

Praktická implementace IPv6

CZ.NIC, z.s.p.o.

Emanuel Petr / emanuel.petr@nic.cz

06.04.2009

www.nic.cz



Osnova

- Jak získat IPv6 adresu
 - 6in4
 - AYIYA
- Nastavení IPv6 adresy
- Základní příkazy pro práci s IPv6

Jak získat IPv6 adresu

- Váš ISP podporuje IPv6
nepodporuje – každý měsíc mail s žádostí o IPv6 ;)
- Tunelováním



6in4

| No. | Time | Source | Destination | Protocol | Info |
|-----|-----------------|-----------------------|-----------------------|----------|---|
| 1 | 17:45:37.167373 | 2001:470:1f08:13f::2 | 2001:610:240:11::c100 | TCP | 41359 > http [SYN] Seq=0 Win=5680 Len=0 MSS=1420 TS |
| 2 | 17:45:37.200572 | 2001:610:240:11::c100 | 2001:470:1f08:13f::2 | TCP | http > 41359 [SYN, ACK] Seq=0 Ack=1 Win=5712 Len=0 |
| 3 | 17:45:37.200677 | 2001:470:1f08:13f::2 | 2001:610:240:11::c100 | TCP | 41359 > http [ACK] Seq=1 Ack=1 Win=5696 Len=0 TSV=6 |
| 4 | 17:45:37.200810 | 2001:470:1f08:13f::2 | 2001:610:240:11::c100 | HTTP | GET / HTTP/1.1 |
| 5 | 17:45:37.245407 | 2001:610:240:11::c100 | 2001:470:1f08:13f::2 | TCP | http > 41359 [ACK] Seq=1 Ack=379 Win=6784 Len=0 TSV |
| 6 | 17:45:37.260730 | 2001:610:240:11::c100 | 2001:470:1f08:13f::2 | TCP | [TCP segment of a reassembled PDU] |

| | |
|---|--|
| ▶ | Frame 6 (1314 bytes on wire, 1314 bytes captured) |
| ▶ | Ethernet II, Src: Belkin_b6:cd:9a (00:17:3f:b6:cd:9a), Dst: HonHaiPr_44:bb:f9 (00:19:7e:44:bb:f9) |
| ▼ | <u>Internet Protocol</u> , Src: 216.66.80.26 (216.66.80.26), Dst: 192.168.2.3 (192.168.2.3) <ul style="list-style-type: none">Version: 4Header length: 20 bytes▶ Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)Total Length: 1300Identification: 0xee3f (60991)▶ Flags: 0x00Fragment offset: 0Time to live: 20Protocol: <u>IPv6 (0x29)</u>▶ Header checksum: 0xc879 [correct]Source: 216.66.80.26 (216.66.80.26)Destination: 192.168.2.3 (192.168.2.3) |
| ▼ | <u>Internet Protocol Version 6</u> <ul style="list-style-type: none">▶ 0110 = Version: 6.... 0000 0000 = Traffic class: 0x00000000.... 0000 0000 0000 0000 0000 = Flowlabel: 0x00000000Payload length: 1240Next header: TCP (0x06)Hop limit: 59Source: 2001:610:240:11::c100:1319 (2001:610:240:11::c100:1319)Destination: 2001:470:1f08:13f::2 (2001:470:1f08:13f::2) |
| ▶ | Transmission Control Protocol, Src Port: http (80), Dst Port: 41359 (41359), Seq: 1, Ack: 379, Len: 1208 |

Tunnel brokers

- Seznam zprostředkovatelů

http://en.wikipedia.org/wiki/List_of_IPv6_tunnel_brokers

- Evropa

<http://www.tunnelbroker.net/> - Hurricane Electric

6in4 static (proto-41 static) - IP zapouzdření

<http://www.sixxs.net/> - SixXS

6in4 static (proto-41 static) - IP zapouzdření

6in4 heartbeat (proto-41 heartbeat) - IP zapouzdření, dynamické

AYIYA – UDP zapouzdření, dynamické

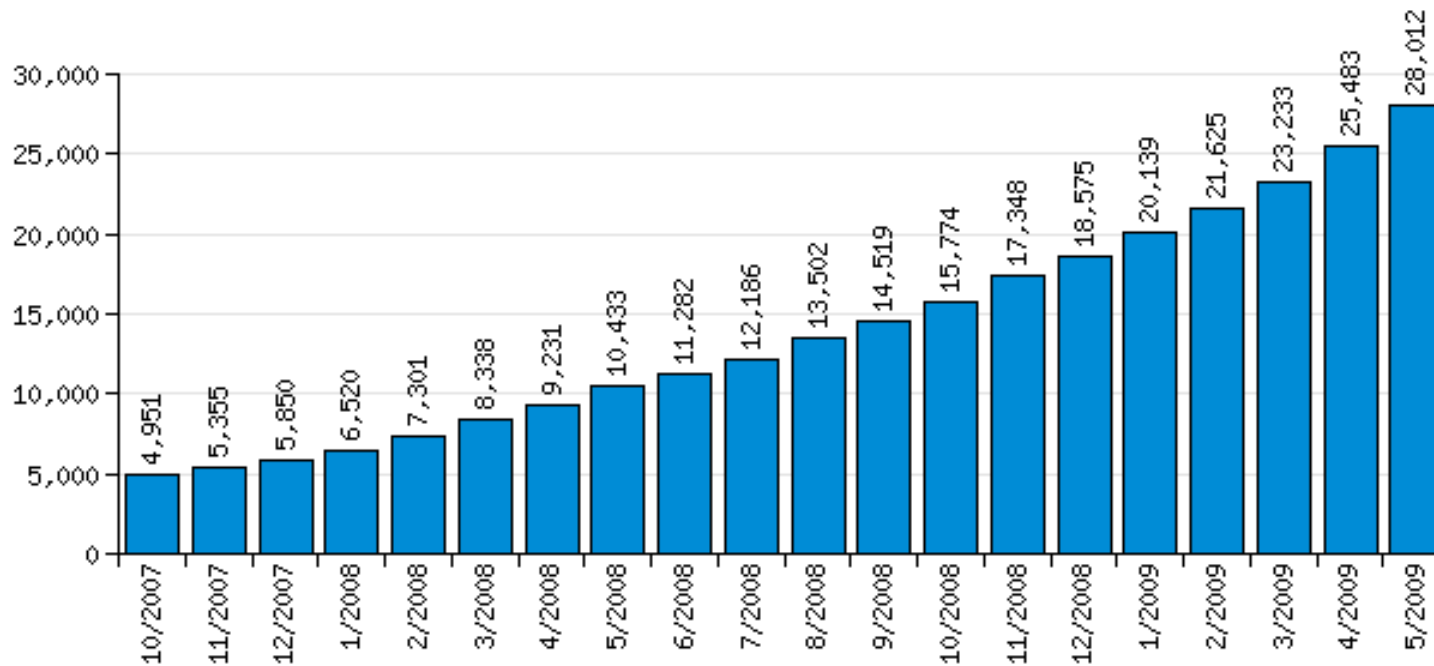
další: 6to4, Teredo, ISATAP, ...

Account Growth Last 20 Months

The Hurricane Electric IPv6 tunnel broker service enables you to reach the IPv6 Internet from any IPv4 network. Every day new users sign up for the service. These are the stats for account signups over the last 20 months.

Sign up today at <http://tunnelbroker.net/>

Account Growth Last 20 Months



Modelová situace

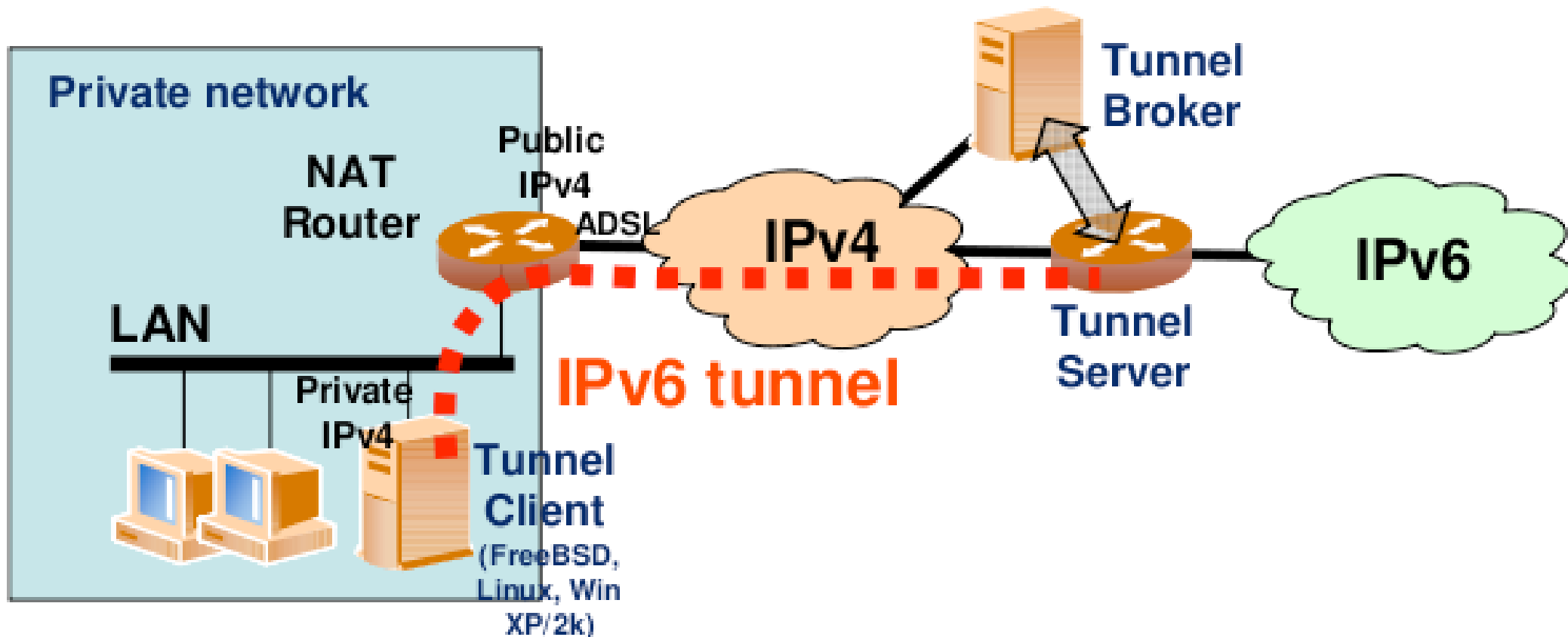


Figure 1-1: IPv6 Tunnels through ADSL Routers with NAT

Registrace tunelu

6in4 static přes www.tunnelbroker.net - za 5minut

Registrace → Heslo (mail) → Vytvoření tunelu → Copy&Past konfigurace

Account: emanuelpetr
Password: IPv4 endpoint: 94.169.120.21
your side of the tunnel)

You are viewing from IP: 94.169.120.21

Which Server Is Closest to you?:

- Asia
 - Hong Kong, HK [216.218.221.6]
- Europe
 - Paris, FR [216.66.84.42]
 - London, UK [216.66.80.26]
- North America
 - Fremont, CA, US [72.52.104.74]
 - Los Angeles, CA, US [66.220.18.42]
 - Seattle, WA, US [216.218.226.238]
 - Ashburn, VA, US [216.66.22.2]
 - Miami, FL, US [209.51.161.58]
 - Chicago, IL, US [209.51.181.2]
 - Dallas, TX, US [216.218.224.42]
 - Toronto, ON, CA [216.66.38.58]
 - New York, NY, US [209.51.161.14]

Submit

Registration

HE.net IPv6 Tunnel Broker Registration

As you enter data in the fields they will validate. If the background of a box changes to light blue you have valid data, if it goes light red you have an error and an error message will appear in red below. After successfully completing registration, an email will be sent with your account password.

Account Name:

Email address:

Real Name:

Street:

City:

State/Region:

Zip/Postal Code:

Country:

Phone:

Tunnel Details

Account: emanuelpetr

Global Tunnel ID: 30964 Local Tunnel ID: 319

Description:

Server IPv4 address: 216.66.80.26

Server IPv6 address: 2001:470:1f08:13f::1/64

Client IPv4 address: **94.169.120.21**

Client IPv6 address: 2001:470:1f08:13f::2/64

Routed /48:

Routed /64: 2001:470:1f09:13f::/64

RDNS Delegation NS1: none

RDNS Delegation NS2: none

RDNS Delegation NS3: none

ASN: none

Registration Date: Tue, May 26, 2009

Example OS Configurations (Windows, Linux, etc.):

Linux-route2

Copy and Paste the following into a command window:

```
modprobe ipv6
ip tunnel add he-ipv6 mode sit remote 216.66.80.26 local 94.169.120.21 ttl 255
ip link set he-ipv6 up
ip addr add 2001:470:1f08:13f::2/64 dev he-ipv6
ip route add :::/0 dev he-ipv6
ip -f inet6 addr
```

NOTE When behind a firewall appliance that passes protocol41, instead of using the IPv4 endpoint you provided to our broker, use the IPv4 address you get from your appliance's DHCP service.

The configurations provided are only example configurations and may be different depending on the version OS or tools you are using. If you have any issues getting your tunnel to work please contact us at ipv6@he.net and we will be happy to assist you.

Registrace a heslo

www.tunnelbroker.net

Po registraci přišlo heslo téměř okamžitě.

Registration

HE.net IPv6 Tunnel Broker Registration

As you enter data in the fields they will validate. If the background of a box changes to light blue you have valid data, if it goes light red you have an error and an error message will appear in red below. After successfully completing registration, an email will be sent with your account password.

Account Name:

Email address:

Real Name:

Street:

City:

State/Region:

Zip/Postal Code:

Country:

Phone:

Vytvoření tunelu

6in4 static přes www.tunnelbroker.net

IPv4 endpoint:
(your side of the tunnel)

You are viewing from IP: 94.169.120.21

Na Váš IPv4 koncový bod
musí být povolen ping.

Which Server Is Closest to you?:

Asia

Hong Kong, HK [216.218.221.6]

Europe

Paris, FR [216.66.84.42]

London, UK [216.66.80.26]

North America

Fremont, CA, US [72.52.104.74]

Los Angeles, CA, US [66.220.18.42]

Seattle, WA, US [216.218.226.238]

Ashburn, VA, US [216.66.22.2]

Miami, FL, US [209.51.161.58]

Chicago, IL, US [209.51.181.2]

Dallas, TX, US [216.218.224.42]

Toronto, ON, CA [216.66.38.58]

New York, NY, US [209.51.161.14]

Submit

Výsledná konfigurace (1)

6in4 static přes www.tunnelbroker.net

Tunnel Details

Account: emanuelpetr Delete Tunnel

Global Tunnel ID: 30964 Local Tunnel ID: 319

Description:

Server IPv4 address: 216.66.80.26

Server IPv6 address: 2001:470:1f08:13f::1/64

Client IPv4 address: **94.169.120.21**

Client IPv6 address: 2001:470:1f08:13f::2/64

Anycasted IPv6 Caching Nameserver: 2001:470:20::2

Anycasted IPv4 Caching Nameserver: 74.82.42.42

Routed /48: Allocate

Routed /64: 2001:470:1f09:13f::/64

RDNS Delegation NS1: **none**

RDNS Delegation NS2: **none**

RDNS Delegation NS3: **none**

ASN: none

Registration Date: Tue, May 26, 2009

... pokračuje na další straně ...

Výsledná konfigurace (2)

6in4 static přes www.tunnelbroker.net

Konfigurace: Linux, Open/Net/FreeBSD, JunOS, IOS, Mikrotik, Solaris, Win.

Linux-route2



Show Config

vhodnou adresu vybere kernel

Copy and Paste the following into a command window:

```
modprobe ipv6
ip tunnel add he-ipv6 mode sit remote 216.66.80.26 local 94.169.120.21 ttl 255
ip link set he-ipv6 up
ip addr add 2001:470:1f08:13f::2/64 dev he-ipv6
ip route add ::/0 dev he-ipv6
ip -f inet6 addr
```

NOTE When behind a firewall appliance that passes protocol41, instead of using the IPv4 endpoint you provided to our broker, use the IPv4 address you get from your appliance's DHCP service.

The configurations provided are only example configurations and may be different depending on the version OS or tools you are using. If you have any issues getting your tunnel to work please contact us at ipv6@he.net and we will be happy to assist you.

IPv6 DNS záznamy

```
$ host 2001:470:1f08:13f::2
```

```
2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.f.3.1.0.8.0.f.1.0.7.4.0.1.0.0.2.ip6.arpa
```

```
domain name pointer emanuelpetr-1-pt.tunnel.tserv5.lon1.ipv6.he.net.
```

```
$ host emanuelpetr-1-pt.tunnel.tserv5.lon1.ipv6.he.net.
```

```
emanuelpetr-1-pt.tunnel.tserv5.lon1.ipv6.he.net has IPv6 address  
2001:470:1f08:13f::2
```

Automatické nastavení

Debian, Ubuntu, ...

/etc/network/interfaces

...

auto *he-ipv6*

iface *he-ipv6* inet6 **v4tunnel**

address 2001:470:1f08:13f::2

netmask 64

endpoint 216.66.80.26

ttl 64

up ip link set mtu 1280 dev he-ipv6

up ip route add default via 2001:470:1f08:13f::1 dev he-ipv6

Nevýhody 6in4 static

- Při registraci vyžaduje funkční ping na veřejnou adresu <http://www.subnetonline.com/pages/network-tools/online-ping-ipv4.php>
- Domácí router musí podporovat NATování protokolu 41
- Problém s vícenásobným NATem
- Směrovače v rámci tunelu nesmí blokovat protokol 41
- Při změně veřejné adresy (lokálního konce tunelu) – nutná manuální úprava konfigurace tunelu na webových stránkách

Tunnel brokers

- <http://www.sixxs.net/> - SixXS

6in4 static (proto-41 static) - IP zapouzdření

6in4 heartbeat (proto-41 heartbeat) - IP zapouzdření, dynamické

AYIYA – UDP zapouzdření, dynamické

AYIYA – Anything In Anything

- řeší zmíněné nevýhody 6in4
- zapouzdřuje IPv6 do UDP protokolu, port UDP/5072
- umožňuje dynamickou a automatickou správu tunelu
- nevýhoda: větší režie oproti 6in4

AYIYA = IPv4(20) + UDP(8) + AYIYA(44) = 72 B

6in4 = IPv4(20) = 20 B

Aplikace AICCU

AICCU - Automatic IPv6 Connectivity Client Utility

- multiplatformní aplikace
- automatizuje konfiguraci tunelu pomocí protokolu TIC (Tunnel Information & Control protocol)
port tcp/3874
- zajišťuje vytvoření tunelu pomocí protokolu AYIAY
- <http://www.sixxs.net/tools/aiccu/>
\$ apt-cache search aiccu
aiccu - SixXS Automatic IPv6 Connectivity Client Utility

Registrace uživatele a tunelu sixxs.net

- Při registraci či žádosti o tunel se musí čekat na schválení správcem SixXS ...
- Kreditní systém – body za aktivní užívání tunelu

Request tunnel: Endpoint identification (1/2)

With this form you can request a new tunnel to one of the PoPs of SixXS. Latency will be checked and the quality of the tunnel is high. If your latency is higher than or around 100ms your tunnel will be request your local ISP to become a SixXS PoP so we can serve you better.

The option for dynamic tunnels allows one to have a non-24/7 dynamic IPv4 address as an endpoint indicating it's current IPv4 address and that it is alive and ready to accept IPv6 in IPv4 packets. The tunnel is reconfigured every few seconds making sure that no packets will be sent to unsuspecting hosts and the tunnel to the new endpoint.

First you'll need to fill in your type of tunnel, [heartbeat/dynamic](#), [AYIYA](#), or static which also requires the endpoints physical location.

Dynamic NAT-traversing IPv4 Endpoint using [AYIYA](#)

Dynamic IPv4 Endpoint using [Heartbeat protocol](#)


Static IPv4 Endpoint:

Please specify the city and country where your side of the tunnel is located.

City:

Country:

[Next step >>](#)

 [AICCU](#) can be used to automatically configure static, AYIYA and heartbeat tunnels.

Request tunnel: Preferred PoP selection (2/2)

The following PoP's are available for your tunnel, please select your preferred one to choose?

Note: You are choosing a preferred PoP, SixXS Staff will direct you onto another one if needed.

The following PoPs should be local to your endpoint or location.

| | |
|--|---|
| nlede01 - BIT BV (Ede, Netherlands, The) - willing | ↑ |
| simbx01 - Amis (Maribor, Slovenia) - public | |
| | ↓ |

Reason for selecting this PoP and description of usage of the requested tunnel (be as verbose as possible):

I want to try IPv6.

[<< Previous step](#)

[Place request for new Tunnel >>](#)

Konfigurace tunelu přes AICCU

- `$ sudo apt-get install aiccu`

```
Configuring aiccu
Please select the tunnel broker you would like to use.
Tunnel broker:
  AARNet
  ACADEMIA Sinica Computing Centre
  ECS Southampton
  Hexago / Freenet6
  SixXS
  UKERNA
  Wanadoo France

<0k>
```

```
Configuring aiccu
To successfully connect, you must provide your SixXS username and
site.
Aiccu username:
EPF2-SIXXS
```

```
Configuring aiccu
To successfully connect, you must provide your SixXS password and
site.
Aiccu password:
*****
```

/etc/aiccu.conf

```
$ sudo cat /etc/aiccu.conf | grep -v "^#"
```

```
username EPF2-SIXXS
```

```
password VaseHeslo
```

```
protocol tic
```

```
server tic.sixxs.net
```

```
tunnel_id T21746
```

```
ipv6_interface sixxs
```

```
verbose false
```

```
daemonize true
```

```
automatic true
```

```
requiretls false
```

aiccu – správa tunelu

aiccu (start|stop|brokers|tunnels|test|autotest|license|version)
[<configfile>]

\$ sudo aiccu tunnels

T21746 2001:15c0:65ff:299::2 ayiya simbx01

\$ sudo aiccu start

\$ ip -6 a show

```
8: sixxs: <POINTOPOINT,MULTICAST,NOARP,UP,LOWER_UP> mtu
1280 qdisc pfifo_fast qlen 500
  inet6 2001:15c0:65ff:299::2/64 scope global
    valid_lft forever preferred_lft forever
  inet6 fe80::14c0:65ff:299:2/64 scope link
    valid_lft forever preferred_lft forever
```

\$ sudo aiccu stop

Recursive Caching Nameserver

Hurricane Electric (anycast) – 2001:470:20::2 ; 74.82.42.42

SixXS – nscache.[eu|us|ap].sixxs.net

```
$ host www.google.com
```

```
www.google.com is an alias for www.l.google.com.
```

```
...
```

```
www.l.google.com has IPv6 address 2001:4860:a005::68
```

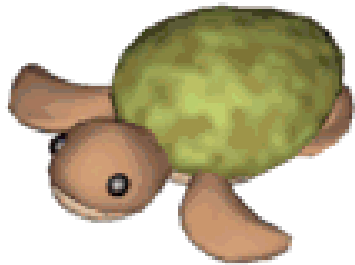
```
$ telnet www.google.com 80
```


```
Trying 2001:4860:a005::68...
```

```
Connected to www.l.google.com.
```

6in4 u HE či AYIYA u SixXS?

You're connected using



 You've got IPv6!
Check out [Cool IPv6 Stuff!](#)
[2001:15c0:65ff:299::2](#)



P Ř I P O J E N O P Ř E S I P V 6

Congratulations

You are accessing this site via IPv6 transport from 2001:470:1f08:13f:2

Aplikace pro IPv6 a zápis IPv6

Název6 nebo volba na příkazové řádce **-6**

ping6, tracepath6 (traceroute6)

wget -6, ip -6, nmap -6, dig -6

ip6tables

Zápis IPv6 adresy v aplikacích

scp user@[2001:610:240:11::c100:1319]:

http://[2001:610:240:11::c100:1319]/

Základní příkazy pro práci s IPv6

\$ ip -6 address show # seznam adres protokolu IPv6

\$ ip -6 r # vypíše routovací tabulku IPv6

\$ ip tunnel show # seznam tunelů

sit0: ipv6/ip remote any local any ttl 64 nopmtudisc

he-ipv6: ipv6/ip remote 216.66.80.26 local any ttl 64

\$ ip t del he-ipv6 # odstraní tunel

Odstraní všechny routy spjaté s he-ipv6 tunelem

\$ ip -6 route flush dev he-ipv6

Základní příkazy pro práci s IPv6 (2)

Zobrazí cestu, která se použije pro cíl. adresu (více IPv6 rozhr.)

```
$ ip -6 r get 2001:4860:a005::68
```

```
2001:4860:a005::68 via 2001:15c0:65ff:299::1 dev sixxs src  
2001:15c0:65ff:299::2 metric 1024 expires 21333882sec mtu  
1280 advmss 1220 hoplimit 4294967295
```

Zrušení autokonfigurace IPv6 u eth0 rozhraní

```
$ sudo sysctl -w net.ipv6.conf.eth0.accept_ra=0
```

IPv4/6 kalkulátor podsítí

```
$ sipcalc 2001:15c0:65ff::0/48
```

Základní příkazy pro práci s IPv6 (3)

Monitoring 6in4 provozu

```
$ sudo tcpdump -n -i eth0 proto 41
```

```
$ tcpdump -i eth0 -n icmp6
```

```
$ sudo tcpdump -i any -n ip6
```

Dotaz na všechny sousedy na daném segmentu

```
$ ping6 -I eth0 ff02::1
```

Dotaz na všechny směrovače daném segmentu

```
$ ping6 -I eth0 ff02::2
```

lokální linková adresa a zóna

```
$ ping6 -I eth0 ff02::1
```

```
PING ff02::1(ff02::1) from fe80::218:8bff:fe48:3750 eth0: 56 data  
bytes
```

```
...
```

```
64 bytes from fe80::219:bbff:fe48:3750: icmp_seq=1 ttl=64  
time=0.484 ms
```

```
$ ssh fe80::219:bbff:fe48:3750%eth0 -v
```

```
OpenSSH_4.7p1 Debian-8ubuntu1.2, OpenSSL 0.9.8g 19 Oct  
2007
```

Děkuji za pozornost

Emanuel Petr

CZ.NIC, z.s.p.o.

e-mail: emanuel.petr@nic.cz

www.nic.cz



Zdroje a užitečné odkazy

- http://en.wikipedia.org/wiki/List_of_IPv6_tunnel_brokers
- <http://www.ipv6tf.org>
- <http://www.ipv6tf.org/index.php?page=using/connectivity/6to4>
- <http://www.ipv6tf.org/index.php?page=using/connectivity/teredo>
- <http://www.deepspace6.net/docs/iproute2tunnel-en.html>
- <http://www.potaroo.net/tools/ipv4/index.html>

Seznamy IPv6 dostupných stránek

- <http://www.ipv6.org/v6-www.html>
- <https://www.sixxs.net/misc/coolstuff/>
- <http://www.seznam6.cz>