RESTORING END-TO-END CONNECTIVITY WITH IPV6

Fixing what’s been broken in our internet for 35 years

AGENDA

1. **The basics of the internet and IPv4**
2. Problems caused by IPv4
3. The basics of IPv6
4. How IPv6 addresses those problems
5. Transitioning to IPv6
6. IPv6 in the wild today

A BRIEF TIMELINE

1981: IPv4 is released

1999: IPv6 is released

WHAT YOU SHOULD KNOW ABOUT IPV4

Addresses are 32-bit numbers

They range from 000.000.000.000 to 255.255.255.255

There are a total of 4 294 967 286 available addresses

SUBNETTING

Divides address space between organizations

Divisions based on the number of bits masked off the address

Written in CIDR notation (/8, /22, /29)

```
00110110000000000000000000000000 /8
00110110101100000000000000000000 /16
00110110101100000000110100000000 /24
```

Left-most digits are locked — Remaining digits can be changed

THE STRUCTURE OF THE INTERNET

“The internet” isn’t a singular entity

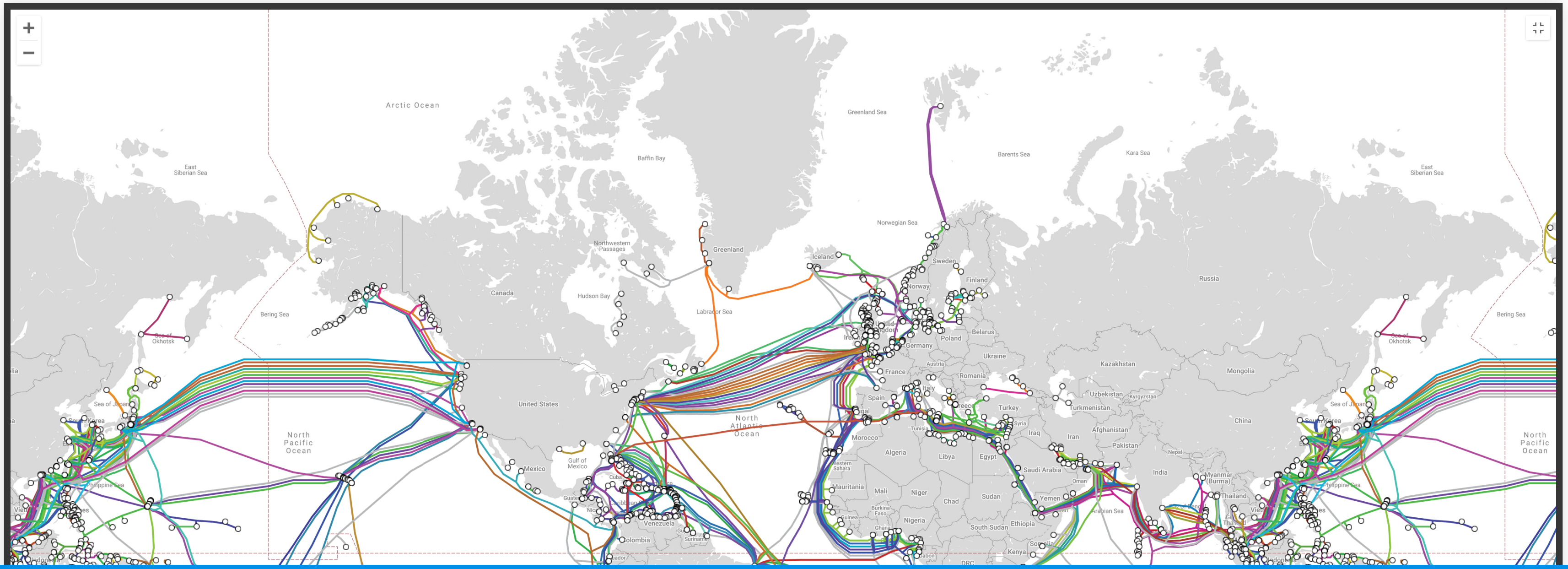
The internet is actually a ton of small interconnected networks

Network traffic travels end-to-end by crossing many different networks

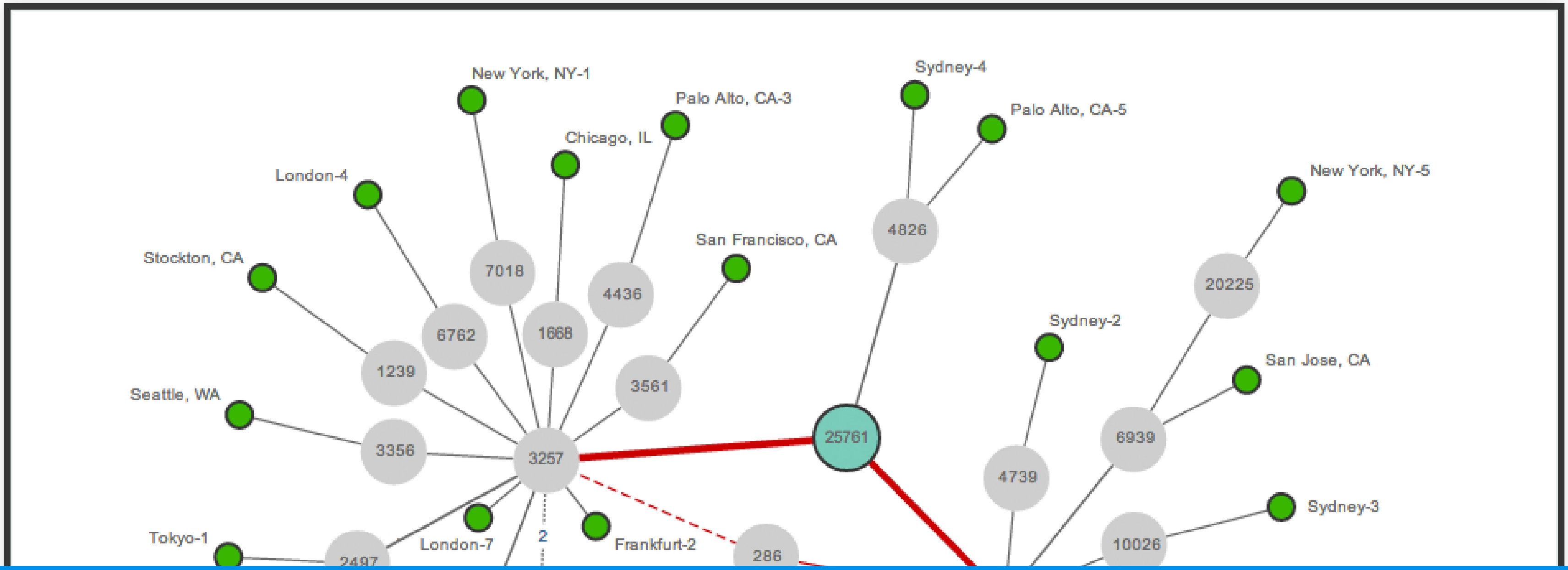
Routers peer to interconnect networks

Traffic takes different routes

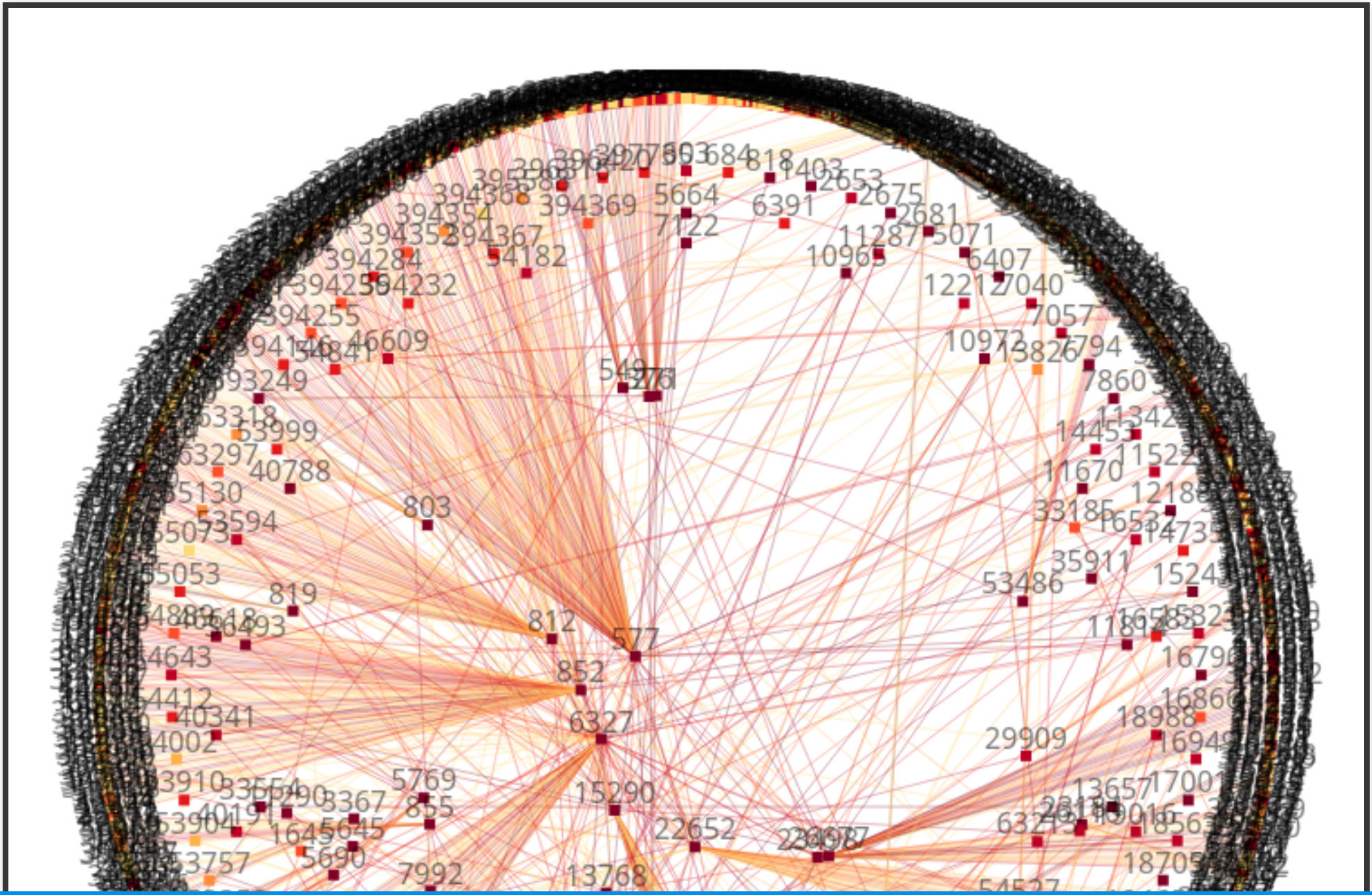
PHYSICAL VIEW OF THE INTERNET



LOGICAL VIEW OF THE INTERNET



LOGICAL VIEW OF THE INTERNET



THE GLOBAL ROUTING TABLE

Contains everyone’s subnets

Used by routers to send traffic to destination

Limited in size, routes are summarized

AGENDA

1. The basics of the internet and IPv4
2. **Problems caused by IPv4**
3. The basics of IPv6
4. How IPv6 addresses those problems
5. Transitioning to IPv6
6. IPv6 in the wild today

THE MAJOR PAIN POINT OF IPV4

ADDRESS EXHAUSTION

The world population is ~8 billion
There are at least that many devices on the internet

There are ~4.3 billion addresses in IPv4

You see the problem…

END-TO-END CONNECTIVITY

Every host can reach every other host

In both directions

Empowers peer-to-peer applications

WHAT WE CAME UP WITH

Unfortunately the answer wasn't "switch to v6"

NAT

Network Address Translation

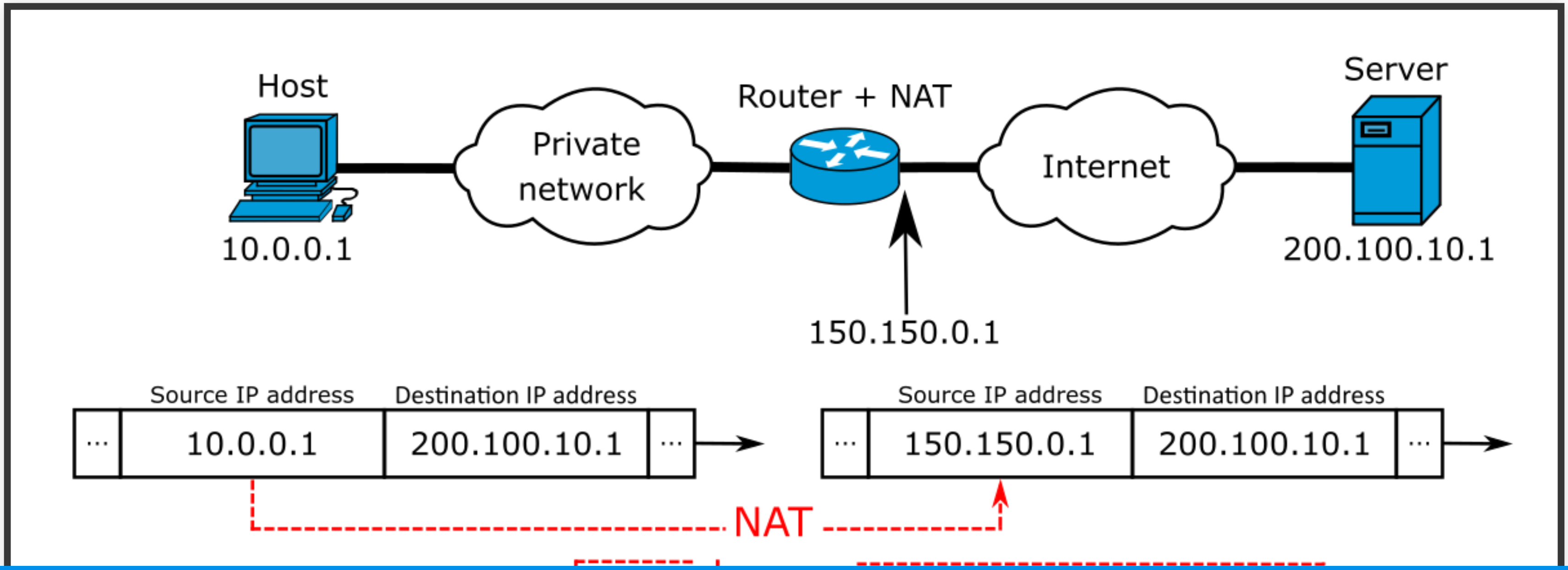
Reserve space for "private" addressing (RFC1918)

`10.0.0.0/8`, `172.16.0.0/12`, `192.168.0.0/16`

Use private addressing "inside" and translate to public addressing "outside"

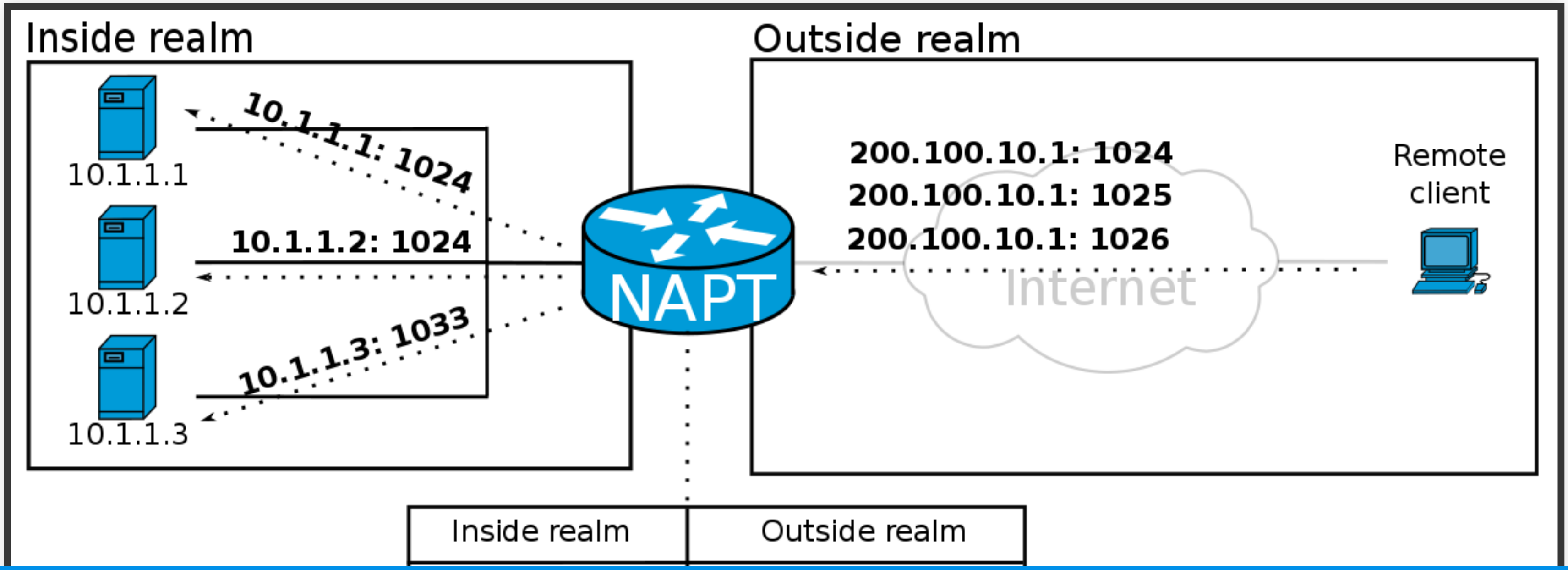
HOW DOES NAT WORK?

SOURCE NAT + MASQUERADE



HOW DOES NAT WORK?

DESTINATION NAT



IF THAT DOESN’T SOUND BAD ENOUGH YET, DON’T WORRY BECAUSE IT GETS WORSE

ENTER CG-NAT

Carrier-Grade NAT

Even internet service providers are running out of IPv4

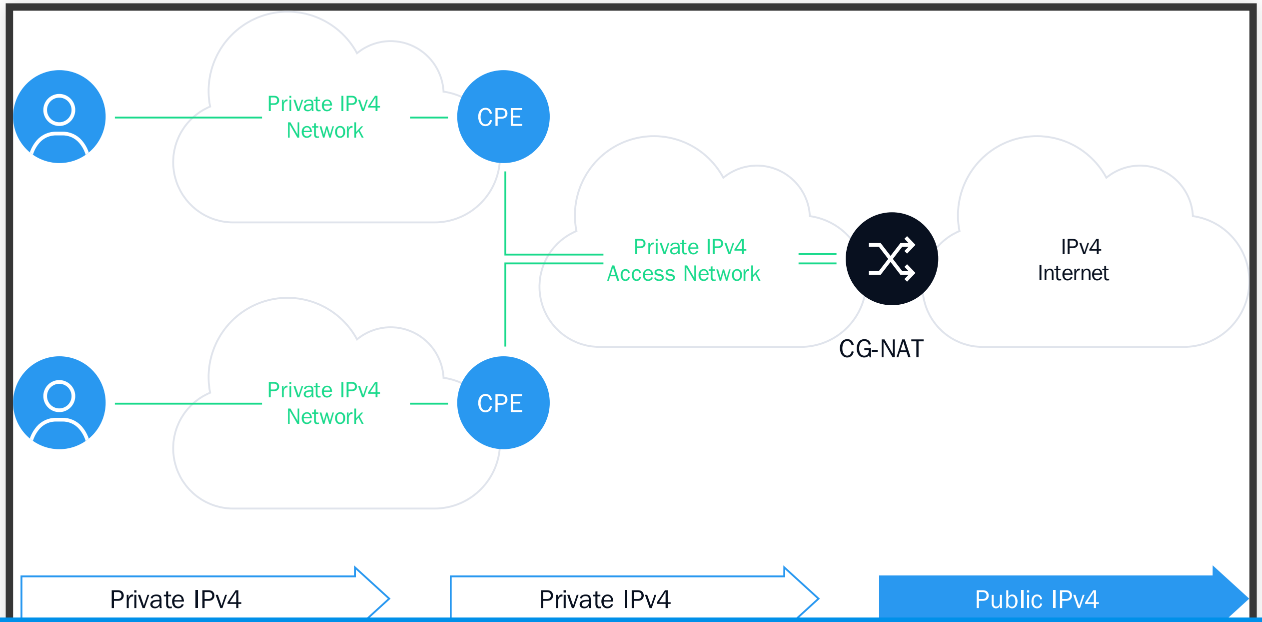
They came up with a brilliant solution

Just stick another NAT between our customers and the internet

`10.64.0.0/10`

HOW DOES NAT WORK?

CG-NAT



AGENDA

1. The basics of the internet and IPv4
2. Problems caused by IPv4
3. **The basics of IPv6**
4. How IPv6 addresses those problems
5. Transitioning to IPv6
6. IPv6 in the wild today

IPV6 TO THE RESCUE!

Selling point: exponentially more addresses (340 Trillion!)

128-bit addresses from
`0000:0000:0000:0000:0000:0000:0000:0000` to
`FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF`

Multiple addresses per interface

Simplified packet header

Address autoconfiguration

Duplicate address detection

Much more

IPV6 ADDRESSES

Can be shortened,

`2607:00de:0045:0000:0000:0000:dead:00e1` ->

`2607:de:45::dead:e1`

Subnetting works the same way but with `/128` bits.

Can be generated based on MAC address

Can be randomized for privacy

There's enough IPv6 for every device in the world

Restore the end-to-end principle

IPV6 ADDRESS TYPES

GUA: `2000::/3`, most like `0.0.0.0/0`

ULA: `fc00::/7`, most like `10.0.0.0/8`

Link-Local: `fe80::/10`, most like `169.254.0.0/16`

SLAAC

StateLess Address Auto Configuration

Devices choose their own address

No need for a DHCP server keeping track of leases

Static Addressing

Privacy Addressing

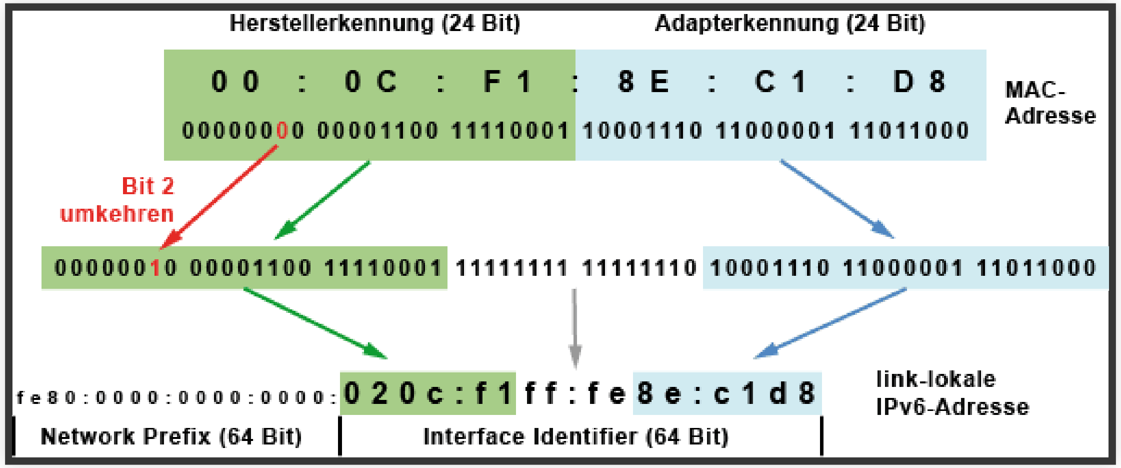
Requires a `/64` or larger subnet

SLAAC

EUI-64 ADDRESS

Predictable and static IP addresses

Available on every interface via link-local address



SLAAC

PRIVACY ADDRESSES

Randomly generated

Multiple addresses

Frequently rotated

```
    inet6 2001:470:b08b:51:7d95:1d02:b4da:a8c/64 scope global temporary dynamic
       valid_lft 520879sec preferred_lft 2027sec
    inet6 2001:470:b08b:51:f2d:3b3e:ba41:10b/64 scope global temporary dynamic
       valid_lft 434933sec preferred_lft 0sec
```

AGENDA

1. The basics of the internet and IPv4
2. Problems caused by IPv4
3. The basics of IPv6
4. **How IPv6 addresses those problems**
5. Transitioning to IPv6
6. IPv6 in the wild today

IMPLICATIONS OF GUA ADDRESSING

Addresses for every device on your internal network

We are STILL protected by firewalls!

Everyone can reach eachother else given correctly configured firewall rules

No more “public” and “private” ip addresses

Only “globally routable” ip addresses

Multiple services can be hosted on the same port within an internal network

COMMON MISCONCEPTIONS ABOUT IPV6

IPv6 is not IPv4 with more address bits

NATs do NOT provide any additional security

Using GUA addresses does not expose your internal network

AGENDA

1. The basics of the internet and IPv4
2. Problems caused by IPv4
3. The basics of IPv6
4. How IPv6 addresses those problems
5. **Transitioning to IPv6**
6. IPv6 in the wild today

TRANSITIONING TO IPV6

Dual-stack networks

Single-stack IPv6 with tunelled/translated IPv4

DUAL-STACK NETWORKING

IPv4 and IPv6 in parallel

Hosts have two different addresses

IPv6 is preferred and IPv4 used when IPv6 is not available

Simple to implement

Good for home/office networks

SINGLE-STACK V6 WITH NAT64 & DNS64

Internal network is IPv6 only

DNS64 synthesizes A responses into AAAA

NAT64 translates between v4/v6 at the network border

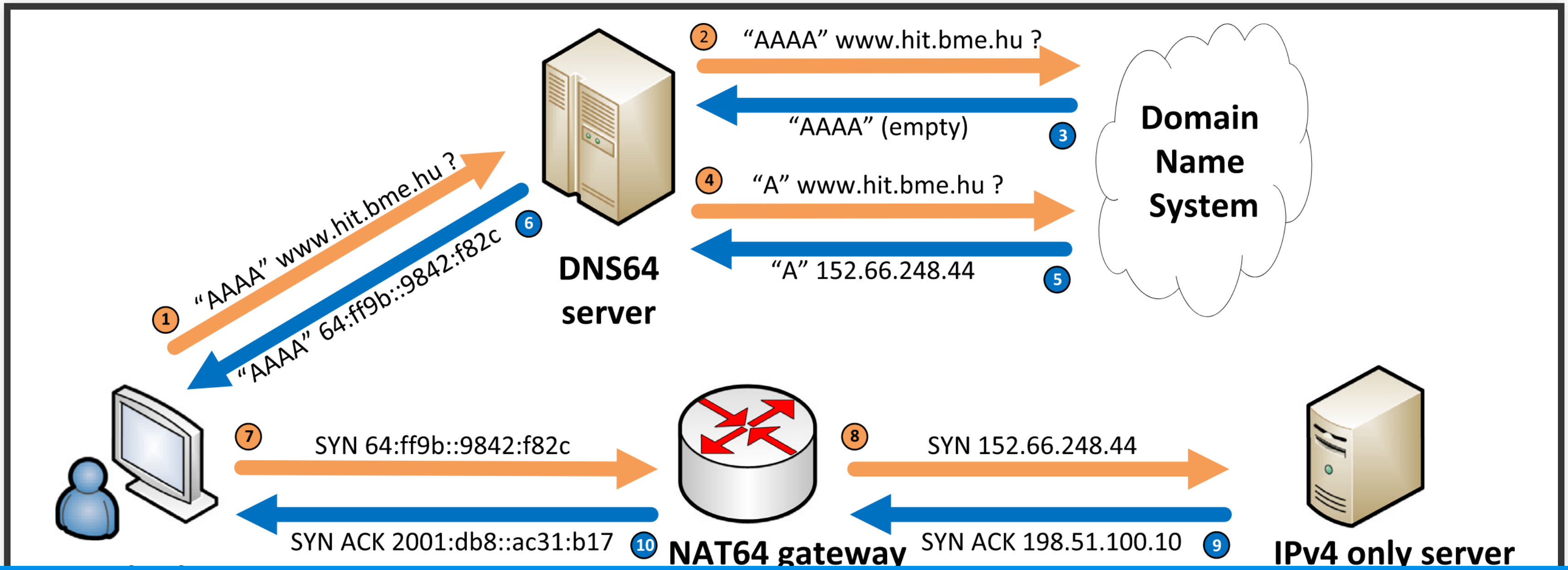
Harder to implement

Breaks certain protocols

Good for server networks

NAT64 & DNS64 ILLUSTRATED

`0.0.0.0/0 -> 64:ff9b::/96`



464XLAT - A MIX OF BOTH

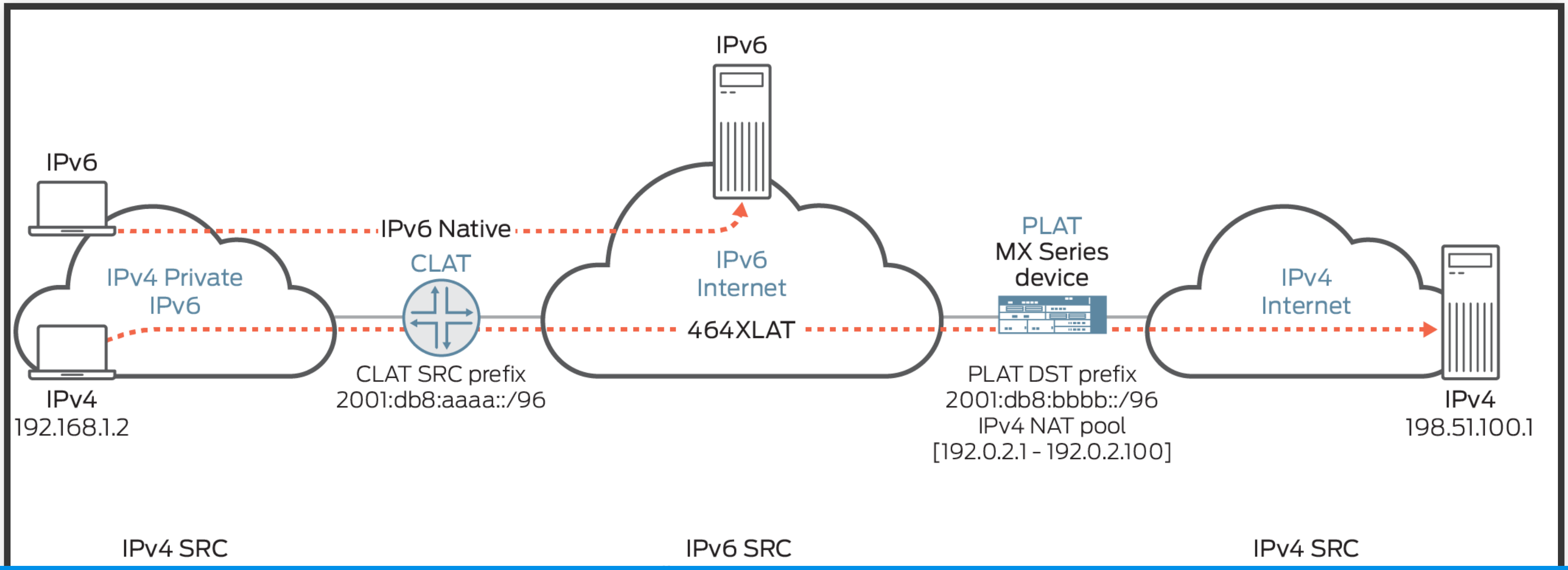
Native IPv6 connectivity

IPv4 is transported over IPv6

End device still has IPv4 support (no protocol breakage)

IPv4 is NAT/CG-NATed

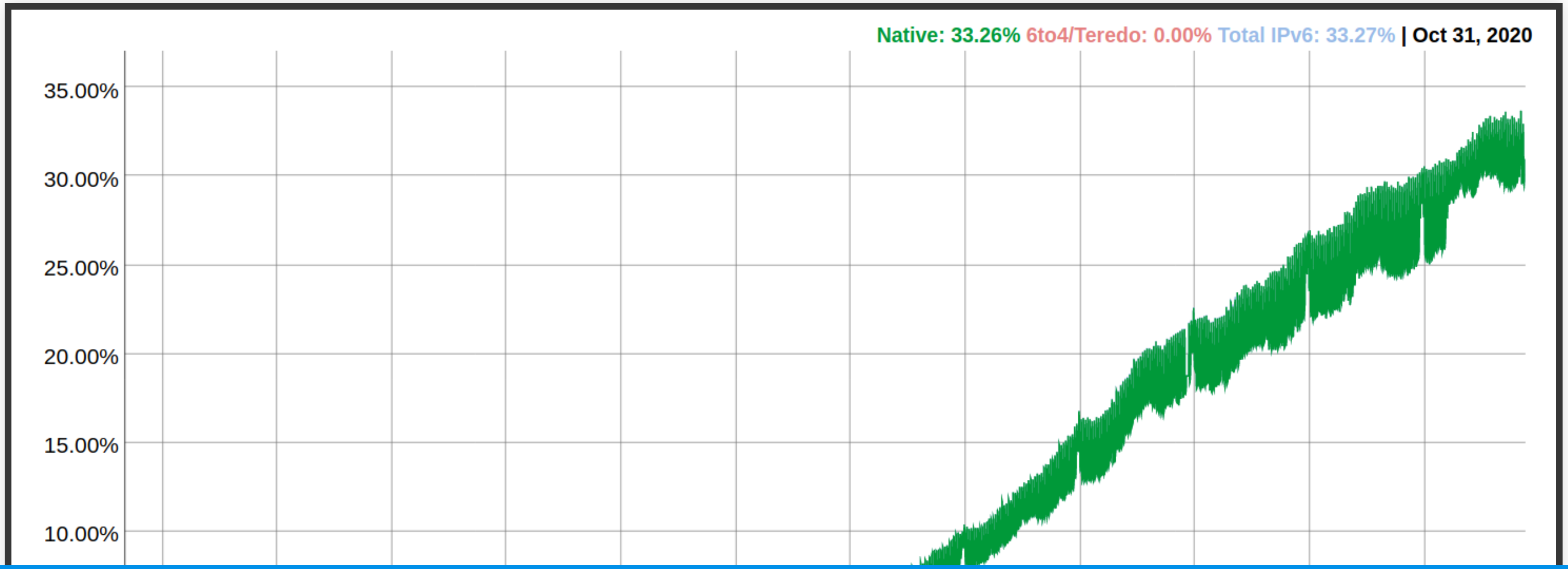
464XLAT ILLUSTRATED



AGENDA

1. The basics of the internet and IPv4
2. Problems caused by IPv4
3. The basics of IPv6
4. How IPv6 addresses those problems
5. Transitioning to IPv6
6. **IPv6 in the wild today**

IPV6 DEPLOYMENT STATISTICS BY GOOGLE



LARGE TECH COMPANIES ARE GOING IPV6-ONLY IN THE DATACENTER

FACEBOOK

LINKEDIN

IPV6 IS UP TO 40% FASTER THAN IPV4

Measured by Facebook end-to-end

Over cellular and wifi networks

Attributed to the lack of middleboxes and NATs

IPV6 DEPLOYMENTS IN CANADA

Mobile networks: Rogers(Fido), Bell(Virgin)

Residential networks: Rogers, Telus, TekSavvy (DSL), Videotron Helix

Tunnels: Videotron 6rd, Hurricane Electric (https://tunnelbroker.net)

👎👎 Videotron Cable, Bell Fibe, Telus Mobility 👎👎

THANKS FOR LISTENING

QUESTIONS WELCOME