Mobile Location

21W.780 – Class 4
March 6, 2007

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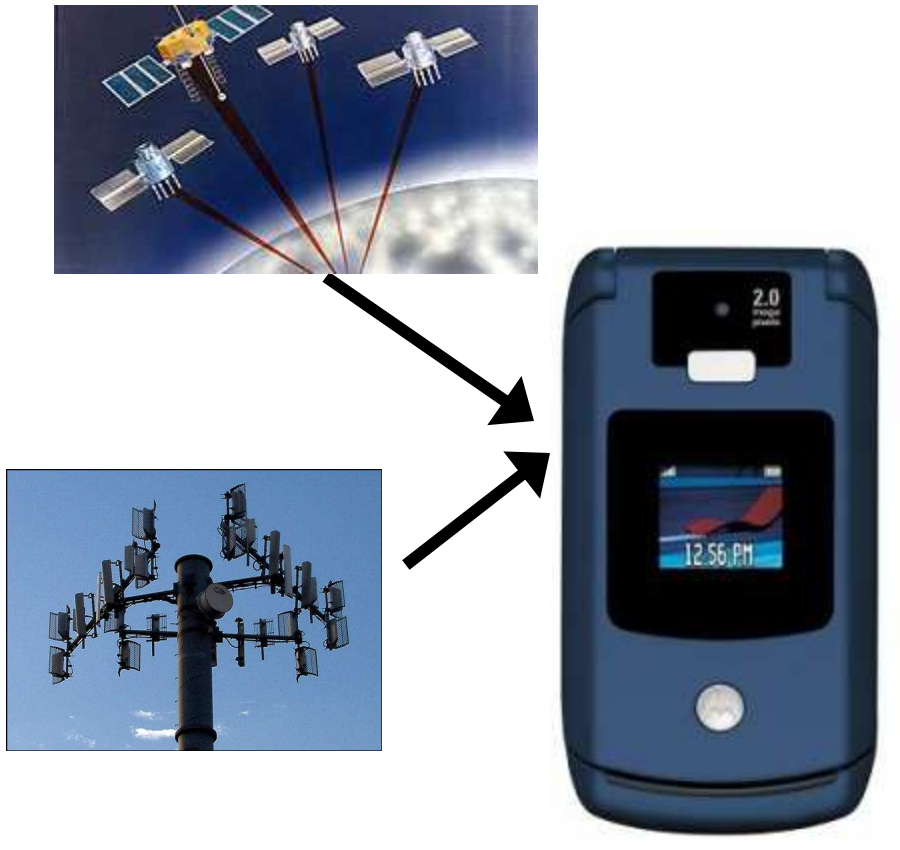


Overview

Getting Location on the Phone

GPS

- **NMEA Streams**
- **Bluetooth GPS solutions**

Cell ID

- **Cell topology**
- **Cell ID -> ZipCode**
- **Cell positioning**

Applications and services

- **ZoneTag**
  - **ZoneTag location API**
- **Place Its**
- **Motion Presence**

Alternatives (Bluetooth Beacons, RFID, etc.)

Getting location on the phone

Two main ways phone can know its location…

- **Exact positioning from GPS Satellites**

- **Inferred position from Cell Towers**

Ways to do both of these from a signed J2ME MIDlet

GPS

30 satellites in earth orbit

6 satellites always in line of site of any place on earth

Receivers must find 4 or more satellites for a fix

Receiver listens for time broadcasts from each satellite and calculates distance based on time delay

Satellites also broadcast Navigation Messages which can be used with the time delays to calculate position

Receivers often provide access to position data as a NMEA stream (National Marine Electronics Association)

GPS - NMEA

A compound string from the NR203 GPS Receiver containing multiple messages. The actual messages decoded include…

ZDA – Standard NMEA $..ZDA Time & Date message

GLL – Standard NMEA $..GLL Geographic Position – Latitude/Longitude message

NSV – NMEA message containing individual satellite information.

Typical ASCII String

$<CR><LF>
MRK,0<CR><LF>
ZDA,123336.8069,17,06,2001,13.0<CR><LF>
GLL,2924.11158,N,1211.07392,W, 75.97,M<CR><LF>
VTG,218.7,T,2.38,H,0.18,V<CR><LF>
SGD,-1.0,G,-1.0,M<CR><LF>
SYS,3T,9<CR><LF>
ZEV,0.28745E-006<CR><LF>
NSV,2,00,000,00,0.0,00.0,00,00,D<CR><LF>
NSV,7,00,000,00,0.0,00.0,00,00,D<CR><LF>
NSV,28,00,000,00,0.0,00.0,00,00,N<CR><LF>
NSV,1,00,000,00,0.0,00.0,00,00,D<CR><LF>
NSV,13,00,000,00,0.0,00.0,00,00,D<CR><LF>
NSV,4,00,000,00,0.0,00.0,00,00,N<CR><LF>
NSV,25,00,000,00,0.0,00.0,00,00,N<CR><LF>
NSV,0,00,000,00,0.0,00.0,00,00,N<CR><LF>
NSV,11,00,000,00,0.0,00.0,00,00,D<CR><LF>
NSV,0,00,000,00,0.0,00.0,00,00,N<CR><LF>
&

(from http://en.wikipedia.org/wiki/NMEA_0183)

GPS on the phone

Some phones have built in GPS

- **All Motorola phones on the iDEN (Nextel) network**
- **Some GSM phones (including european version of the a780)**
- **Many CDMA phones (e.g. RAZR on Verizon)**

Phones that don't have built-in GPS can use a bluetooth unit

- **sends a NMEA stream to the phone**
- **phone can listen through a BT serial connection**

GPS – pros and cons

Pros

- Exact position (within 10m)
- Altitude information
- Fast update frequency (new fix every 3 seconds)

Cons

- Does not work indoors, under trees, or downtown (some AGPS solutions are overcoming this)
- External GPS units must be kept near the phone
- Long time to get position (up to 2 minutes for a first fix, 30 seconds or so with a warm start)

Cell ID

Use the cell infrastructure to know when you are in a given location

- In GSM networks, all cells in the world have a globally unique ID made up of four numbers:
  cell id, lac, mnc, and mmc
- Databases are being made that map cell IDs into locations
- Cells can be manually mapped to semantic locations (e.g. Campus, Home, Downtown Boston, etc.)

Cell topology

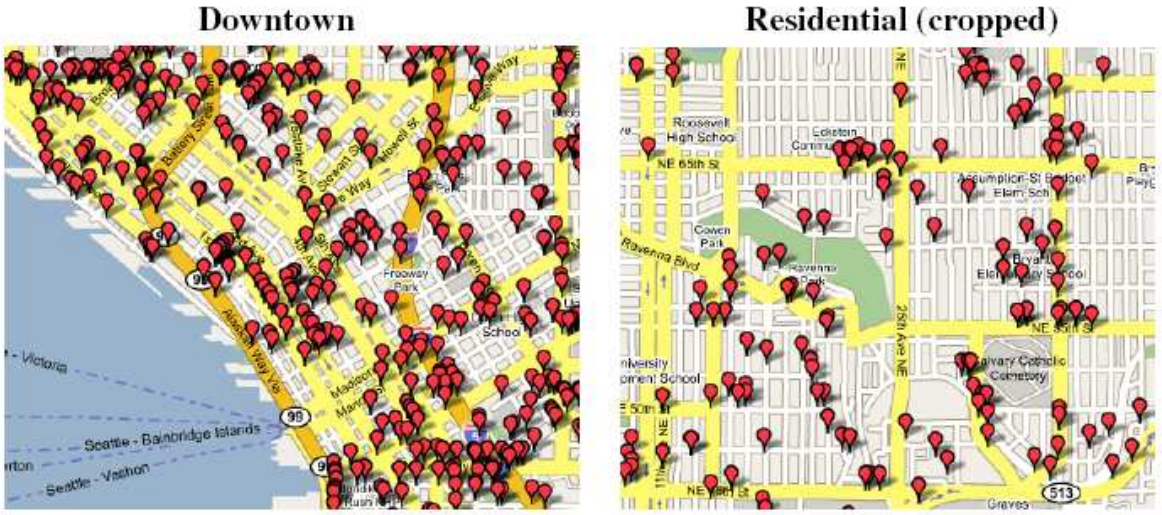


Fig. 3. Cell location map for the three network providers; each dot represents the estimated location of a cell. The left map shows Downtown with an average density of 66 cells/Km^2. The right map shows a cropped Residential region with an average cell density of 26 cells/Km^2.

(from Chen et al 2006, http://www.intel-research.net/Publications/Seattle/100920061625_366.pdf)

Much greater density in cities where places are also more dense

Cell ID -> Location

Databases exist that are trying to map a large number of Cell IDs to locations

Place Lab

- Intel project mapping WiFi and GSM Cell ID to GPS coordinates

ZoneTag

- Yahoo! Research Berkeley project mapping GSM Cell ID to Zip Code

You can contribute data you collect in this class to either database

Cell positioning

People have used Cell ID to:

- Determine when someone was at a given place (e.g. home) (see Sohn et al ‘05)
- Distinguish between walking/driving/stationary (see Sohn et al ’06)
- Provide accurate positioning (e.g. Chen et al ’06)

    Down to 95% error of 163m with all visible cells

Cell ID – the details…

```
String cellID = System.getProperty("CellID");
String lac = System.getProperty("LocAreaCode");
String imsi = System.getProperty("IMSI");
String mcc = imsi.substring(0,3);
String mnc = imsi.substring(3,6);

cellID + lac + mcc + mnc = a globally unique ID for a cell tower
```

Applications

ZoneTag

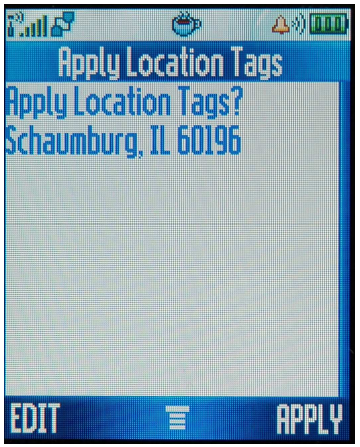
Place Its

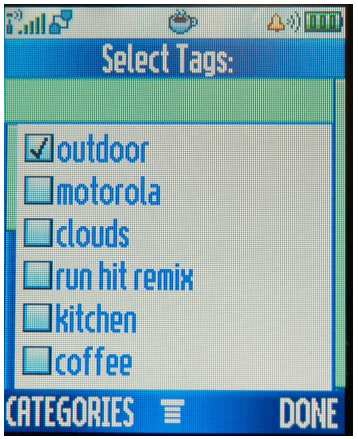
Motion Presence

ZoneTag

Two main components:

1) Web service that converts Cell ID to city, state, zip and suggested tags
2) Mobile application that allows users to upload photos to flickr with location and tag information





Zone Tag API

Open to mobile developers. Contact Rahul Nair at YRB for application and user tokens

Simple web API:

http://zonetag.research.yahoo.com/zonetag/phonesuggested.php?apptoken=XXX&usertoken=XXX&cellid=10241&lac=7836&mnc=260&mcc=310&version=1.0.2&output=xml

Receive City, State, Zip, and Suggested Tags:

<location>
<country>USA</country>
<state>IL</state>
<city>Schaumburg</city>
<zipcode>60196</zipcode>
<neighbourhood/>
</location>
…
<tag>
<text>motorola</text>
<catid>1</catid>
</tag>

Place Its

The problem: getting reminders in particular locations (e.g. call my mom when I get home, stop at the grocery store on the way home, etc.)

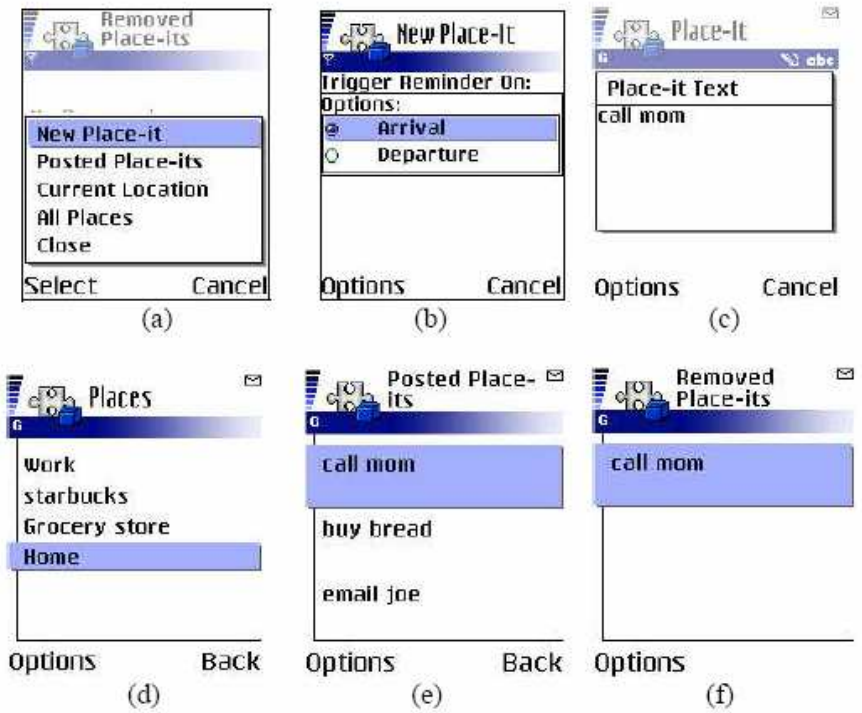


Figure 1. (a) Creating a new Place-It note; **(b)** Setting the note to be triggered upon arrival; **(c)** Typing the text of the note; **(d)** Posting the note to 'Home'; **(e)** Showing all posted Place-It notes; **(f)** The reminder is triggered when Jill arrives at the home and the note is removed.

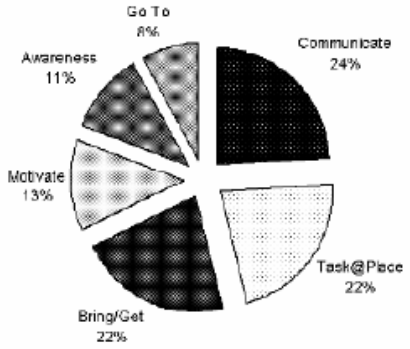
Place Its

The system:

- Use Cell ID to determine when the user is in a given place
- Manually connect sets of Cell IDs to places in people's lives
- When user enters a given 'place,' if there are any alerts for them, notify them (also can have leaving alerts)

Study:

- fielded application with 10 users
- used application for two weeks
- ~9 reminders per user created

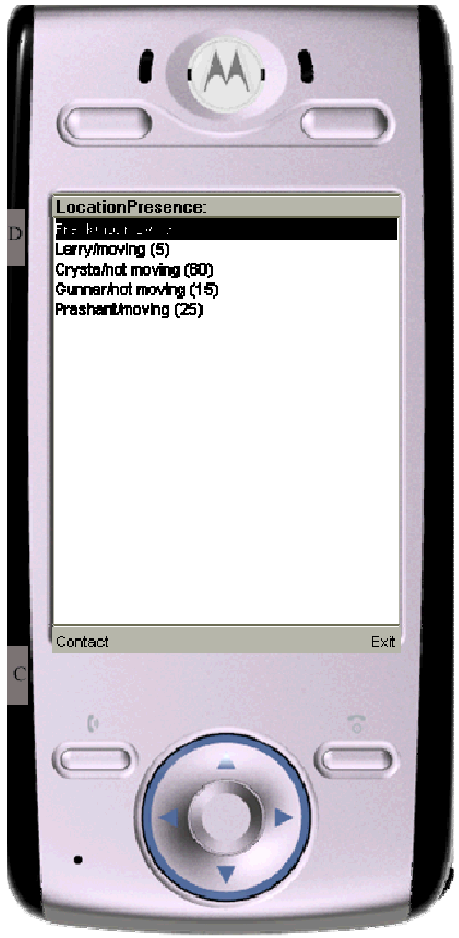


Motion Presence

The application: See when close friends or family are currently moving or not moving

Research Questions:

- Among a close social group, is motion presence used to infer something other than motion? If so, what?
- Does having motion information about a potential communication partner influence when people initiate a communication with them?
- Does having motion information about a potential communication partner affect how “connected” people feel?
- How do ambiguities and errors in motion presence detection/presentation affect the derived value of the application?
- In a close social group, what privacy concerns are raised by the use of this prototype?



Study Methodology

10 participants – 3 groups of couples, one group of four friends

Participants used the phone as their primary mobile phone for a period of two weeks (their SIM and phonebook were transferred to our phone)

Usage data of the application was logged, including when communication was initiated from the application

Participants were asked to record phone calls to other participants in the study

Participants called a voicemail nightly to discuss their use of the application

Final in person interview to discuss use and overall impressions of application

Motion Presence Findings

Inferences

Participants were able to infer:

- **Location**
- **Activity**
- **Availability**
- **Arrival Time**
- **Destination**

For the most part, the motion data acted to confirm what they already assumed the person was doing based on previous conversation, knowledge of one's schedule, etc.

Motion Presence Findings

Inferences

"MP7, I knew he was going to work, but I wasn't sure if he got there already and I saw that he was not moving for 12 minutes. So judging by that I'm getting that he was already at work so I didn't bother calling him." (MP8)

"I knew he had, it was either a 10am or 11am meeting Cleveland time, so I was checking. I actually checked that application to see whether he was moving or not to know whether I should call. I didn't want to disturb him in his meeting so if it said 'not moving' I wasn't going to call." (MP4)

Motion Presence Findings

Uses

Participants used the application to:

- **Moderate availability**
- **Micro-coordinate**
  - **Arrive at the same time**
  - **Get more time at their current activity**
- **See people were following through on commitments**
- **Check on other's safety**
- **Social awareness – know what's going on with others**

These uses highly overlap with the uses found in previous research. This simple form of ambient communication can go far to get people the information they need and share today.

Motion Presence Findings

Uses

"If you knew someone was going to go pick you up or if someone was going to go someplace and you knew that and you know about what time, you could see if they were actually on their way or if they were running late. … Kind of lets you know when you should be ready or things like that." (MP10)

"I could tell when he was leaving work by when he went off of 'not moving.' … It was like, ok, I saw that he was already on his way and we'd get there about the same time." (MP8)

"Oh, he's not in class, he's moving, he must be on his way home, I need milk!" (MP2)

Motion Presence Findings

Privacy

Privacy not a major concern with close friends and family

Participants all wanted more information shared

- **Direction/Heading**
- **Distance from you**
- **Speed**
- **Map w/ directions**
- **History of motion information**
- **Custom “away” messages**

Motion Presence Findings

Privacy

“As a couple we wouldn’t turn it off.” (MP6)

“It would be helpful if there was a line in there saying, kind of, what the last batch of moving was, so that you kind of knew that this was the next segment.” (MP4)

“I think it would be a situation in which the other person, you could be checking on the other person and it would create conflicts.” (MP1)

Motion Presence Findings

Ambiguities/Errors

Motion Data was seen to be correct almost all of the time

Times when participants mental model did not agree with application's model:

- **walking around a large (1/2 square mile) warehouse**
- **taking a stop for gas and snacks on a long trip**

Most issues could be solved with a visualization of motion history

Motion Presence Findings

Ambiguities/Errors

“It didn’t really tell me anything unless I kind of knew in my mind, I had some theory in my mind about what she was doing.” (MP3)

“He was supposed to be at home and it said he wasn’t moving. But he ended up not being at home. So it didn’t really help me.” (MP9)

“Maybe they thought I was going to lunch at like 10:00 or whatever but I was still at the warehouse working.” (MP10)

Motion Presence Findings

Feelings of “Connectedness”

Learn more about patterns of friends and family

“Check up” on others safety (e.g. still moving when they were on a long road trip, etc.)

Find out when friends were going out to the bars at night, even if they were not going to join them

Stay connected to home events while traveling (e.g. walking dog)

Motion Presence Findings

Feelings of "Connectedness"

"I've been working a lot and I'm not with [MP5], so I've been looking at it just to see the motion on the phone." (MP6)

"I'd be worried, like if it was late and she was coming home from a client in Wisconsin. If I knew she should be coming home and she wasn't [moving]." (MP3)

"I'd be like, oh, this guy actually left for work at 7:30 and then I felt bad for him. I knew he went to work way earlier than I ever woke up, but I never knew exactly when. When it hit the same time everyday, I was like, that's kinda cool." (MP7)

Implications

Motion data is useful, but it's not enough

- **Sharing of specific locations / away message functionality desired**
- **Tell them something they don't know**

With friends and family, sharing motion information does not raise significant privacy concerns

It's possible for users to infer rich context information from relatively poor sensor data with the context that they add

Cell ID is a reliable way to determine motion

Alternatives to GPS and Cell ID

Bluetooth Beacons

- Known bluetooth devices associated with a given locations

WiFi positioning

- Known wifi SSIDs mapped to locations

Bluetooth proximity

- Around Ed, Dan, students = in class

RFID

- Tags associated with places, reader in handset

References

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Next Steps…

Show network apps

Due next week:

1) Build a phone application that you can use to determine the number of cells in your carrier's network on the MIT campus

2) Readings on Mobile Imaging

Next week we have two guests:

Maia Garau from Tinypictures

Jon Markowitz Bijur of the MIT Cellphone Photo Contest