

I Tag, You Tag, Everybody Tags!

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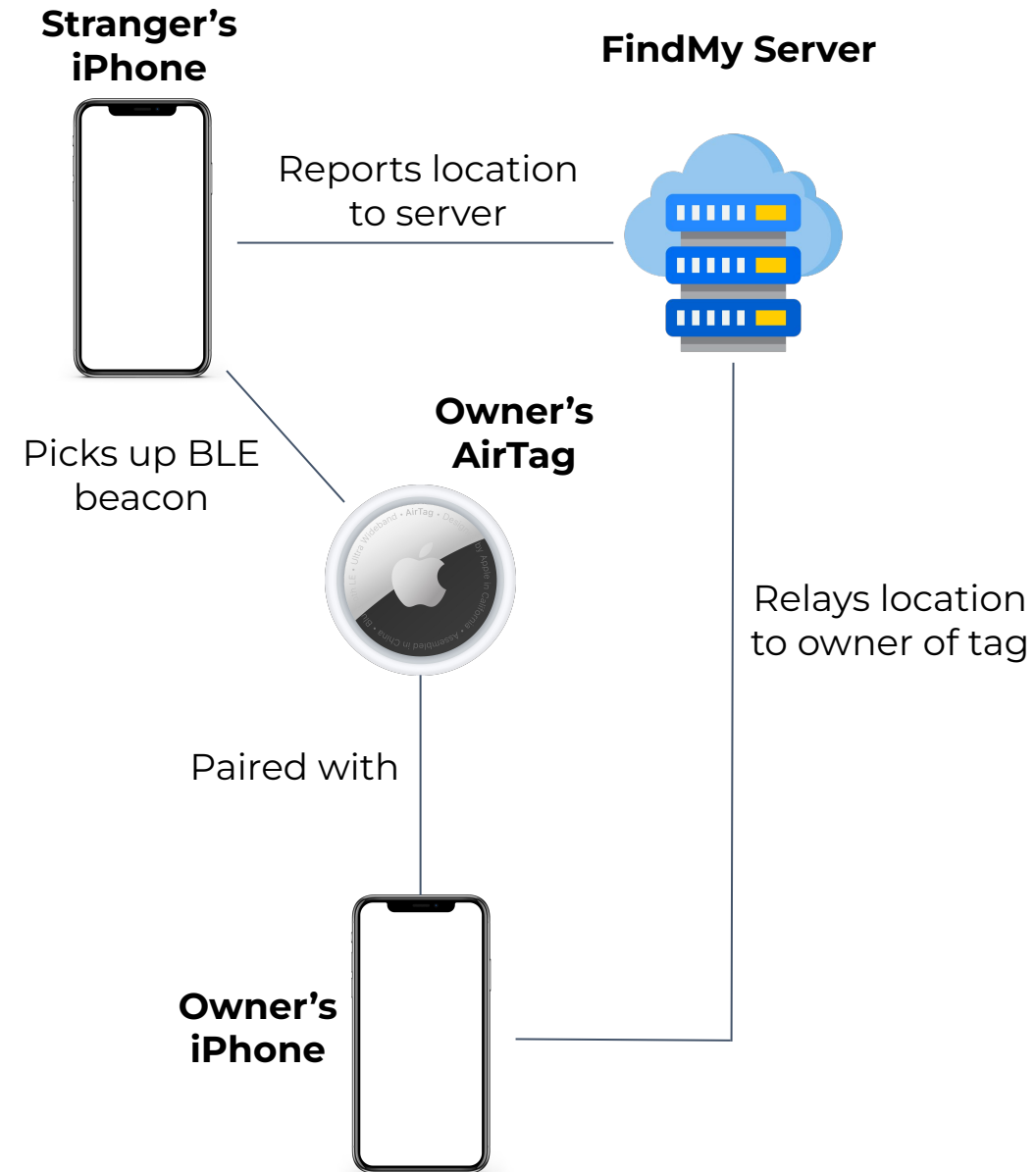
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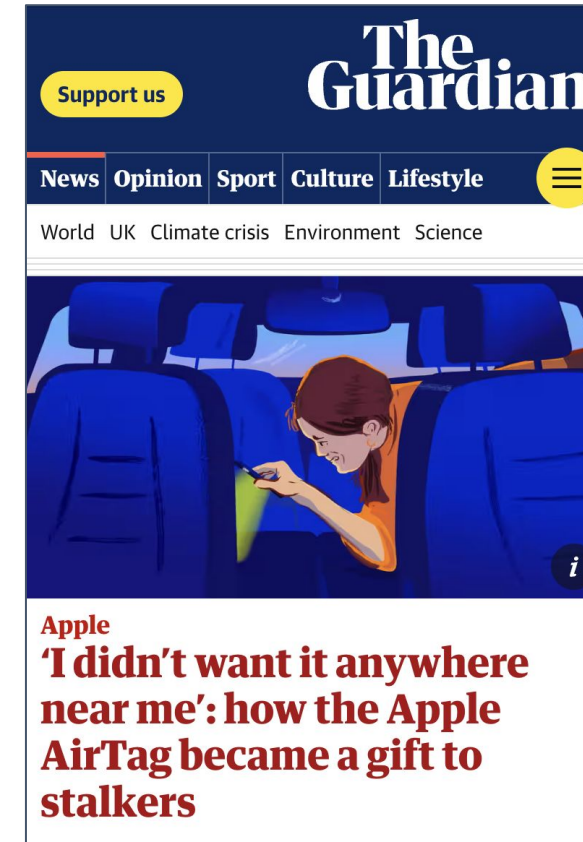
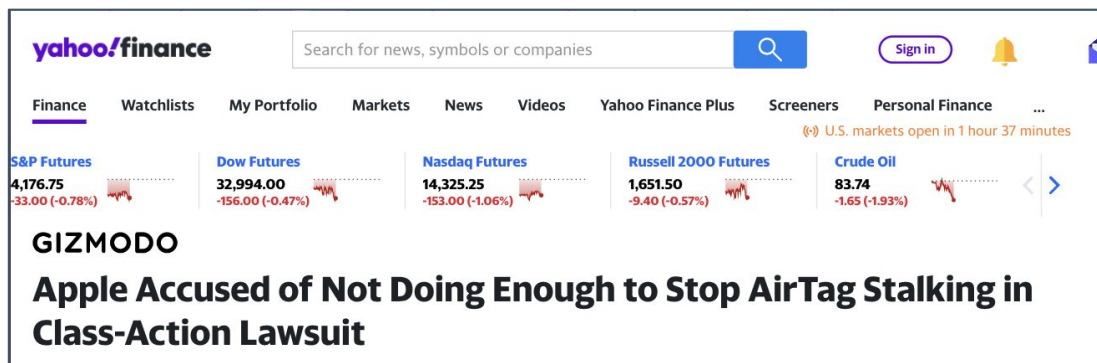
How do location tags work?

Location tags rely on BLE to report their location based on the GPS location of a compatible device nearby.



The problem

Location tags could possibly be misused
to *stalk* people



In the wild experiment goals

- Understand how accurate and responsive different tags are in reporting their location
- Understand how this accuracy changes based on different mobility factors

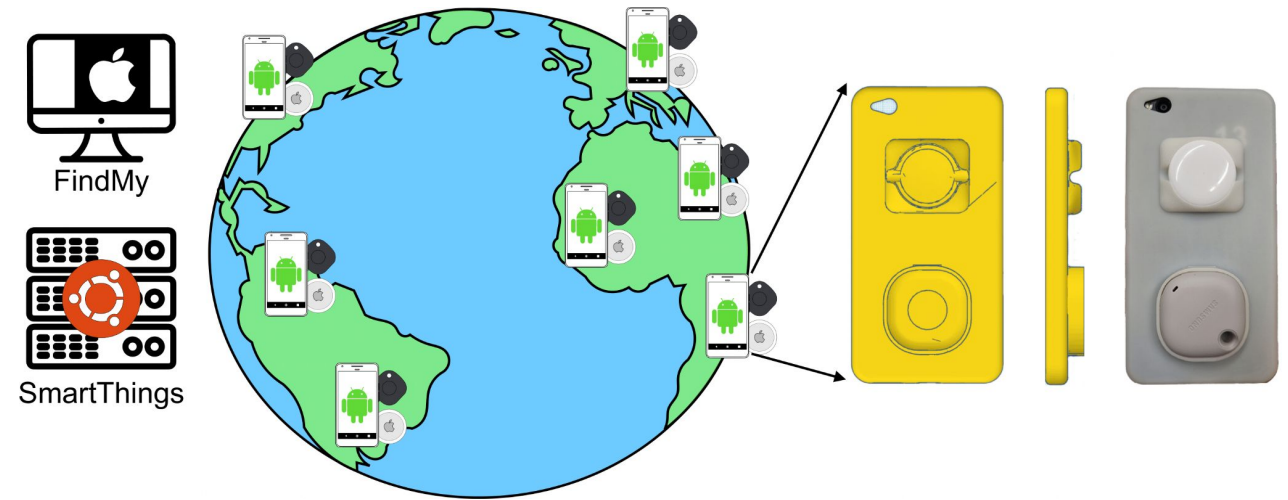
Experimental Setup

1. Vantage points

- Xiaomi Redmi Go used to report true GPS location
- Apple AirTag
- Samsung SmartTag

2. Scrapers

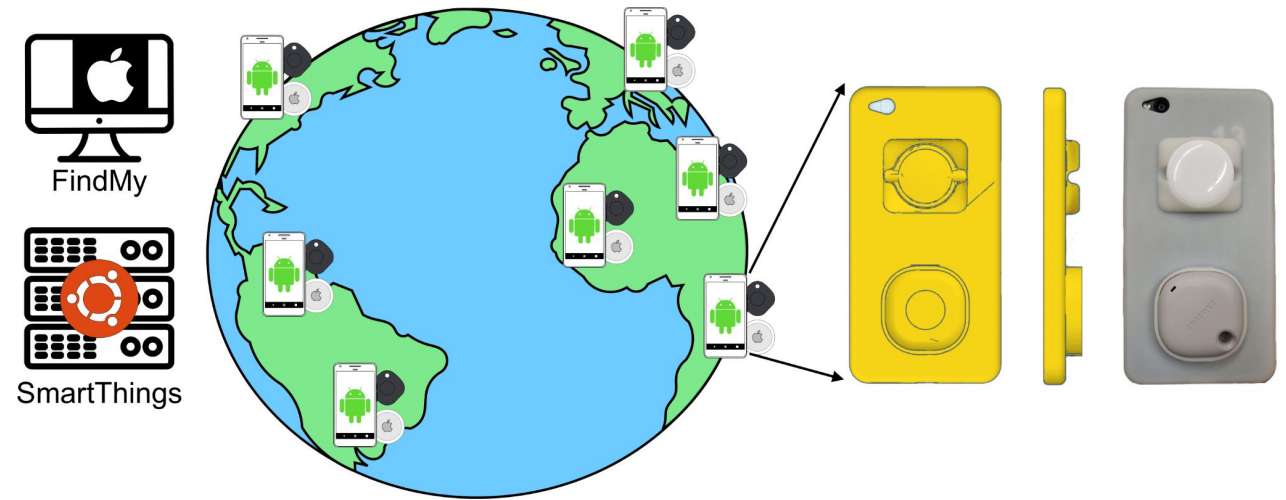
- Collect information reported on FindMy and SmartThings apps



Experimental Setup

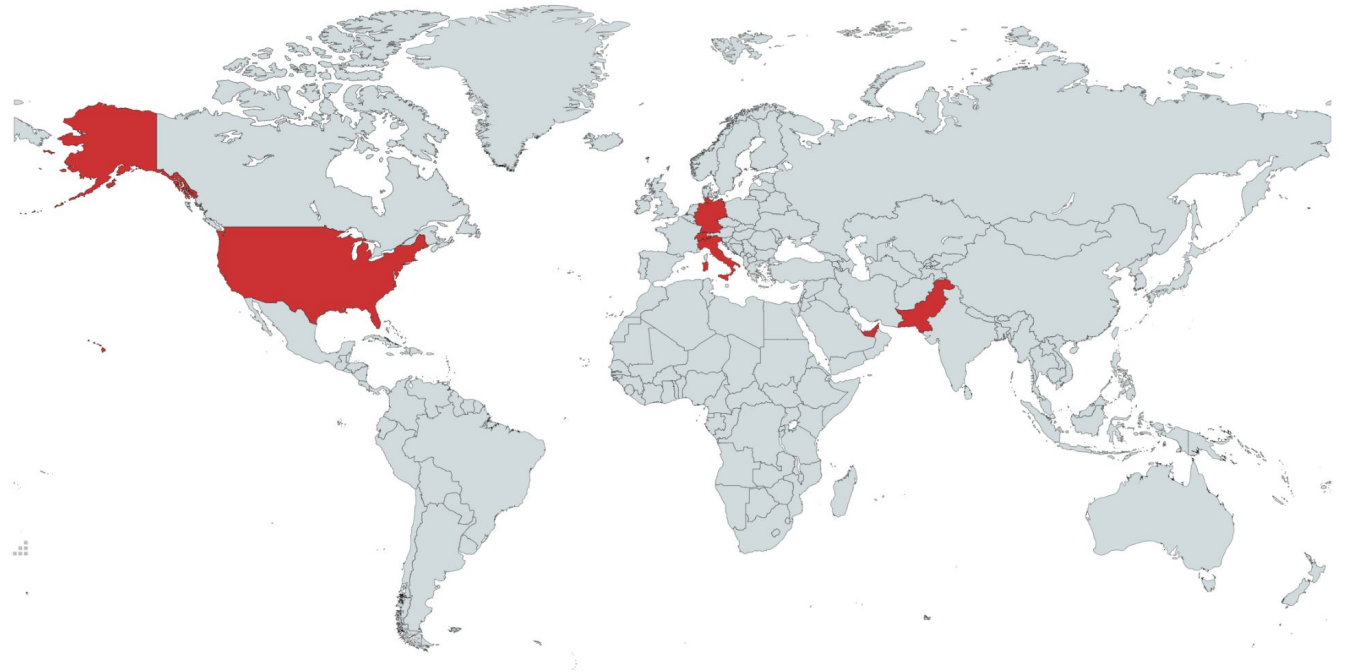
3. What is an accurate location report?

- A tag is said to have reported its location correctly if it reports its location to be within a given radius from the true GPS location and within a given timeframe
- Different radii and timeframe thresholds tested

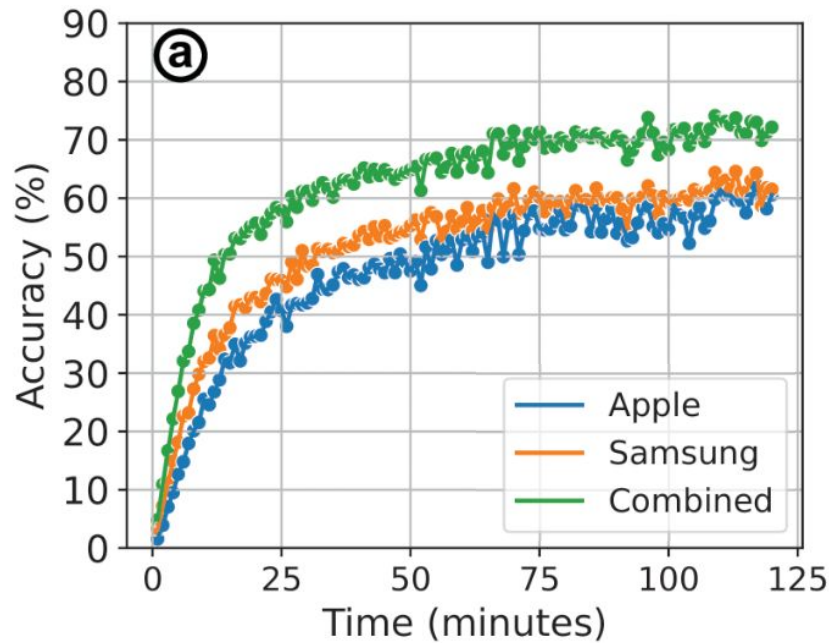


In the wild experiment

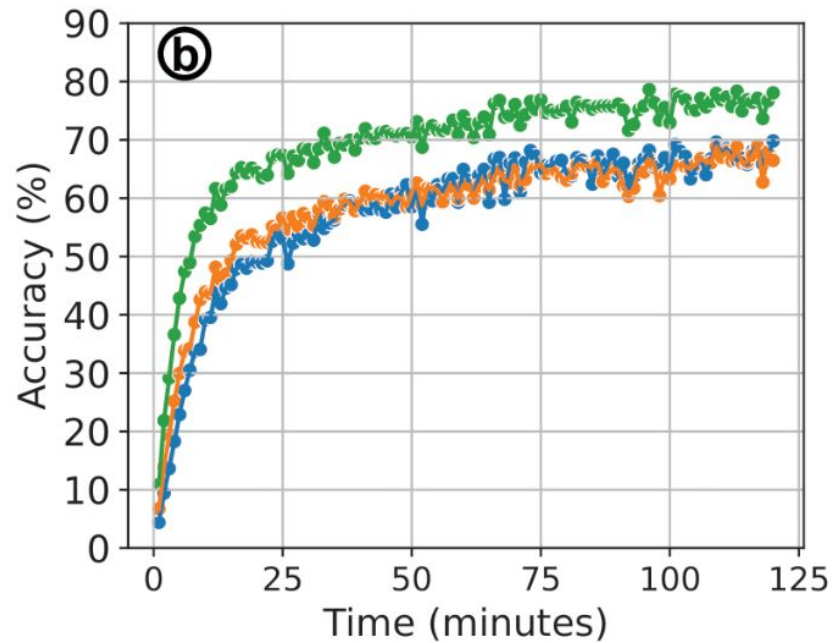
- Data collected spans:
 - 6 different countries
 - 20 different cities
 - 120 days
 - 24,000 locations reports
- Discarding home information:
 - All data collected at locations where participants lived was discarded to not skew results



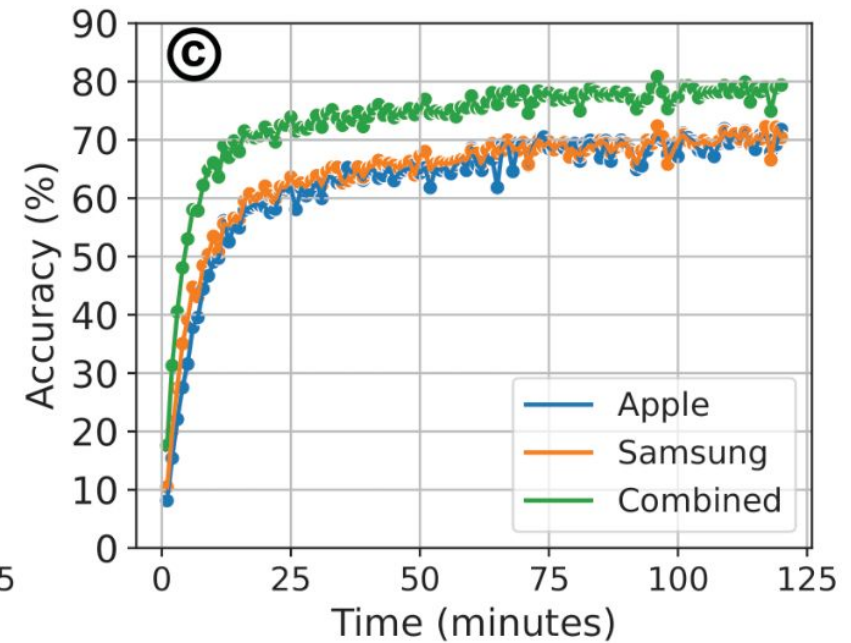
Effect of distance and time on accuracy



10 meter radius

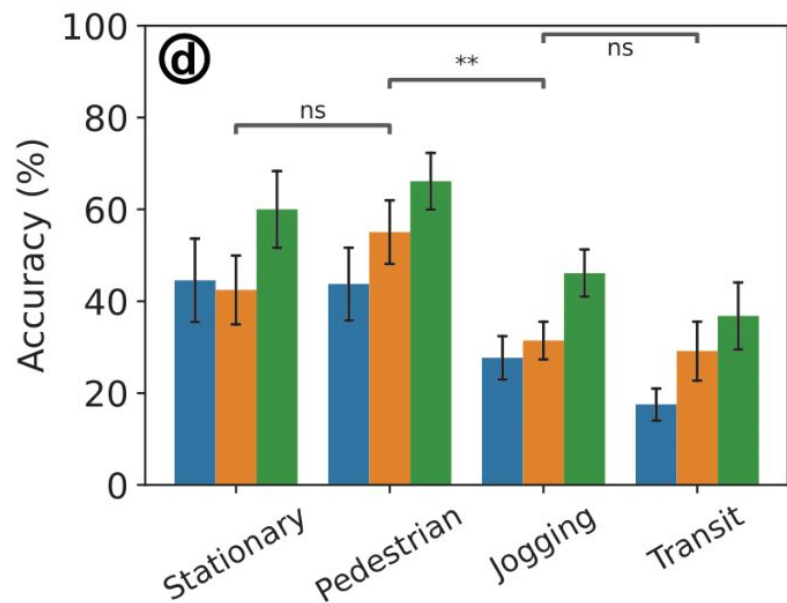


25 meter radius

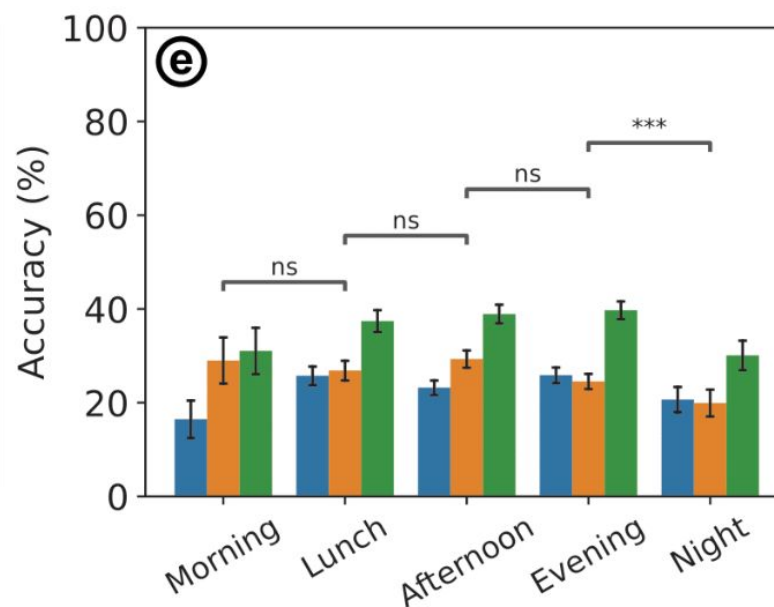


100 meter radius

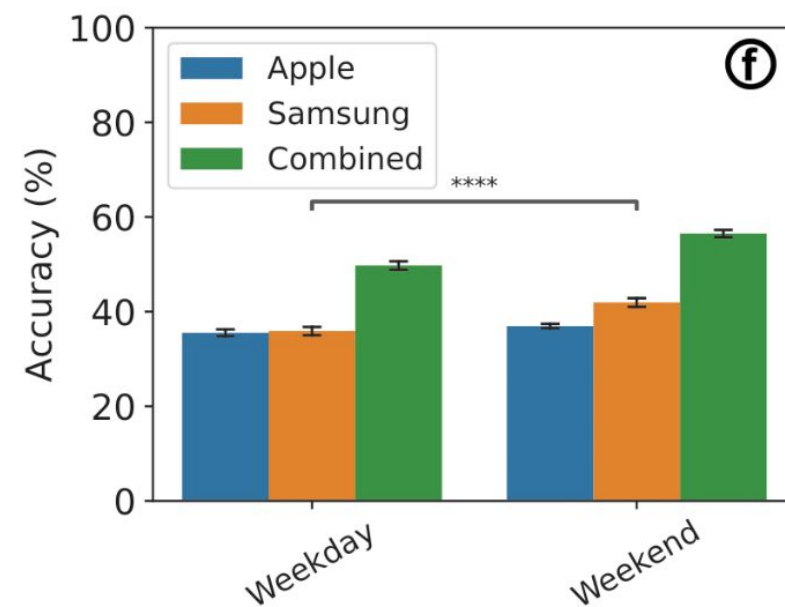
Effect of mobility and time of day on accuracy



Movement speed



Time of day

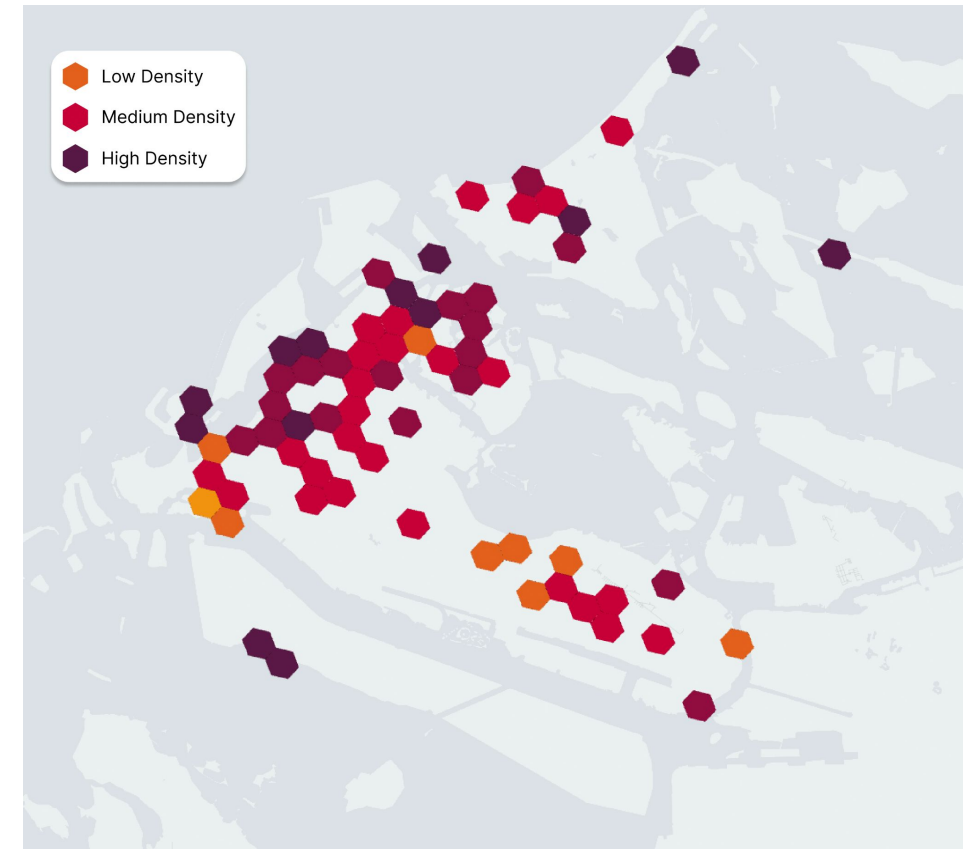


Day of the week

Population density

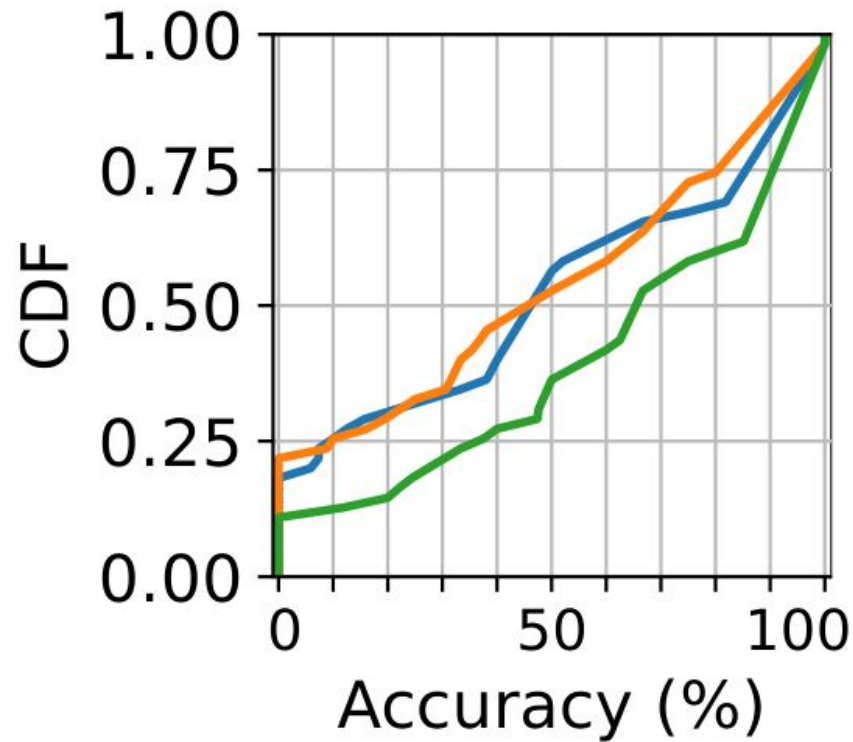
Understanding relationship of accuracy to population density requires dividing locations visited into different segments

- We use Uber's Hexagonal Hierarchical Spatial index to segment locations into hexagons of roughly equal size.
- We use the Kontur population density dataset which reports population within a given hexagon

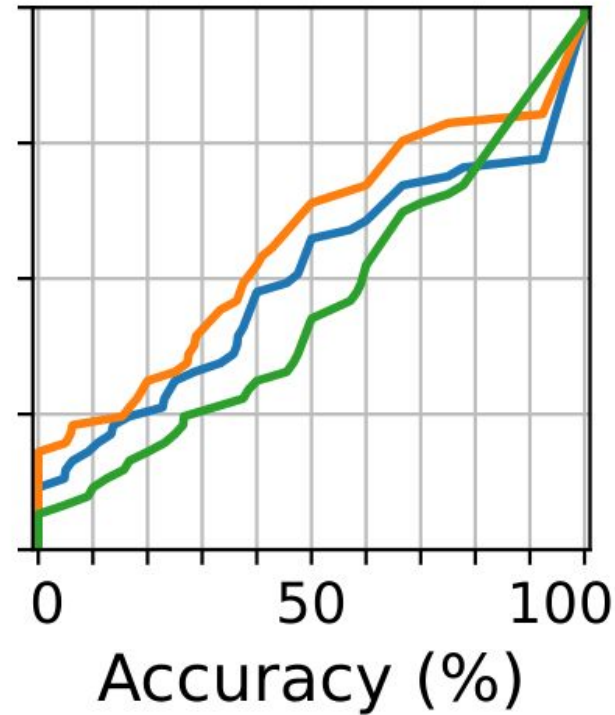


Locations visited in Abu Dhabi

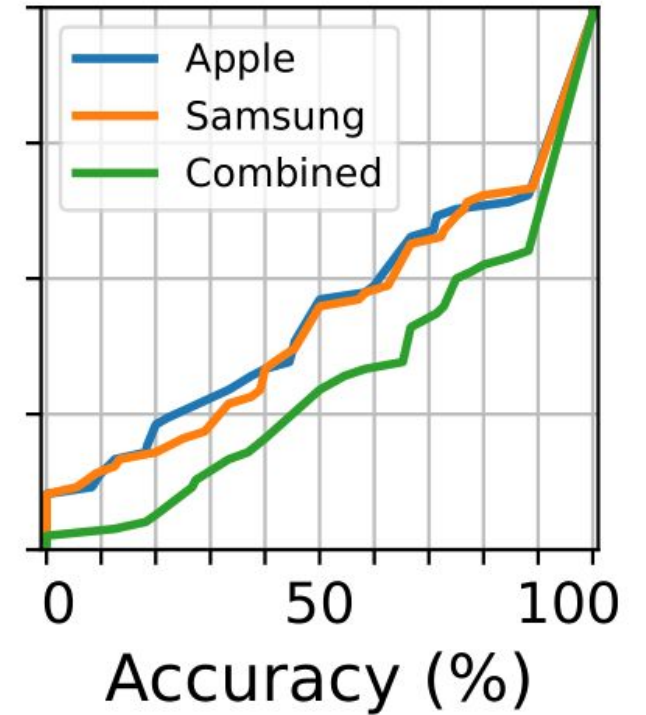
Effect of population density on accuracy



Low density areas



Medium density areas



High density areas

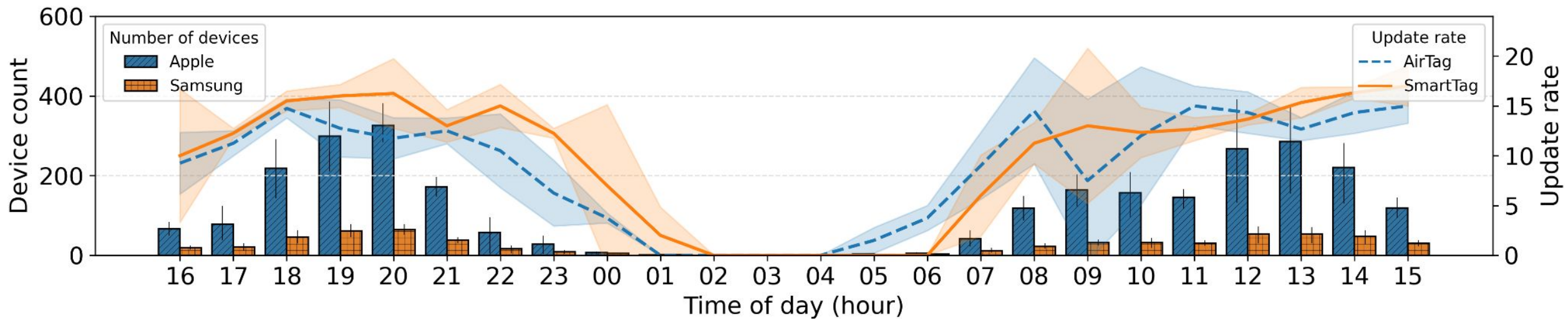
Controlled experiment goals

- Understand the relationship between number of location-reporting devices and update rate
- Understand the signal strength of both location tags

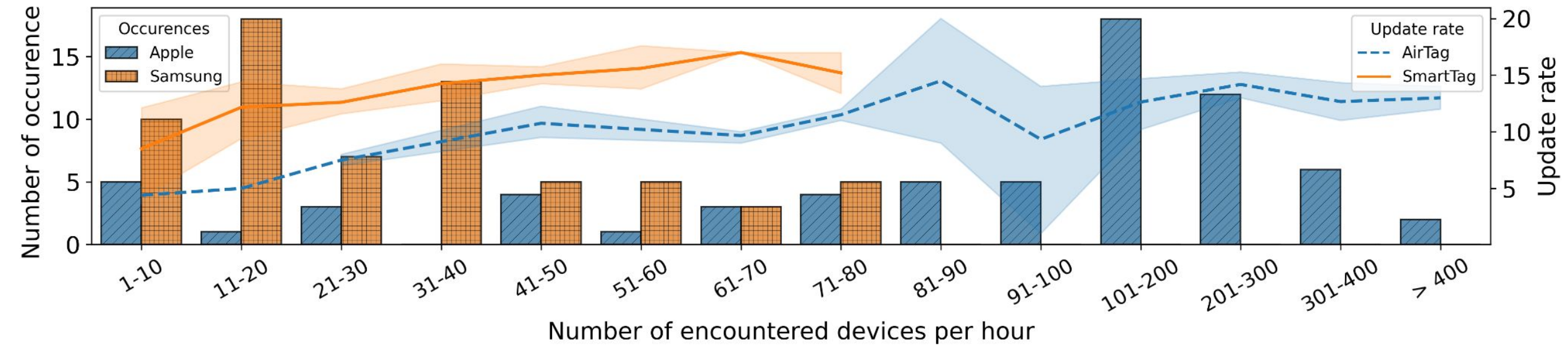
How to control for number of phones in vicinity of tags?

- Deploy the phones in a controlled environment, like a university cafeteria!
- Vantage point was placed in a high flux area (cashier) to maximize number of phones encountered for 5 days.
- Information regarding the number of Apple and Samsung devices in the cafeteria at a given time was retrieved with the help of the university's IT department.

Effect of number of devices and time of day on update rate

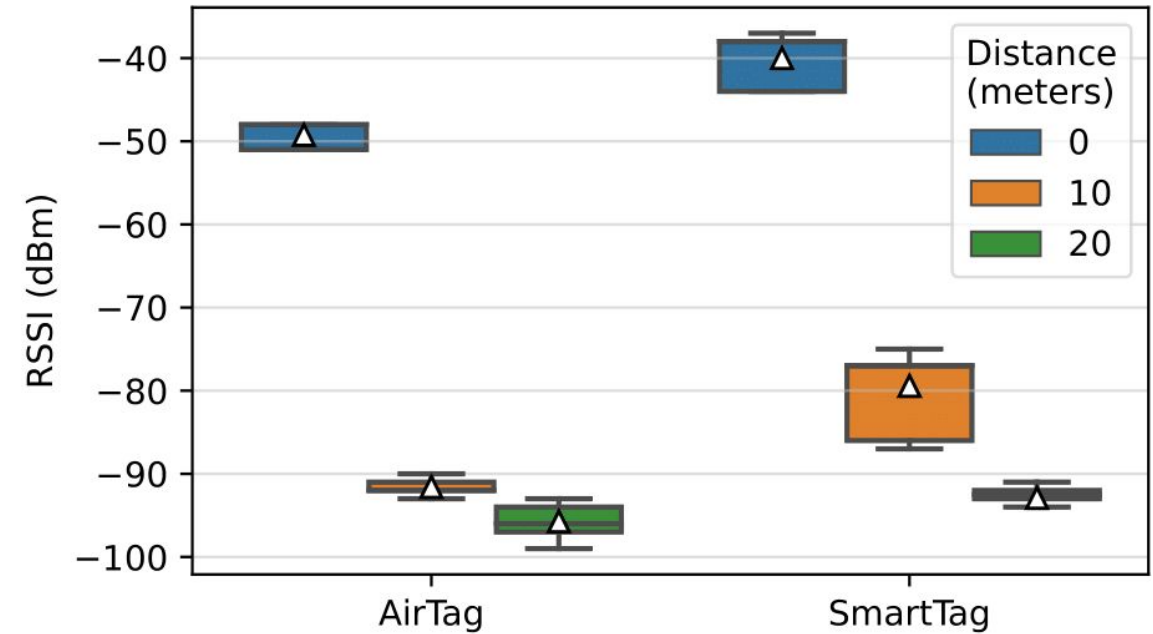


Effect of number of devices on update rate



Signal Strength vs. Distance

- Deployed a SmartTag and AirTag in a secluded area
 - Helps that Abu Dhabi has many desert areas!
- Measured signal strength at different distance intervals from the tags



Potential for stalking

- While these tags can not provide their precise location immediately, they can still offer an approximate location with just a one hour delay.
- Potential for misuse by bad actors, such as government surveillance of dissidents or domestic abuse stalking
- More research is needed to study methods to combat misuse

Future work

- Scaling up this experiment to test the accuracy of these tags (and more tags such as Tile mate) in new locations and scenarios
- Expanding AmiGo experiment to more locations with 5G capable phones!
 - Get in touch with me, or Matteo Varvello if you'd like to collaborate or run some measurements across multiple global locations in the wild.
 - Varvello, Matteo, and Yasir Zaki. "**A Worldwide Look Into Mobile Access Networks Through the Eyes of AmiGos.**" 2023 TMA. IEEE, 2023.



Thank you for your attention!

More work from our lab

1. Ibrahim, Hazem, et al. "Perception, performance, and detectability of conversational artificial intelligence across 32 university courses." Scientific Reports
2. Ibrahim, Hazem, et al. "Rethinking Homework in the Age of Artificial Intelligence." IEEE Intelligent Systems
3. Ibrahim, Hazem, et al. "YouTube's recommendation algorithm is left-leaning in the United States." PNAS Nexus
4. Chaqfeh, Moumena, et al. "Towards a World Wide Web without digital inequality." Proceedings of the National Academy of Sciences
5. Varvello, Matteo, and Yasir Zaki. "A Worldwide Look Into Mobile Access Networks Through the Eyes of AmiGos." 2023 TMA. IEEE, 2023.

