# Policy Certification and Verification for Cybersecurity in the IoT

Anna Maria Mandalari


UCL

RIPE NCC
RIPE NETWORK COORDINATION CENTRE

# Agenda

01 **Problem: IoT Devices Expose Information Over the Internet**

Reasons you shouldn’t watch TV
Reasons you shouldn’t use smart medical devices.

02 **Privacy and Security Certification/Regulation**

EU Cyber Resilience Act (CRA)
GDPR

03 **IoT Automating Testing and Compliance**

IoTrim ++
Black box assessment

04 **Standards**

Standardization request
ETSI/CEN-CENELC WGs

05 **Gaps**

IoT Manufactures
SMEs

06 **Conclusion**

What’s next?

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What's next?

# 210 devices in different countries

01

# Reasons You Shouldn't Watch TV

# Motivation

I Still Know What You Watched
Privacy of the HbbTV Protocol in
Smart TV Landscape

Carlotta Tagliaro
TU Wien
Austria
carlotta@seclab.wien

Janus Varmarken*, Jad Al Aaraj, Rahmadi Trimananda, and Athina Markopoulou

**FingerprinTV: Fingerprinting Smart TV Apps**

**Watching You Watch: The Tracking Ecosystem of Over-the-Top TV Streaming Devices**

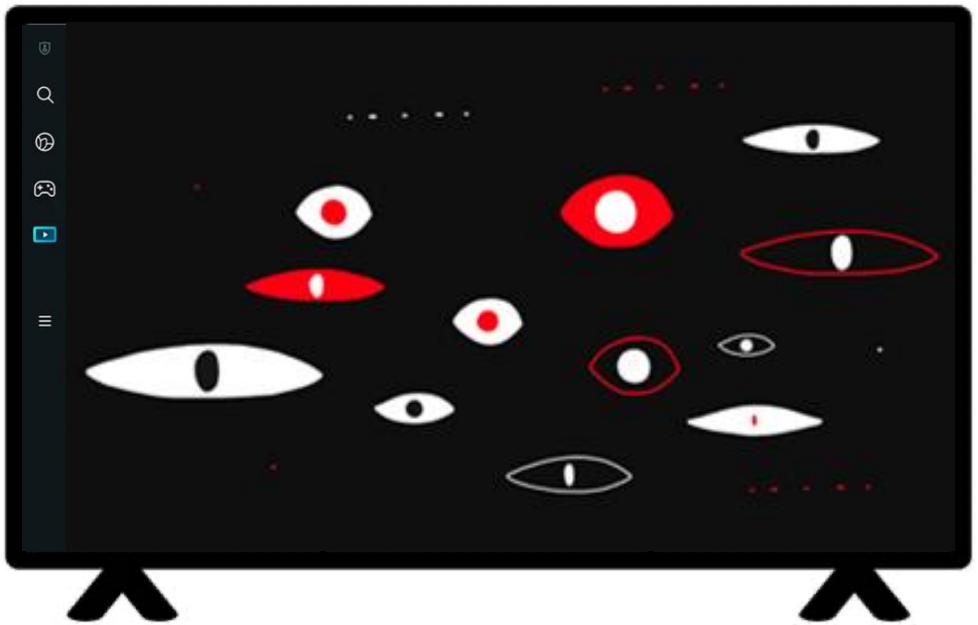
Hooman Mohajeri Moghaddam, Gunes Acar, Ben Burgess, Arunesh Mathur, Danny Yuxing Huang,
Nick Feamster*, Edward W. Felten, Prateek Mittal, Arvind Narayanan
Princeton University and University of Chicago*

Marcos Tileria* a

**Watch Over Your TV: A Security and Privacy Analysis of the Android TV Ecosystem**

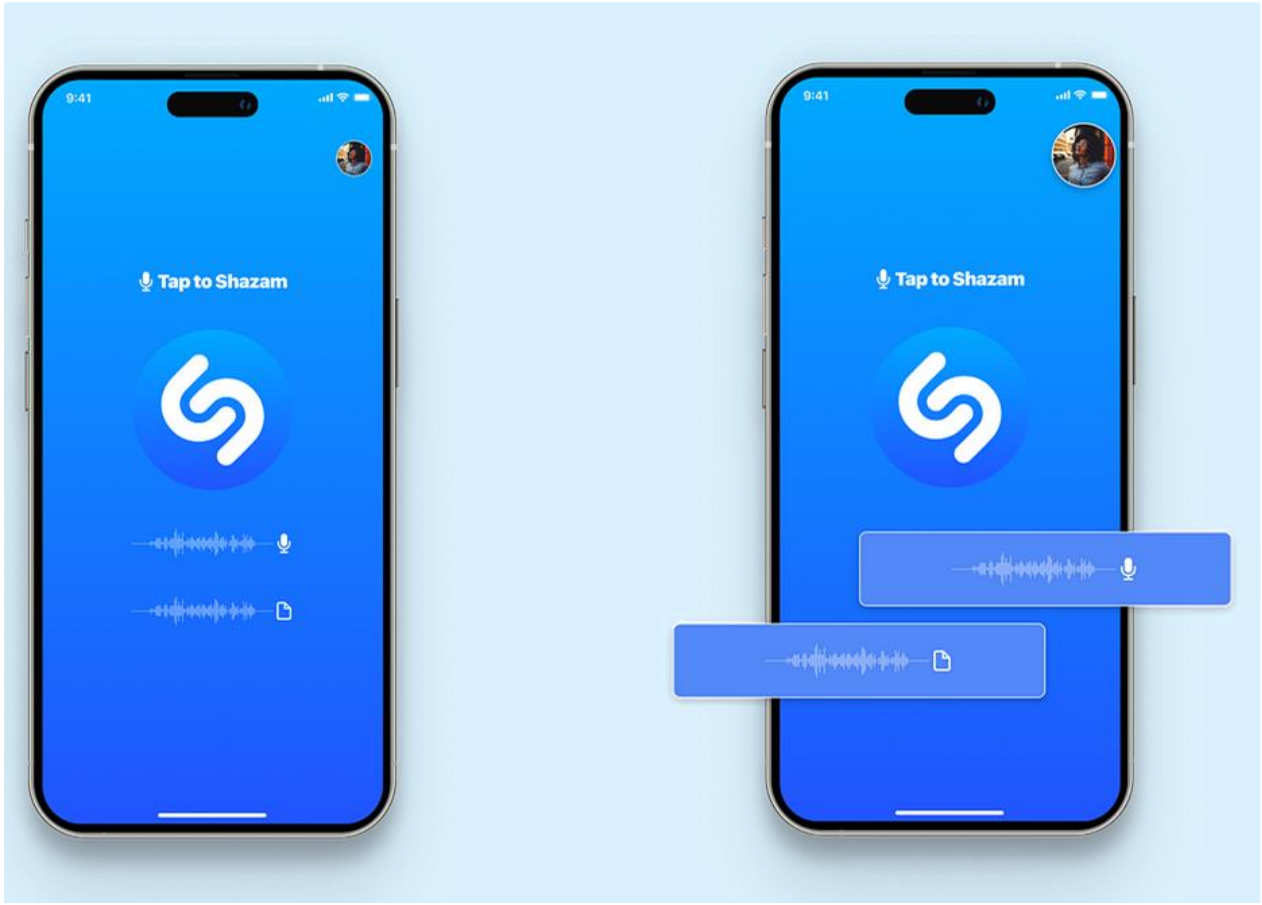
Janus Varmarken†*, Hieu Le†, Anastasia Shuba, Athina Markopoulou, and Zubair Shafiq

**The TV is Smart and Full of Trackers: Measuring Smart TV Advertising and Tracking**

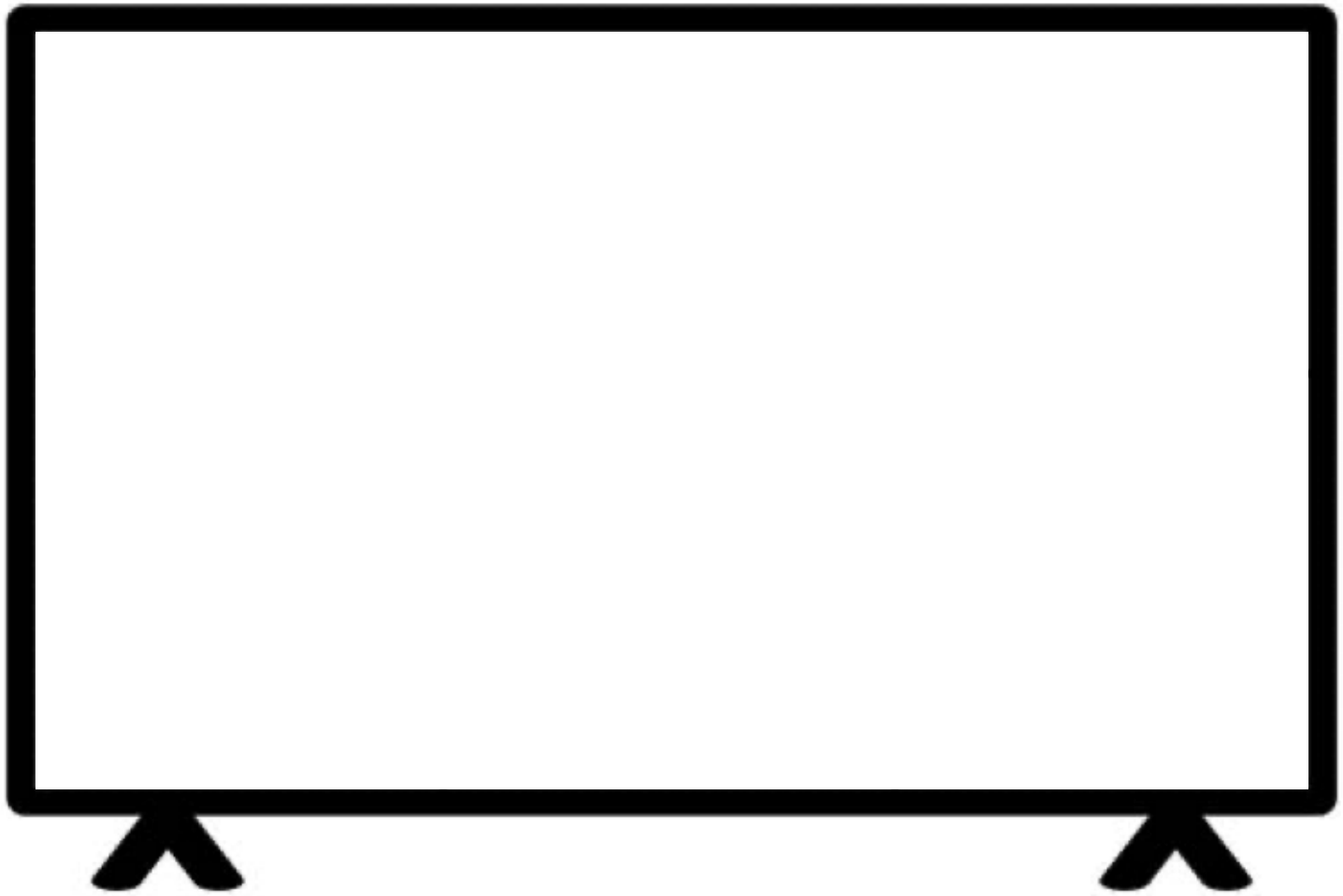



3P apps or services

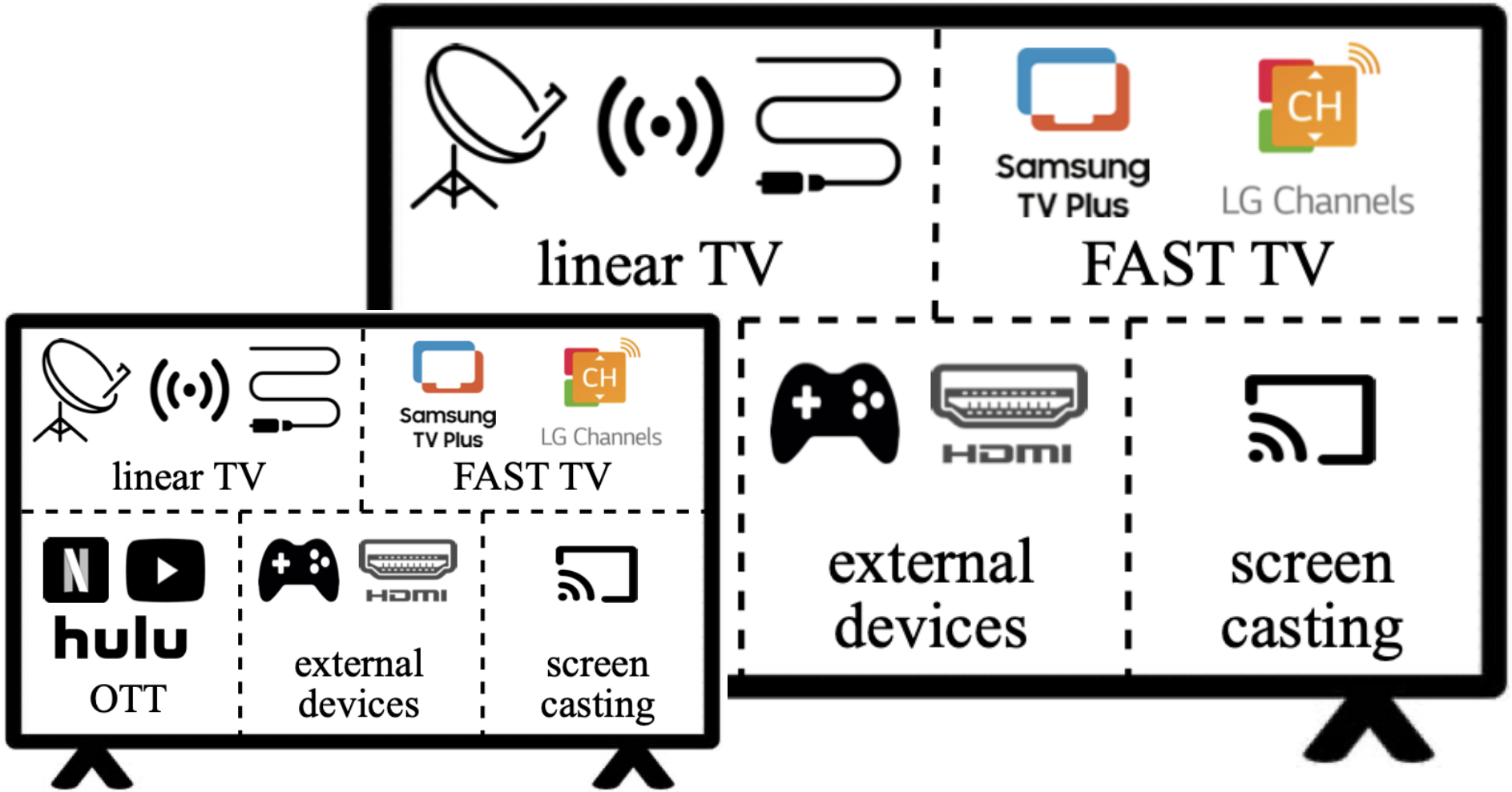
# ACR = OS-integrated Shazam-like technology



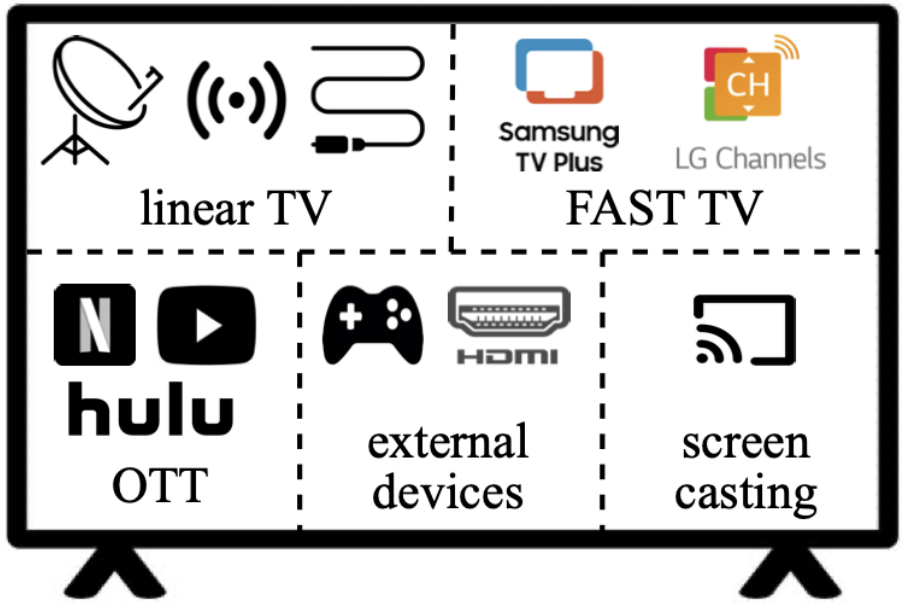

# Smart TV Functionalities



# Automatic Content Recognition (ACR)

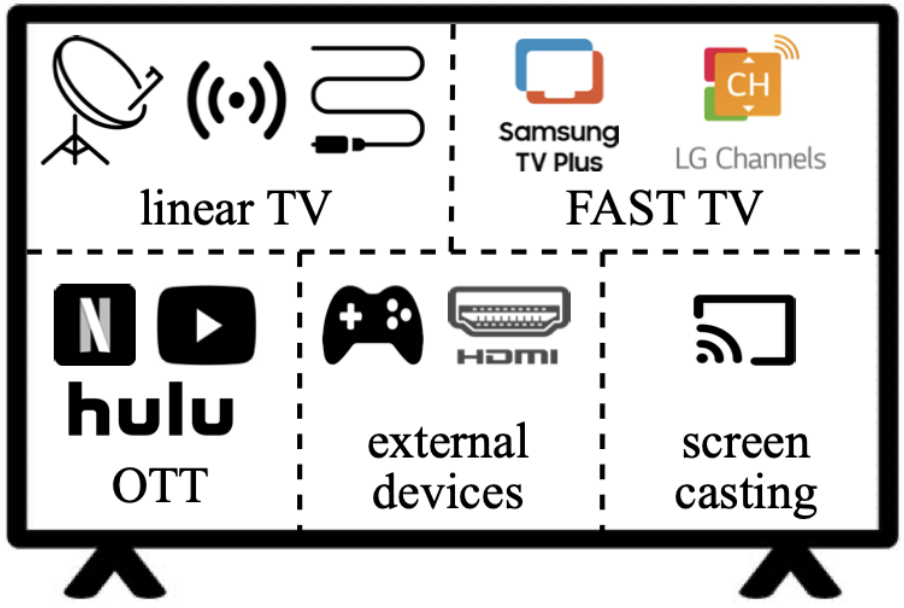


# ACR Client

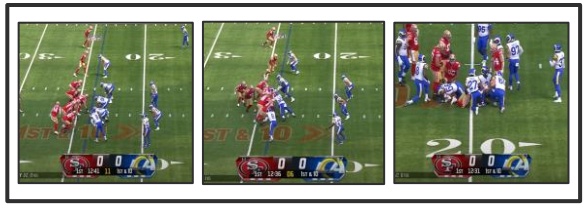

linear TV
Samsung TV Plus
LG Channels
FAST TV
hulu
OTT
HDMI
external devices
screen casting

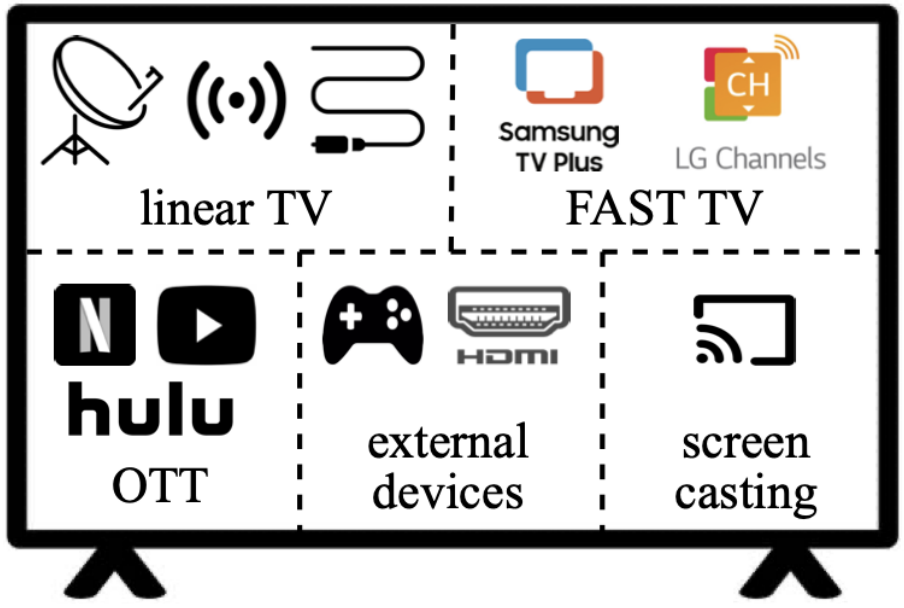

TV

## ACR Client


Samsung TV Plus
LG Channels
linear TV
FAST TV
hulu
OTT
HDMI
external devices
screen casting


Captured frames



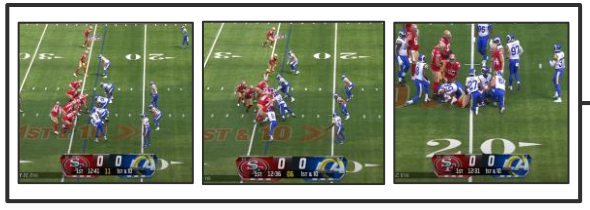


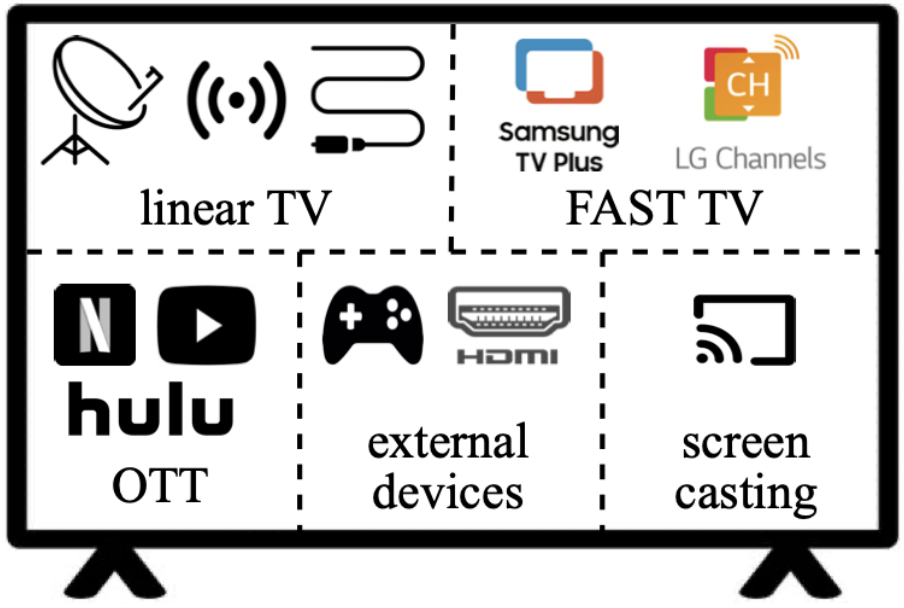

## ACR Client


Captured frames

Content fingerprint

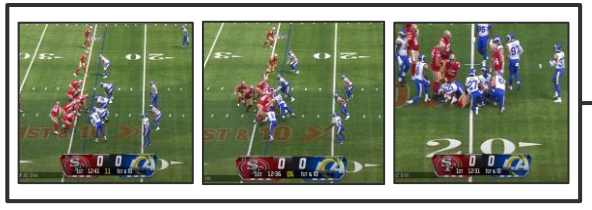
**ACR Client**



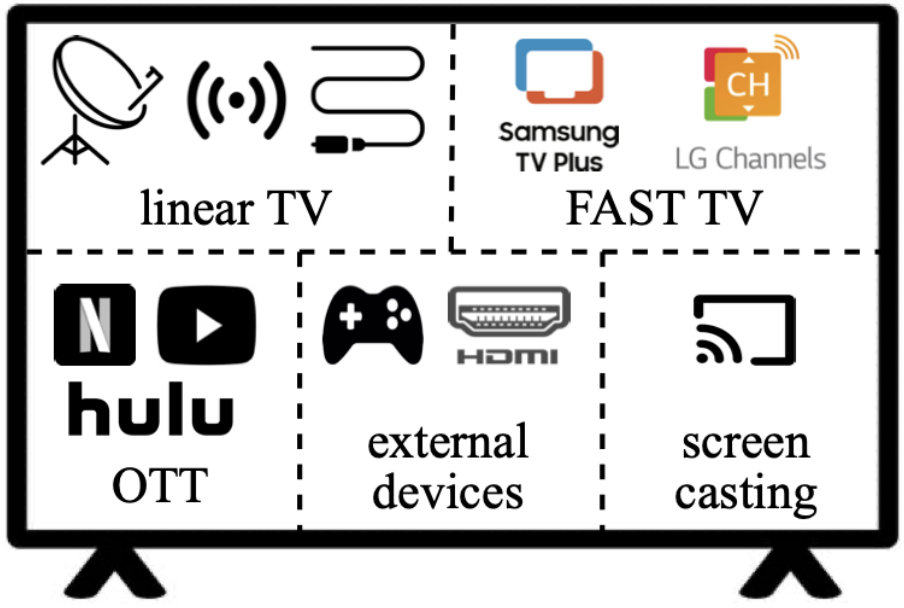



Captured frames

Content fingerprint

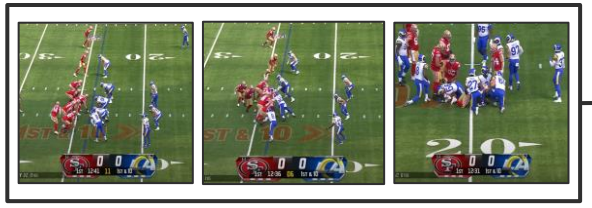


**ACR Client**




**ACR Server**

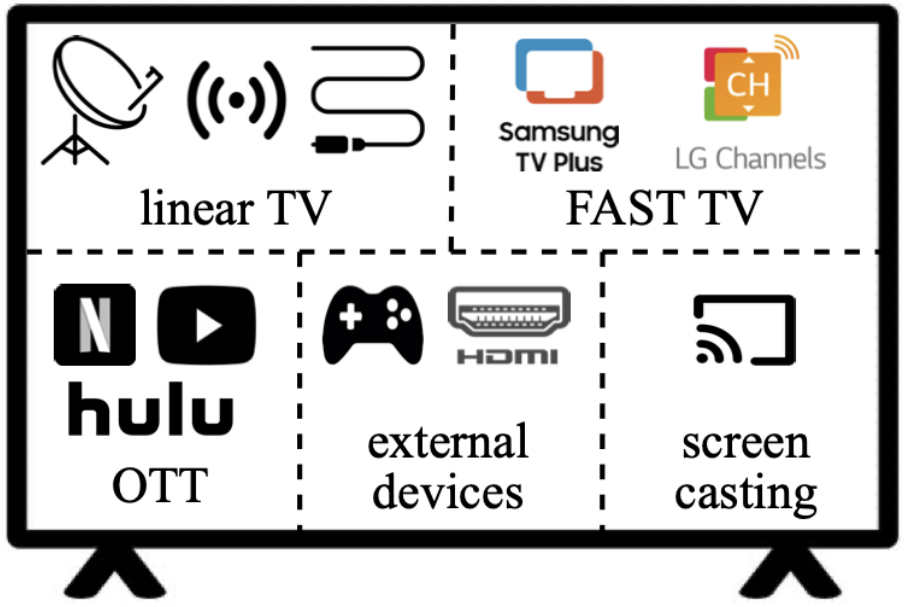

Captured frames



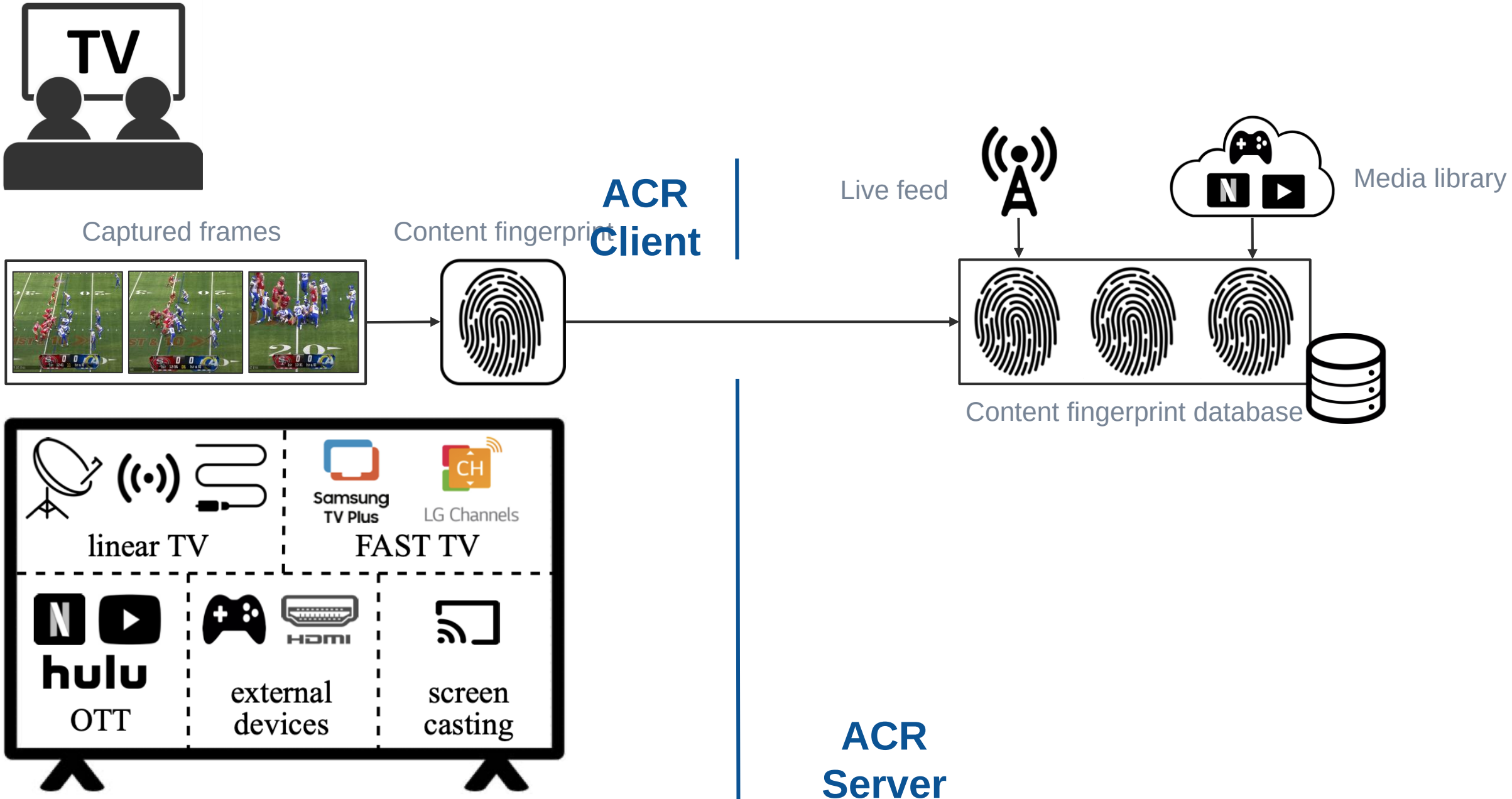
Content fingerprint

**ACR Client**

Content fingerprint database




**ACR Server**


TV
Captured frames
Content fingerprint
ACR Client
Live feed
Media library
Content fingerprint database
linear TV
Samsung TV Plus
LG Channels
FAST TV
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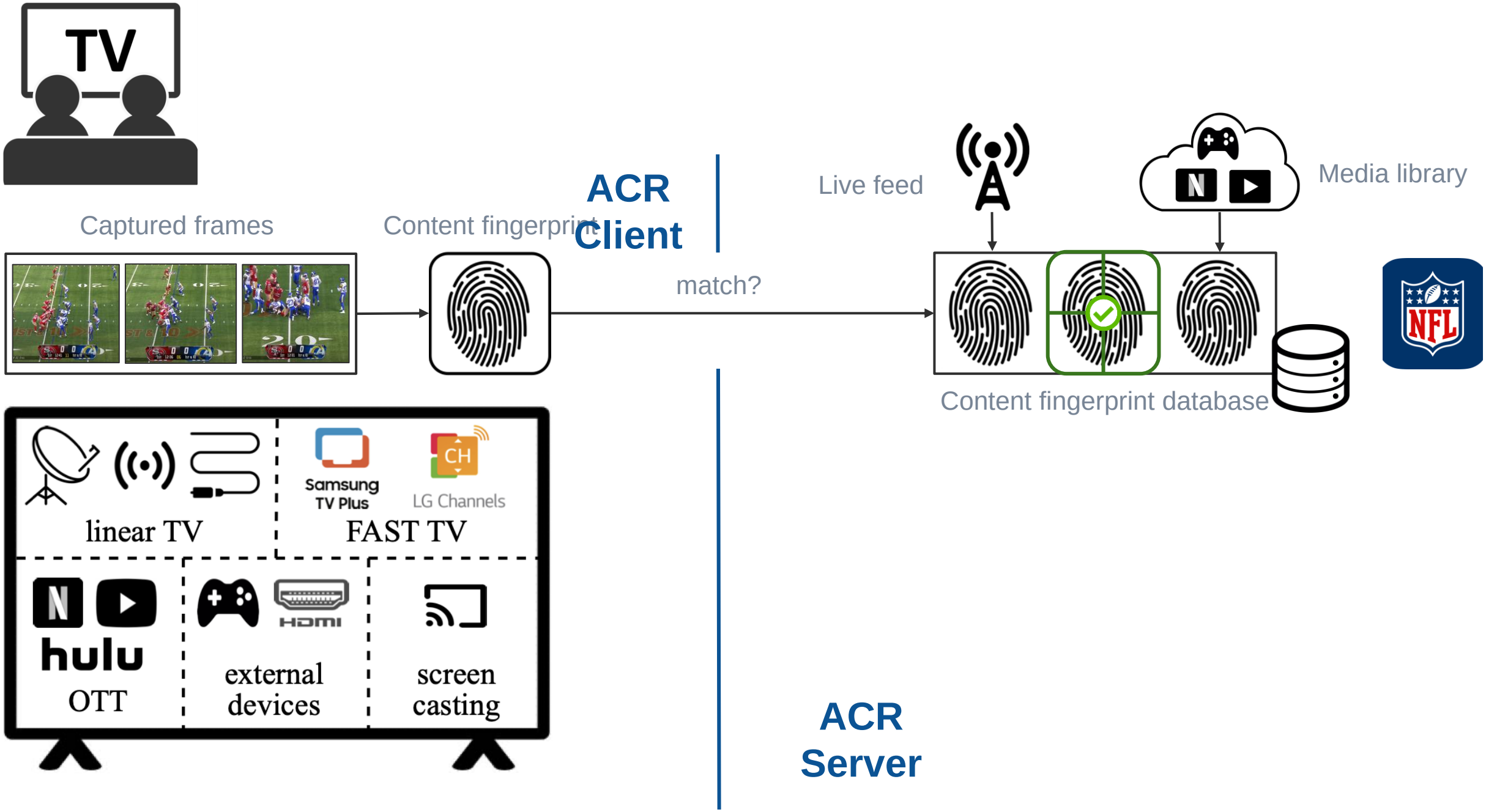
OTT
external devices
HDMI
screen casting
ACR Server


TV
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Content fingerprint
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match?
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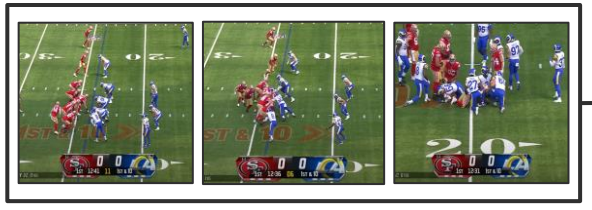
Captured frames



Content fingerprint

**ACR Client**

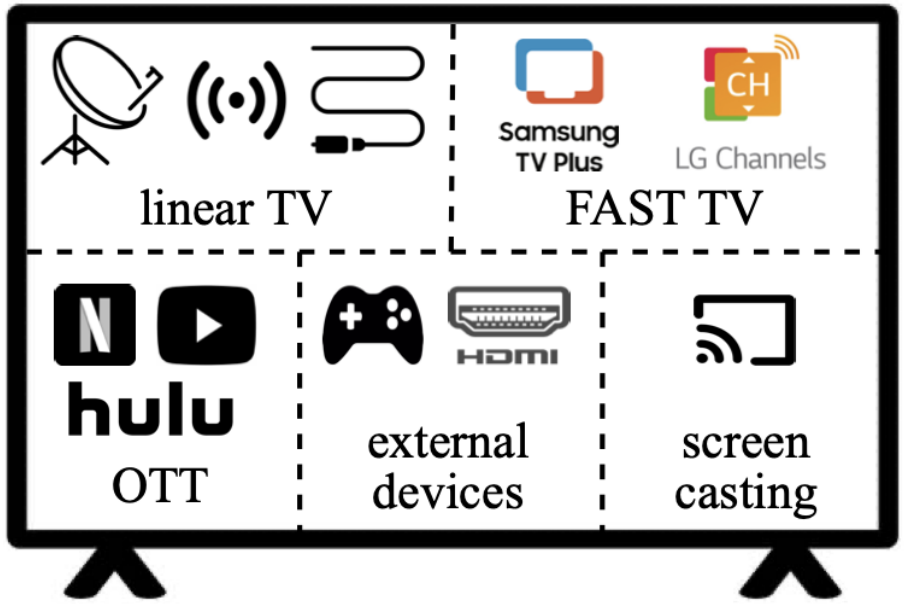
match?

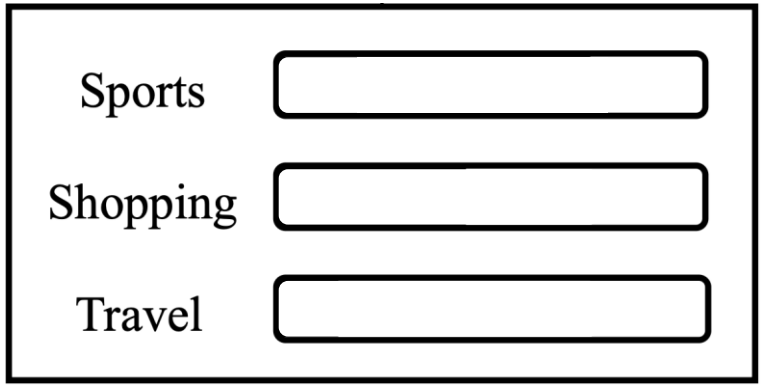
Live feed

Media library



Content fingerprint database

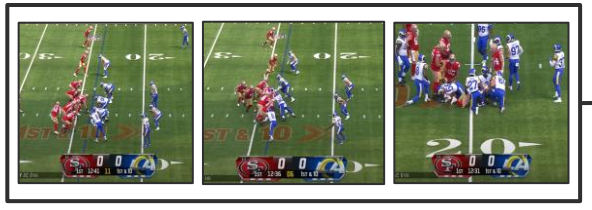



Audience segments

**ACR Server**


Captured frames



Content fingerprint

**ACR Client**

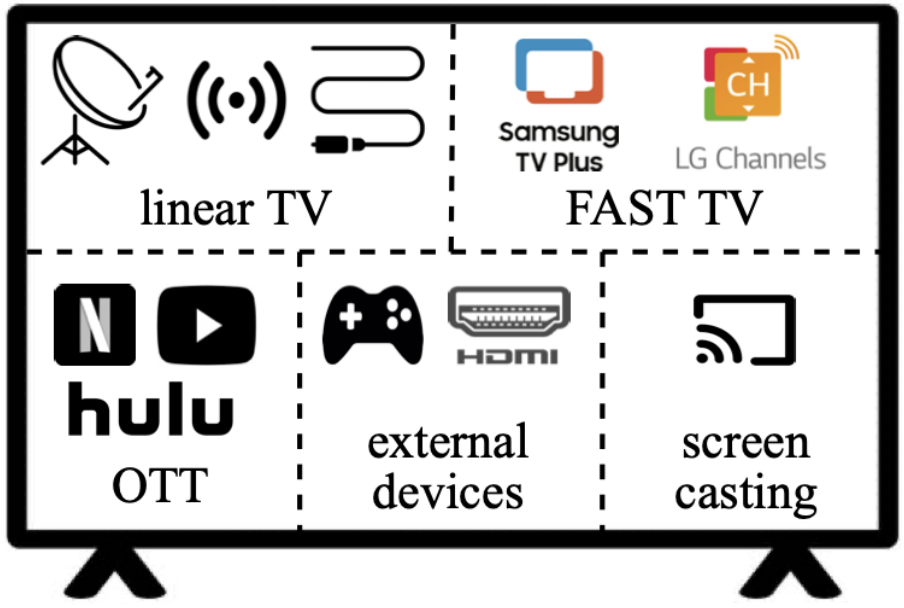
match?

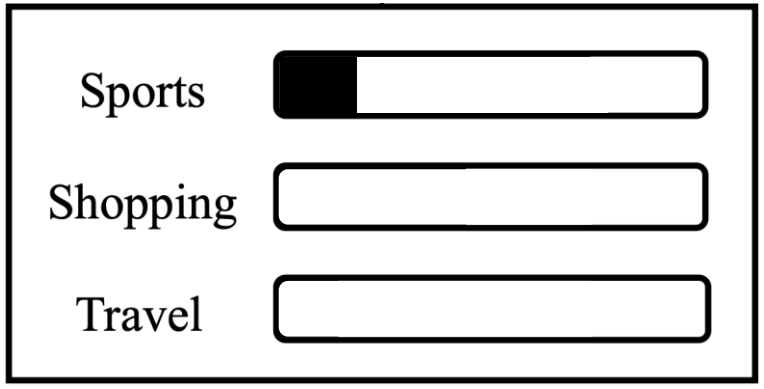
Live feed

Media library



Content fingerprint database




Audience segments

**ACR Server**

# How frequently does *ACR* capture snapshots of your viewing activities?

*It varies from manufacturer to manufacturer …*

*Captures video snapshots*

**500ms**

SAMSUNG

TIZEN™

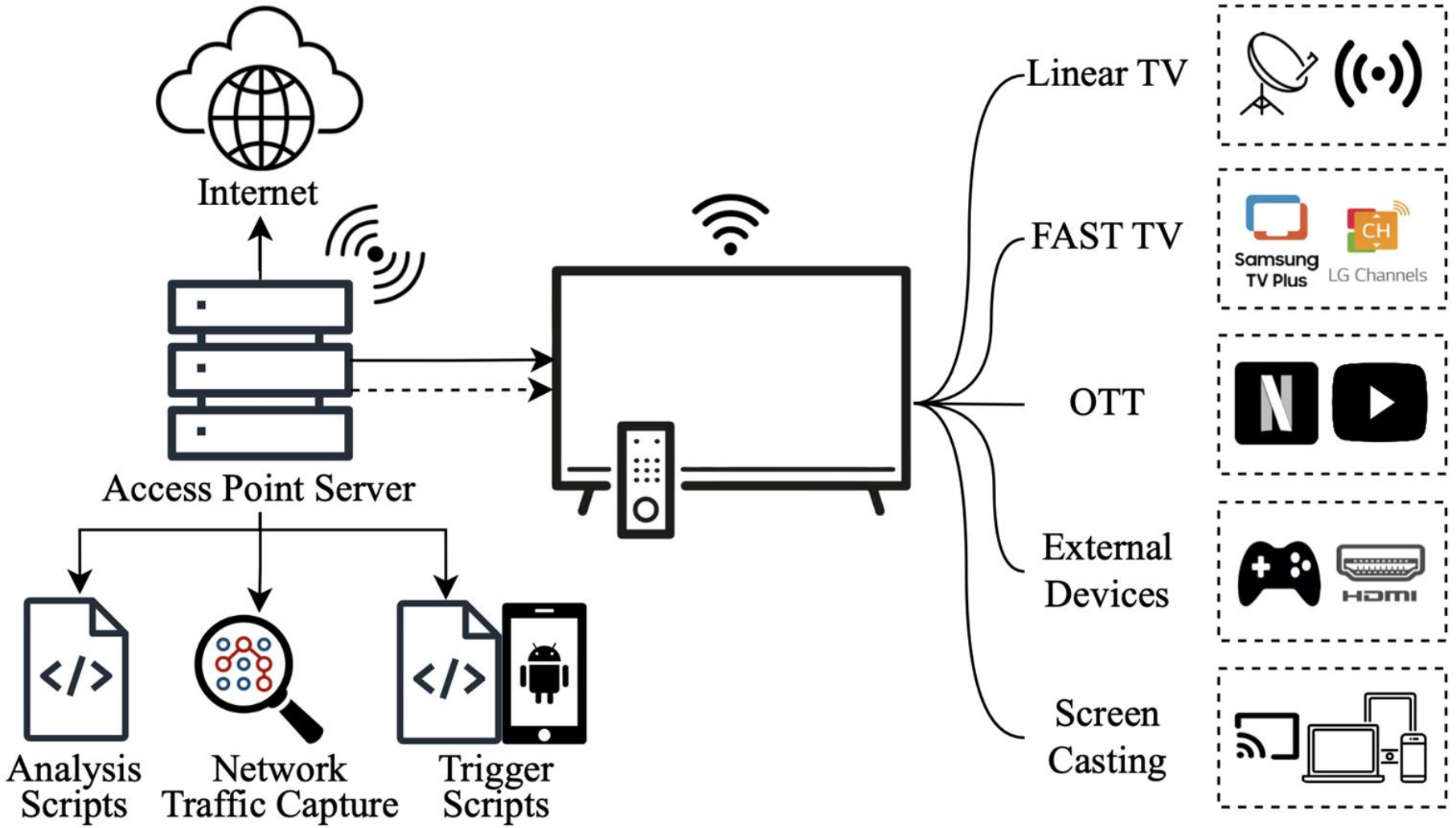
*Captures audio snapshots*

**10ms**

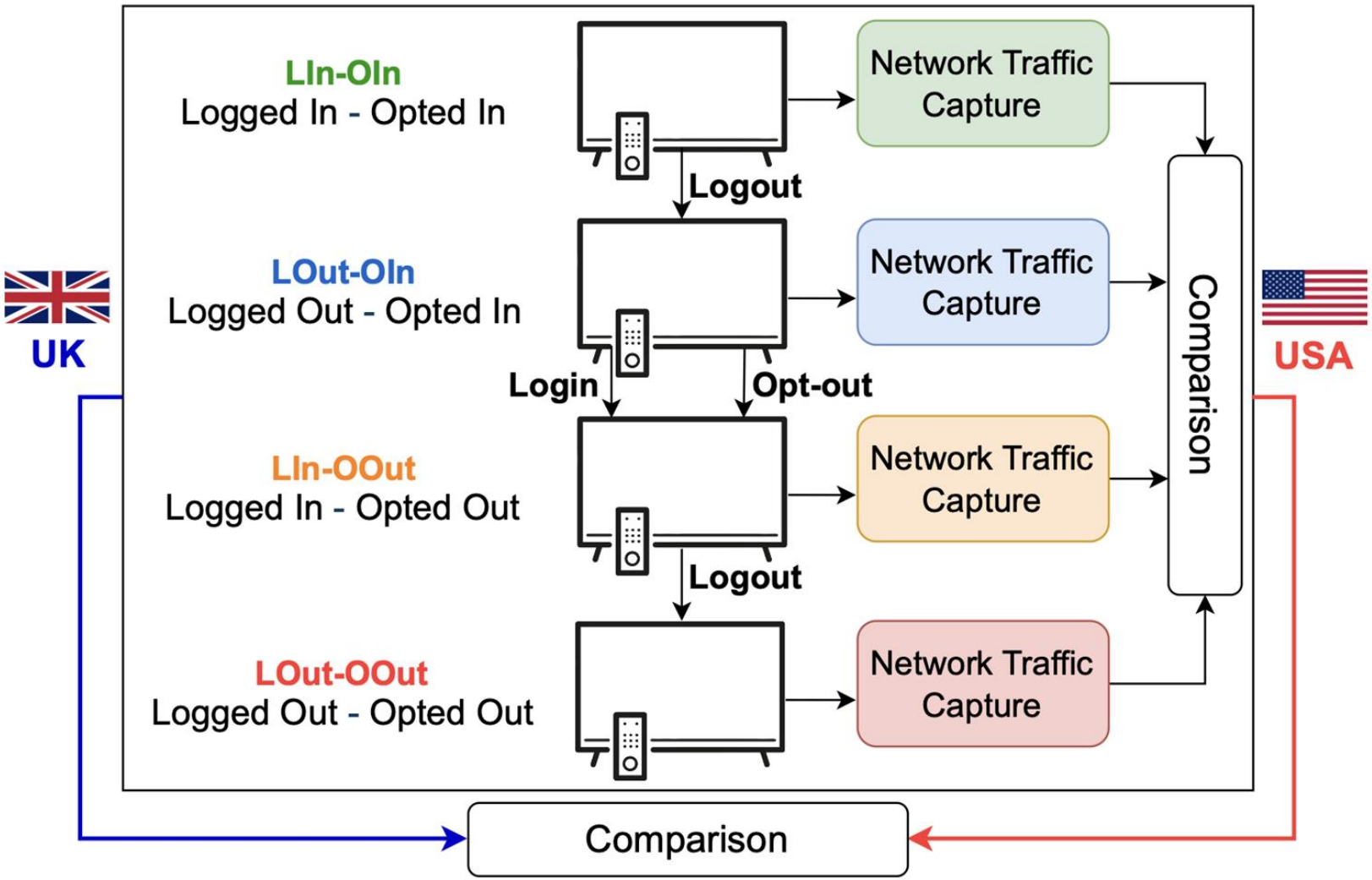
LG

webOS

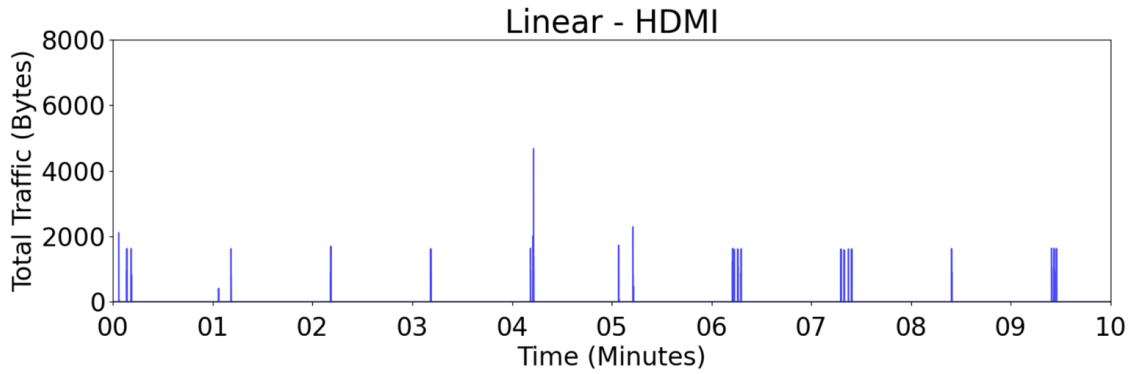
# Experimental Infrastructure

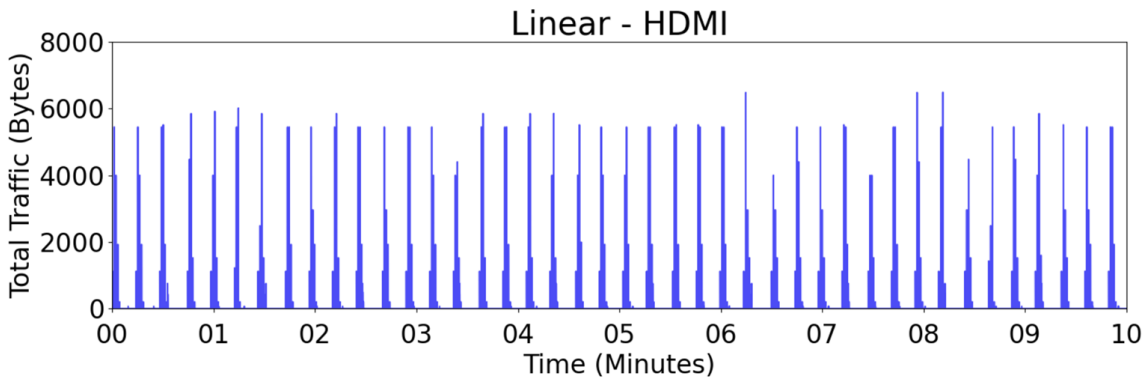


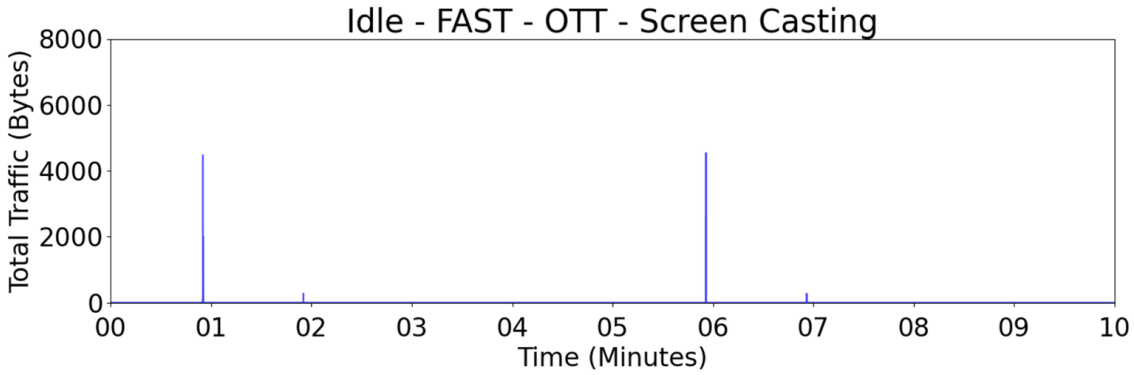
# Methodology

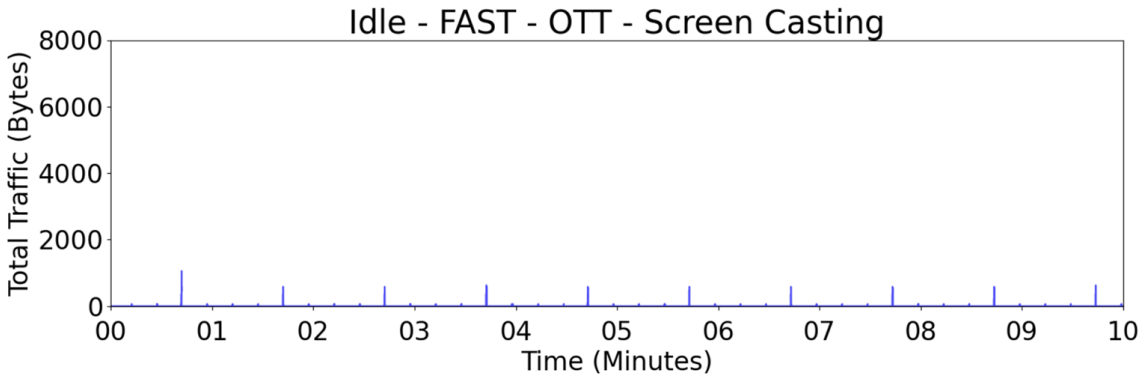


# Results: Comparison across Smart TV



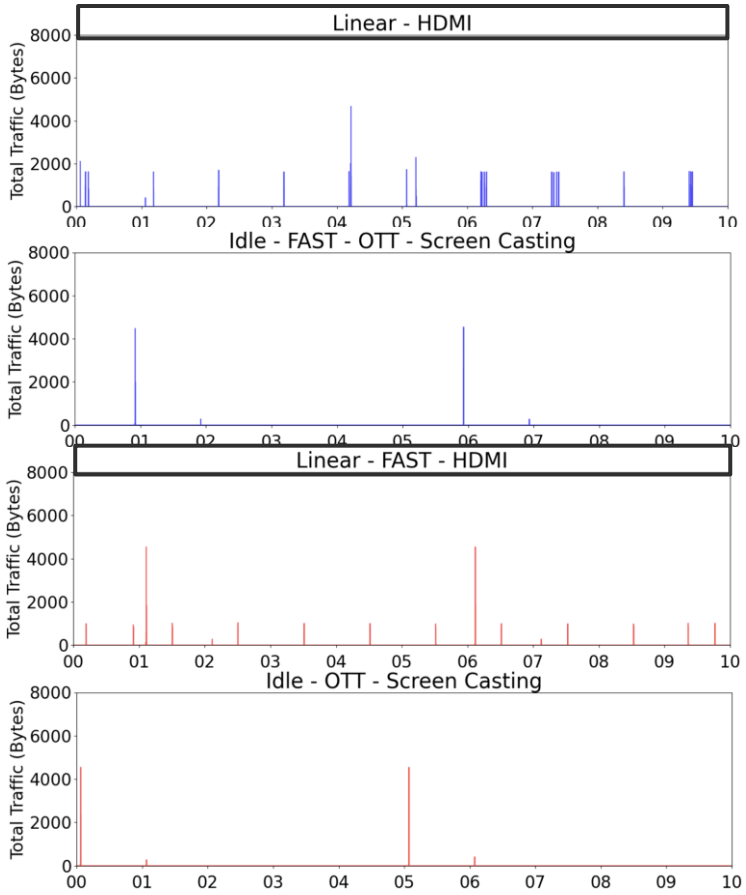



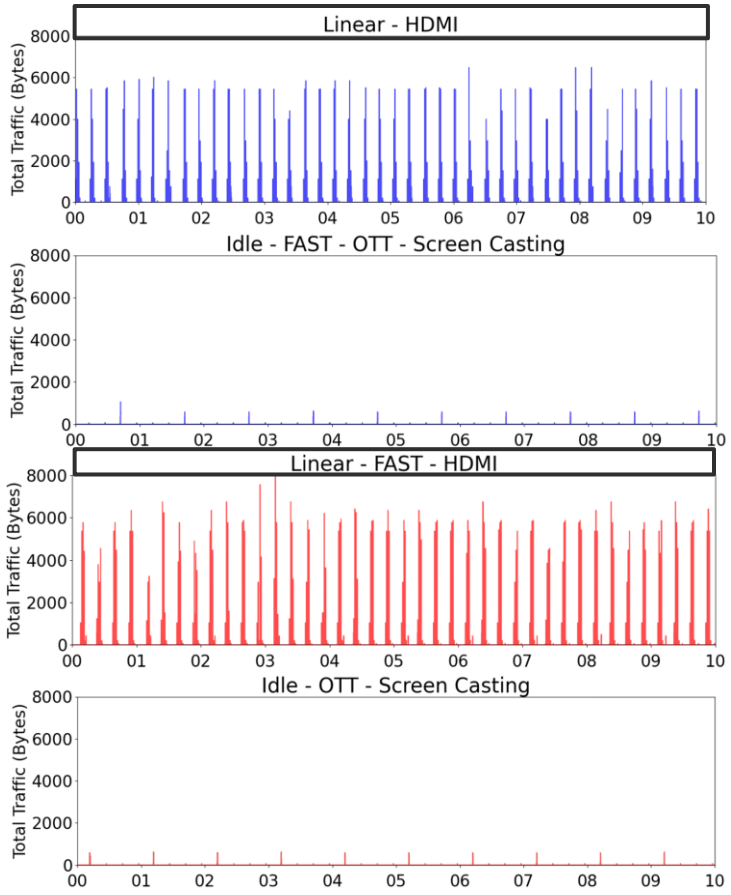

SAMSUNG

LG

# Smart TVs record your screen even *when used* as a “DUMB” display using HDMI

# Results: Comparison across the UK and US




SAMSUNG

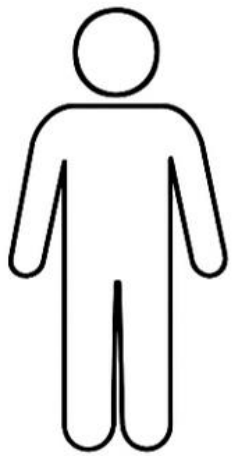
LG

01

# Reasons You Shouldn’t Use Smart Medical Devices

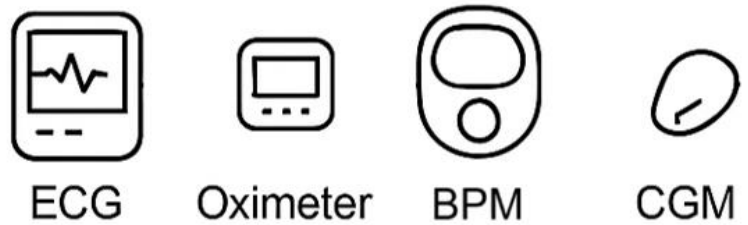
**Victim:**

- Blood pressure lability
- Heart arrhythmia
- Hypoxemia
- Diabetes

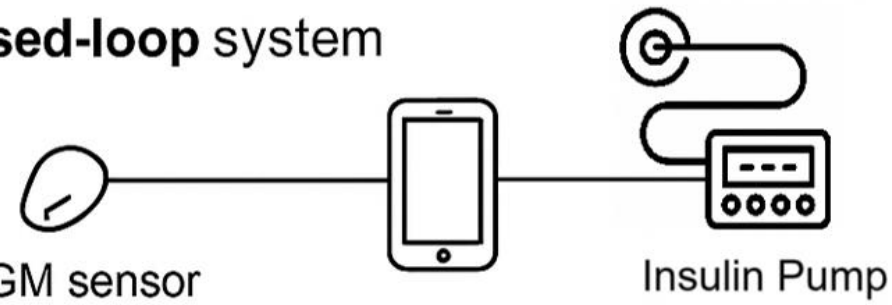


**System:**

**Open-loop** system

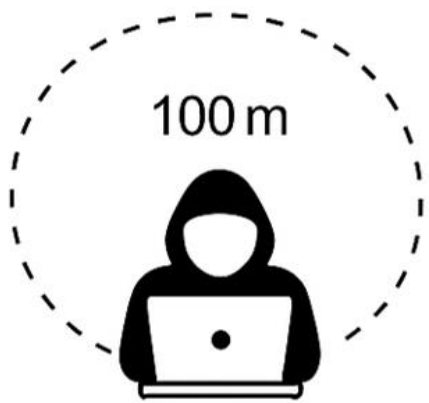



**Closed-loop** system



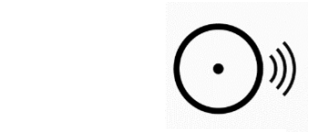

**Adversary:**

BLE 4.0 / BLE 5.0

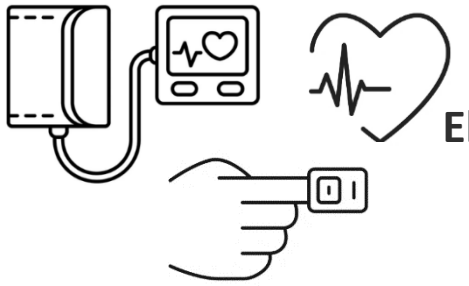



Passive (Sniffing/Eavesdropping) and
Active (MITM, DoS)

Dexcom ONE and
FreeStlye Libre2
**Continious Glocuse Monitors (CGM)**



**Wellue Blood Pressure Monitors (BPM)**



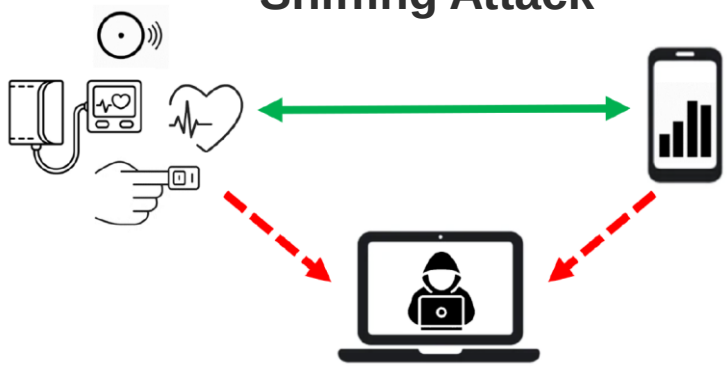
Oxylink and
SleepO2 1400
**Oximeters**

nRF52840 Nordic
Sniffer Dongle

SnapECG and
DuoEK Wellue
**Electrocardiograms (ECG)**

Bluetooth 4.0
Adapter USB
Dongles

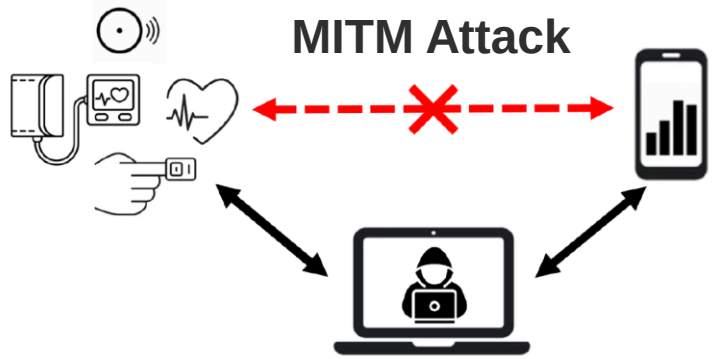
**Sniffing Attack**



iPhone 13
Pro/Google
Pixel 3

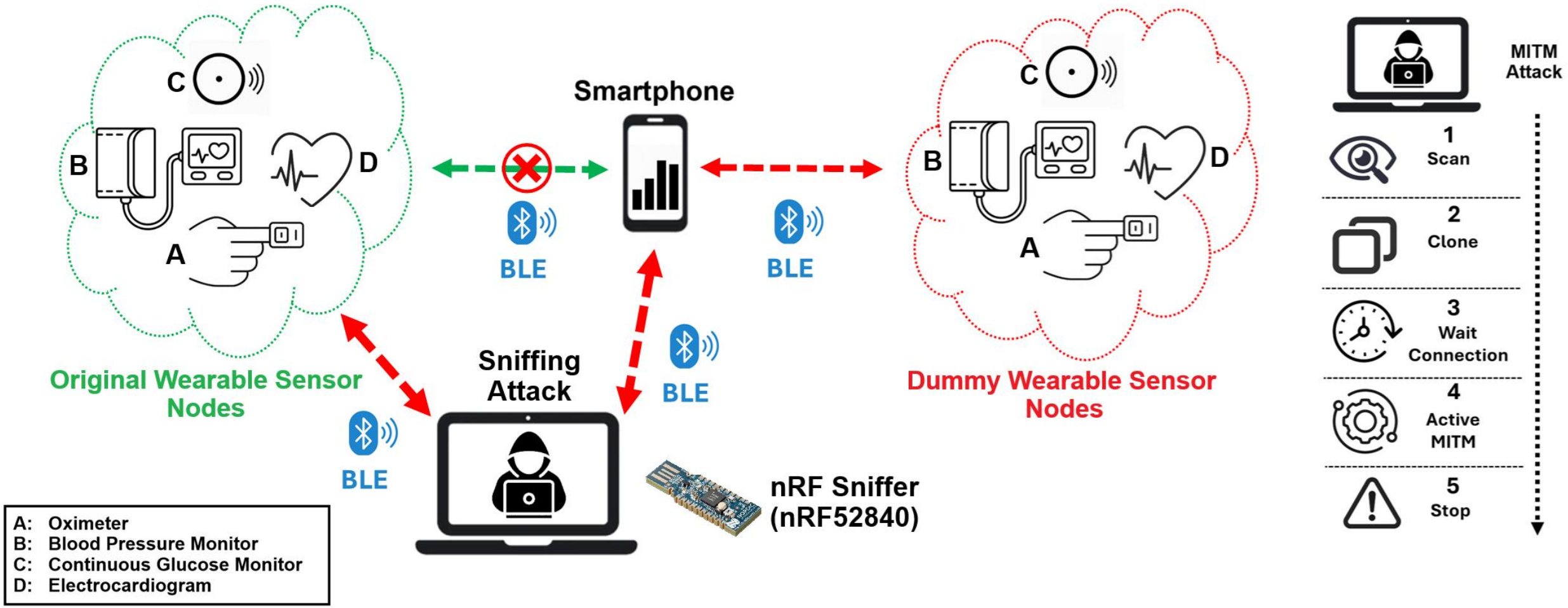
Wireshark Tool

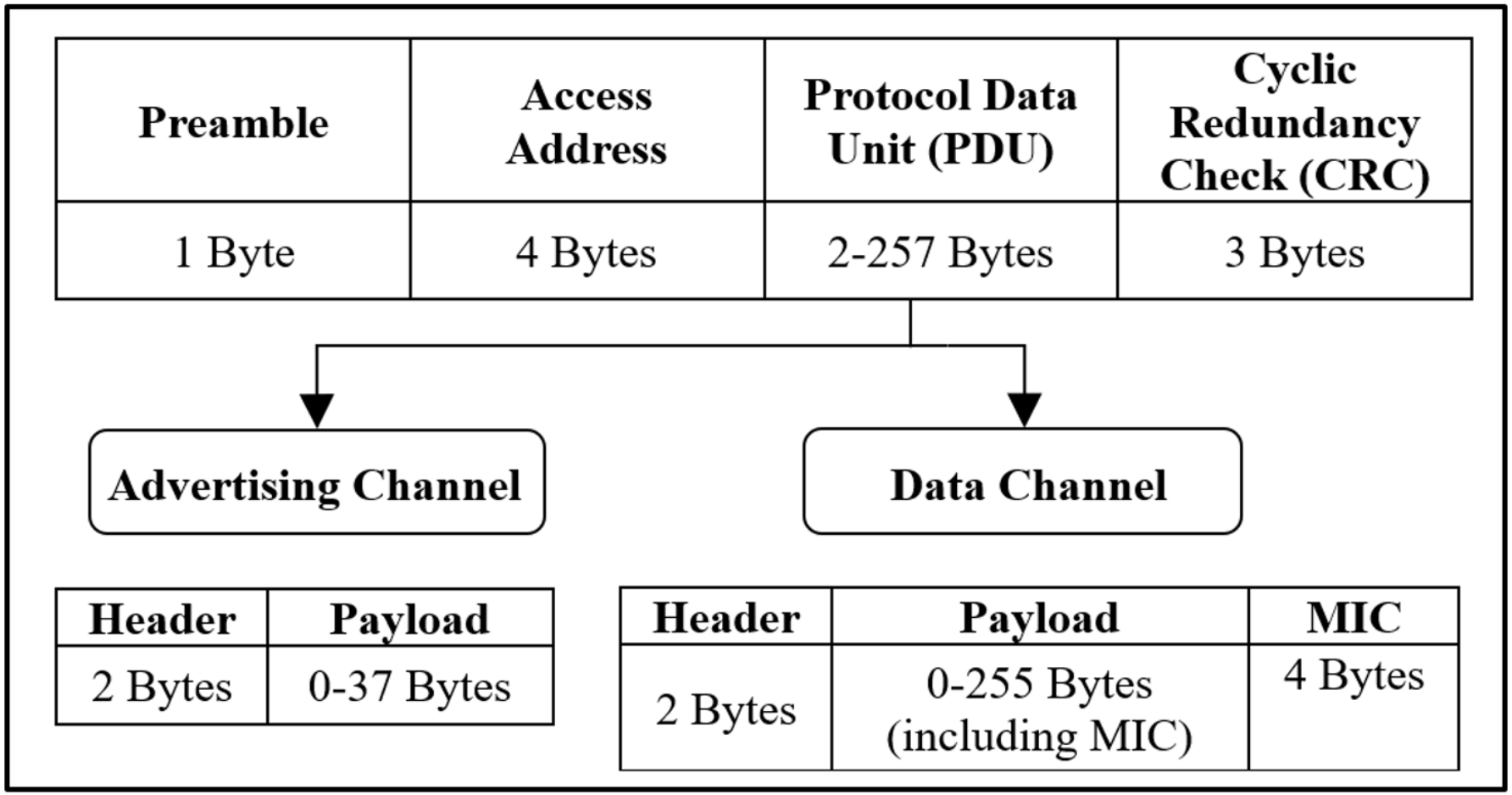
**MITM Attack**



iPhone 13
Pro/Google
Pixel 3

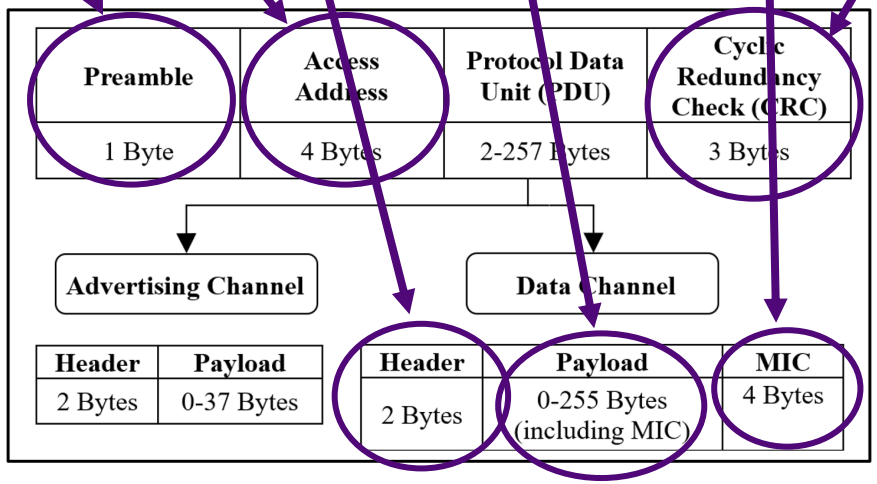
Kali Linux
Mirage Tool


C
B
D
A
Original Wearable Sensor Nodes
Smartphone
BLE
BLE
BLE
BLE
Sniffing Attack
nRF Sniffer (nRF52840)
C
B
D
A
Dummy Wearable Sensor Nodes
MITM Attack
1 Scan
2 Clone
3 Wait Connection
4 Active MITM
5 Stop
A: Oximeter
B: Blood Pressure Monitor
C: Continuous Glucose Monitor
D: Electrocardiogram


Preamble
Access Address
Protocol Data Unit (PDU)
Cyclic Redundancy Check (CRC)
1 Byte
4 Bytes
2-257 Bytes
3 Bytes
Advertising Channel
Data Channel
Header
Payload
2 Bytes
0-37 Bytes
Header
Payload
MIC
2 Bytes
0-255 Bytes (including MIC)
4 Bytes

**Oxylink Oximeter Encrypted Payload Content**:

Handle “0x19”: 5500ff00000d00615e00000000004200070e0100




615e00000000

61 (hex) = 97 (dec)

97% Oxygen Level

5e (hex) = 94 (dec)

94/min Heart Rate

**???**

**Original:** Handle “0x19”: 5500ff00000d00615e00000000004200070e0100

**Key:** “39”

**Replay:** Handle “0x19”: 5500ff00000d00604100000000005500000501 00

**Key:** “db”

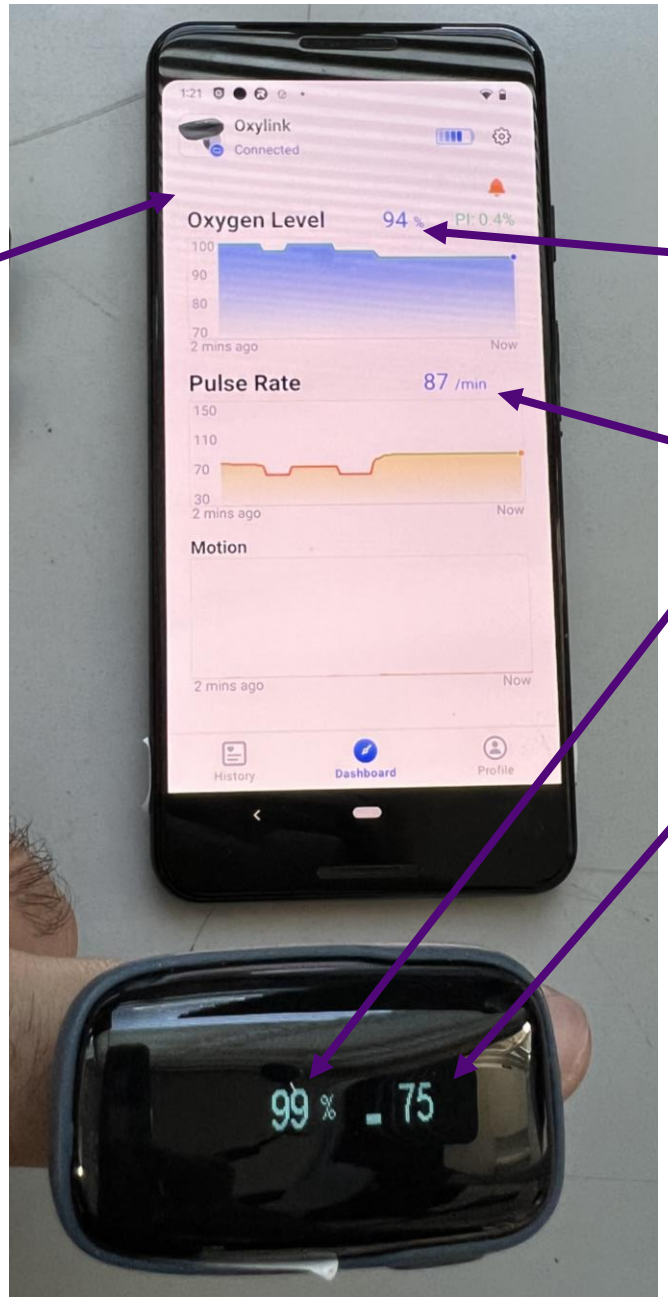
60 (hex) = 96 (dec)

96% Oxygen Level

41 (hex) = 65 (dec)

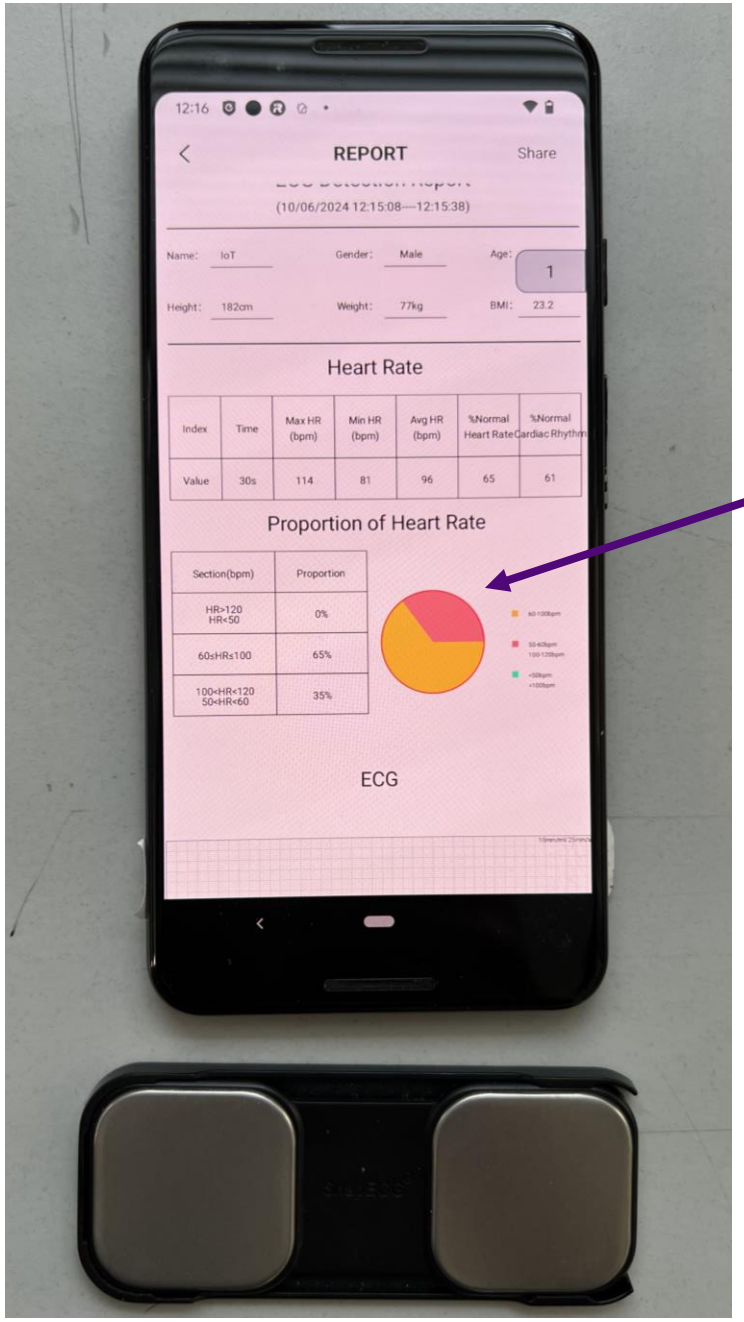
65/min Heart Rate

ViHealth App
Real-time Data
Manipulation

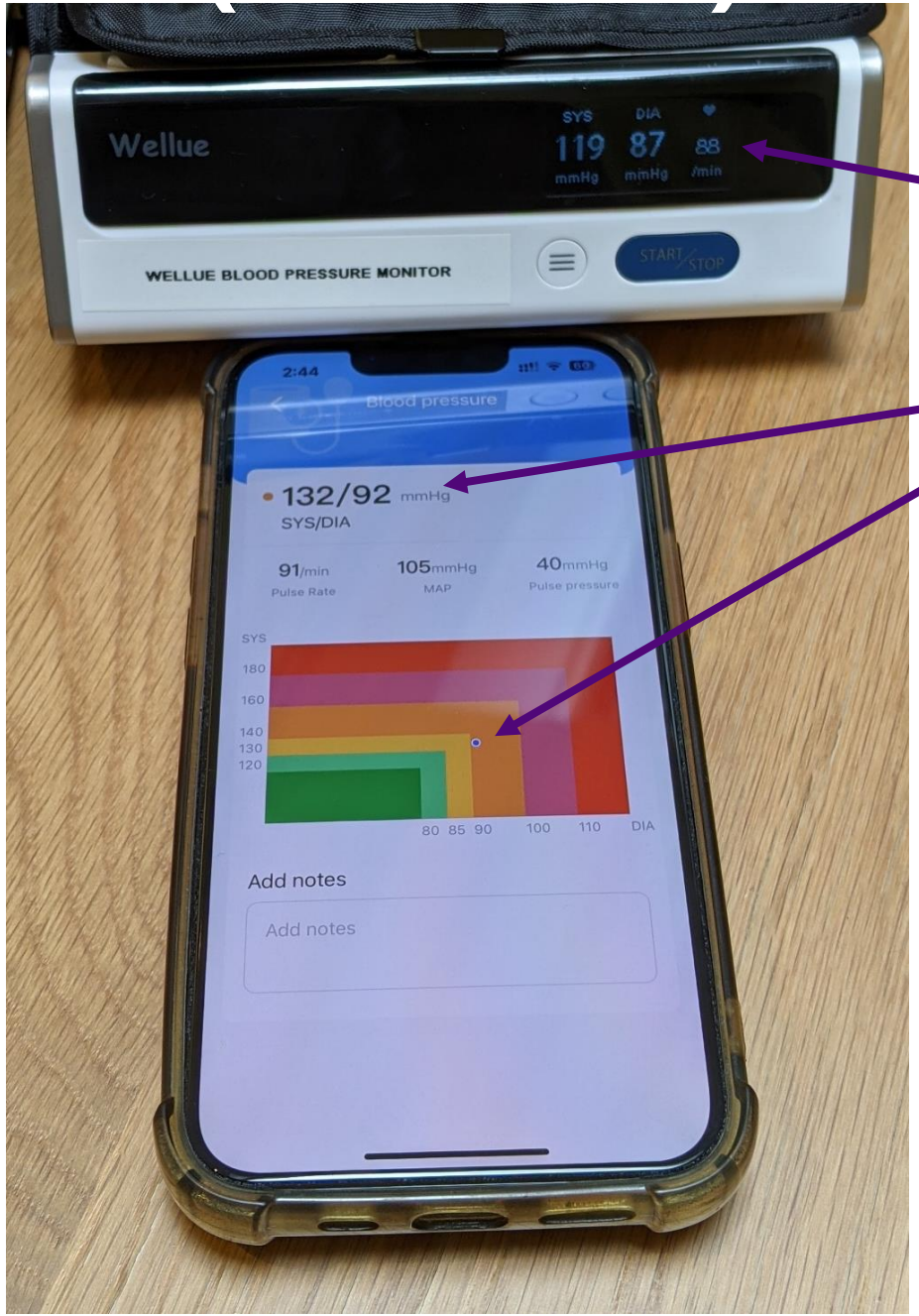



Oxygen Level
Manipulation

Pulse Rate
Manipulation




Unhealthy Report




Typical Normal Reading

Hypertension Stage 1

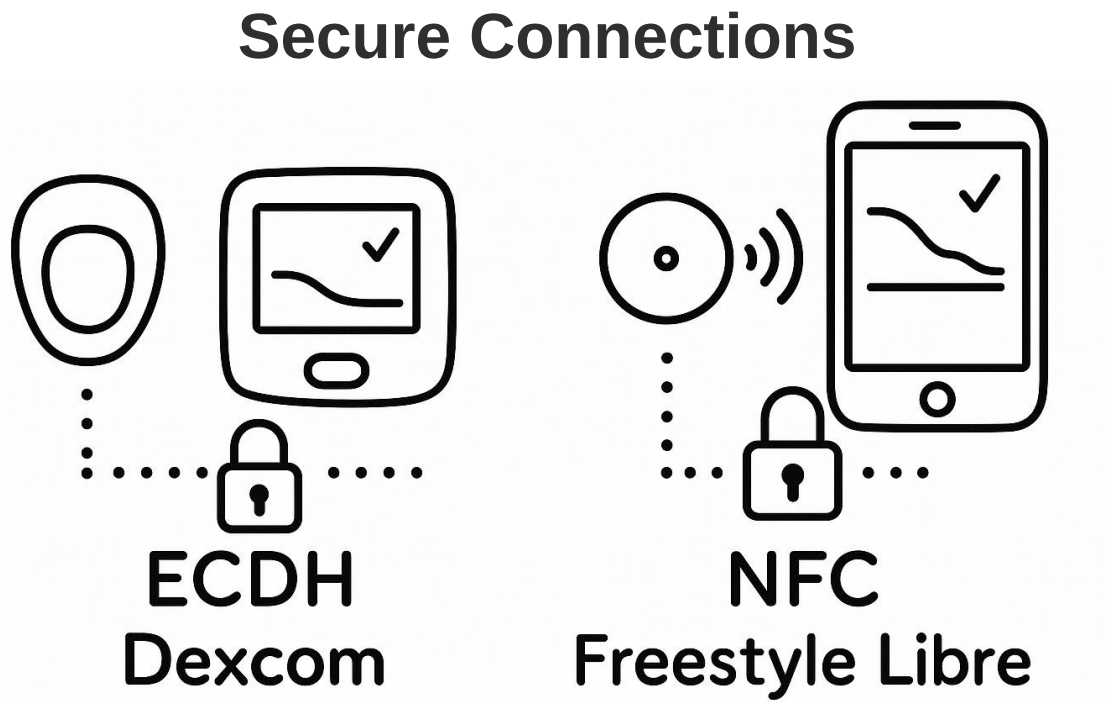
Secure Connections (for initial pairing and keys exchange):

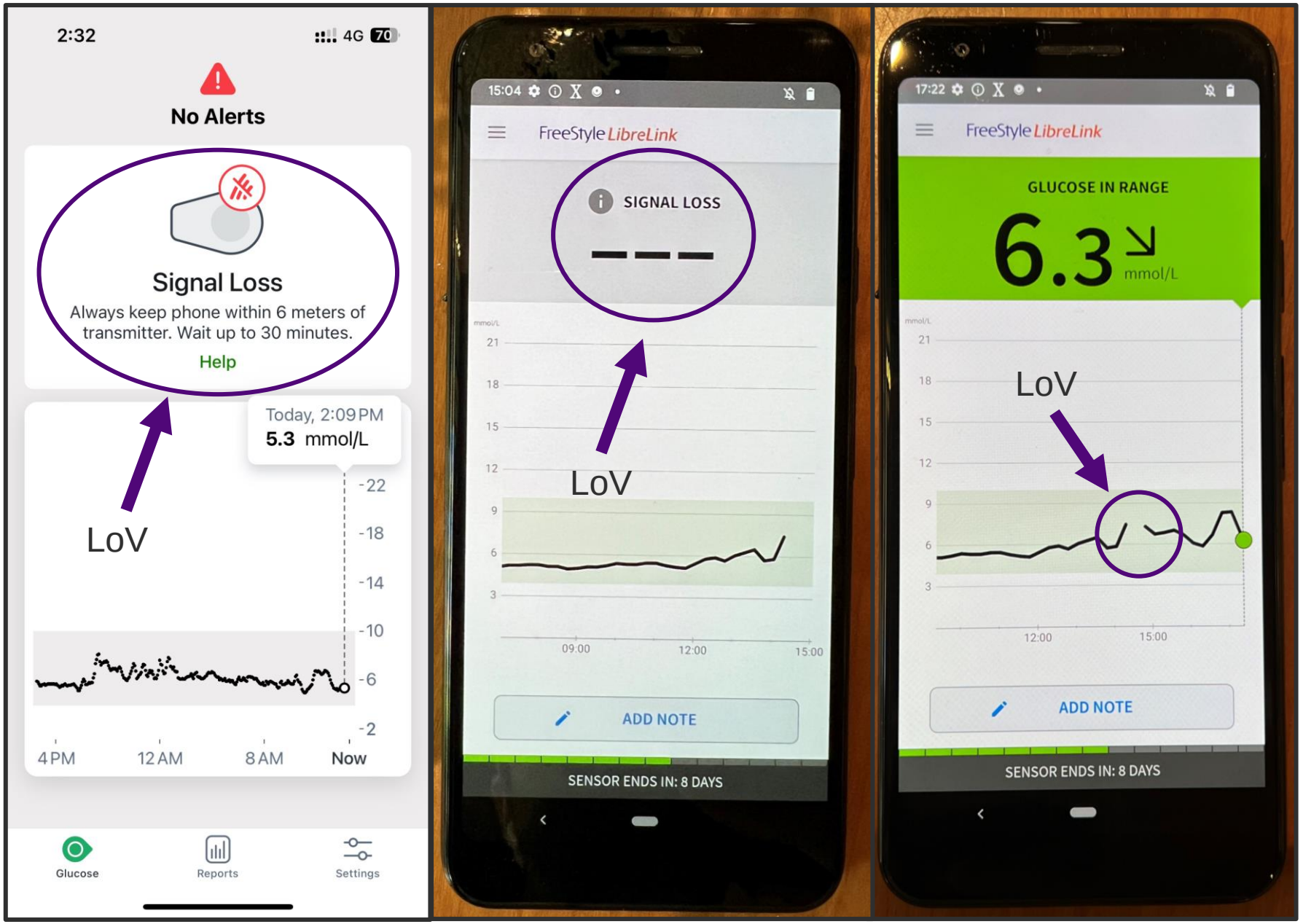
- **Elliptic Curve Diffie-Hellman (ECDH)**.

  → Private keys → Public keys → ECDH → Shared secret →
  KDFs → rand → EDIV → IVs →


Session key

- **Near Field Communication (NFC)**.

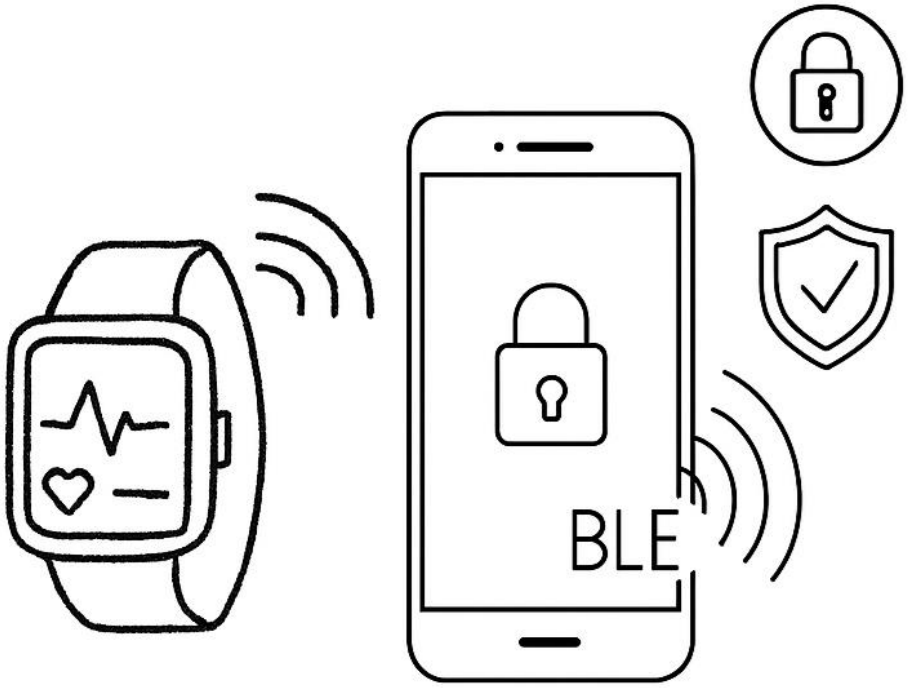



2:32
4G
No Alerts
Signal Loss
Always keep phone within 6 meters of transmitter. Wait up to 30 minutes.
Help
Today, 2:09 PM
5.3 mmol/L
LoV
22
18
14
10
6
2
4 PM
12 AM
8 AM
Now
Glucose
Reports
Settings
15:04
FreeStyle LibreLink
SIGNAL LOSS
LoV
21
18
15
12
9
6
3
09:00
12:00
15:00
ADD NOTE
SENSOR ENDS IN: 8 DAYS
17:22
FreeStyle LibreLink
GLUCOSE IN RANGE
6.3
mmol/L
LoV
21
18
15
12
9
6
3
12:00
15:00
ADD NOTE
SENSOR ENDS IN: 8 DAYS

| Devices | Types of Attacks | | | |
|---|---|---|---|---|
| | Sniffing (Eavesdropping) | Passive MITM (Eavesdropping) | Active MITM (Data Manipulation) | DoS (Loss of View) |
| SnapECG **(ECG)** | ✓ | ✓ | ✓ | ✓ |
| DuoEK Wellue **(ECG)** | ✓ | ✗ | ✗ | ✓ |
| OXYLINK **(Oximeter)** | ✓ | ✓ | ✓ | ✓ |
| SleepO2 1400 **(Oximeter)** | ✓ | ✓ | ✓ | ✓ |
| Wellue BP2A 2031 **(BPM)** | ✓ | ✓ | ✓ | ✓ |
| Dexcom ONE **(CGM)** | ✓ | ✗ | ✗ | ✓ |
| FreeStyle Libre 2 **(CGM)** | ✓ | ✗ | ✗ | ✓ |

- Significant **vulnerabilities** in BLE-enabled Wearable Sensor Nodes.

- Recommendations for **improving security**:
  - Stronger encryption
  - Multi-layered approach
  - Secure authentication
  - Real-time monitoring of device performance and security status.
- Call to action for **manufacturers & stakeholders** to address these issues.



# Agenda

01 **Problem: IoT Devices Expose Information Over the Internet**

Reasons you shouldn’t watch TV
Reasons you shouldn’t use smart medical devices.

02 **Privacy and Security Certification/Regulation**

EU Cyber Resilience Act (CRA)
GDPR

03 **IoT Automating Testing and Compliance**

IoTrim ++
Black box assessment

04 **Standards**

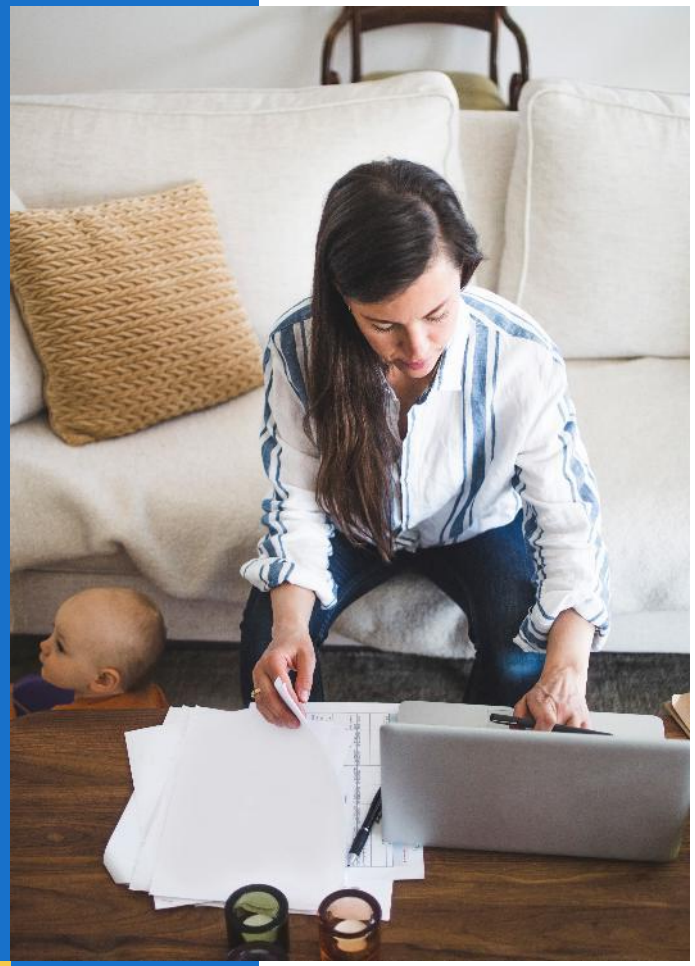
Standardization request
ETSI/CEN-CENELC WGs

05 **Gaps**

IoT Manufactures
SMEs

06 **Conclusion**

What’s next?



02

# Big Mess?

# EU Cyber Resilience Act (CRA)

- In the general case, they will do a self-assesment
- If their product is on the list of “important” products, they will either need to follow standards or do a third-party assessment
- If their product is on the critical list, they will need to undergo a third-party assessment and possibly be certified in the future.
- FOSS (Free and Open Source Software) products do self assessments except for critical products

# GDPR

- Information Commissioner's Office (ICO) IoT guidelines [to be released in June for consultation]
- IoT device manufacturers must ensure data protection by design and by default
- They are obligated to provide clear, accessible information to users about data collection

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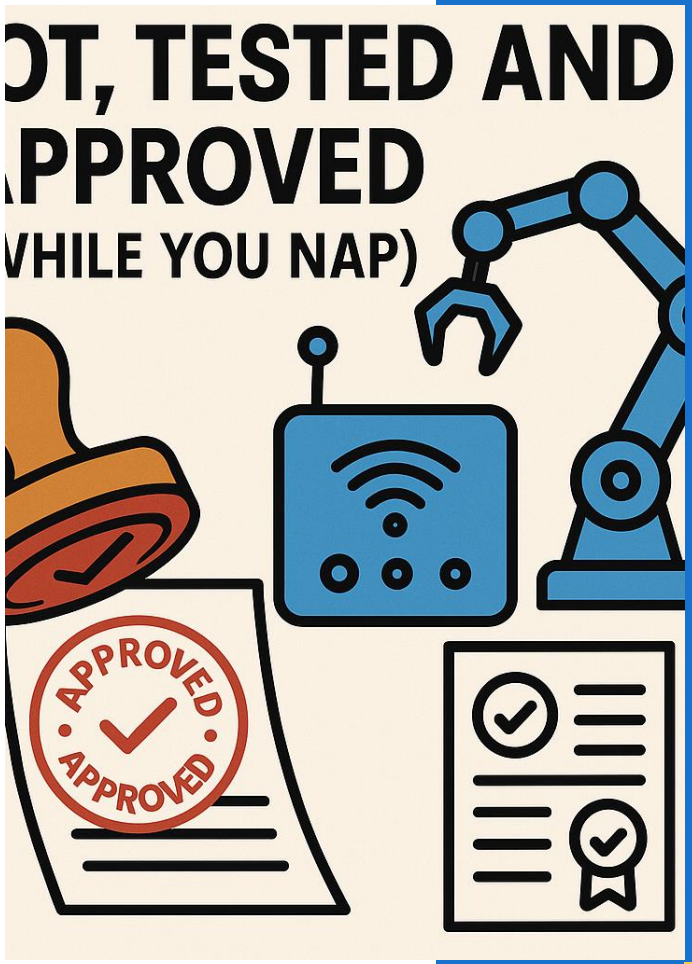
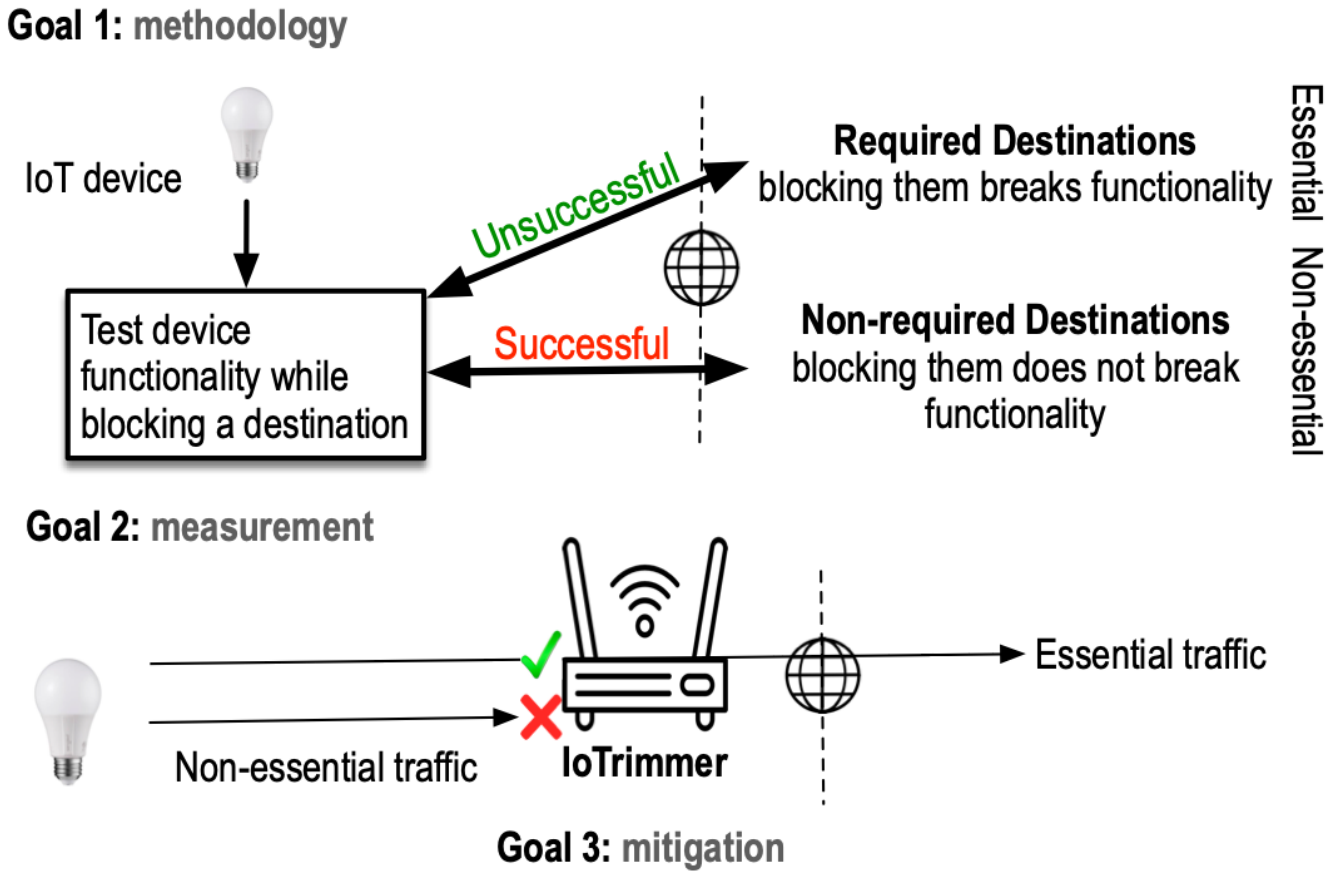
# Compliance Without Tears: Let the IoT Do It



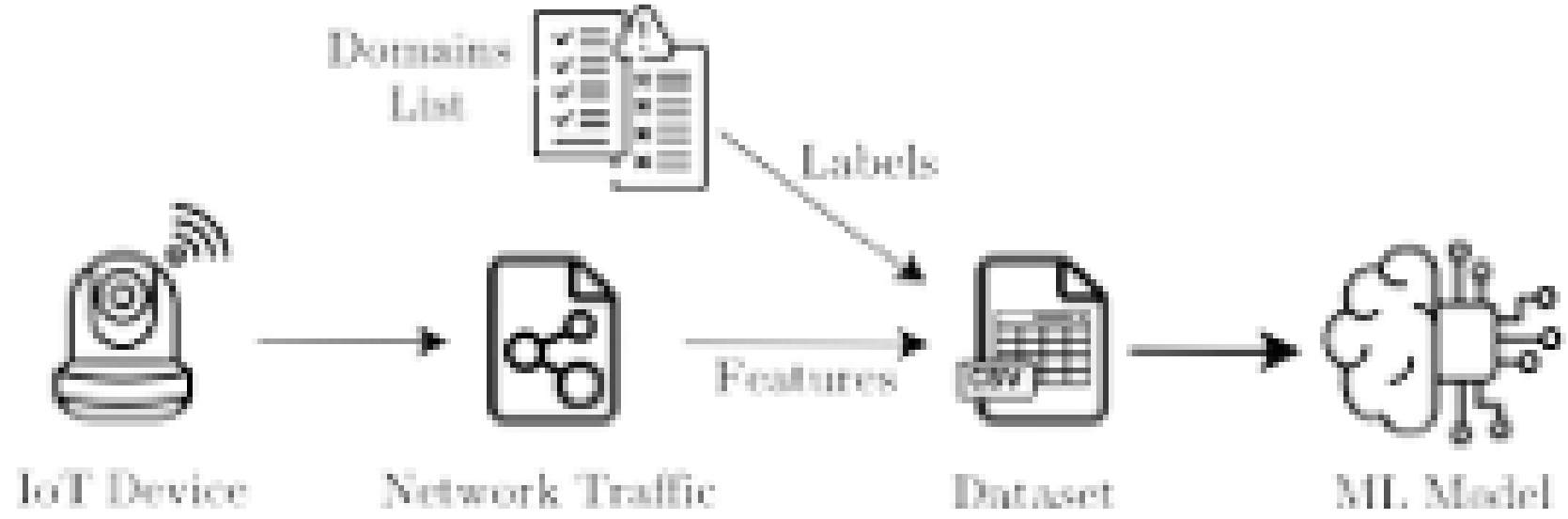
# IoTrim++



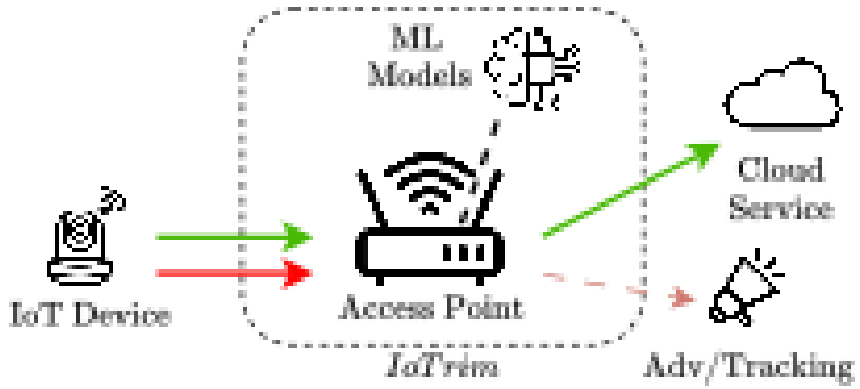

/ Generalizable

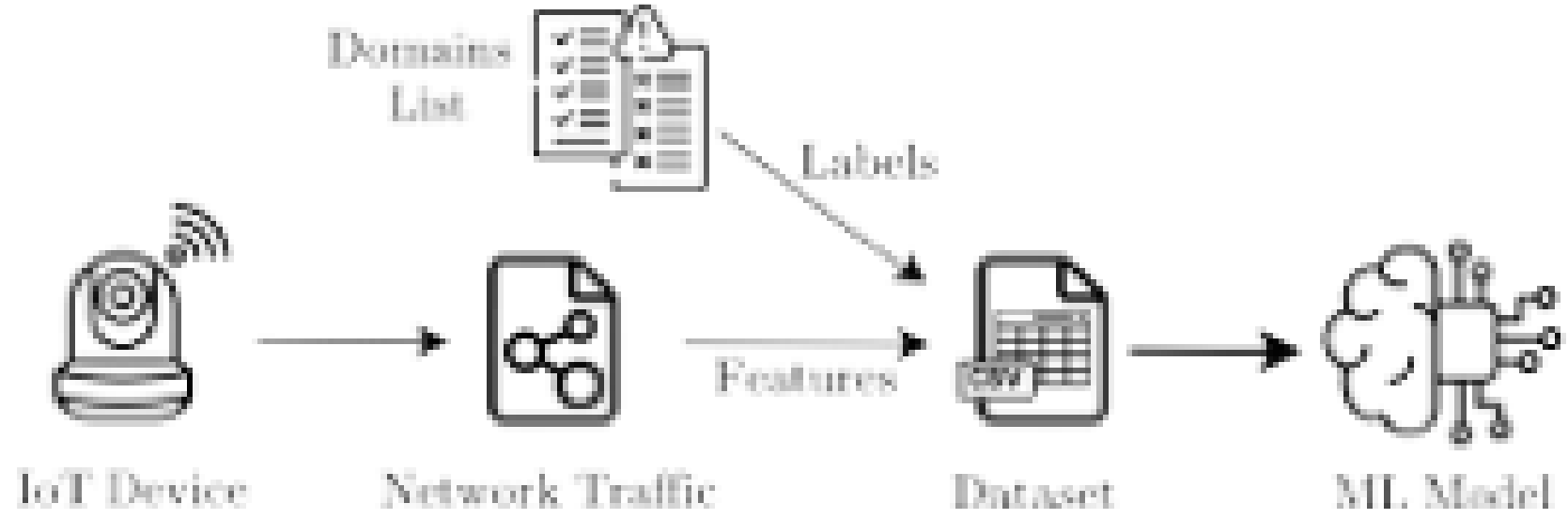
/ Self adaptive

/ Accurate IoT blocker




# Automatically detecting non-essential destinations



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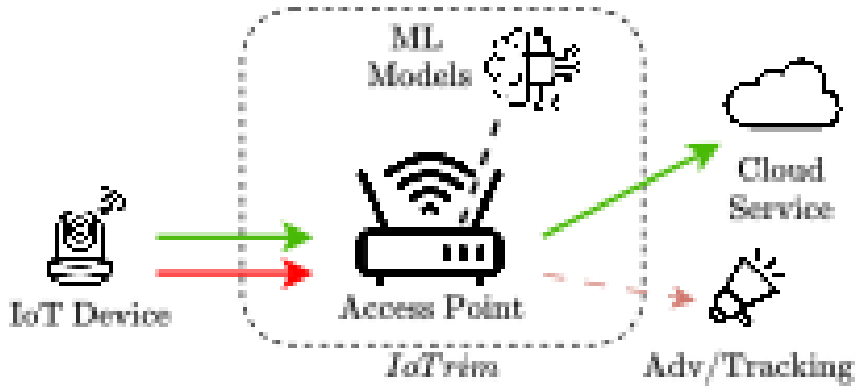

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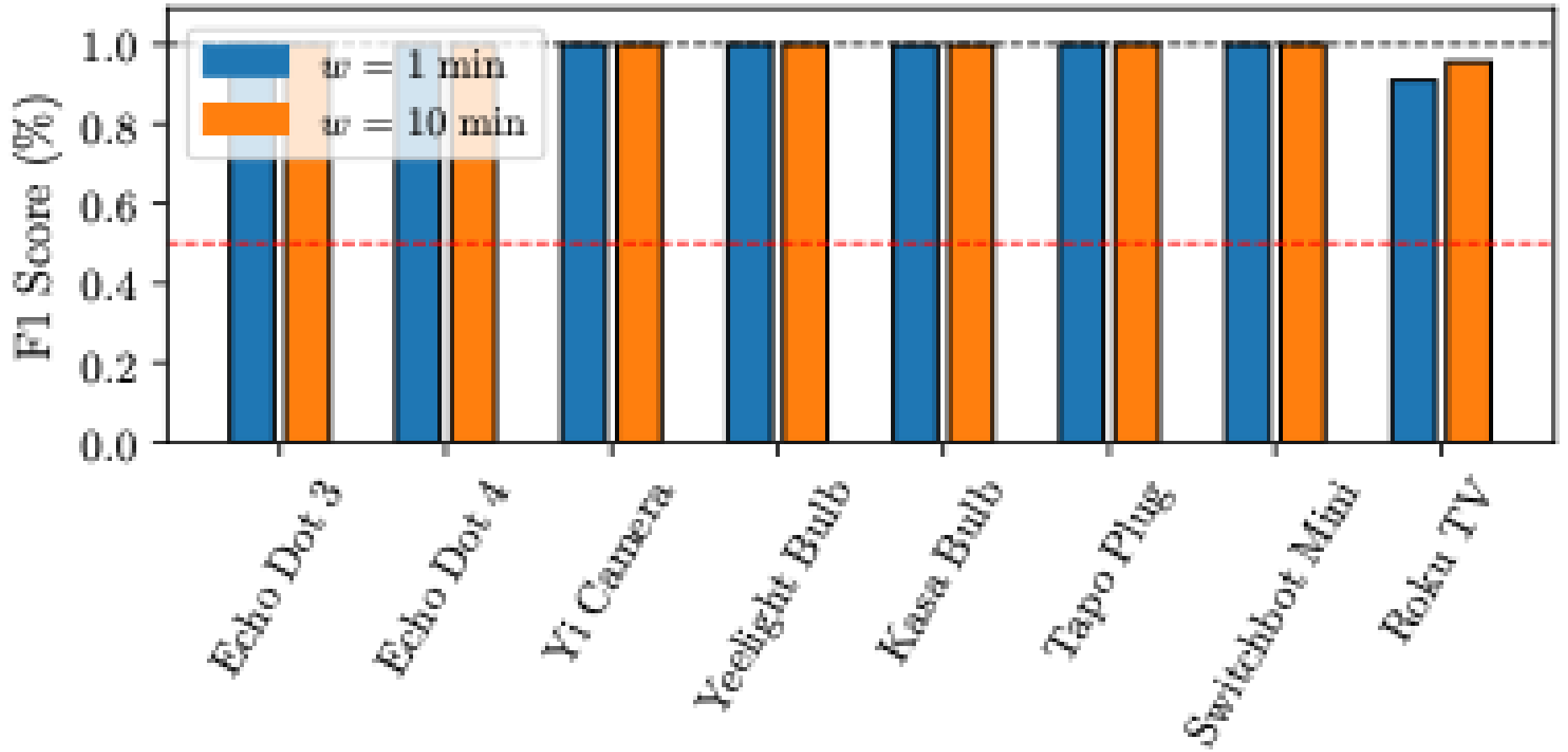
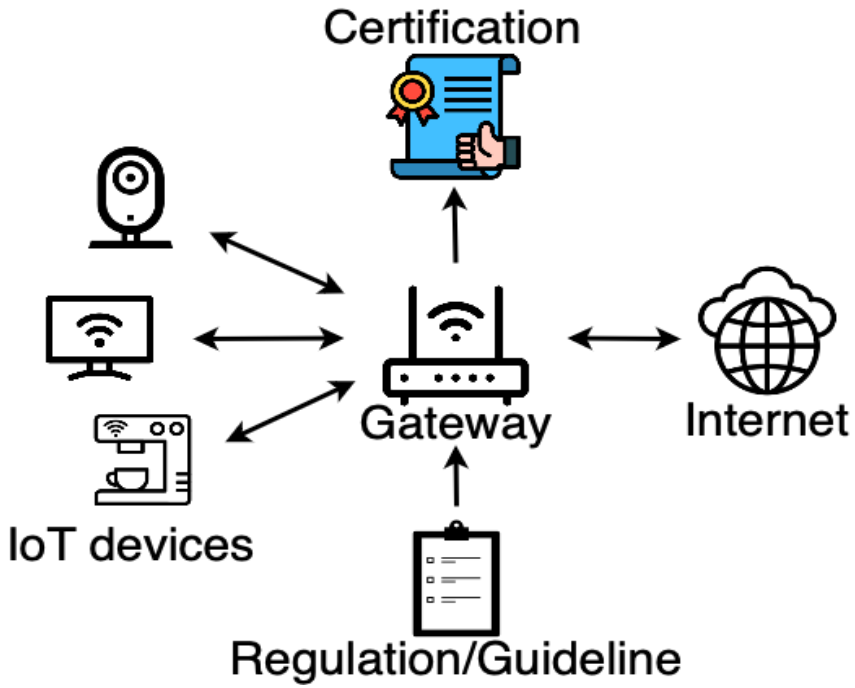
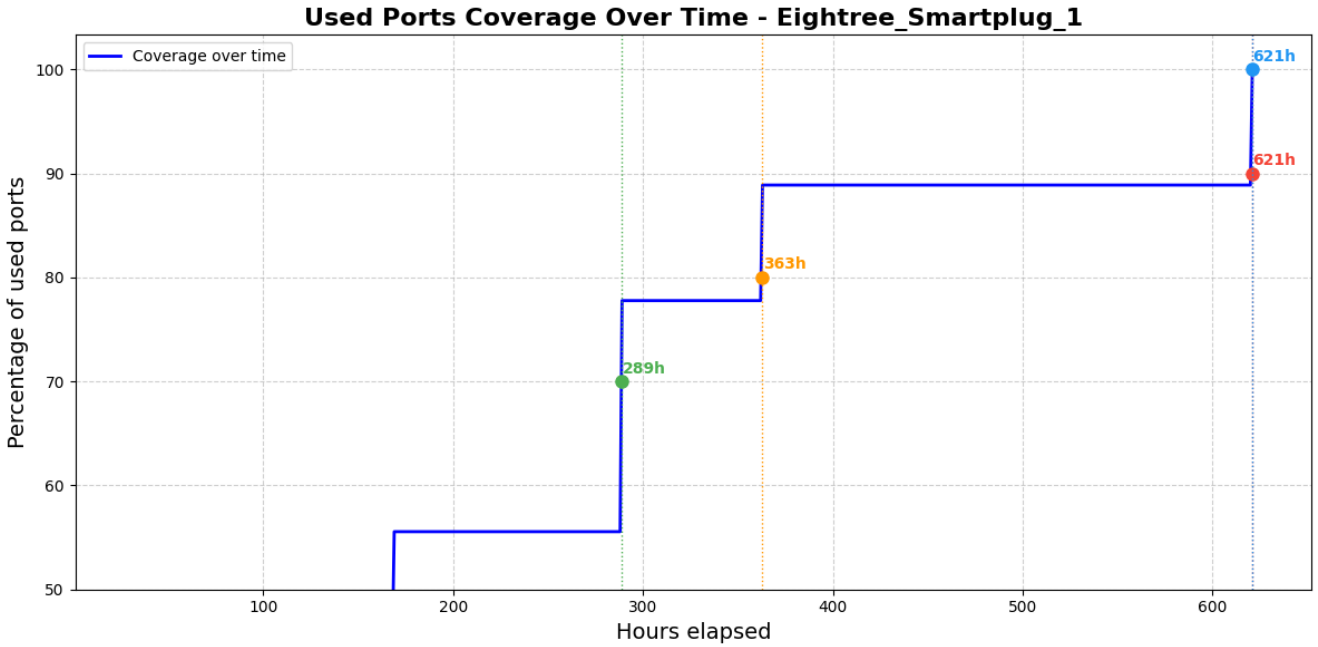


# Black Box Assessment

Select security guidelines and privacy regulations → Turn them into metrics → Define experiments to test the extracted metrics on IoT devices → Produce a certification label for the tested device




# Testing Requirements

For how long do we need to test the device?

Used Ports

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# When in Doubt, Create Another Standard!

# CRA Standardization Effort

## Current Focus Areas

- Mapping existing standards to CRA requirements
- Defining **secure lifecycle processes** for digital products
- Ensuring **interoperability** and **compliance frameworks**
- Supporting **conformity assessment** procedures

## Impact

- Streamlined compliance for EU manufacturers
- Stronger cybersecurity baseline across digital products
- Cross-sector adoption of harmonized security standards

## ETSI

- Leading development of technical standards and specifications for ICT
- Key standards: ETSI EN 303 645 (IoT security baseline)

## CEN-CENELEC

- Aligning and integrating standards into the EU regulatory framework
- Developing Harmonized Standards (HAS) for CRA compliance
  Coordinating with EC and stakeholders through JTC 13 (Cybersecurity & Data Protection)

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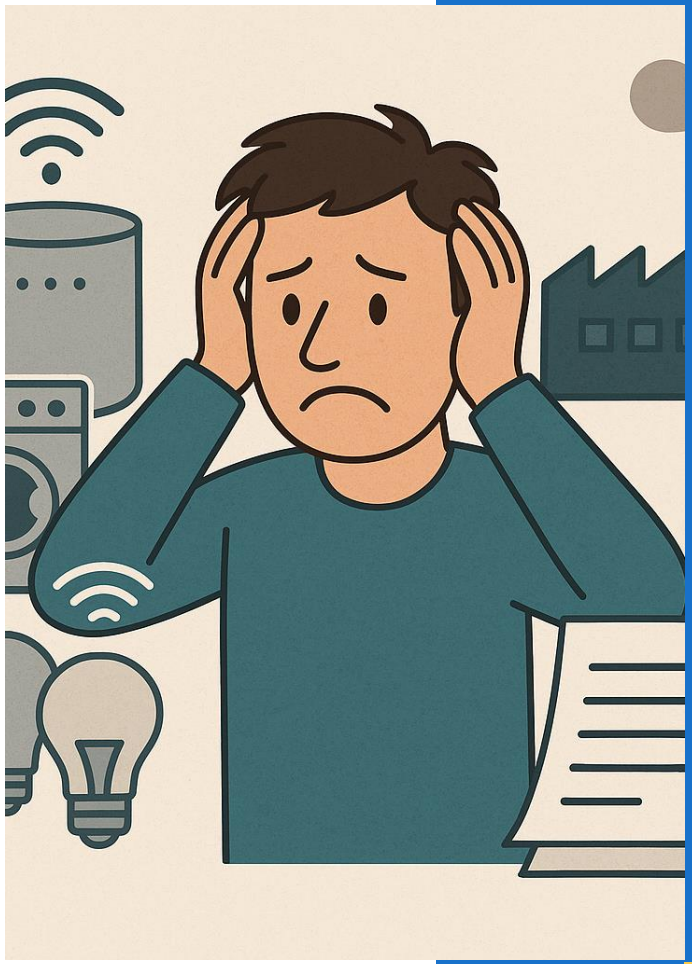
# When Your Toaster Is Smarter Than Your Compliance Process



# Gap

IoT Manufactures and SMEs need help!

# Gap

How can we create a standard based on network behaviour of IoT devices?

# Helping Manufacturers and SMEs to be Automatically Compliant

## Mulini

One click. More security and privacy.

## RIPE NCC Community Projects Fund

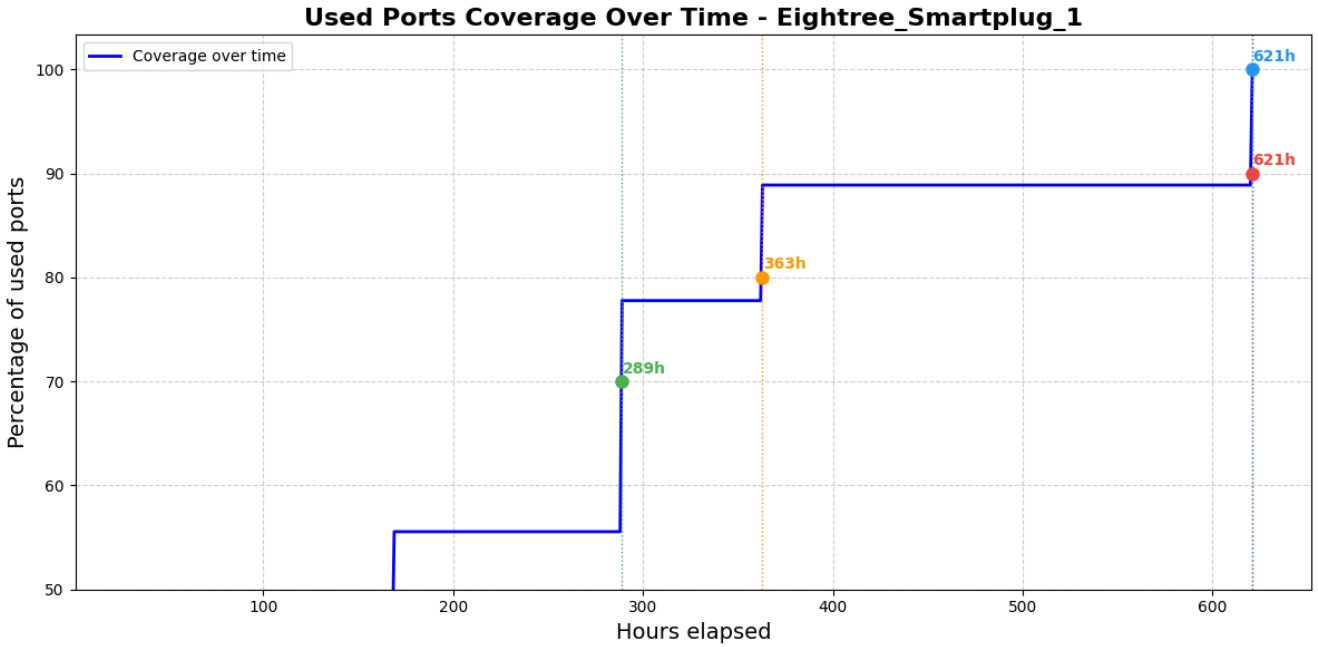
The project automates IoT security checks using machine learning and real-world monitoring to ensure compliance with cybersecurity standards.

## Final Goal

Open tool for developers and regulatory compliance auditors for independent compliance checking and security threat detection.

## Stakeholders involvement

SMEs
IoT Manufacturers
Policy Makers

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# Help!

If interested, please get in touch!

Internet of Things Working Group

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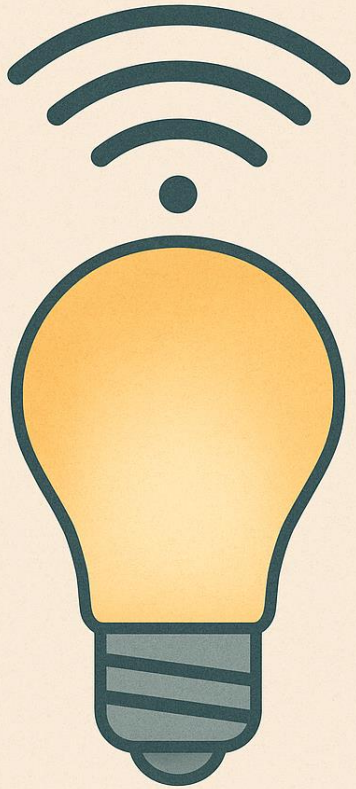


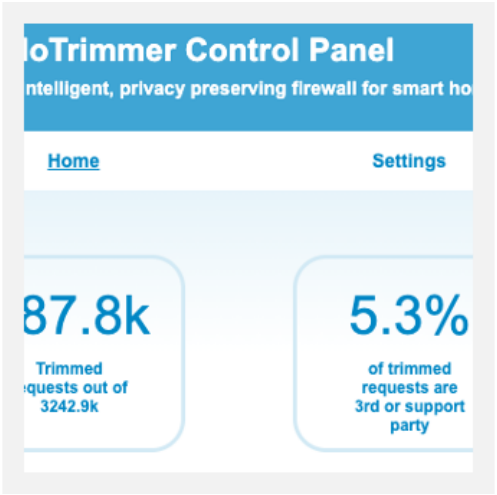
06

# Making Compliance So Easy, Even Your Lightbulb Could Do It

# What's Next?

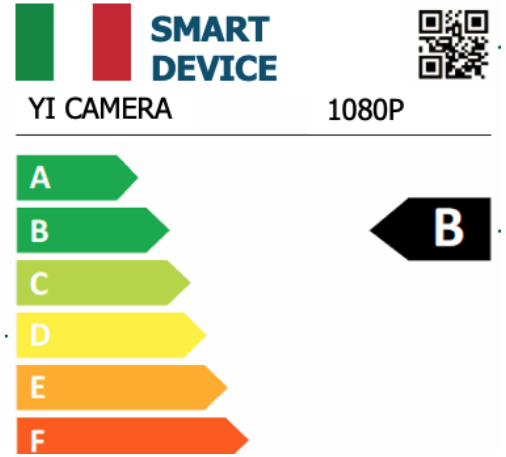
**Privacy Preserving IoT Security Management**

- Real IoT gateway




**Mitigation**

- Real deployment and evaluation
- Third party certification




**Privacy and Security Label/Certification**

- Privacy and security by default
- Shared Database privacy and security vulnerabilities of IoT

# Thank You

mulini