add -net 192.0.2.0/24 gw 198.51.100.1
(ip route add 192.0.2.0/24 via 198.51.100.1)
 - ip route add 2001:db8:42::/64 via 2001:db8:37::1

Command line #2

- iptables -I INPUT -s 192.0.2.0/24 -p tcp --dport 22 -j ACCEPT
 - ip6tables -I INPUT -s 2001:db8:42::/64 -p tcp --dport 22 -j ACCEPT
- tcpdump -ni wlan0 host 192.0.2.42 and port 80
 - tcpdump -ni wlan0 host 2001:db8:42::17 and port 80
 - tcpdump -npi any ip6
 - tcpdump -npi wlan0 icmp6
- arping -i wlan0 8f:3d:96:74:5a:2e
 - ping fe80::8f3d:96ff:fe74:5a2e%wlan0
- hrpa alata (ssh, ping, rsync, ss, telnet, swaks, nc...) ima -4 / -6

Dual-stack Debian

/etc/network/interfaces

```
auto eth0
```

```
iface eth0 inet static
```

```
    address 192.168.9.73
```

```
    netmask 255.255.255.0
```

```
    gateway 192.168.9.254
```

```
#iface eth0 inet6 auto # auto=SLAAC / dhcp=DHCP6
```

```
iface eth0 inet6 static
```

```
    address 2001:db8:42::17/64
```

```
    gateway 2001:db8:37::1
```

Debian /etc/network/interfaces extras

- preferred-lifetime (v. “ip -6 a“ / “preferred_lft forever”)
- dad-attempts (0 disables)
- privext (0=off, 1=assign, 2=prefer)
- accept_ra / autoconf
- scope (global, site, link, host)
- man 5 interfaces

IOS/Zebra/Quagga/FRR IPv6/SLAAC

- interface eth_lan
ipv6 address 2001:db8:42:190::1/64
ipv6 nd prefix 2001:db8:42:190::/64
ipv6 nd ra-interval 10
link-detect
no ipv6 nd suppress-ra
- “show ipv6” umjesto “show ip”

IPv6 SLAAC /etc/radvd.conf

```
# apt install radvd
interface eth0
{
    IgnoreIfMissing off;
    AdvSendAdvert on;
    MinRtrAdvInterval 5;
    MaxRtrAdvInterval 10;
    AdvDefaultLifetime 60;

    prefix 2001:db8:42:190::/64
    {
        AdvValidLifetime 86400;
        AdvPreferredLifetime 14400;
        AdvOnLink on;
        AdvAutonomous on;
    };

    RDNSS 2001:db8:42:190::1 2001:470:20::2
    {
        AdvRDNSSLifetime 15;
    };
};
```

IPv6 / IPv4 preference

- Web browseri – Happy Eyeballs (RFC 6555 / RFC 8305)
- /etc/gai.conf:
 - default prefer IPv6
 - #precedence ::ffff:0:0/96 100

netstat / ss

- `ss -ltpn`

State	Local Address:Port	Peer Address:Port	Process
LISTEN	127.0.0.1:9050	0.0.0.0:*	users:(("tor",pid=1940,fd=7))
LISTEN	0.0.0.0:22	0.0.0.0:*	users:(("sshd",pid=1908,fd=3))
LISTEN	:::22	:::*	users:(("sshd",pid=1908,fd=4))
LISTEN	:::1:53	:::*	users:(("dnsmasq",pid=243,fd=9))

- IPv6 literals u []
- nekad servisi slušaju posebno na 0.0.0.0, a posebno na ::
- nekad servis na :: sluša i IPv4 i IPv6 (/proc/sys/net/ipv6/bindv6only)

DNS #1

- CARNet (i ostatak svijeta) podržava IPv6 glue / delegacije
- apt install bind9-dnsutils
- “dig aaaa” (umjesto “dig a”) ili “host -t aaaa”
 - default “any” je loš!
- trace gdje je problem:
 - dig aaaa ipv6.google.com (i v. /etc/resolv.conf, /etc/nsswitch.conf)
 - dig +norecurse aaaa ipv6.google.com @a.root-servers.net.
 - dig +norecurse aaaa ipv6.google.com @a.gtld-servers.net.
 - dig +norecurse aaaa ipv6.google.com @ns1.google.com

Troubleshoot #1

- **uvijek** “ping -n” !!
- ping6 -n ipv6.google.com # ipv6 routing+dns
- ping6 -n 2001:470:20::2 # je li DNS problem?
- traceroute -n 2001:470:20::2

Troubleshoot #2

- možemo li “ping6 -n ff02:2” odnosno “ping6 -n default_ipv6_gateway”?
- ip -6 addr; ip -6 route; ip -6 neigh
 - STALE/FAILED, preferred_lft...
- ping6 -n ::1 # ima li uopće IPv6 stack radeći?
- ip6tables-save; dmesg # firewall?

Troubleshoot #3

- možemo li “ping6 -n ff02:1” # bilo koji node?
- imamo li “ip -6 addr show” adrese sa “scope global”?
- ping6 -n fe80::ba23:dbff:fe43:1e14%eth0
 - link-local adresa nekog drugog stroja u istom lanu
- je li problem DNS (ako adrese rade a imena ne)
- tcpdump -npi eth0 ip6 # na obje strane kabla

Linkovi

- <https://test-ipv6.com/> - browser test
- <https://ipv6.he.net/certification/> - učenje i testovi
- <https://lg.he.net/> - looking glass
- BGP: telnet route-server.he.net
- <http://linux.voyager.hr/ipv6/> - ova i druge moje IPv6 prezentacije