

# MOBILE LOCATION NETWORKING

21w.789

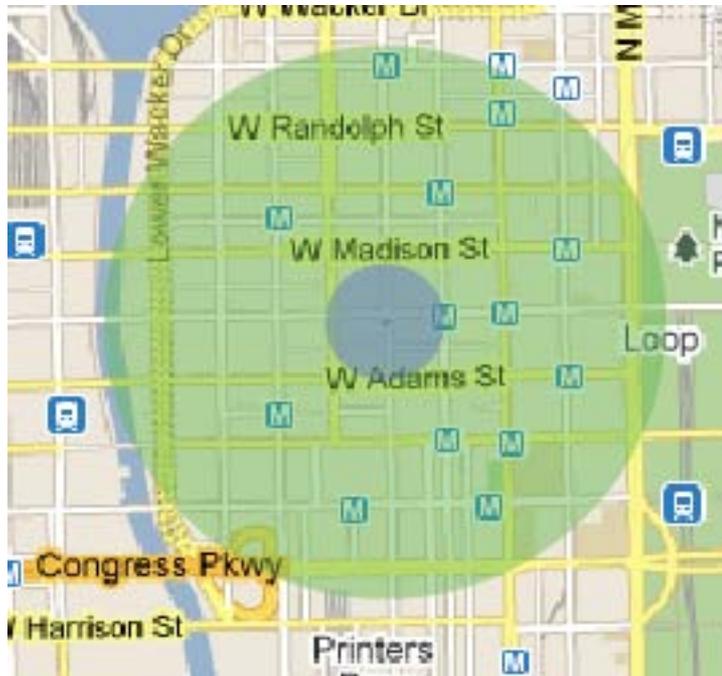
Spring 2011

# Mobile Location

- Location Tech
  - ▣ GPS
  - ▣ Cell ID
  - ▣ WiFi
- Mixed Methods (Skyhook)
- Location in Android
- Location on iPhone
- Example Applications
  - ▣ ZoneTag
  - ▣ Motion Presence
  - ▣ Place Its
  - ▣ Jogging the Distance
  - ▣ Serendipitous Stories

# Location Fidelity

- Cell ID: A ZipCode (~150-2000m)
- WiFi: A block (~100m)
- GPS: A side of the street (~10m)



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# Cell ID

- Use the cell infrastructure to know when you are in a given location (Zip Code level accuracy)
- 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 exist
- Cells also 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<sup>2</sup>. The right map shows a cropped Residential region with an average cell density of 26 cells/Km<sup>2</sup>.

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

Source: Chen, M., et al. "Practical Metropolitan-Scale Positioning for GSM Phones." *Lecture Notes in Computer Science* 4206/2006 (2006): 225-242.

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**Much greater density in cities where places are also more dense**

# Cell ID -> Location

- Databases exist that map a large number of Cell IDs to locations
  - Google
  - Yahoo
- Now part of most mobile platforms...transparent to developer/user

# Cell ID - Applications

- 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
  - ▣ Currently used to save power over GPS/when only approximate locations are needed or indoors (e.g. find nearest movie theater, etc.)

# Wifi Positioning

- Use available SSIDs to determine location
- Up to 40m accuracy in cities
  
- Issues:
  - ▣ Need to have sampled fairly closely to where you want to get location
  - ▣ Not practical until recently when combined with other methods to bootstrap (Google trucks, apps that report Cell ID, SSID, GPS to large databases)

# 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>  
&

# GPS on the Phone

- Most smartphones have built in GPS
  - ▣ iPhone, Android, Blackberry, Palm
- 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
  - ▣ Can also save power when used with modern smartphones (bluetooth uses 22% of the power of GPS)

# Mixed Methods

- Phones have GPS, Wifi, Cell ID
- Use any available to determine location
  - ▣ Save other data to help improve location for others
- Provides “good-enough” positioning in seconds while waiting for GPS to attach and converge
- iPhone using Skyhook (100m requests/day)

# Alternatives to GPS and Cell ID

- Bluetooth Beacons
  - ▣ Known bluetooth devices associated with a given locations
- Bluetooth proximity
  - ▣ Around a professor, students = in class
- RFID
  - ▣ Tags associated with places, reader in handset

# Location on Android

- LocationManager
  - ▣ locationManager = (LocationManager) getSystemService(Context.LOCATION\_SERVICE);
  - ▣ Location location = locationManager.getCurrentLocation("gps");
- Getting updates:
  - ▣ locationManager = (LocationManager) getSystemService(Context.LOCATION\_SERVICE);
  - ▣ locationManager.requestLocationUpdates(LocationManager.NETWORK\_PROVIDER, // GPS\_PROVIDER
  - ▣ REQUEST\_LOCATION\_UPDATE\_TIMER, // 5\*60\*1000
  - ▣ REQUEST\_LOCATION\_UPDATE\_MINDISTANCE\_METER, // 500
  - ▣ this);

# Useful Location Methods

- Accuracy:
  - getAccuracy() Returns the accuracy of the fix in meters.
- Providers:
  - getProvider() Returns the name of the provider that generated this fix, or null if it is not associated with a provider.
- Speed:
  - getSpeed() Returns the speed of the device over ground in meters/second.

# Location on iPhone

- All location queries handled by CLLocation Manager
  - ▣ Uses a variety of means to determine location (Cell ID, Wifi positioning, AGPS, GPS)
  - ▣ Returns asynchronously as location is refined
  - ▣ Gives accuracy with each response
- `locationManager = [[[CLLocationManager alloc] init] autorelease];`  
`locationManager.delegate = self;`  
`[locationManager startUpdatingLocation];`
- `// Called when the location is updated`  
`- (void)locationManager:(CLLocationManager`  
`*)managerdidUpdateToLocation:(CLLocation *)newLocation`  
`fromLocation:(CLLocation *)oldLocation`

# Applications

- Location Centered Applications
  - ZoneTag
  - Motion Presence
  - Place Its
  - Jogging Over a Distance
  - Serendipitous Stories
- Location as an enhancement
  - Flixster
  - Yelp
  - Countless other iPhone/Android applications

# ZoneTag (2006)

- Yahoo! Research project (J2ME app in collaboration with Motorola)
  - ▣ Find zip-code-level location using Cell ID
  - ▣ Use Yahoo! Local + social tag history to suggest tags to apply to photos
  - ▣ Upload to Flickr with tags and location

# Motion Presence (2006)

- Inspiration:
  - ▣ Trying to identify transition times between places
- Research questions:
  - ▣ Will knowing if someone is in motion or at a place help people micro-coordinate?
  - ▣ Does not sharing the location itself mitigate privacy concerns?
  - ▣ What can be inferred from motion data?



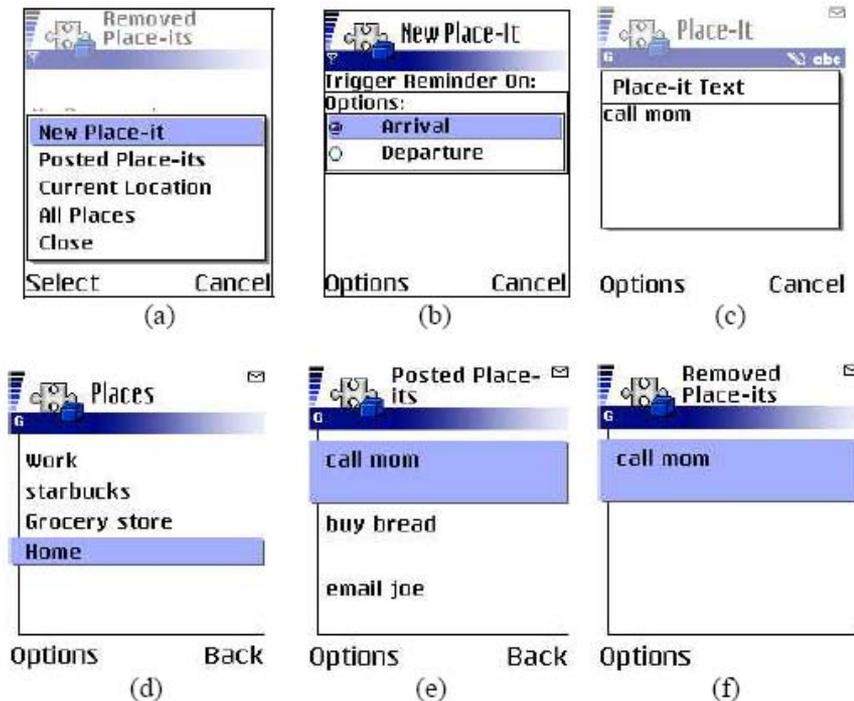
Source: Bentley, F., and C. Metcalf. "Sharing Motion Information with Close Family and Friends." *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. © Copyright 2007 by ACM, Inc.

# Motion Presence – Findings

- Participants were able to infer: Location, Activity, Availability, Arrival Time, Destination
- Participants used the application to:
  - Moderate availability
  - 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
- Privacy not a major concern given plausible deniability

# Place Its (2006)

- 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.

Source: Sohn, T., et al. "Place-Its: A Study of Location-Based Reminders on Mobile Phones." © Springer. All rights reserved. This content is excluded from our Creative Commons license. For more information see

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# Jogging the Distance (2007)

- Uses GPS to determine who is running faster
- Changes audio to sound like you're ahead or behind your running partner
- Demonstrated at CHI 2007

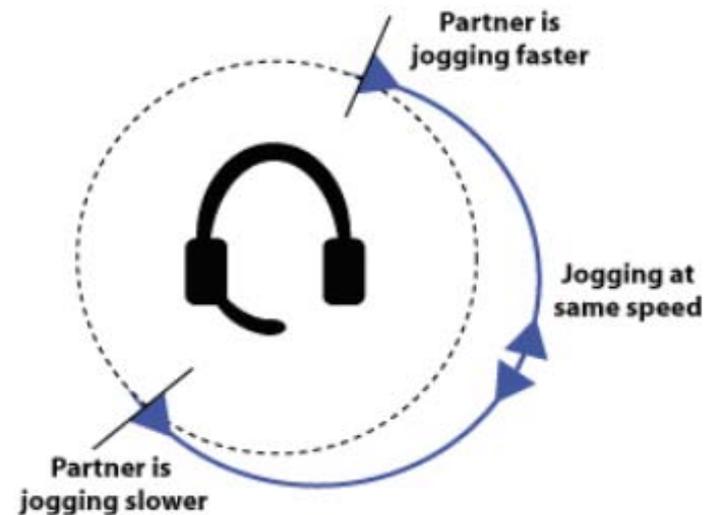


Figure 2. Bird's eye view of spatialized sound.

Jogging the Distance

Courtesy of Floyd Mueller. Used with permission.

# REXplorer (Ballagas 2007)

- Tourist game in Regensburg, Germany
- Uses location to tell story, allow for interactions as visitors explore the city
- Accelerometer gestures to cast spells – bring back characters from city's past

# Serendipitous Stories (2010)

- Asynchronous location-based communication
- Record a video, save it in a place, share it with friends
- Friends serendipitously discover videos when they approach the location of a video (phone vibrates)
- Built in summer 2010, field study (n=20) in fall 2010

# SFS Findings

- Everyday places took on new meanings
  - ▣ Bridge where grandmother met grandfather
  - ▣ School that used to be an amusement park where aunt used to go all the time
- Ramping communication
  - ▣ Seeing a story led to a “like” or a text which led to phone calls and discussion in-person
- Increased feelings of connection
  - ▣ “My mom was there...”
  - ▣ Increased communication between sender and recipient

# Location as access control

- TuVista system
  - ▣ Content owners have different rights for content in different places
    - Stadium owners have content rights within the stadium
    - Broadcasters/leagues have rights outside
  - ▣ Use location to determine which content is available
  - ▣ Currently deployed with the Denver Broncos



# Location as UI Enhancement

- New applications where location is meant to improve interaction, not be the central component
  - ▣ Make search/navigation easier (Yelp/OpenTable)
  - ▣ Jump to relevant information (Flixster)

# Location Assignment

## **Location Assignment**

The purpose of this assignment is to explore the properties of various location services that are available on the phone in real-world settings. You will be creating a small application and testing it and presenting the results in a short report.

You should build an application on your smartphone platform of choice that captures location (lat/lon) as well as accuracy error and logs it to a file. You should be able to run the application in three modes (wifi and GPS off, wifi on and GPS off, and wifi and GPS on). You should follow a route near your home or school in each of these conditions and save the log files. This route should include both indoor and outdoor locations.

Analyze the log files to find differences in error in each case. Try to discover why the error occurred and why it was greater in some places than others. Write 2 pages (including figures where necessary) describing your findings. Submit this text along with your log files for this assignment.

# Progress Updates

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- What were major findings from usability evaluation?
- What has been implemented so far for final project?
- What will be implemented by next class (poster and demo session)?

# Mobile Networking

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- Properties of Mobile Networks
- Persistence of Connections
- Congestion Management
- Notifications/Push

# Mobile Networking

- Variety of networks available on mobile devices today
- Devices often switch between networks frequently throughout a day
- Different data speeds/latencies on different networks
- Congestion (stadiums, etc.)

# Network speeds and latencies

<b>Technology</b>	<b>Uplink Speed (mbps)</b>	<b>Downlink Speed (mbps)</b>	<b>Observed Speeds (mbps)</b>
LTE (4G)	80	360	N/A
WiMAX (4G)	35	144	1.39-2.05
WiFi	288.9	288.9	0.3-4.8
HSPA+ (3G)	22	56	N/A
HSDPA+ (3G)	5.76	14.4	0.03-1.36
EVDO Rev A (3G)	1.8	3.1	N/A
EDGE (2.5G)	0.9	1.9	0.011-0.136
GPRS (2G)	0.4	0.9	N/A

<b>Technology</b>	<b>Latency</b>	<b>Observed Latency</b>
GPRS	600ms-1s	N/A
EDGE	150ms	401-4479
3G (EV-DO)	120ms	230-10396ms

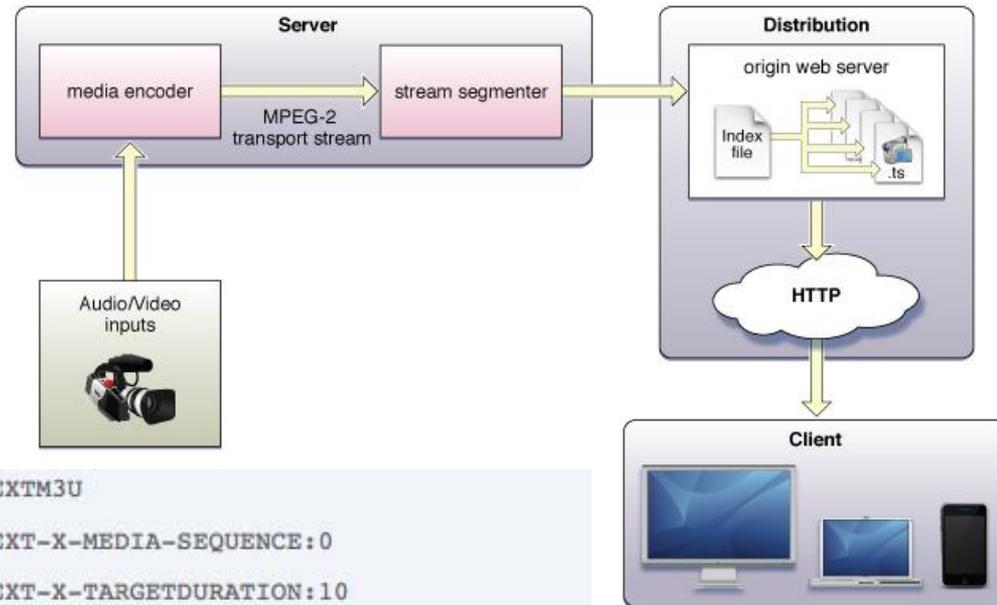
# Common networking issues...

- “Persistent” connections do not persist
  - ▣ Phones sleep after 1-5 minutes
  - ▣ Changing networks can change IP address of device, drop all active connections
  
- Network freezes
  - ▣ Common to have connections hang for 20 seconds
    - Sometimes when switching to a new tower or from 2G-3G
    - Sometimes for totally unexplained reasons
  - ▣ Be patient and set long timeouts

# Strategies for congestion

## □ Adaptive Streaming

- HTTP Live Streaming adjusts bandwidth of segments of a file to correspond to available network bandwidth
- Video file chunked in 10s segments
- Each segment is encoded at various rates (gears)
- Based on time to download previous segment(s), “gear” for next segment is chosen, and appropriate file is downloaded



```
#EXTM3U
#EXT-X-MEDIA-SEQUENCE:0
#EXT-X-TARGETDURATION:10
#EXTINF:10,
http://media.example.com/segment1.ts
#EXTINF:10,
http://media.example.com/segment2.ts
#EXTINF:10,
http://media.example.com/segment3.ts
#EXT-X-ENDLIST
```

# HLS and iPhone

- Any app that streams video over cellular connections must implement HLS to be approved in the iTunes App Store
- Over wifi you can do whatever you want
- Apple has a tool on their website to chunk videos (only runs on macos)

# Strategies for congestion

- Cacheing
  - ▣ Save as much data as possible
  - ▣ App should be able to start immediately and show something useful without a data connection
  - ▣ App might pre-cache data that is anticipated
  - ▣ Nice examples:
    - Triplt
    - Gmail
    - Various transit apps

# Push Channels

- Way for a server to notify mobile device of item of interest
- Apple's Channel
  - ▣ Shows a popup with custom text
  - ▣ Can start your application
  - ▣ Cannot start the running of arbitrary code
- Android's Push Connection
  - ▣ Available in Android 2.2 and higher
  - ▣ Uses existing GMail push connection to send intents to other applications
- Rolling your own XMPP connection
  - ▣ Maintains open connection to server
  - ▣ Can execute any code you want at any time
- SMS
  - ▣ Sending SMS messages to a particular port that your applications listens too
  - ▣ Popular in J2ME Applications

# Network Tests

- Good practice when testing an application that uses networking
  - ▣ Test what happens when network disappears in the middle of loading a screen/video (go in a basement, etc.)
  - ▣ Test what happens when networks change (e.g. wifi on/off – unplug your router, walk outside)
  - ▣ Test what happens if no network is available at all (launch app in an area with no network, go to a different screen in an area with no network)
- Ensure appropriate error messages are shown (or even better, try to cache data so no message needs to be shown)

# Networking Assignment

- Measure the download speed and latency of downloading a file on multiple networks in multiple conditions
- Write a simple program that downloads a file of between 1 and 2 MB and records the latency (time until first byte is received) and the throughput (bytes/sec) for each 10 second interval.
- Download the file on EDGE, 3G, WiFi, and 4G (if available on your device) networks in at least three different places. Try to pick different places (at home, inside a building on campus, outdoors, etc.). Most phones let you disable 3G in the settings in order to get 2G in the same location.
- Write 2 pages on your results where you explain your methods, data observed, and any interesting findings. Submit this along with your log files.

# Next Class

- Guest Speaker: Henriette Cramer of the MobileLife Centre in Stockholm
- Poster and demo session (how researchers share current progress at conferences)
  - ▣ Prepare a poster explaining your project, initial research investigation, and progress to date
  - ▣ Have a demo of the core use cases of your system working on the device
  - ▣ Will rotate around (similar to usability evaluation) and comment on other groups' projects, get feedback from us

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21W.789 Communicating with Mobile Technology  
Spring 2011

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