A Tagging Solution to Discover IoT Devices in Apartments

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Agenda

- Motivation
- Tag models
- Implementation
- Evaluation
- Future work
Motivation
More IoT Devices at Home...

- Smart homes use IoT devices to improve the occupants’ lives.
- As of 2021, 43% of households in the U.S. own a smart device, increasing from 33% in 2019.
Multi-User Smart Homes

Example: rental apartment

- Device owners are not always the users (e.g., landlord vs. tenant).

- Increasing number of devices installed by different people are harder to manage.

- Specific IoT devices can exist out of sight.
How to manage IoT devices from users’ perspectives?

- Discover and locate
  - Any IoT devices in the home whether on or off
  - WiFi, Zigbee, ...

- Identify and inventory
  - Detailed information about the device (e.g., type, vendor, user review, security features, ...)

- The solution must be easy and cheap to use
Our Contribution

- A tagging implementation for discovering and identifying hidden IoT devices
- A user study on the tags that focuses on participants’ comfort levels and price acceptability
- An analysis of our wireless tagging solution’s feasibility
Tag Models
Threat Model

Collaborative setting

- Landlords are willing to introduce the tenants to the loop of managing the devices to use.
- Vendors want to improve public relationship by implementing privacy-friendly products.
Wireless Tags

Different ranges and different power consumptions

- BLE
- UWB
- NFC
Privacy: Two Modes, Two Purposes

- **Discover and locate**
  - Longer detection distance
  - Direction information to the device
  - Not reveal detailed device information

- **Identify and inventory**
  - Only the user can access the detailed device information.
  - Proximity requirement
Two-Tag Model

Two-tag model balances utility and privacy

- **Location mode**
  - BLE with buzzer (i.e., BLE-AC)
  - UWB (i.e., UWB-RAW)

- **Inventory mode with NFC**
  - Detailed device information is stored in the NFC tag.

**Tag reader**

- Smartphone for BLE and NFC
- UWB adapter connected on smartphone for UWB
Implementations
Tag Models

- **BLE-AC**
  - ItsyBitsy nRF52840 Express with a buzzer

- **UWB-RAW**
  - DWM1001-DEV
Tag Reader App: DIAL

Location Mode

5:38
Devices Found: 2

MAC | Distance  | Locate
---|-----------|-------
FE:90:61:33:97 | More than 2 meters away  | Activate Sound
DA:63:34:EF:30:66 | More than 2 meters away  | Activate Sound

Inventory Mode

Device URL: shorturl.at/cqBEI
Evaluation
# Accessibility: Cost and Battery Life

| Model Name | Price  | Battery Life Minimum (6000 mAh) | Battery Life Maximum (9000 mAh) |
|------------|--------|----------------------------------|----------------------------------|
| BLE-AC     | $21.66 | 250 days                         | 375 days                         |
| UWB-RAW    | $20.26 | 3.3 days                         | 5 days                           |
Battery Life Clarification

- UWB-RAW is designed to be an anchor point instead of turning off UWB when unused.

- BLE-AC consumes less than one milli amperes, but our power meter could not read less than that.
Usability of Tags

Tag hunt trials with 23 users

|            | UWB-RAW (s) | BLE-AC 1 (s) | BLE-AC 2 (s) |
|------------|-------------|--------------|--------------|
| Avg.       | 51.44       | 22.63        | 25.62        |
| Std.       | 13.59       | 8.93         | 22.08        |

They found our tag models easy to learn and use.
| Question                                                                 | Average Score |
|-------------------------------------------------------------------------|---------------|
| I think that I want to use this system frequently.                      | 4.43          |
| I found the system unnecessarily complex.                               | 1.30          |
| I thought the system was easy to use.                                  | 4.78          |
| I think that I would need the support of a technical person to be able to use this system. | 1.61          |
| I found that the various functions in this system were well integrated. | 4.74          |
| I thought there was too much inconsistency in this system.             | 1.35          |
| I would imagine that most people would learn to use this system quickly.| 4.52          |
| I found the system very cumbersome to use.                             | 1.48          |
| I felt very confident using the system.                                | 4.74          |
| I needed to learn a lot of things before I could get going with this system. | 1.56          |

- Our lowest-scored question is whether the user can interact with this system without a technical person.
- The second lowest-rated question is if the user would use this system frequently.
Future Work

- Evaluation for skyscrapers or stadiums

- Additional user study:
  - Price acceptability
  - Landlord or vendor willingness to tag the devices

- Add low-power configured BLE to inventory mode
Q & A