Probr – A Generic and Passive WiFi Tracking System

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Motivation
Probr-Architecture
Case Study
Conclusions

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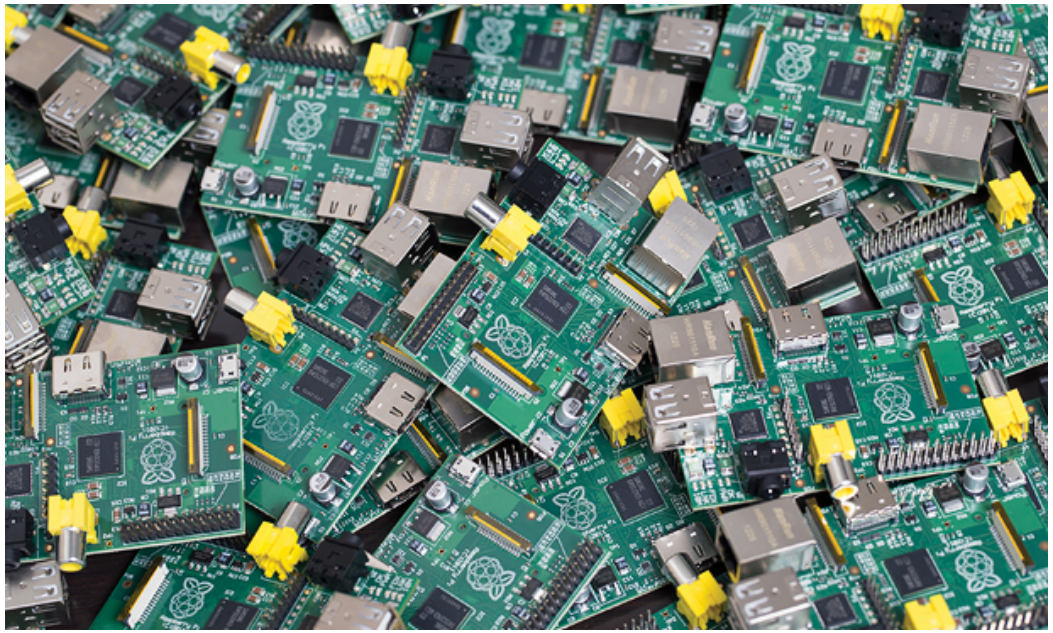
Motivation (1)

Ubiquity of WiFi-enabled devices

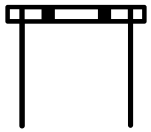
- WiFi traces can reveal interesting patterns

Motivation (2)



- Advent of affordable mini computers
  - Hardware for WiFi capturing is at hand

Motivation (3)



Hurdle for distributed analysis

- Infrastructure setup is time-consuming
  - Set up devices
  - Manage devices (e.g., start, pause, resume, stop experiment)
  - Debug strangely behaving devices
  - Collect results

Design Goals

	Snoopy [35]	Mo-Fi [31]	CreepyDOL [28]	Probr
On-line Use Cases	✘	✔	✔	✔
Support Commodity Capturing Devices	✔	✔	✔	✔
Support Ad-hoc Experimentation	✘	✘	✘	✔
Extensible Architecture for Analysis	✔	✘	✘	✔
Entirely Open Source and Free	✘	✘	✘	✔

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The Probr System

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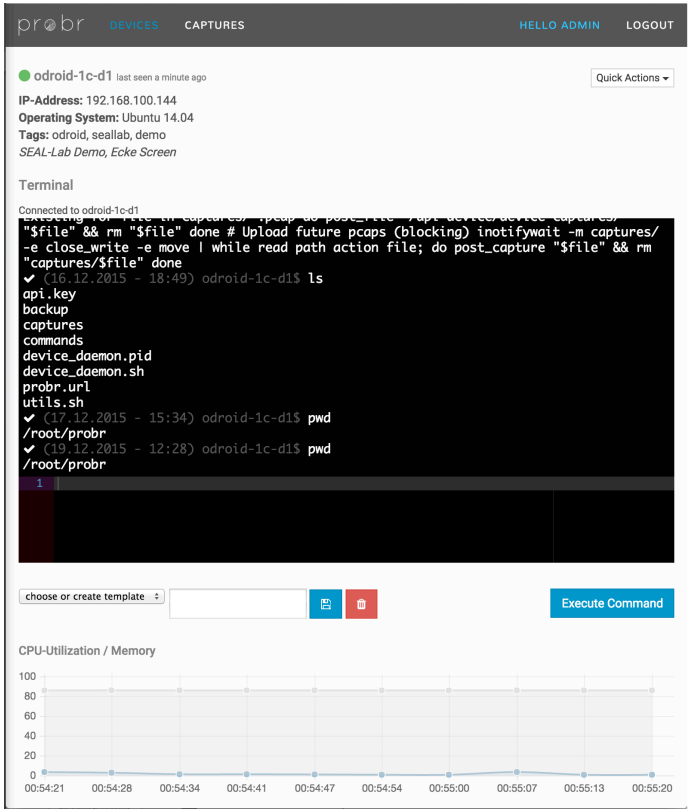
Probr Architecture (1)

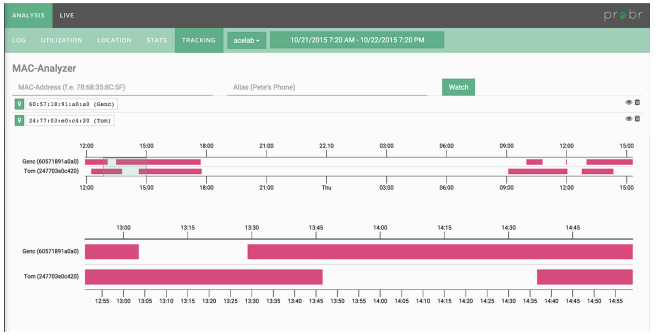
Probr-Core

- Manage devices (register, start monitoring)
- Execute commands

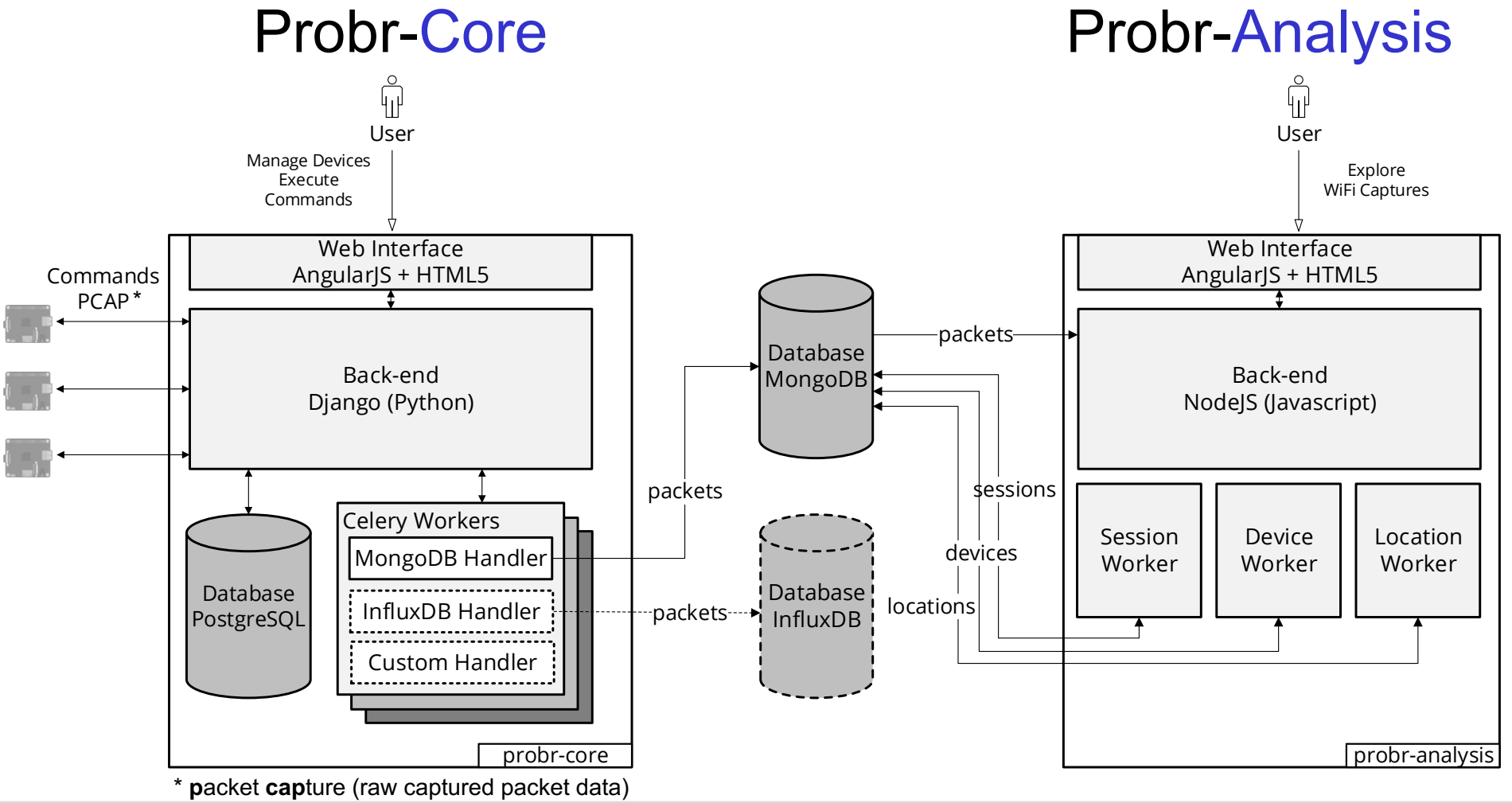


Probr-Analysis

- Explore WiFi captures



Probr Architecture (2)



Use Cases

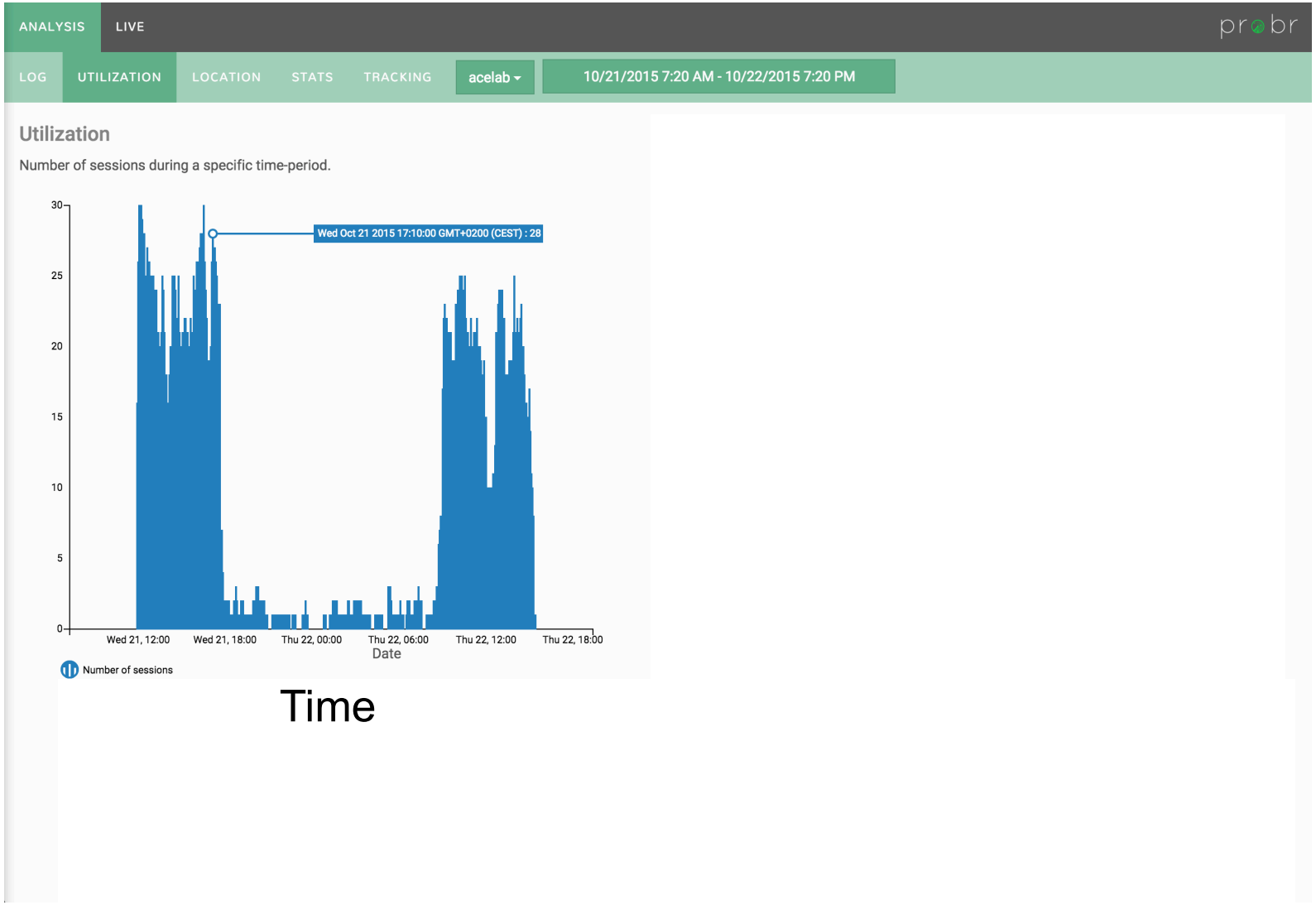
- U1) Room utilization
  - How many people are in a room at any given time?
- U2) Device localization
  - Where are devices located in a room?
- U3) Person tracking
  - Is it possible to reproduce the daily routine of a person?
- U4) Device statistics
  - Can the data expose device vendor preferences for different communities?

Terminology

- Probr Packet
  - Represents a single WiFi probe request
    - Category 802.11 management frames
  - Contains
    - Timestamp
    - Source Media Access Control (MAC) address
    - Destination MAC address
    - Service Set Identifier (SSID)
    - Received Signal Strength Indicator (RSSI)

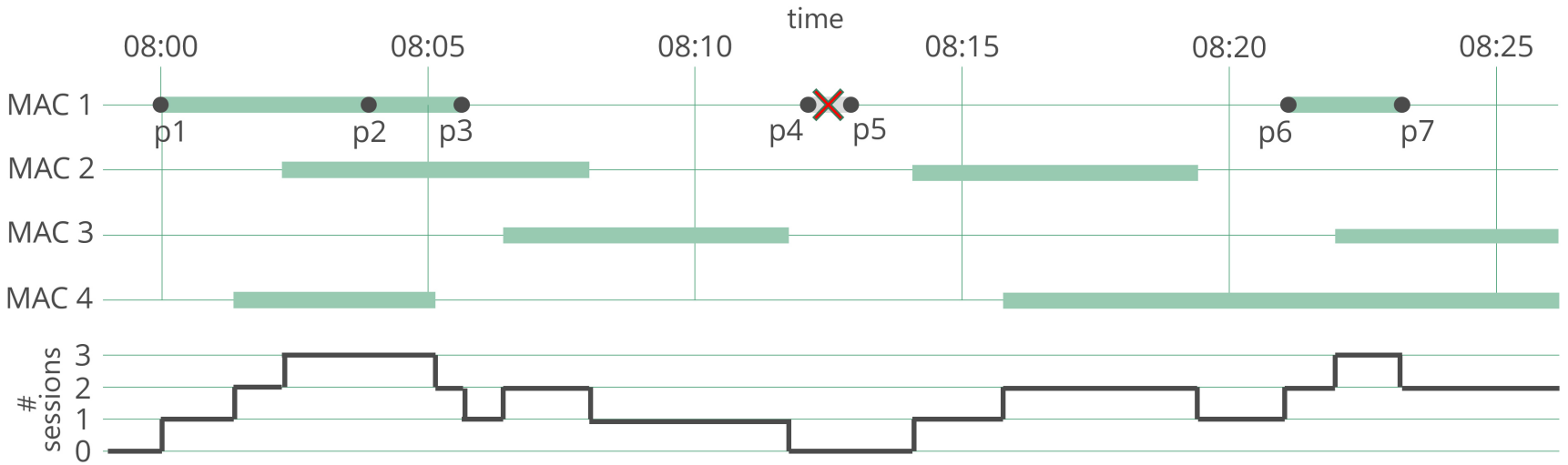
    - Tags (Probr-defined)
    - Location of capturing device (Probr-defined)

U1) Room Utilization – Web Interface

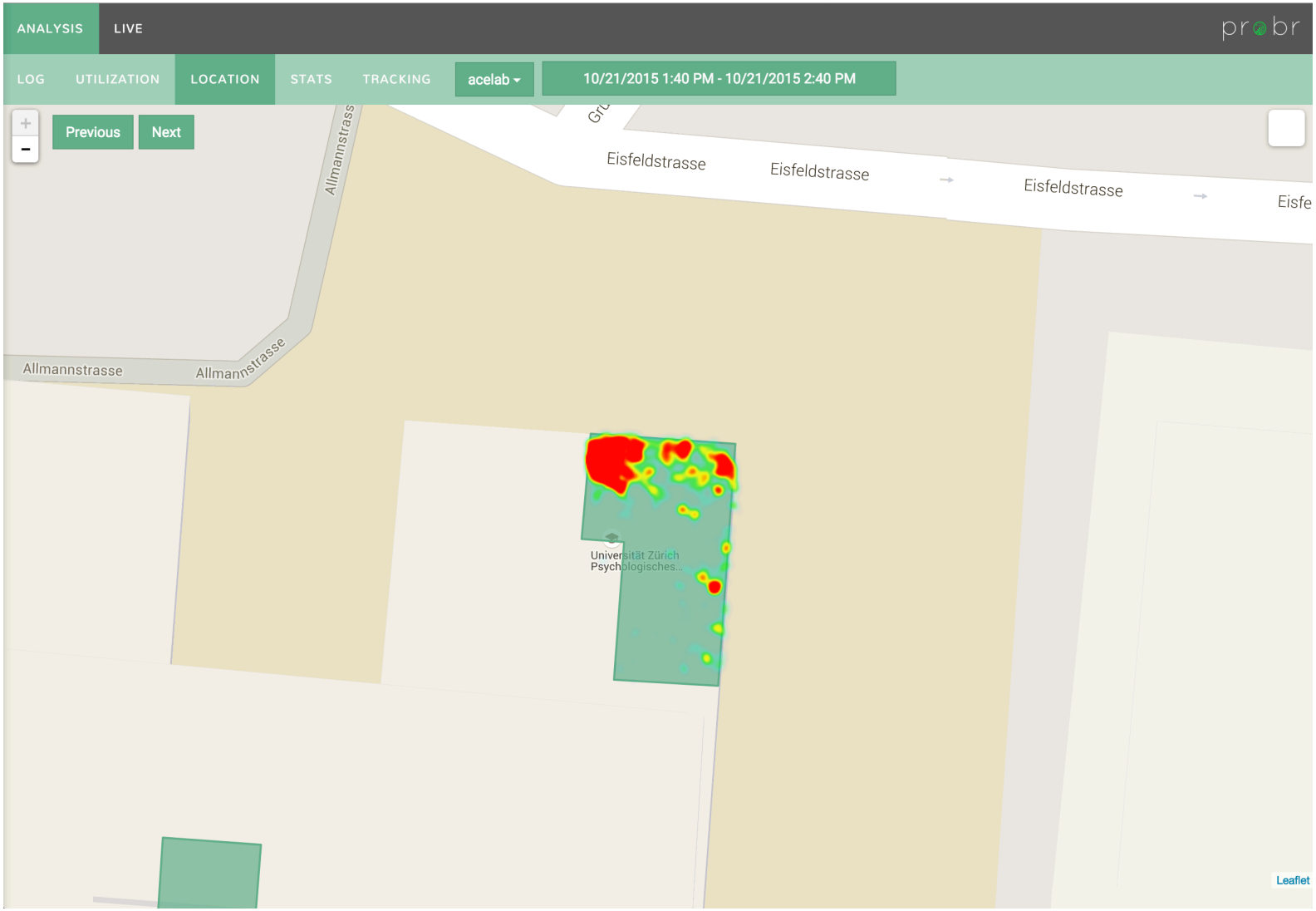


U1) Room Utilization – Session Model

- Session covers multiple Probr packets from the same source MAC address
- Conditions
  - Maximum inter-packet time (e.g., 5 min)
  - Minimum session length (e.g., 1 min)

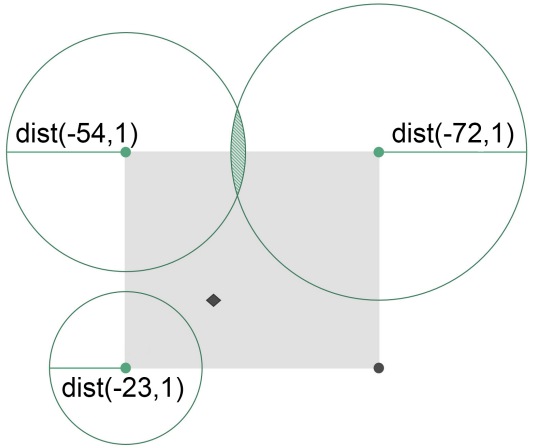


U2) Device Localization – Web Interface

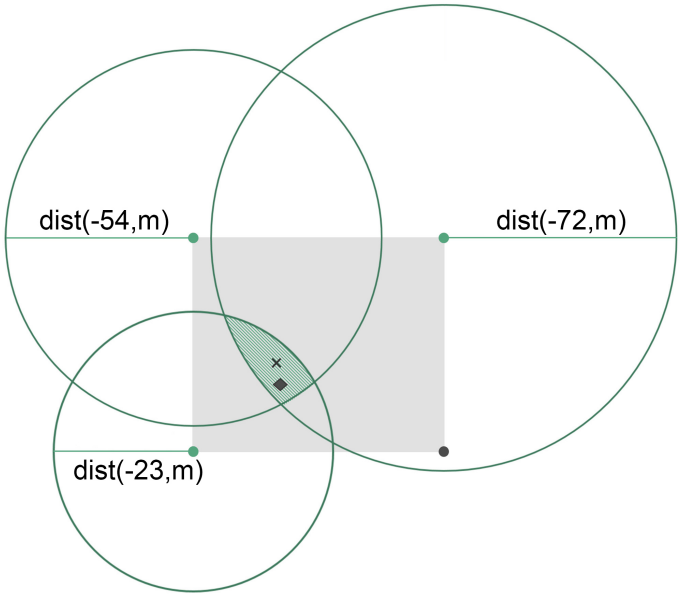


U2) Device Localization

- Proportional growth multilateration algorithm
  - RSSI as indicator of physical distance
  - Based on experimentally derived formula from [36]



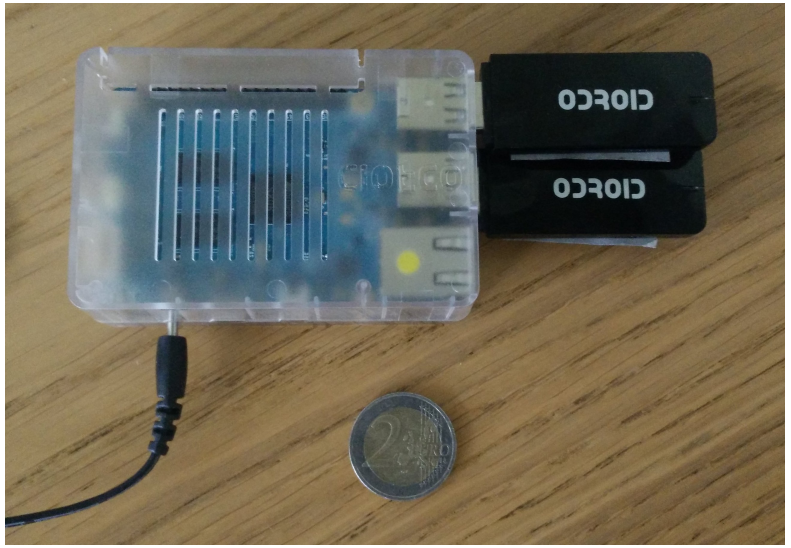
Initial Intersections

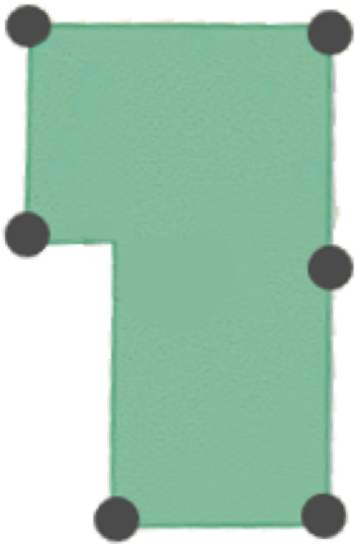


Final Trilateration

Case Study

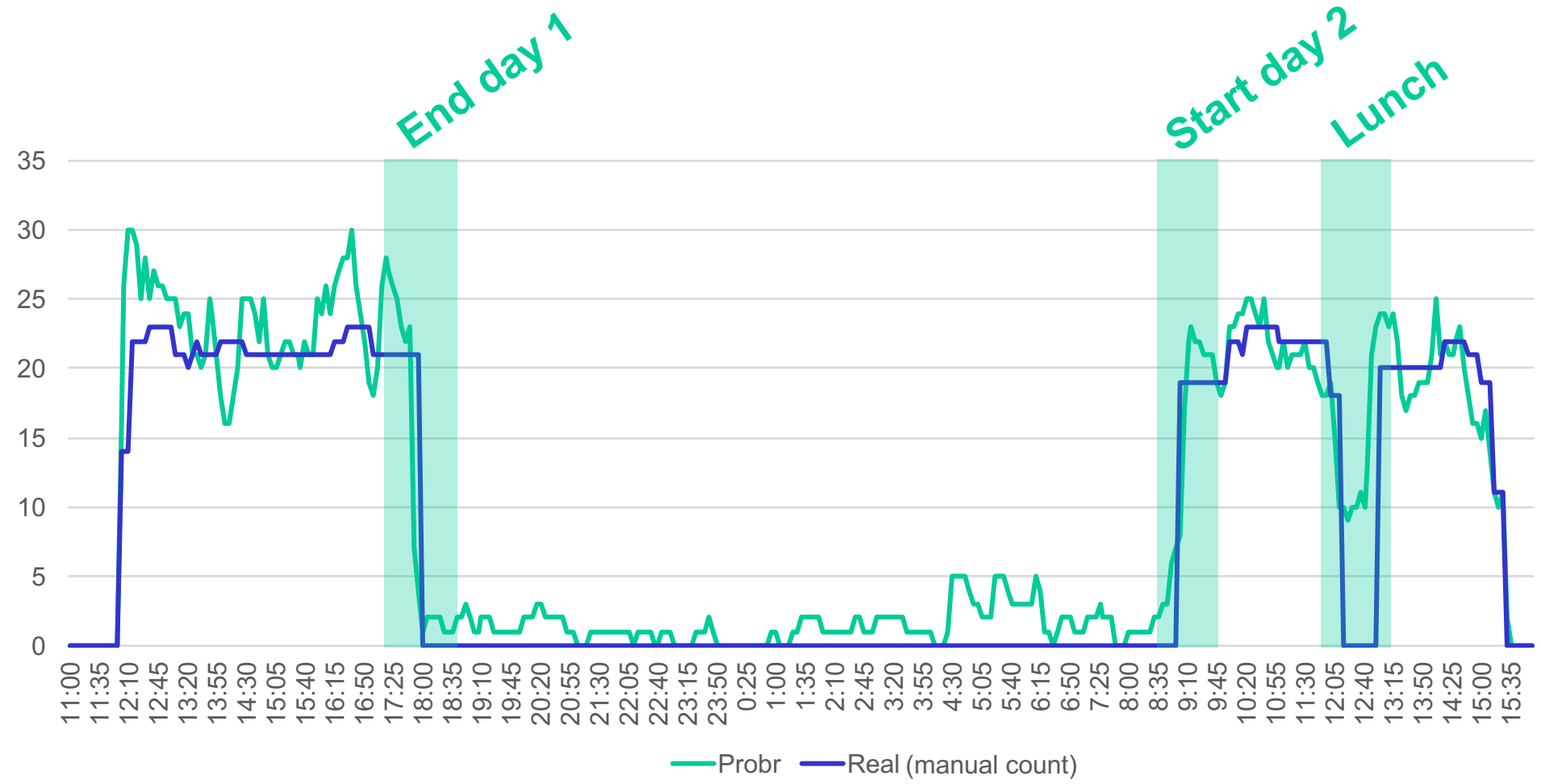
- 2 days experiment in a ~35 m^2 meeting room
- 20-25 people attending a scientific project meeting
- > 200,000 probe requests
- Capturing devices
  - 6x ODROID-C1 single-board computers





ODROID-C1

Case Study – U1) Room Utilization



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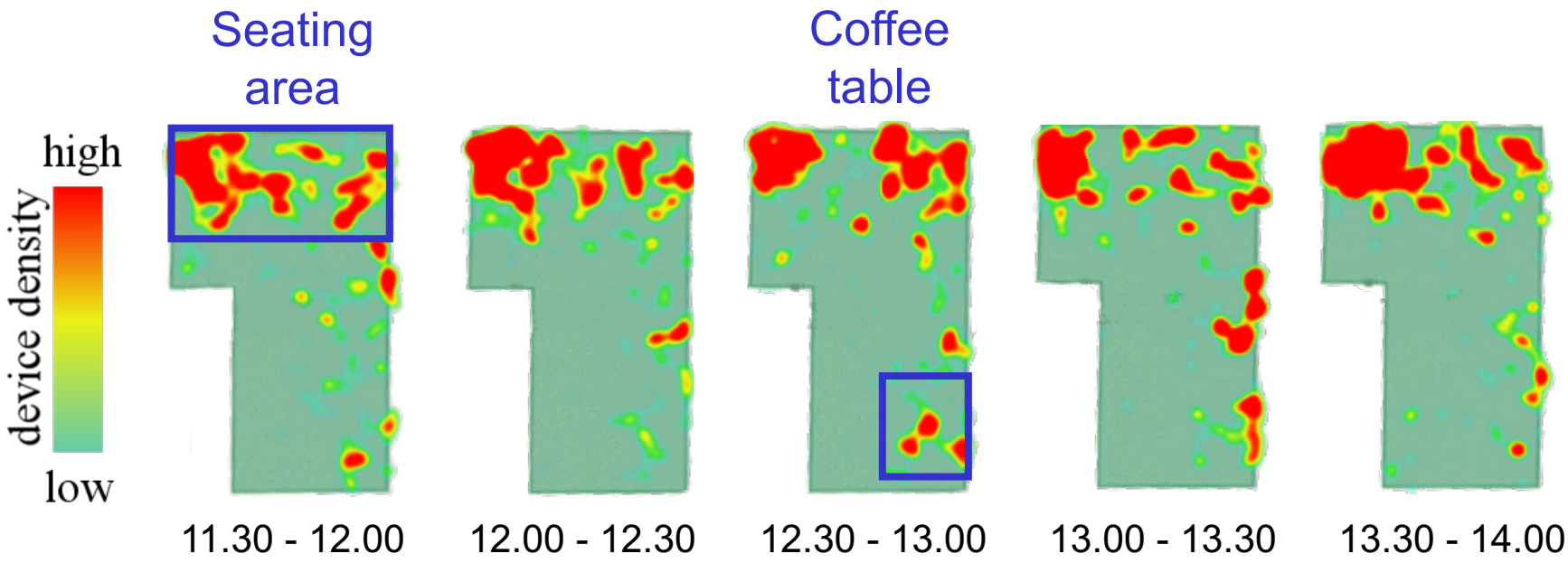
Case Study – U2) Device Localization



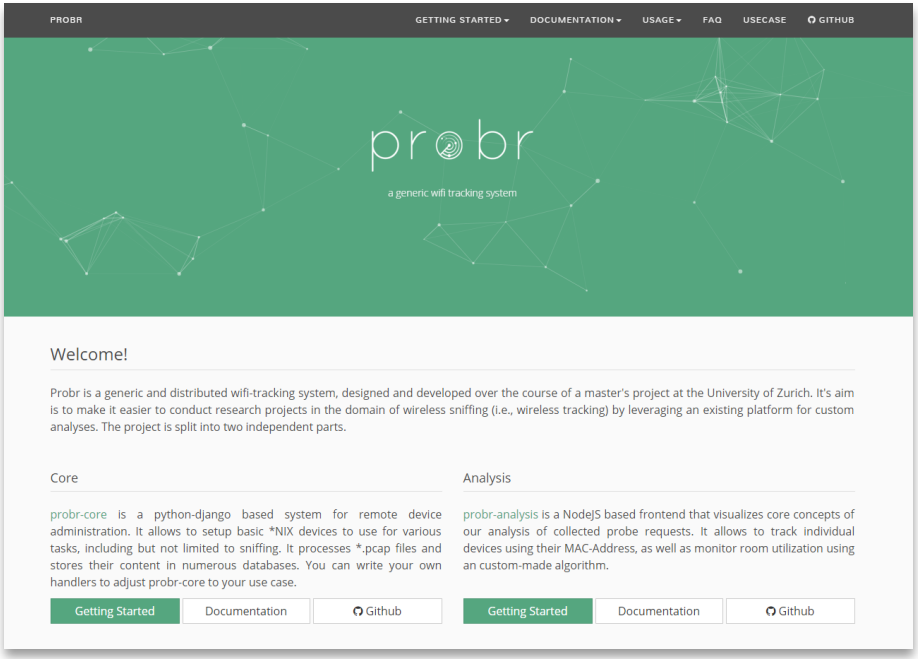
Summary – Probr

- On-line use cases
  - Perform incremental analysis
- Support commodity capturing devices
  - Portable shell client
- Support ad-hoc experimentation
  - Integrated device administration
- Extensible analysis use cases
  - Modularization (Core + Analysis), plugin architecture
- Entirely open source (MIT License)
  - github.com/probr

Conclusions

- U1) Room utilization
  - How many people are in a room at any given time?
    - Utilization graph shows room utilization over time tolerating slight overestimation
- U2) Device localization
  - Where are devices located in a room?
    - Heatmap indicates where the majority of devices are located

probr



docs & setup: probr.ch

fork us: github.com/probr

FLAMINGO Project

Appendix

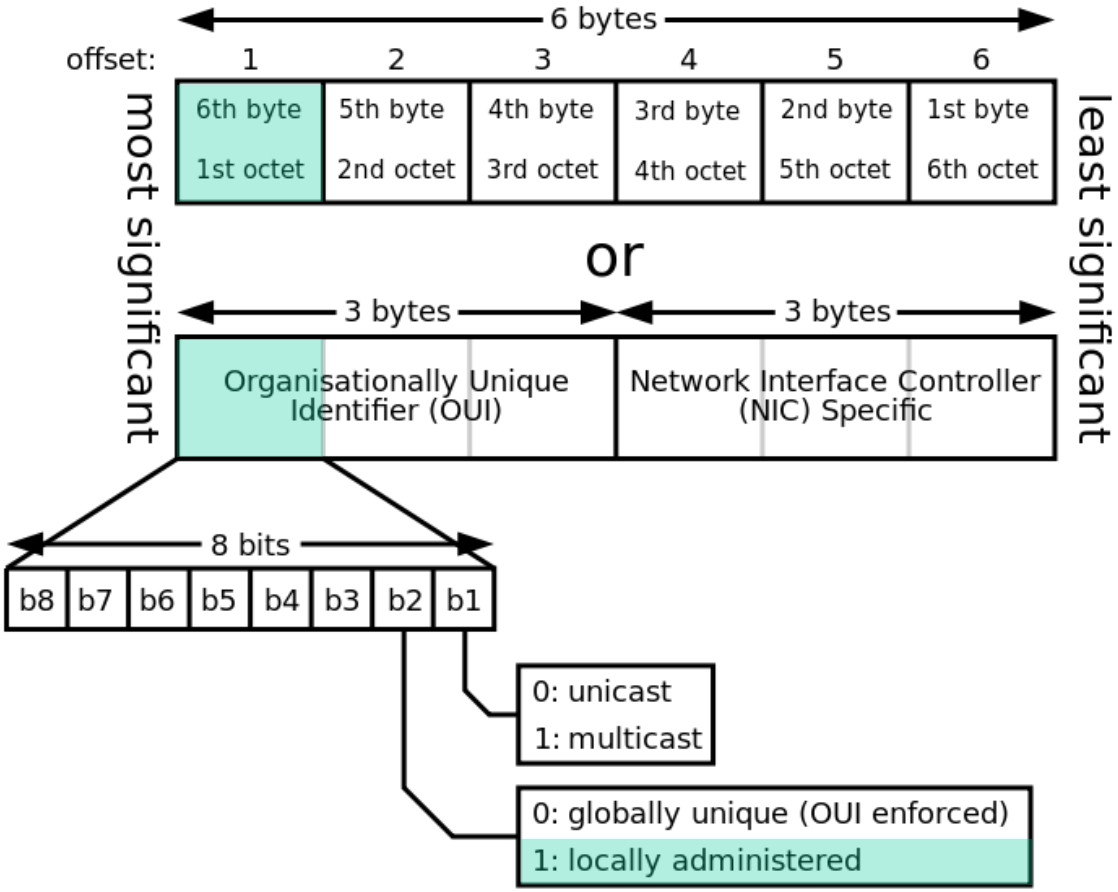
Probr in Numbers

- Operated >4 months
- Captured almost 30 000 000 probe requests
- 30 GB of WiFi traces

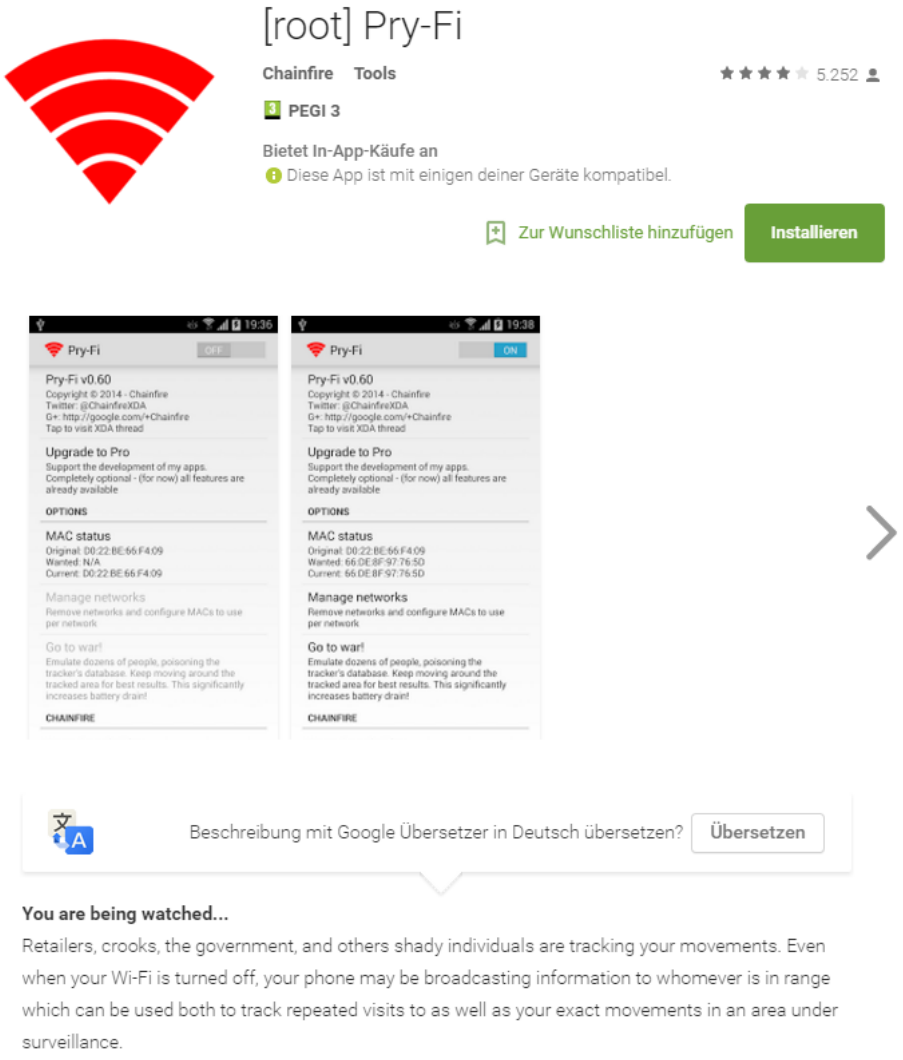
Future Work

- Probr
  - Currently only considers probe requests
  - Countermeasures against MAC-Randomization
    - Device fingerprinting (e.g., based on sequence numbers, SSIDs)
- Case study
  - Larger room and more participants
  - Quantitive analysis of localization accuracy

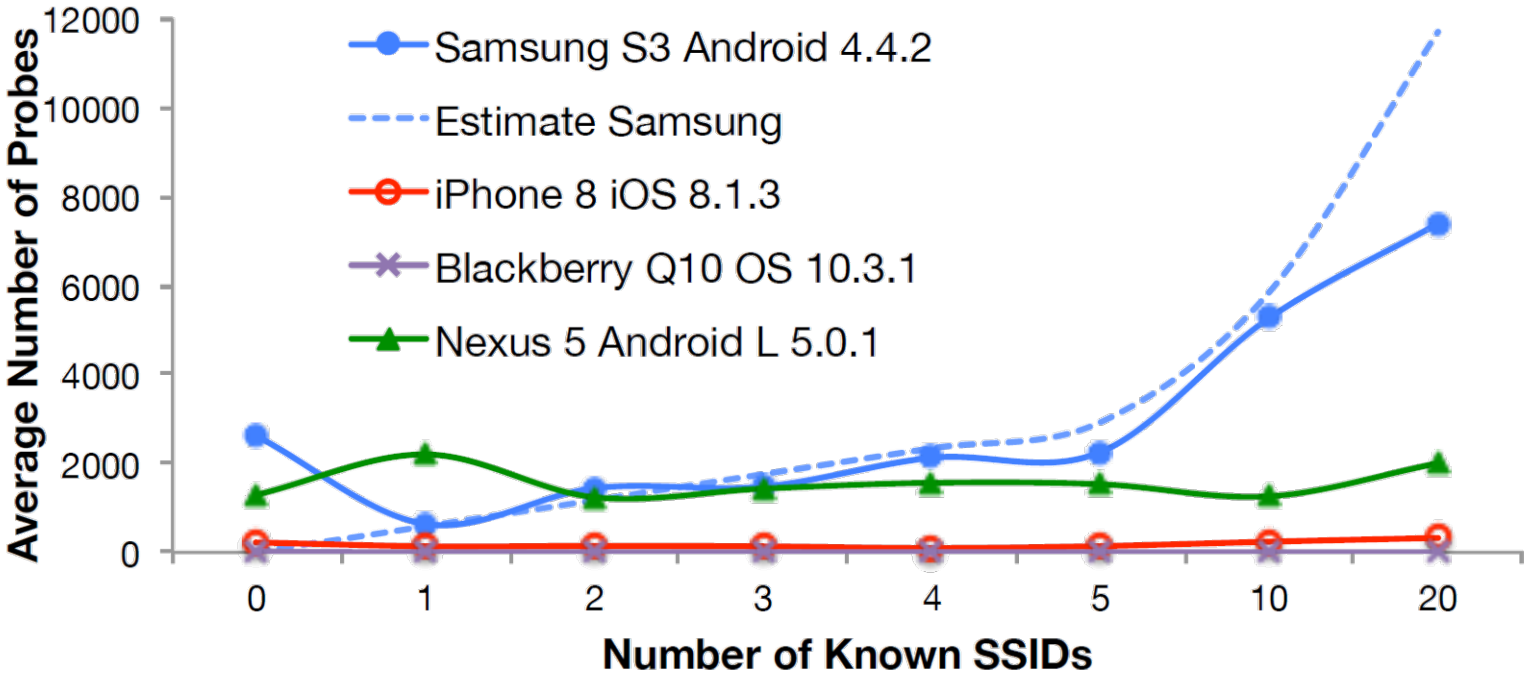
MAC Randomization



Countermeasures



Probing Behavior

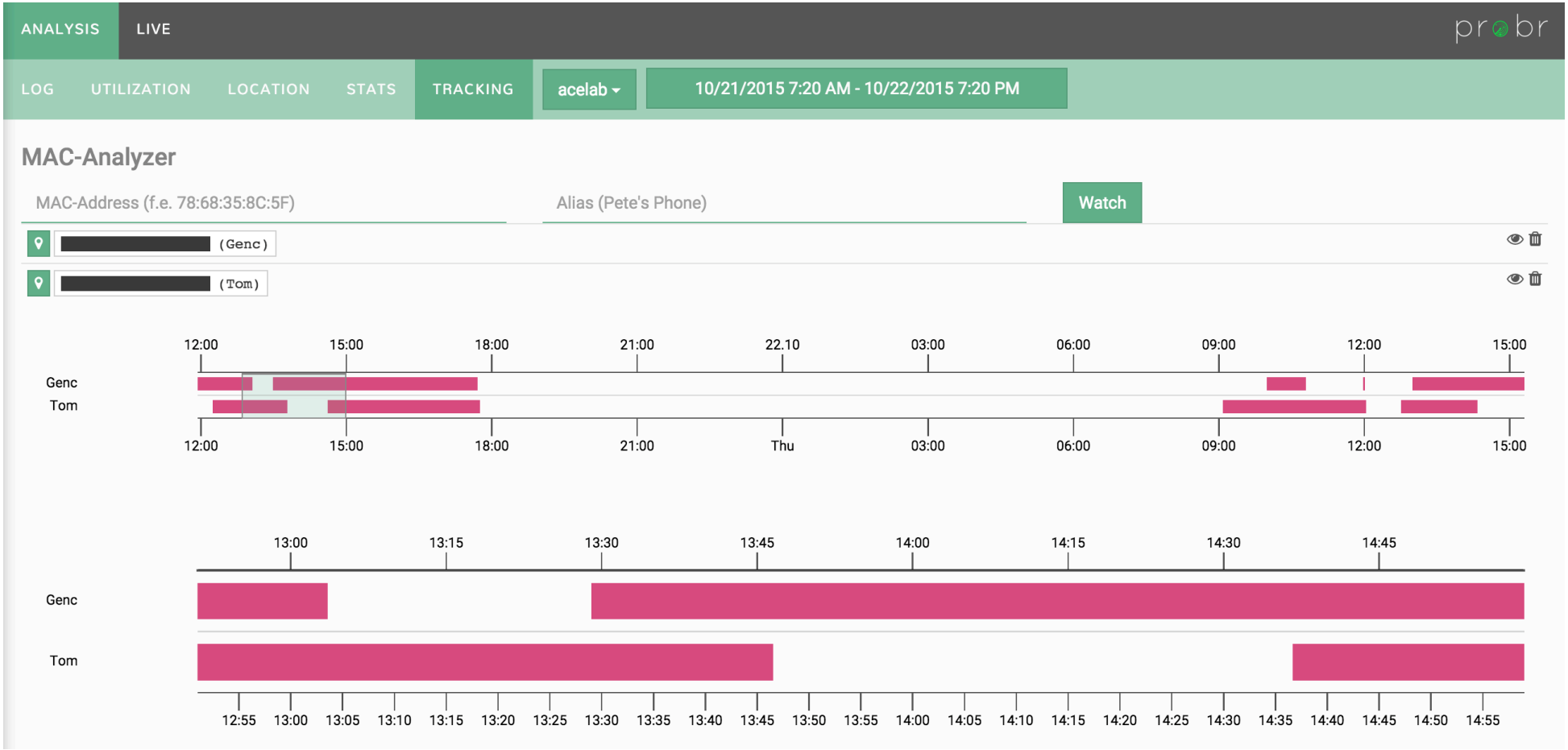


Freudiger, J. (2015, June). How talkative is your mobile device?: an experimental study of Wi-Fi probe requests.

Challenges

- Probr
  - Big data (up to 30 million packets)
  - Generic device support
- Case study
  - Legal situation
    - Informed the meeting attendees
    - Anonymous analysis (no mapping of MAC addresses to participants)
    - Attendees could request exclusion of their devices

U3) Person Tracking – Web Interface



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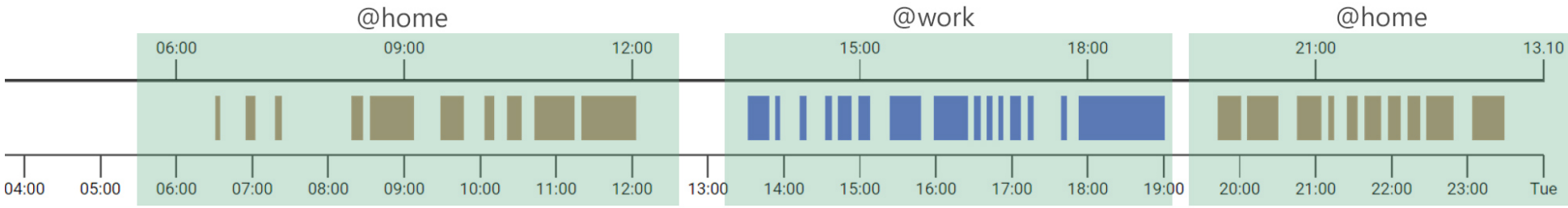
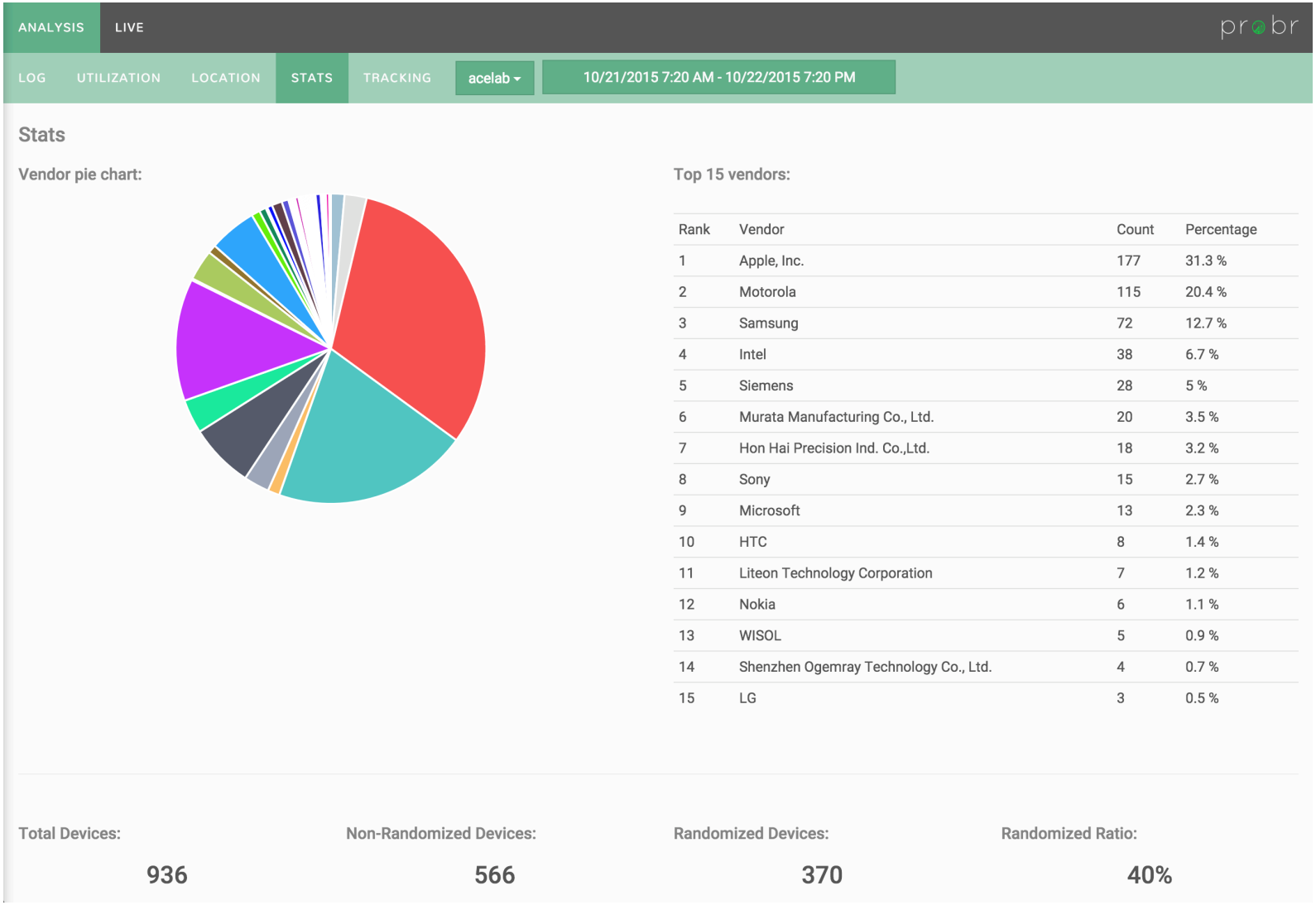
Case Study – U3) Person Tracking



U4) Device Statistics – Web Interface



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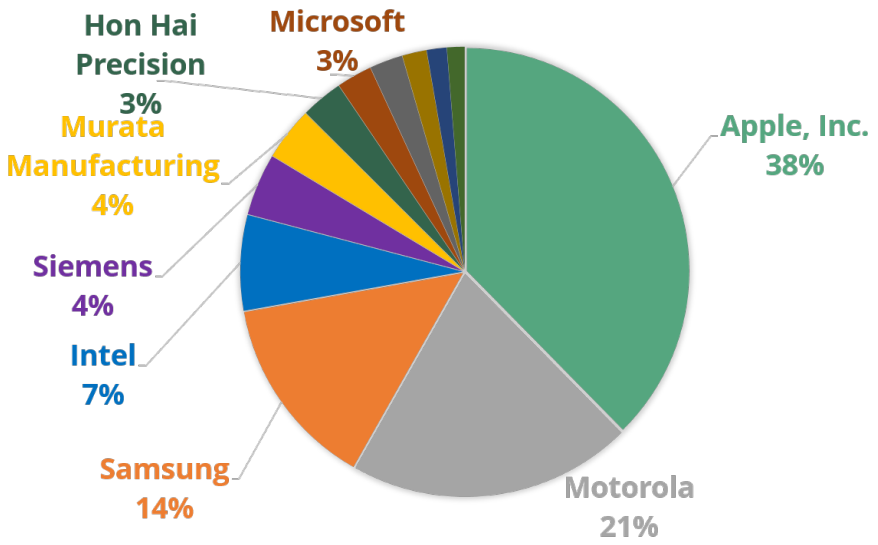
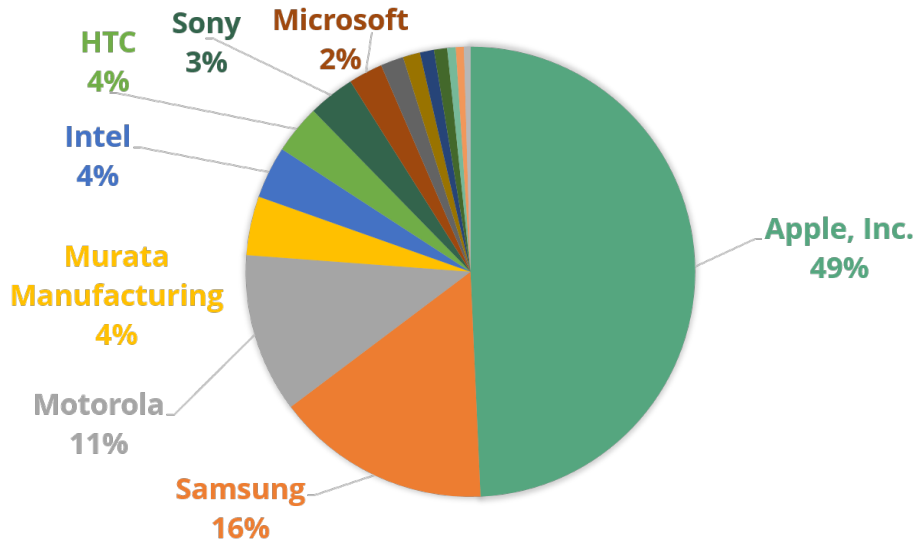
Case Study – U4) Device Statistics



(a) Distribution during Case Study



(b) Distribution over 4 Months

Device Vendor Distributions