Detecting Consumer IoT Devices Through the Lens of an ISP

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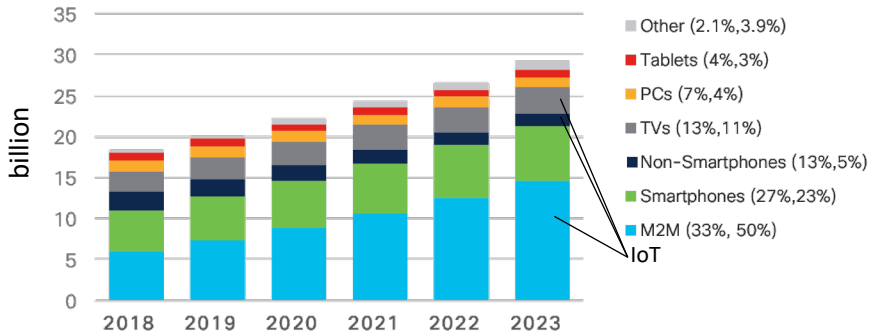
17+ billion IoT devices by 2023



Source: Cisco Annual Internet Report, 2018–2023

Hackers Used New Weapons to Disrupt Major Websites Across U.S.

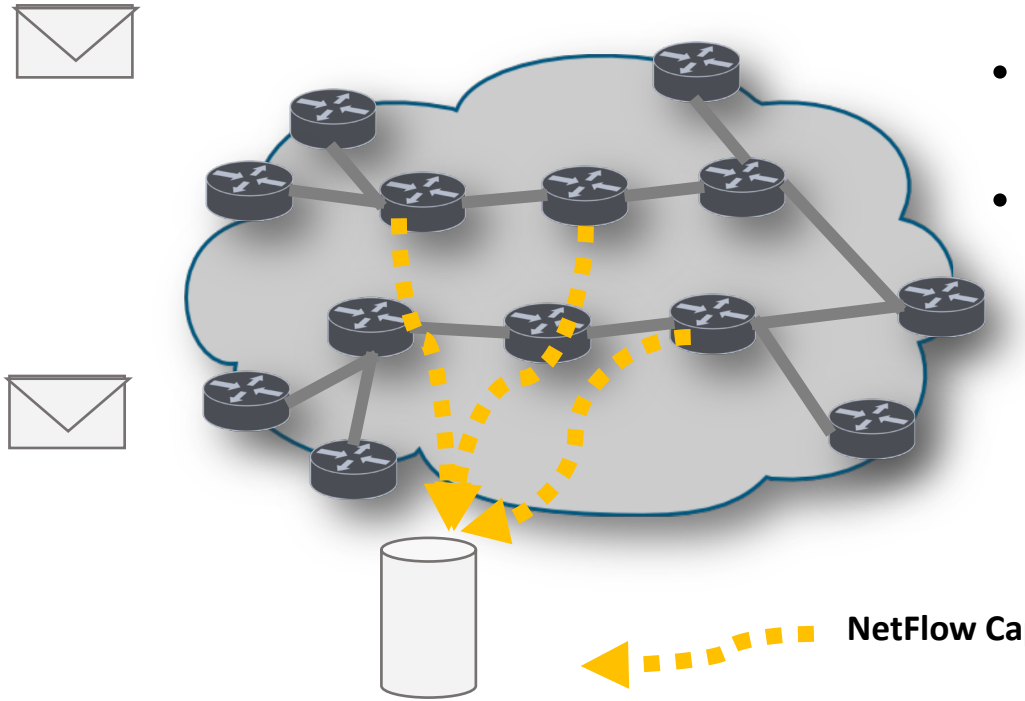
Can we “*identify*” and “*locate*” IoT devices in our networks

Detecting IoT Devices at the Provider is Challenging

- Traffic patterns across IoT devices are diverse
- Deploying an agent inside at each ISP customers is not scalable *
- Active measurements do not work with devices behind NAT
- Deep packet inspection raises privacy concerns

*Kumar et al., USENIX Security'19, All Things Considered: An Analysis of IoT Devices on Home Networks

NetFlow captures for IoT-device discovery



- Collected for other operational purposes
- Sampled, no payload
- Header-only:
  src_ip, dst_ip, src_port, dst_port,proto...
  192.168.1.1,10.1.1.1,12345,1883,TCP

Detection of IoT devices in **limited, passive,** and **sparsely sampled** flow data in the **wild**

At what granularities can we detect IoT devices?

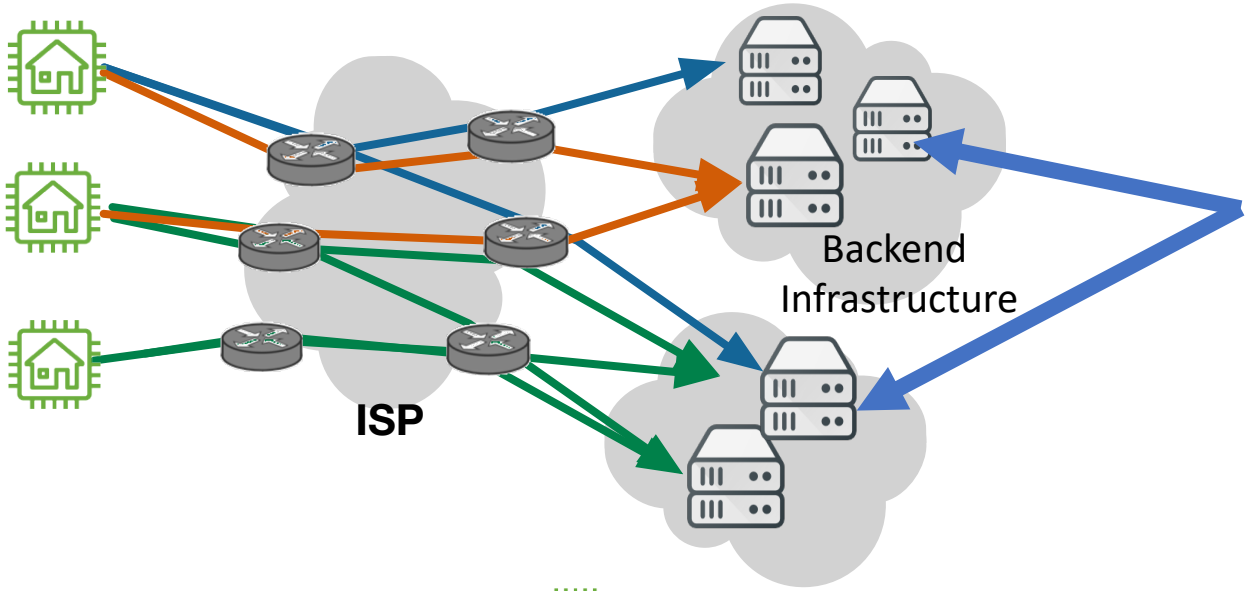
How fast can we detect IoT-devices?

How are IoT devices deployed today, as observed in flow data?

Key Insights

- Devices have repeating patterns of communication that appear even in sparsely sampled data
- Detection rules can be generated using limited packet fields
- Detected devices from 77% of studied IoT manufacturers in an ISP within minutes to hours

IoT Communication Pattern



Focus on the destinations contacted by IoT devices

IoT Device A Flow

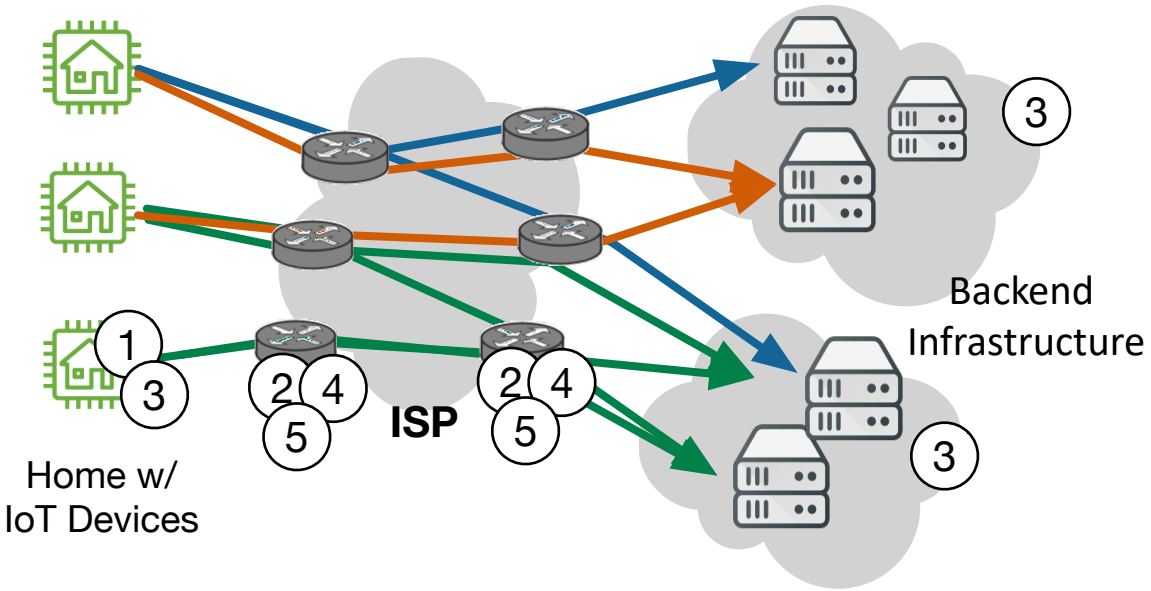
IoT Device B Flow

IoT Device C Flow

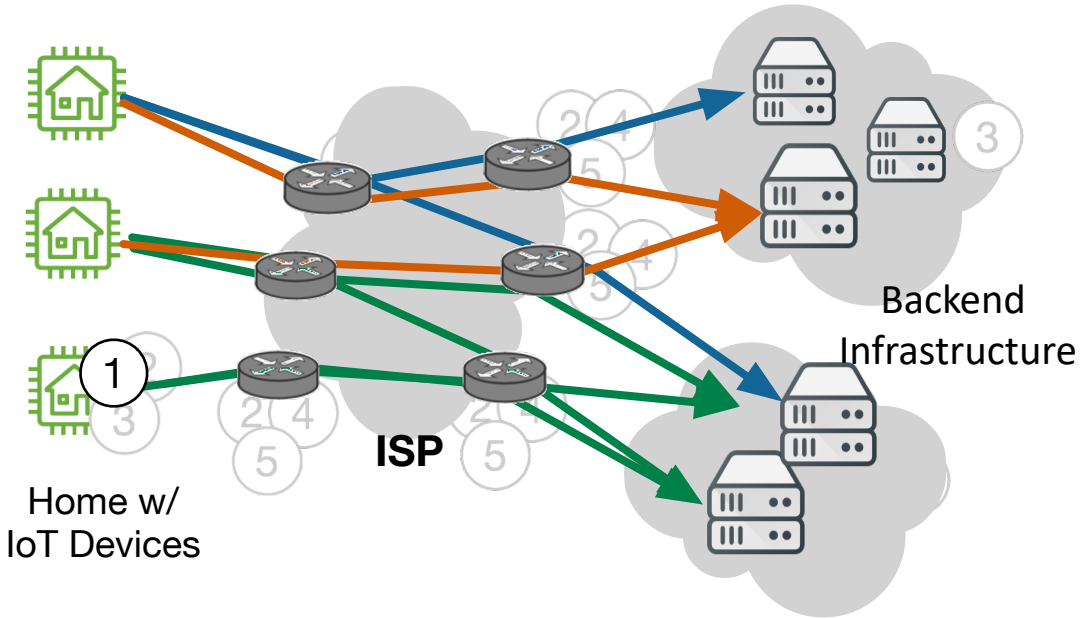
Subscriber w/ IoT

Server

Overview of Methodology



1. Generate IoT Traffic
2. Check Visibility of IoT Traffic at ISP Vantage Point
3. Identify Domains, IPs, and Port numbers and Generate Detection Rules
4. Cross check Detection Rules
5. Detect IoT Devices in the Wild



1 Generate IoT Traffic

2 Check Visibility of GT at ISP Vantage Point

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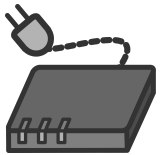
IoT Traffic: Setting up Test Beds

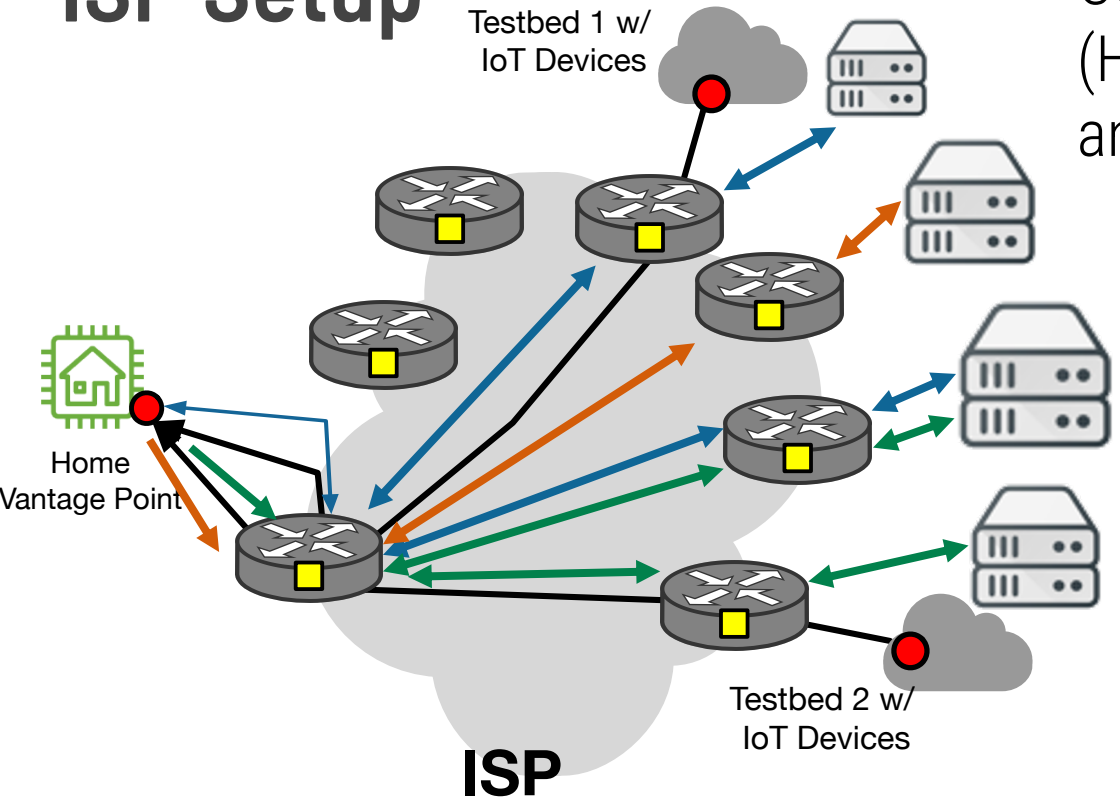
56 IoT Products from 40 Vendors in 2 Testbeds

13 Cameras	8 Smart Hubs	14 Home Automation	5 TVs	10 Appliances	6 Speakers



ISP Setup



Connected IoT labs to our Home (Home VP)* inside ISP network and captured at ISP routers

IoT Traffic through VPN

Device A IoT Service Flow

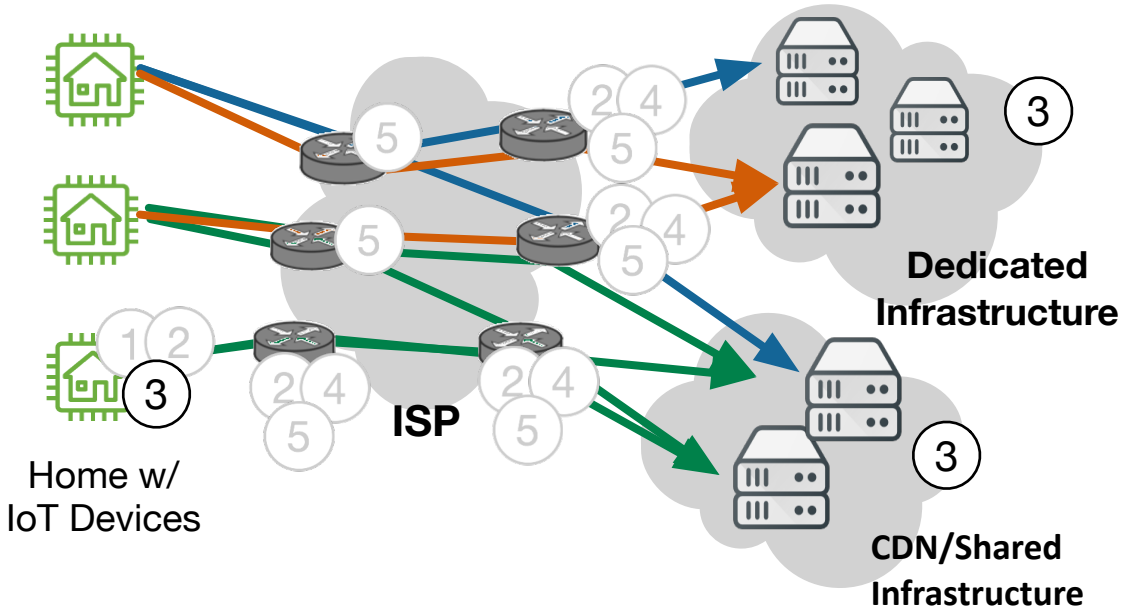
Device B IoT Service Flow

Device C IoT Service Flow

Packet Capture Point

Flow Capture Point

*consenting customer



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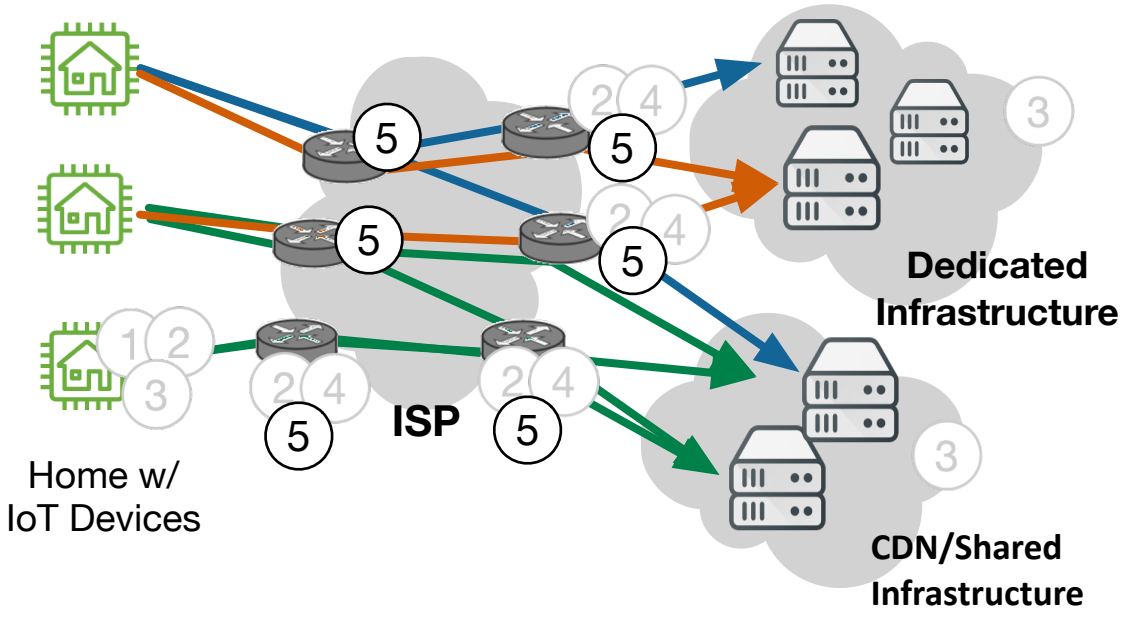
Detection Rules

Product-level: Amazon Echo -> **11 Products**

Manufacturer-level: a Samsung Device -> **20 Manufacturers**

Platform-level: a generic IoT device -> **4 IoT Platforms**
(we can't infer the product type or manufacturer)

77% of the manufacturers in the testbeds



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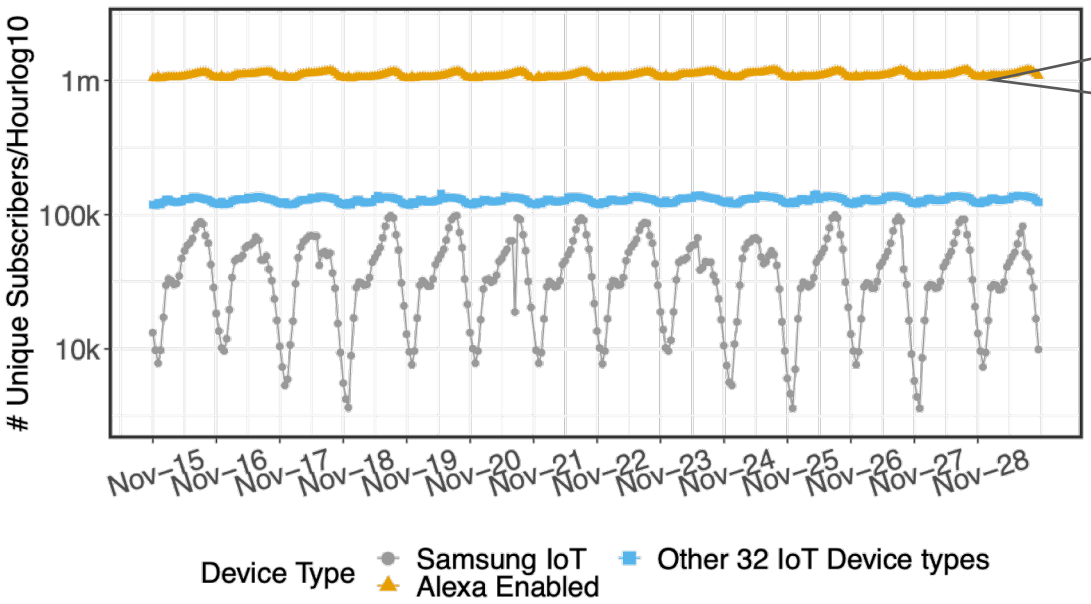
of ISP Subscribers with IoT Devices (Per Hour)

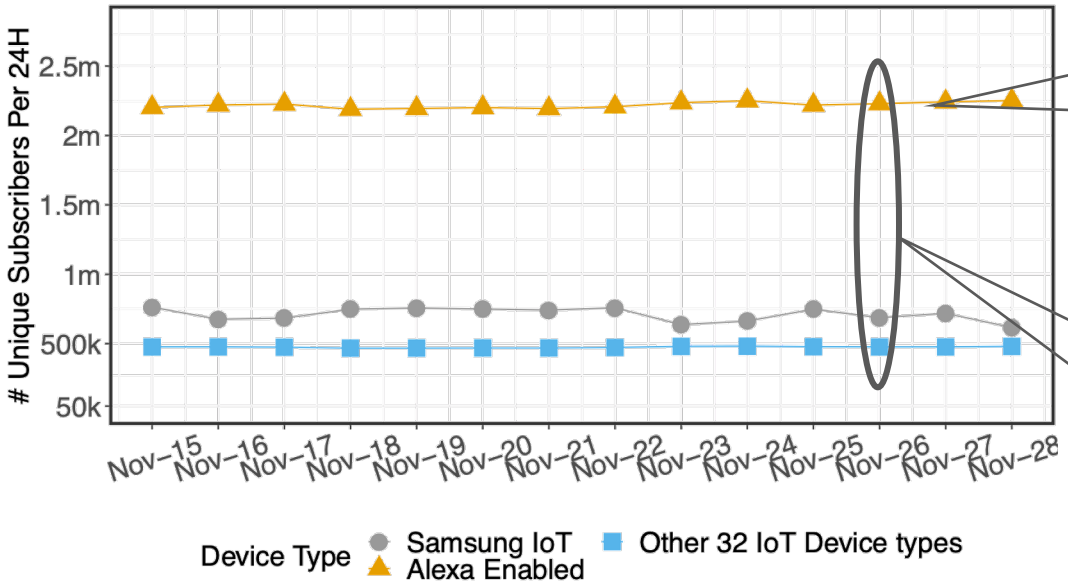


1m+ subscribers with Alexa-enabled devices

- Some diurnal patterns for Alexa and Samsung IoT devices

Alexa-enabled: Any device that responds to Amazon Alexa voice service commands

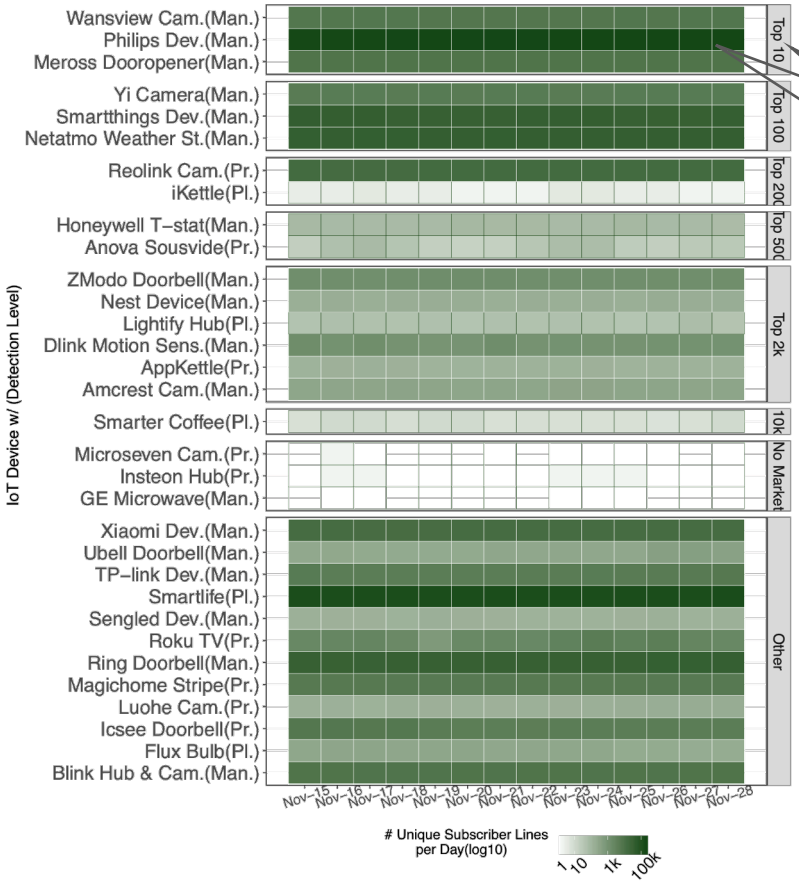
of ISP-subscribers with IoT Devices (per 24 hours)



Increasing observation period, helped detecting more devices

IoT activity for ~20% of ISP subscriber lines

Breakdown of Detected IoT Devices



Device popularity in the Amazon and ISP look correlated.

Limitations

- Generating rules require studying a range of manufacturers' products
- Domain names and IPs might change
- Detection of devices with small activity

Conclusions and Future Work

- A methodology to detect IoT devices based on limited, sampled flow data
- Detected devices from more than 77% of studied IoT manufacturers in a large ISP
- Future Work: Identifying non-essential IoT traffic at scale
- Domains and rules are available at : **https://moniotrlab.ccis.neu.edu/imc20/**