ACM IMC 2024
MADRID

IoT Bricks over v6

Understanding IPv6 Usages in Smart Homes

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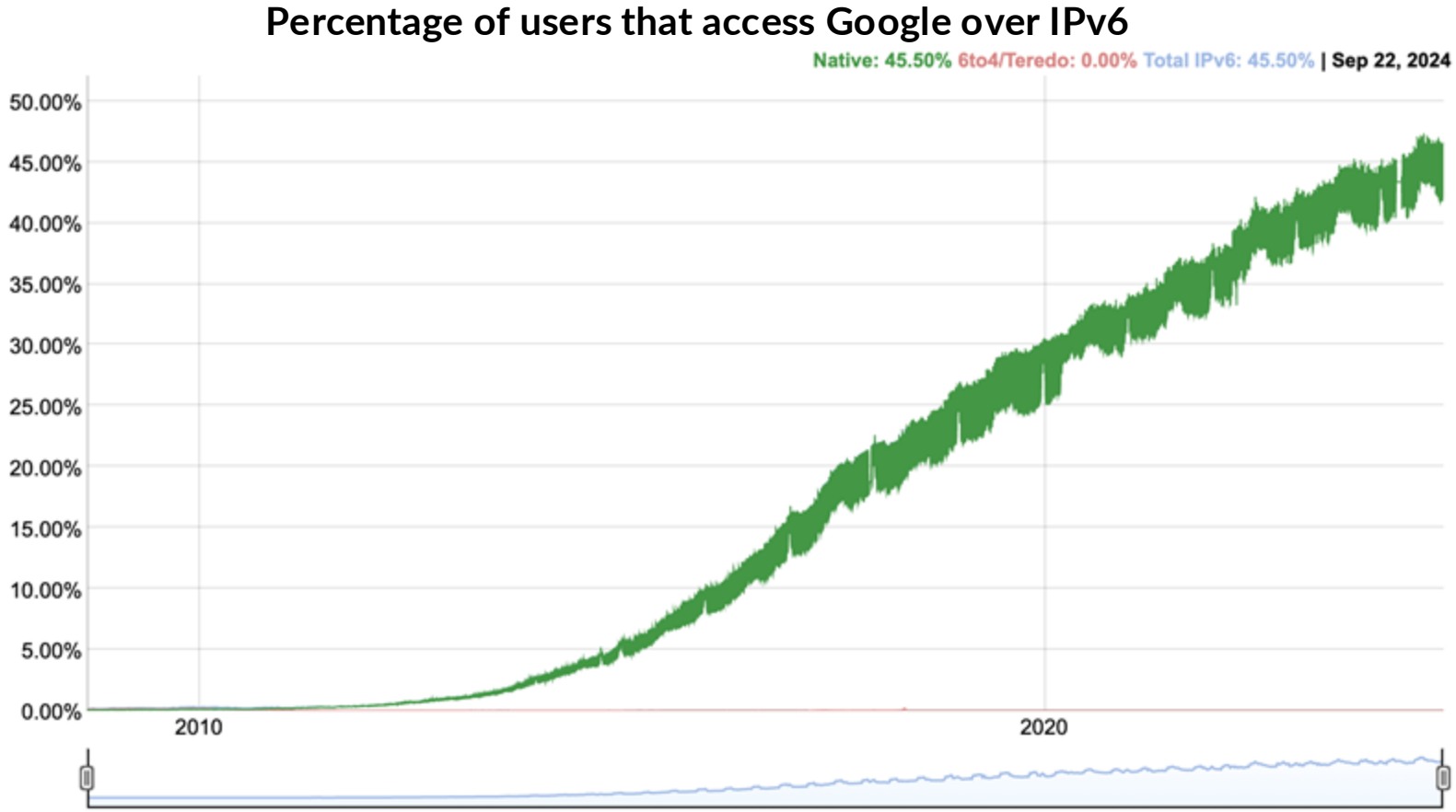
SPHERE RESEARCH INFRASTRUCTURE

ProperData

NSF

Background



https://www.google.com/intl/en/ipv6/statistics.html#tab=ipv6-adoption

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IPv6 ready 

https://en.wikipedia.org/wiki/Comparison_of_IPv6_support_in_operating_systems

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IPv6 ready

IPv6 not ready

Nintendo Switch OS

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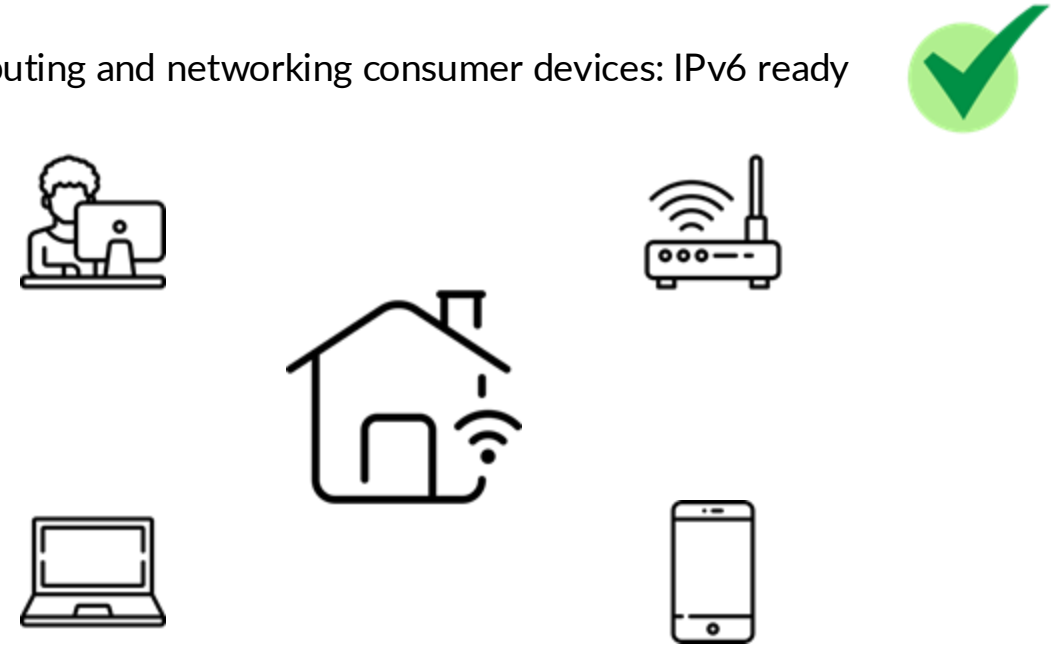
Background

Most general purpose computing and networking consumer devices: IPv6 ready



Icons by Freepik, Flaticon, Icons8

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Household penetration rate (Excluding smart TVs)

US: 52.4%
EU: 24.9%
Worldwide: 18.9%

Data source: Statista

Internet-enabled smart home

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(How) do smart home IoT devices use IPv6 ?

Research Questions

Goal 1: Are consumer IoT devices ready for IPv6?

- If not, why?
- To what extent are IPv6 features supported?
- What IP version do IoT devices prefer in a dual-stack network?

Goal 2: What are the privacy and security implications?

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93 IP-based devices from 7 categories and 45 manufacturers

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- Dual-stack (2 configurations)

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Check out our paper for more details on methodology

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Check if primary function operates as expected

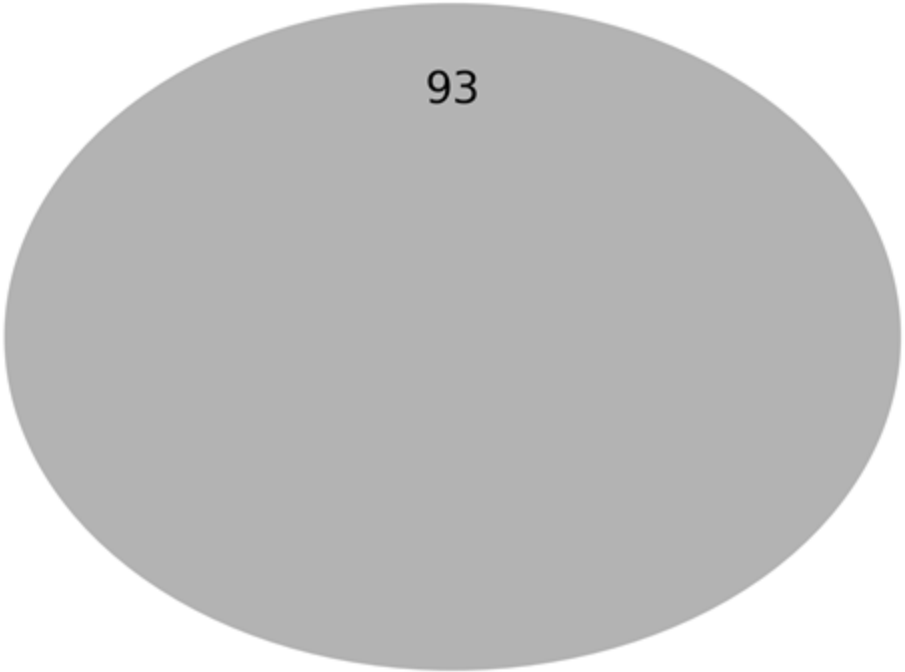
- Toggling device state via the companion app (e.g., on/off and open/close)
- Streaming YouTube on TVs
- etc.

Results

Are consumer IoT devices ready for IPv6?

IPv6-only experiments

- 93 devices



Are consumer IoT devices ready for IPv6?

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IPv6-only experiments

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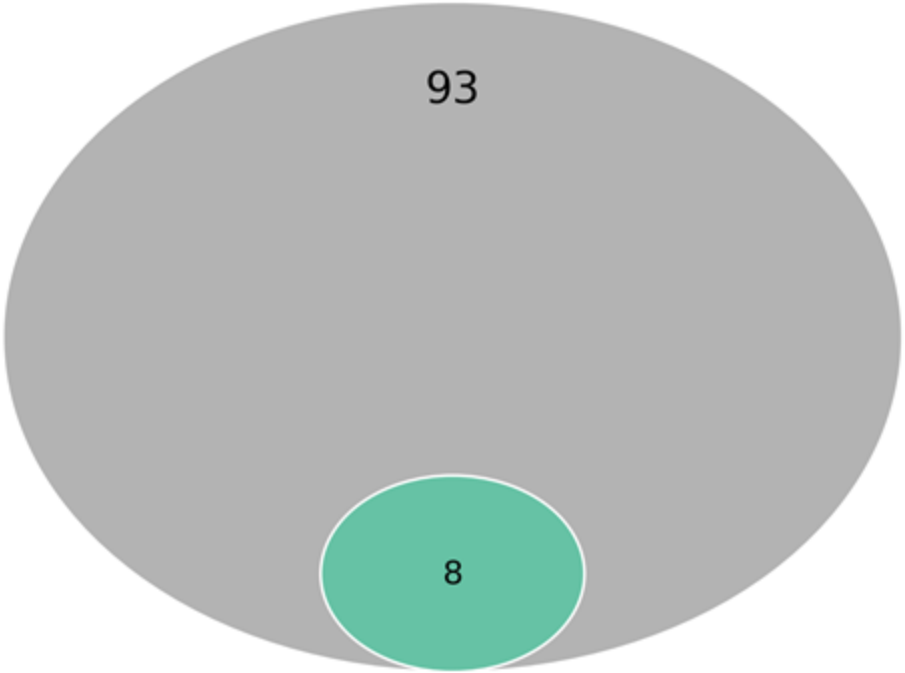

- 8 functional in IPv6-only network

To what extent are IPv6 feature supported?

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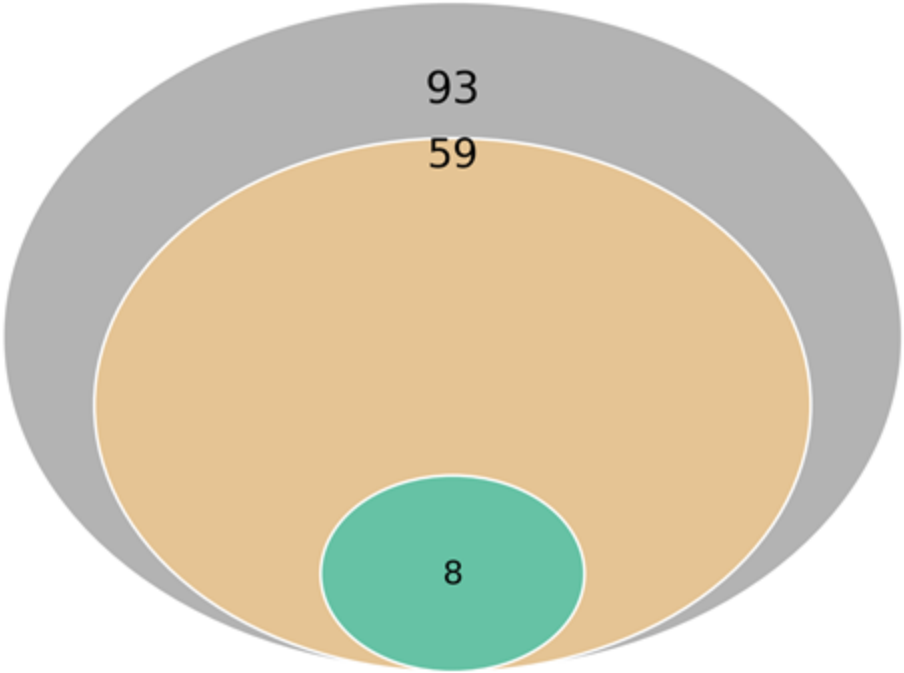

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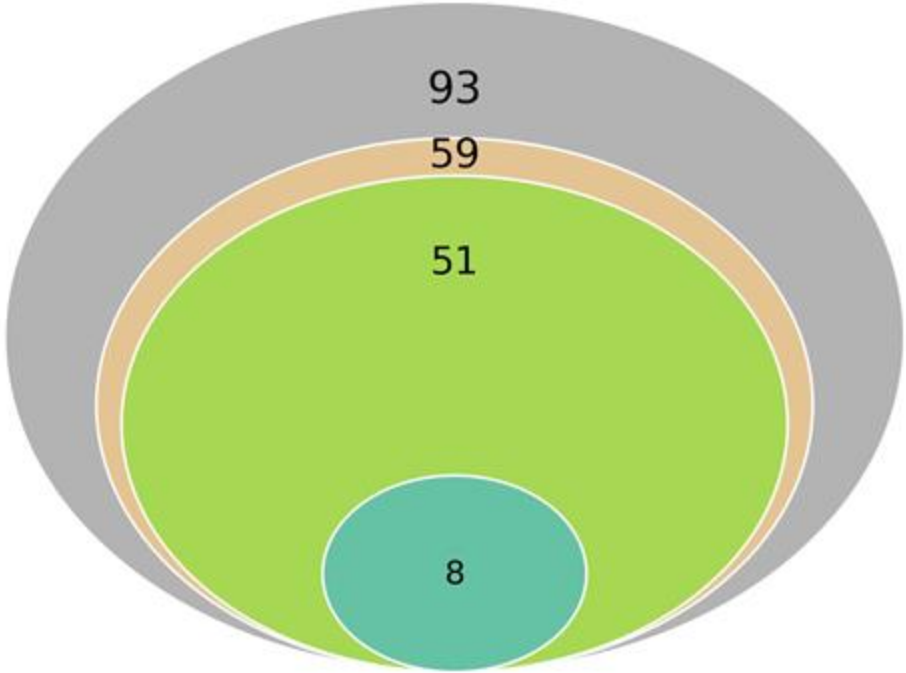

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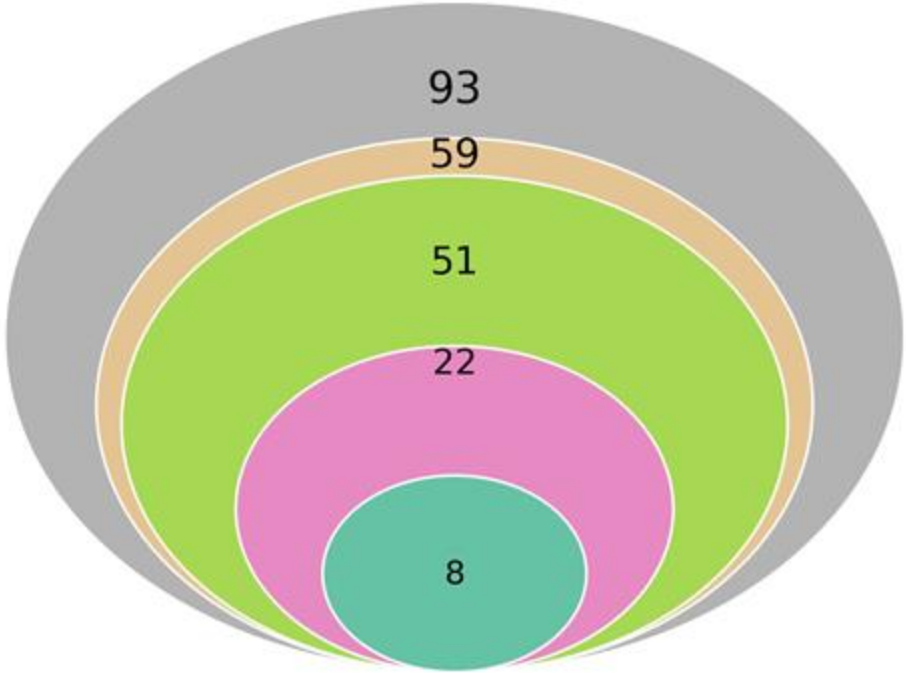

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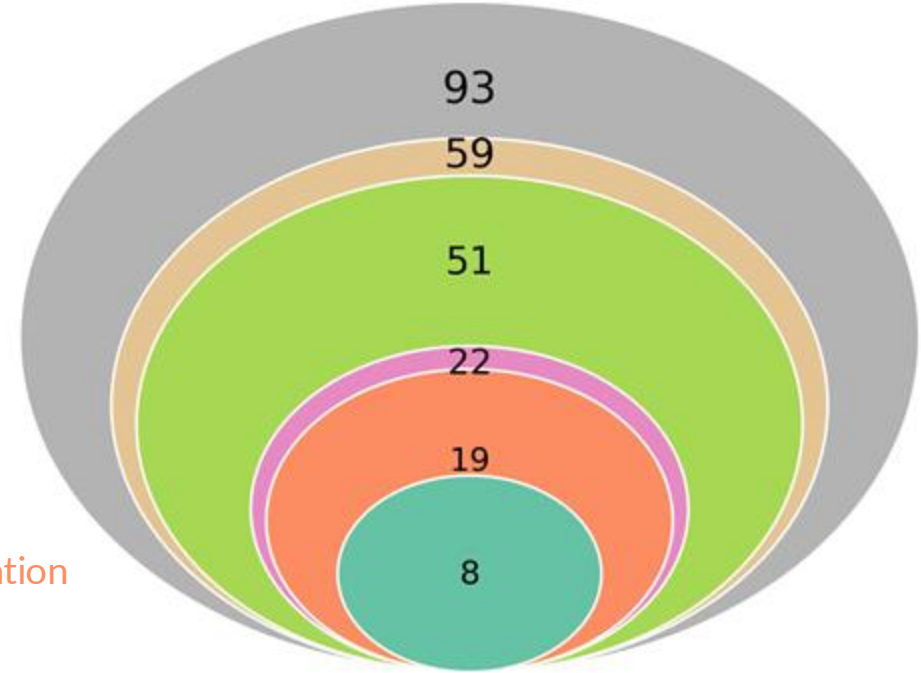

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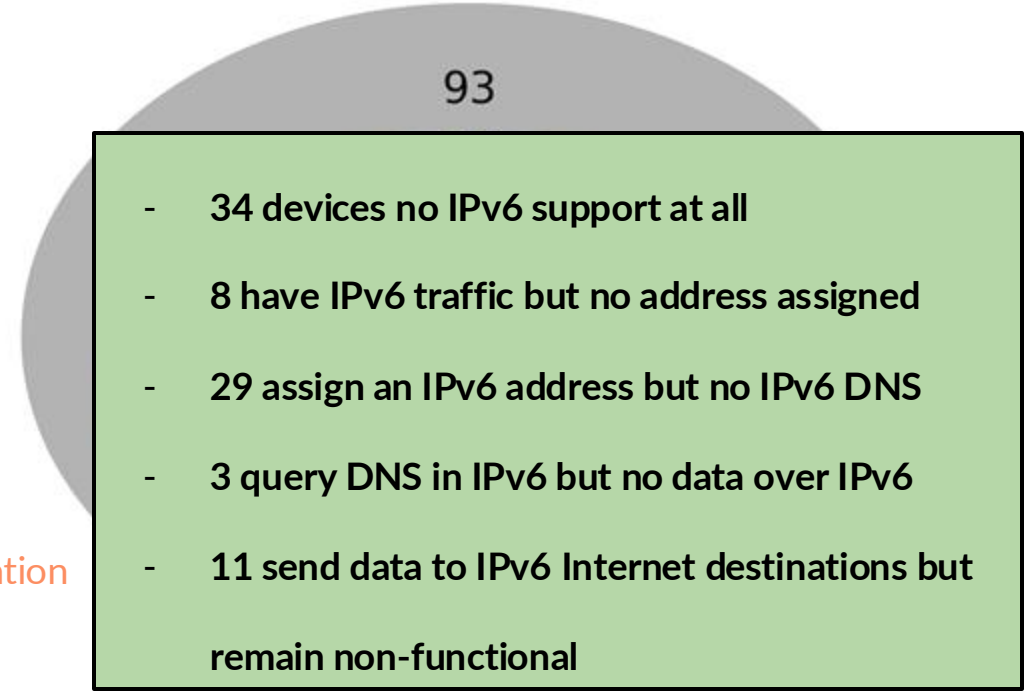

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Failure to provide (server) and/or use (client) IPv6 DNS AAAA entries

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- DNS server is not fully ready for IPv6
  - Active DNS AAAA queries:
    - 8 functional devices: **73%** of destinations AAAA available
    - 85 non-functional devices: **31.1%** of destinations AAAA available

Cases on incomplete support

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Lack of IPv6 Global Unique Address - They use IPv6 local addresses for HomeKit, Matter, etc.

Functional vs Non-functional Devices

- Google Home Mini
- Google Nest Mini
- Chromecast Google TV
- Nest Hub Max
- Nest Hub
- Meta Portal Mini
- Apple TV
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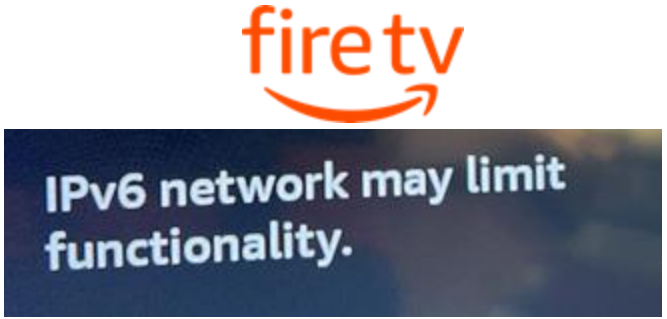

amazon echo SmartThings tuya

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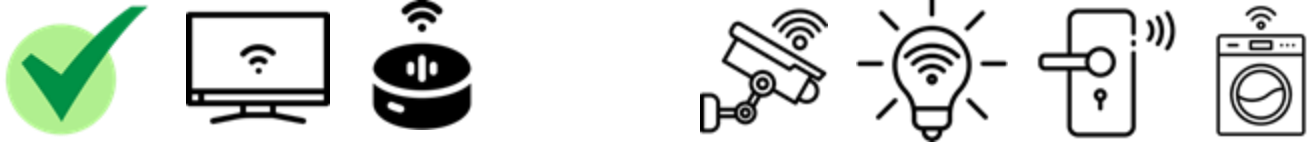
Device Category has a significant impact on IPv6 support

Smart TVs, Speakers, Gateways >> Home Automation, Health, Camera, Appliance



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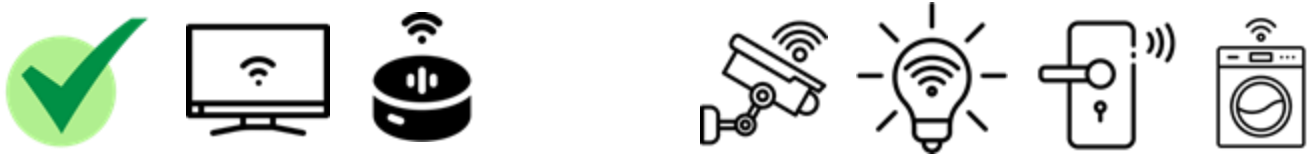

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What IP version do IoT devices prefer in a dual-stack network?

In dual-stack networks:

- 2.8% of domains use **IPv4-only** despite receiving **valid AAAA** records
- 11.2% domains from **IPv6-only** experiments fully switch to **IPv4** when available

[RFC 6724] recommends prioritizing IPv6 over IPv4 - not the case for smart homes

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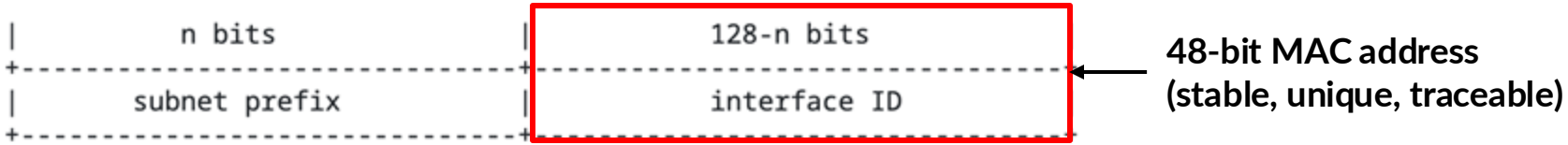

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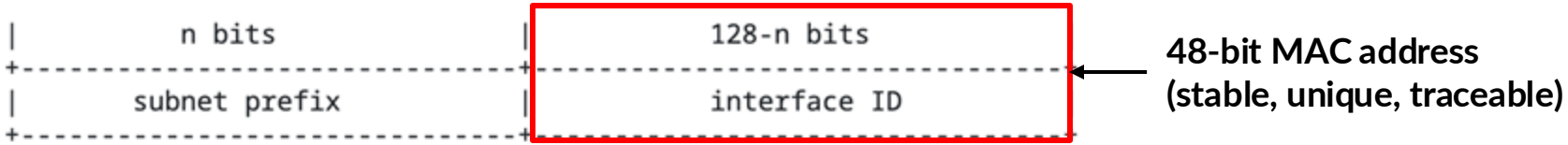

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Latest RFCs: SHOULD NOT do this

- Alissa Cooper, Fernando Gont, and Dave Thaler. 2016. Security and Privacy Considerations for IPv6 Address Generation Mechanisms. *RFC 7721*. https: //doi.org/10.17487/RFC7721
- Saidi, Said Jawad, Oliver Gasser, and Georgios Smaragdakis. "One bad apple can spoil your IPv6 privacy." *ACM SIGCOMM Computer Communication Review* 52.2 (2022): 10-19.

What are the privacy and security implications?

Analysis of traceable EUI-64 addresses in IoT devices:

- 8 devices use them for DNS requests
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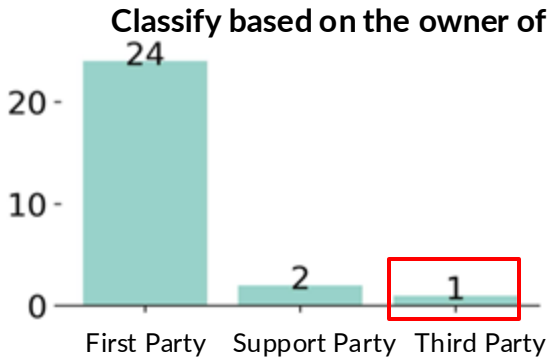

An analytic service

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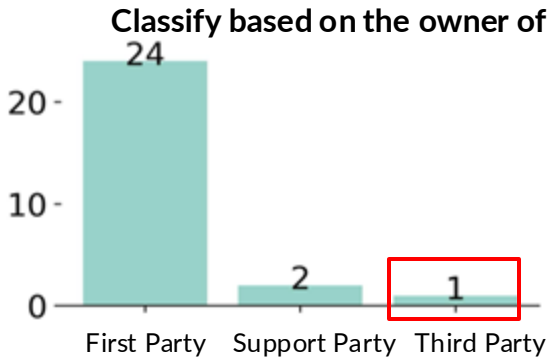

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Disclosure: Google, Amazon, Samsung acknowledged our findings

What We Learned

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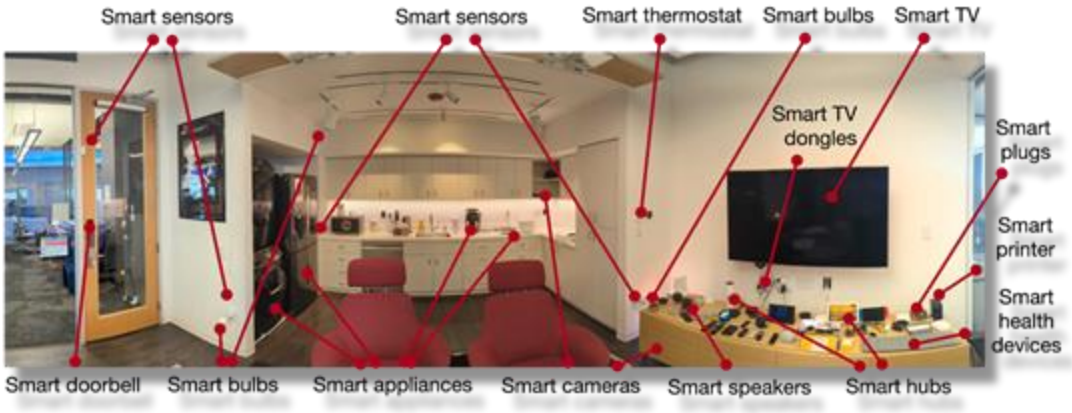
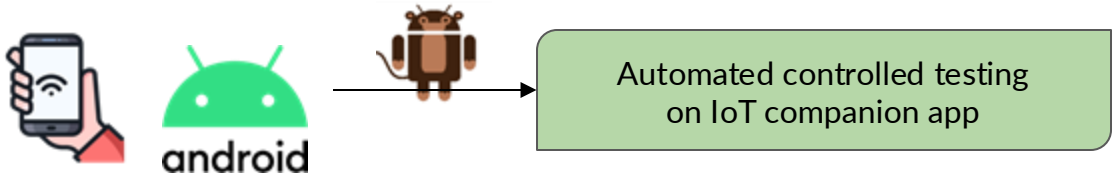
- New Local IPv6-based Standards: Matter – not the solution but a first step

Our Research Overview

Our Smart Home IoT Measurement Research over 7 years

120+ smart home devices
All network traffic collected





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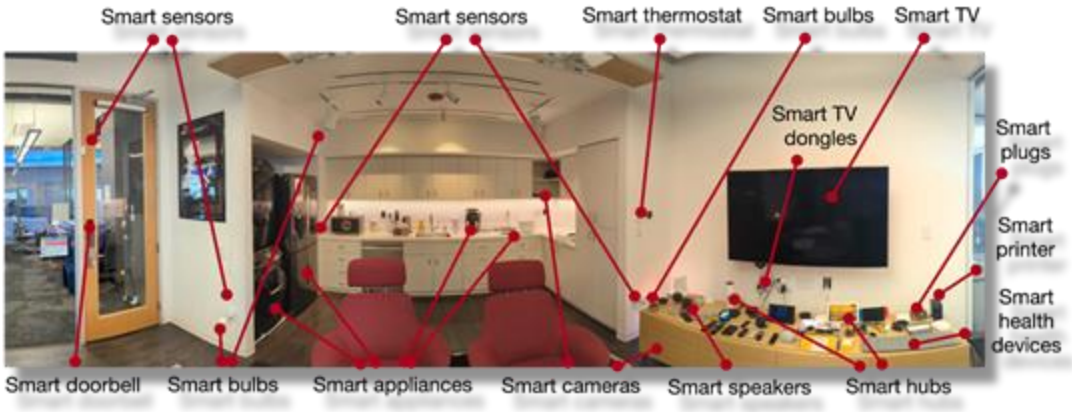

- 12 publications
- Public network datasets
- Public software
  - Testbed
  - etc.
- Remotely accessible IoT testbed: under construction now
  - See https://sphere-project.net/ for more details
- Collaboration with EU labs and California labs: GDPR, CCAP

Automated controlled testing on IoT companion app

Open to more collaboration!

Thank you!

- Smart home is **NOT** fully ready for IPv6 – **IoT Bricks over v6**
- Lack of incentives
- Need joint efforts from all stakeholders
- Create incentives

Our papers, datasets, code available here:
https://moniotrlab.khoury.northeastern.edu

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Computer Sciences

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