Master Thesis |
Midtermpresentation

WiFi Relink: Analysis of Plaintext WiFi Sidechannels for Unique Device

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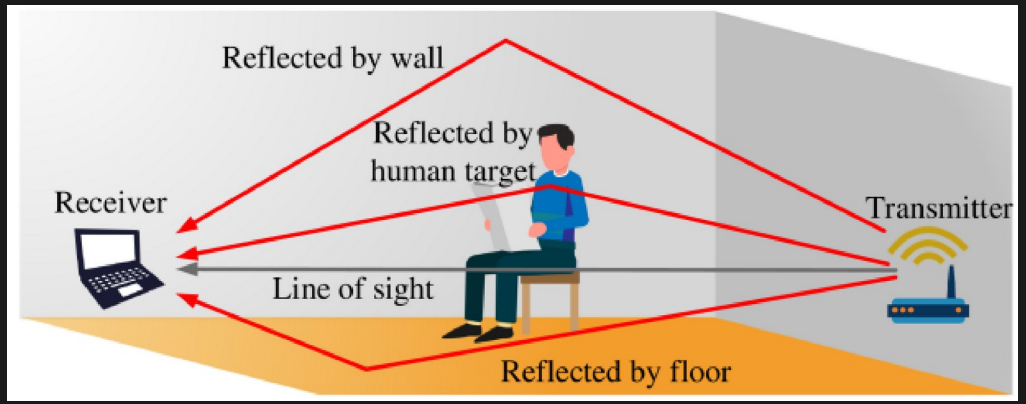
Agenda

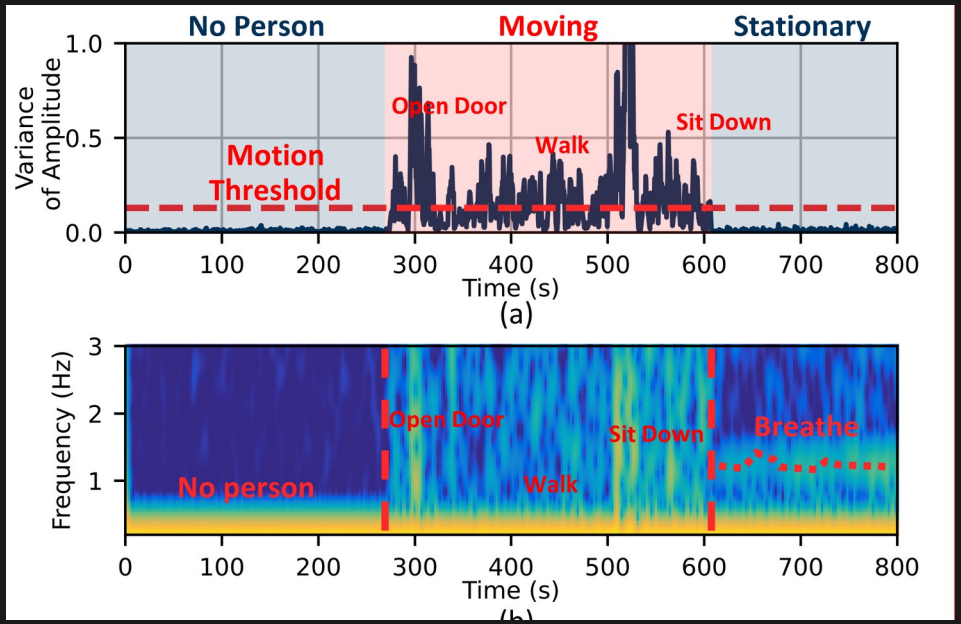
- Motivation
- Background
- Selected related work
- Design
- Preliminary results
- Outlook

Motivation

WiFi Sensing

- Occupancy, Activity Detection of Humans
- Identity Inference





Motivation

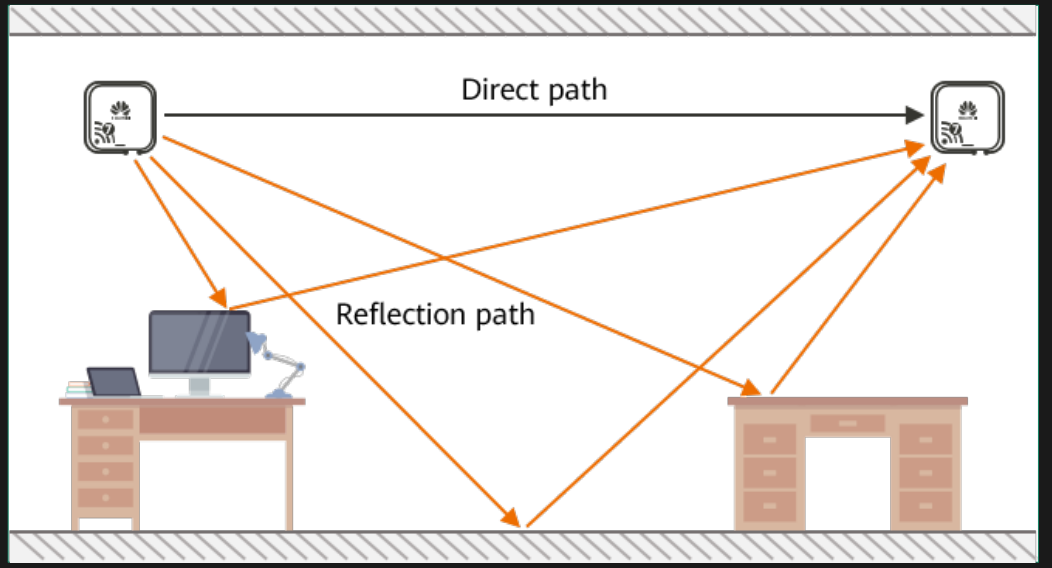
Thesis Aim

Apply WiFi Sensing side channels to relink devices which randomize their MAC address

Background

Channel State Information (CSI)

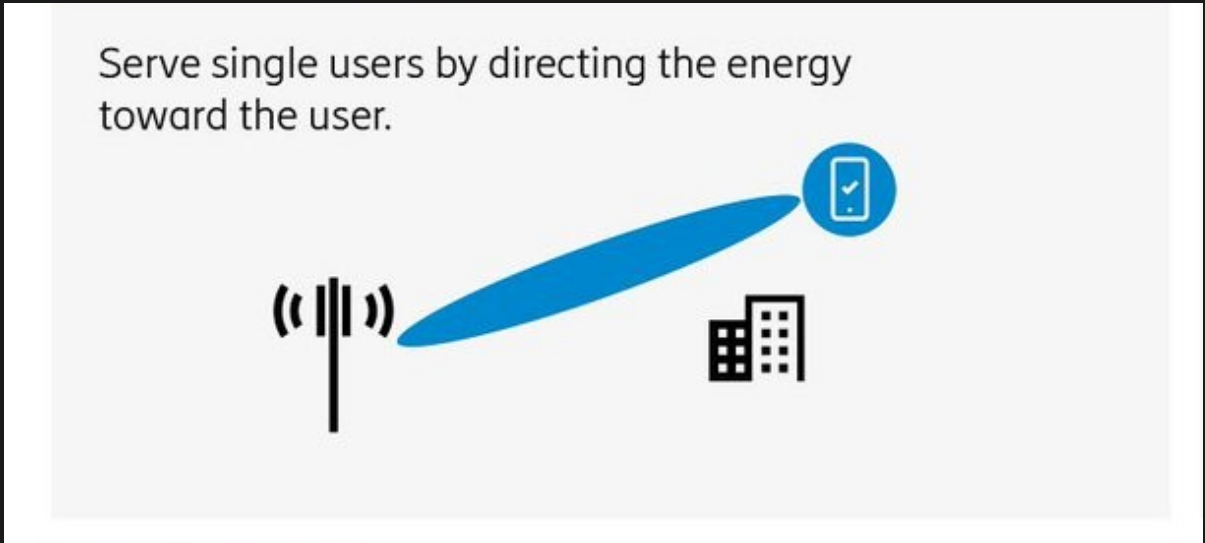
- Multipath effect
- Amplitude attenuation
- Phase offset of radio signal per subcarrier



$$H \in \mathbb{C}^{N \times M \times K}$$

Background

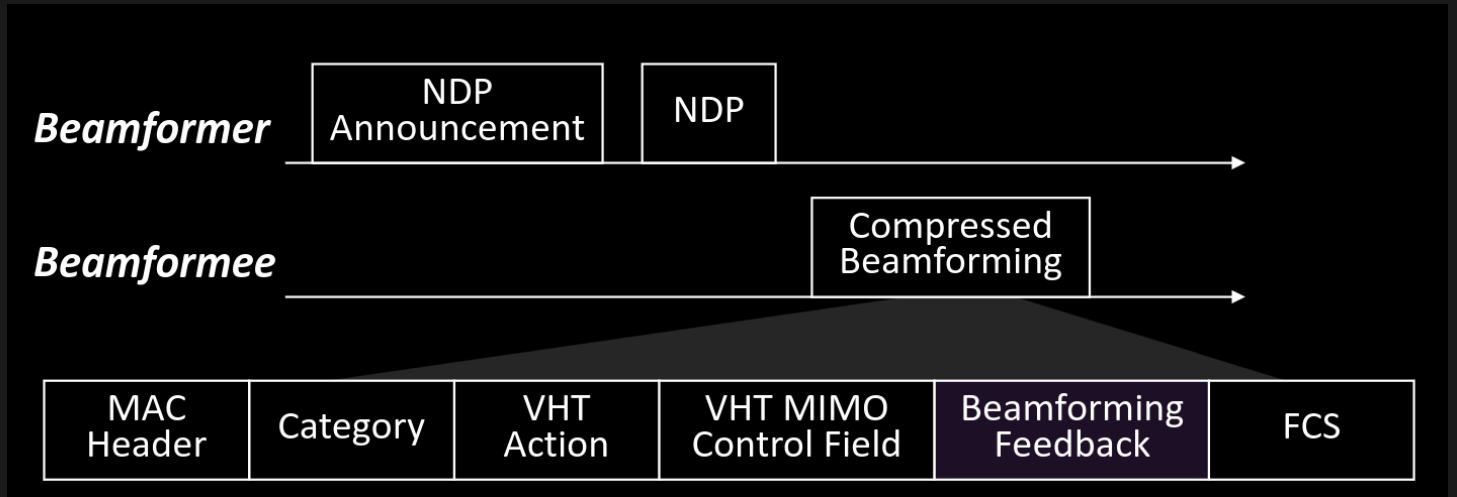
Beamforming



Background

Beamforming Information (BFI)

- Introduced in Wifi 5 802.11ac
- Access Point (AP), the Beamformer, requests BFI
- Associated devices, the beamformees calcutate BFI based on CSI and send it back to the AP in **plaintext**



Background

Beamforming Steering Matrix

$$\mathbf{H} = \mathbf{U}\mathbf{\Sigma}\mathbf{V}^{H}$$

Selected Related Work

Mac Relinking Attacks

- Utilize Probe Requests in disassociated state
- Based on content and timing of Information Elements (IE)

Selected Related Work

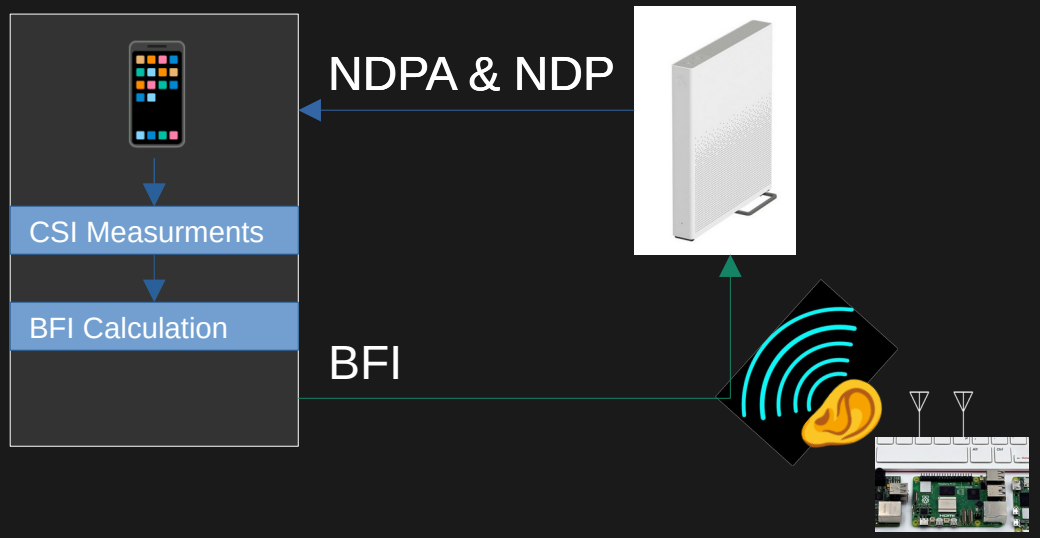
Limitations of previous work

- Mostly defeated with IE cycling on newer Operating Systems
- Can only reach disassociated devices
- Fingerprinting based on hardware imperfection assume the use of software defined radios

Design

Attack Scenario

- Low-cost
- Passive



Design

WiFi Relink: Research Prototype

- Included capture pipeline for CSI & BFI
- No MAC oracle
- No feature analysis

Design

Experiment Setup

Design

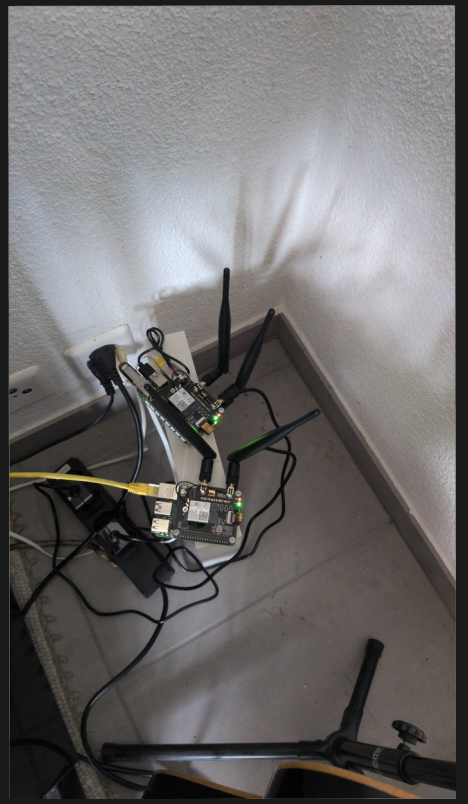
Test Devices / Mac Rotation Oracle

- Fleet of five ESP C5 with custom firmware
- Rotate mac adress every 15 minutes
- Simulate internet traffic for 10 minutes
- Use static IP pool to identify

Design

Capturing Devices (sniffers)

- 2 Rasperry Pi 5
- AX210 network card
- Connected to local network via ethernet cables.
- Sniffs only for BFI packets which are addressed to my AP

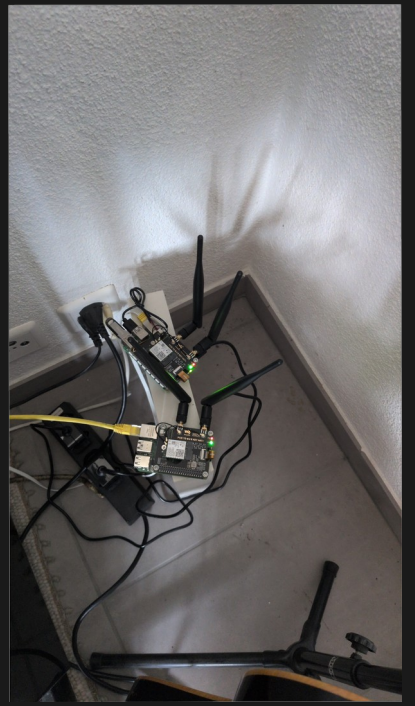


Design

Experiments

Experiment 01:

- 3 MAC rotating, stationary (non moving) C5s
- 2 sniffing pis
- 5 day observation window



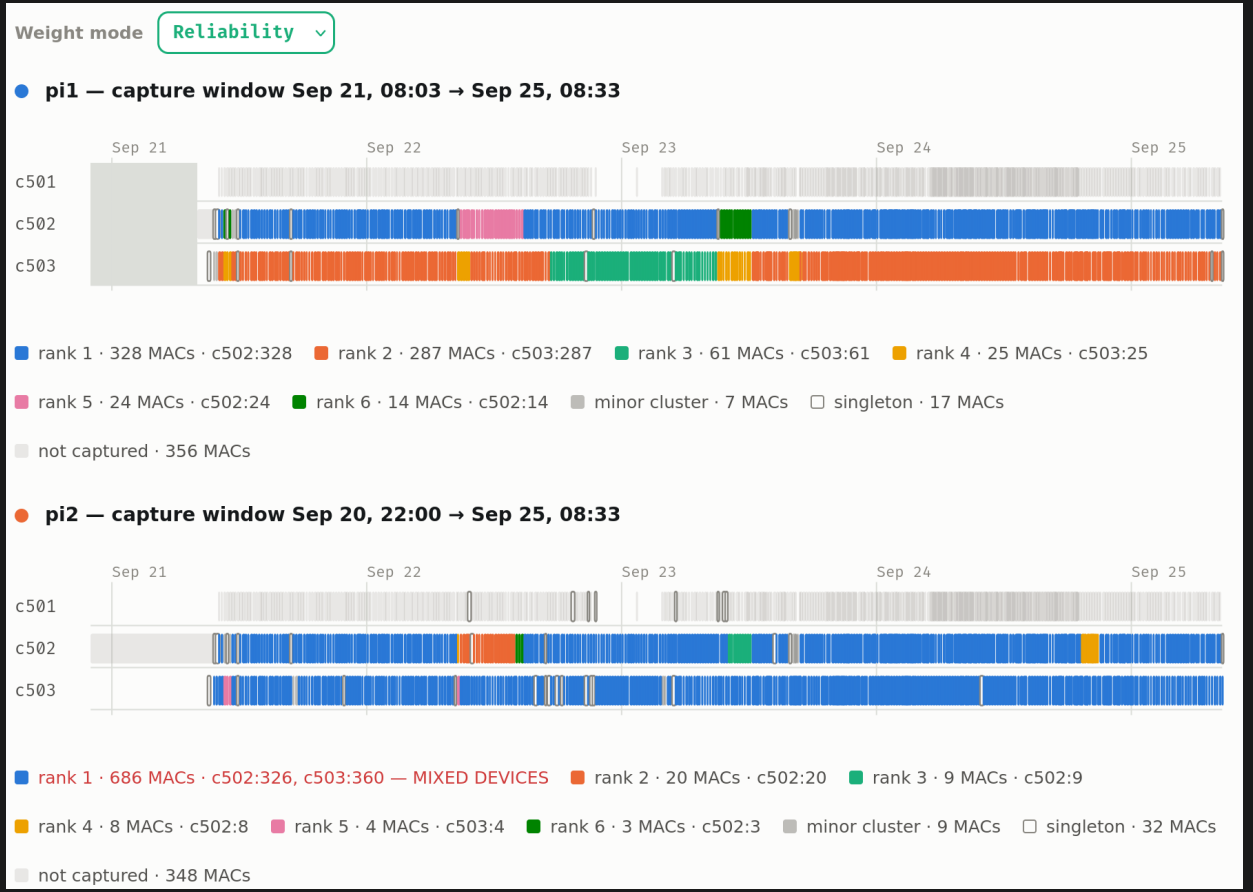
Experiment 02:

- 5 MAC rotating C5s
- 2 sniffing pis
- 8 day observation window
- 1 change in location of the C5s

Preleminary Results

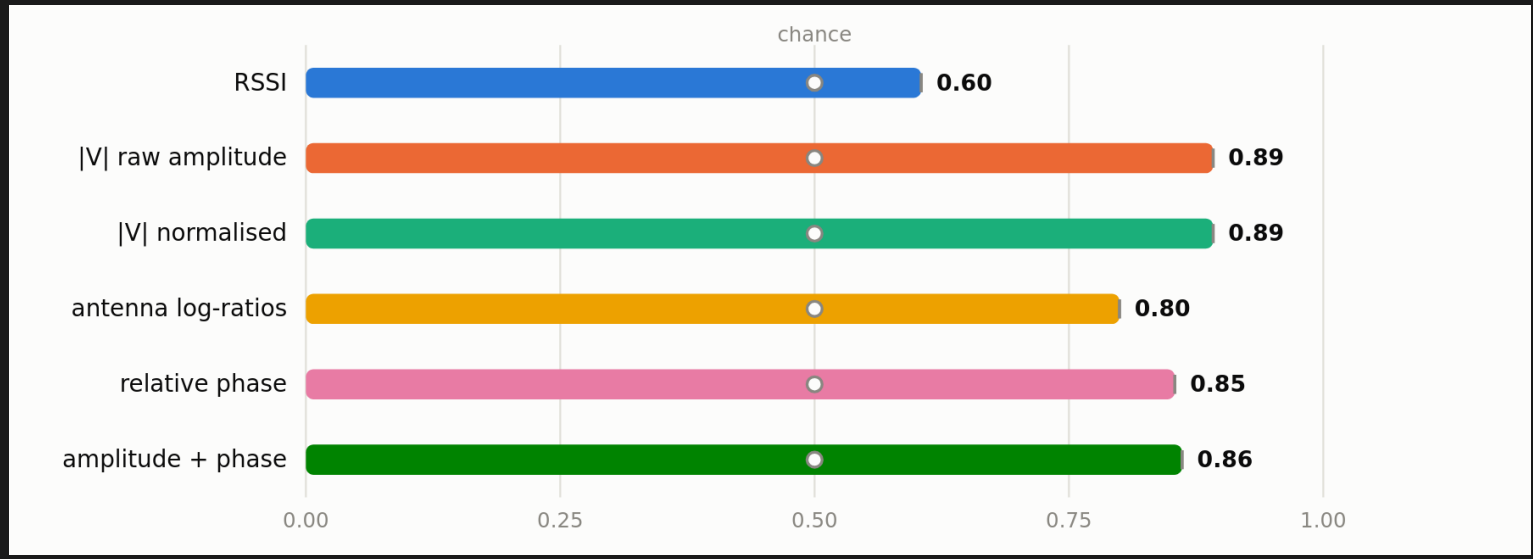
Experiment 01: Clustering

Clustering on raw BFI body bytes and RSSI



Preleminary Results

Experiment 01: BFI Features



Same-device pairs (necessarily spanning a MAC rotation) vs. different-device pairs, as the ROC-AUC
"small cosine distance ⇒ same device".

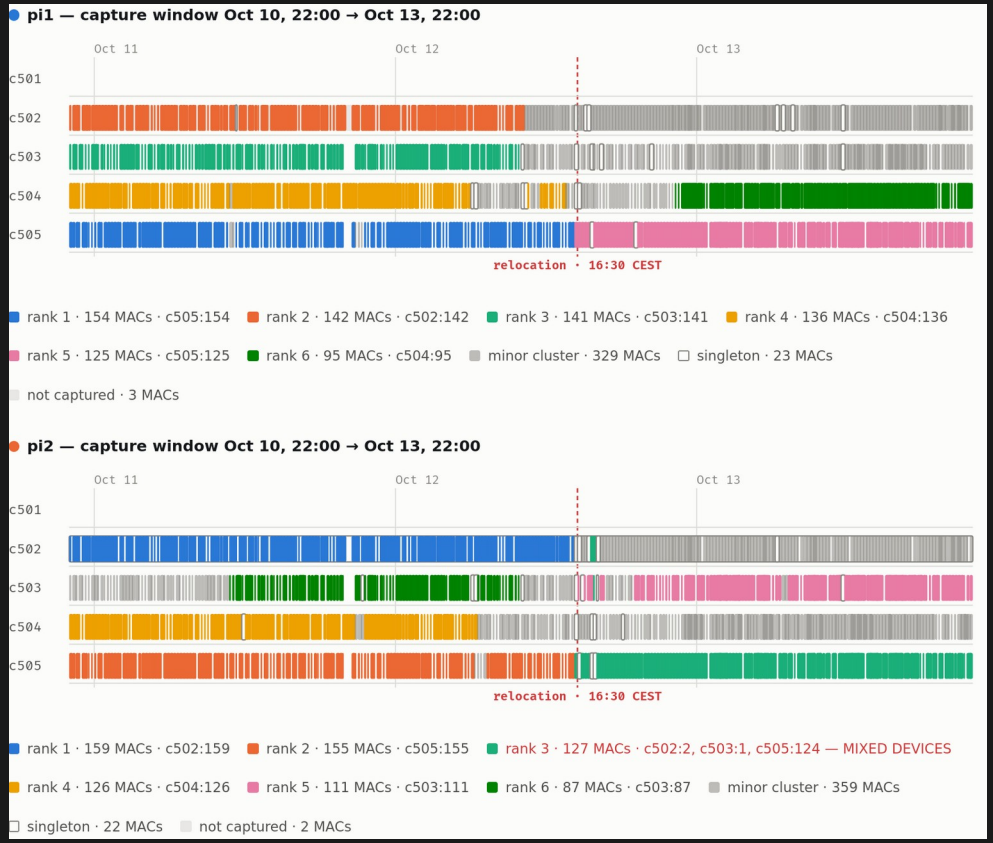
Preleminary Results

Experiment 01: Interpretation

- Clustering is decent but not perfect
- Only 2 test devices worked
- Only considers the stationary case
- RSSI is sensitive to antenna setup of sniffers

Preleminary Results

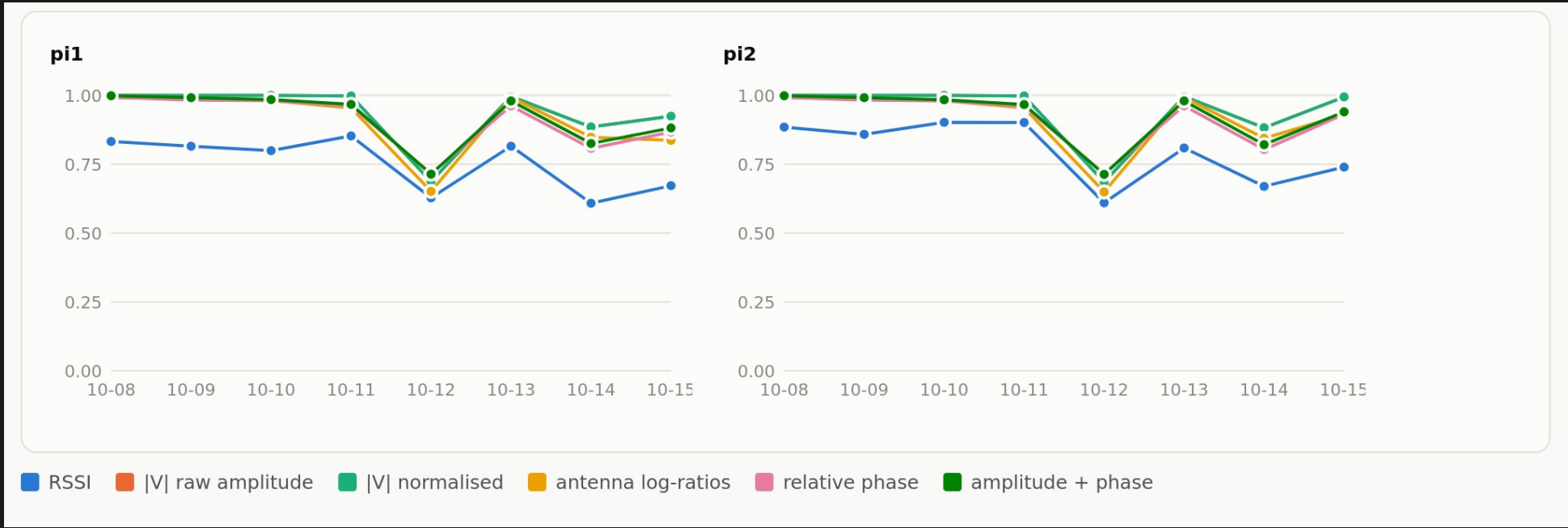
Experiment 02: Clustering



Preleminary Results

Experiment 02: BFI Features

Single day runs AUC across observed days



Preleminary Results

Experiment 02: BFI Features

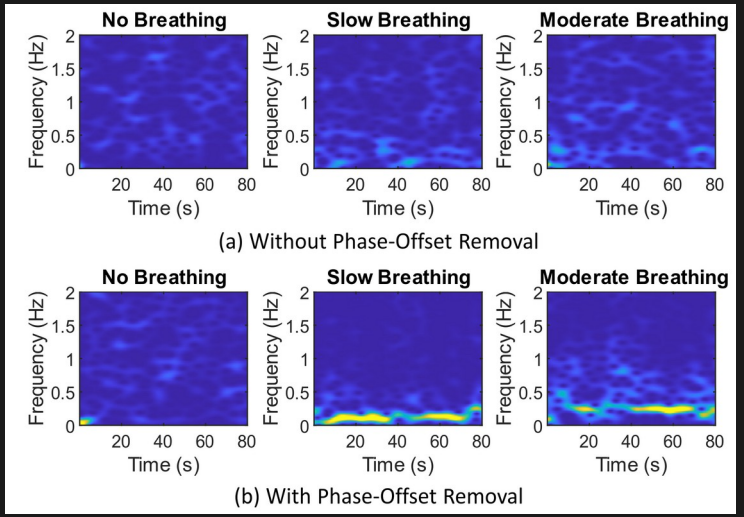
- Clustering is almost perfect before location change

- Clusters and feature surivals are location sensitive

Outlook

Next Steps

- Explore timing attacks of BFI sounding
- Do additional preprocessing of the BFI steering matrix besides simple decoding
- Run more experiments
- Document results



Q / A

Acknowledgement

- Thanks to Bruno and Karim for the excellent supervision so far
- Helpful research prototype which accelerated initial progress

References

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