
A Tagging Solution to Discover IoT Devices in Apartments

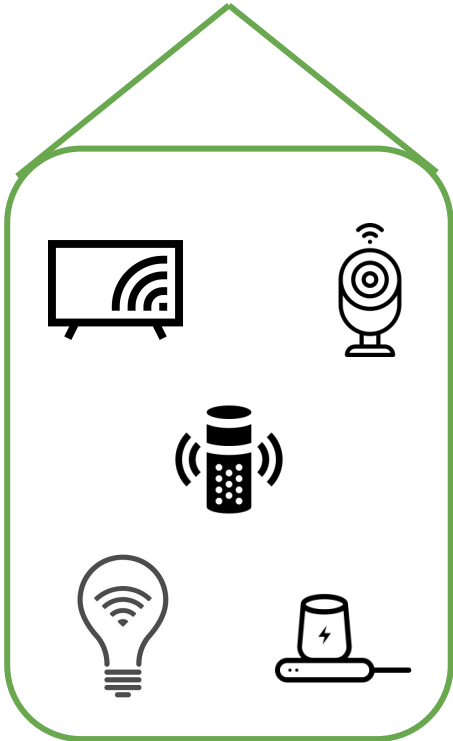
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Agenda

- Motivation
 - Tag models
 - Implementation
 - Evaluation
 - Future work
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Motivation

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
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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.
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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
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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
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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.
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TAG MODELS



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
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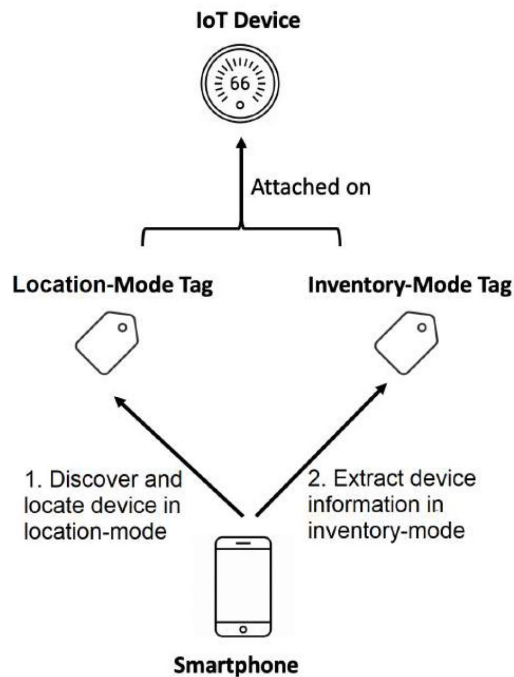
Two-Tag Model

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.

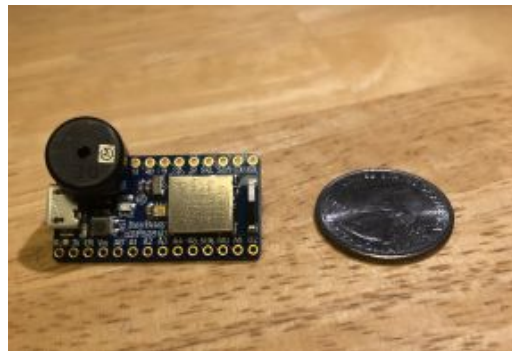
Tag reader

- Smartphone for BLE and NFC
- UWB adapter connected on smartphone for UWB



Implementations

Tag Models

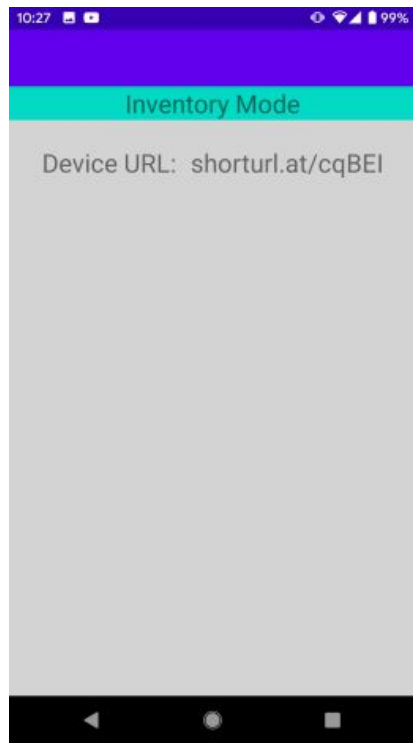


- BLE-AC
 - ItsyBitsy nRF52840 Express with a buzzer



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



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.

System Usability Scale (SUS)

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.
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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
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Q & A
