

RFC 9386 - IPv6 Deployment

Status, Remaining Challenges, and the Way Forward



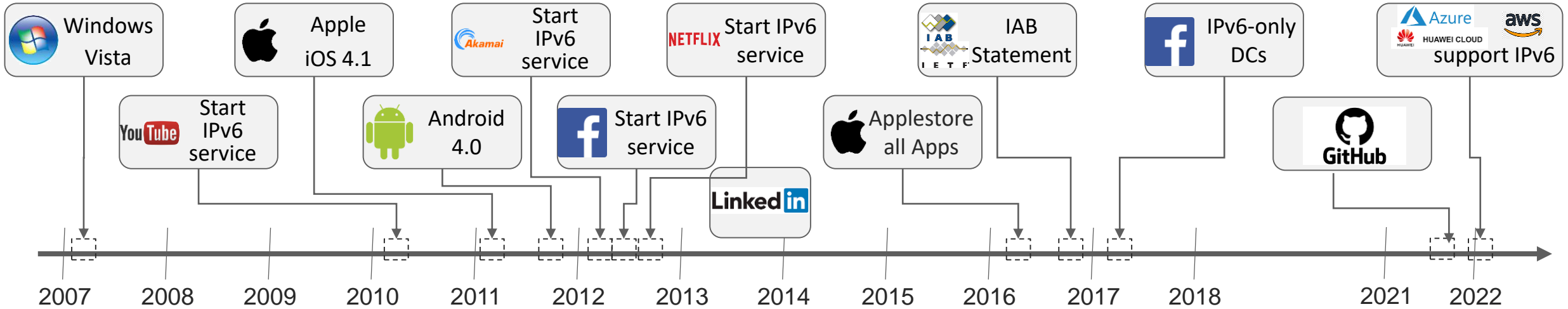
Agenda

- **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]



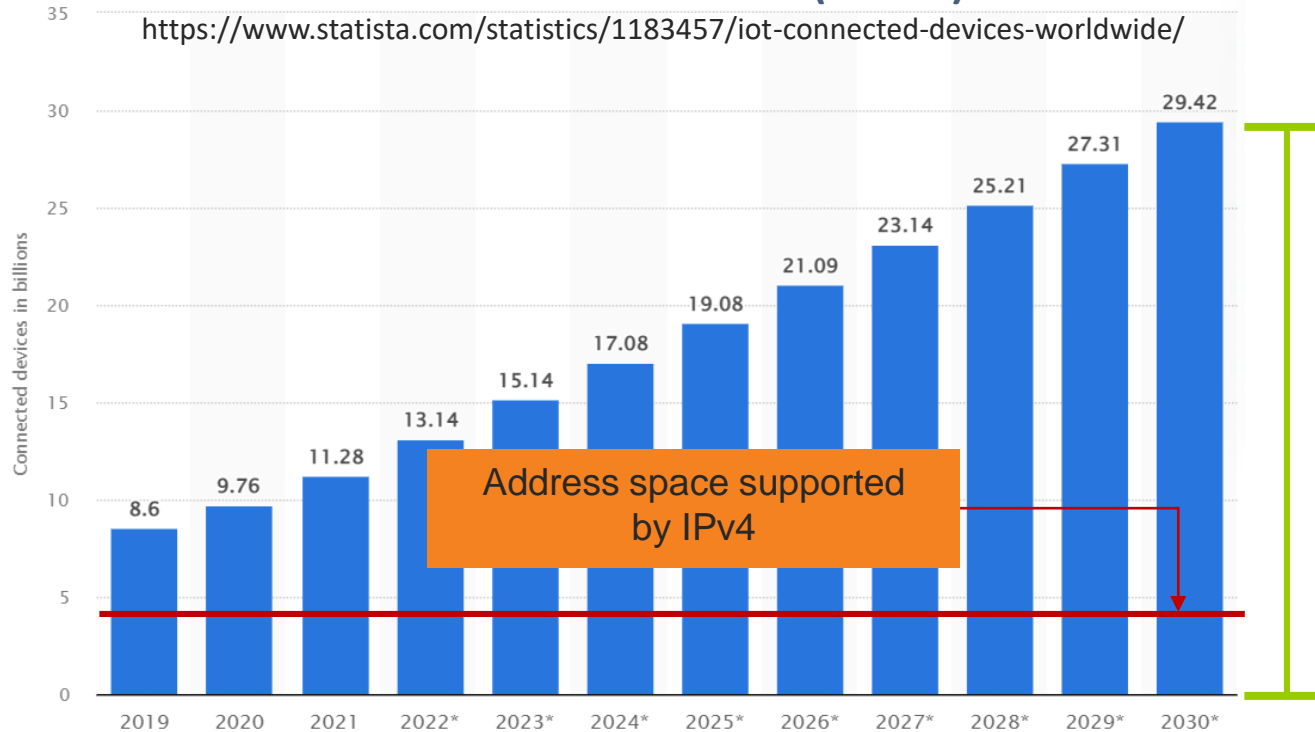
Clouds: **70%+** support IPv6 [3]



[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

IoT connected devices worldwide 2019-2021, with forecasts to 2030 (billion)



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

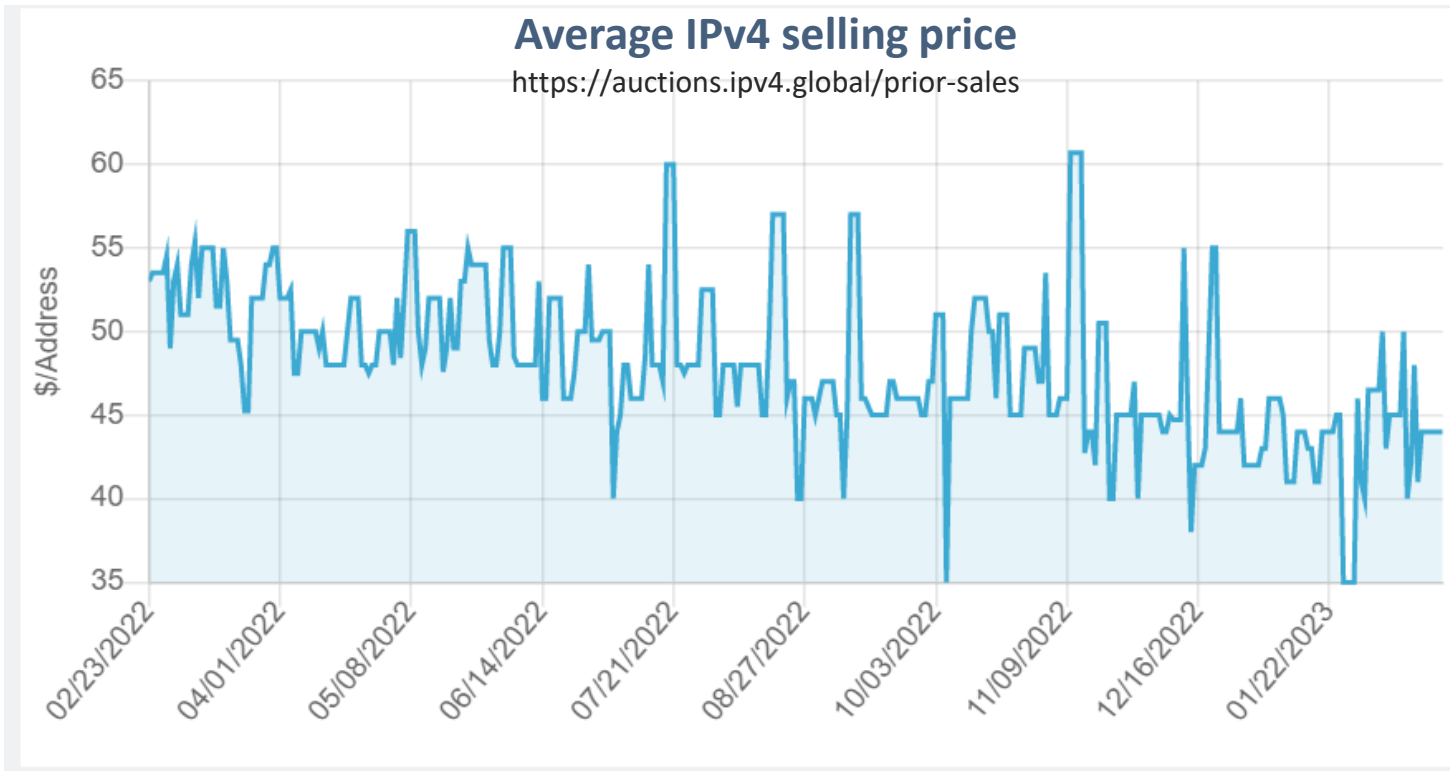
https://www.arcep.fr/fileadmin/reprise/observatoire/ipv6/Arcep_2020_Barometer_of_the_Transition_to_IPv6_dec2020.pdf

[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



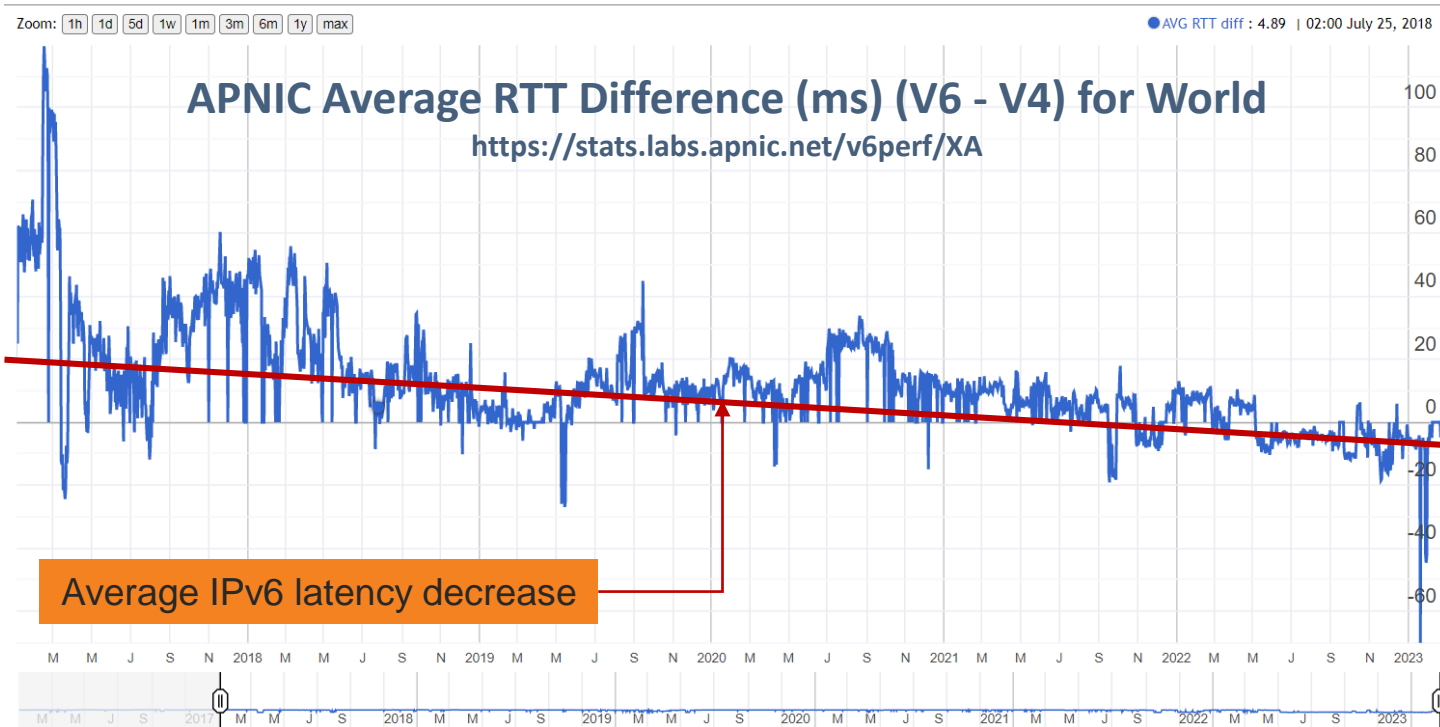
CG-NAT Removal Case

- 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.

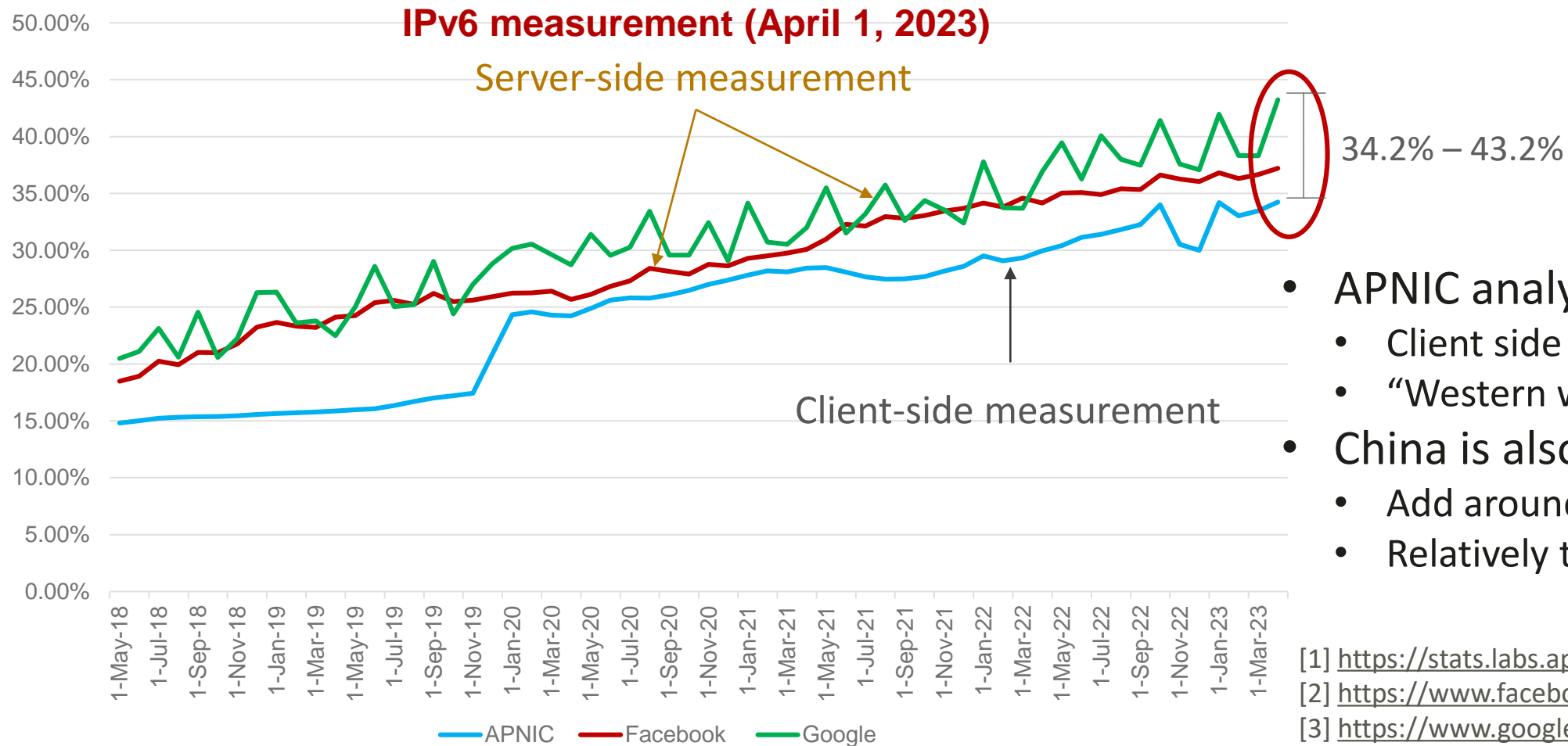
Akamai Experience Shared at APNIC 52 (<https://conference.apnic.net/52/assets/files/APBS588/akamai-ipv4-ipv6-experience.pdf>)

- 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/>

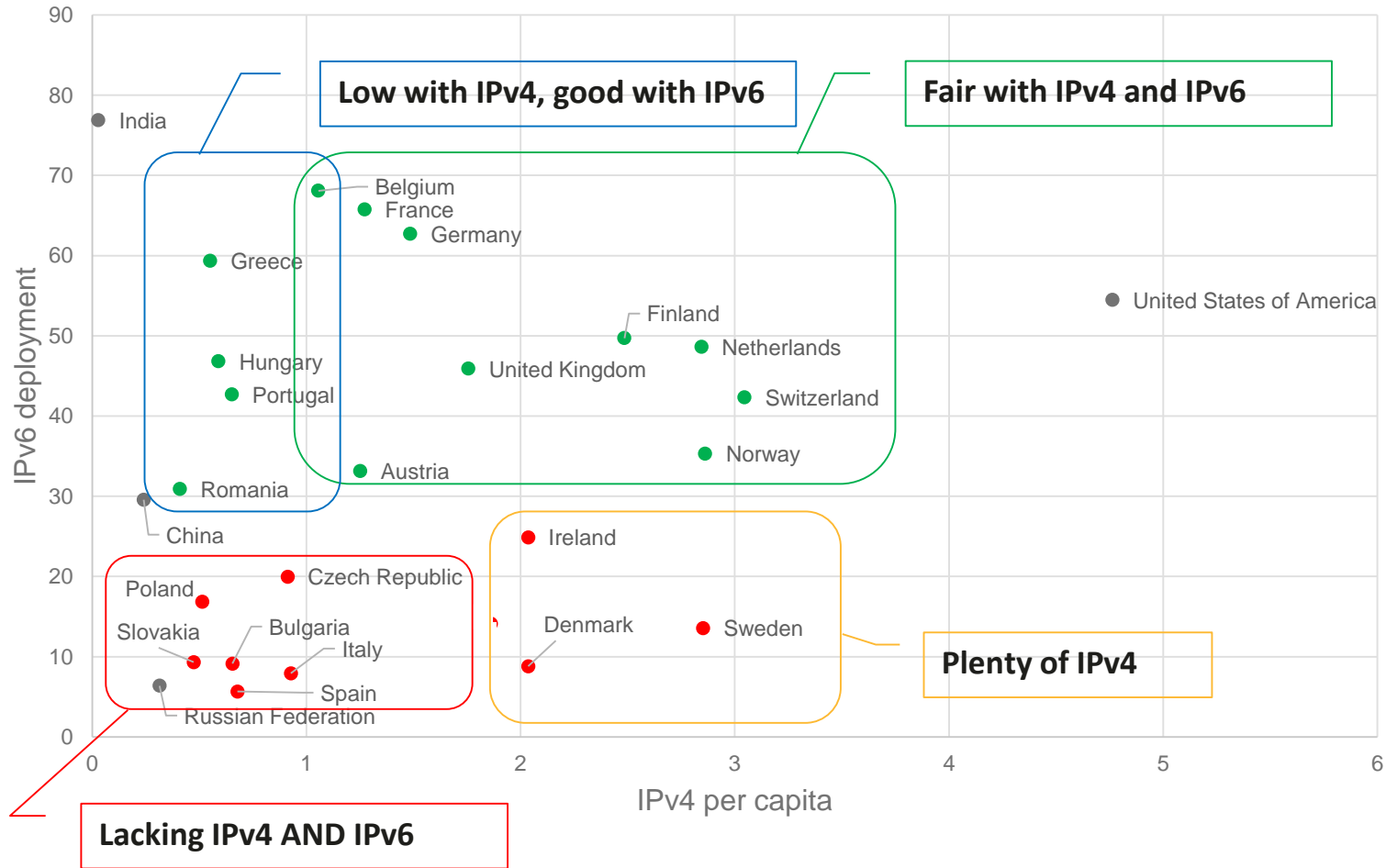
[2] https://www.facebook.com/ipv6/?tab=ipv6_country

[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

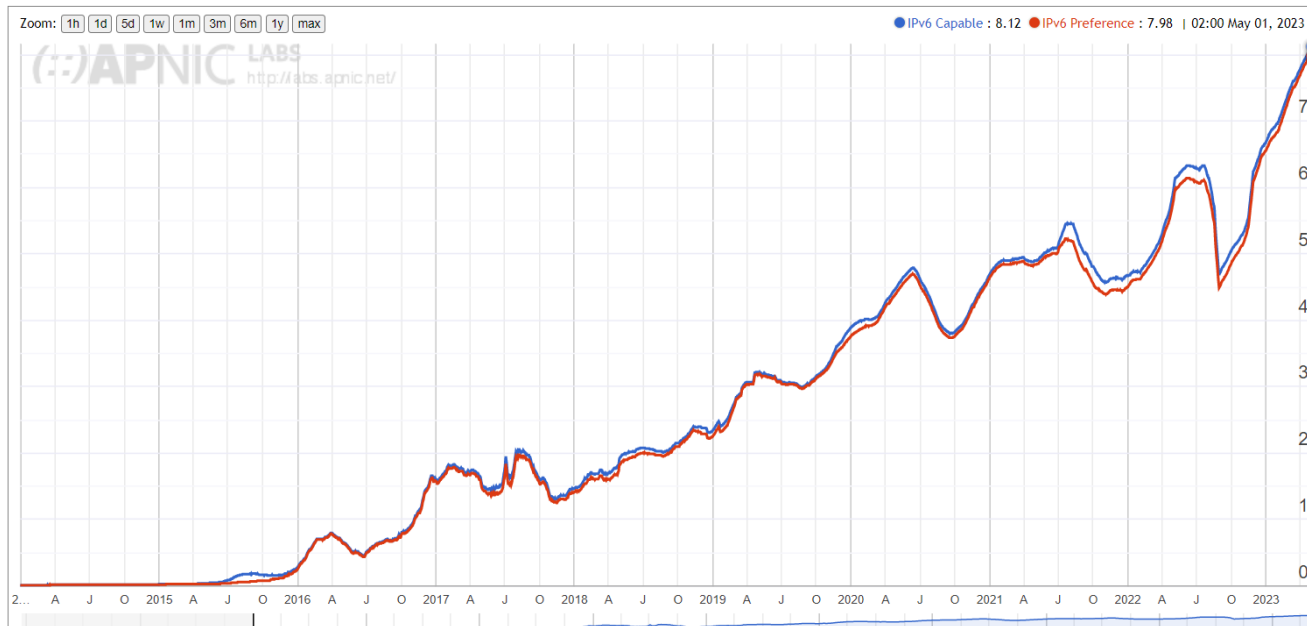


- The graph shows the “IPv4 per capita” availability per country.
- In Europe, the lack of IPv4 addresses is not necessarily a reason for deploying IPv6.
- Regulatory or government push, instead, has an important effect.
- **Red Country:** quite below the world IPv6 trends (lack of actions)
- **Green 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 Italy



Code	Country	Avg RTT Diff (V6-V4)	Samples
AL	Albania, Southern Europe, Europe	2.91 ms	19,710
MK	North Macedonia, Southern Europe, Europe	1.23 ms	57
RS	Serbia, Southern Europe, Europe	0.34 ms	60,190
HR	Croatia, Southern Europe, Europe	-0.94 ms	15,941
SM	San Marino, Southern Europe, Europe	-1.20 ms	2
SI	Slovenia, Southern Europe, Europe	-1.66 ms	17,918
GI	Gibraltar, Southern Europe, Europe	-2.97 ms	5
PT	Portugal, Southern Europe, Europe	-3.89 ms	253,620
IT	Italy, Southern Europe, Europe	-4.75 ms	251,981
ME	Montenegro, Southern Europe, Europe	-4.85 ms	31
GR	Greece, Southern Europe, Europe	-5.84 ms	573,028
ES	Spain, Southern Europe, Europe	-7.12 ms	132,357
AD	Andorra, Southern Europe, Europe	-7.62 ms	10
MT	Malta, Southern Europe, Europe	-8.11 ms	52
BA	Bosnia and Herzegovina, Southern Europe, Europe	-10.50 ms	39,522

ASN	AS Name	IPv6 Capable	IPv6 Preferred	Samp
AS30722	VODAFONE-IT-ASN	0.86%	0.83%	6,508
AS1267	ASN-WINDTRE IUNET	4.28%	4.19%	6,505,808
AS3269	ASN-IBSNAZ	0.03%	0.02%	6,464,939
AS12874	FASTWEB	45.63%	44.89%	3,019,801
AS16232	ASN-TIM Service Provider	0.06%	0.05%	2,681,479
AS29447	TIF-AS Iliad Italia S.p.A	5.14%	5.07%	2,360,366
AS210278	SKYIT-BB	88.93%	87.92%	739,139
AS35612	NGI-AS	0.03%	0.02%	590,466
AS8612	TISCALI-	0.04%	0.03%	496,959
AS198471	LINKEM-AS	0.03%	0.02%	360,905
AS15404	COLT Technology Services Group	0.03%	0.03%	115,240
AS202422	GHOST	2.79%	2.66%	44,513
AS31115	INTRED-AS	0.03%	0.03%	38,589
AS24608	WINDTRE-AS	0.05%	0.03%	38,233
AS210218	OPENFIBER-ITALY	0.03%	0.03%	36,695
AS137	ASGARR Consortium GARR	2.66%	2.52%	34,812
AS31404	LYCATEL-AS	0.02%	0.02%	33,304
AS39120	CONVERGENZE-AS ISP services in Italy	2.55%	2.50%	25,808
AS34606	ASN-BBBELL	0.05%	0.01%	25,395
AS47217	PLANETEL-SPA	38.33%	37.73%	23,098

Source: <https://stats.labs.apnic.net/> (May 1, 2023)

- Italy is well below the world's average.
- Ordering the list of ASNs based on the number of samples collected by APNIC, only 3 out of 20 are above 10% IPv6 adoption.
- RTT difference is good.

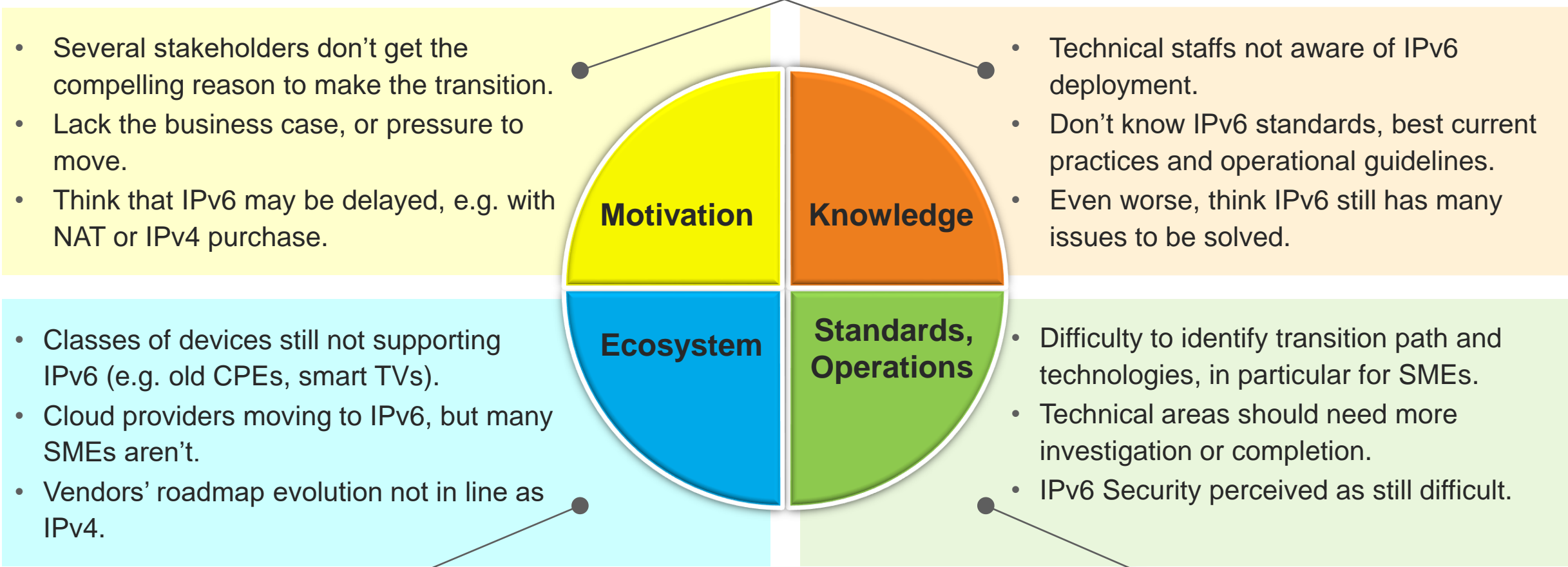
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Remaining Challenges: Cooperation to Work Them out

Areas often affecting enterprises.

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



Vendors' legacy.

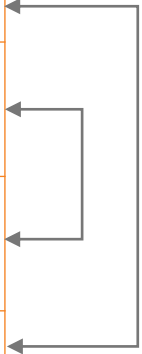
ICT industry as a whole needs to act.

Open aspects in standardization.

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

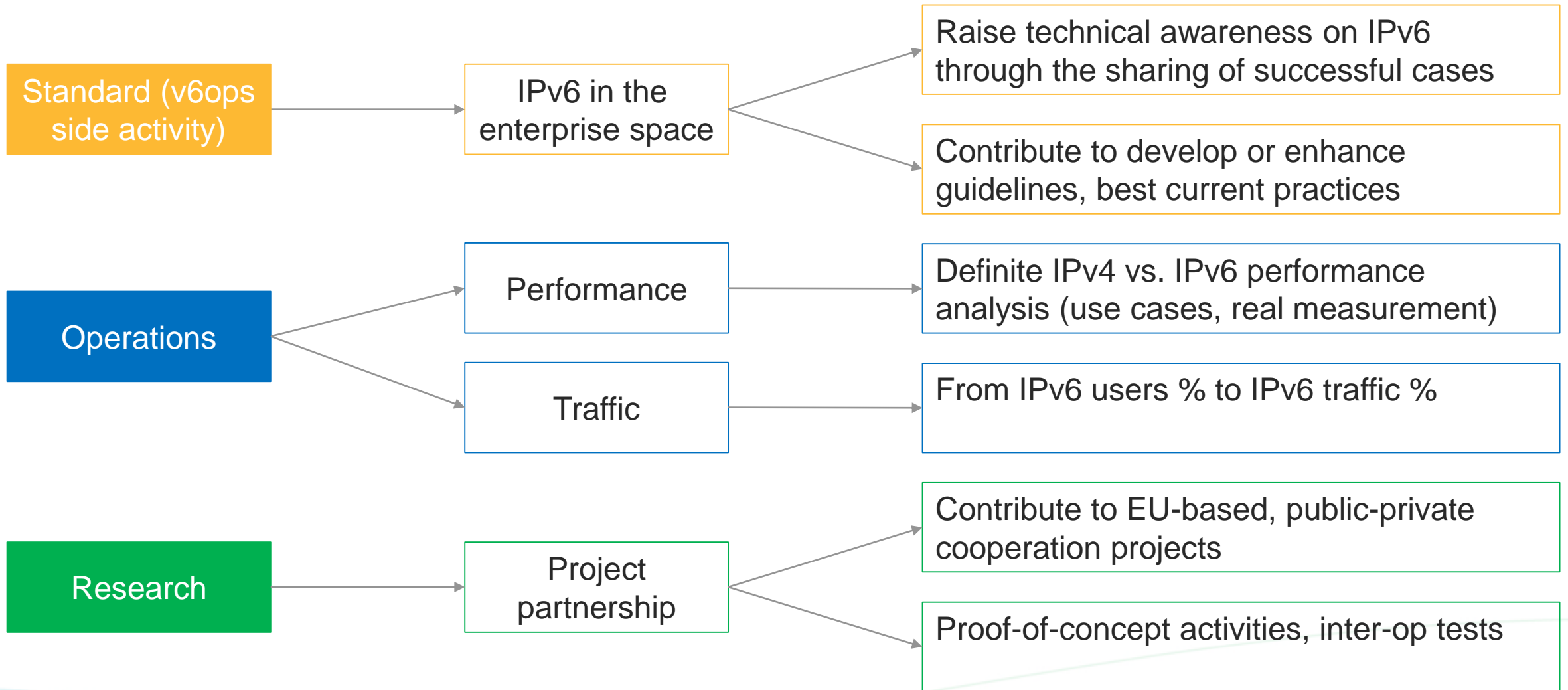
Current Topics in Standardization

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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