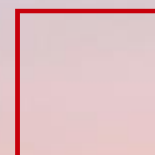


IPv6 in 2021: Status, Momentum & Challenges

XiPeng Xiao

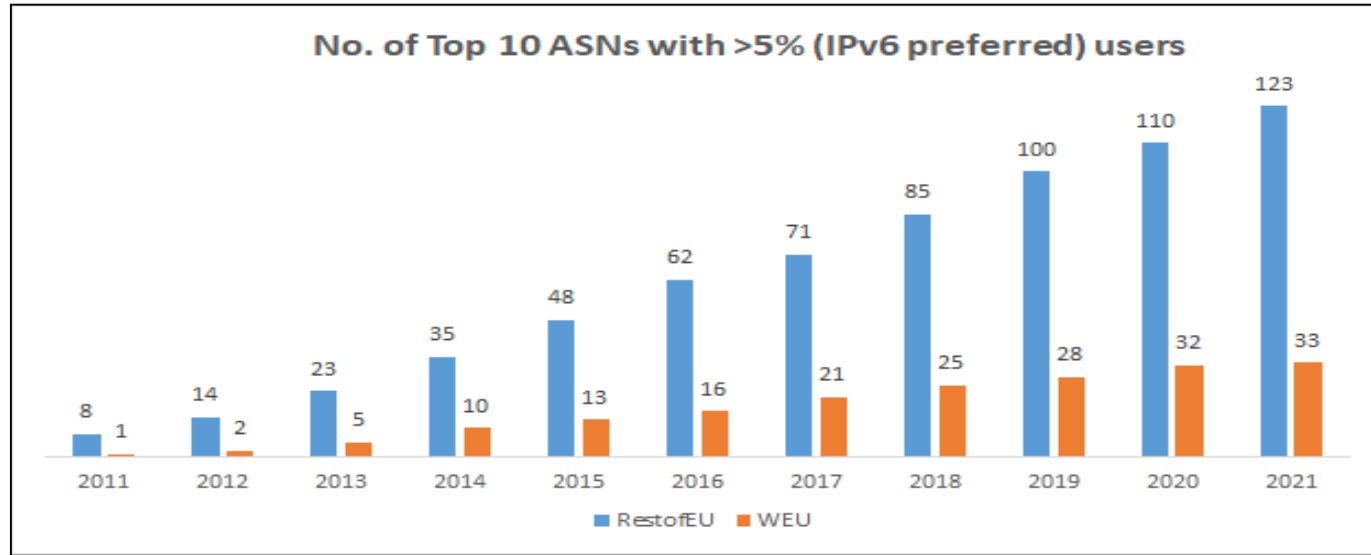
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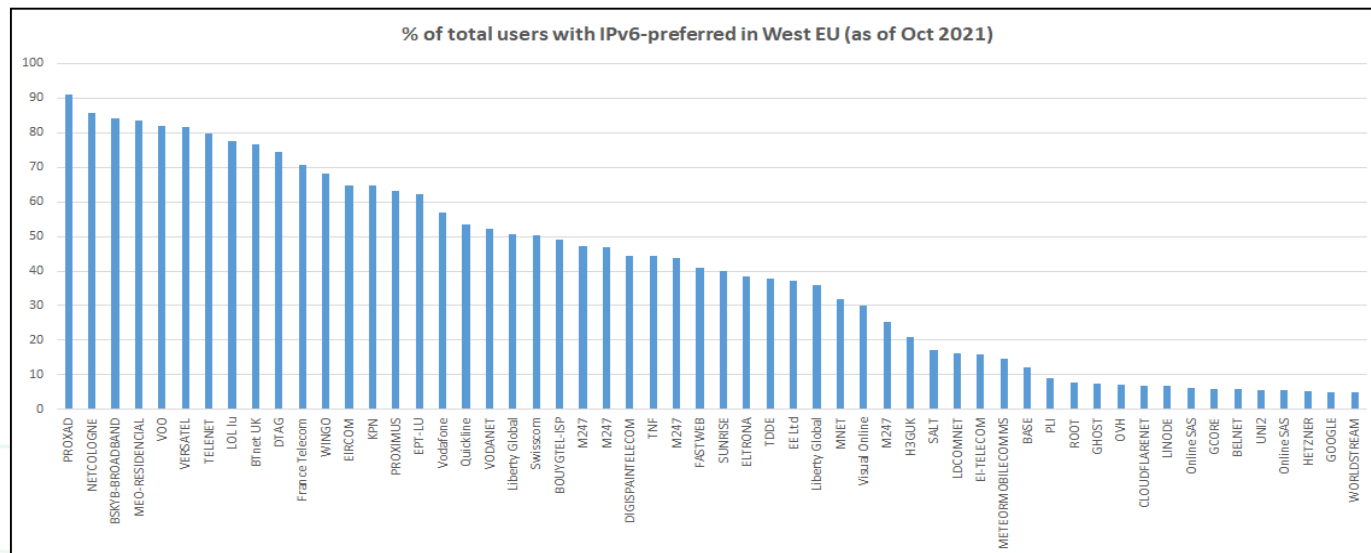
Agenda

- Current status
- New momentum
- Remaining challenges & possible solutions

IPv6 Network Deployment Pace Steady Since 2011. Some Networks Have High % of IPv6-Preferred Users



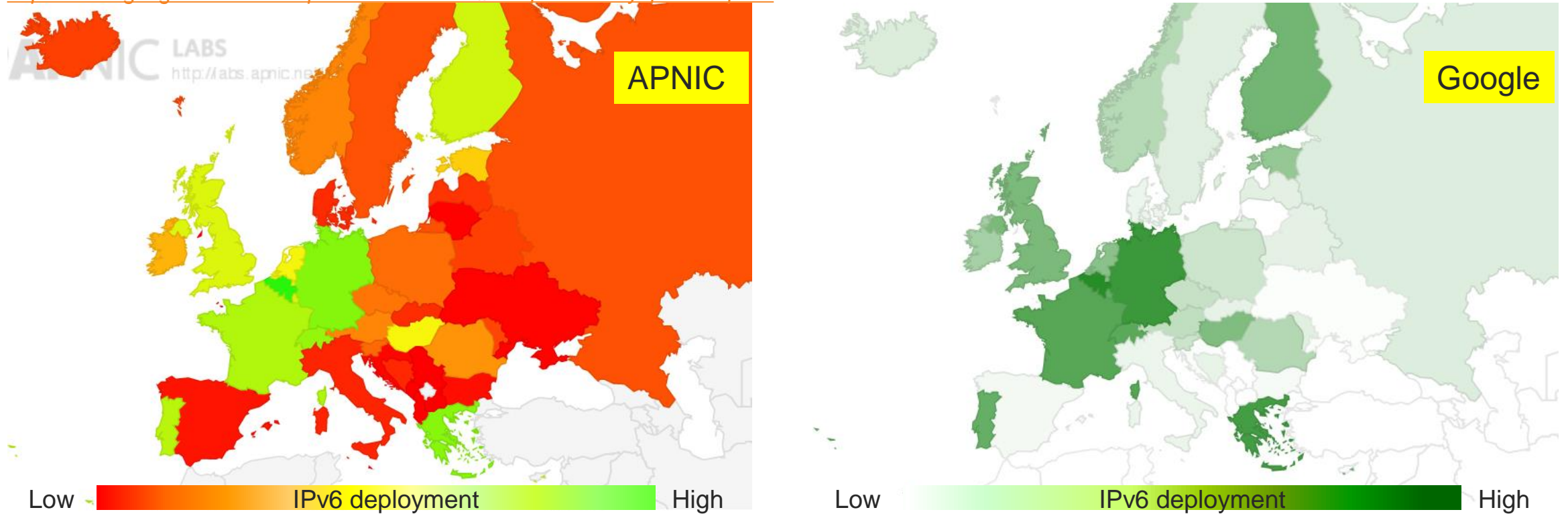
- In WEU, 2-5 operators are deploying IPv6 every year
- In rest of EU, 10-15 operators are deploying IPv6 every year



- Many operators already a very high % of IPv6 preferred users

IPv6 Adoption in Europe Highly Uneven

Traffic ranked as number of connections (IPv6-capable users). Source: <https://stats.labs.apnic.net/ipv6/XE;>
<https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption>



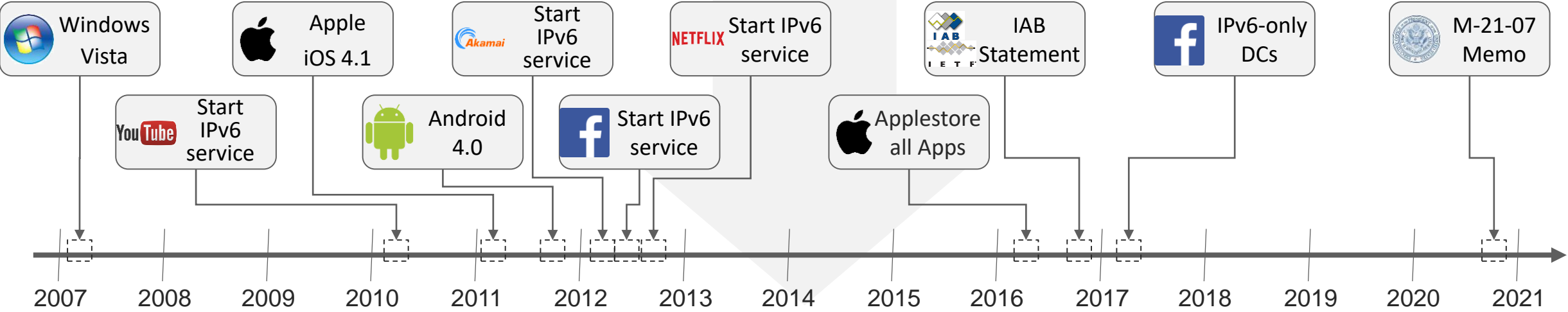
Analytics	Spain	UK	France	Italy	Germany
APNIC	2.53%	36.39%	42.70%	4.68%	48.88%
Google	2.85%	34.73%	44.19%	4.62%	51.62%

Agenda

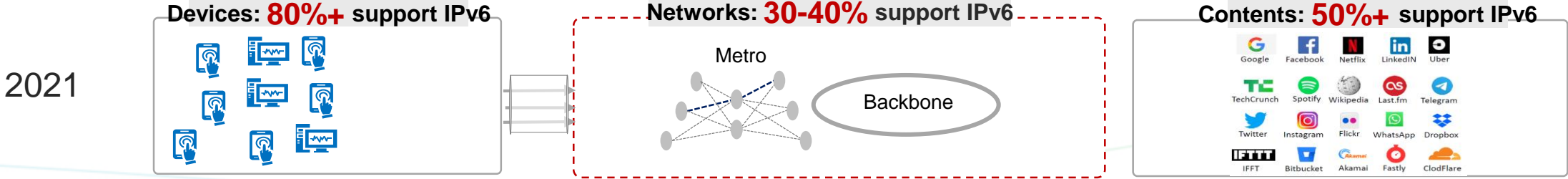
- Current status
- **New momentum**
- Remaining challenges & possible solutions

IPv6 "Device – Network – Content" Value Chain Largely Ready

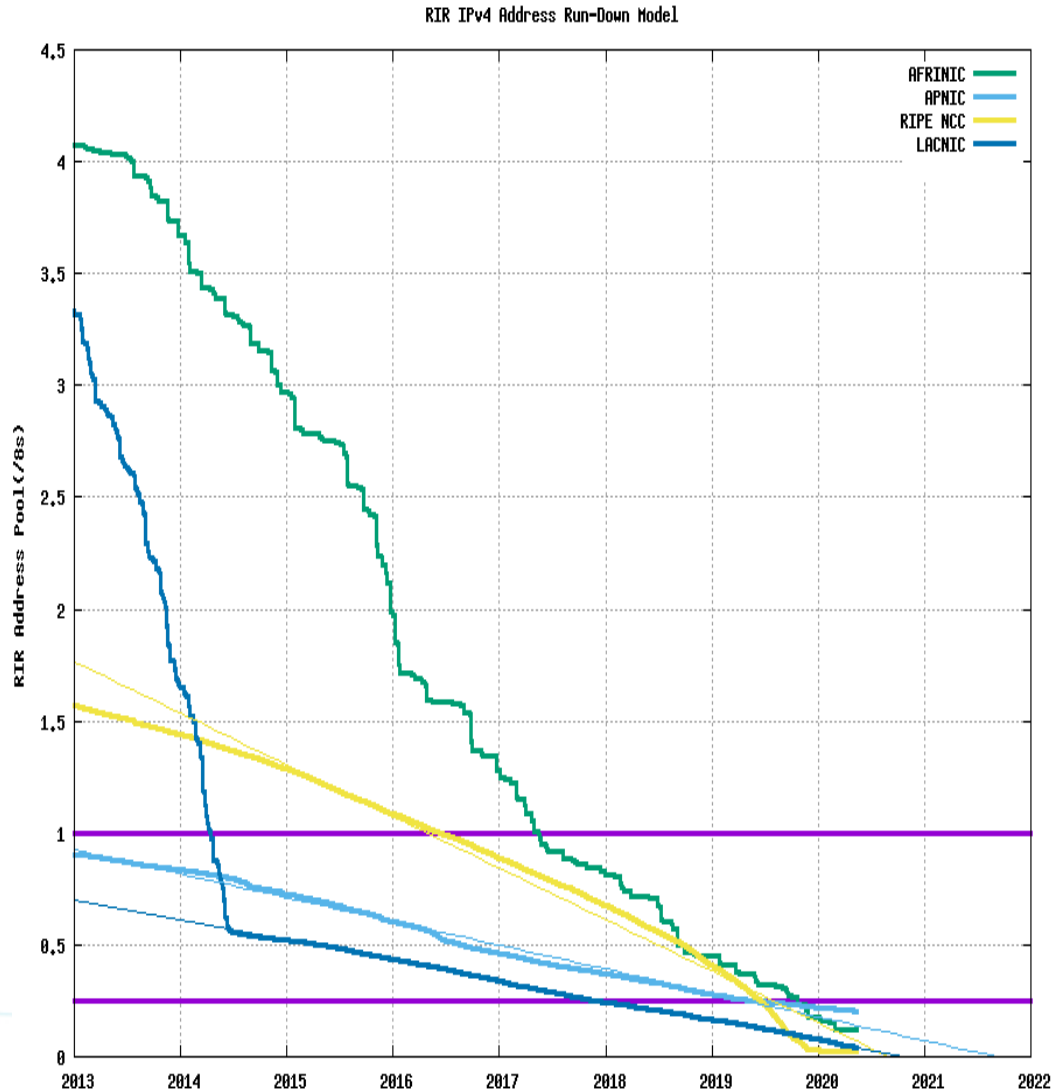
Big contents IPv6 ready by 2013, devices (i.e. Apps) ready by 2017



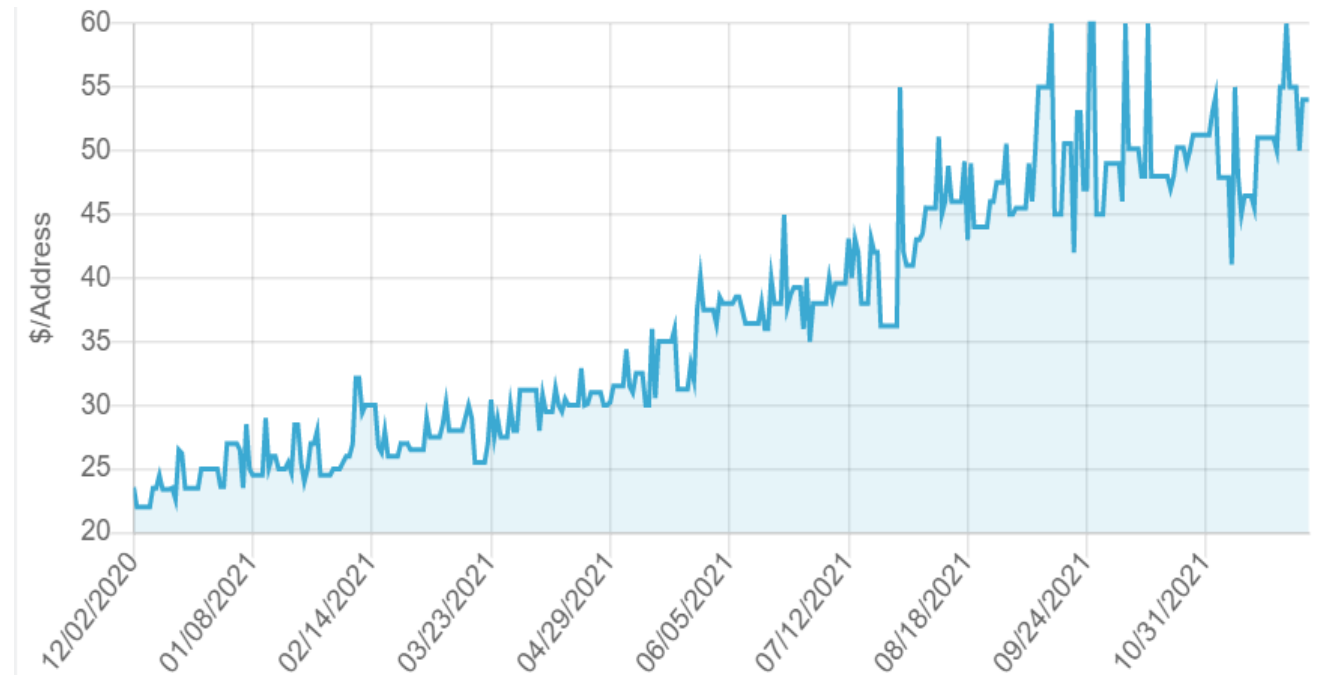
Overview of IPv6 value chain: devices and content ready, while networks lagging behind



IPv4 Addresses Exhausted & Price Doubled in 2021



- Price per IPv4 address doubled in last 12 months to \$50



<https://auctions.ipv4.global/prior-sales>

Many Countries Set New IPv6 Policy Requirements



France

- Lack of IPv4 addresses may result in insufficient competition in telecom industry; new operators have no IPv4 address space for subscribers
- Smart home, online gaming may not be deployed, hindering the formation of new industries
- **5G license-holder must make its mobile network compatible with IPv6 by the end of 2020**



USA

- US Federal Office of Management and Budget issued memorandum M-21-07
- Will accelerate Federal information network systems migration to IPv6-only
- Milestones set: **20%+ by 2023, 50%+ by 2024, 80%+ by 2025**



China

- IPv6 is the core of the new infrastructure
- **Over 50% IPv6 traffic in mobile networks and over 15% in fixed networks by 2023**

DG Connect expects IPv6 to further accelerate in 2022

- Head of Sector, Internet Governance and Multi-Stakeholder Dialogue at European Commission:
 - IPv6 is a corner stone of broadband infrastructure
 - DG connect is doing a study on IPv6. It will be released in Feb. or March 2022
 - **We expect IPv6 to further accelerate in 2022**

5G & IoT Adding Momentum to IPv6?

- 5G brings new builds. Some operators take the opportunity to deploy IPv6
 - France regulator ARCEP requires 5G spectrum bidders be IPv6 ready by end of 2020
- 6LoWPAN had been widely deployed in the smart grid world.
 - G3-PLC (6LoWPAN+LOADng): ~50M devices [1]
 - Wi-SUN (6LoWPAN+RPL): ~91M devices [2]
- We are seeking more data points to prove or disprove this view point

Source:

[1]: <https://www.lesechos.fr/industrie-36services/energie-environnement/quatre-questions-sur-le-financement-des-compteurs-linky-1319915>

[2]: Wi-SUN Alliance marks a year of strong growth in membership and 91 million devices awarded globally, Wi-SUN Alliance, Apr. 15, 2019

Summary: Deployment of IPv6 in Overlay (i.e. Service Layer) is Well Justifiable

- Why would a company deploy IPv6 service (i.e. overlay)?
 - **Need addresses for growth**, e.g. Versatel, Sky Italia, FREE, cable operators (mostly competitive operators).
 - **Want future proof**, i.e. IPv6 ensures that, if future services need many addresses, they are ready, e.g. BT, DT, Proximus (mostly incumbent operators)
 - **Meet government guidance**, e.g. German/French/Belgian operators
- TCO to deploy IPv6 service is justifiable
 - CAPEX is low if IPv6 introduction is sync'ed with life cycle replacement
 - Can also save on NAT, or sell IPv4 (normally \$20-25/address, but in 2021 price doubled to \$50/address)
 - OPEX
 - Training of staff, upgrade of certain software, etc are needed. But many operators have done it → doable
 - **IPv6 growing faster than IPv4 in every aspect → TCO of IPv6 overlay justifiable**
- Do you agree with these view points?

Agenda

- Current status
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Deployment of IPv6 in Underlay (i.e. Network) is More Difficult: the Challenges

IPv6 Councils can help here

Challenge 1

- By using NAT or purchasing IPv4 addresses, many companies think IPv6 can be avoided or delayed: no will to deploy IPv6
- Any new industry has its challenges. In the absence of policy guidance, enterprises lack the motivation or pressure to take the first step.

Challenge 2

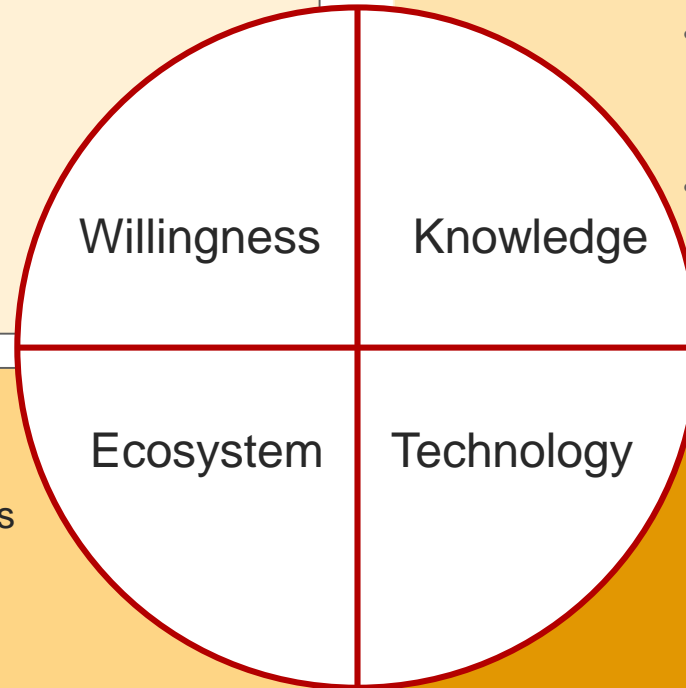
- Not aware of latest IPv6 standards, products, and deployment progress; think there are still many problems with IPv6.
- Insufficient IPv6 talents and insufficient confidence in IPv6 deployment and O&M.

Challenge 3

- Most terminals that use mainstream operating systems support IPv6. Non-mainstream (such as smart TVs) are still not supporting IPv6.
- Most of the leading websites support IPv6, but many SME websites still do not support IPv6.

Challenge 4

- Old CPEs may not support (certain) IPv6 transition solutions
- IPv6 products not as field-proved as IPv4.
- IPv6 solutions, especially OAM, NMS, LI are incomplete or immature.



The industry will solve this problem. Government policy may accelerate this process

Focus of our discussion today

Technical Challenges & Progresses 1/2

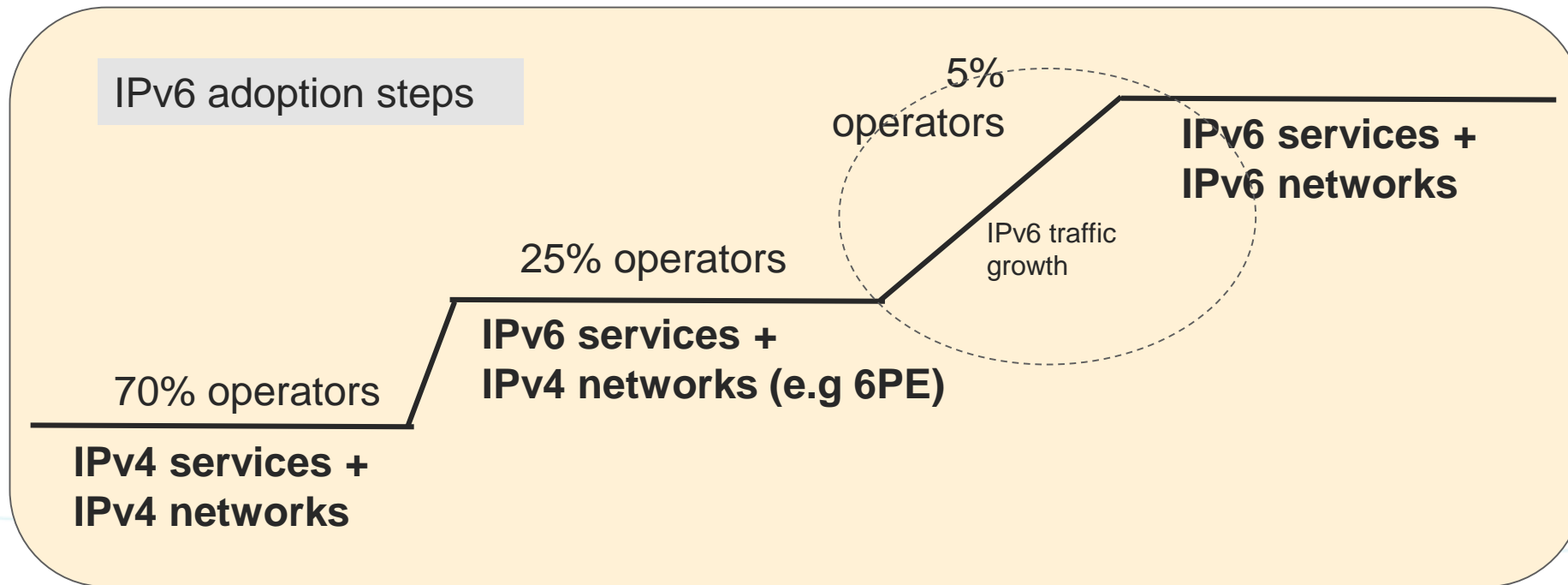
- MTU
 - Combination of (1) larger header and (2) fragmentation only at source leads to packet drops and low NPS
 - Progress: problem recognized and fixes offered
- NMS (i.e. FCAPS)
 - IPv6 NMS not as complete or mature as IPv4 NMS
 - Do you see progress from vendors?
- Address management
 - (1) IPv6 addresses long and intimidating. Is CLI still useable? (2) Each interface can have multiple IPv6 addresses. Is there any complication for network management? (3) GUA vs ULA selection: GUA for interfaces, ULA for loopbacks? (4) source/destination address selection complication, MHMP issues – challenges for vendors, not for operators.
 - Do you see these problems, or have any advices?

Technical Challenges & Progresses 2/2

- Security concern
 - Many people believe that IPv6 has many security problems, e.g. extension headers may cause routers to crash
 - Progress: RFC 9099 documented most known issues and solutions
 - Do you see vendor implementation issues in live networks?
- Incompatible vendor roadmaps
 - May lead operators to think that IPv6 solutions are immature
 - Vendor's responsibility to solve this issue
- Legacy equipment
 - Phase them out at end of life cycle, but this takes time
- 20M IP engineers don't understand IPv6
 - IPv6 Councils can help

IPv6 Services (Overlay) will Eventually Lead to IPv6 Networks (Underlay)

- When IPv6 traffic > IPv4 traffic, it makes sense to migrate IPv4 underlay (e.g. 6PE) to IPv6 underlay
 - When IPv6 service introduced: IPv6 underlay will appear at places without tunnels, e.g. peering points, GI LAN. Network is Dual-Stack in **limited** places. IPv6 traffic tunneled over IPv4 in many places
 - When IPv6 traffic > IPv4 traffic, network will be Dual-Stack in **many** places, with IPv4 traffic tunneled over IPv6 in some places
- Do you agree with this viewpoint?





Thank You.

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