Et Tu Alexa?
When Commodity WiFi Devices Turn into Adversarial Motion Sensors

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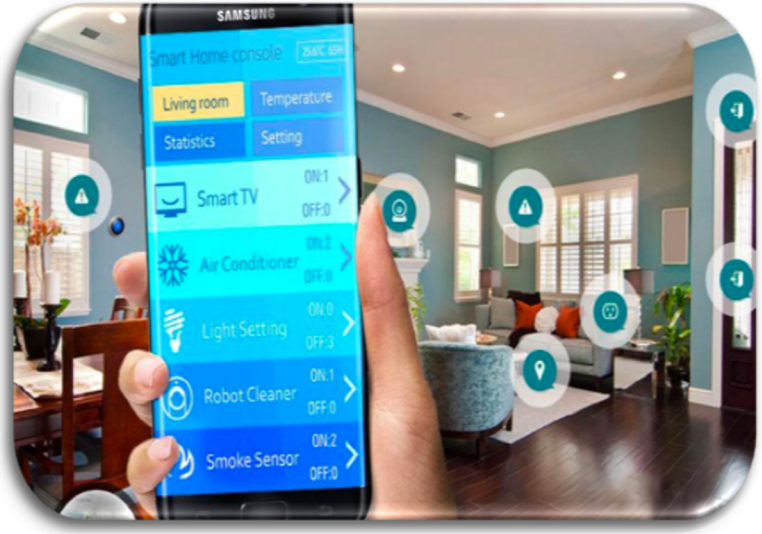
Smart Devices are Everywhere

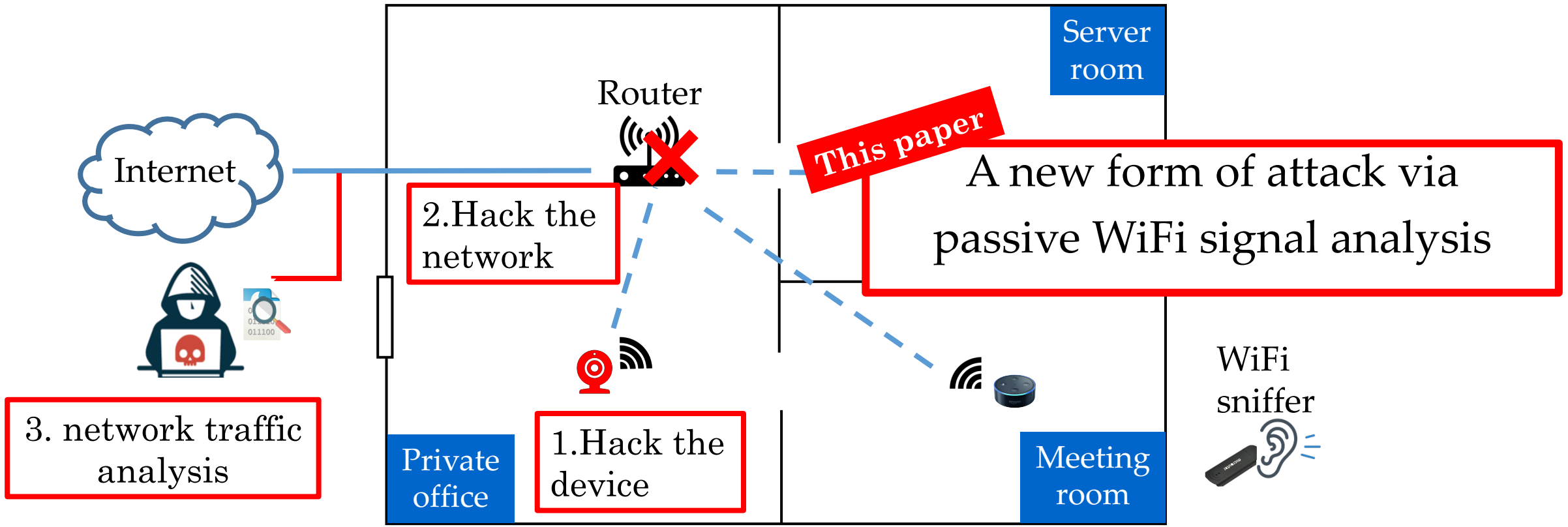


Smart Home

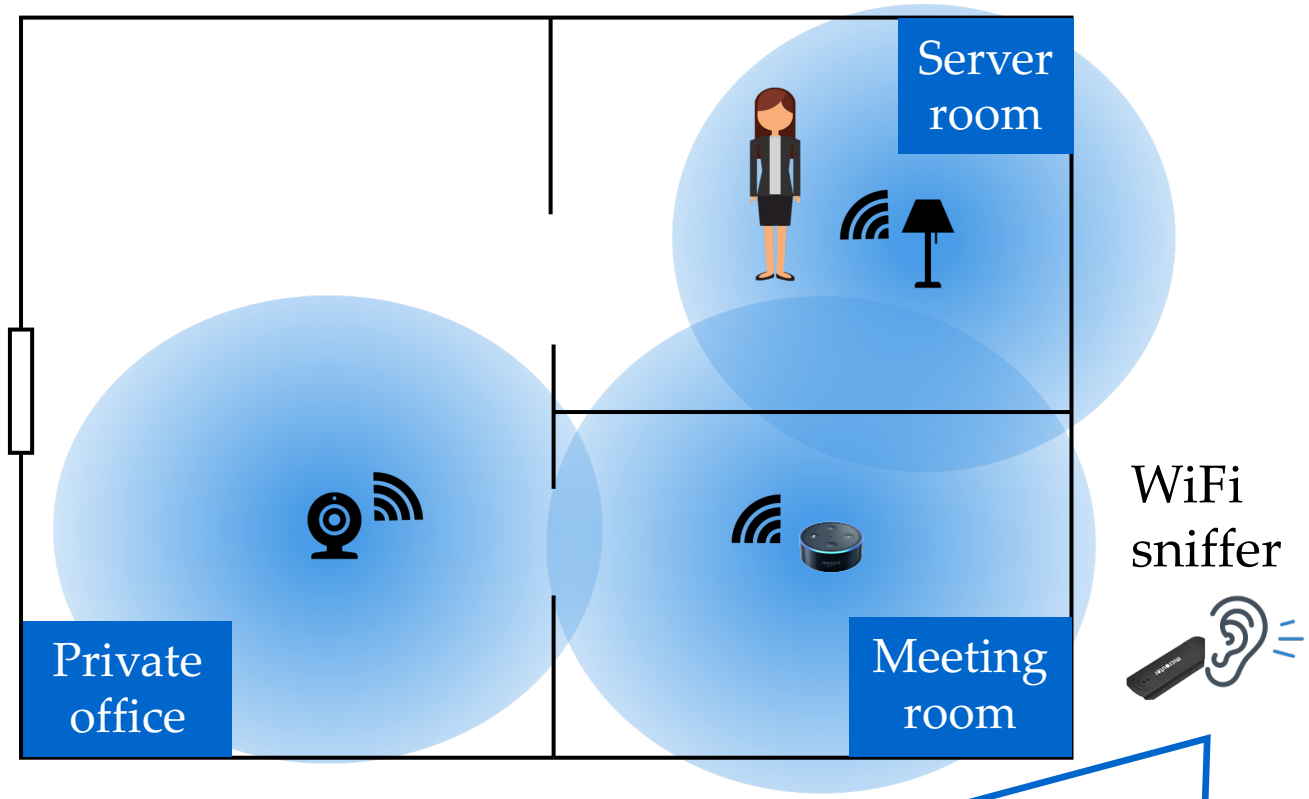
Smart Factory

Smart Office

Attacks Enabled by Smart Devices



Silent Reconnaissance Attack



Continuous motion tracking:

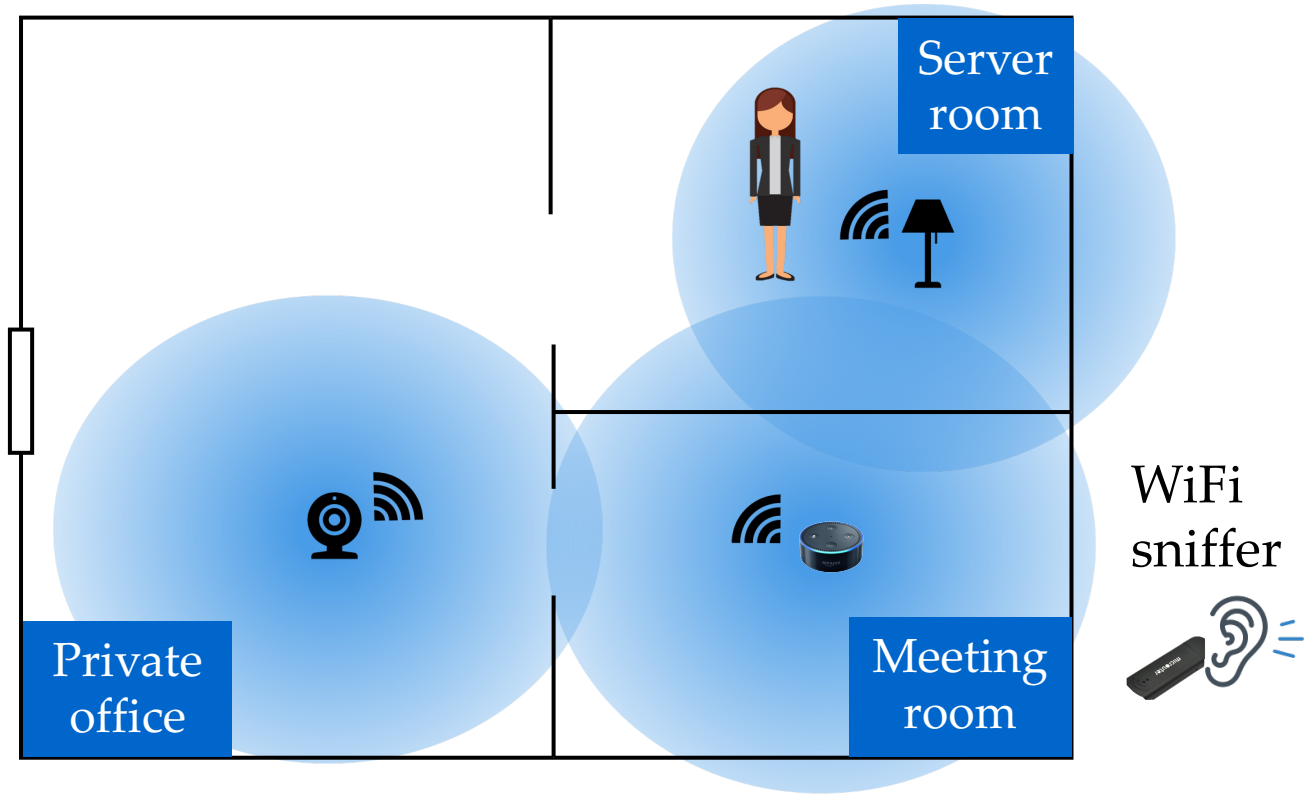
13:35:00 move in server room

13:45:00 leave server room

13:45:20 move in private office

13:55:20 leave private office

Silent Reconnaissance Attack

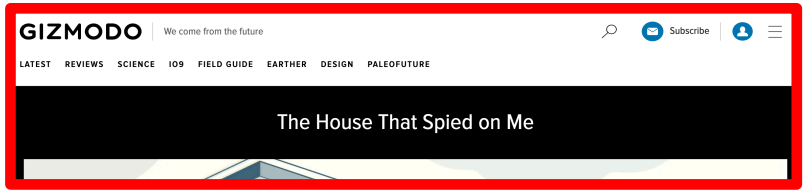


Reconnaissance attack via listening to (w/o decoding) WiFi signals

Leveraging Two Facts

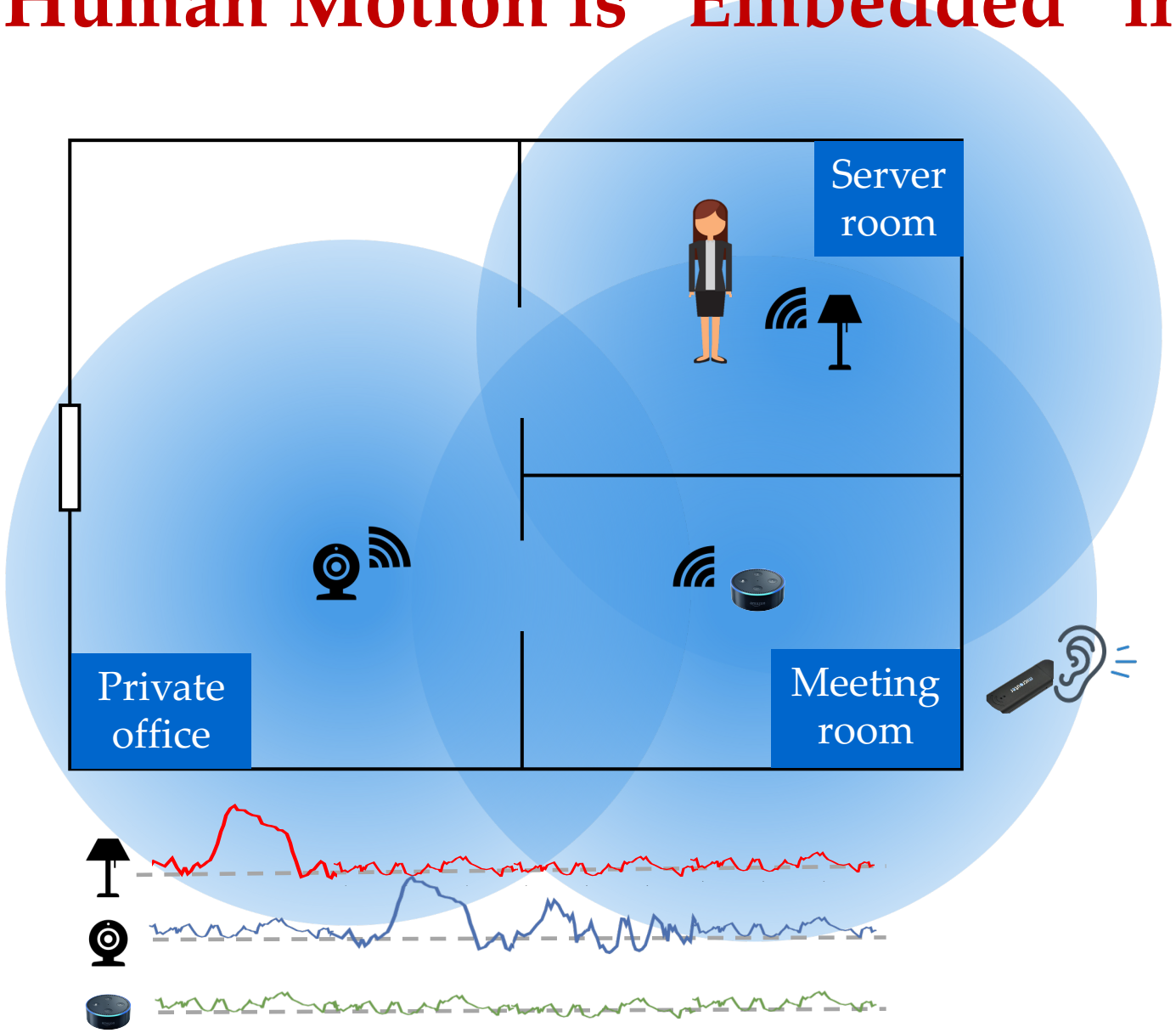
(1) Smart devices are filling our home/office/factory; each room has multiple devices.

(2) Smart devices transmit WiFi data regularly.



Device	Packets sent per second	
	Active	Idle
	108	≥ 0.5
	16	2
	200	6.64
	≥ 3.33	≥ 2.44
	257	28.6

Human Motion is "Embedded" in Ambient WiFi Signals



Ambient WiFi signals fluctuate when humans move.

Sniffer captures such fluctuation.

Threat model:

1. Non-intrusive
2. Undetectable

Outline

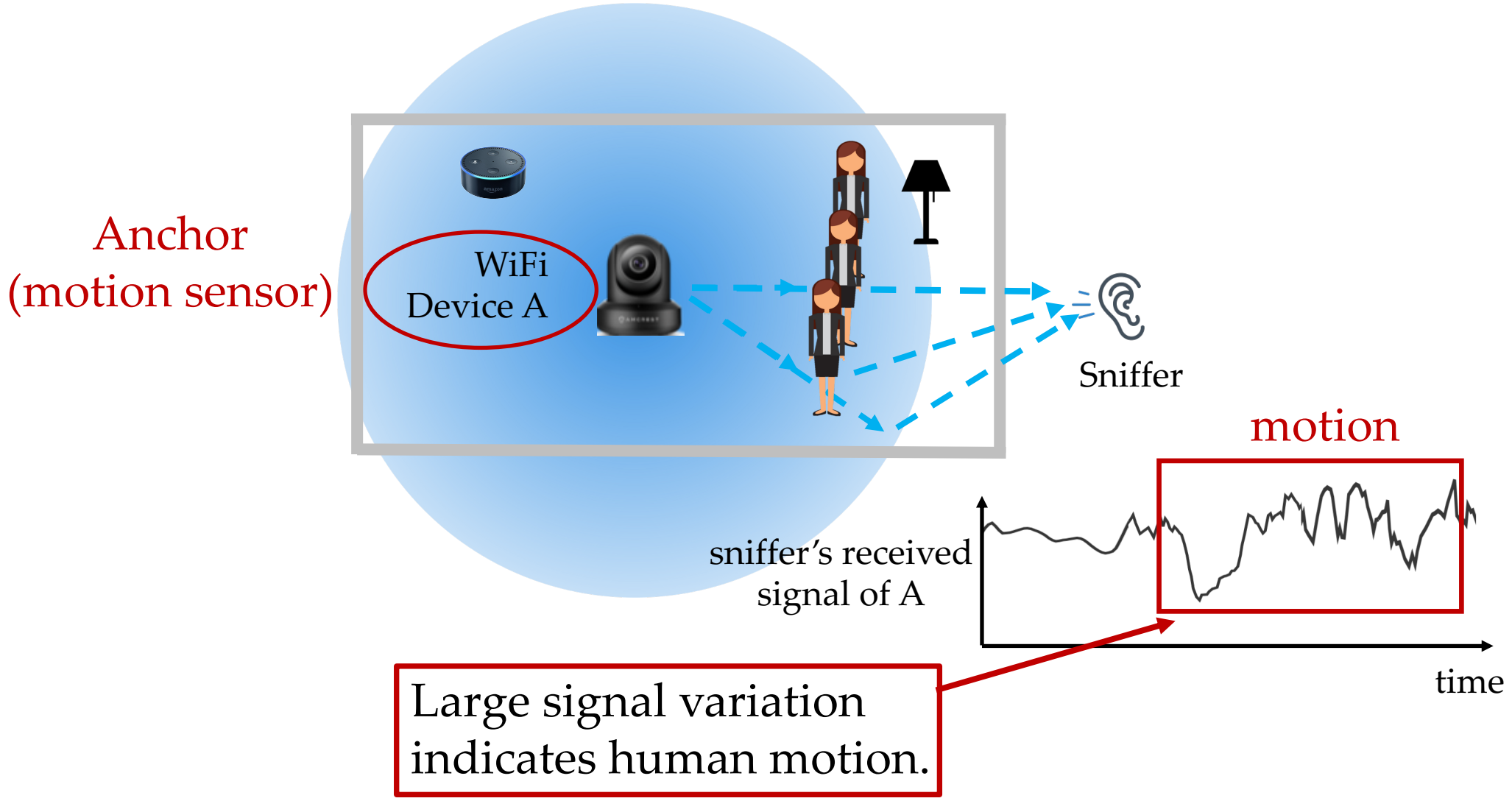
Introduction

Silent Reconnaissance Attack

Attack Implementation & Real-world Evaluation

Defense

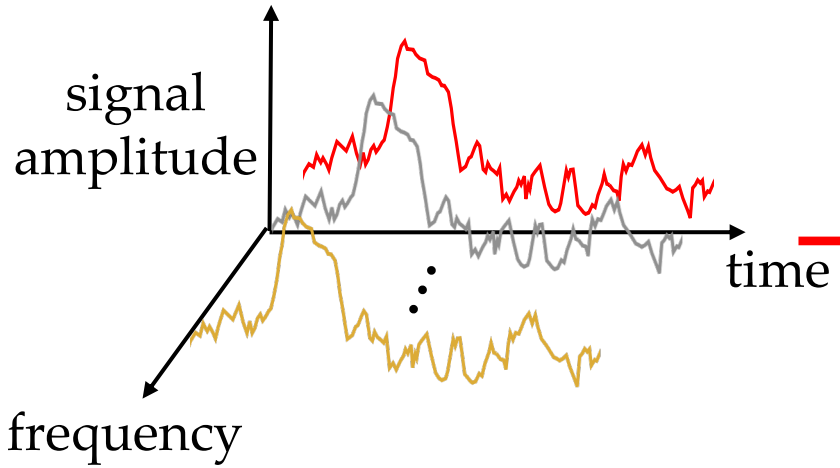
How is Human Motion Embedded in WiFi Signals



Measure Signal Variation via CSI

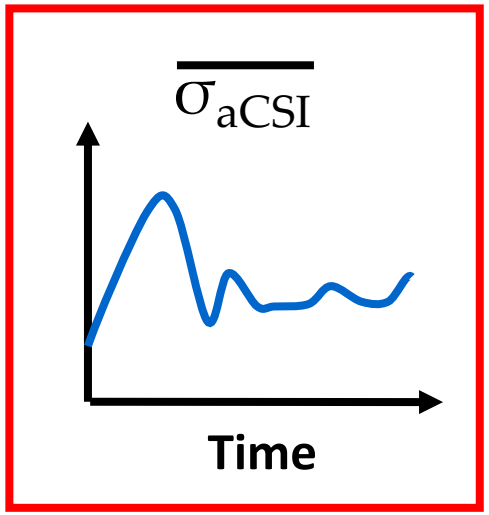
Our solution: leverage Channel State Information (CSI)

- CSI = signal strength at different sub-frequencies



1. Compute std for each sub-frequency

2. Average std across sub-frequencies

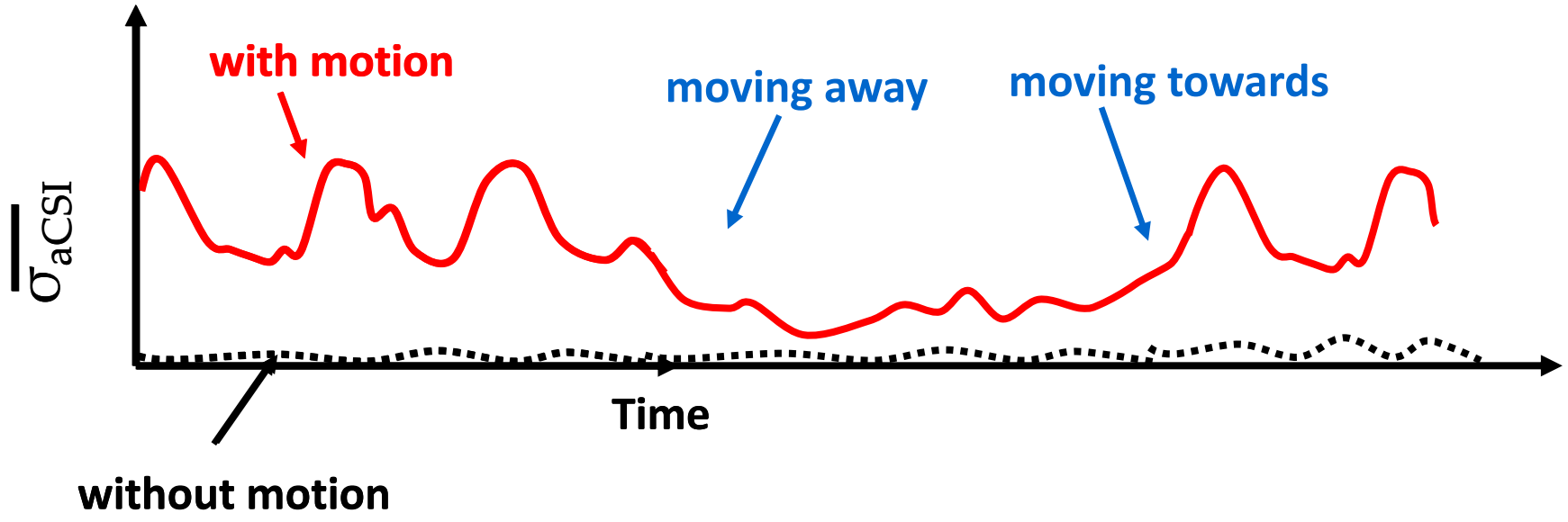


Our final metric

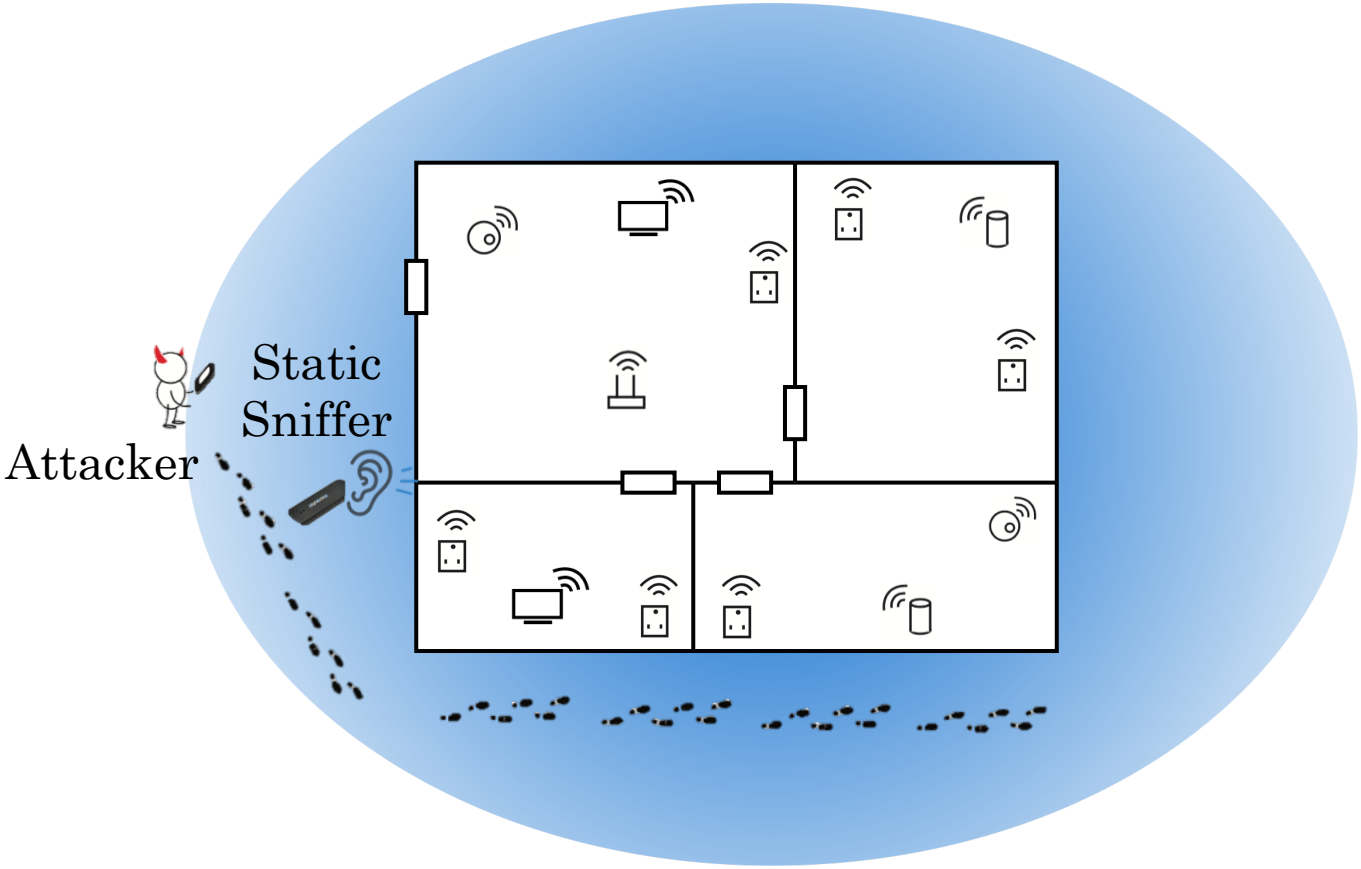
$\overline{\sigma_{aCSI}}$ Captures Human Motion

$\overline{\sigma_{aCSI}}$ can separate with and without human motion.

$\overline{\sigma_{aCSI}}$ can tell human is moving towards or away from anchor.



Our Attack: End-to-end View



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Phase 1: bootstrapping

Identify and locate static WiFi devices to their individual rooms

2

Phase 2: continuous monitoring

Human motion sensing by a static sniffer

Attack Implementation & Real-world Evaluation

Implementation

- Modified WiFi firmware to passively collect CSI
  - **1st to enable passive CSI collection of any commodity WiFi devices***

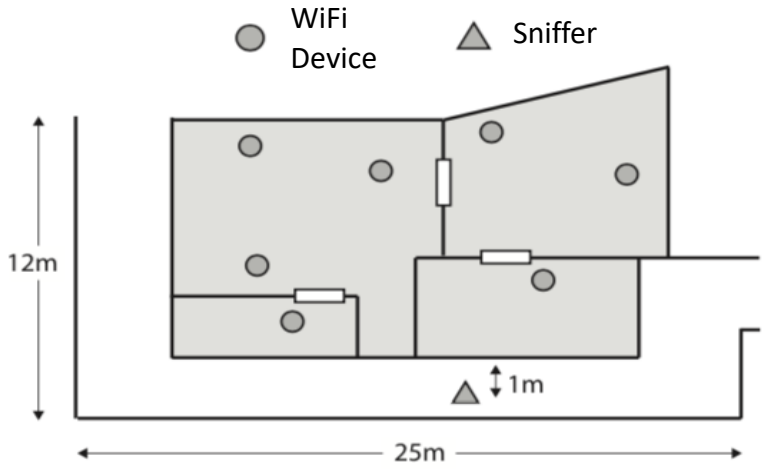
Experiments

- 11 homes & offices with various floorplans
- 31 WiFi devices & 5 volunteers

Measurements

- 41 hours of data (~8 hours of human motion)

Sniffer: Nexus 5 w/ modified WiFi firmware



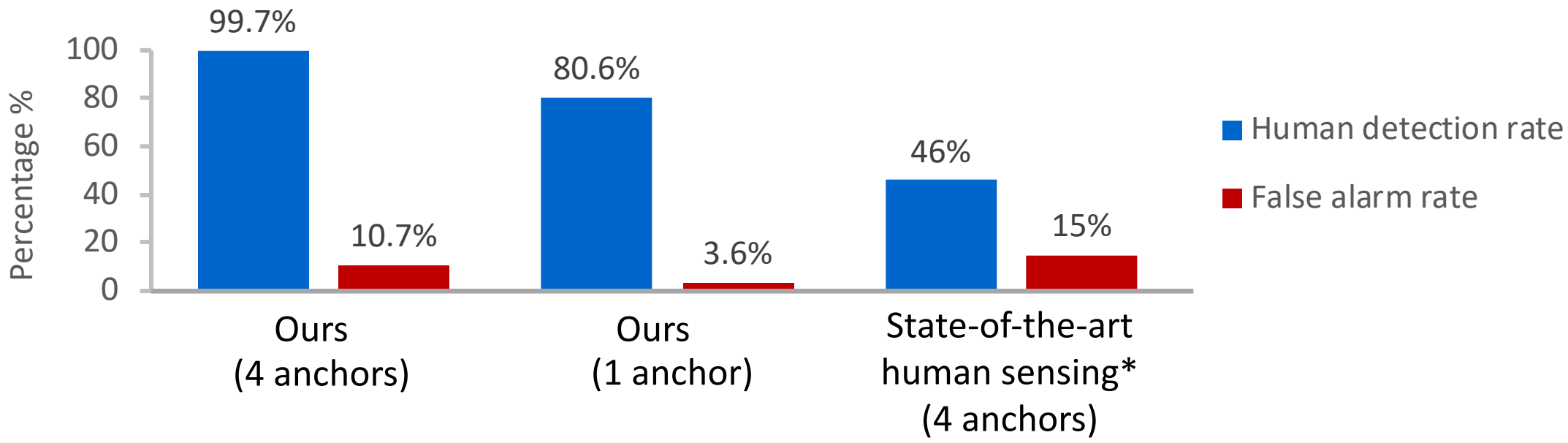
Setup Example

**Previous work can not collect CSI continuously on commodity devices.*

Attack is Effective

$$\text{Human detection rate} = \frac{T(\text{attacker reports room has human inside})}{T(\text{room has human inside})}$$

$$\text{False alarm rate} = \frac{T(\text{room does not have human inside})}{T(\text{attacker reports room has human inside})}$$



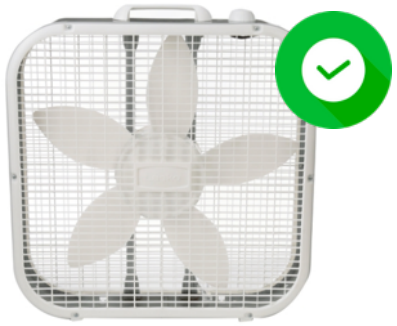
** LiFS: Low human-effort, device-free localization with fine-grained subcarrier information. MobiCom'16.*

Attack is Robust

How effective is our attack at low packet rate?

- Human detection rate drops only 1.5% when anchor transmits at 2 packets per second (pps), compared to full rate 11pps.

How about non-human sources of motion?

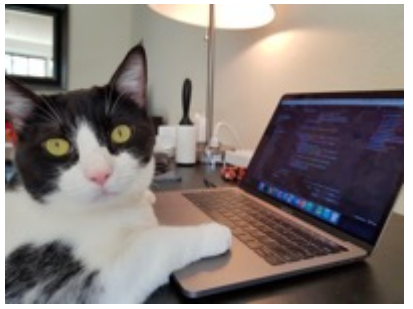


No Impact

Fans

Distinguishable

Oscillating Fans

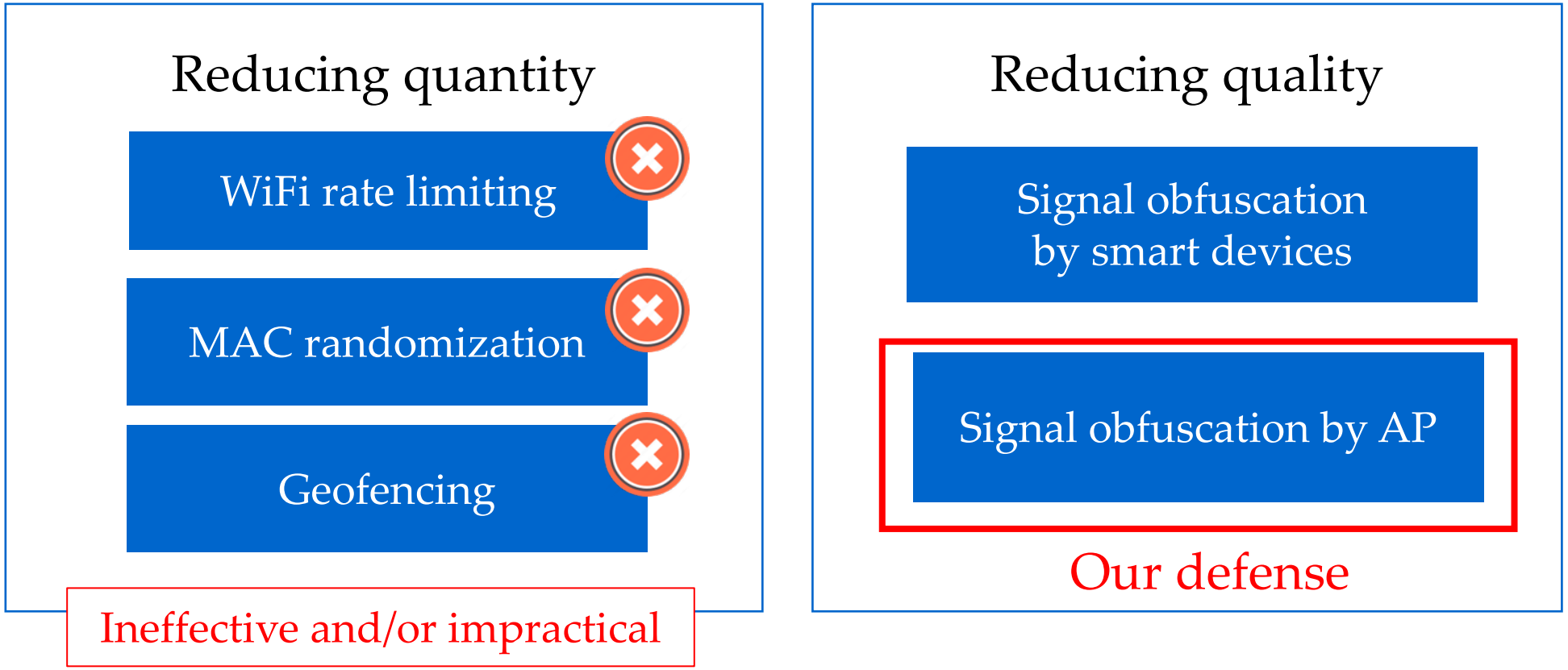


Similar to Human

Pets

Defense via Corrupting Attacker's Received Signal

Observation: the effectiveness of this attack depends on **quantity** and **quality** of signals.



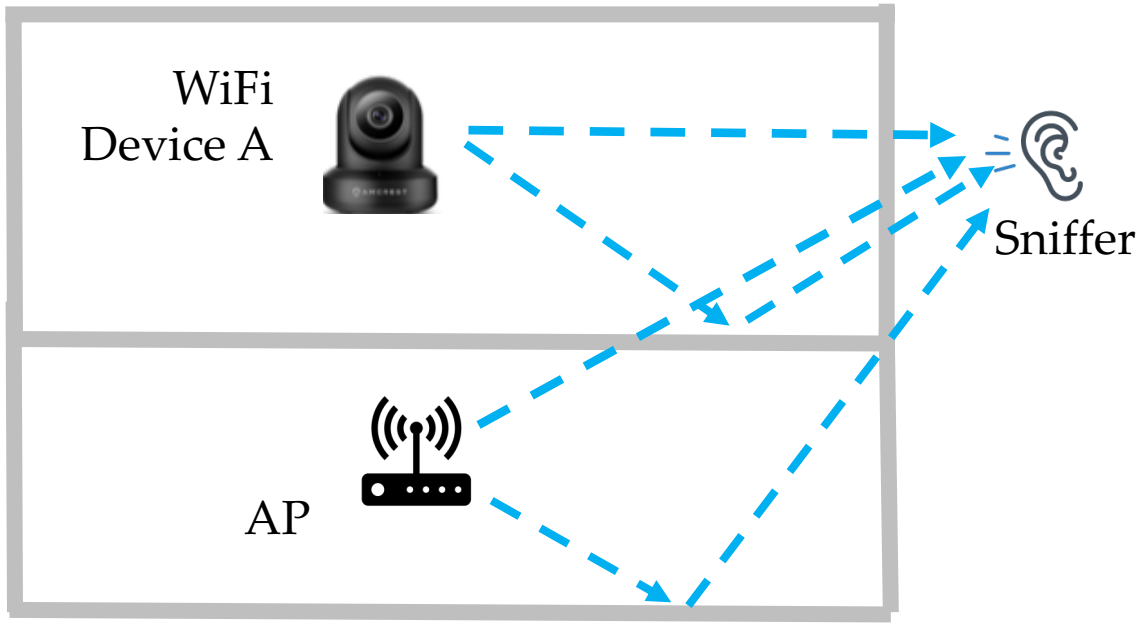
Our Proposal: AP-Based Obfuscation

Spatial Obfuscation

AP sends cover traffic on behalf of each smart device (using its MAC address).

Temporal Obfuscation

AP randomly vary power over time.



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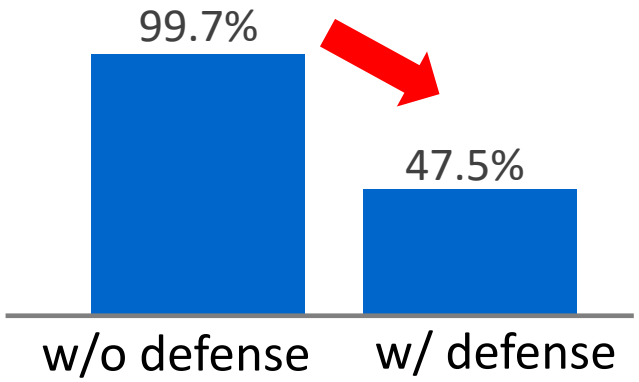

Temporal Obfuscation

AP randomly vary power over time.

With defense, human detection rate drops significantly.

Conclusion

Undetectable silent reconnaissance attack

- No hacking needed, only passive WiFi signal analysis

Effective in real-world evaluations

- 11 homes/offices, 31 WiFi devices

New defenses

- AP-based obfuscation is effective

Thank you
Any questions?