Location, Location, Location
Larry Rudolph

Outline

• Administrative remarks and requests
• Positioning Technology
  • GPS and others
• Location Specifiers
• Privacy Issues
Asking for help

- For 3rd edition phones, need to rebuild binaries.
  - We have code for doing cache-less Bluetooth scanning. I need someone to rebuild the library
- Let’s test the theory about phone scanning
  - Want to try to have everyone call at same time so must bring in phones.
- Cell tower hand-offs
  - Discuss potential extra-credit problem set.

Mobile Connectivity

- Cellular Network (big brother)
  - Turn on, connect to tower & register
  - Tower’s hand-off control of phone
- Wifi Base Stations (proactive grown-up)
  - Turn on; connect to station & register
  - When signal lost, device looks for new one
- Is there a middle ground?
  - Suppose there is a group of friends?
How can you be found?

- Big brother keeps track of controlling tower
- Responsible grown-up always tells DNS its loc.

Knowing where you are?

- Big Brother: Ask network for your location
- Big Family: Listen to a bunch of beacons and their locations, then triangulate
- Loner: Figure it out for yourself
  - Cell tower(s) and switching pattern
  - Notice landmarks
  - Dead reckoning
Universal Location

- On earth, we need three piece of information:
  - latitude, longitude, & altitude
  - there are other possibilities
- Global Positioning Systems can give us that information
- Can then use mapping to do something useful with that information

Global Positioning Systems

- 1978 US Department of Defense begins project
- 1984 Crash of Korean Flight due to poor navigational equipment ==> gps for civilian use
- 1985 Complete system fully operational
  - 24 satellites (11,000 mile orbit) & $12 billion
- 2000, selective availability turned off
  - 3 to 15 meter accuracy for everyone
How it works

- Receiver measures travel time of random code sent from satellite (about 0.1 sec)
  - compute distance, call it X
- Receiver’s position can be anywhere on a sphere of radius X with satellite at center
- Given four satellite readings, can figure out position in 3 dimensions
- Let’s look at some government slides
  - mms.nps.gov/gis/gps/How_GPS_Works.ppt

GPS

- Python interface to a bluetooth gps
- Connect to the GPS normally:
  
  from socket import *
  sock = socket(AF_BT, SOCK_STREAM)
  Read input from ‘$’ up to a ‘\r’ character using the sock.recv(1) command (reading one byte at a time).
GPS (cont)

buf = sock.recv(1)
while buf != '$':
    buf = sock.recv(1)
while buf[-1] != '\r':
    buf += sock.recv(1)
if buf[0:6] == "$GPGGA":
    (GPGGA, utcTime, lat, ns, lon, ew, postfix, sats, hdop, alt, altunits, sep, sepunits, age, sid) = buf.split(",")
    latitude = float(lat)
    longitude = float(lon)

$GPGGA
Global Positioning System Fix Data
eg1. SGPGGA,170834,4124.8963,N,08151.6838,W,1.05,1.5,280.2,M,-34.0,M,,,75

<table>
<thead>
<tr>
<th>Name</th>
<th>Example Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentence Identifier</td>
<td>$GPGGA</td>
<td>Global Positioning System Fix Data</td>
</tr>
<tr>
<td>Time</td>
<td>170834</td>
<td>17:08:34 UTC</td>
</tr>
<tr>
<td>Latitude</td>
<td>4124.8963,N</td>
<td>41d 24.8963' N or 41d 24' 54&quot; N</td>
</tr>
<tr>
<td>Longitude</td>
<td>08151.6838,W</td>
<td>81d 51.6838' W or 81d 51' 41&quot; W</td>
</tr>
<tr>
<td>Fix Quality:</td>
<td>1</td>
<td>Data is from a GPS fix</td>
</tr>
<tr>
<td>0 = Invalid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-1 = GPS fix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2 = DGPS fix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Satellites</td>
<td>05</td>
<td>5 Satellites are in view</td>
</tr>
<tr>
<td>Horizontal Dilution of Precision (HDOP)</td>
<td>1.5</td>
<td>Relative accuracy of horizontal position</td>
</tr>
<tr>
<td>Altitude</td>
<td>280.2,M</td>
<td>280.2 meters above mean sea level</td>
</tr>
<tr>
<td>Height of geoid above WGS84 ellipsoid</td>
<td>-34.0,M</td>
<td>-34.0 meters</td>
</tr>
<tr>
<td>Time since last DGPS update</td>
<td>blank</td>
<td>No last update</td>
</tr>
<tr>
<td>DGPS reference station id</td>
<td>blank</td>
<td>No station id</td>
</tr>
<tr>
<td>Checksum</td>
<td>*75</td>
<td>Used by program to check for transmission errors</td>
</tr>
</tbody>
</table>

Courtesy of Brian McClure, N8PQI.
GSM Cellular location

- **GSM mobile telephone network: cells**
  - towers fixed, signal available indoors
  - unaffected by “urban canyon effect”
- **CellID:** detect base transceiver stations (BTS)
  - phone is registered with a BTS
  - usually, but not always, the closest one
GSM Cellular Location

- Cell size depends on terrain & number of users
- Error: about 500 m (urban) to 15km (rural)
- Base stations have 3 antennas, 120 degree sectors

Enhanced Method

- E-OTD: Enhanced observed time difference
- Time from base station to phone
- Time from base station to fixed location
  - Ratio gives better estimation of position
- Also use triangulation (from several bases)
- Both yield order of magnitude improvement
  - and lots of research for even better results
What good is GPS?

- It is universal
- But is it what we want?
- Human-centric versions of location:
  - name of place
  - map of place

Other Data Formats

- Geographic Information System (GIS)
  - developed set of XML descriptions
    - static (river): Geo Markup Language
    - dynamic (cars, events): Point-of-interest
- NVML: Navigation mark-up language
- SKiCAL: iCalendar VEVENT used to describe event information
  - event meta-info: location
Spatial Databases

- Set of functions to
  - quickly search, query, analyze spatial info
  - how objects spatially relate to each other
  - many geometry types and typical queries

People don’t speak GPS

- Different people have different views of the world.
Places -- big and small

- People refer to location as places
  - countries, cities, towns, streets, buildings
  - rooms, spaces within buildings
  - relation to other places,
    - e.g. across from Starbucks
- GPS is too precise and may require accurate map or building plan
  - Jim might be at 42.3325N, -71.11861E
  - but is he in the shower at the moment?

Location Tracking: Good, Bad, or Ugly?

- Not too many people seem to be concerned about location-based services tracking them.
- “You have no privacy, get over it”
  - -- Scott McNealy, CEO Sun
Can we study this?

• Before investing heavily in location-based services, we should find out if people will use them.
• The evidence is still mixed

<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service A: Ringing profiles in private settings</td>
<td>The mobile phone ‘knows’ when the user is in a meeting or in class</td>
</tr>
<tr>
<td>Service B: Ringing profiles in public settings</td>
<td>The mobile phone ‘knows’ when the user enters a movie theater or a restaurant</td>
</tr>
<tr>
<td>Service C: Lunch service</td>
<td>A suggestion for lunch is pushed by the retailer to the mobile phone when the user is around a restaurant or fast food place</td>
</tr>
<tr>
<td>Service D: Localization of predefined friends</td>
<td>The mobile phone can locate predefined friends and alert the user when they are within a certain distance</td>
</tr>
</tbody>
</table>

Table 1: Location-Based Services
<table>
<thead>
<tr>
<th>Service</th>
<th>Rated usefulness</th>
<th>Rated intrusiveness</th>
<th>Average # of daily use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service A: Private ringing profiles</td>
<td>3.75</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Service B: Public ringing profiles</td>
<td>2.6</td>
<td>2.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Service C: Lunch service</td>
<td>2.2</td>
<td>3.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Service D: Localization of predefined friends</td>
<td>3.75</td>
<td>3.25</td>
<td>1.3</td>
</tr>
</tbody>
</table>

1 = not useful at all, 5 = very useful
1 = not intrusive, 5 = very intrusive

**Table 2:** Average rating of the services.

<table>
<thead>
<tr>
<th>Service</th>
<th>Personalization</th>
<th>Passive Context-Awareness</th>
<th>Active Context-Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Private ringing profiles</td>
<td>Different ringing profiles that are set manually</td>
<td>The phone prompts the user to adjust the profile when sensing it is in a meeting or class</td>
<td>The phone automatically changes profile when sensing the user is at a meeting or in class</td>
</tr>
<tr>
<td>B: Public ringing profiles</td>
<td>Different ringing profiles that are set manually</td>
<td>The phone prompts the user to adjust the profile when sensing it is in a movie theater or as a restaurant</td>
<td>The phone automatically changes profile when sensing the user is at a movie theater or at a restaurant</td>
</tr>
<tr>
<td>C: Lunch service</td>
<td>Manual search for appropriate lunch place</td>
<td>Single alert sound for lunch place according to user's preferences</td>
<td>Alerts the user when passing by a lunch place of relevance and suggests places at noon</td>
</tr>
<tr>
<td>D: Class slides</td>
<td>Manual search to see if class slides are available online</td>
<td>If signed up, the phone alerts user of available slides for class</td>
<td>Automatic alert every time the teacher updates class slide website</td>
</tr>
<tr>
<td>E: Location tracking</td>
<td>Manually location tracking of predefined friends</td>
<td>Locations tracking of friends and setting to alerts when they are within a certain range</td>
<td>Location detection of friends that alerts when they are within 300 feet of user</td>
</tr>
<tr>
<td>F: Activity tracking</td>
<td>Display of potential caller's social situation (e.g. meeting, home, out)</td>
<td>In a new context, the phone prompts the user to display the user's situation to possible callers</td>
<td>Automatic switch to display of social situation when entering a new context</td>
</tr>
</tbody>
</table>
Does Age Matter?

- Not much in this sample of 23 participants.
- surprising result

Table 2. General participant demographics.

<table>
<thead>
<tr>
<th></th>
<th>Personalization</th>
<th>Passive Context-Awareness</th>
<th>Active Context-Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Average age</td>
<td>23.7</td>
<td>22.9</td>
<td>25</td>
</tr>
<tr>
<td>Average mobile phone ownership</td>
<td>2.2 years</td>
<td>2.6 years</td>
<td>2.7 years</td>
</tr>
<tr>
<td>Average user level (a scale from 1–6)</td>
<td>3.1</td>
<td>3.8</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Their Conclusions

The finding that participants felt they had less control in the context-aware groups but still preferred the context-aware approaches, might at first seem contradictory. However, it should be considered that owning a mobile phone in itself constitutes some lack of control since the user can be reached anywhere at anytime; the user might have less control, but are aware that this is the cost of becoming more interactive and in achieving a smoother everyday experience.

Although our study results provide support for highly interactive applications for mobile computing, by indicating that people would use them to a fairly high degree, the applications should still be developed with caution. The incurred cost due to loss of control can result in users turning off a service. While the participants initially liked many of the active context-aware services, they might become frustrated by their perceived lack of control and eventually turn the service off.