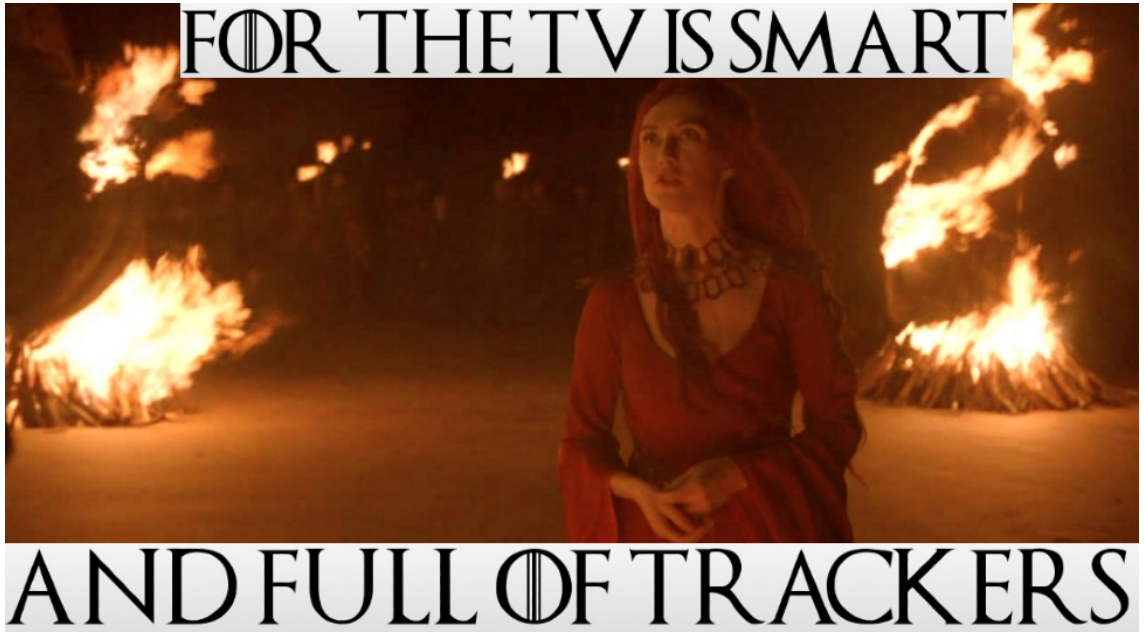

Measuring Smart TV Advertising and Tracking

Janus Varmarken†, Hieu Le†, Anastasia Shuba, Athina Markopoulou, Zubair Shafiq

† The two first authors made equal contributions and share the first authorship

UCI University of California, Irvine

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IOWA

Background

- Smart TV: an Internet-connected TV
- Two flavors of smart TVs
  - Built-in smart TVs
  - External box/stick
- Multiple vendors/platforms
- Paid vs. free apps
- Advertising and tracking services (ATS)

SAMSUNG TIZEN

amazon fire OS

tvOS

ROKU

Motivation

- At least one smart TV in 80% of US households
- Platform with large audience for (targeted) ads

- Contact more third parties than other IoT devices [Ren et al., IMC’19]

Related Work

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Platform	Prior Work	Fine-grained Blocking
Desktop Browser	✓ [Mayer & Mitchell, S&P'12] [Gill et al., IMC'13] [Englehardt & Narayanan, CCS'16]	✓ (e.g., uBlock Origin)
Mobile	✓ [Razaghpanah et al., NDSS'18] [Ren et al., MobiSys'16] [Shuba et al., PETs'18]	✓ (e.g., NoMoAds)
Smart TV	✗ [Huang et al., arXiv'19] [Moghaddam et al., CCS'19]	✗ (DNS-based blocklists)

Research Questions

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1. What does the smart TV ATS ecosystem look like?

Network Measurement Approach

- Smart TVs in the wild
- Smart TVs in a testbed

2. How effective are existing privacy-enhancing tools?

Analyze DNS-Based Blocklists

- Pi-hole Default (PD)
- The Firebog (TF)
- Mother of all Ad-Blocking (MoaAB)
- StopAd (SATV)

Smart TVs in the Wild

- Traffic from smart TVs in 41 US homes
  - Minim Inc.

Smart TVs in the Wild

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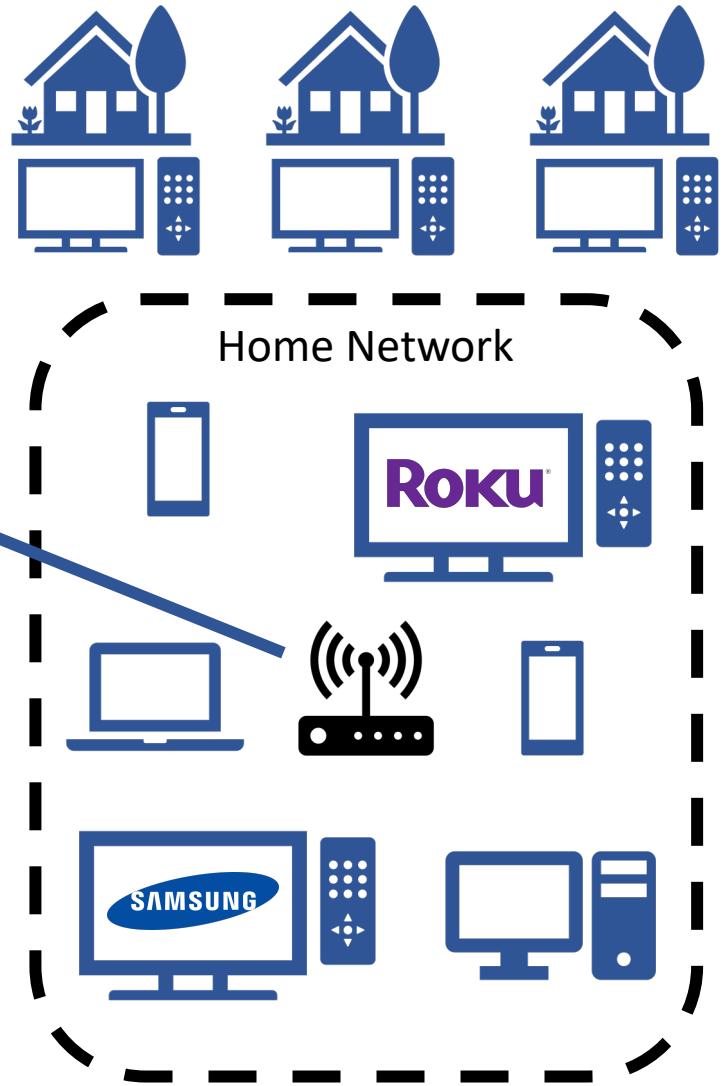
Flow-level summary traffic logs collected at home gateway



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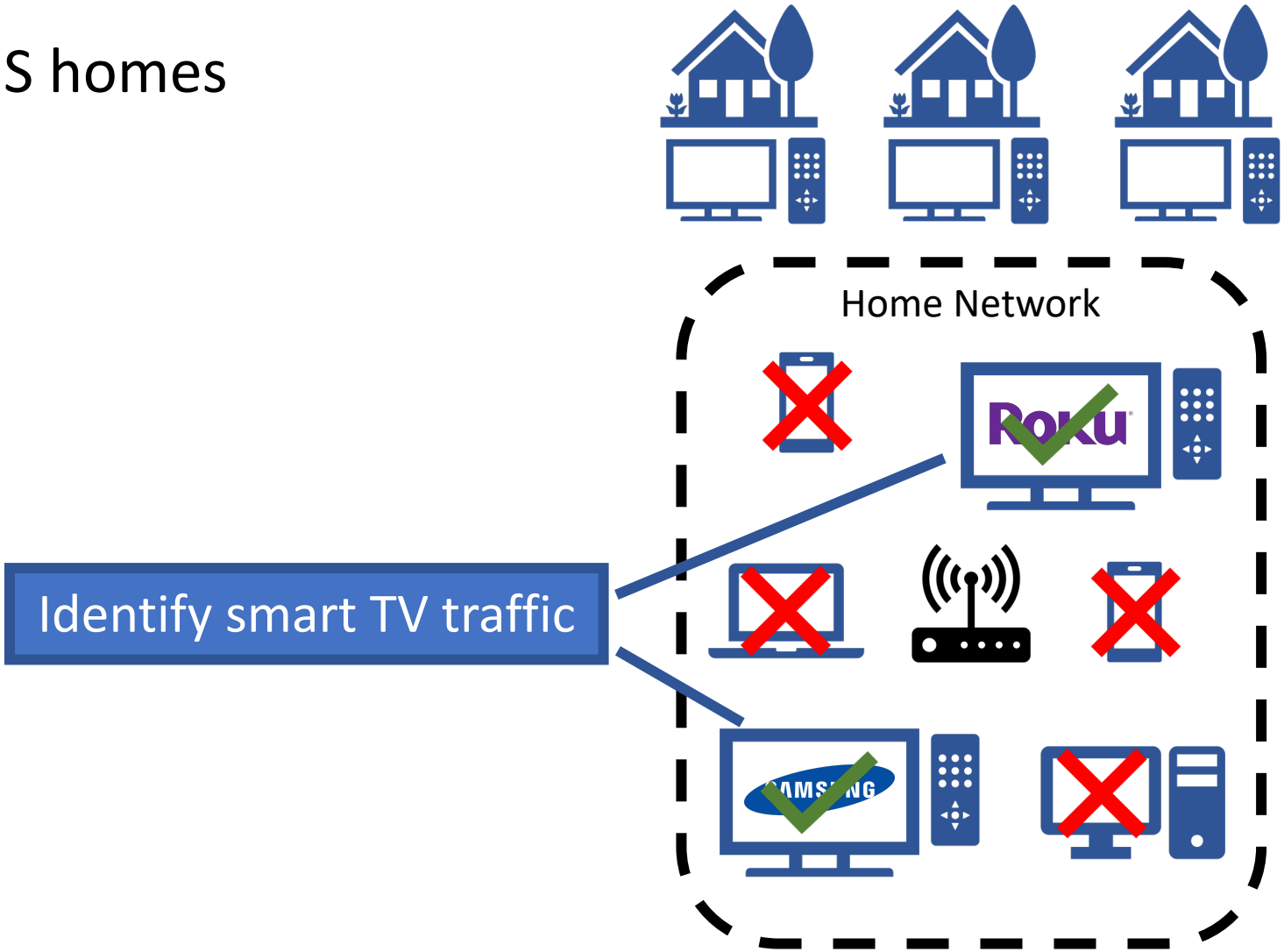
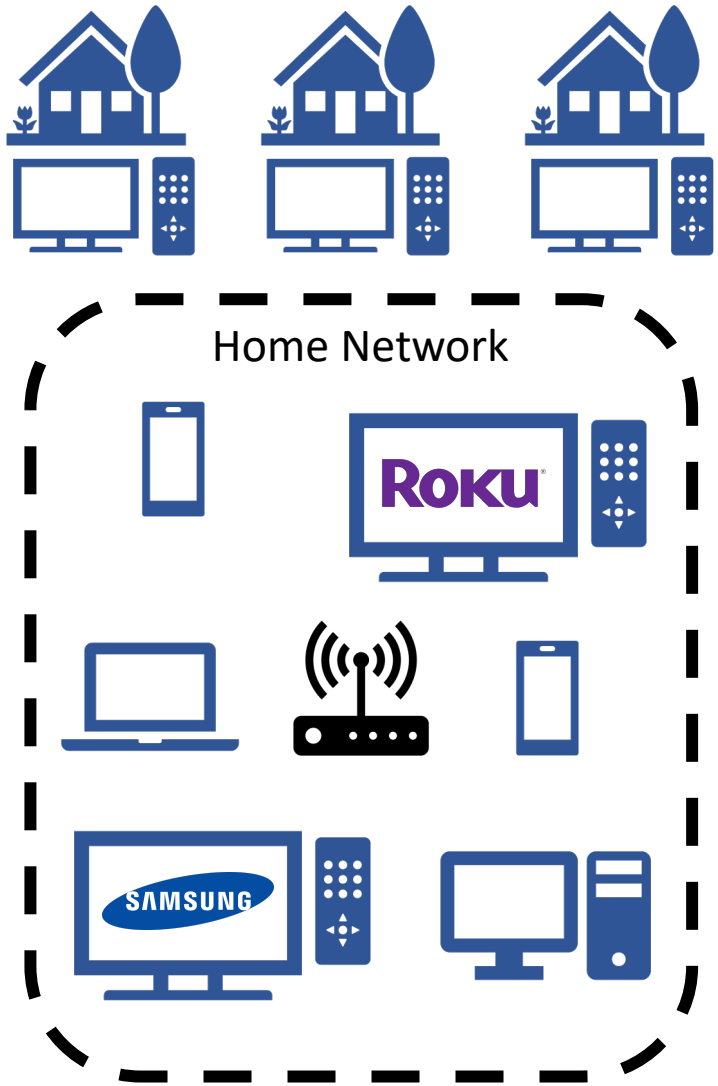


Smart TVs in the Wild

- Traffic from smart TVs in 41 US homes
  - Minim Inc.
- 57 smart TVs, 3 weeks



Smart TVs in the Wild

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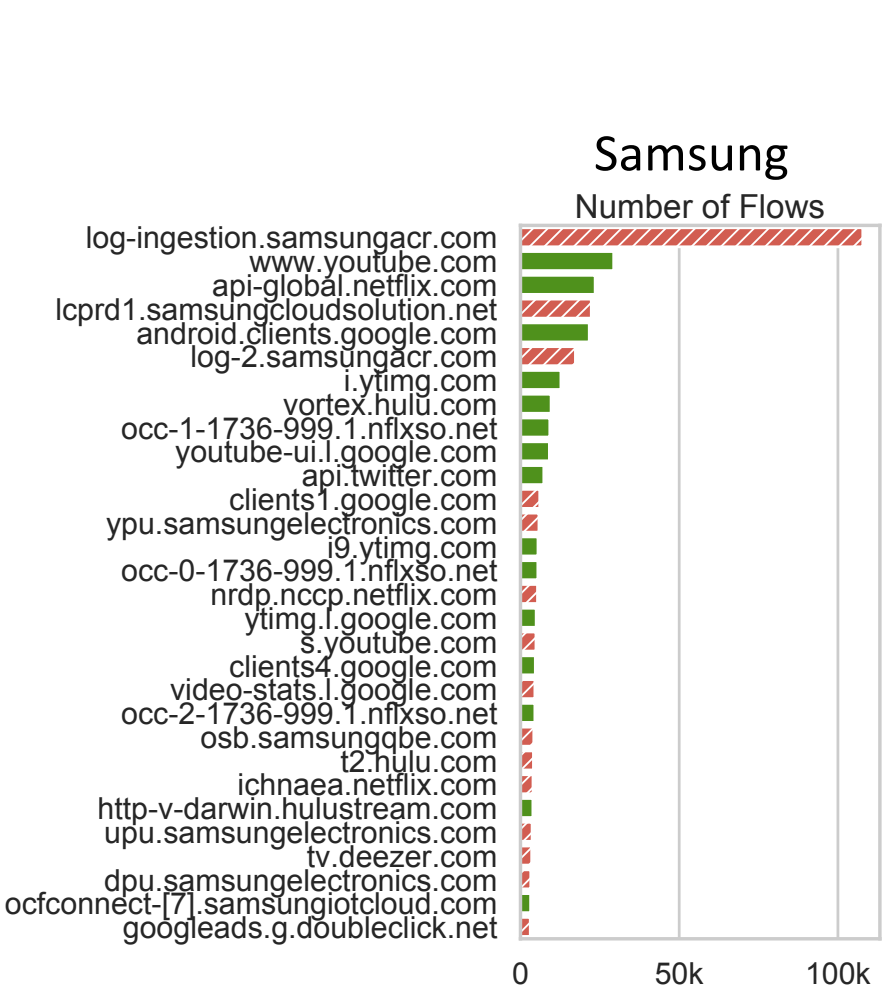
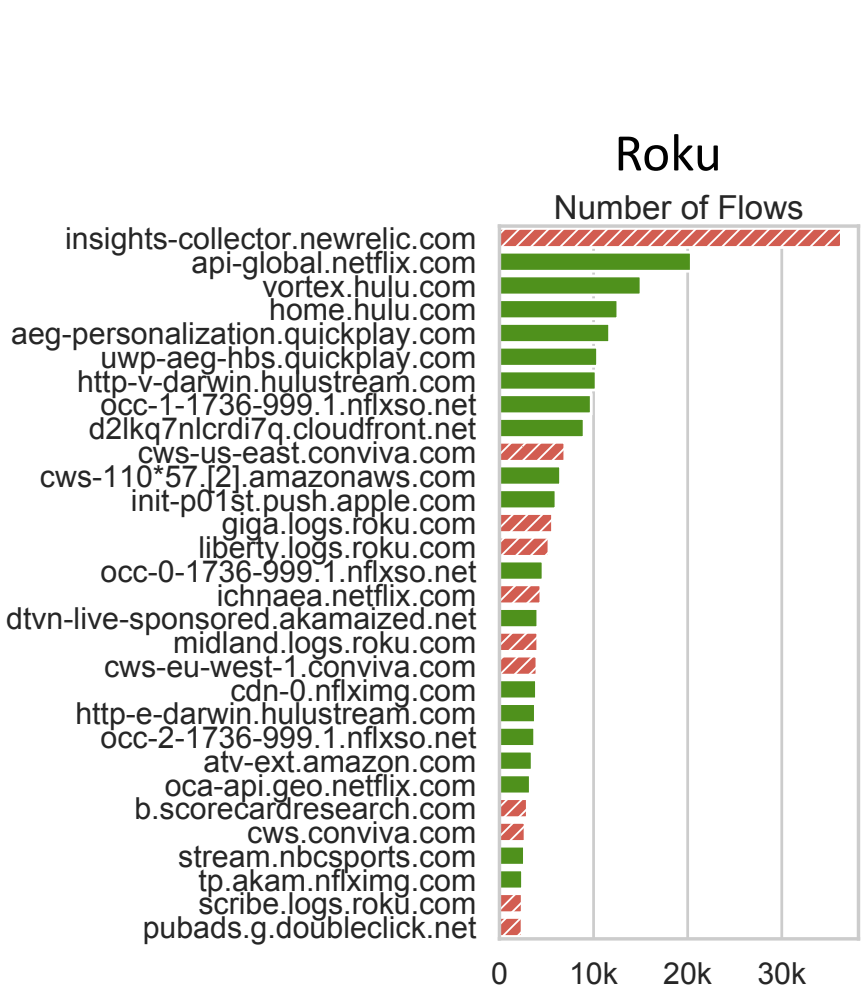
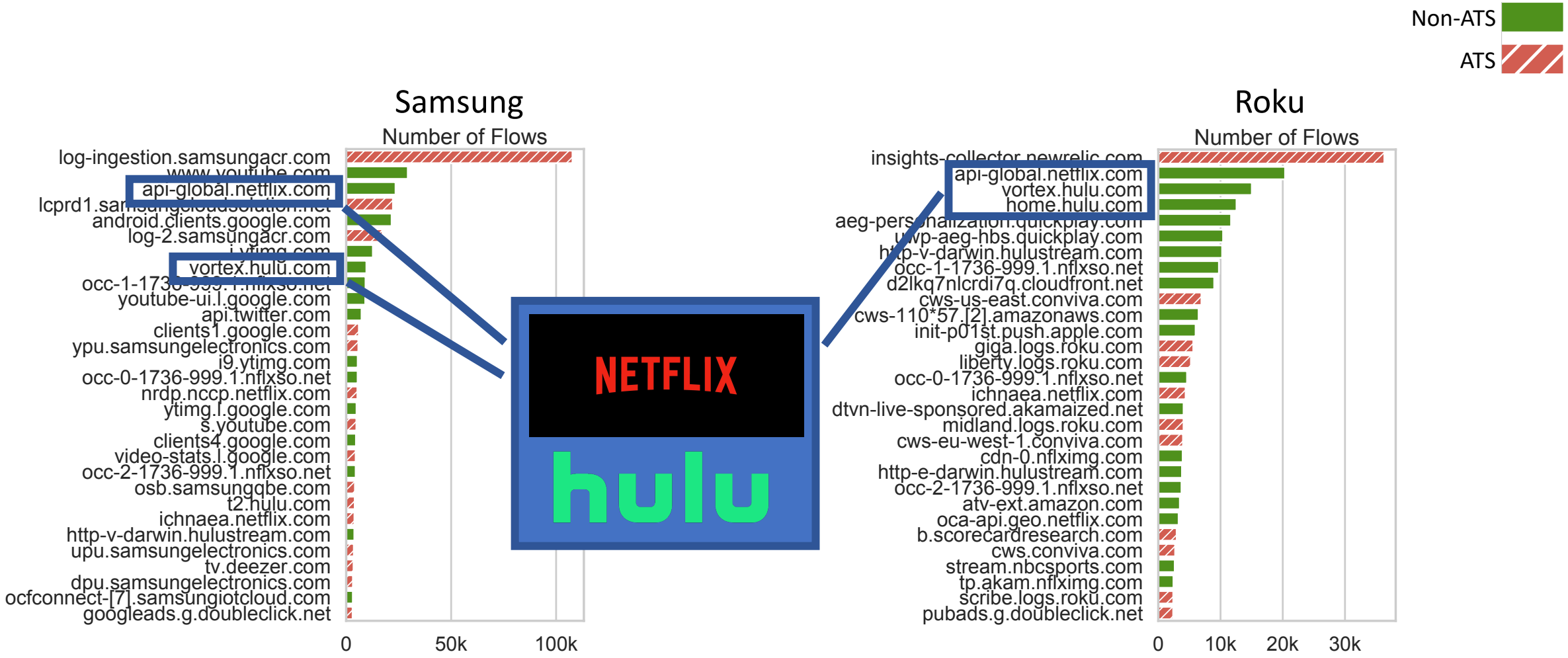




Smart TVs in the Wild



Smart TVs in the Wild

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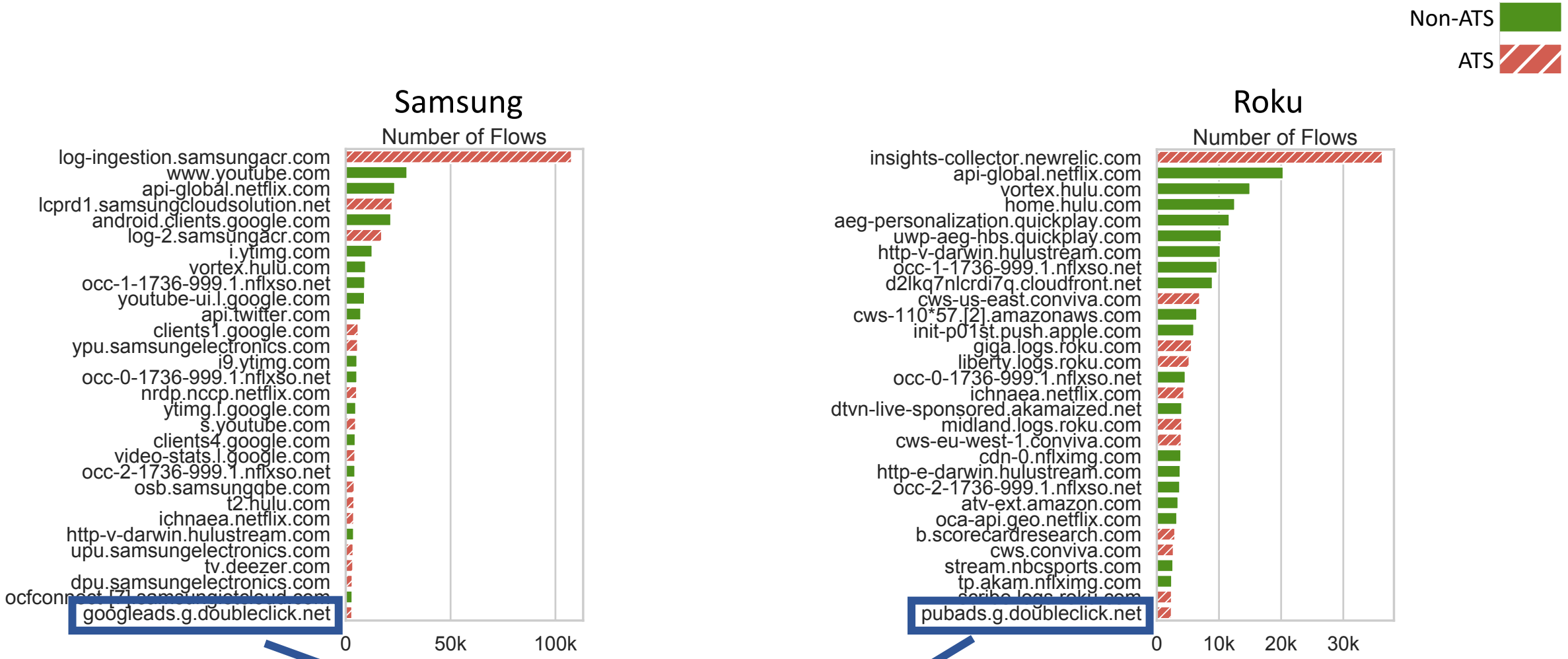
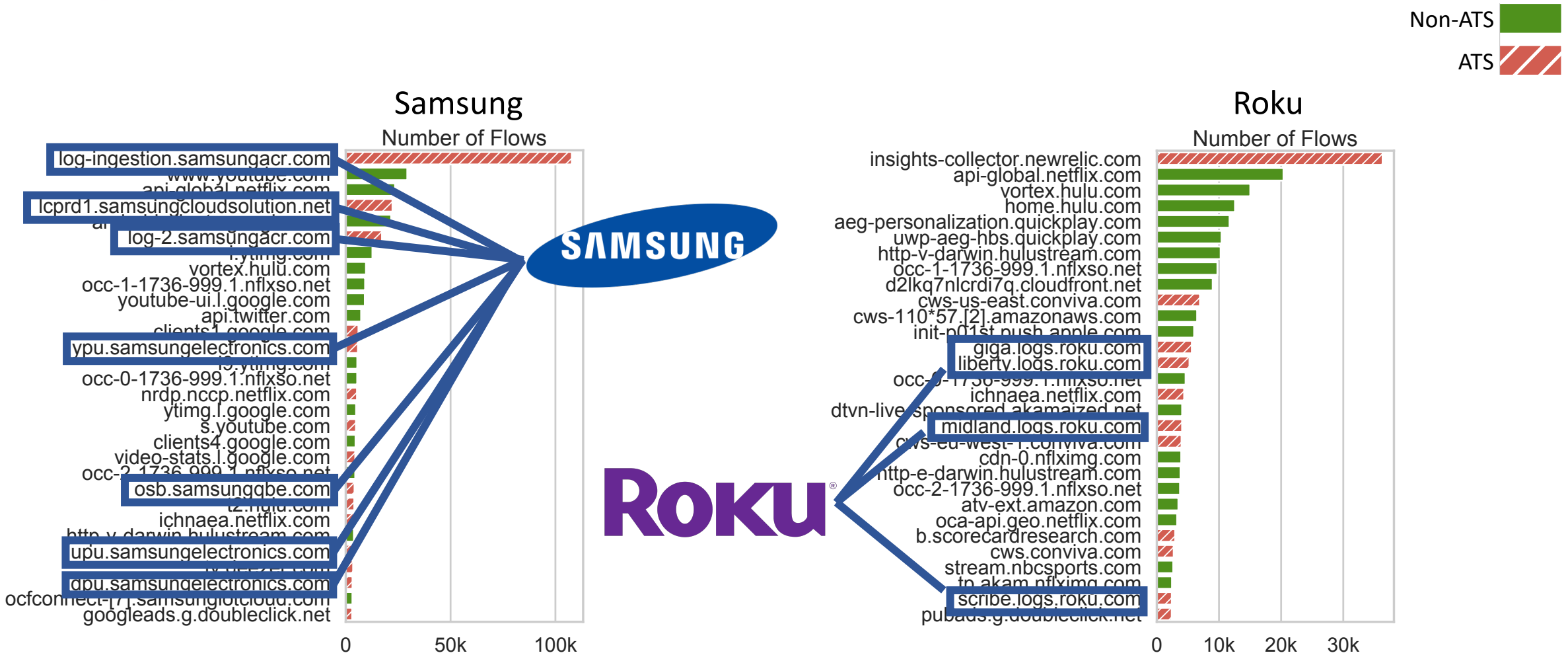


Smart TVs in the Wild

UCI Samueli School of Engineering



Smart TV Instrumentation

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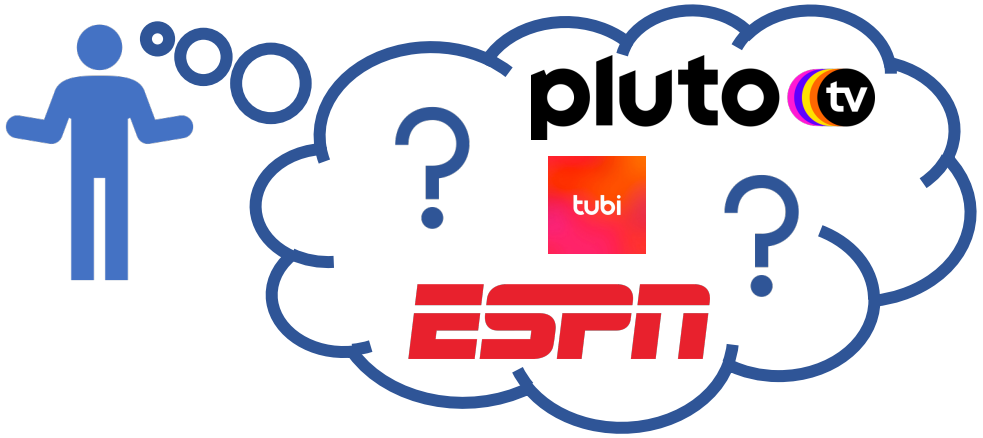
Smart TVs in the wild



Smart TVs in a testbed

Roku

fire tv

US Top-2

Ad requests

- Instrumentation tools' designs
- App selection methodology
- Analysis of collected traffic

Instrumentation: Rokustic

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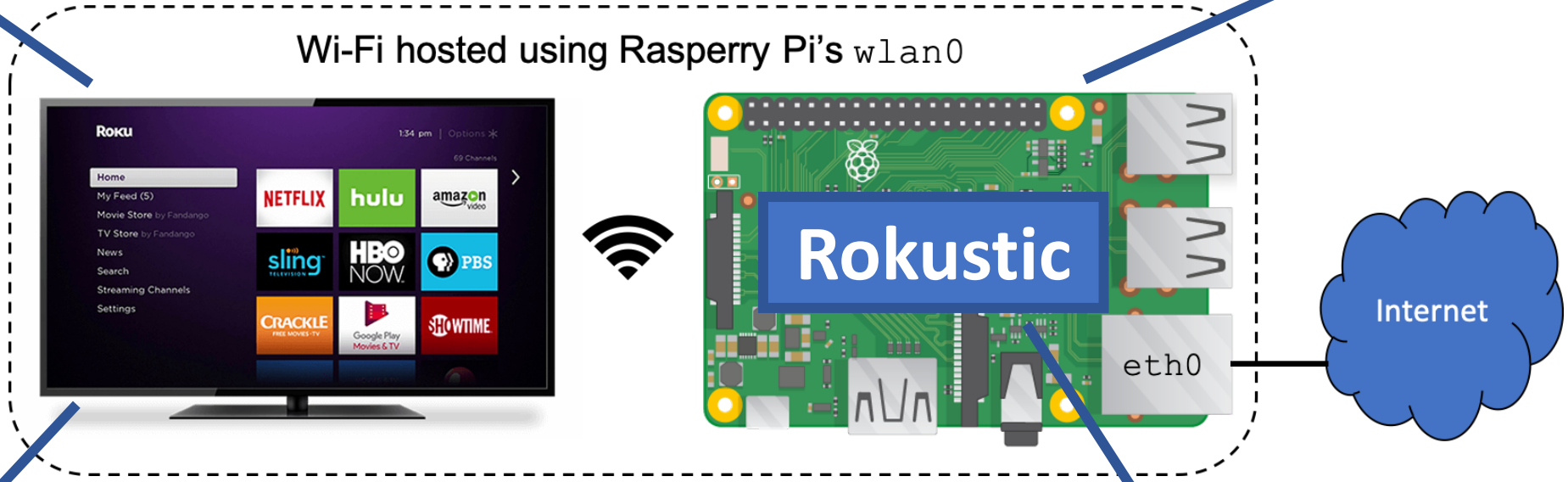
Roku connects to RPi AP

- Hosts local Wi-Fi network
- Acts as gateway



- No background app activity
- Traffic pertains to app under test (or system)

- tcpdump to capture Roku's traffic
- Send virtual keypresses

Instrumentation: Rokustic

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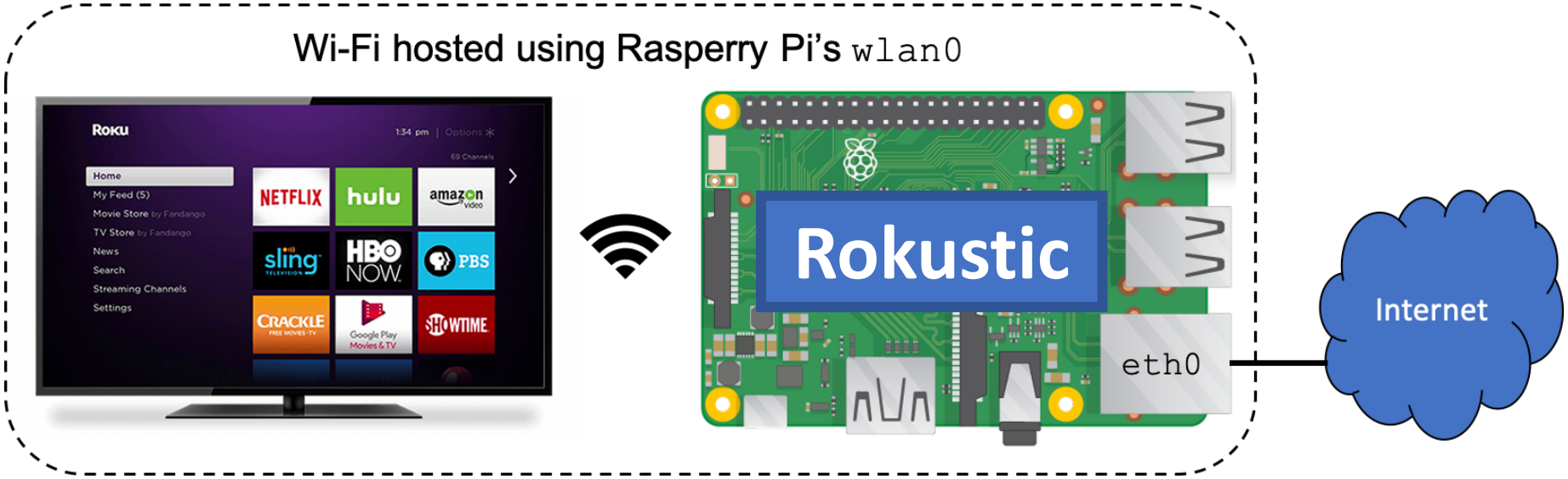
Enables installation & testing of apps in large batches



Instrumentation: Firetastic

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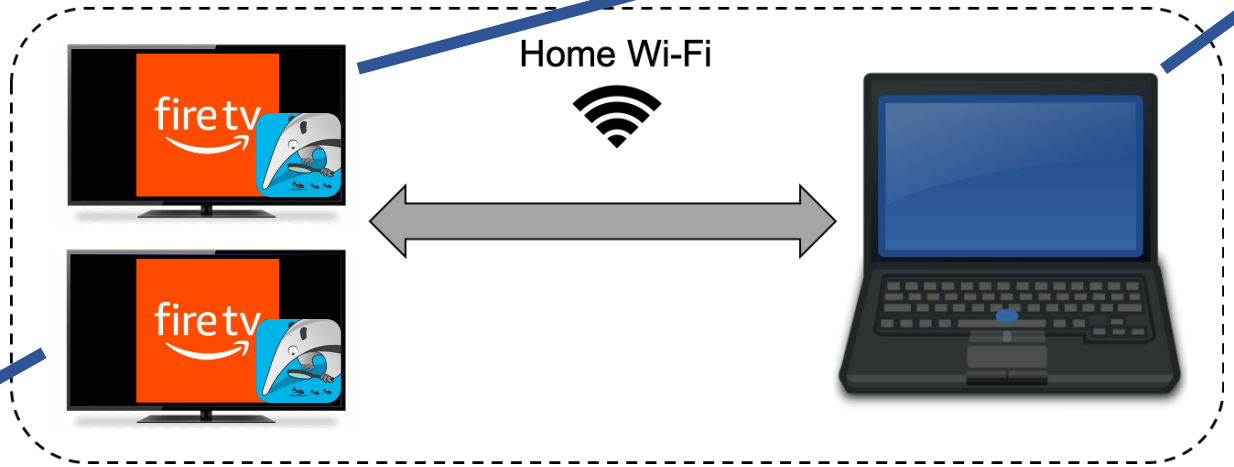
DroidBot automates interaction with UI



- VPN-based traffic interception tool, AntMonitor, runs locally on Fire TV
- AntMonitor labels packets with responsible process

Instrumentation: Firetastic

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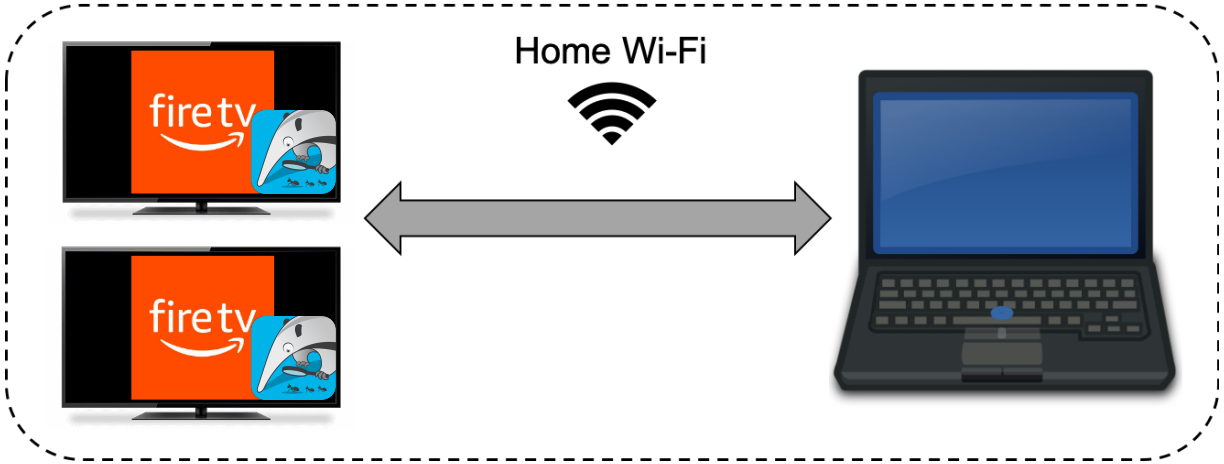
Enables installation & testing of apps in large batches



App Selection

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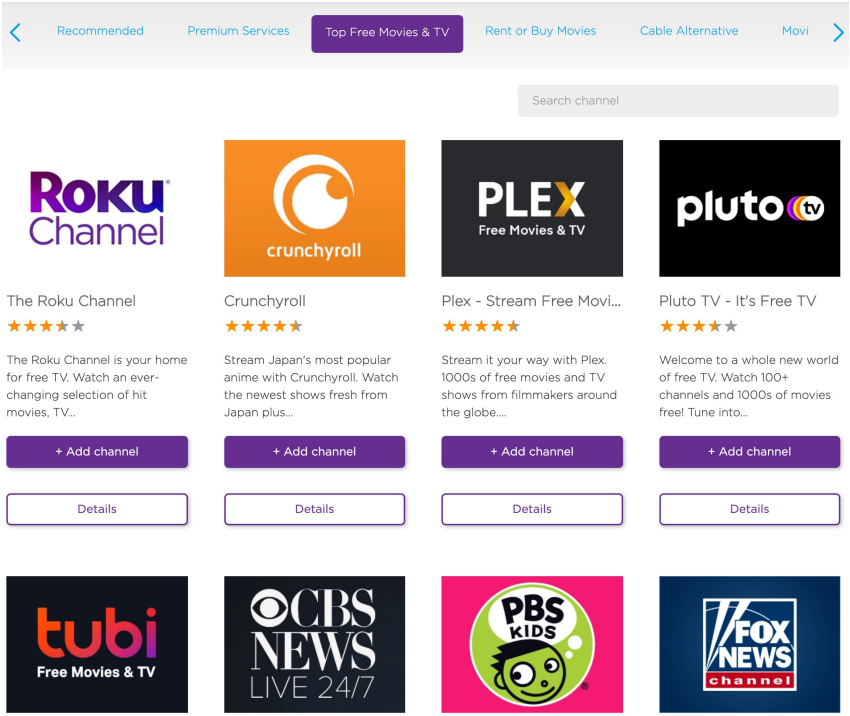
Roku

Top-50 apps of each category

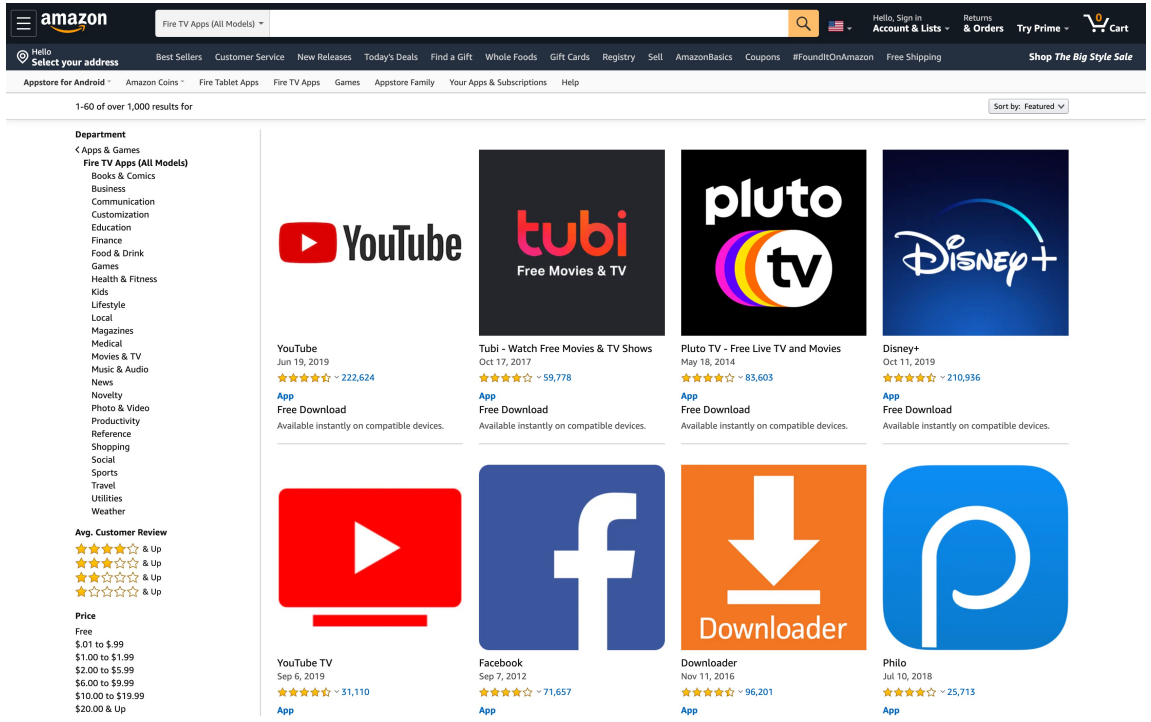
Total of 1,044 apps (12% of all apps)



fire tv

Amazon's "Top Featured" apps

Total of 1,010 apps (25% of all apps)



Testbed Dataset: Overview

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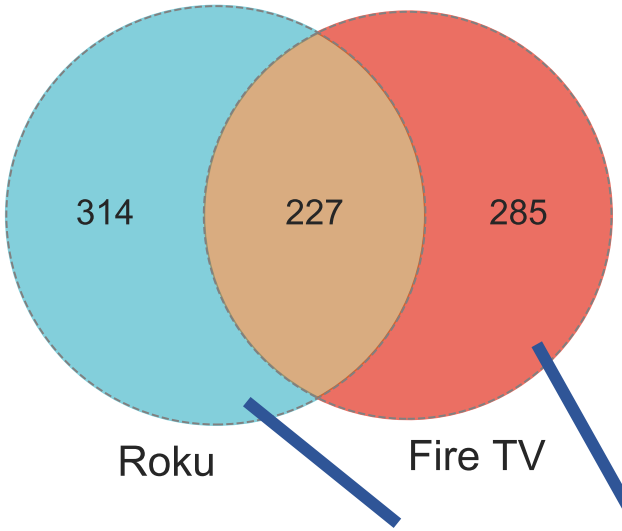
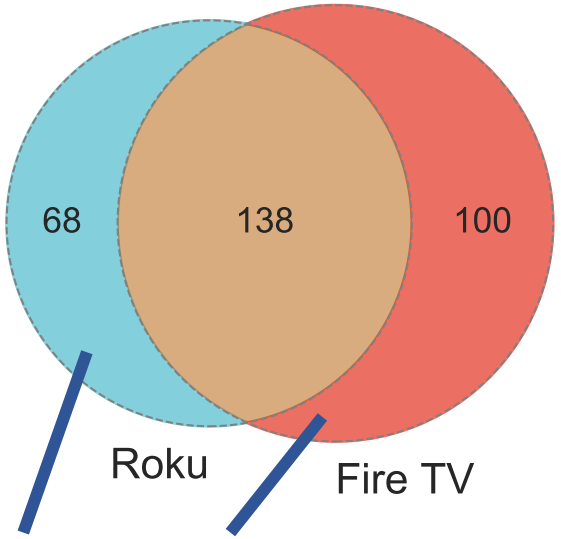
- 15 minutes/app
- Labeled FQDNs as ATS/non-ATS

Fully Qualified Domain Names (FQDNs)	
Roku	Fire TV
2191	1734

FQDNs

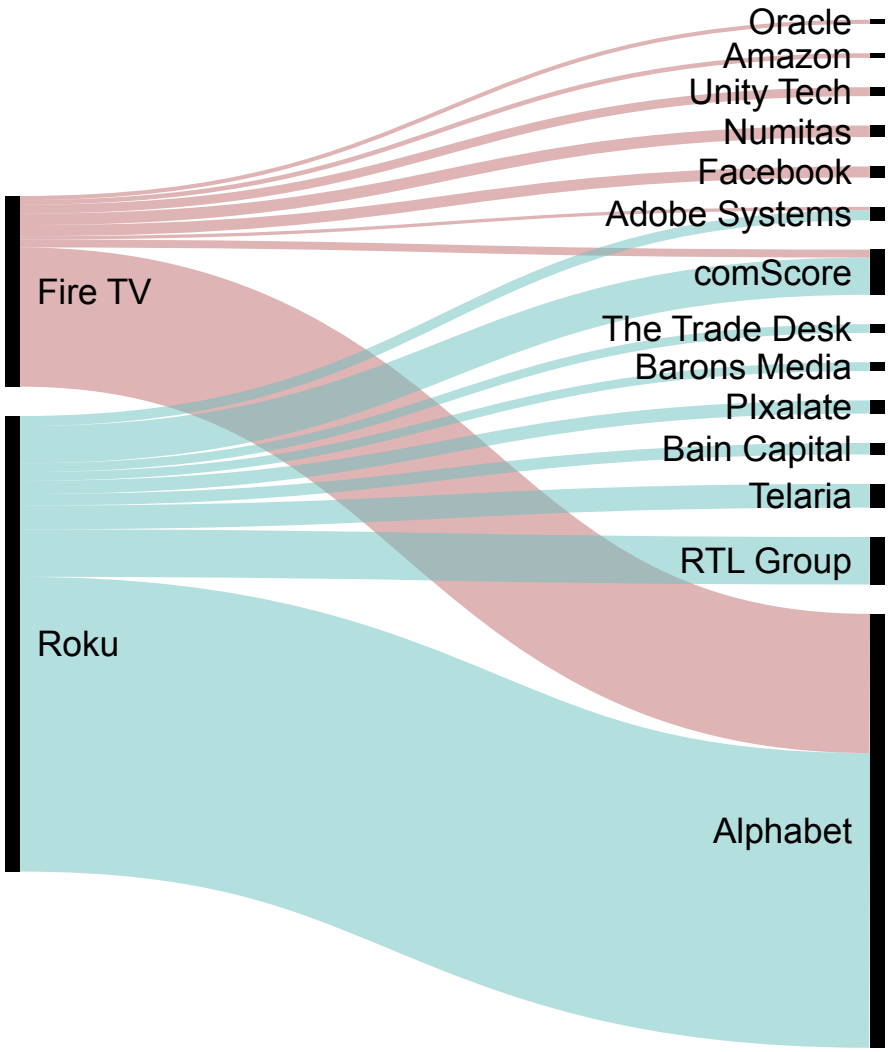


Effective Second-level Domains (eSLDs)



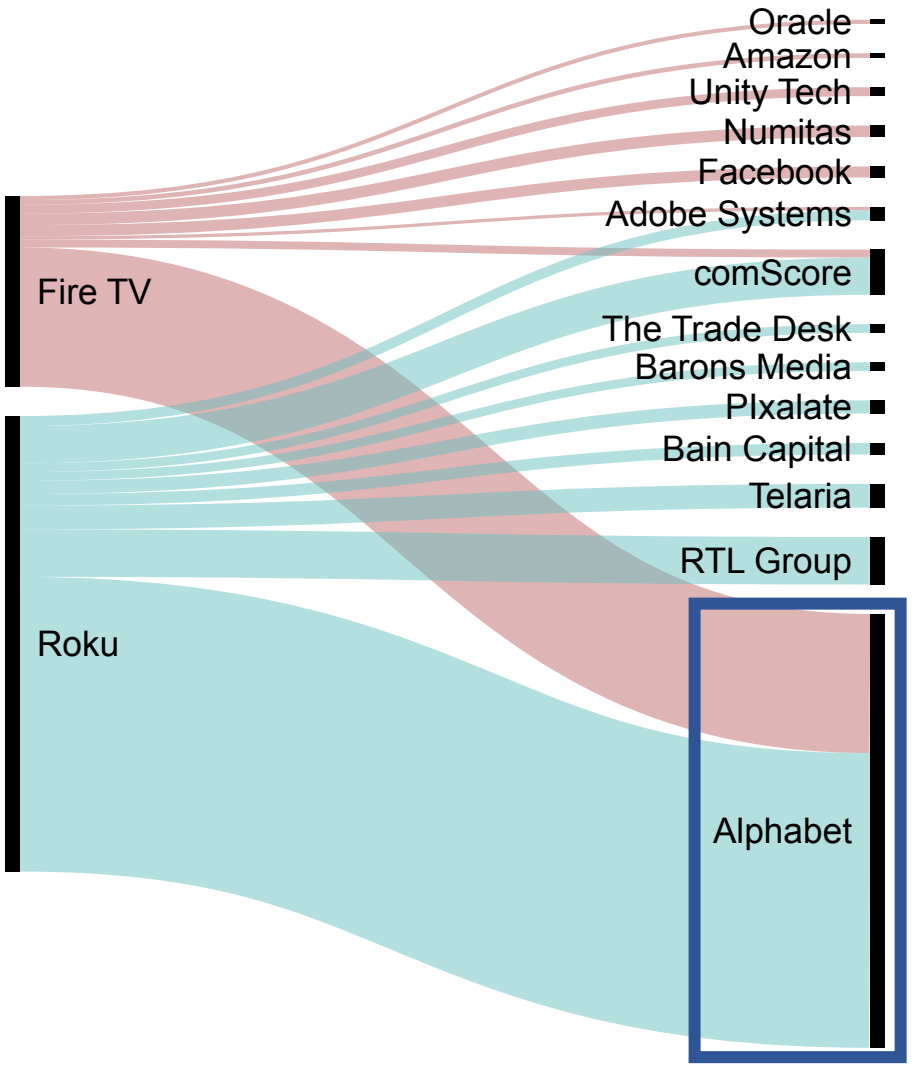
Many domains only present on one platform

Testbed Dataset: 3rd-Party ATS



Edge-width: Number of apps that contact the organization

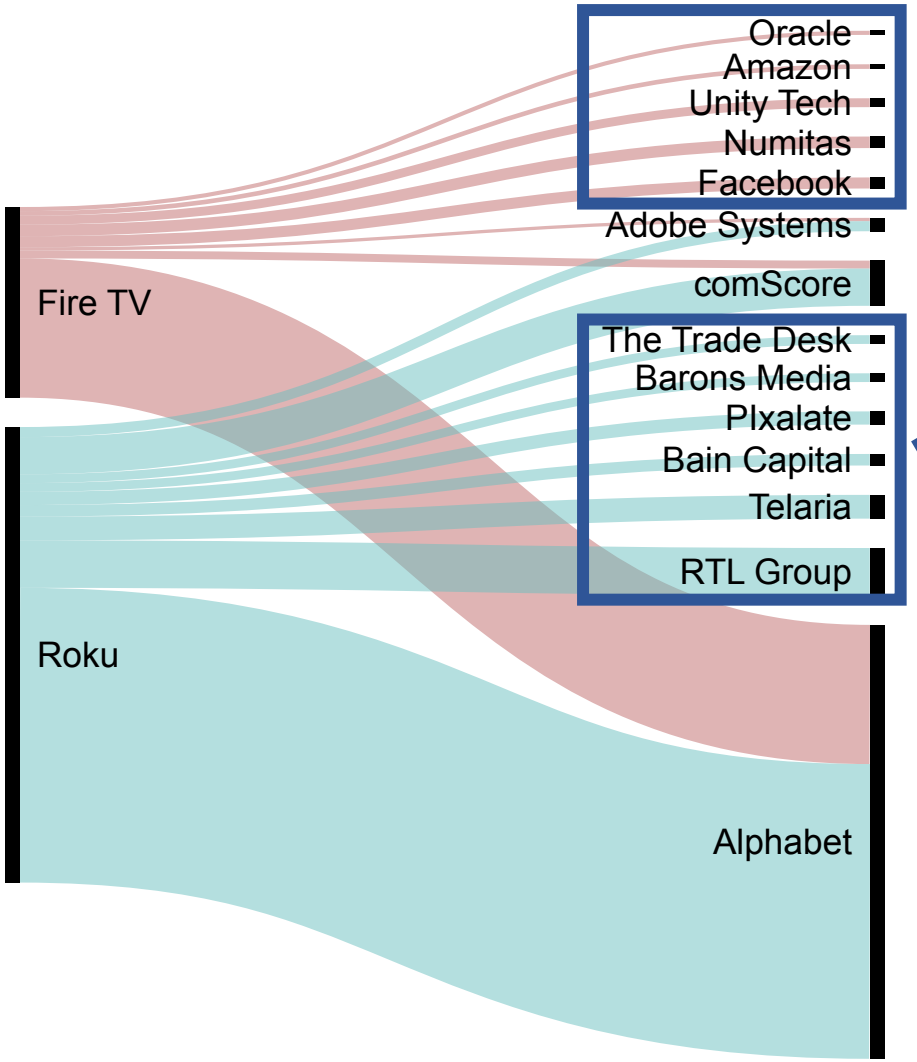
Testbed Dataset: 3rd-Party ATS



Strong Alphabet presence on both platforms

Edge-width: Number of apps that contact the organization

Testbed Dataset: 3rd-Party ATS



Prominent third parties differ

Edge-width: Number of apps that contact the organization

Testbed Dataset: Common Apps

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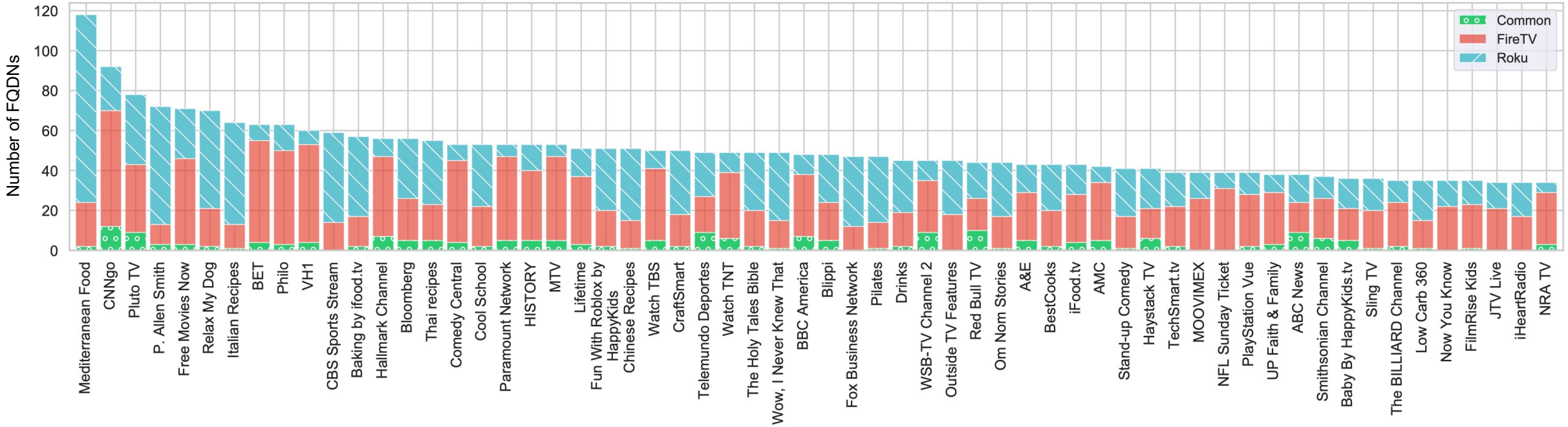
- Common apps: apps present in both Roku and Fire TV dataset
- Slight variations in app names → identified by fuzzy matching on app name
  - E.g., “TechSmart.tv” on Roku vs. “TechSmart” on Fire TV
- Analyzed (overlap in) FQDNs contacted by same app on the two platforms



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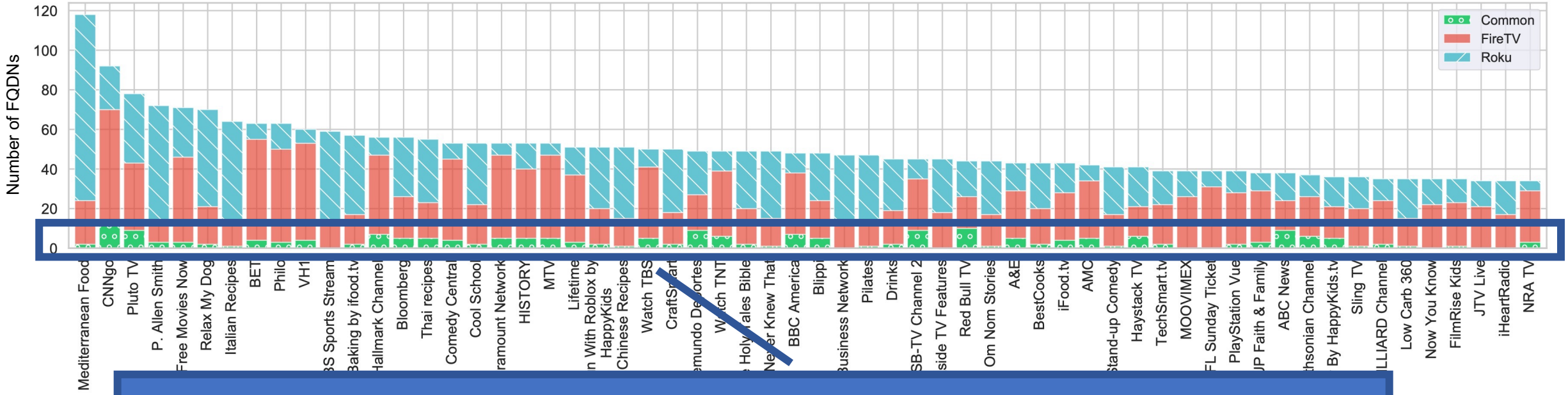
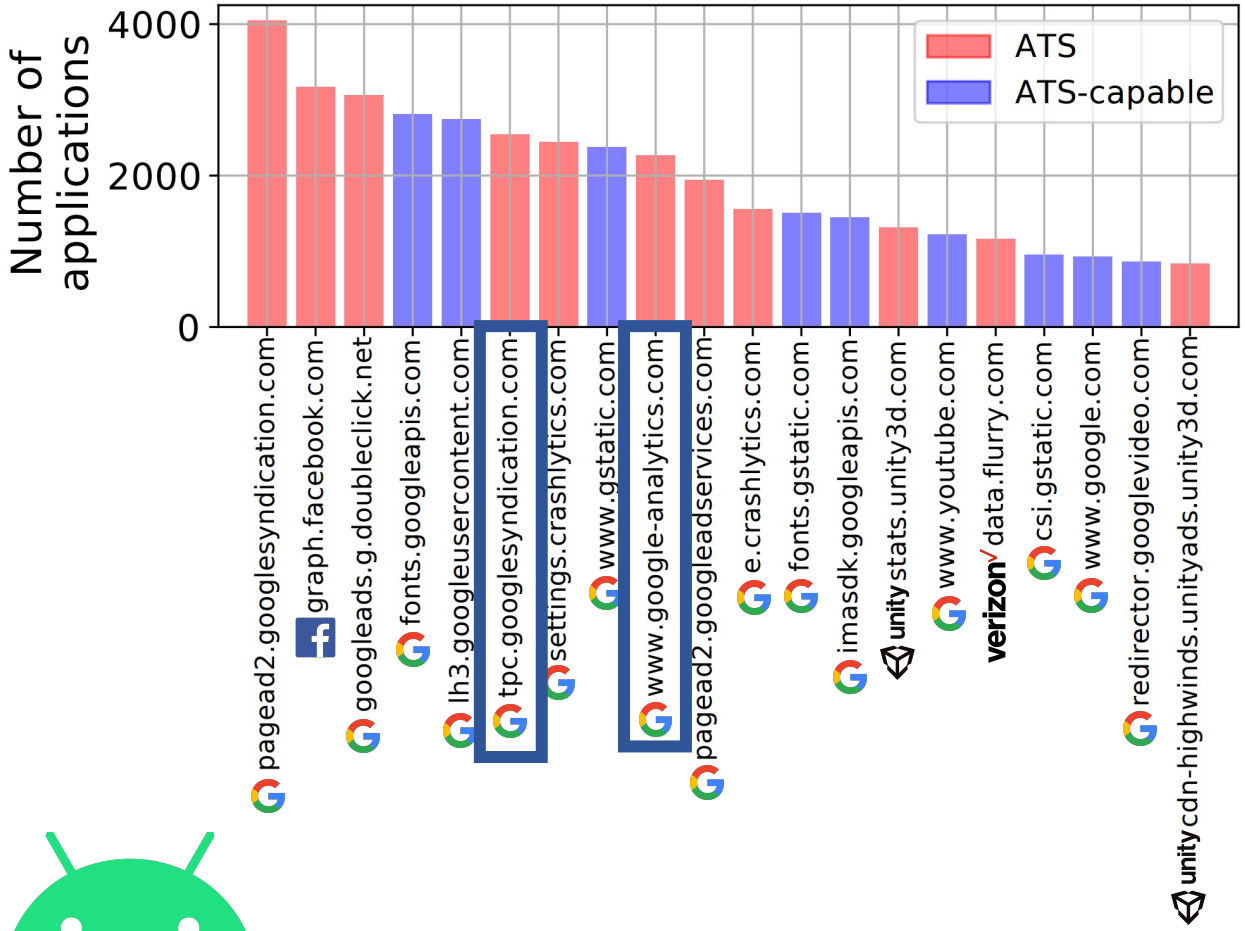
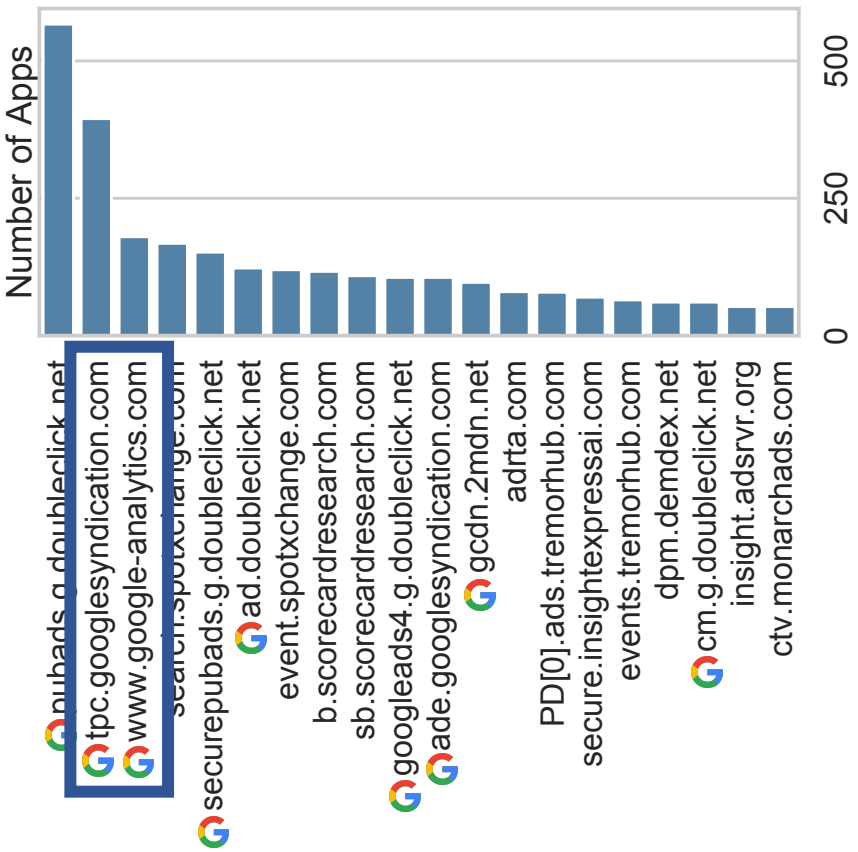


Only minor overlap in domains accessed by same app on the two platforms

Comparison to Android

[Razaghpanah et al., NDSS'18]

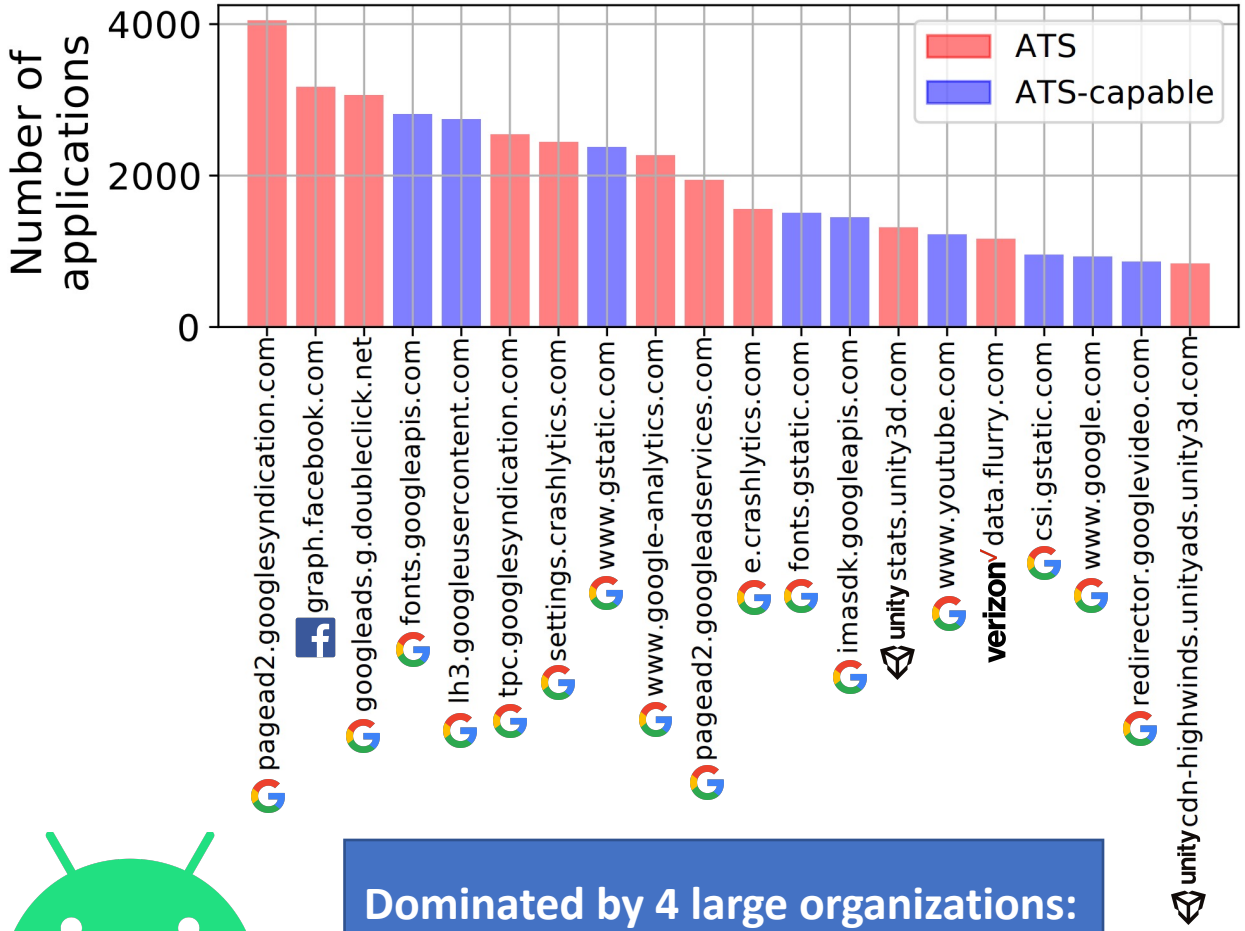


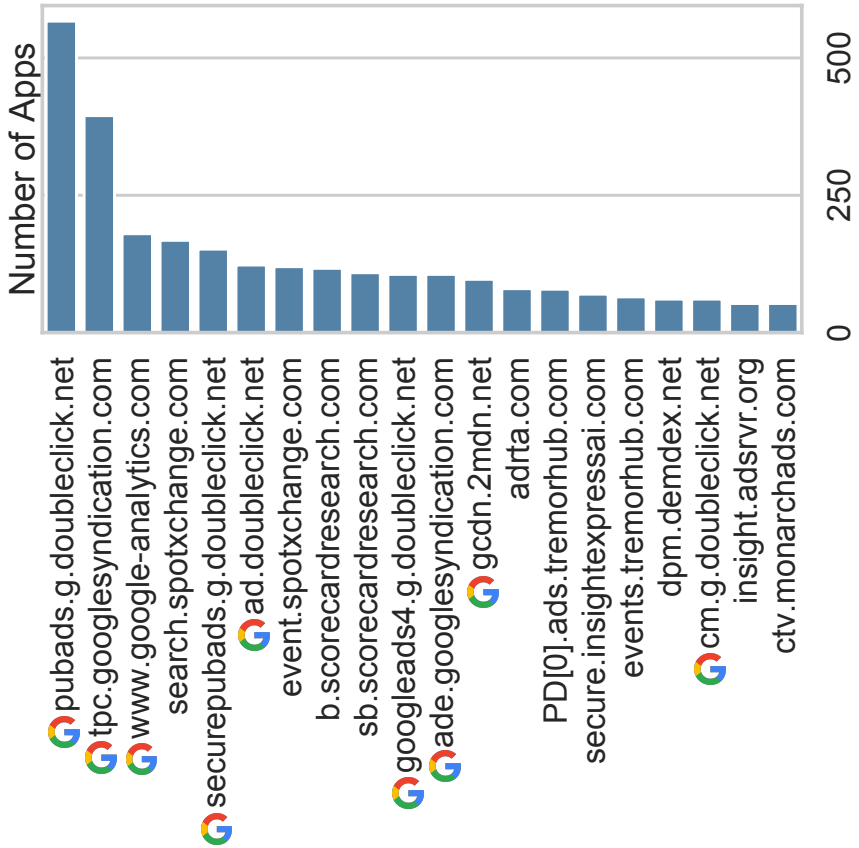


Overlap of only 2 domains

Comparison to Android

[Razaghpanah et al., NDSS'18]



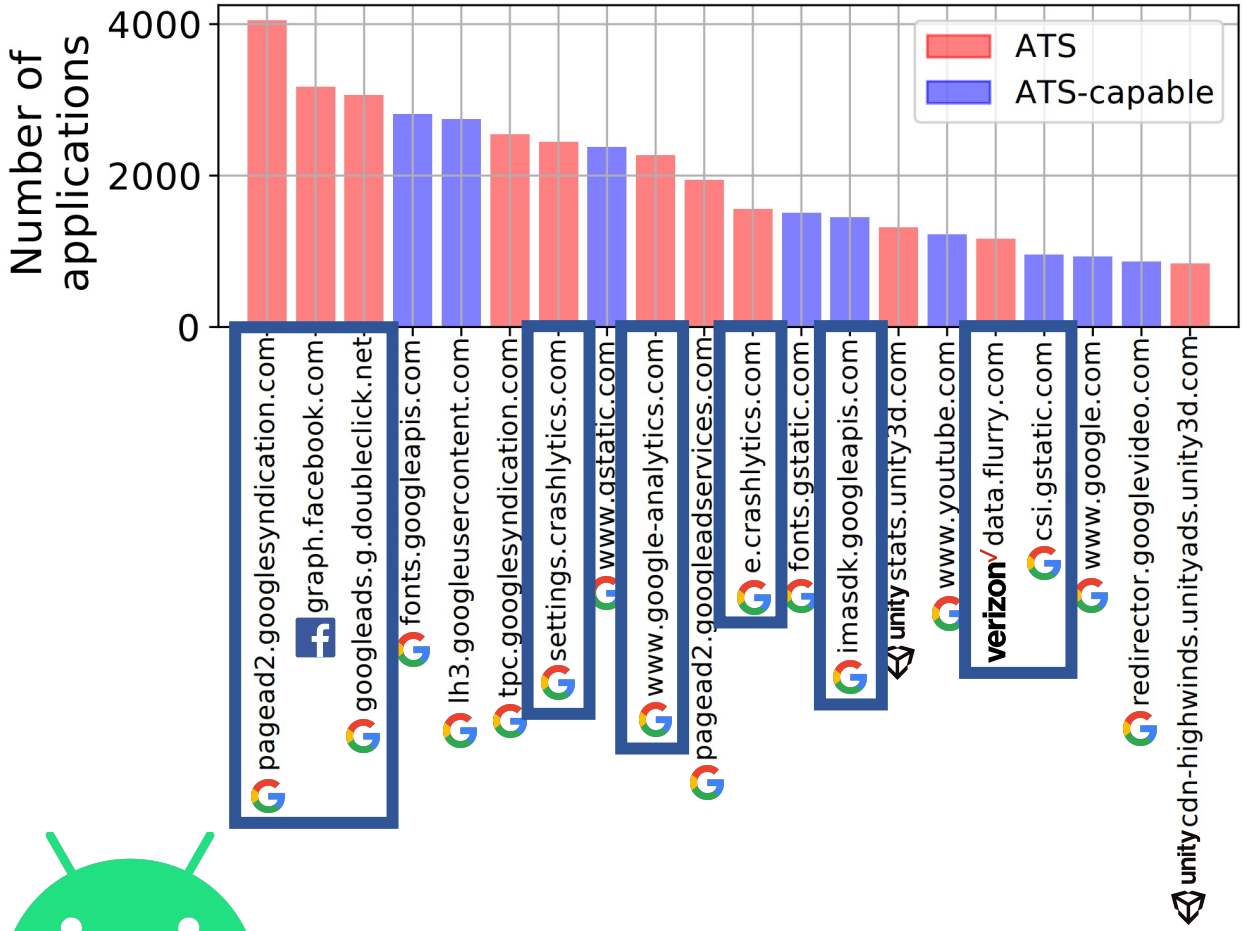


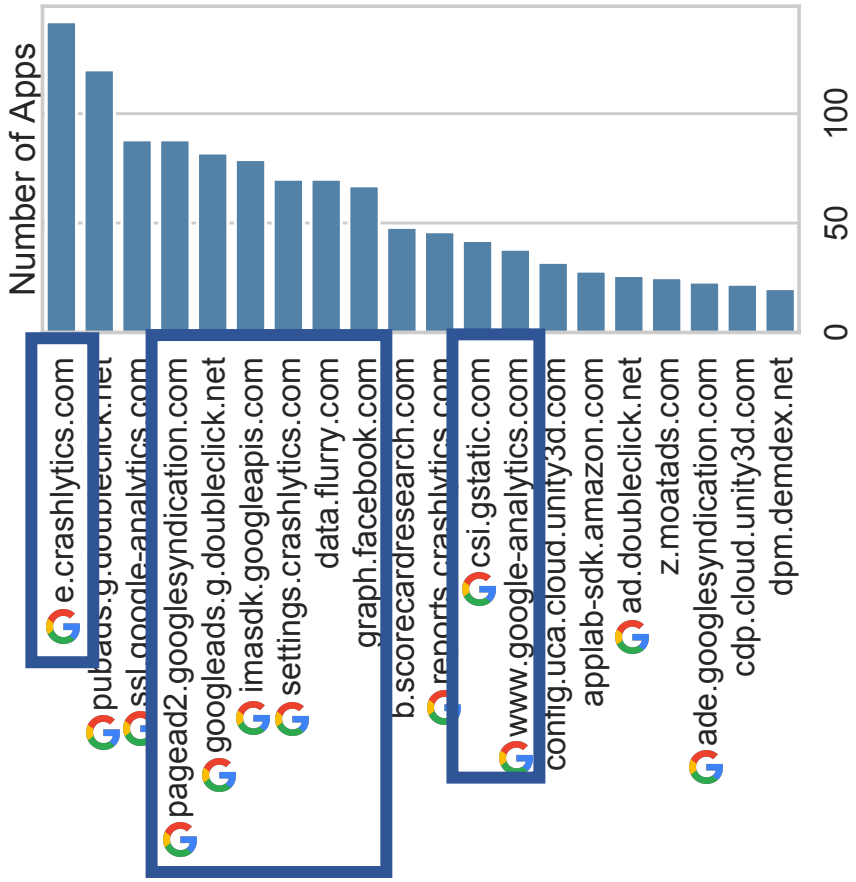
Dominated by 4 large organizations: Alphabet, Facebook, Unity & Verizon

More diverse: Alphabet, SpotX, comScore, Pixalate, Telaria, The Trade Desk, Barons Media, Bain Capital, RTL Group

Comparison to Android

[Razaghpanah et al., NDSS'18]





Domain overlap (9) much larger for Fire TV

Research Questions

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1. What does the smart TV ATS ecosystem look like?

Network Measurement Approach

- Smart TVs in the wild
- Smart TVs in a testbed

2. How effective are existing privacy-enhancing tools?

Analyze DNS-Based Blocklists

- Pi-hole Default (PD)
- The Firebog (TF)
- Mother of all Ad-Blocking (MoaAB)
- StopAd (SATV)

Effectiveness of Blocklists

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How effective are existing privacy-enhancing tools?

Blocklist	Rules	Smart TVs?
Pi-hole Default (PD)	133K	✗
The Firebog (TF)	162K	✓
Mother of all Ad-Blocking (MoaAB)	255K	✗
StopAd (SATV)	3K	✓

Block Rates

Platform	# Domains	Block Rate (%) PD	TF	MoaAB	SATV
Dataset obtained "in the wild"					
Apple	3179	10%	13%	12%	5%
Samsumg	1765	14%	19%	15%	8%
Chromecast	1576	9%	15%	15%	5%
Roku	2312	15%	19%	18%	7%
Vizio	942	16%	18%	16%	11%
LG	627	45%	54%	50%	27%
Sony	119	16%	24%	16%	7%
Dataset obtained in our testbed					
Roku	2191	17%	22%	20%	9%
Fire TV	1734	22%	27%	22%	9%

Block Rate:

$$\frac{\#\text{FQDNs blocked}}{\#\text{FQDNs in dataset}}$$

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Performs best

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Performs best

Performs worst

Block Rate:

$$\frac{\#\text{FQDNs blocked}}{\#\text{FQDNs in dataset}}$$

Blocklist Mistakes

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High block rates possibly due to mistakes

Blocklist Mistakes

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10 apps/platform
- 3 common
- Top-4 free
- 3 random

		App Name	No List		PD		TF		MoaAB		SATV	
			No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage
Roku	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		iFood.tv	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
		Tubi	✓	✓	✓	✓	—	✖	✓	✓	✓	✓
	Top	YouTube	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		CBS News Live	✗	✓	✓	✖	✓	✖	✓	✖	✓	✓
		The Roku Channel	✗	✓	✓	✓	✓	✖	✓	✓	✗	✓
		Sony Crackle	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
	Random	WatchFreeComedyFlix	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓
		Live Past 100 Well	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		SmartWoman	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fire TV	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✗	✗	✖
		iFood.tv	✗	✓	✓	✓	—	✖	—	✖	✓	✓
		Tubi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Top	Downloader	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		The CW for Fire TV	✗	✓	—	✖	—	✖	—	✖	✗	✓
		FoxNow	✗	✓	—	✖	—	✖	✗	✓	✗	✓
		Watch TNT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Random	KCRA3 Sacramento	✗	✓	✓	✓	—	✖	—	✖	✗	✗
		Watch the Weather Channel	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
		Jackpot Pokers by PokerStars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

Blocklist Mistakes

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5 sets of experiments
- No list as baseline
- Individually apply each list

10 apps/platform
- 3 common
- Top-4 free
- 3 random

		App Name	No List		PD		TF		MoaAB		SATV	
			No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage
Roku	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		iFood.tv	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
		Tubi	✓	✓	✓	✓	—	✖	✓	✓	✓	✓
	Top	YouTube	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		CBS News Live	✗	✓	✓	✖	✓	✖	✓	✖	✓	✓
		The Roku Channel	✗	✓	✓	✓	✓	✖	✓	✓	✗	✓
		Sony Crackle	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
	Random	WatchFreeComedyFlix	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓
		Live Past 100 Well	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		SmartWoman	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fire TV	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✗	✗	✖
		iFood.tv	✗	✓	✓	✓	—	✖	—	✖	✓	✓
		Tubi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Top	Downloader	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		The CW for Fire TV	✗	✓	—	✖	—	✖	—	✖	✗	✓
		FoxNow	✗	✓	—	✖	—	✖	✗	✓	✗	✓
		Watch TNT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Random	KCRA3 Sacramento	✗	✓	✓	✓	—	✖	—	✖	✗	✗
		Watch the Weather Channel	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
		Jackpot Pokers by PokerStars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

Blocklist Mistakes

UCI Samueli School of Engineering

10 apps/platform
- 3 common
- Top-4 free
- 3 random

		App Name	No List		PD		TF		MoaAB		SATV	
			No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage
Roku	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		iFood.tv	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
		Tubi	✓	✓	✓	✓	—	✖	✓	✓	✓	✓
	Top	YouTube	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		CBS News Live	✗	✓	✓	✖	✓	✖	✓	✖	✓	✓
		The Roku Channel	✗	✓	✓	✓	✓	✖	✓	✓	✗	✓
		Sony Crackle	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
	Random	WatchFreeComedyFlix	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓
		Live Past 100 Well	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		SmartWoman	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fire TV	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✗	✗	✖
		iFood.tv	✗	✓	✓	✓	—	✖	—	✖	✓	✓
		Tubi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Top	Downloader	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		The CW for Fire TV	✗	✓	—	✖	—	✖	—	✖	✗	✓
		FoxNow	✗	✓	—	✖	—	✖	✗	✓	✗	✓
		Watch TNT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Random	KCRA3 Sacramento	✗	✓	✓	✓	—	✖	—	✖	✗	✗
		Watch the Weather Channel	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
		Jackpot Pokers by PokerStars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

✗ Ad(s)
✓ No ads

Blocklist Mistakes

UCI Samueli School of Engineering

10 apps/platform
- 3 common
- Top-4 free
- 3 random

		App Name	No List		PD		TF		MoaAB		SATV	
			No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage
Roku	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		iFood.tv	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
		Tubi	✓	✓	✓	✓	—	✖	✓	✓	✓	✓
	Top	YouTube	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		CBS News Live	✗	✓	✓	✖	✓	✖	✓	✖	✓	✓
		The Roku Channel	✗	✓	✓	✓	✓	✖	✓	✓	✗	✓
		Sony Crackle	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
	Random	WatchFreeComedyFlix	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓
		Live Past 100 Well	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		SmartWoman	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fire TV	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✗	✗	✖
		iFood.tv	✗	✓	✓	✓	—	✖	—	✖	✓	✓
		Tubi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Top	Downloader	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		The CW for Fire TV	✗	✓	—	✖	—	✖	—	✖	✗	✓
		FoxNow	✗	✓	—	✖	—	✖	✗	✓	✗	✓
		Watch TNT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Random	KCRA3 Sacramento	✗	✓	✓	✓	—	✖	—	✖	✗	✗
		Watch the Weather Channel	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
		Jackpot Pokers by PokerStars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

✗ Ad(s)
✓ No ads

✗ Minor breakage
✖ Major breakage
✓ No breakage

Blocklist Mistakes

UCI Samueli School of Engineering

10 apps/platform
- 3 common
- Top-4 free
- 3 random

		App Name	No List		PD		TF		MoaAB		SATV	
			No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage
Roku	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		iFood.tv	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
		Tubi	✓	✓	✓	✓	—	✖	✓	✓	✓	✓
	Top	YouTube	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		CBS News Live	✗	✓	✓	✖	✓	✖	✓	✖	✓	✓
		The Roku Channel	✗	✓	✓	✓	✓	✖	✓	✓	✗	✓
		Sony Crackle	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
	Random	WatchFreeComedyFlix	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓
		Live Past 100 Well	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		SmartWoman	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fire TV	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✗	✗	✖
		iFood.tv	✗	✓	✓	✓	—	✖	—	✖	✓	✓
		Tubi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Top	Downloader	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		The CW for Fire TV	✗	✓	—	✖	—	✖	—	✖	✗	✓
		FoxNow	✗	✓	—	✖	—	✖	✗	✓	✗	✓
		Watch TNT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Random	KCRA3 Sacramento	✗	✓	✓	✓	—	✖	—	✖	✗	✗
		Watch the Weather Channel	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
		Jackpot Pokers by PokerStars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

✗ Ad(s)
✓ No ads

✗ Minor breakage
✖ Major breakage
✓ No breakage

Blocks the most ads

Blocklist Mistakes

UCI Samueli School of Engineering

10 apps/platform
- 3 common
- Top-4 free
- 3 random

		App Name	No List		PD		TF		MoaAB		SATV	
			No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage
Roku	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		iFood.tv	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
		Tubi	✓	✓	✓	✓	—	✖	✓	✓	✓	✓
	Top	YouTube	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		CBS News Live	✗	✓	✓	✖	✓	✖	✓	✖	✓	✓
		The Roku Channel	✗	✓	✓	✓	✓	✖	✓	✓	✗	✓
		Sony Crackle	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
	Random	WatchFreeComedyFlix	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓
		Live Past 100 Well	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		SmartWoman	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fire TV	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✗	✗	✖
		iFood.tv	✗	✓	✓	✓	—	✖	—	✖	✓	✓
		Tubi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Top	Downloader	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		The CW for Fire TV	✗	✓	—	✖	—	✖	—	✖	✗	✓
		FoxNow	✗	✓	—	✖	—	✖	✗	✓	✗	✓
		Watch TNT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Random	KCRA3 Sacramento	✗	✓	✓	✓	—	✖	—	✖	✗	✗
		Watch the Weather Channel	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
		Jackpot Pokers by PokerStars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

✗ Ad(s)
✓ No ads

✗ Minor breakage
✖ Major breakage
✓ No breakage

Blocks the least ads

Blocklist Mistakes

UCI Samueli School of Engineering

10 apps/platform
- 3 common
- Top-4 free
- 3 random

		App Name	No List		PD		TF		MoaAB		SATV	
			No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage
Roku	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		iFood.tv	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
		Tubi	✓	✓	✓	✓	—	✖	✓	✓	✓	✓
	Top	YouTube	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		CBS News Live	✗	✓	✓	✖	✓	✖	✓	✖	✓	✓
		The Roku Channel	✗	✓	✓	✓	✓	✖	✓	✓	✗	✓
		Sony Crackle	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
	Random	WatchFreeComedyFlix	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓
		Live Past 100 Well	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		SmartWoman	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fire TV	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✗	✗	✖
		iFood.tv	✗	✓	✓	✓	—	✖	—	✖	✓	✓
		Tubi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Top	Downloader	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		The CW for Fire TV	✗	✓	—	✖	—	✖	—	✖	✗	✓
		FoxNow	✗	✓	—	✖	—	✖	✗	✓	✗	✓
		Watch TNT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Random	KCRA3 Sacramento	✗	✓	✓	✓	—	✖	—	✖	✗	✗
		Watch the Weather Channel	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
		Jackpot Pokers by PokerStars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

✗ Ad(s)
✓ No ads

✗ Minor breakage
✖ Major breakage
✓ No breakage

Best trade-off

Blocklist Mistakes

UCI Samueli School of Engineering

10 apps/platform
- 3 common
- Top-4 free
- 3 random

		App Name	No List		PD		TF		MoaAB		SATV	
			No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage	No Ads	No Breakage
Roku	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		iFood.tv	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
		Tubi	✓	✓	✓	✓	—	✖	✓	✓	✓	✓
	Top	YouTube	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
		CBS News Live	✗	✓	✓	✖	✓	✖	✓	✖	✓	✓
		The Roku Channel	✗	✓	✓	✓	✓	✖	✓	✓	✗	✓
		Sony Crackle	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓
	Random	WatchFreeComedyFlix	✗	✓	✓	✓	✓	✓	✗	✓	✗	✓
		Live Past 100 Well	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		SmartWoman	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fire TV	Common	Pluto TV	✗	✓	✗	✓	✗	✓	✗	✗	✗	✖
		iFood.tv	✗	✓	✓	✓	—	✖	—	✖	✓	✓
		Tubi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Top	Downloader	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		The CW for Fire TV	✗	✓	—	✖	—	✖	—	✖	✗	✓
		FoxNow	✗	✓	—	✖	—	✖	✗	✓	✗	✓
		Watch TNT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Random	KCRA3 Sacramento	✗	✓	✓	✓	—	✖	—	✖	✗	✗
		Watch the Weather Channel	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓
		Jackpot Pokers by PokerStars	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

✗ Ad(s)
✓ No ads

✗ Minor breakage
✖ Major breakage
✓ No breakage

No blocklist prevents all ads, and all incur major breakage

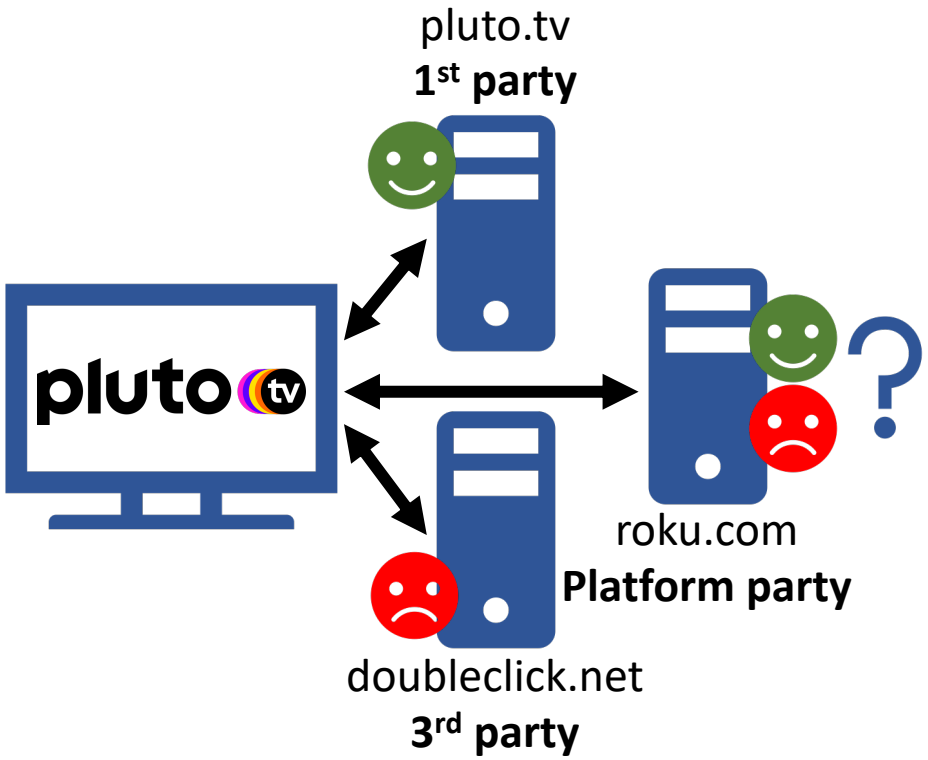
PII Exposure

UCI Samueli School of Engineering

Prevalence of Personally Identifiable Information exposures?
Blocklists' ability to prevent them?

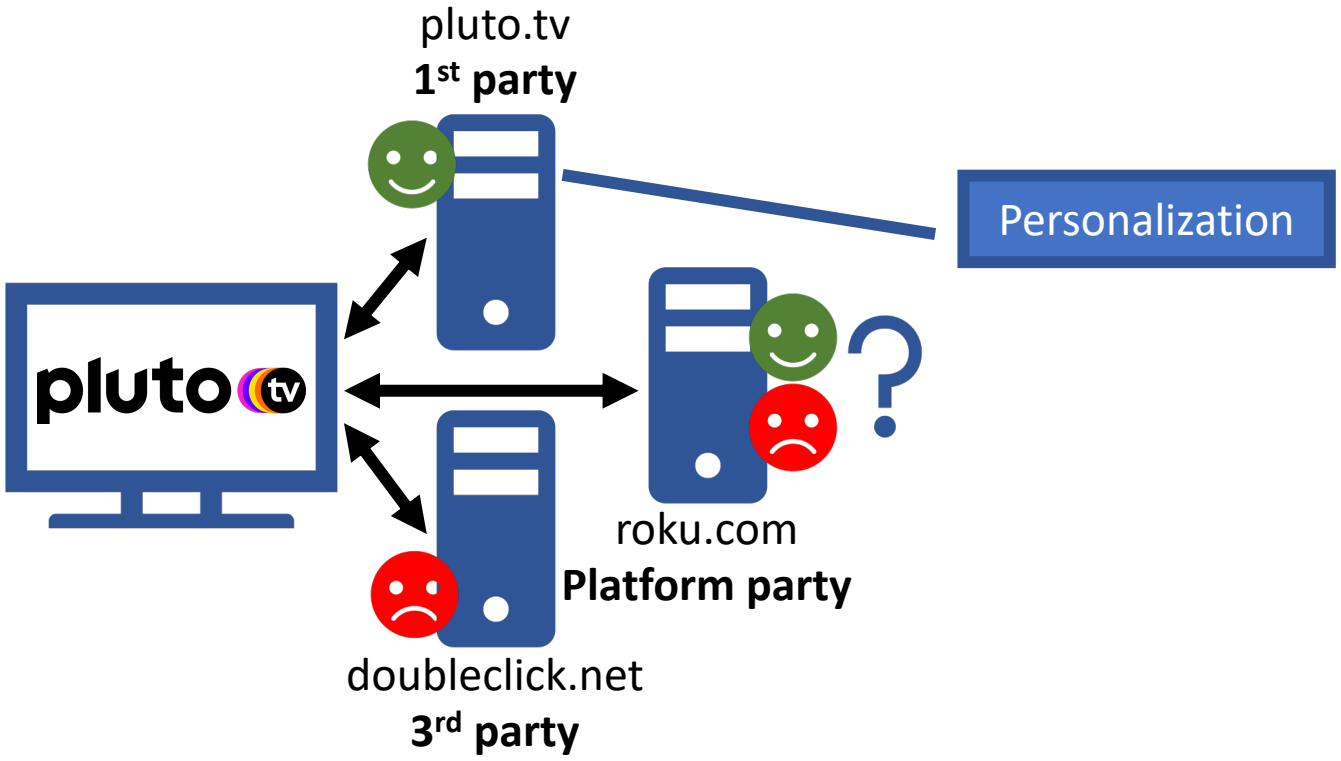
PII Exposure

Prevalence of Personally Identifiable Information exposures?
Blocklists' ability to prevent them?



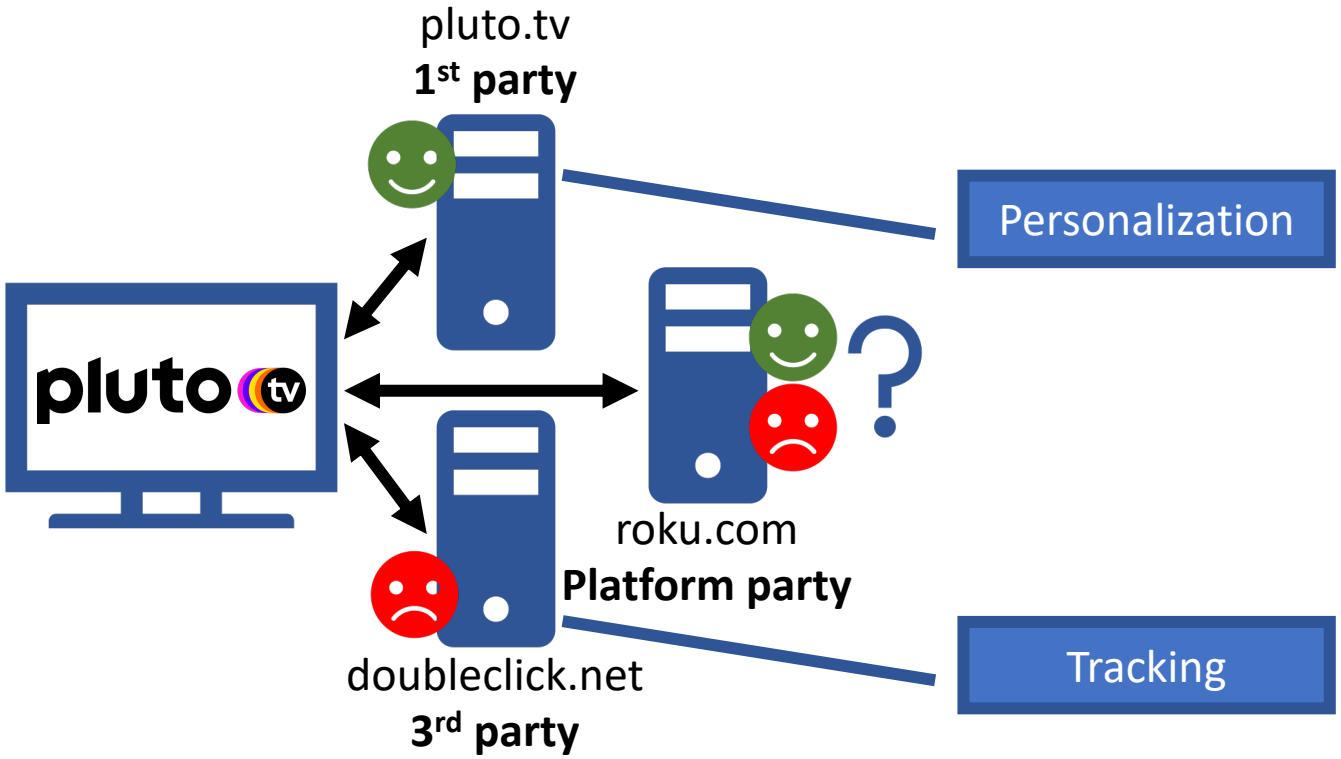
PII Exposure

Prevalence of Personally Identifiable Information exposures?
Blocklists' ability to prevent them?



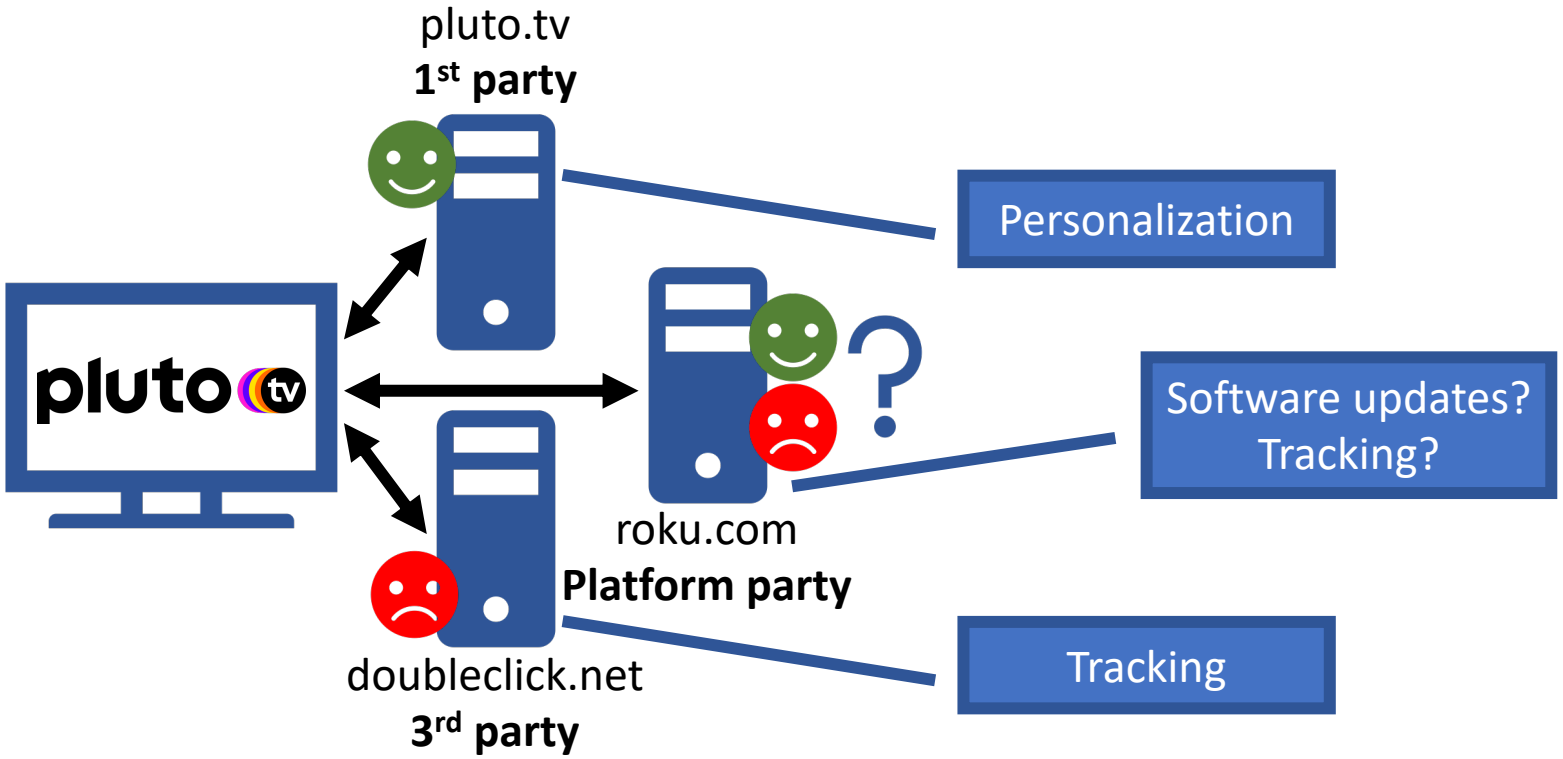
PII Exposure

Prevalence of Personally Identifiable Information exposures?
Blocklists' ability to prevent them?



PII Exposure

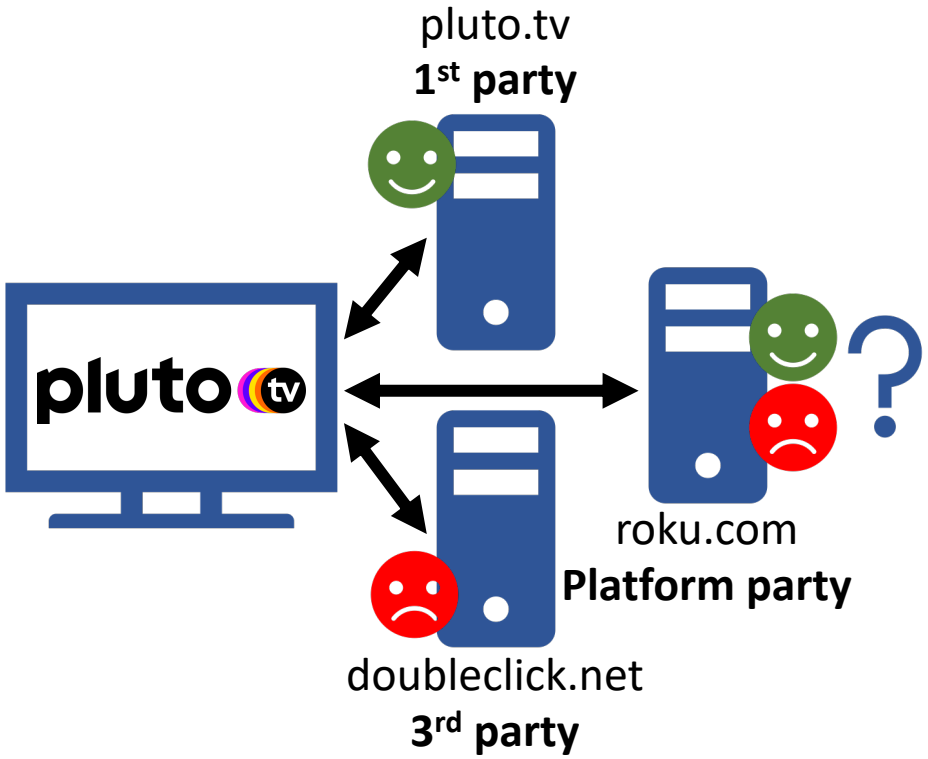
Prevalence of Personally Identifiable Information exposures?
Blocklists' ability to prevent them?



PII Exposure

UCI Samueli School of Engineering

Prevalence of Personally Identifiable Information exposures? Blocklists' ability to prevent them?



	PII	1st Party		3rd Party		Platform Party	
		Apps	Block Rate	Apps	Block Rate	Apps	Block Rate
Roku	Ad ID	4	25%	263	88%	0	-
	Serial Number	48	5%	128	74%	0	-
	Device ID	N/A	-	N/A	-	N/A	-
fire tv	Ad ID	17	25%	53	78%	715	71%
	Serial Number	10	0%	51	33%	867	9%
	Device ID	19	8%	153	36%	819	14%

PII Exposure

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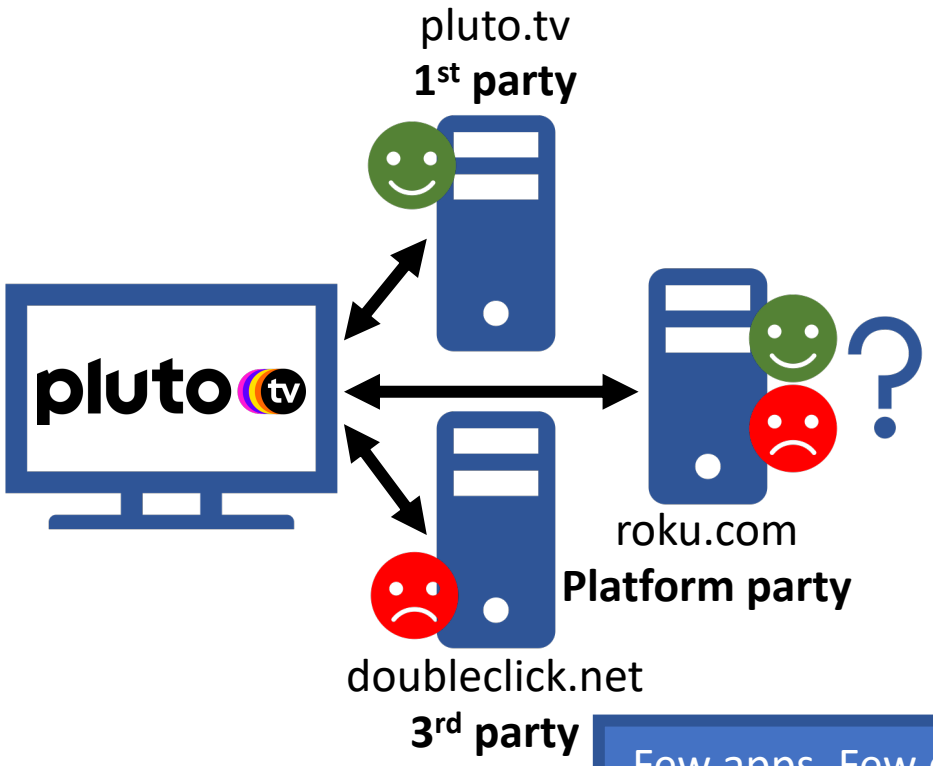
Prevalence of Personally Identifiable Information exposures?
Blocklists' ability to prevent them?



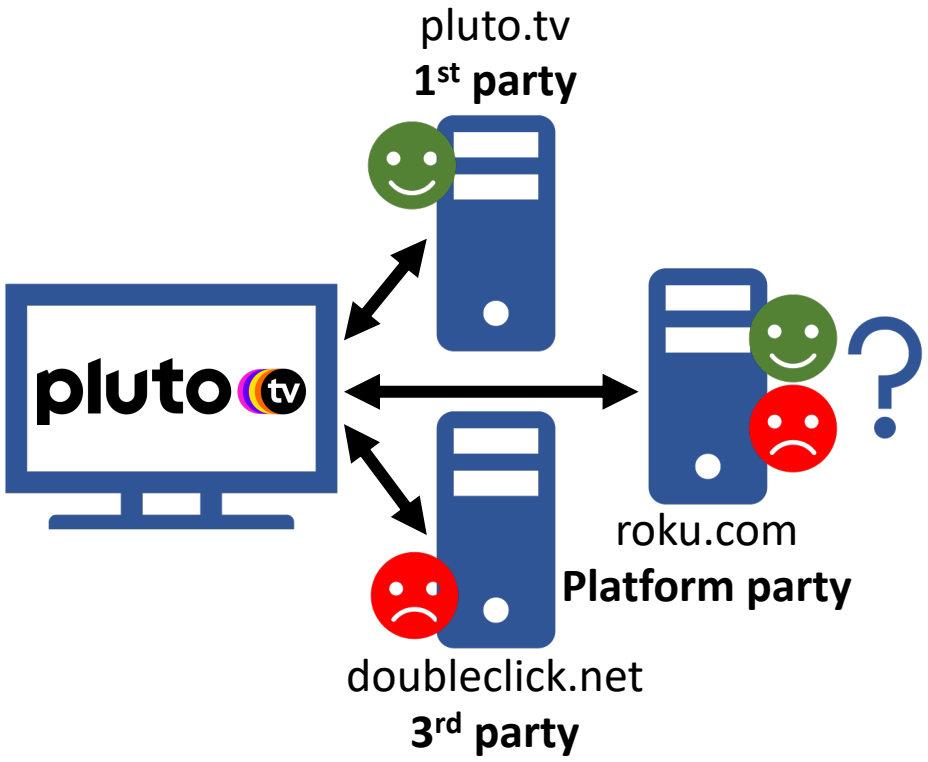
	PII	1st Party		3rd Party		Platform Party	
		Apps	Block Rate	Apps	Block Rate	Apps	Block Rate
Roku	Ad ID	4	25%	263	88%	0	-
Roku	Serial Number	48	5%	128	74%	0	-
Roku	Device ID	N/A	-	N/A	-	N/A	-
fire tv	Ad ID	17	25%	53	78%	715	71%
fire tv	Serial Number	10	0%	51	33%	867	9%
fire tv	Device ID	19	8%	153	36%	819	14%

Few apps. Few domains blocked.

PII Exposure

UCI Samueli School of Engineering

Prevalence of Personally Identifiable Information exposures?
Blocklists' ability to prevent them?



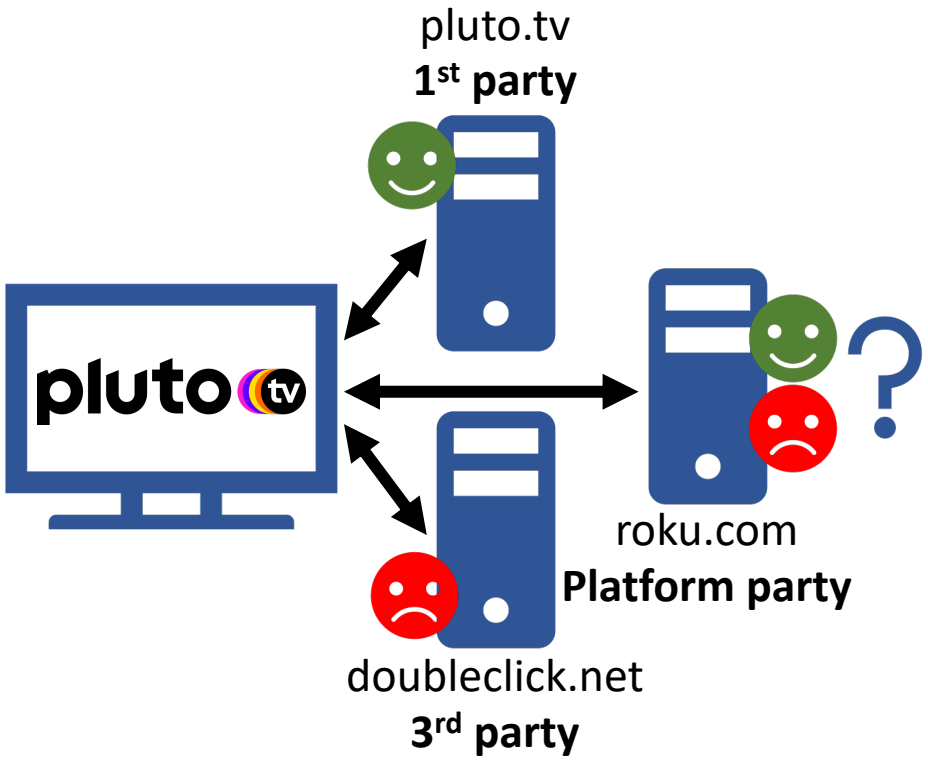
	PII	1st Party		3rd Party		Platform Party	
		Apps	Block Rate	Apps	Block Rate	Apps	Block Rate
Roku	Ad ID	4	25%	263	88%	0	-
Roku	Serial Number	48	5%	128	74%	0	-
Roku	Device ID	N/A	-	N/A	-	N/A	-
fire tv	Ad ID	17	25%	53	78%	715	71%
fire tv	Serial Number	10	0%	51	33%	867	9%
fire tv	Device ID	19	8%	153	36%	819	14%

Many apps. Most domains blocked.

PII Exposure

UCI Samueli School of Engineering

Prevalence of Personally Identifiable Information exposures?
Blocklists' ability to prevent them?



	PII	1st Party		3rd Party		Platform Party	
		Apps	Block Rate	Apps	Block Rate	Apps	Block Rate
Roku	Ad ID	4	25%	263	88%	0	-
	Serial Number	48	5%	128	74%	0	-
	Device ID	N/A	-	N/A	-	N/A	-
fire tv	Ad ID	17	25%	53	78%	715	71%
	Serial Number	10	0%	51	33%	867	9%
	Device ID	19	8%	153	36%	819	14%

Many apps. Many missed domains.

PII Exposure

UCI Samueli School of Engineering

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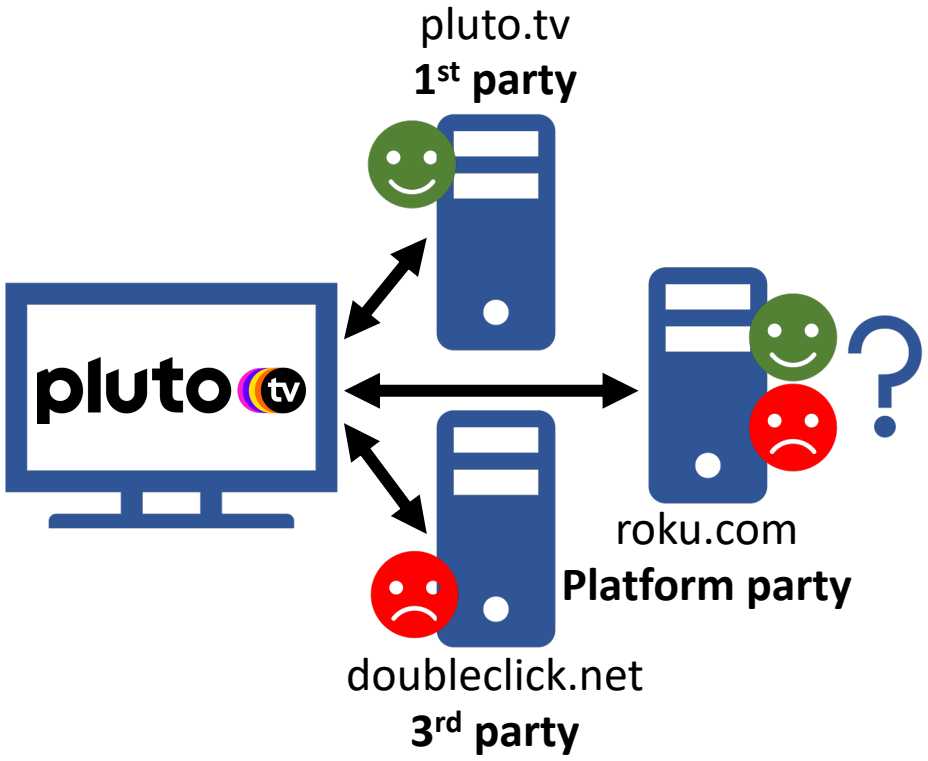

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Close to all apps. Many missed domains.

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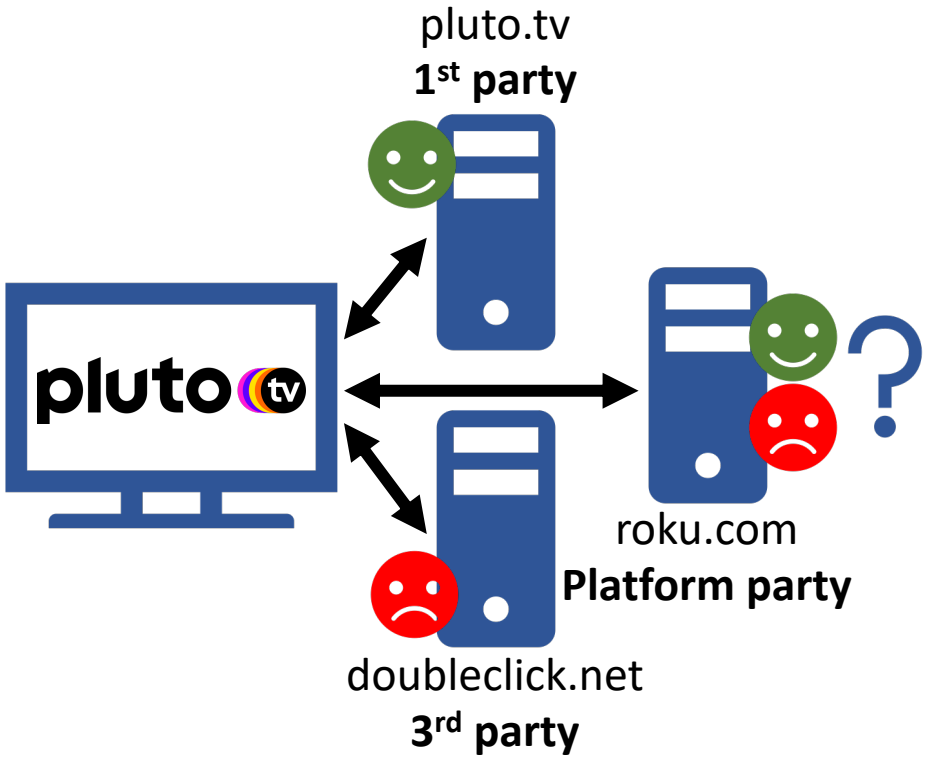

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- Sent by **697** apps to aviary.amazon.com/**GetAds**
- **Allows linking of reset advertising ID**

PII Exposure

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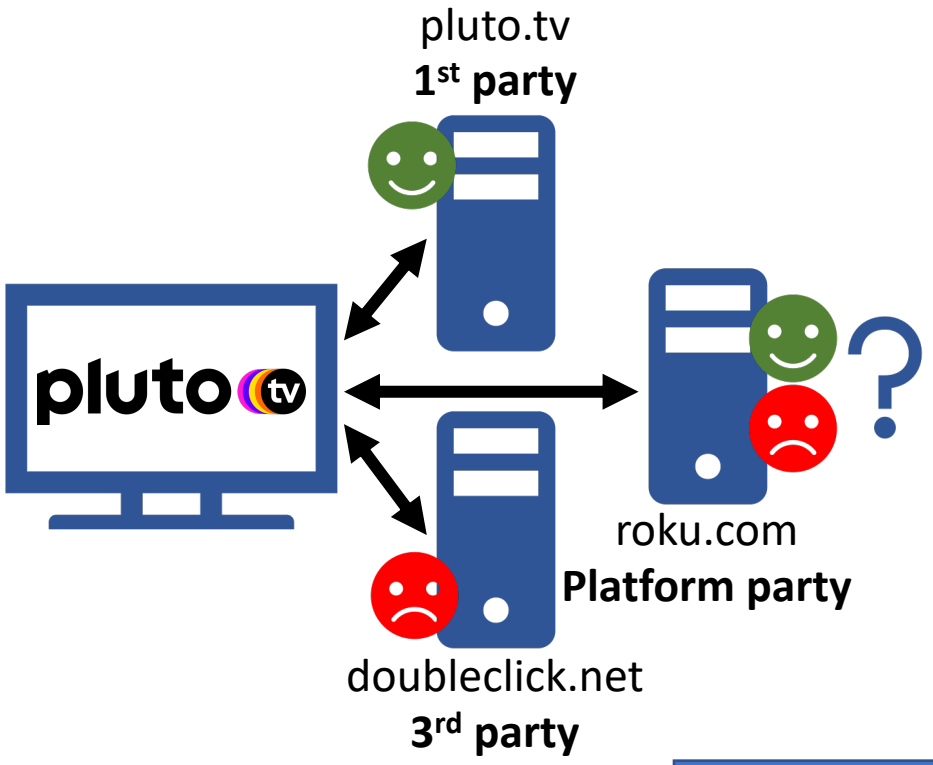

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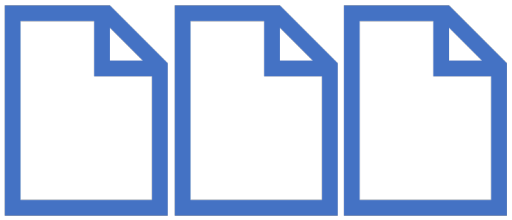
- 100s of apps expose PII
- Blocklists **effective** for Roku
- Blocklists **ineffective** for Fire TV

Conclusion

- Overview of smart TV platforms' ATS ecosystems
  - Smart TVs deployed in the wild
  - Smart TVs in a testbed setting
- Evaluated DNS-based blocklists
  - Mistakes
  - Prevent some PII exposures
- https://athinagroup.eng.uci.edu/projects/smarttv/



Dataset

Tools

MoaAB