# RFC 9386 - IPv6 Deployment

# Status, Remaining Challenges, and the Way Forward

HUAWEI

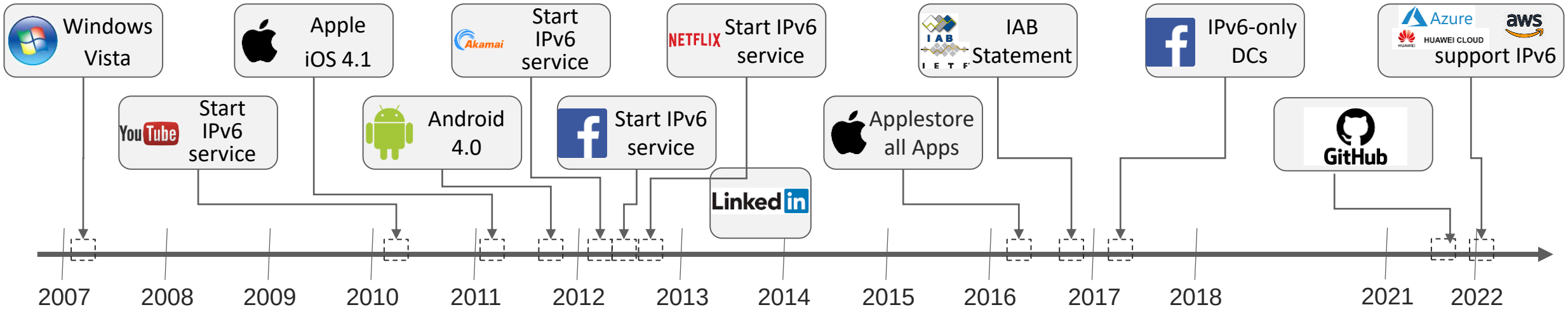
# Agenda

- **The Value of IPv6**
- IPv6 Status
- Challenges and Collaboration Areas

# IPv6 Grows Fast since 2017

## “UEs – Networks – Applications" Value Chain Ready

**IETF transition solutions ready by 2011; UEs & big applications ready by 2017; public clouds getting ready in 2022 (to move SMEs to IPv6)**



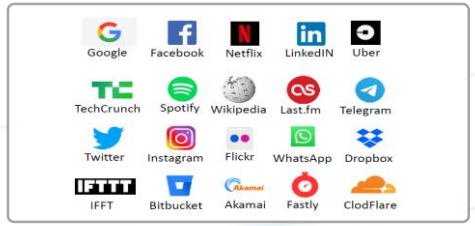

**In IPv6 value chain, networks slightly behind UEs and big applications/clouds**

2023

**UEs: 90%+ support IPv6 [1]**

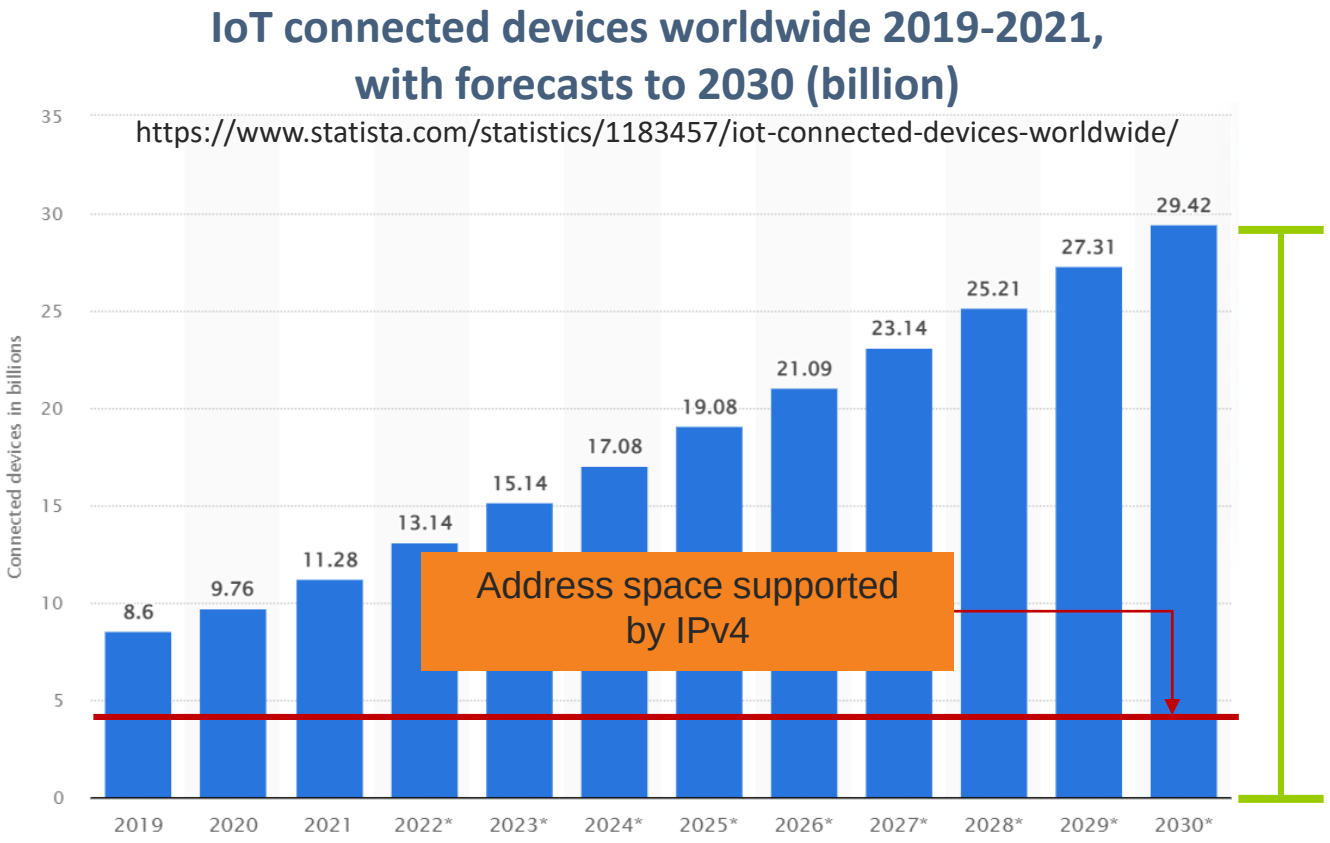
**Networks: ~45% support IPv6 [2]**


**Clouds: 70%+ support IPv6 [3]**




[1] https://www.ipv6ready.org/ [2] https://bgp.potaroo.net/as2.0/bgp-active.html + https://bgp.potaroo.net/v6/as2.0/index.html
[3] https://www.statista.com/statistics/267184/content-delivery-network-internet-traffic-worldwide/

# IPv6 Enables New Applications




**Demand For Wider Address Space**

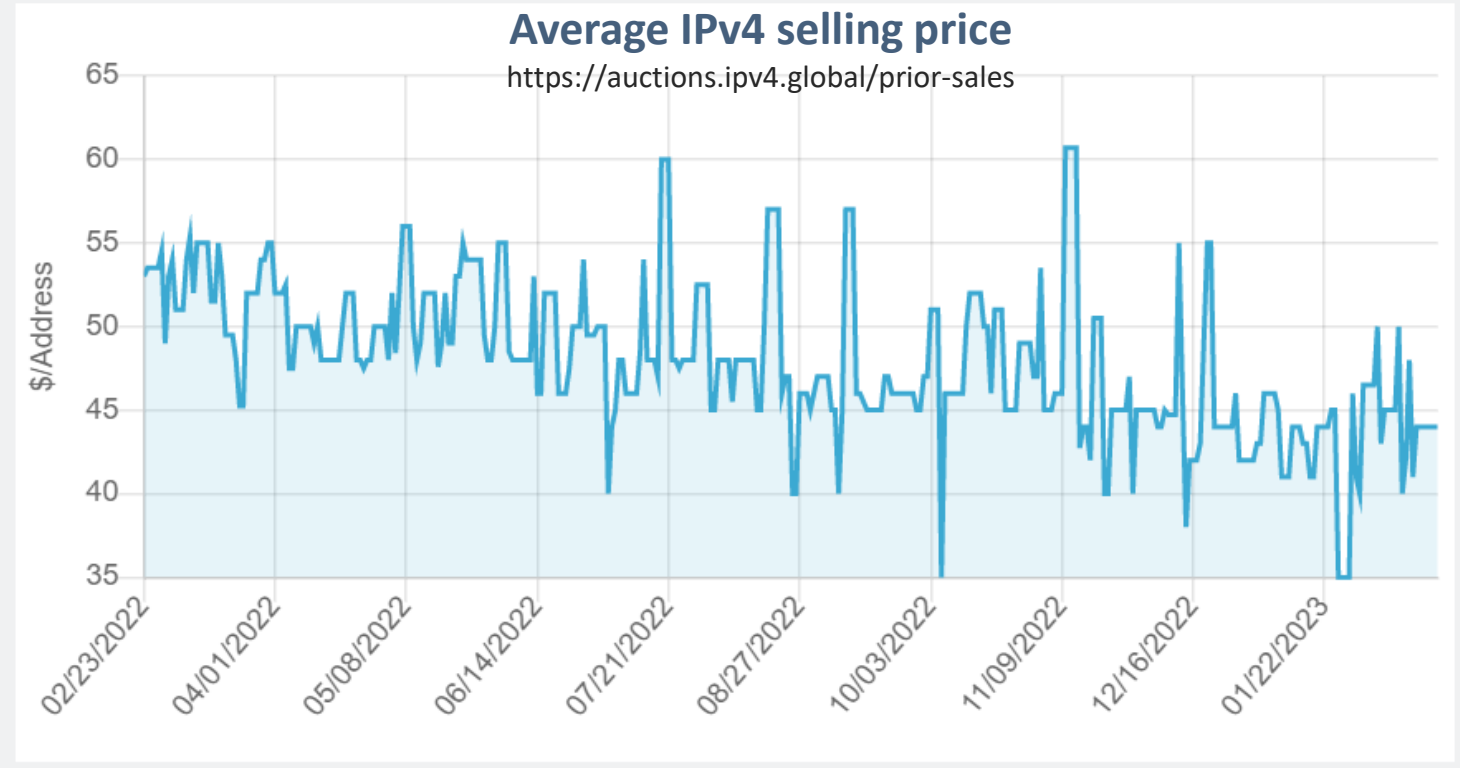
- New applications (e.g., IoT, VR/AR, V2X…) demand increased address spacing.
- IoT domain expected to reach ~30B devices.
- Many will need external, bidirectional communication.
- Arcep [1]: IPv6 key to ensuring competitiveness, fair access to the market, and innovation.

[1] Arcep IPv6 Barometer https://www.arcep.fr/fileadmin/reprise/observatoire/ipv6/Arcep_2020_Barometer_of_the_Transition_to_IPv6_dec2020.pdf
[2] IPv6 @ Facebook, https://www.ipv6.org.uk/wp-content/uploads/2018/10/FB_IPv6-UK-Council_Dec2017.pdf

**Use of IPv6 address space in Content and Cloud Providers**

- The driver is the high number of addresses required to connect the virtual and physical elements in a DC to overcome the limitation posed by private IPv4 addressing [RFC1918].
- They are at different stages in the transition to an IPv6-only [2]. RFC 9386 contains several references to look at.

# IPv4 Is Getting Costly



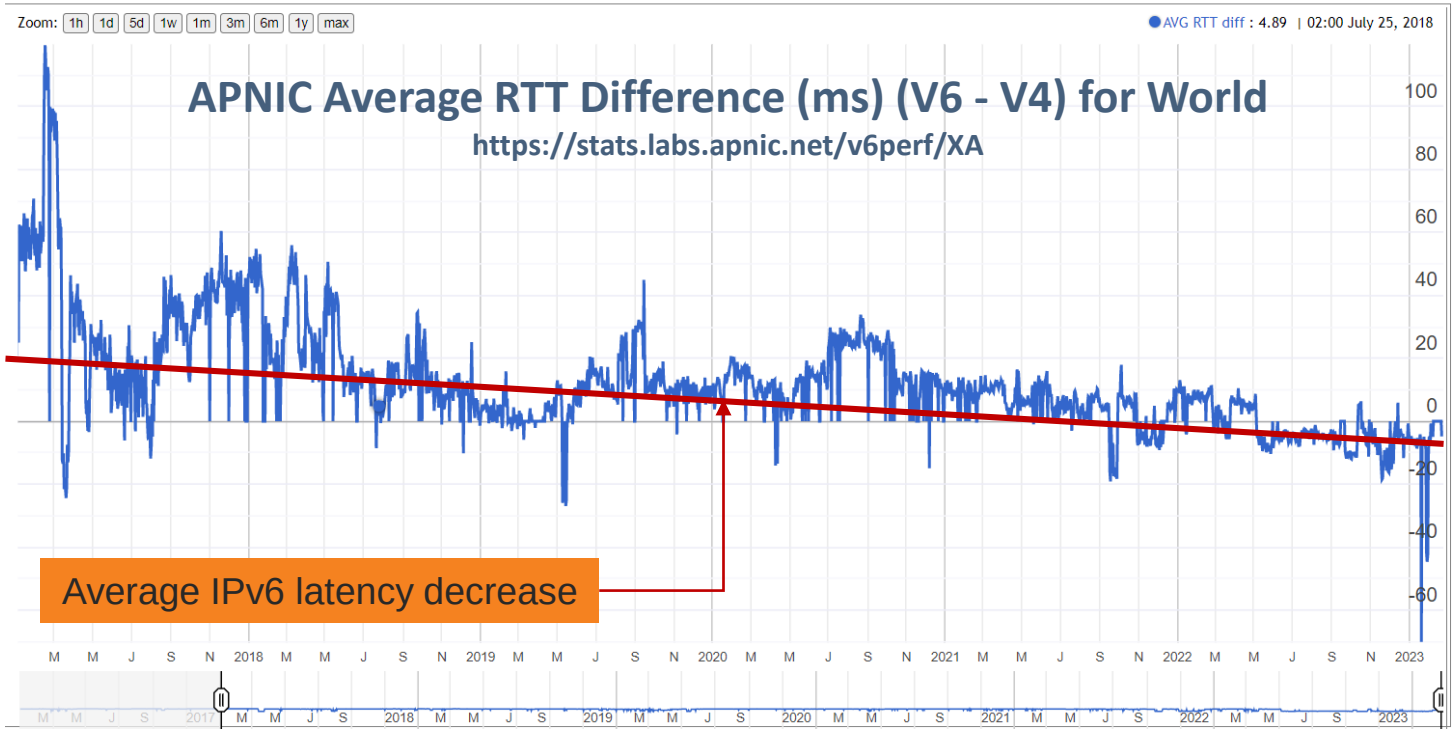

**CG-NAT Removal Case**

- Removal of CG-NAT and adoption of IPv6 saves operational cost in millions.
- Case discussion:
  - Average selling price per IPv4 address in 2022-2023: 50 USD per address
  - 16:1 IPv4 sharing
  - For 1M users, 1M * 50 / 16 = 3.12M USD only for avoiding IPv4 address usage
  - In addition, saving on NAT hardware and log (ca. 1M USD every 1M users).
- Plus: sell or rent IPv4 for millions in profit.

**Mythic Beasts Hosting Provider (**https://datatracker.ietf.org/doc/slides-115-v6ops-08-mythic-beasts-ipv6-only-hosting/)

- Infrastructure based on both IPv4 and IPv6 Virtual Machines running on Raspberry PI servers deployed in 6 DCs.
- Strive to keep pace with the growth of servers in cloud configuration. IPv4 address cost main issue. IPv6 transition a necessity.
- When business started, IPv4 address cost was 1-2$, a Raspberry server was 5$. Today, costs are 50$ and 5$, respectively.
- Business case proposal: renting a $50 IPv4 for $2/month, annual return is 48%. US 10Y yield 4%.

# IPv6 Provides Better Performance




**IPv6 Lower Latency**

- Worse IPv4 latency related to NAT / middle-boxes traversal.
  - Contribution of NAT traversal itself.
  - Traffic detour in carriers' networks to reach a centralized CG-NAT.
- IPv6 steering not affected, hence a general decrease of IPv6 latency across regions.

**Akamai Experience Shared at APNIC 52 (**https://conference.apnic.net/52/assets/files/APBS588/akamai-ipv4-ipv6-experience.pdf)

- In their measurement, delivering content via dual-stack, IPv6 usually reaches lower Round Trip Time (RTT).
- Among the reasons, Akamai lists:
  - More efficient routing, with often smaller routing table in IPv6.
  - IPv6 routers do not need to fragment, as fragmentation is handled by source devices.
  - Fewer middle boxes to cause latency increase.

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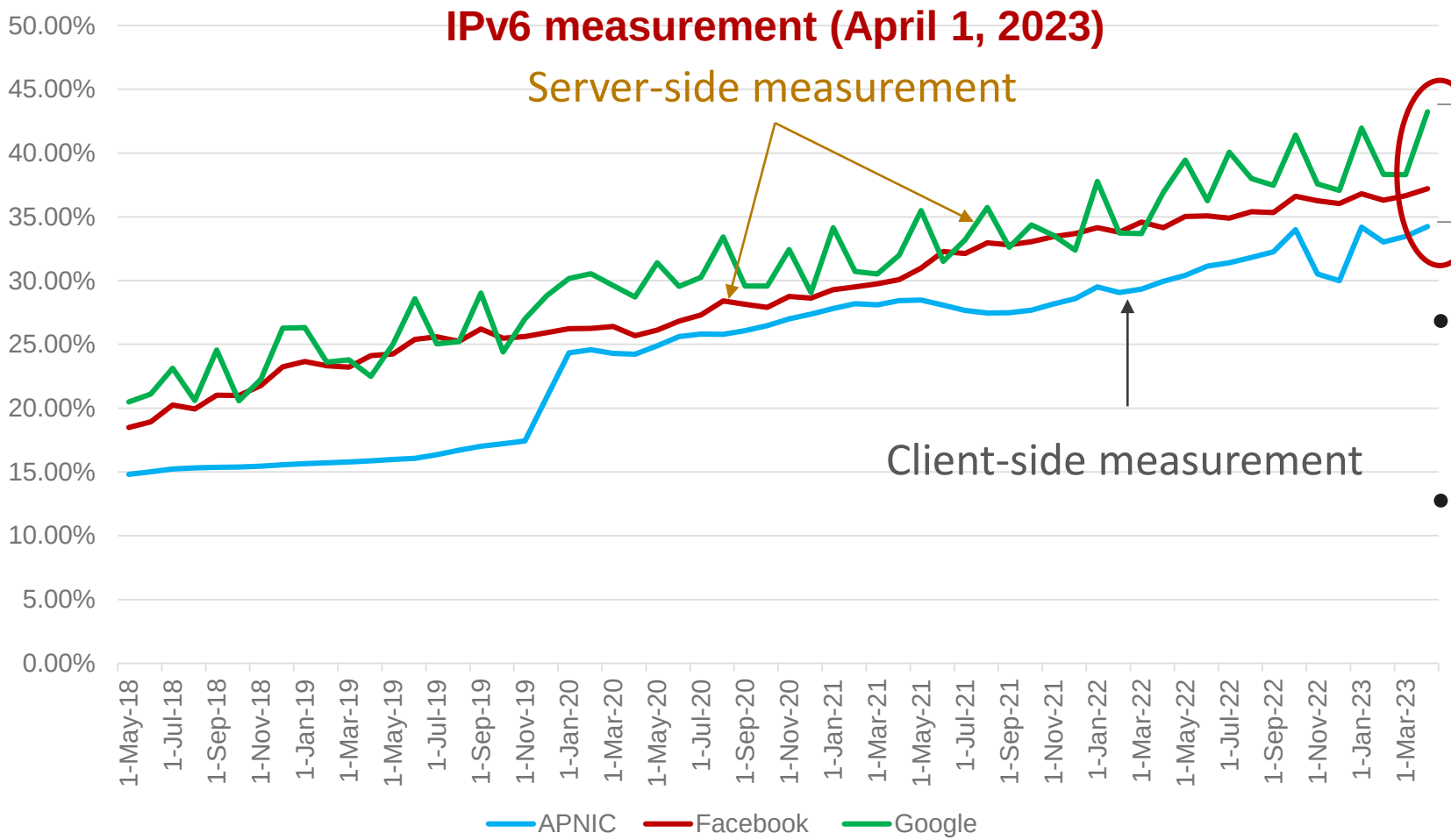
# IPv6 Growth Is Steady

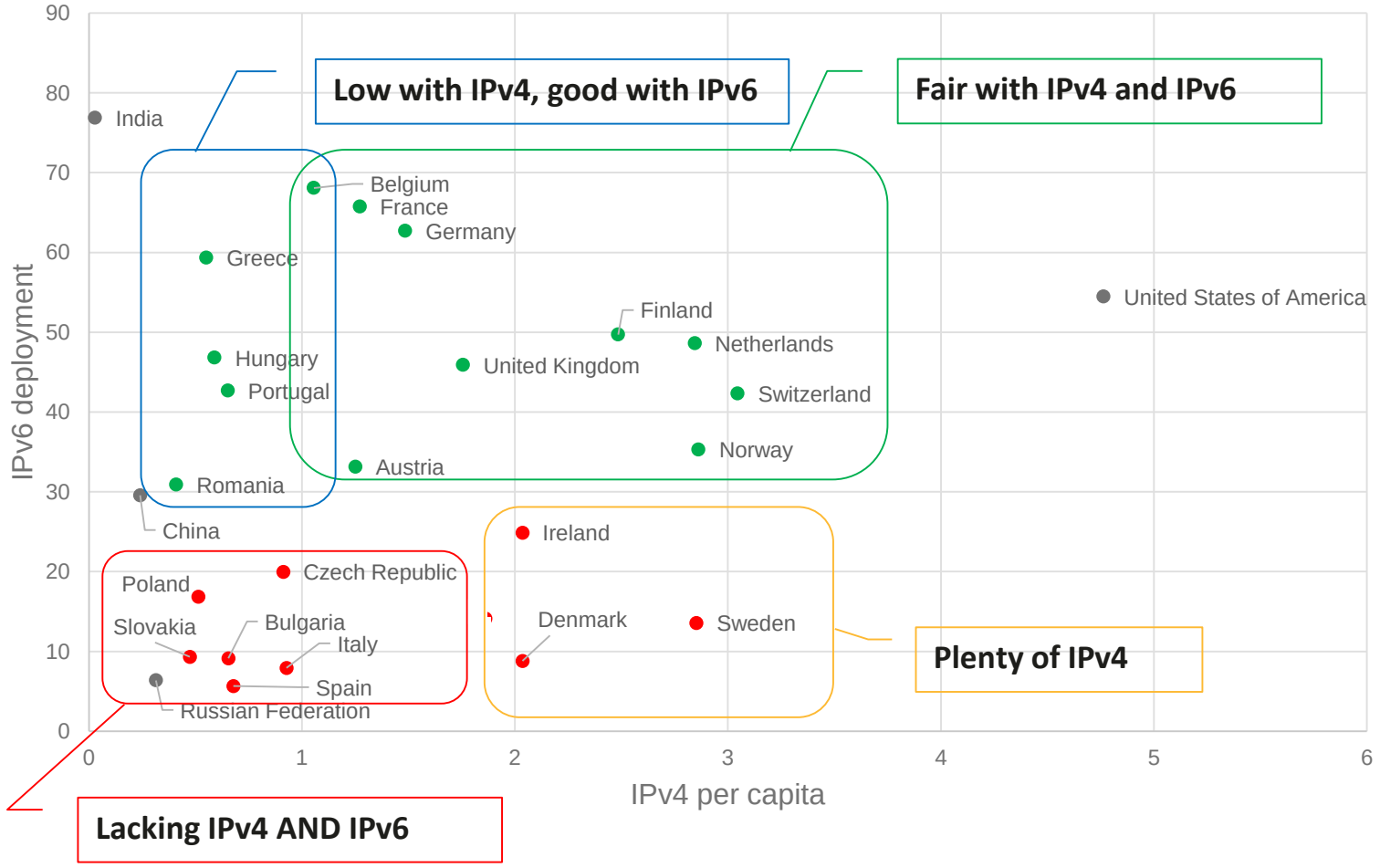



- APNIC analytics:
  - Client side is considered.
  - “Western world” view.
- China is also active in IPv6:
  - Add around 500M users [4].
  - Relatively to APNIC, add ~10%.


[1] https://stats.labs.apnic.net/
[2] https://www.facebook.com/ipv6/?tab=ipv6_country
[3] https://www.google.com/intl/en/ipv6/statistics.html
[4] https://www.china-ipv6.cn/


**The growth of IPv6 users is steady, pushed by need of addresses and government policies.**

# Government Policies And Market Ambition Could Harmonize IPv6 Adoption In Europe




- The graph shows the “IPv4 per capita” availability per country.
- In Europe, the lack of IPv4 addresses is not necessarily a reason for deploying IPv6.
- Regulatory or government push, instead, has an important effect.

  - Red Country: quite below the world IPv6 trends (lack of actions)
  - Green Country: close or above the world trends.

[1] https://datatracker.ietf.org/doc/draft-ietf-v6ops-ipv6-deployment/
[2] https://resources.potaroo.net/iso3166/v4cc.html
[3] https://resources.potaroo.net/iso3166/v6cc.html

**If governments, industry, market take actions then IPv6 moves ahead, as in Belgium, France, Germany.**

# IPv6 Adoption Across Spain


| Code | Country | Avg RTT Diff (V6-V4) | Samples |
|---|---|---|---|
| AL | Albania, Southern Europe, Europe | 2.38 ms | 20,905 |
| RS | Serbia, Southern Europe, Europe | 0.30 ms | 66,122 |
| MK | North Macedonia, Southern Europe, Europe | 0.27 ms | 79 |
| HR | Croatia, Southern Europe, Europe | -0.93 ms | 16,582 |
| ME | Montenegro, Southern Europe, Europe | -1.16 ms | 44 |
| SM | San Marino, Southern Europe, Europe | -1.20 ms | 2 |
| SI | Slovenia, Southern Europe, Europe | -1.70 ms | 20,462 |
| AD | Andorra, Southern Europe, Europe | -2.10 ms | 11 |
| PT | Portugal, Southern Europe, Europe | -3.81 ms | 271,109 |
| GI | Gibraltar, Southern Europe, Europe | -3.91 ms | 8 |
| VA | Holy See, Southern Europe, Europe | -3.91 ms | 1 |
| IT | Italy, Southern Europe, Europe | -4.36 ms | 280,663 |
| MT | Malta, Southern Europe, Europe | -5.31 ms | 49 |
| GR | Greece, Southern Europe, Europe | -5.99 ms | 623,265 |
| ES | Spain, Southern Europe, Europe | -7.15 ms | 132,992 |
| BA | Bosnia and Herzegovina, Southern Europe, Europe | -10.68 ms | 43,745 |

| ASN | AS Name | IPv6 Capable | IPv6 Preferred | Samples |
|---|---|---|---|---|
| AS3352 | TELEFONICA_DE_ESPANA | 8.20% | 8.00% | 1,712,492 |
| AS12479 | UNI2-AS | 3.48% | 3.41% | 1,334,830 |
| AS15704 | XTRA Telecom | 0.12% | 0.11% | 916,688 |
| AS12430 | VODAFONE_ES | 0.02% | 0.02% | 722,234 |
| AS57269 | DIGISPAINTELECOM | 52.36% | 51.23% | 392,680 |
| AS6739 | ONO-AS Cableuropa - ONO | 0.01% | 0.01% | 349,089 |
| AS12338 | EUSKALTEL | 0.01% | 0.01% | 151,301 |
| AS200845 | ESWIKIKER AVATEL TELECOM | 0.01% | 0.01% | 114,727 |
| AS29119 | SERVIHOSTING-AS AireNetworks | 2.24% | 2.18% | 61,380 |
| AS12334 | Galicia - Spain | 0.02% | 0.02% | 52,720 |
| AS35699 | ADAMOEU-AS Adamo Telecom Iberia S.A. | 0.01% | 0.01% | 42,942 |
| AS34977 | PROCONO-AS | 0.02% | 0.01% | 37,483 |
| AS12946 | TELECABLE Spain | 0.02% | 0.02% | 32,776 |
| AS48146 | TRIPLEA | 0.03% | 0.03% | 24,823 |
| AS201746 | OLIVENET-AS | 0.04% | 0.04% | 13,098 |

Source: https://stats.labs.apnic.net/ (May 14, 2023)

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# Remaining Challenges: Cooperation to Work Them out

*Areas often affecting enterprises.*

Experience sharing from **leading carriers and IPv6 councils** can greatly help.

- Several stakeholders don't get the compelling reason to make the transition.
- Lack the business case, or pressure to move.
- Think that IPv6 may be delayed, e.g. with NAT or IPv4 purchase.


- Technical staffs not aware of IPv6 deployment.
- Don't know IPv6 standards, best current practices and operational guidelines.
- Even worse, think IPv6 still has many issues to be solved.

- Classes of devices still not supporting IPv6 (e.g. old CPEs, smart TVs).
- Cloud providers moving to IPv6, but many SMEs aren't.
- Vendors' roadmap evolution not in line as IPv4.

- Difficulty to identify transition path and technologies, in particular for SMEs.
- Technical areas should need more investigation or completion.
- IPv6 Security perceived as still difficult.

*Vendors' legacy.*

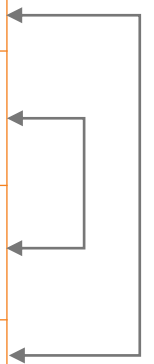
**ICT industry** as a whole needs to act.

*Open aspects in standardization.*

**RIPE, NOGs…** can lead to solve the technical issues.

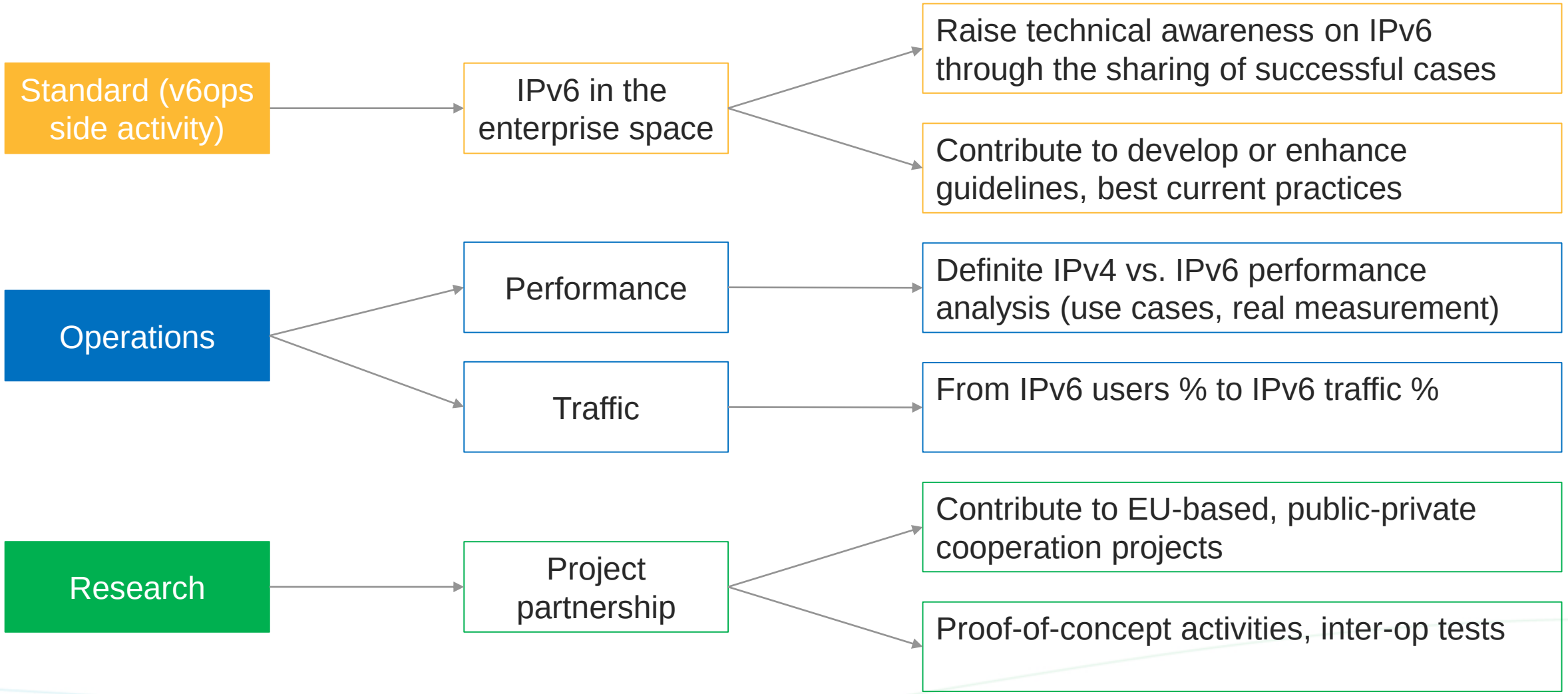
# Current Topics in Standardization

| IETF WG | Topic | References https://datatracker.ietf.org/doc/ |
|---|---|---|
| v6ops | Hosts isolation to prevent potential neighbor discovery protocol issues | draft-ietf-v6ops-nd-considerations/ |
| v6ops | Site connectivity to many carriers | draft-fbnvv-v6ops-site-multihoming/ |
| v6ops | Limiting the sending/processing of IPv6 EHs | draft-ietf-6man-eh-limits/ |
| v6ops | Using DHCP-PD to allocate unique IPv6 prefix per host in broadcast networks | draft-collink-v6ops-ent64pd/ |
| 6man | Signaling DHCPv6 prefix delegation availability to hosts | draft-collink-6man-pio-pflag/ |
| 6man | IPv6 Hop-by-Hop Options processing procedures | draft-ietf-6man-hbh-processing/ |
| 6man | Architecture and framework for IPv6 over Non-Broadcast Access | draft-ietf-6man-ipv6-over-wireless/ |
| Spring | SRv6 related work | Very active working group! |



**Is there anything missing? We are very open to listen to you for any requirements left out!**

# Pushing IPv6 Further – Areas for Cooperation




**We welcome further ideas to promote IPv6 deployment.**

# Summary

- IPv6 progression is steady.
  - The value chain is ready.
  - Approaching the critical threshold of 50% Internet users.
  - IPv6 performance better than IPv4.
- Industry needs to jointly work to overcome the last few challenges.
  - Addressing the concerns of enterprises and verticals still lagging behind with IPv4 services.
  - Working with policy-makers to make them aware of the need to transition to IPv6 to create market stimulus.
  - Providing coordination across stakeholders to drive Internet evolution to IPv6.
- Feel free to engage with us for an open and cooperative action to further encourage the Industry to adopt IPv6.

Thank You.

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