

# RFC 9386 - IPv6 Deployment

## Status, Remaining Challenges, and the Way Forward



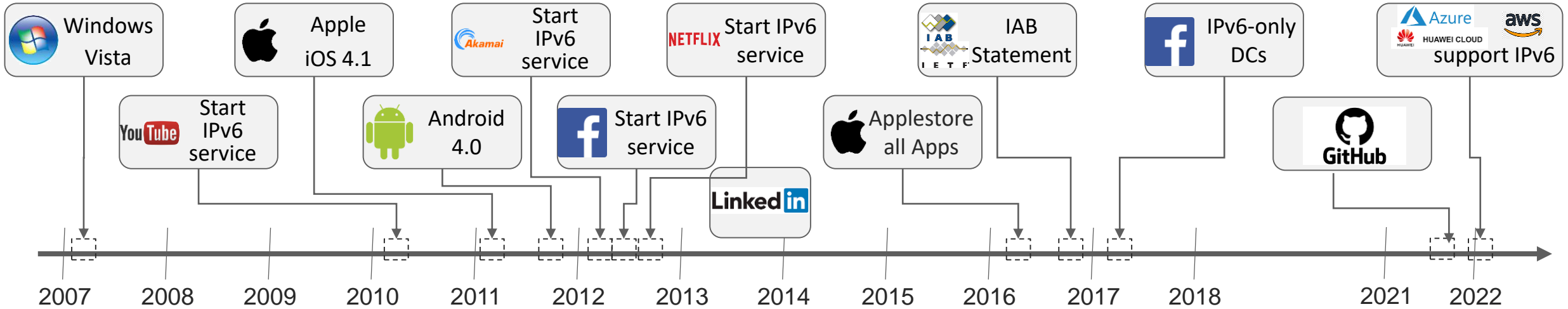
# Agenda

- **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]



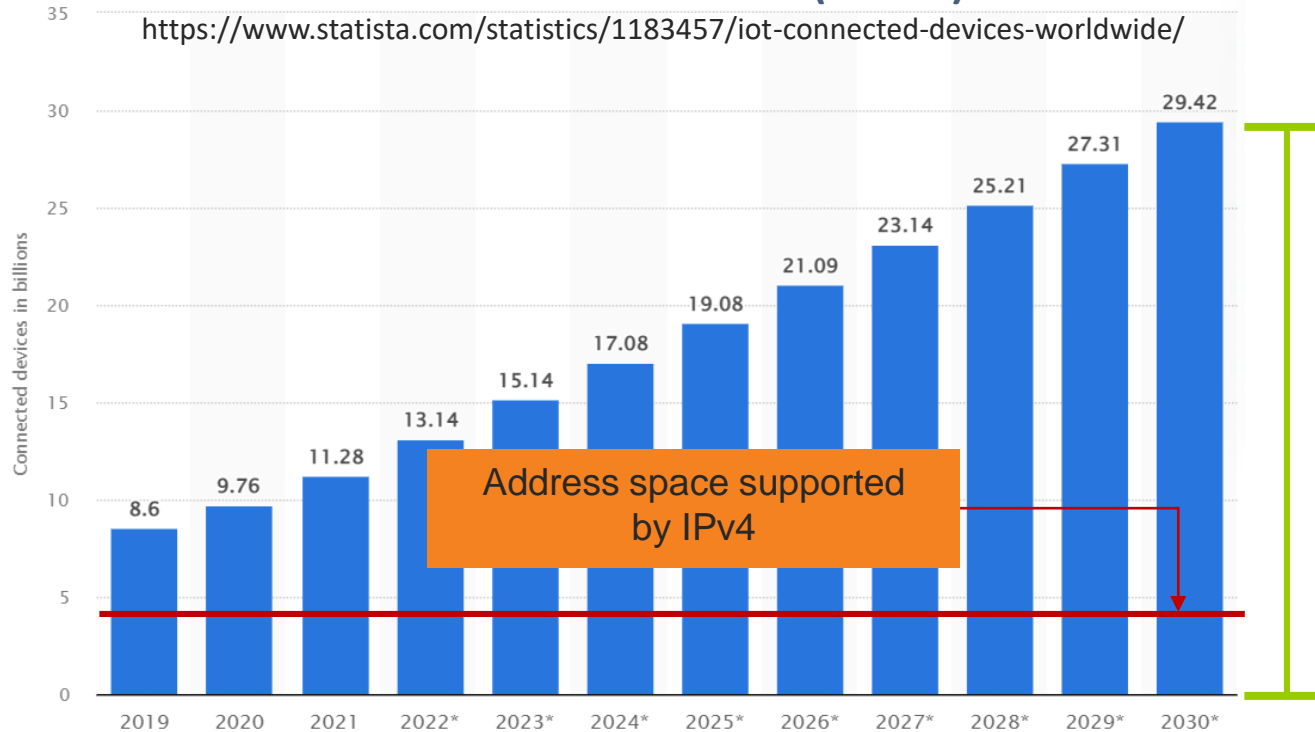
Clouds: **70%+** support IPv6 [3]



[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](https://www.arcep.fr/fileadmin/reprise/observatoire/ipv6/Arcep_2020_Barometer_of_the_Transition_to_IPv6_dec2020.pdf)

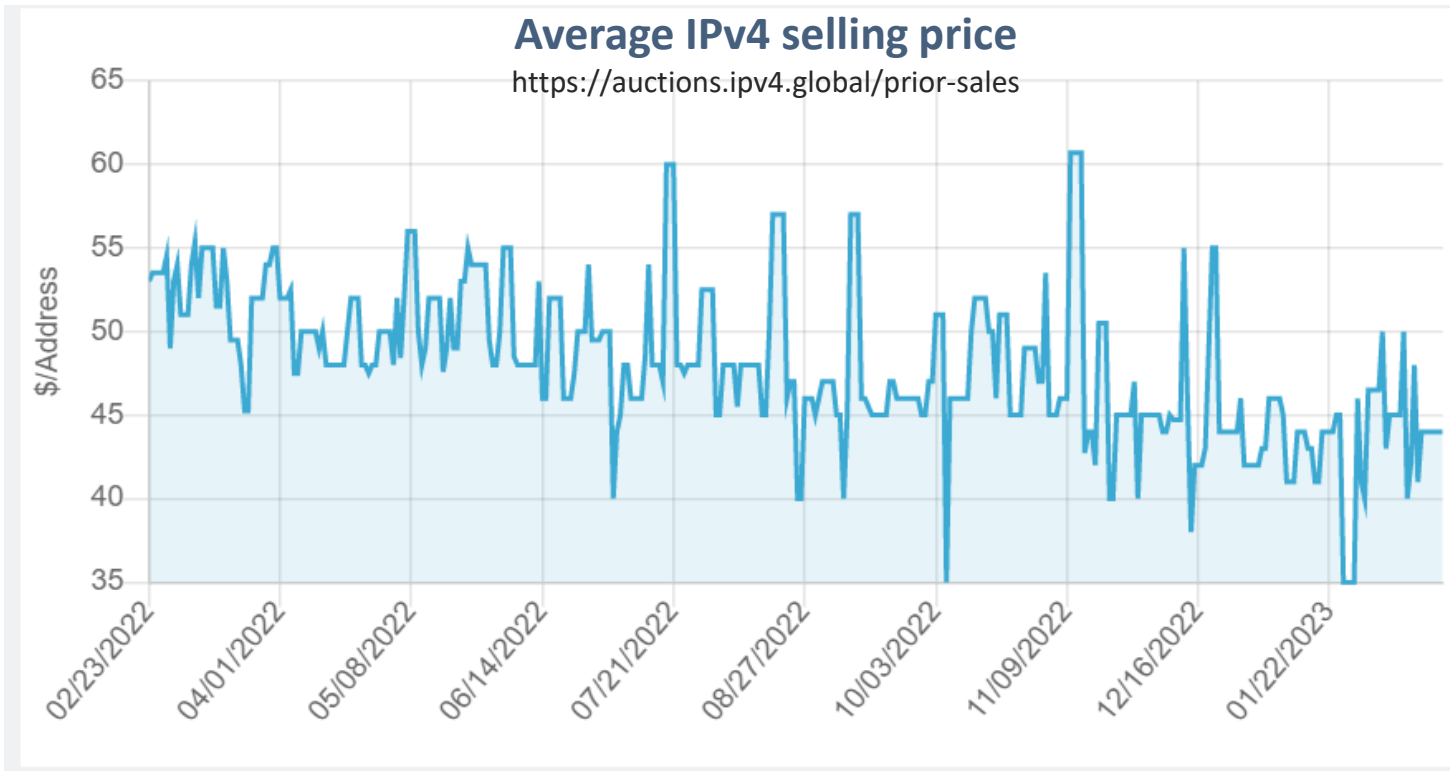
[2] IPv6 @ Facebook, [https://www.ipv6.org.uk/wp-](https://www.ipv6.org.uk/wp-content/uploads/2018/10/FB_IPv6-UK-Council_Dec2017.pdf)

[content/uploads/2018/10/FB\\_IPv6-UK-Council\\_Dec2017.pdf](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



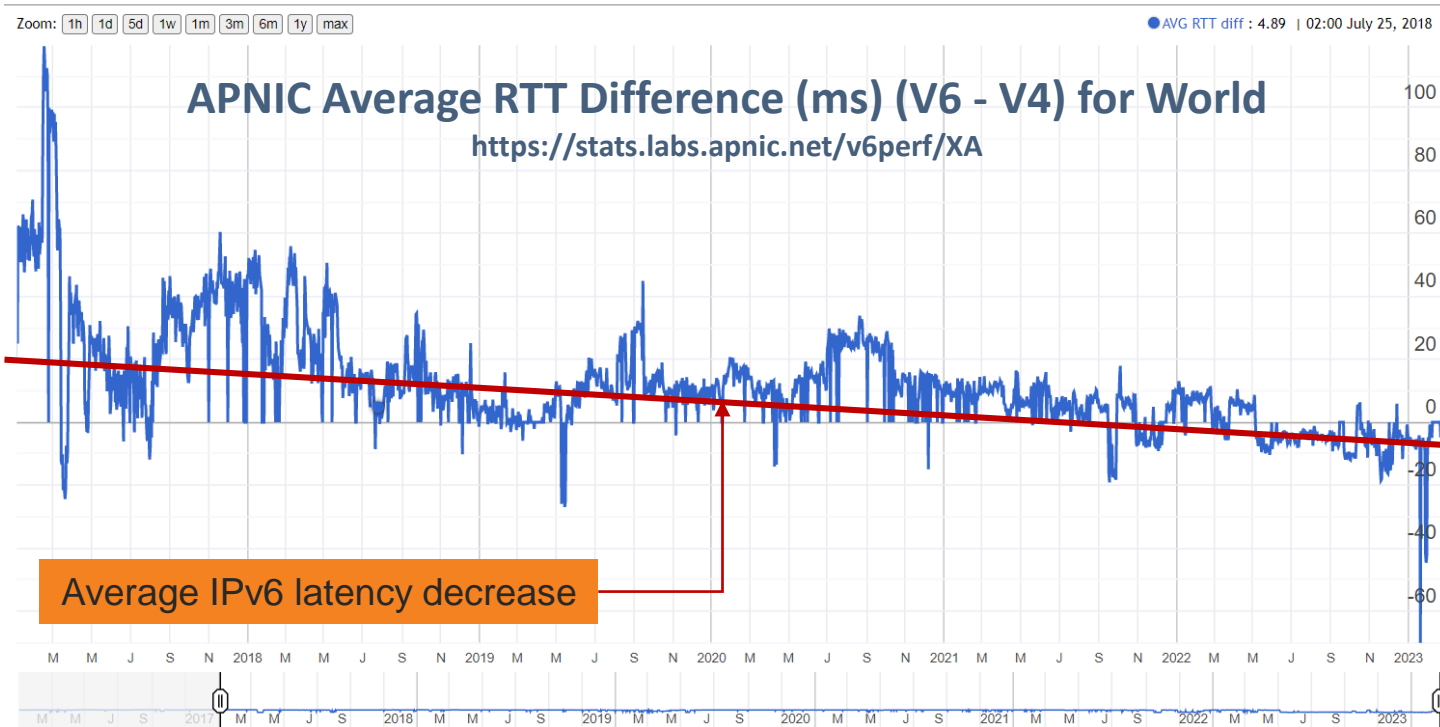
## CG-NAT Removal Case

- 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.

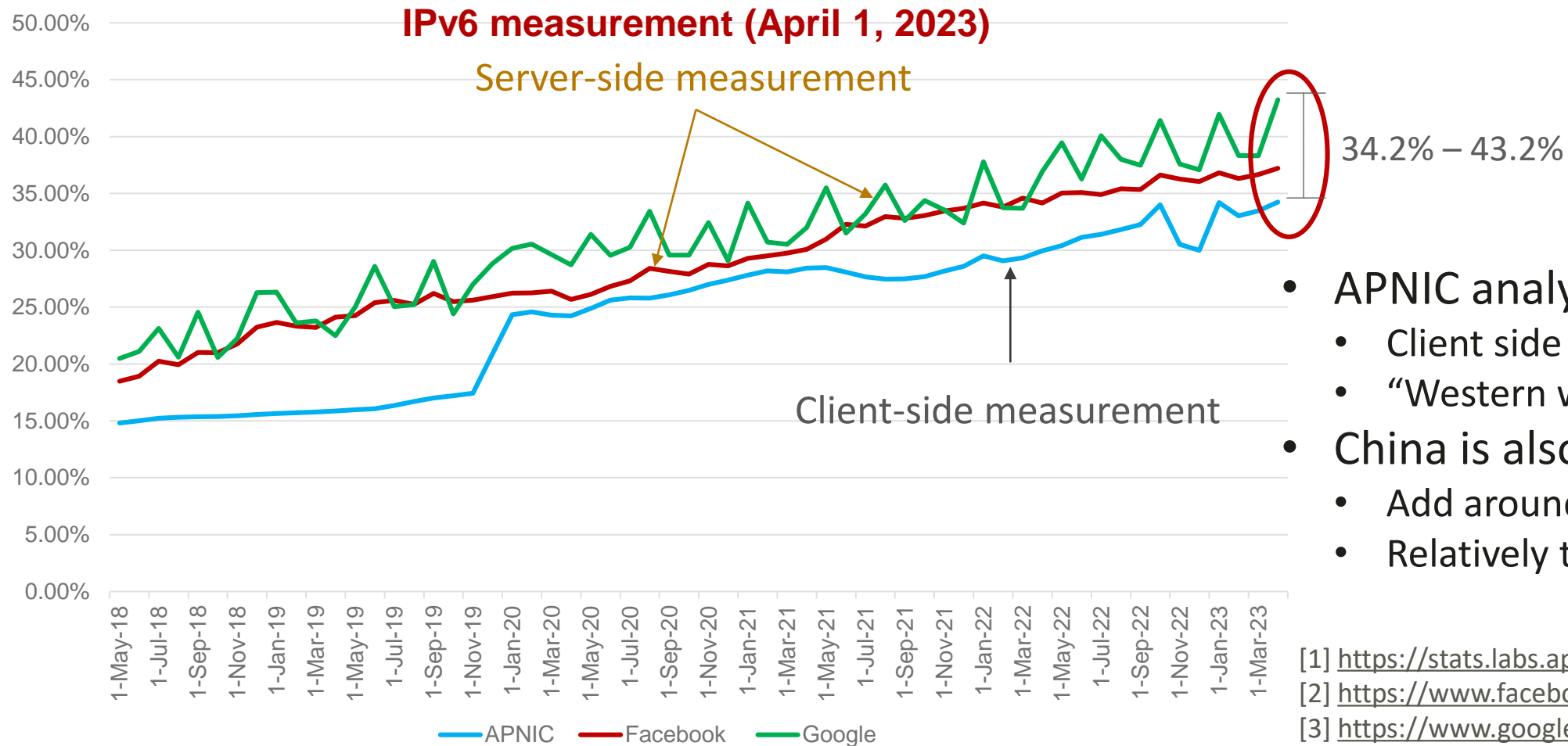
## Akamai Experience Shared at APNIC 52 (<https://conference.apnic.net/52/assets/files/APBS588/akamai-ipv4-ipv6-experience.pdf>)

- 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](https://www.facebook.com/ipv6/?tab=ipv6_country)

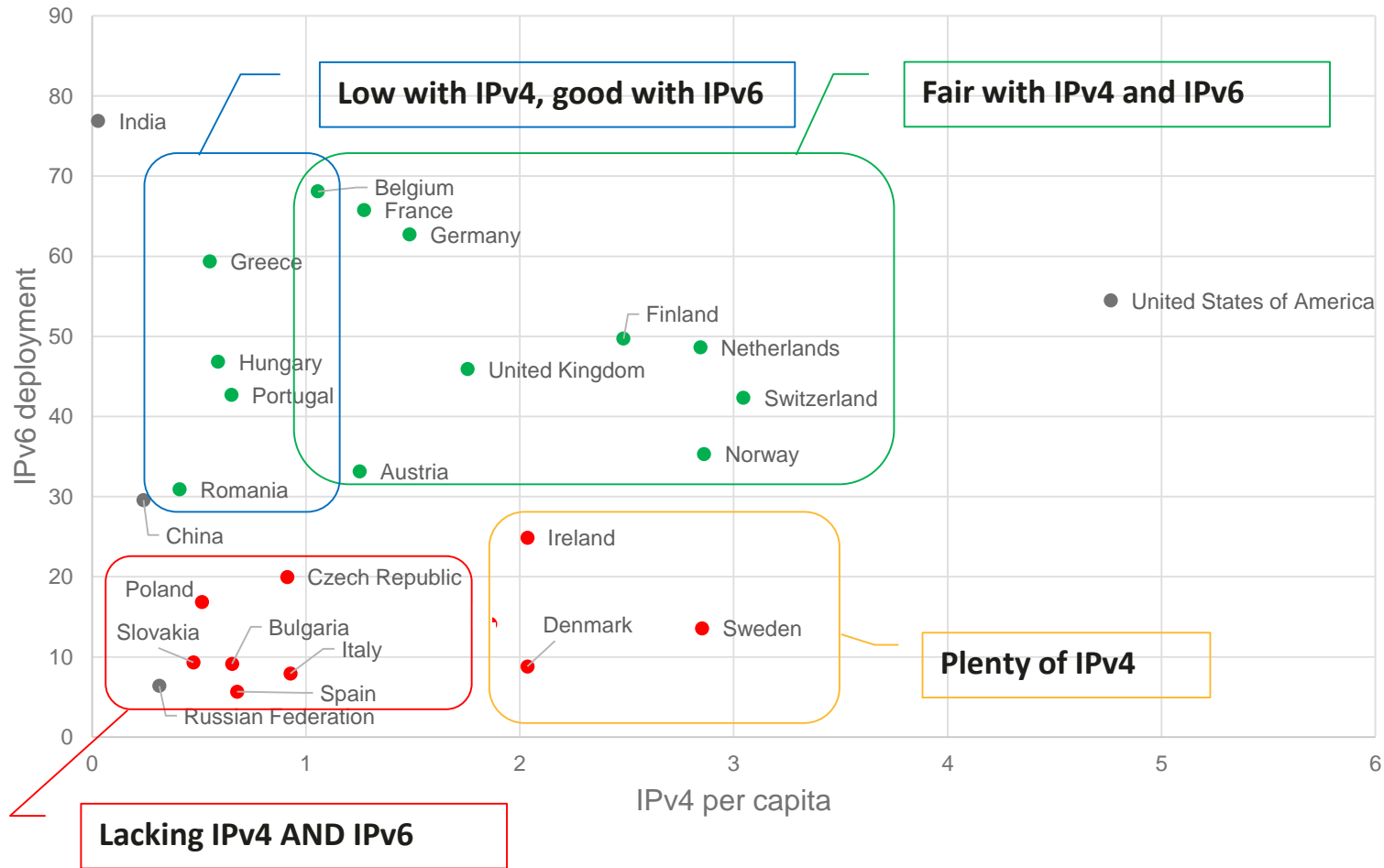
[3] <https://www.google.com/intl/en/ipv6/statistics.html>

[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
<b>ES</b>	<b>Spain, Southern Europe, Europe</b>	<b>-7.15 ms</b>	<b>132,992</b>
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
<b>AS57269</b>	<b>DIGISPAINTELECOM</b>	<b>52.36%</b>	<b>51.23%</b>	<b>392,680</b>
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)

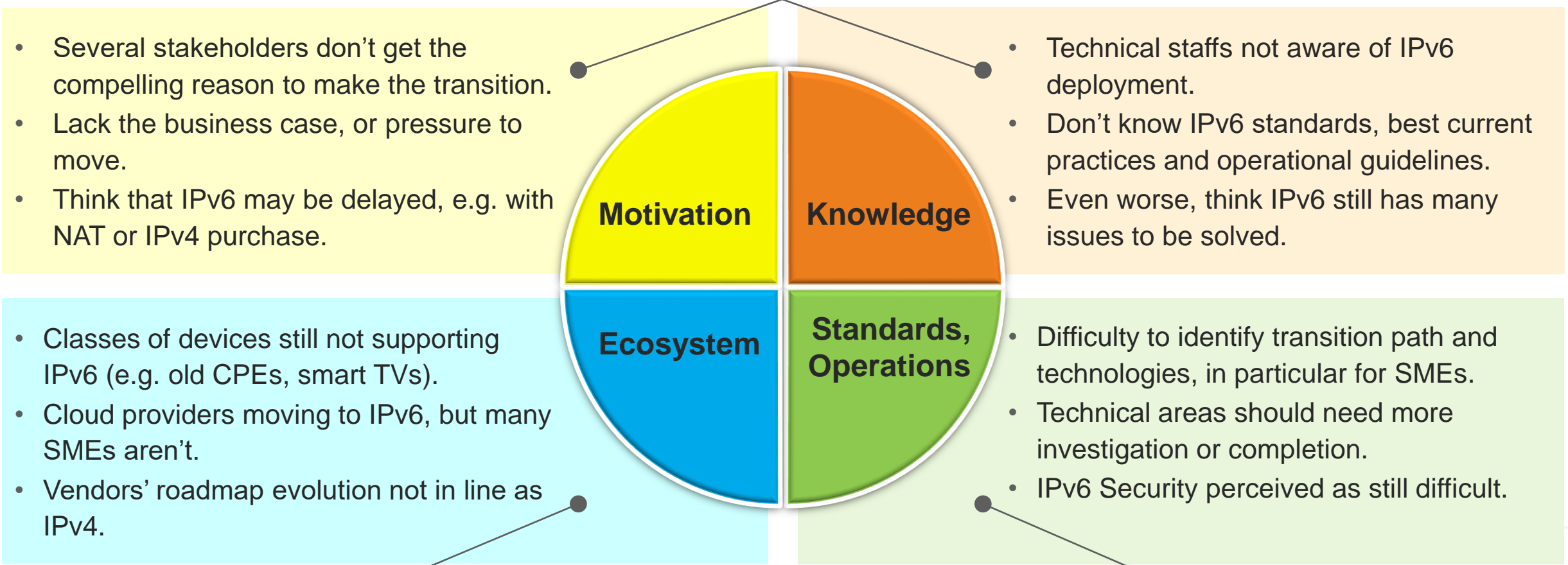
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# Remaining Challenges: Cooperation to Work Them out

*Areas often affecting enterprises.*

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



*Vendors' legacy.*

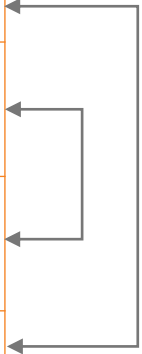
**ICT industry** as a whole needs to act.

*Open aspects in standardization.*

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

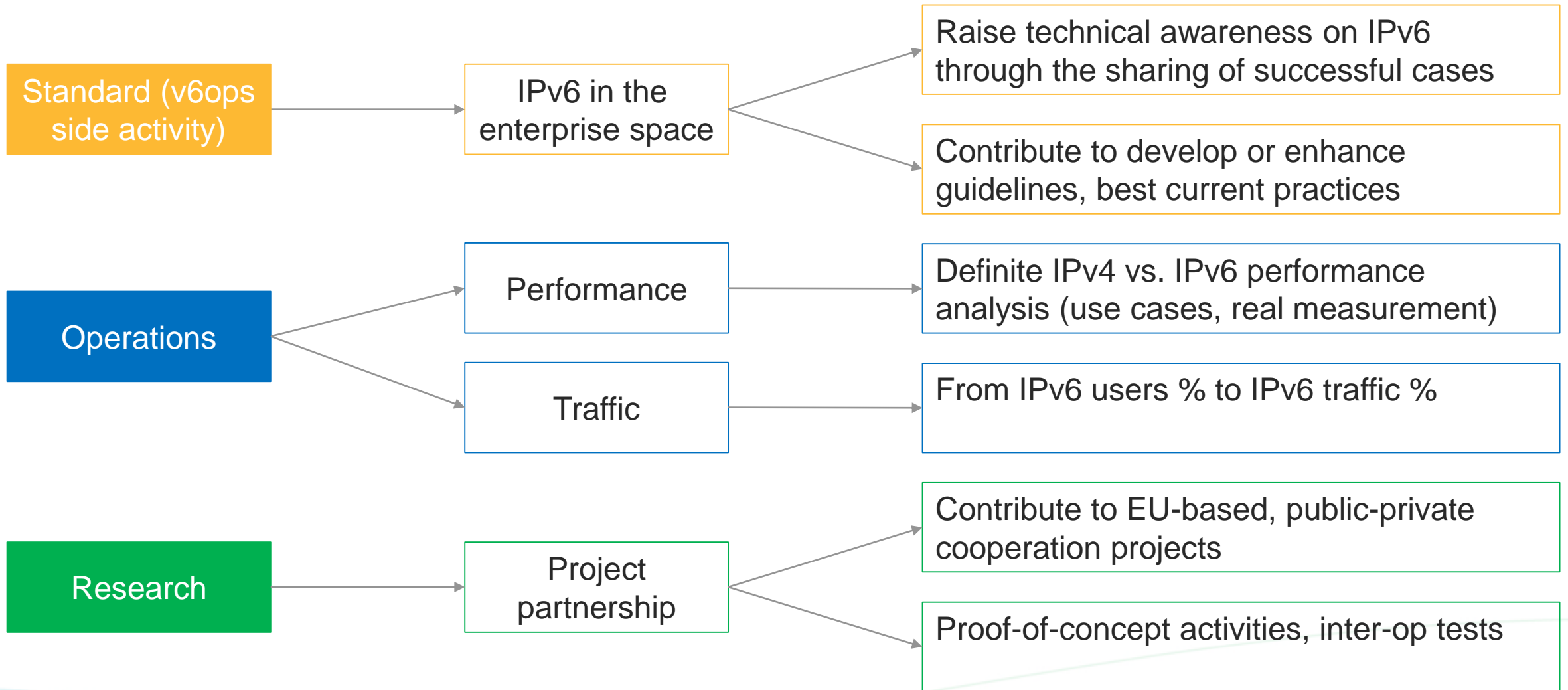
# Current Topics in Standardization

IETF WG	Topic	References <a href="https://datatracker.ietf.org/doc/">https://datatracker.ietf.org/doc/</a>
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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