

AIDE: Augmented Onboarding of IoT Devices at Ease

Huanle Zhang[#], Mostafa Uddin[&], Fang Hao[&], Sarit Mukherjee[&], Prasant Mohapatra[#]

[#]University of California, Davis, California

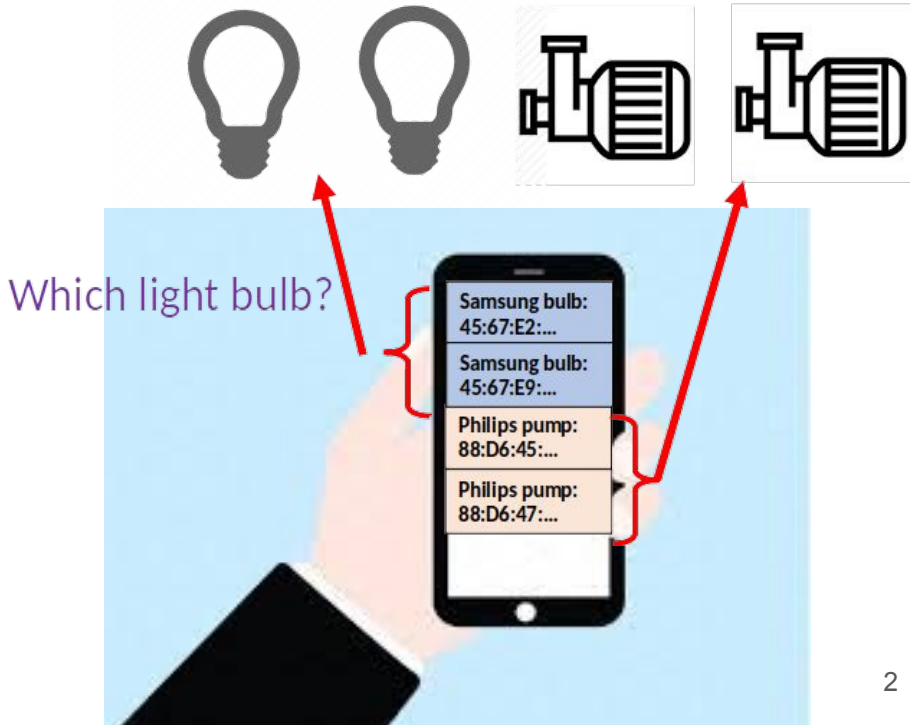
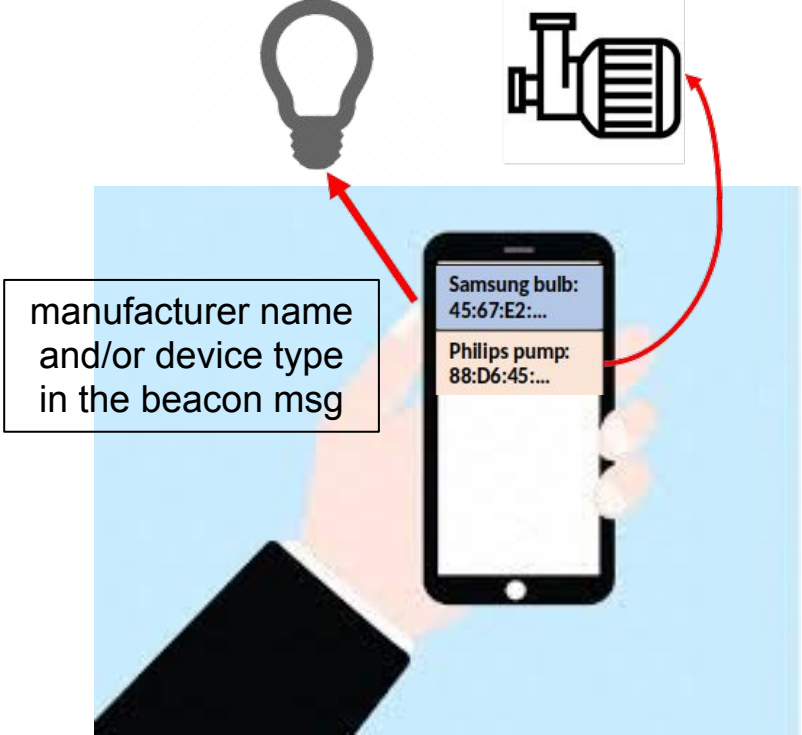
[&]Nokia Bell Labs, Murray Hill, New Jersey

ACM HotMobile 2019, Santa Cruz, California

Onboard Multiple IoT Devices of Identical appearance

Devices of different manufacturer or type

Devices of same manufacturer and type



Status Quo: Manual Onboarding



Industry floor with large number of IoT devices
(types, instances per type)

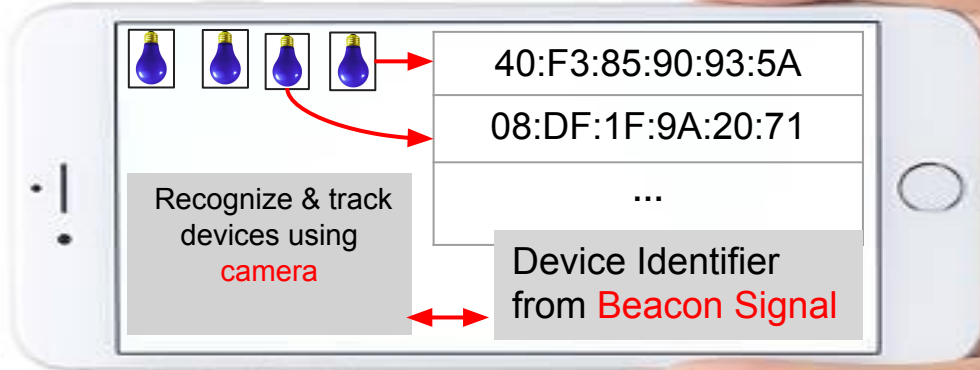
Legacy Manual Procedure

- Enter device ID (e.g., MAC address) from the original package of each device.
- Connect with each MAC address and control them to visually identify.

Shortcomings

- Tedious and error-prone
- Hard to verify (visually) for some devices

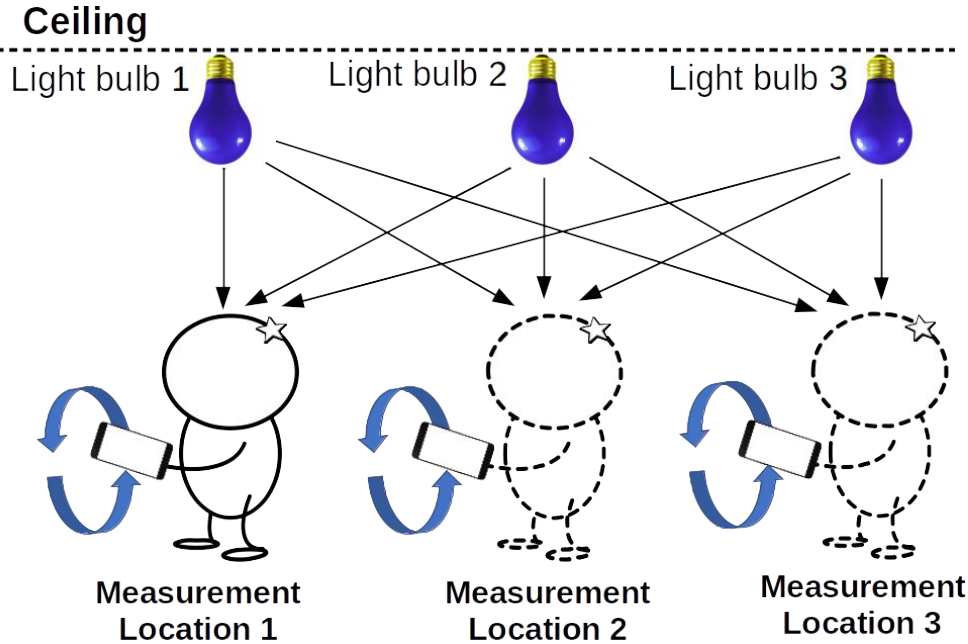
Onboarding of seemingly identical devices



Mapping?

Map Visual Identity with Beacon Signals through systematic **RSS contrast** measurement at **different locations**

Measuring Procedure



1. Each measurement location **correspond** to a target device.
2. A measurement location (Location 1) of a target device (light bulb 1) is the **position that is closest** to that device compared to the other measurement locations.
3. A measurement location should be **as close as possible** to the target device.

Voting-Based Algorithm

- Likelihood of each device ID at each measurement location.
 - $M \geq N$, M : number of devices (including target and non-target devices)
 - N : number of measurement locations

$$D = \begin{bmatrix} d_{11} & d_{12} & \dots & d_{1N} \\ d_{21} & d_{22} & \dots & d_{2N} \\ \dots & \dots & \dots & \dots \\ d_{M1} & d_{M2} & \dots & d_{MN} \end{bmatrix}$$



$$V = \begin{bmatrix} \sum_{j=1}^N (d_{11} - d_{1j}) & \dots & \sum_{j=1}^N (d_{1N} - d_{1j}) \\ \sum_{j=1}^N (d_{21} - d_{2j}) & \dots & \sum_{j=1}^N (d_{2N} - d_{2j}) \\ \dots & \dots & \dots \\ \sum_{j=1}^N (d_{M1} - d_{Mj}) & \dots & \sum_{j=1}^N (d_{MN} - d_{Mj}) \end{bmatrix}$$

Voting matrix

d_{ij} = RSS measurement profile (e.g., mean, median, 95-th percentile etc.) of i^{th} device ID at j^{th} location

$$\sum_{k=1}^N (d_{ij} - d_{ik}) = \text{Likelihood vote of device } i \text{ being at location } j$$

Find the maximum likelihood summation from voting matrix that make one-to-one mapping between a device ID and location ID

Evaluation: Line & Grid Topology

Algorithm	Topology: Line 2 feet apart on ceiling	Topology: Grid 4 feet apart on ceiling
Naive	53.8 %	62.2 %
Greedy	76.5 %	64.4 %
AIDE	87.9 %	84.4 %

Naïve: Device ID that has the strongest RSS in one location

Greedy: Device ID that has the strongest RSS in all locations iteratively

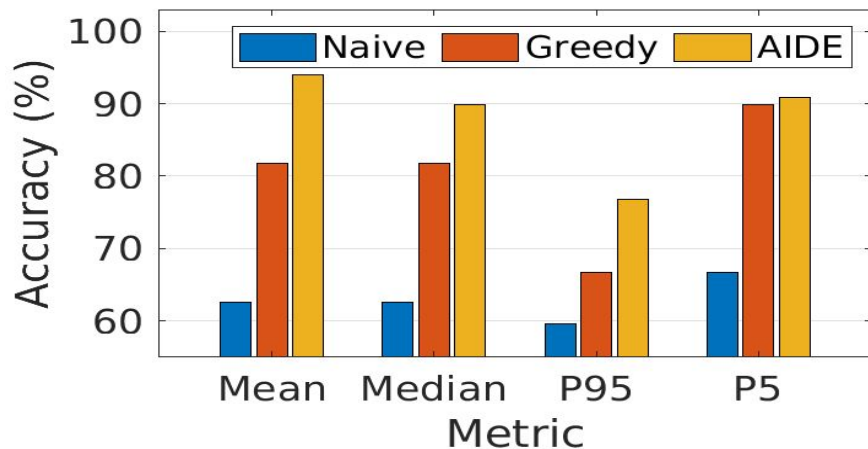
Thanks

Demo was given yesterday

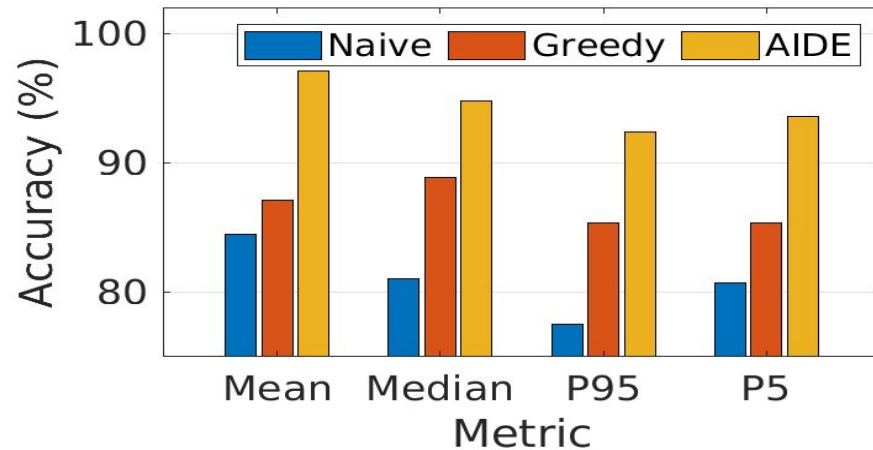
Demo code is available at

<https://github.com/dtczh/AIDE-HotMobile19>

Evaluation: 2 Devices



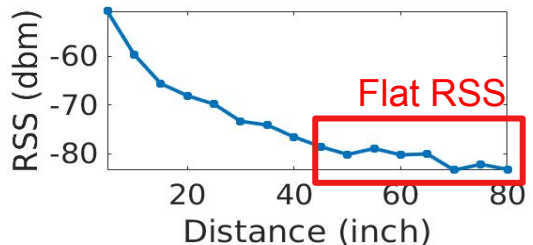
Devices 2 feet apart



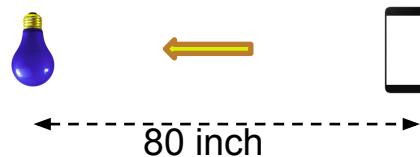
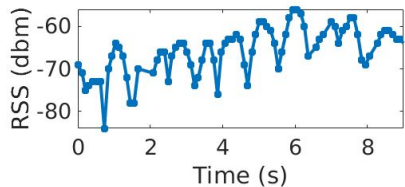
Devices 4 feet apart

Measuring Constraint

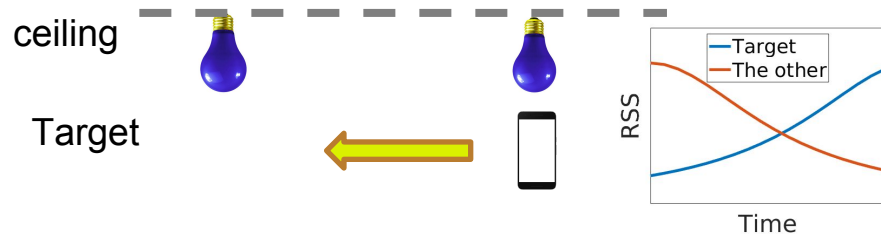
1. Devices have **different** transmission powers
2. Beyond certain distance change in signal strength is **indistinguishable**.



3. Noisy RSS Data due to **Multipath Effect** at Indoor environment.



1. Devices may **not be approachable** (e.g., devices on ceiling)



2. Device **placement** (e.g., devices are close to each other)

