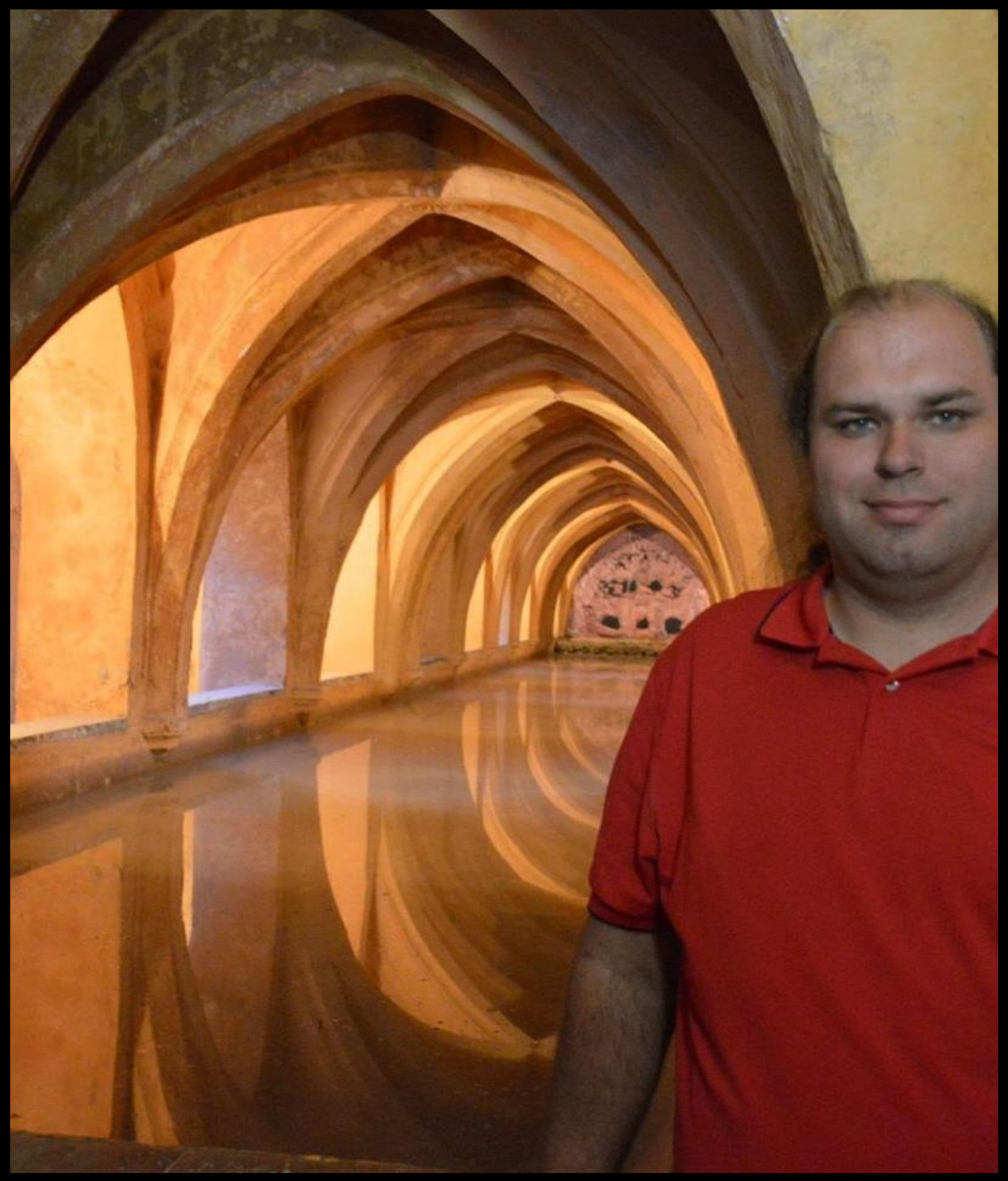
IPV6

The ip address of the future, today!

A little housekeeping

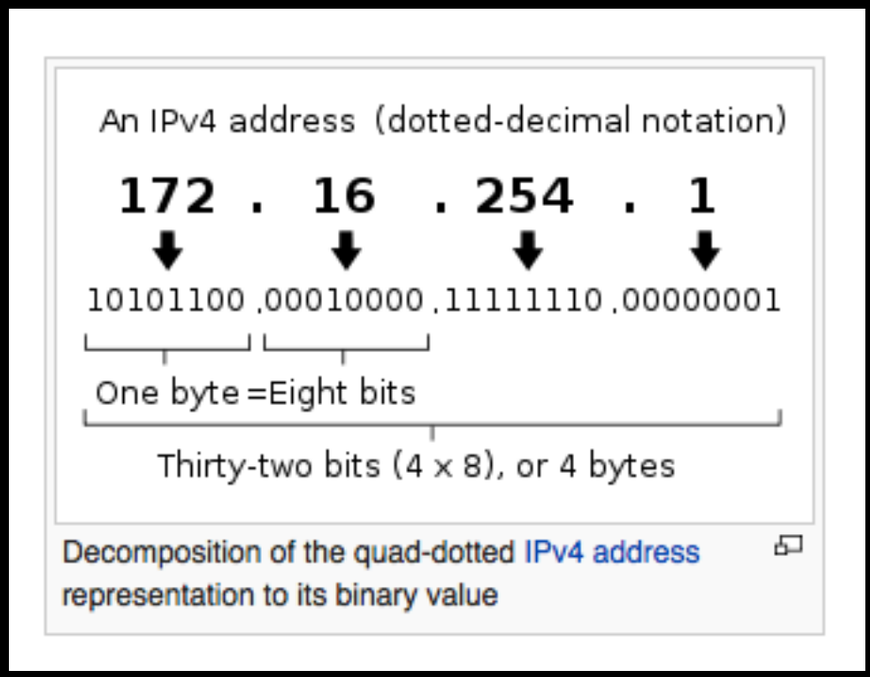
- Welcome to CIALUG
- The slide deck will be on http://denner.co later tonight
- email: denner@gmail.com
- twitter: @adenner



—"Futurama" Godfellas (TV Episode 2002)

First there was IPV4…

- IPv4 allows for ~4.3 Billion Addresses
- Large blocks were reserved for special use (ie 127.0.0.0/8 as loopback 224.0.0.0/8–239.0.0.0/8 as multicast and 240.0.0.0/8–255.0.0.0/8 as “reserved for future use”
- originally class A addresses (/8) were handed out like candy



Decomposition of the quad-dotted IPv4 address representation to its binary value

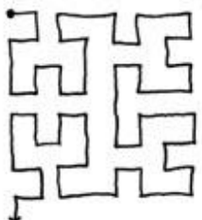
CIDR	Host bits	Netmask	Addresses in subnet	Typical usage
/8	24	255.0.0.0	16777216 = 2^{24}	Largest block allocation made by IANA
/9	23	255.128.0.0	8388608 = 2^{23}	
/10	22	255.192.0.0	4194304 = 2^{22}	
/11	21	255.224.0.0	2097152 = 2^{21}	
/12	20	255.240.0.0	1048576 = 2^{20}	
/13	19	255.248.0.0	524288 = 2^{19}	
/14	18	255.252.0.0	262144 = 2^{18}	
/15	17	255.254.0.0	131072 = 2^{17}	
/16	16	255.255.0.0	65536 = 2^{16}	
/17	15	255.255.128.0	32768 = 2^{15}	ISP / large business
/18	14	255.255.192.0	16384 = 2^{14}	ISP / large business
/19	13	255.255.224.0	8192 = 2^{13}	ISP / large business
/20	12	255.255.240.0	4096 = 2^{12}	Small ISP / large business
/21	11	255.255.248.0	2048 = 2^{11}	Small ISP / large business
/22	10	255.255.252.0	1024 = 2^{10}	
/23	9	255.255.254.0	512 = 2^{9}	
/24	8	255.255.255.0	256 = 2^{8}	Large LAN
/25	7	255.255.255.128	128 = 2^{7}	Large LAN
/26	6	255.255.255.192	64 = 2^{6}	Small LAN
/27	5	255.255.255.224	32 = 2^{5}	Small LAN
/28	4	255.255.255.240	16 = 2^{4}	Small LAN
/29	3	255.255.255.248	8 = 2^{3}	Smallest multi-host network
/30	2	255.255.255.252	4 = 2^{2}	"Glue network" (point to point links)
/31	1	255.255.255.254	2 = 2^{1}	Point to point links (RFC 3021)
/32	0	255.255.255.255	1 = 2^{0}	Host route

MAP OF THE INTERNET

THE IPv4 SPACE, 2006

THIS CHART SHOWS THE IP ADDRESS SPACE ON A PLANE USING A FRACTAL MAPPING WHICH PRESERVES GROUPING -- ANY CONSECUTIVE STRING OF IPs WILL TRANSLATE TO A SINGLE COMPACT, CONTIGUOUS REGION ON THE MAP. EACH OF THE 256 NUMBERED BLOCKS REPRESENTS ONE /8 SUBNET (CONTAINING ALL IPs THAT START WITH THAT NUMBER). THE UPPER LEFT SECTION SHOWS THE BLOCKS SOLD DIRECTLY TO CORPORATIONS AND GOVERNMENTS IN THE 1990's BEFORE THE RIRs TOOK OVER ALLOCATION.

0 1 14 15 16 19 →
3 2 13 12 17 18
4 7 8 11
5 6 9 10



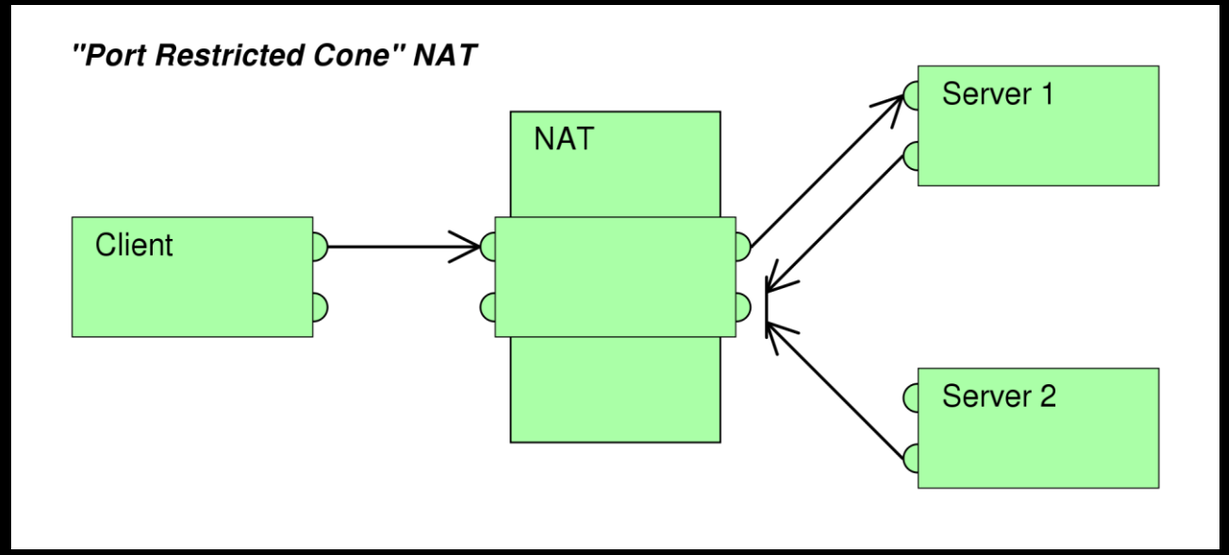
= UNALLOCATED BLOCK

https://xkcd.com/195/

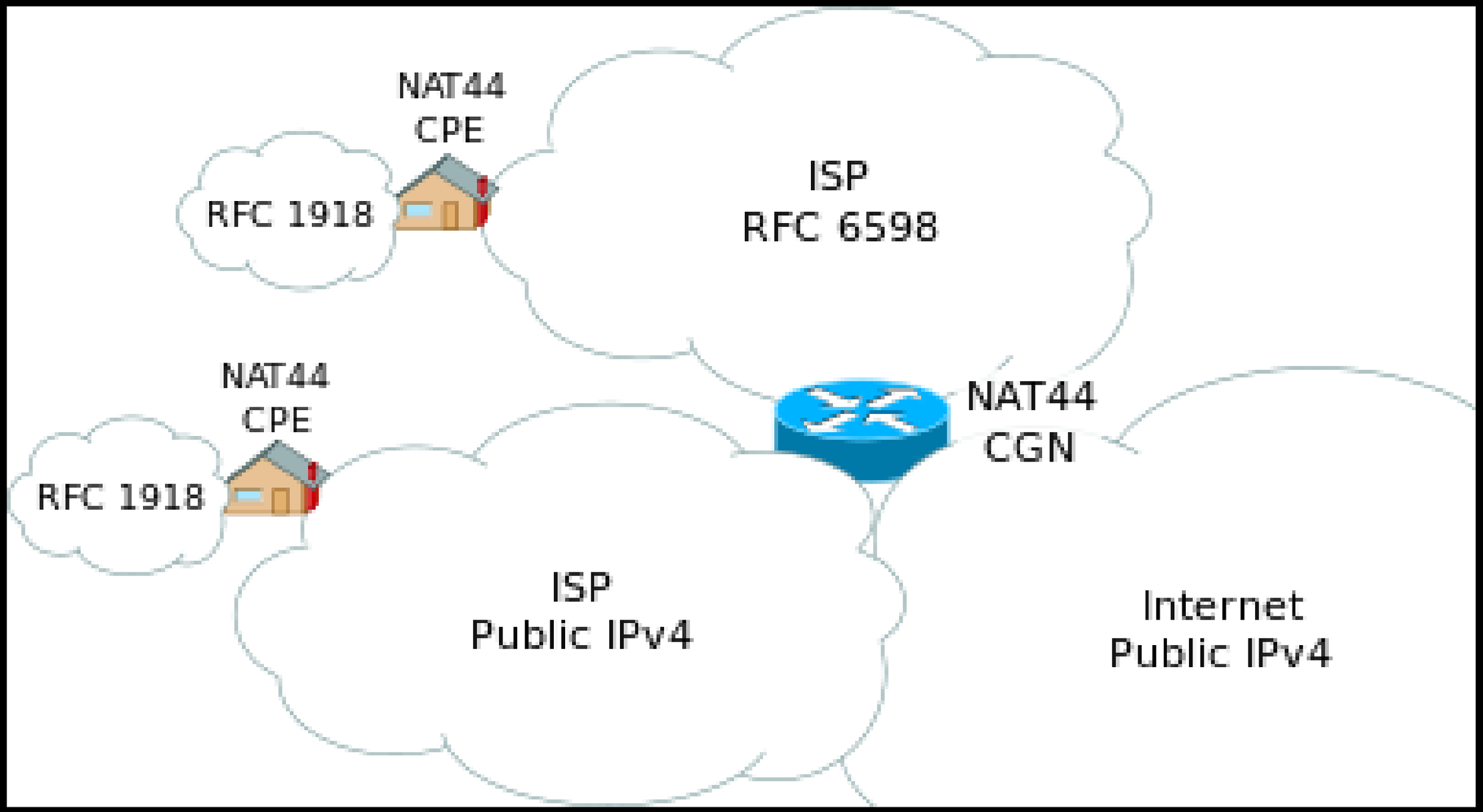
Current Workarounds

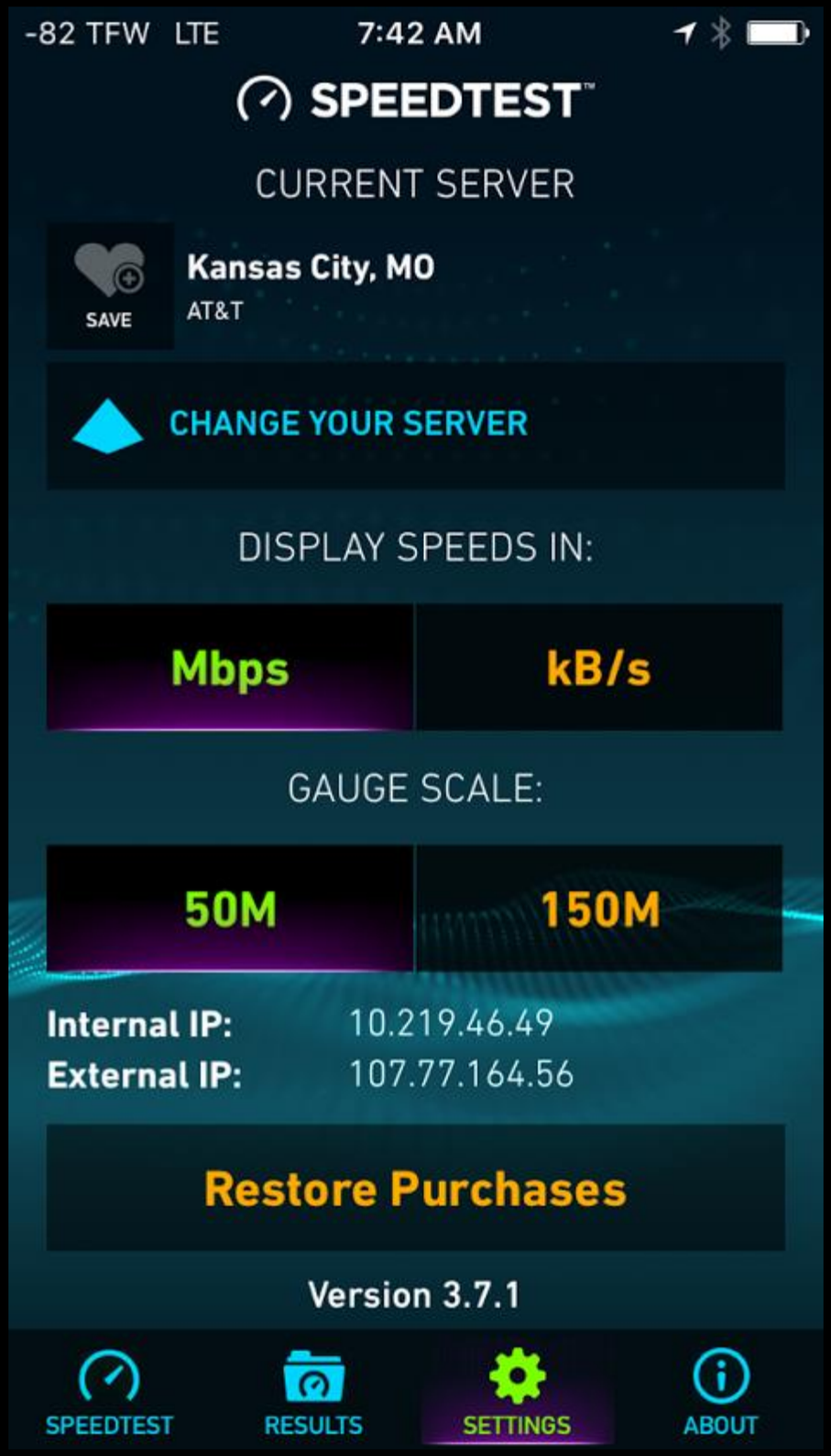
NAT

Name	Address range	Number of addresses	*Classful* description	Largest CIDR block
24-bit block	10.0.0.0–10.255.255.255	16 777 216	Single Class A	10.0.0.0/8
20-bit block	172.16.0.0–172.31.255.255	1 048 576	Contiguous range of 16 Class B blocks	172.16.0.0/12
16-bit block	192.168.0.0–192.168.255.255	65 536	Contiguous range of 256 Class C blocks	192.168.0.0/16



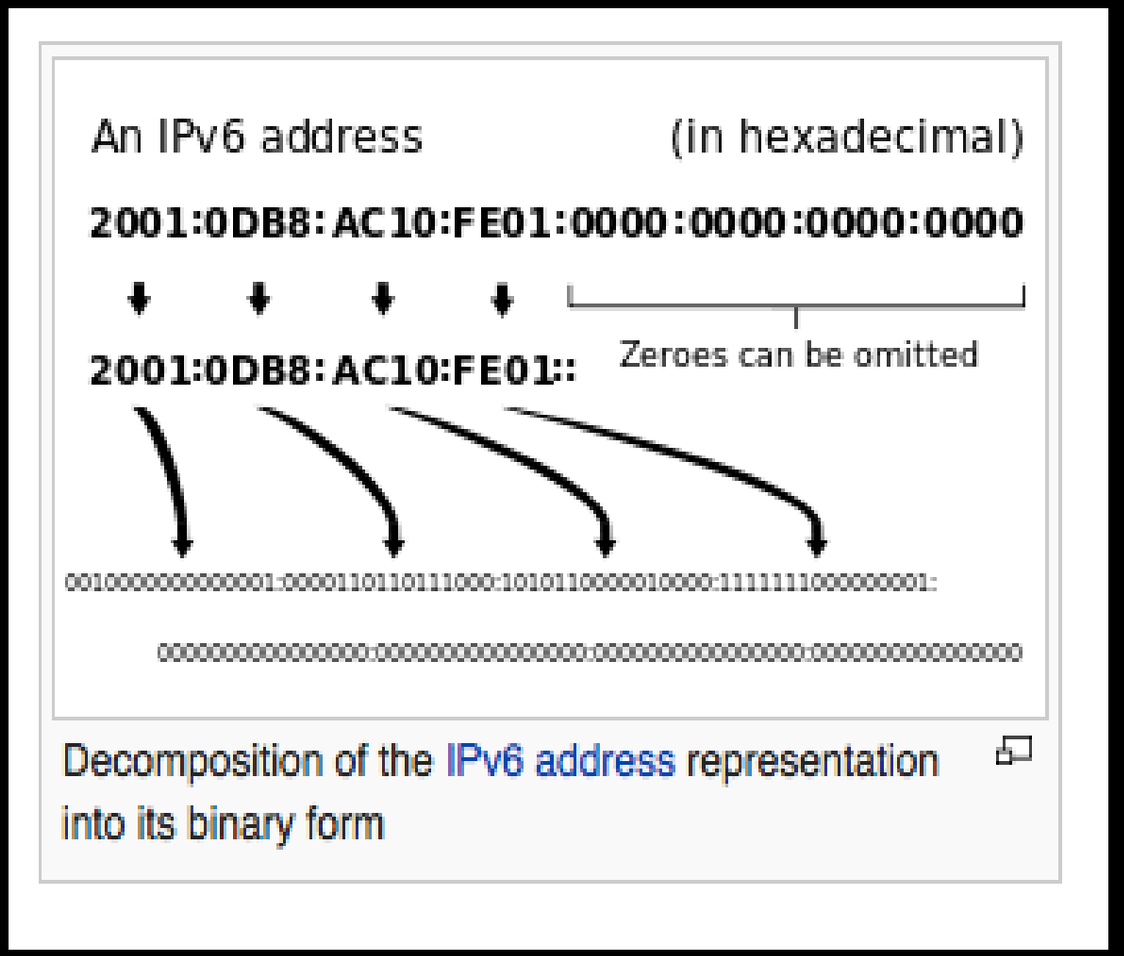
Carrier-grade NAT

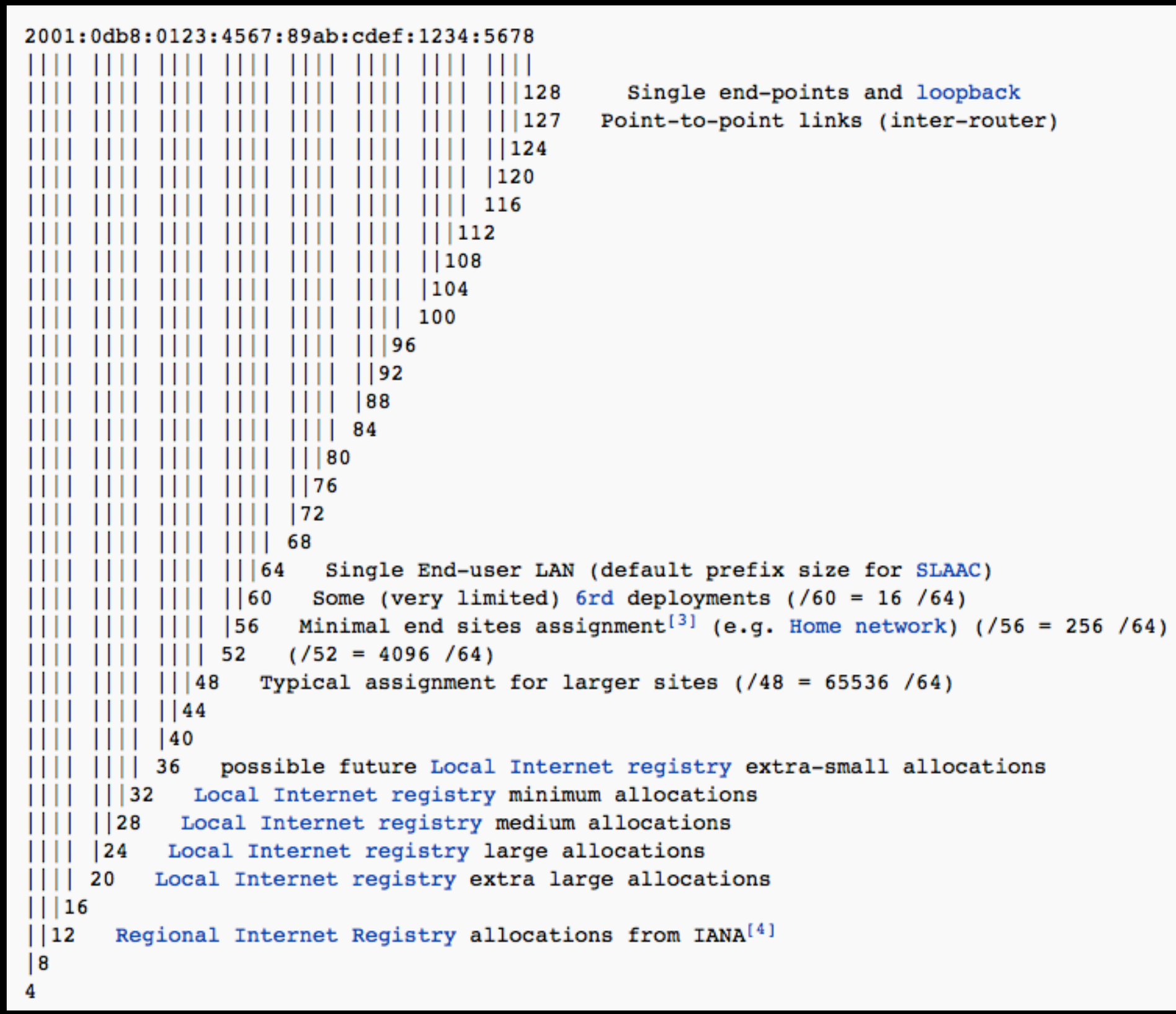



-82 TFW LTE
7:42 AM
SPEEDTEST
CURRENT SERVER
SAVE
Kansas City, MO
AT&T
CHANGE YOUR SERVER
DISPLAY SPEEDS IN:
Mbps
kB/s
GAUGE SCALE:
50M
150M
Internal IP: 10.219.46.49
External IP: 107.77.164.56
Restore Purchases
Version 3.7.1
SPEEDTEST
RESULTS
SETTINGS
ABOUT

IPv6

- Allows for 2^{40} subnets organizing 2^{50} hosts (theoretically) (340,282,366,920,938,463,463,374,607 ,431,768,211,456)
- Address autoconfiguration (RFC2462)
- Anycast addresses (“one-out-of many”)
- Mandatory multicast addresses
- IPsec (IP security)
- Simplified header structure
- Mobile IP
- IPv6-to-IPv4 transition mechanisms
- Privacy Benefits
- Jumbograms



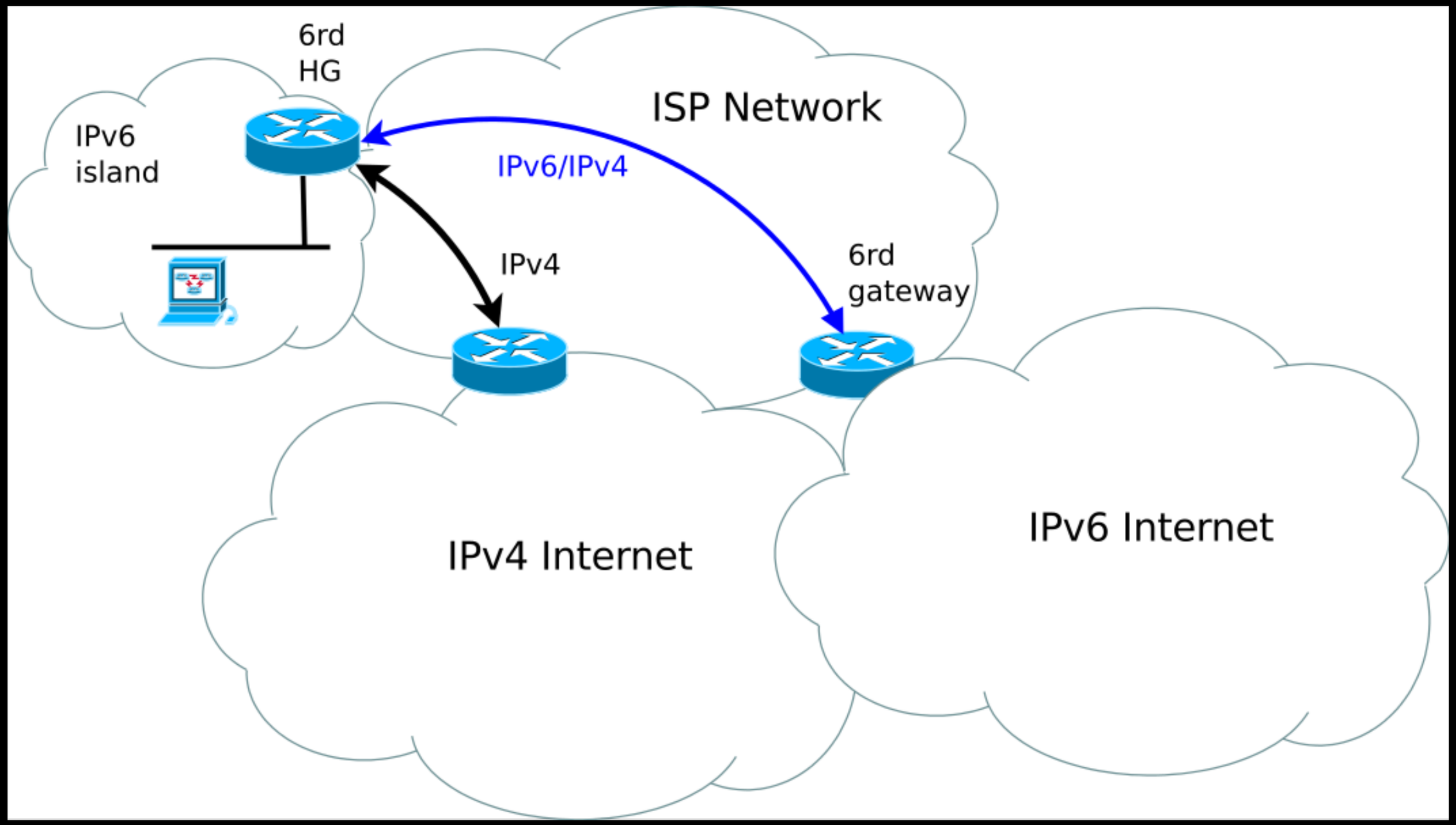

2001:0db8:0123:4567:89ab:cdef:1234:5678
128
127
124
120
116
112
108
104
100
96
92
88
84
80
76
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
Single end-points and loopback
Point-to-point links (inter-router)
Single End-user LAN (default prefix size for SLAAC)
Some (very limited) 6rd deployments (/60 = 16 /64)
Minimal end sites assignment[3] (e.g. Home network) (/56 = 256 /64)
52 (/52 = 4096 /64)
Typical assignment for larger sites (/48 = 65536 /64)
possible future Local Internet registry extra-small allocations
Local Internet registry minimum allocations
Local Internet registry medium allocations
Local Internet registry large allocations
Local Internet registry extra large allocations
Regional Internet Registry allocations from IANA[4]

IPv6 address	Prefix length (bits)	Description	Notes
`::`	128	unspecified	Used for default route and *router solicitations*. cf. `0.0.0.0` in IPv4
`::1`	128	loopback address	cf. `127.0.0.1` in IPv4
`::ffff:a.b.c.d`	96	IPv4 mapped IPv6 address	The lower 32 bits are the IPv4 address. Used in socket API's to represent IPv4 hosts.
`fe80::`	10	link-local	Unroutable autoconfigured addresses used on a LAN, e.g. for DHCPv6
`fc00::`	7	unique local	Addresses used only within an *autonomous system*, unroutable globally. Cf. RFC 1918 addresses such as used in NAT.
`ff00::`	8	multicast	
`2000::`	3	global unicast	All global unicast addresses currently begin with 2.

Native IPv6

- Best option!
- Most mainline LTE networks provide i.e. Verizon
- Some ISP

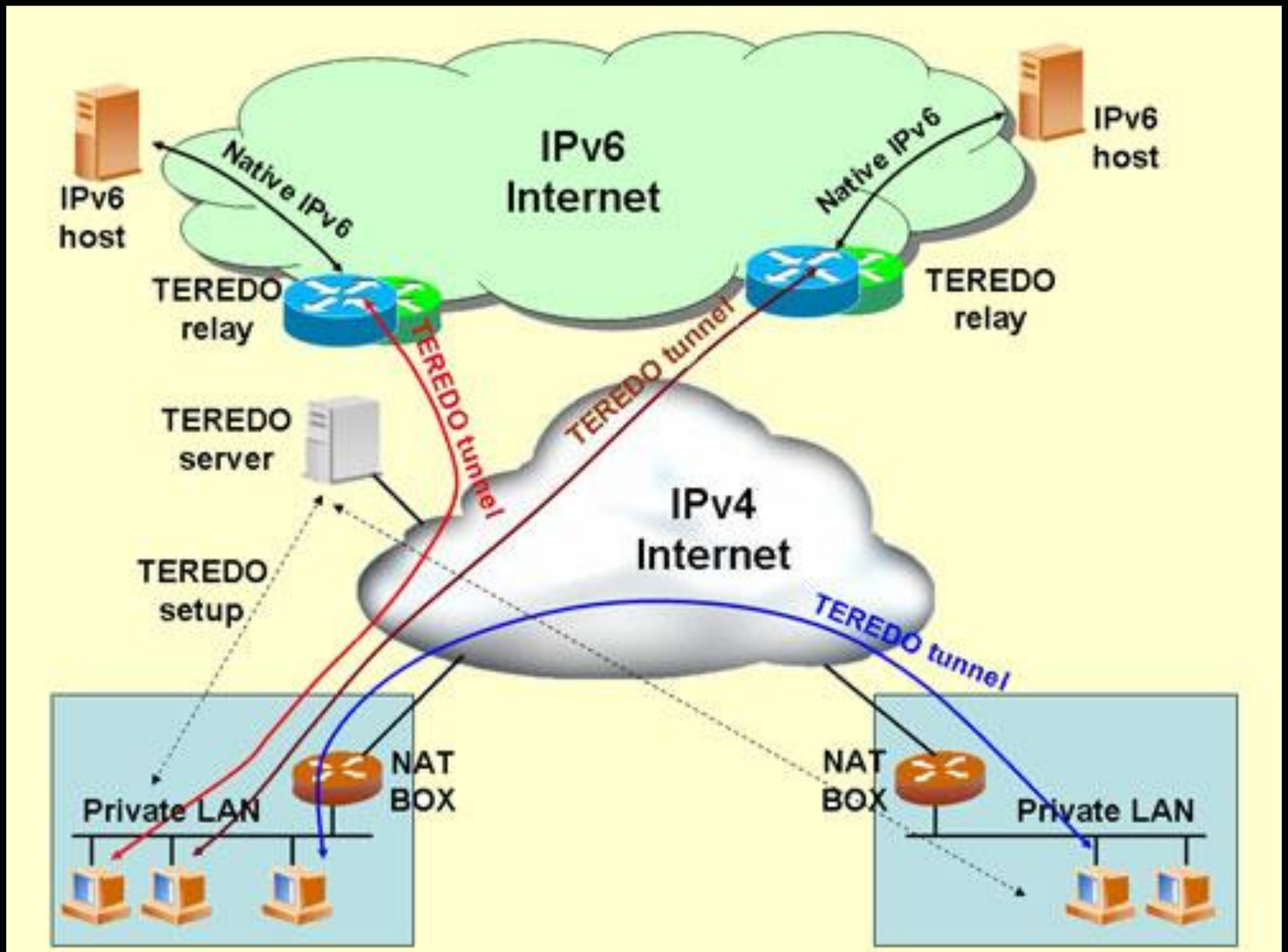
6rd


6rd
HG
ISP Network
IPv6
island
IPv6/IPv4
IPv4
6rd
gateway
IPv4 Internet
IPv6 Internet

HE-Tunnel Broker

- https://www.tunnelbroker.net/
- Uses 6in4 protocol 41
- Need to know your IPv4 address and needs to be reachable via ICMP Echo_REQUEST
- NAT needs to forward protocol 41

Teredo


IPv6
host
Native IPv6
IPv6
Internet
Native IPv6
IPv6
host
TEREDO
relay
TEREDO
relay
TEREDO tunnel
TEREDO tunnel
TEREDO
server
IPv4
Internet
TEREDO
setup
TEREDO tunnel
NAT
BOX
Private LAN
NAT
BOX
Private LAN

I have IPv6 how do I get my settings

- Hopefully automagically (ok it's via Neighbor Discovery Protocol
- (NDP) (RFC 4861)
- Sends out a ICMPv6 packet asking "who can do…"
- In linux you can use radvd to advertise these services

Using IPv6

```
adenner@li117-82:~$ traceroute6 denner.co
traceroute to denner.co (2400:cb00:2048:1::681c:174e), 30 hops max, 80 byte packets
 1  2600:3c00::8678:acff:fe0d:97c1 (2600:3c00::8678:acff:fe0d:97c1)  1.234 ms  1.237 ms  1.279 ms
 2  0.00.0000.ip4.static.sl-reverse.com (2607:f0d0:2:4::2:0)  0.235 ms  0.262 ms  0.250 ms
 3  8.00.0000.ip4.static.sl-reverse.com (2607:f0d0:2:4::1:8)  0.677 ms 0.00.0000.ip4.static.sl-reverse.com (2607:f0d0
:2:4::1:c)  1.148 ms 8.00.0000.ip4.static.sl-reverse.com (2607:f0d0:2:4::1:8)  0.746 ms
 4  2607:f0d0:1900:1::10 (2607:f0d0:1900:1::10)  0.357 ms 2607:f0d0:1900:1::a (2607:f0d0:1900:1::a)  0.380 ms 2607:f0
d0:1900:1::10 (2607:f0d0:1900:1::10)  0.353 ms
 5  8010.0000.0000.0000.2000.2000.0d0f.7062.ip6.static.sl-reverse.com (2607:f0d0:2:2::108)  0.918 ms  0.545 ms  0.584
 ms
 6  xe-0-0-3.edge01.dfw01.as13335.net (2001:504:0:5:0:1:3335:1)  0.541 ms  0.530 ms  0.512 ms
 7  2400:cb00:15:1024::6ca2:dc8c (2400:cb00:15:1024::6ca2:dc8c)  0.513 ms 2400:cb00:15:1024::a29e:446e (2400:cb00:15:
1024::a29e:446e)  0.513 ms  0.453 ms
adenner@li117-82:~$
```