Abuse-Resistant Location Tracking: Balancing Privacy and Safety in the Offline Finding Ecosystem Gabrielle Beck Matthew Green Harry Eldridge



Nadia Heninger **Abhishek Jain**

UC San Diego

- Track physical objects: keys, luggage, pets, etc.
- Works via a crowd-sourced location tracking system





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- Secretly place an LTA you own on a person's belongings, follow their movement.
- Detected by recognizing a persistent nearby ID



AirTag Detected Near You

First seen with you today at 15:37



Play Sound Locate AirTag



Pause Tracking Notifications



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Mitigations

- Apple's current approach is to rotate the ID every 24 hours
- This means honest users can be tracked for 24 hours
- Can we do better?



e the ID every 24 hours

Hope



Stalking victims will be in **continuous proximity** to an LTA



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Tracking adversaries will only see broadcasts in short bursts





Stalking victims will be in **continuous proximity** to an LTA

We want a scheme where you can only **link** broadcasts together if you have **seen enough of them**

Tracking adversaries will only see broadcasts in short bursts



























C

С

Secret Sharing Alone Isn't Enough B С A C B A ????? B A AB

Multi-Dealer Secret Sharing

T = 3 Reconstruct S S





























Reconstruct











S

 Privacy against trackers follows from unlinkability





 Privacy against trackers follows from unlinkability

K = 3 Argoi Planeda E 39th St St Paul HAMPDEN WAVERLY La Cuchara **Johns Hopkins** The Weinberg Y in Waverly University **ROOSEVELT PARK** E 33rd St Wyman P Mame irse ore Museum of Art COLDSTREAM - HOMESTEAD Exeter Hall Ave E 28th St - MONTEBELLO CHARLES VIL E 25 h St Irk Lake Dr Safeway 63 (25) Druid P2 The National Great **OLD GOUCHER** Wilson House **Blacks In Wax Muse Bed & Breakfast** Top rated N NORTH BYP (40) STATION NORTH **Green Mount Cemetery** Federal St **BOLTON HILL** The Lyric Baltimore 🤜 E Preston St man St MID-TOWN BELVEDERE WINCHESTER M E Biddle St JOHNSTON SQUARE GAY STREET P UPTON Residence Inn by P Marriott Baltimore at... N Fremont Ave MT VERNON E Madison St ayette Ave Œ The Walters Art Museum BROMO ARTS ondson Ave



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We want **K** and **T** to be as close as possible!

K = 3

J MDSS? D = 2

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D: Number of Dealers

T: Shares until stalker is detected

$sh_i = (a_i, p(a_i))$

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Problem: T > K * D

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T: Shares until stalker is detected

Better MDSS

- Problem: **T** > **D** * **K**
- Solution: Use a different type of code

•
$$sh_i = (a_i, p_1(a_i), p_2(a_i), \ldots)$$

- dealer secrets
- Better Bound (approximate)

- **D**: Number of Dealers
- **T**: Shares until stalker is detected
- **K**: Shares until unlinkability is broken

$$.\,,p_c(a_i))$$

[BKY04, CS03, CH11] too inefficient and only work for random errors. We modify [CH11] to heuristically recover

):
$$T > \frac{1}{c+1}(D + c \cdot K)$$



Implementation Stats

- Allow up to 3 simultaneous stalkers
- New Share every 60 seconds
- Detect stalkers in 1 hour
- Stay unlinkable for 41 minutes



Implementation Runtime



Generates shares in 0.05 seconds



Decodes in **1.27** seconds



Conclusion

Balancing stalker detection and tracker privacy is possible!

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Thank you!

Image Attributions

- AirTag: <u>https://www.apple.com/shop/buy-airtag/airtag/1-pack</u>
- Puck.js: <u>https://shop.espruino.com/puckjs</u>
- model-b/

Raspberry Pi 3B: <u>https://www.raspberrypi.com/products/raspberry-pi-3-</u>