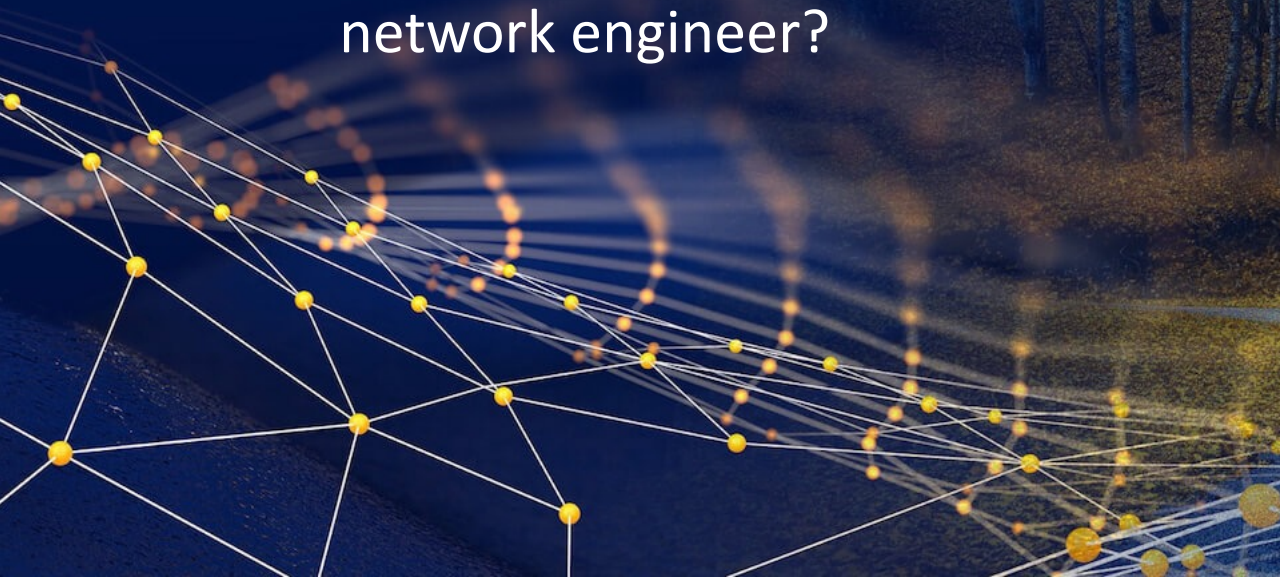# ROUTE 128

IPv6

The next or the last thing you will see as a network engineer?
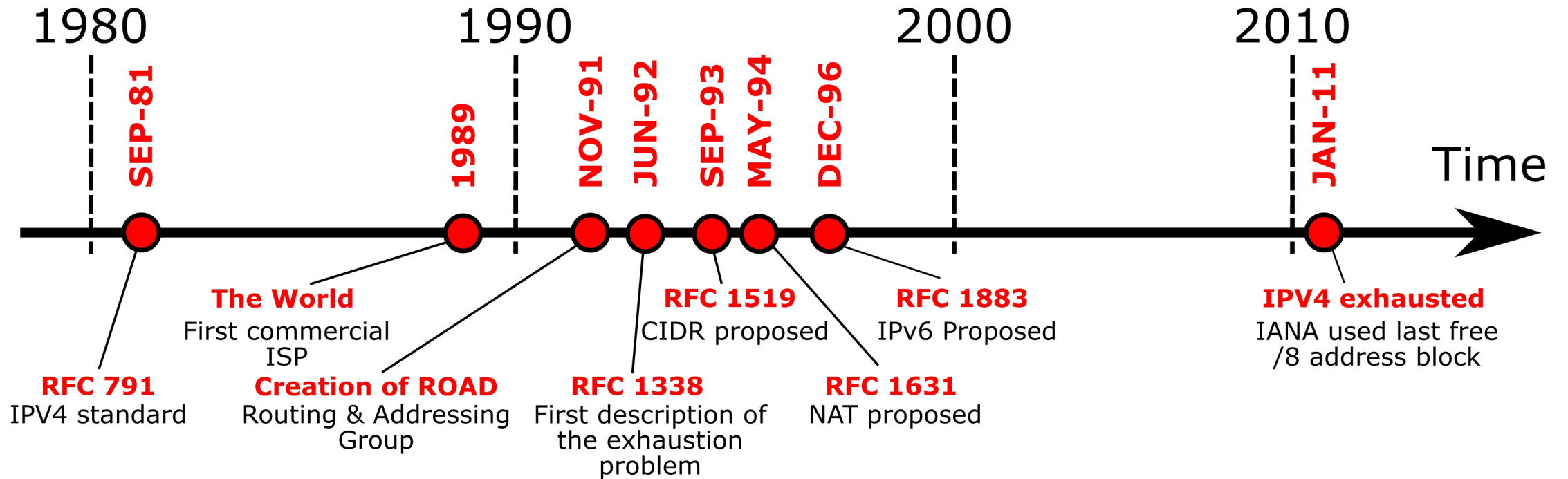
What People Say

IPv6 is:

- Faster
- More Secure
- All Routing
- End-to-End Communication
- Firewall
- No NAT
- PI by sponsoring LIR
- Powering the Mobile World
- Better for VoIP and Multimedia

IPv6 is not:

- Using RFC1918
- Less Secure
- Hard to learn
- About addresses
- Hard to get
- Only for nerds or technicians
- Too new
- About extra fees for IPv6

ROUTE 128

But …

SEP-81

1989

NOV-91

JUN-92

SEP-93

MAY-94

DEC-96

JAN-11

1980   1990   2000   2010   Time

The World
First commercial
ISP

RFC 1519
CIDR proposed

RFC 1883
IPv6 Proposed

IPV4 exhausted
IANA used last free
/8 address block

RFC 791
IPV4 standard

Creation of ROAD
Routing & Addressing
Group

RFC 1338
First description of
the exhaustion
problem

RFC 1631
NAT proposed

Use of IPv6

Use of IPv6 for Ireland (IE)

https://stats.labs.apnic.net/ipv6/IE

Use of IPv6 for Germany (DE)

https://stats.labs.apnic.net/ipv6/DE

ROUTE 128

RFC 9386 - IPv6 Deployment Status

Table 2: IPv6-Capable Users against Total Users (in Millions) as of January 2022

	Jan 2018	Jan 2019	Jan 2020	Jan 2021	Jan 2022	CAGR
IPv6	513.07	574.02	989.25	1,136.28	1,207.61	23.9%
World	3,410.27	3,470.36	4,065.00	4,091.62	4,093.69	4.7%
Ratio	15.0%	16.5%	24.3%	27.8%	29.5%	18.4%

Table 3: Usage of IPv6 in Websites (as of January 2022)

| Worldwide Websites	Jan 2018	Jan 2019	Jan 2020	Jan 2021	Jan 2022	CAGR
% of IPv6	11.4%	13.3%	15.0%	17.5%	20.6%	15.9%

ROUTE 128

RFC 9386 - IPv6 Deployment Status

| Table 7: IPv6 Support for External-Facing Services (as of January 2022)				
Country	Domains analyzed	DNS	Mail	Website
China	478	74.7%	0.0%	19.7%
India	104	51.9%	15.4%	16.3%
United States of America	1070	66.8%	21.2%	6.3%

ROUTE 128

Deployment

2013-2022

Percentage of requests over IPv6 to a subset of dual-stack sites on Akamai from July 2013 to May 2022 for top 10 global economies (by GDP in 2022, per IMF).
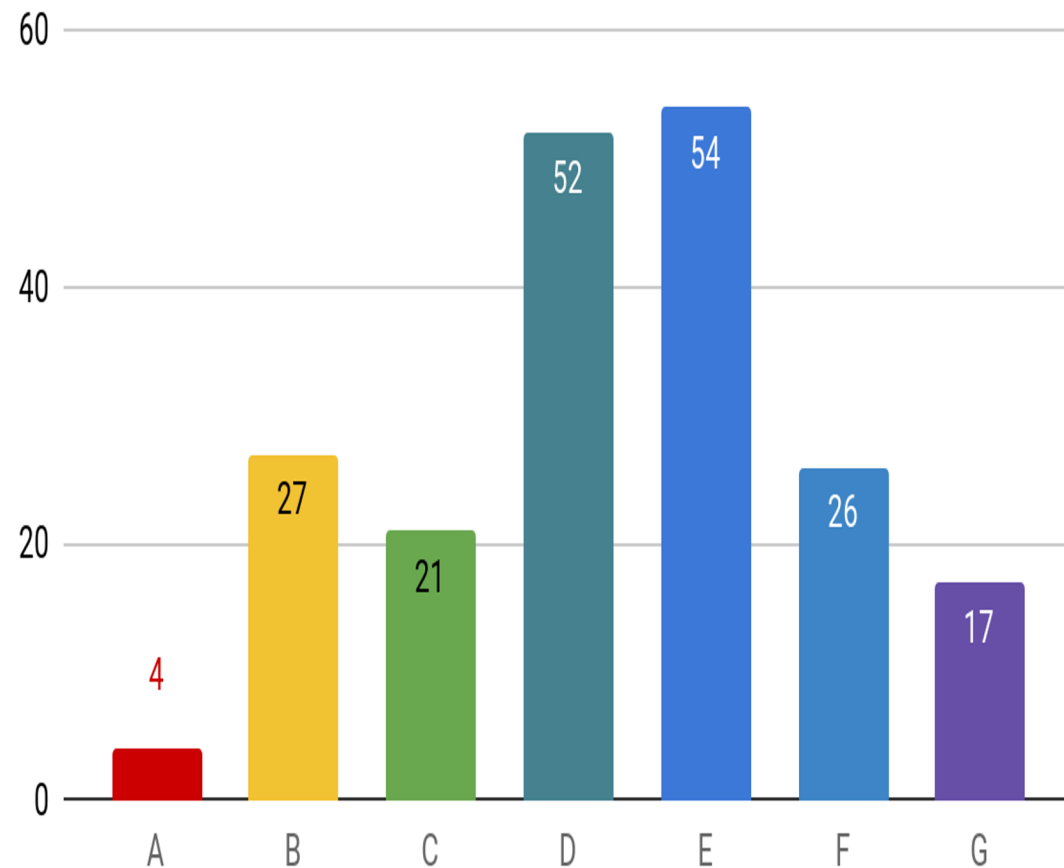
ROUTE 128
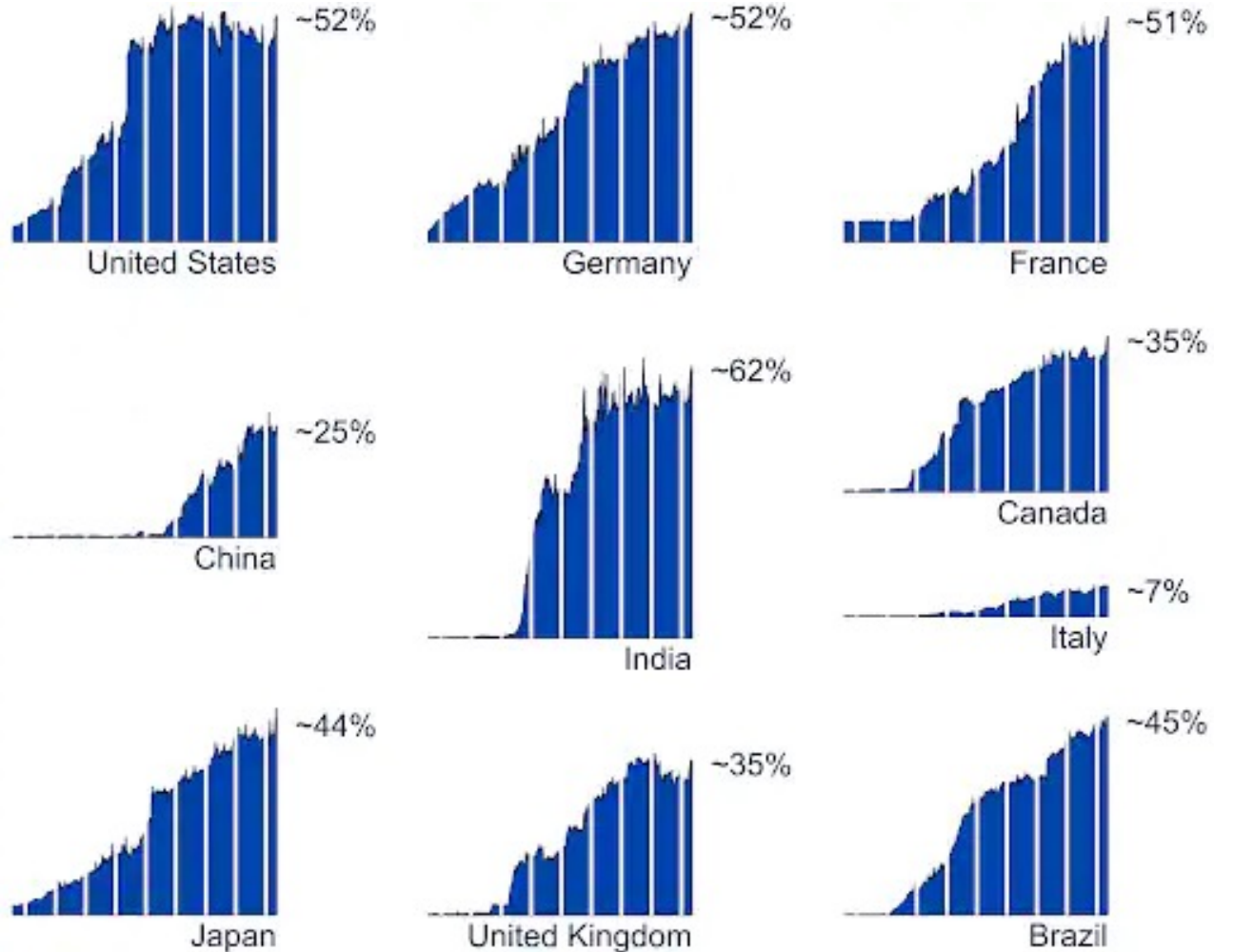
eco - IPv4/IPv6 Results
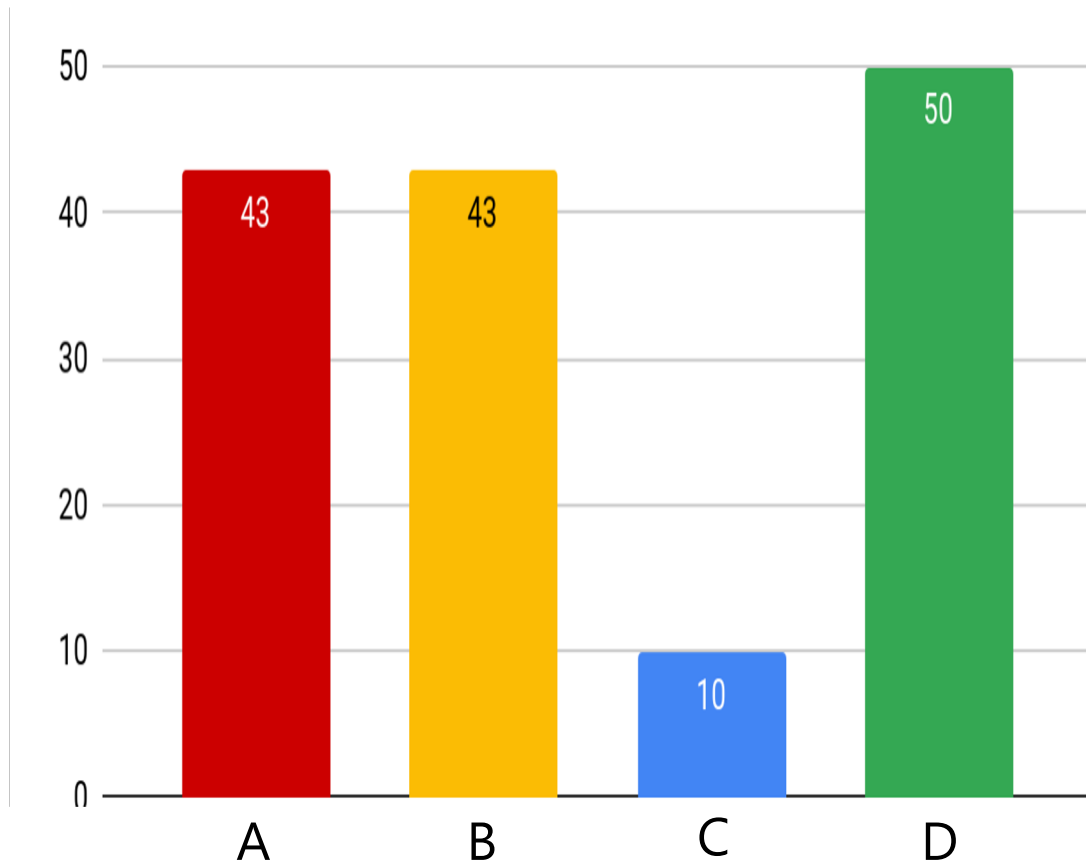
Question: "In your opinion, what stumbling blocks stand in the way of broad acceptance?"

A No know-how

B No necessity

C Cost reasons

D Other

ROUTE 128

eco - IPv4/IPv6 Results

Question: "Which of the following activities are most likely to apply to you? (multiple choice)"

A IPv6 is a hype that we are not currently participating in

B We are still completely on IPv4 and are not currently planning a switchover

C We are still completely on IPv4, but have concrete plans to switch to IPv6

D We are "halfway there", so to speak

E We mainly use IPv6, but we cannot do without IPv4 in the next few years

F We use over 90% IPv6

G We consider IPv4 to be dispensable for our services from 2026 at the latest

ROUTE 128

Do you feel sufficiently informed?

You have to actively look for information - but IPv6 should be a "debt to be discharged"!

nave already successfully implemented several IPv6 projects.

I am not aware of the latest developments

have been offering IPv4 and IPv6 in our data center for years

Manual for the SOHO sector would help

Shared NAT64/DNS64 are available to our customers to reach IPv4 residual ramp

We have been IPv6 ready for years!

Special topic; not the focus of perception

We are pioneers in IPv6 introduction (telephone) and migration (DS-Lite+PCP)

I feel well informed

Information from RIPE is known, but difficult to implement

IPv6 in use since 2013

IPv6 is well known. Protocol not a big hit. IPv4 / IPv6 will continue to exist in parallel

ROUTE 128

eco

What are the stumbling blocks?

"No know-how" and "costs" are used as an excuse

No attention in management

Vocational schools still teach Class A/B/C networks

Knowledge gaps in the customer environment

Inadequate address assignment by provider

Customers see no need

No time/resources for implementation!

Lack of awareness of necessity

No need as long as IPv4 addresses are available and DualStack is used

Perception: "IPv6 is extra work"

Layer 8 problem ;-)

too few services are IPv6 only

No need to exchange, sell or lease IP blocks

System compatibility with legacy hardware

eco

eco - Result

- No Know-How
- Vocational schools still teach Class A/B/C networks
- Information from RIPE is known, but difficult to implement
- Costs
- Customer see no need
- Not enough services on IPv6-only
- No attention in management (Layer8)

ROUTE 128

No Need?

	World IPv6 Launch (2012)	10 years later (2022)
Peak IPv6 traffic	~1 Gbps	41 Tbps (> 41,000 Gbps)
Daily IPv6 requests	3.9 billion per day (and 8 million in 2011)	> 4,000 billion per day
IPv6 addresses observed per day	19 million	7.5 billion (across 2.2 billion "/64" prefixes)

How IPv6 traffic on the Akamai CDN has grown in the decade since World IPv6 Launch

https://www.akamai.com/blog/trends/10-years-since-world-ipv6-launch

ROUTE 128

Schools - German UNIVERSITIES

IPv6-Status ℹ

Institution	HTTP	DNS	MX	Groupware	IMAP	POP3	Submission	Webmail	VPN	Portal	User-Portal	IDP	NTP
BelWü ↗	✔	✔	✔	✔	✔	✔	✔	✔	✔	○	✔	○	✔
Duale Hochschule Baden-Württemberg ↗	✖	✔	✖	✖	○	○	✖	✖	○	✖	✖	○	○
Hochschule Heilbronn ↗	✔	—	✔	✖	✔	✔	✔	✖	✔	✖	✖	✖	○
Hochschule für Technik Stuttgart ↗	✔	✔	✖	✖	✖	✖	✖	✖	✖	✖	○	✖	○
Karlsruher Institut für Technologie ↗	✔	✔	✔	✔	✔	✔	✔	✔	⚠	✔	✔	✔	✔
Universität Freiburg ↗	✖	✔	✔	○	✔	✔	✔	✔	✔	✖	✖	✖	✔
Universität Heidelberg ↗	✖	—	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖
Universität Hohenheim ↗	✔	✔	✔	○	✔	✔	✔	✔	✔	✔	✖	✔	✔
Universität Konstanz ↗	✔	✔	✔	○	✔	○	✔	✔	✔	✖	○	✔	✔
Universität Mannheim ↗	✔	✔	✔	✔	⚠	⚠	✔	✔	✔	✔	○	✔	✔
Universität Stuttgart ↗	✔	✔	✔	✔	✔	✔	✔	✔	✔	✖	✔	✔	✔
Universität Tübingen ↗	✔	✔	✔	○	✖	✖	✔	✔	✖	✖	○	✖	✔
Universität Ulm ↗	✔	✔	✔	○	✔	○	✔	✔	✔	✔	○	✔	✔
Hochschule Offenburg ✱ ↗	✔	✔	✔	○	✔	✔	✔	✖	✔	✖	○	✔	✔
Staatliche Hochschule für Gestaltung Karlsruhe ✱ ↗	✔	✔	✔	○	✔	○	✔	✔	○	○	✔	○	○

https://status.bwipv6.de

To be reached at:
193.196.32.30
2a00:139e:3:1:250:56ff:fe86:7e0d

ℹ Dies ist eine Übersicht des IPv6-Status der Projektteilnehmer am Projekt bwIPv6@Academia. Diese Seite gibt nur einen groben Überblick und hat keinen Anspruch, die reale Situtation vollumfänglich widerzuspiegeln. Insbesondere setzt der erfolgreiche Abschluss des bwIPv6@Academia-Projekts nicht die IPv6-Anbindung aller auf dieser Seite gelisteten Dienste voraus.

✱ Kein offizieller Projektteilnehmer
Status vom 05.03.24 um 17:00 | Rohdaten (JSON)

ROUTE 128

German ISP

- e.g. German Telecom (80% IPv6 Deployment 2023)
  - Fixed /48 IPv6 and /29 IPv4 Prefixes for ConnectIP
  - Fixed /56 IPv6 and /32 IPv4 Prefixes for Company PRO (xDSL)
  - Not Fixed /56 IPv6 and DS-Light (CGN) IPv4 Prefixes for Private Customer (xDSL)
- Almost all business operators in Germany offer IPv6 for companies with fixed addresses
- Wikipedia adoption level of 68% by June 2023
  https://en.wikipedia.org/wiki/IPv6_deployment
- Google adoption level of 72.01% by March 2024
  https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption

ROUTE 128

Governments

- **2030**
  German Gov IPv6only, in 2022
  52% IPv6 Elster Tax
  (Ripe84 – Berlin)

- **2032 6th of June**
  Czech Republic Gov IPv6-only

- **2025**
  80% of U.S. Federal Networks IPv6-only
  (https://www.cio.gov/assets/resources/internet-protocol-version6-draft.pdf)

IPv6-only Websites:

- https://clintonwhitehouse1.archives.gov/
- https://clintonwhitehouse2.archives.gov/

ROUTE 128

HyperScalers

NETFLIX

… estimated 9 Mio IPv4 Addresses
　　for their deployment at AWS

… only solution was IPv6

AWS

… $0.005 per hour, $43.0 per
year per IPv4 Address

(https://aws.amazon.com/de/blogs/aws/new-aws-public-ipv4-address-charge-public-ip-insights/9)

Azure

… $0.0036 per hour, $31.536
　　per year per Basic IPv4
　　Address

ROUTE 128

Prices for IPv4 Space

- AWS

IPv4	hour	year
1 Address (/32)	$0.005	$43.80
6 Addresses (/29)	$0.03	$262.80
14 Addresses (/28)	$0.07	$613.20
254 Addresses (/24)	$1.27	$11,125.20

- AZURE

IPv4	hour	year
1 Address (/32)	$0.0036	$0.12
6 Addresses (/29)	$0.0216	$189.22
14 Addresses (/28)	$0.0504	$441.50
254 Addresses (/24)	$0.9144	$8010.14

ROUTE 128

IPv6 enables better performance

Studies over the past few years show dramatic IPv6 performance improvements:

- Facebook performed a study in 2015 that showed that websites load 10%–15% faster over IPv6.

- Akamai's customer AbemaTV did a case study in 2019, which showed that IPv6 improved the throughput by 38% on average when compared with connections via IPv4.

- Apple announced during the Worldwide Developers Conference 2020 that median connection setup times are 1.4x faster when IPv6 is in use when compared with IPv4.

IPv6 Performance:

- Websites load 10-15% faster

- Stream throughput improved by 38%

- Median connection setup time 40% faster

From „https://www.akamai.com/blog/trends/10-years-since-world-ipv6-launch "

What could we do …

- IPv6 mandatory at universities and schools
- Use NAT64 and DNS64 in the office
- Industry IPv6-only Support on Servers and Storage
- Switch Monitoring to IPv6
- Smart ~~documentation~~ cookbook to help the migration
- Supporting the day-to-day operation of IPv6 networks with smart tools and knowledge bases
- Offer more ipv6only services

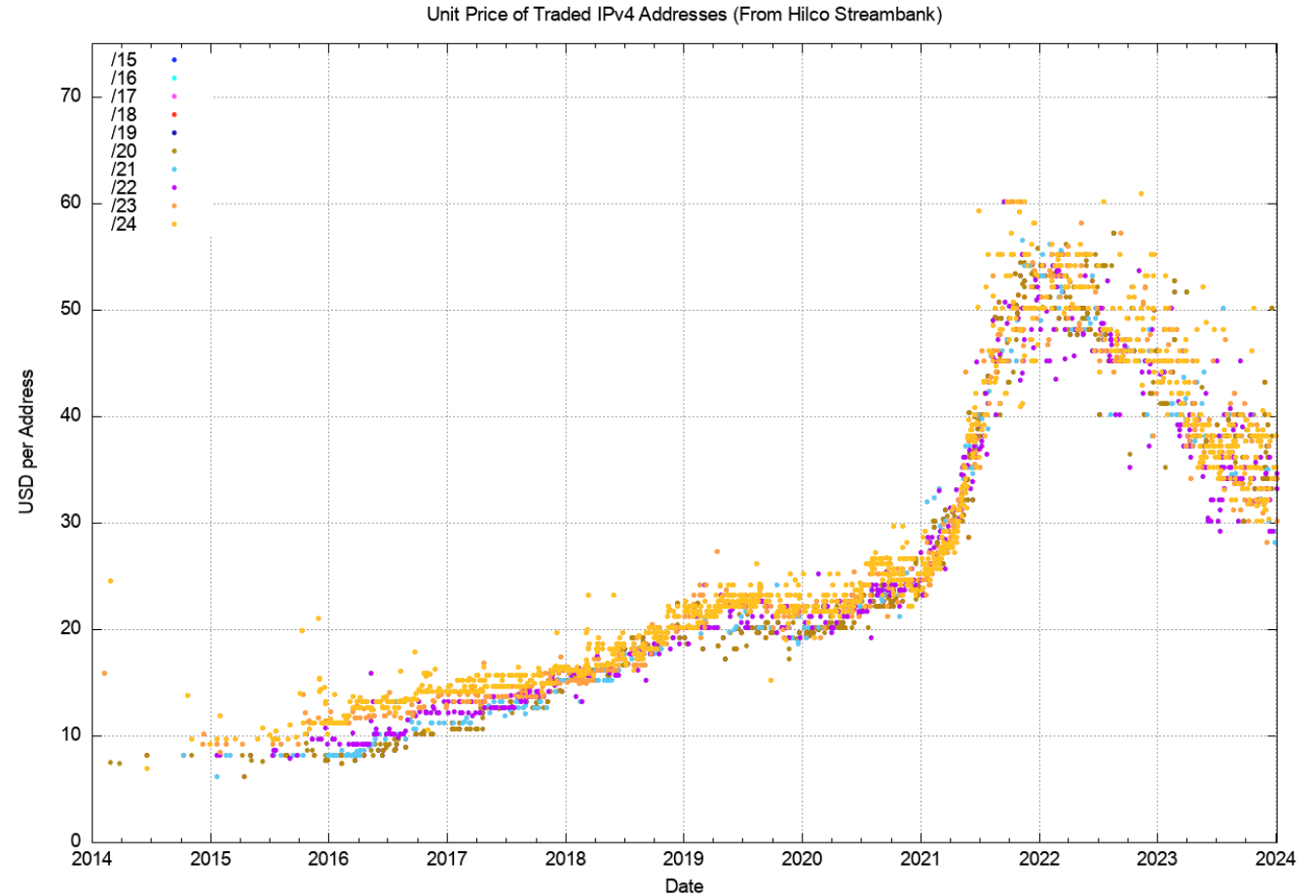ROUTE 128

Smart Cookbook

What are the people not using IPv6

Customer	IPv6 Activation	Fixed IP	IPv6 Präfix	IPv4 Präfix	IPv6 (March 2024)	Numbers (2021)
Consumer	Automatic	No	/56	Shared	72%	37.000.000
Mobile User	Automatic	No	/64	Shared	99%	
Small Business	Automatic	On Request	/56	/32	72 %	465.000
Midsized Business	On Request	Yes	/48	/29	20% ?	80.000
Enterprises	On Request	Yes	/48 (PI)	/28 - /24	0% ?	21.000
IP Transit	On Request	Yes	Supplied by Customer	Supplied by Customer		2.300 (RIPE Routed LIR)

curl --location --request GET "https://stat.ripe.net/data/country-asns/data.json?resource=DE"

ROUTE 128

What else could we do

- Switch off IPv4 on IXP worldwide?

- Sell all your IPv4 space now!

- Test and use RFC like:

  - RFC 8950
    Advertising IPv4 Network Layer Reachability Information (NLRI) with an IPv6 Next Hop

  - RFC 7381
    Enterprise IPv6 Deployment Guidelines

IPv4 Price Time Series (data from Hilco Streambank) from https://www.potaroo.net/ispcol/2024-01/addr2023.html

The answer:
IPv6
The next ~~or the last~~ thing you will see
as a network engineer!

Stefan Wahl
swahl@route128.net
https://www.route128.net

ROUTE 128