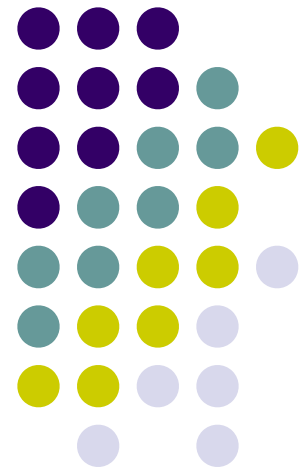
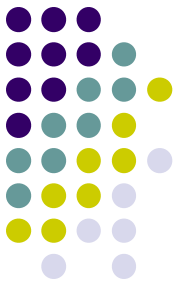


# Ubiquitous and Mobile Computing

## CS 528: *Decentralized Lost and Found with Geolocation*

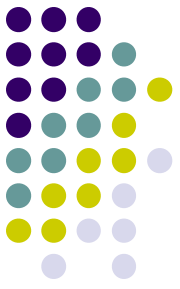
*Evin Ugur*  
*Worcester Polytechnic Institute (WPI)*





# Contents

- Overview
  - Summary/Proposal
  - Vision
  - Related Work
- Methodology/Implementation
  - Application Architecture
  - Location Algorithm
- Results



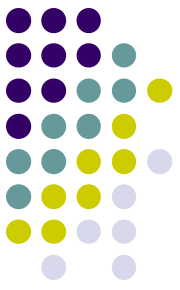
# We all lose stuff!

- People lose items everyday
  - the average person loses \$5,591 worth of valuables in a lifetime (Pebblebee)
- Sometimes we find things that people lost
  - There might not always be a lost and found
- These occurrences are very regular on large shared spaces
  - WPI
  - Office
  - Public Event (Festival, Town Meeting)

# Proposal



- Decentralized Lost and Found (LAF) app based primarily based on geolocation
  - Camera, and other Ubicomp concepts can be integrated
- App provides way for users to:
  - Report an item of theirs as missing - including the location where it was lost
  - Log unattended items as missing
    - If you lost an item maybe someone already found it
  - Report a missing item as found
    - Notion of Location history - *for example if you found some missing headphones in Zoolabs, you can log that and then bring them to the WPI Lost and Found Office*
  - Notify users when they are near misplaced stuff (*more to come...*)
  - Users can interact directly with an item they are reporting or responding to, as well as indirectly with other users using the item as a means of communication.
    - ultimately leading to missing items being resolved



# The Vision

- Goal of this project is to show proof-of-concept decentralized LAF service
- Actual Implementations would have to have a layer of social interactions on top of software concept to mitigate against theft.
- Different Social/Usage Models Based on top of Tech:
  - Notion of friends in the app - *When you report to the app that you lost something have option to limit its visibility to only friends*
  - Notion of bounties - have payment interaction around the process
  - Gamification - not mutually exclusive with other approaches
  - Limit Audience - perhaps this service would be very effective exclusively on large communal spaces
    - Large Office Campus
    - TV/Movie Production Sets

# Related Work



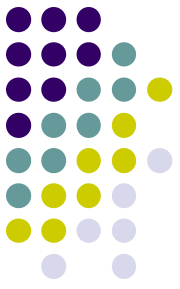
- Bluetooth Low Energy Attachments
  - Attach a device to your item - items can't be found retroactively
  - > Chipolo > Pebblebee
  - TrackR uses geolocation when other TrackR users walk near their device - still reliant on hardware and service!
- You can't install hardware onto everything
- Proposed approach isn't mutually exclusive
- Hardware trackers are marketed for very important things
  - Wallet - Keys - Dog (attach tracker to collar)
  - Would you use one for your (still important) notepad?

# Application Architecture

- Android Application with permission based access to sensors
- Server is hosted by Google App Engine - Part of Cloud Platform
  - Allows easy pulling in of other Google APIs - i.e. PlacePicker
  - Cloud Endpoints provide RESTful interface to backend - Gradle task automatically generates Android client library
  - MySQL DB
    - Captures Users, MissingItems, Locations
    - Captures Interactions Between Entities



# Finding Nearby Items - Haversine Formula (Theory)



- Great-Circle Distance: *shortest distance between two points on the surface of a sphere (Earth)*
- Haversine formula - computes GCD from latitude and longitude of two points
  - $d$  = distance between points
  - $r$  = sphere radius
  - $\varphi/\lambda$  - lat/lon

$$\text{hav}\left(\frac{d}{r}\right) = \text{hav}(\varphi_2 - \varphi_1) + \cos(\varphi_1) \cos(\varphi_2) \text{hav}(\lambda_2 - \lambda_1)$$

$$\text{hav}(\theta) = \sin^2\left(\frac{\theta}{2}\right) = \frac{1 - \cos(\theta)}{2}$$



# Finding Nearby Items - Haversine Formula Example SQL



```
SELECT id,  
       ( 3959 * Acos(Cos(Radians(37)) * Cos(Radians(lat)) * Cos(  
         Radians(lng) - Radians(-122)) +  
         Sin(  
           Radians(37)) * Sin(Radians(lat))) ) AS distance
```

```
FROM markers  
HAVING distance < 25  
ORDER BY distance  
LIMIT 0, 20;
```

- Query returns 20 closest location IDs that are within a 25 mile radius of the point lat: -122; lon: 37
- In the LAF Cloud Service, the latitude and longitude are much more precise - and the radius should be very small (Currently experimenting)
- 3959 is the radius of the earth (in miles!)

# Android Report Found/Lost Flows



Decentralized Lost and Found

YOUR ACCOUNT REPORT FOUND REPORT LOST NEARBY CASES

### Identify a Misplaced Item

Name **Android Ranch Book**



**TAKE PHOTO**

Item Description

has some pencil notes written inside  
2nd edition  
minor wear

X: -71.81 - Y: 42.27 **REPORT ITEM LOCATION**

Location Description **Fuller zoo labs**

**SUBMIT REPORT**

Decentralized Lost and Found

YOUR ACCOUNT REPORT FOUND REPORT LOST NEARBY CASES

### No Location Selected

Where were you last? **CHOOSE LOCATION**

What did you lose?  
ID Card

Item Description

Enter any information that might help find  
identify your missing item

Location Description

Reception Area

**REPORT MISSING ITEM**

Pick a place



**Fuller Laboratories**  
Worcester, MA 01609, United States

NEARBY PLACES

**Worcester Polytechnic Institute**  
100 Institute Rd, Worcester, MA 01609, Unite...

Decentralized Lost and Found

YOUR ACCOUNT REPORT FOUND REPORT LOST NEARBY CASES

### Fuller Laboratories

Where were you last? **CHOOSE LOCATION**

What did you lose?  
MacBook Charger

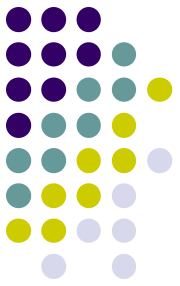
Item Description

has black electrical tape

Location Description

**Fuller Lounge**

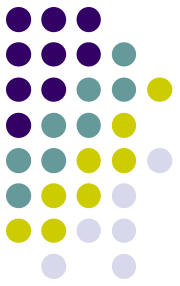
**REPORT MISSING ITEM**

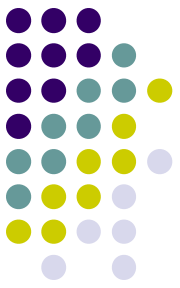


# Between Now and Tuesday

- Between Now and Code Deliverable Deadline  
The Largest Hurdle Remaining is integrating the nearby items (which is on the backend) into Android in an intuitive way.
- Other UI tweaks/testing

**Thanks!**  
**Questions?**





## References

- *Tile: Never Lose Anything* <https://www.thetileapp.com/>
- *Mozy: Lost and Found Reports* <https://mozy.com/about/news/reports/lost-and-found/>
- *Lost Items Cost Americans \$5951* <http://www.nydailynews.com/news/national/lost-items-cost-americans-5-591-survey-article-1.2237244>