

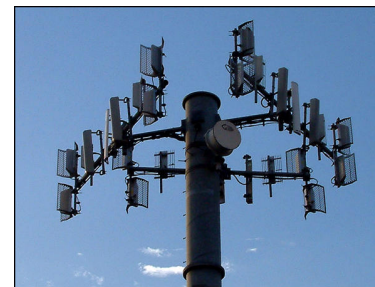
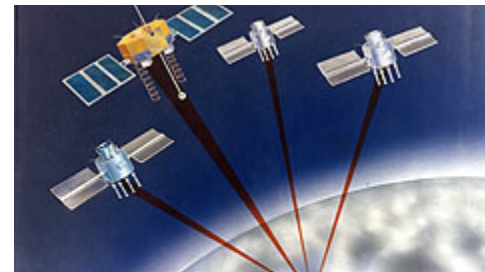
MOBILE LOCATION NETWORKING

21w.789

Spring 2011

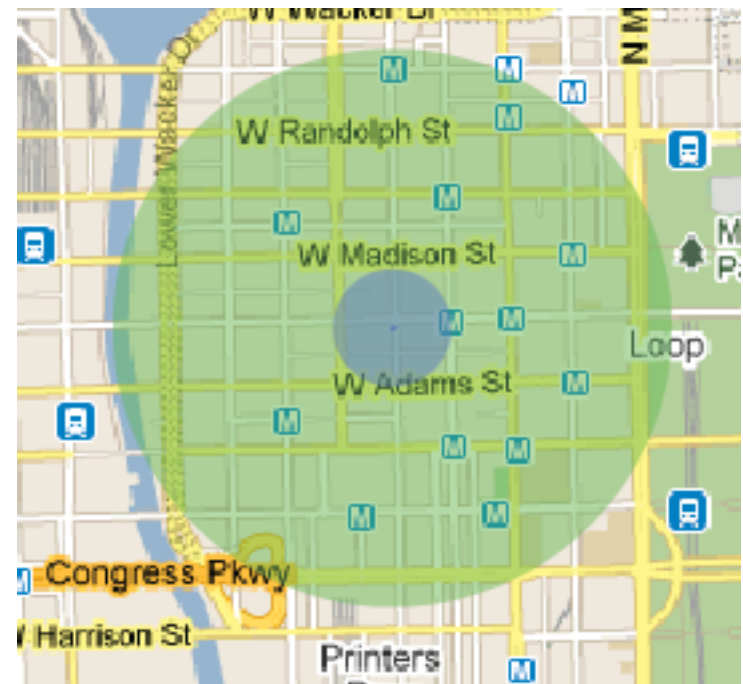
Mobile Location

- 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)



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 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>
&
```

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

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 Ed, 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`

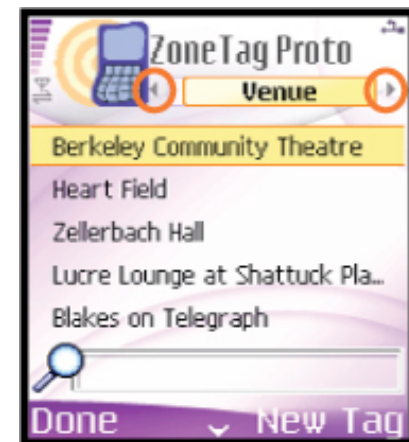
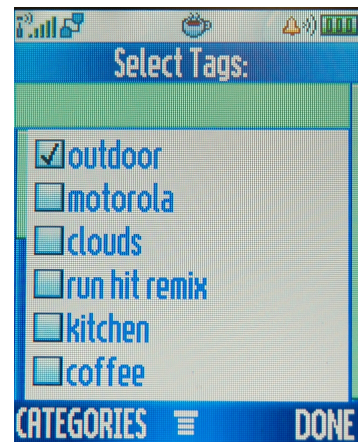
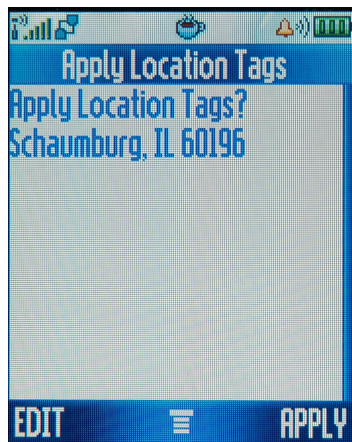
Applications



- 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?



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.)

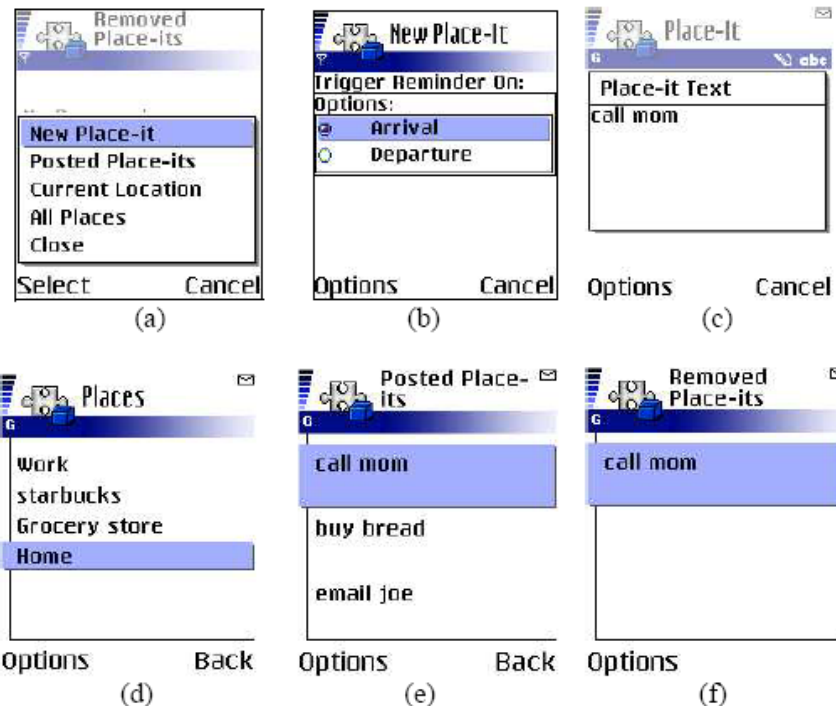
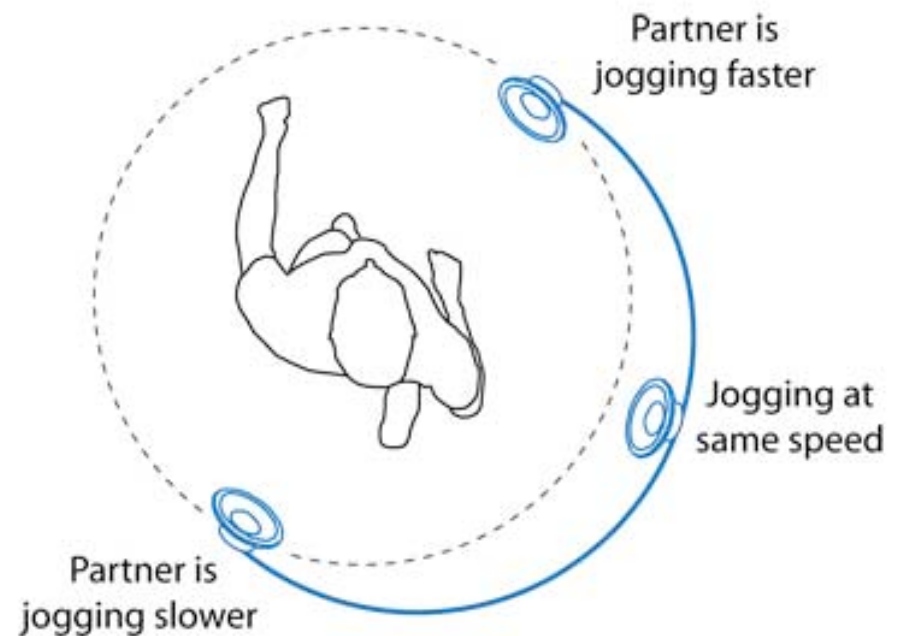


Figure 1. (a) Creating a new Place-It note; (b) Setting the note to be triggered upon arrival; (c) Typing the text of the note; (d) Posting the note to 'Home'; (e) Showing all posted Place-It notes; (f) The reminder is triggered when Jill arrives at the home and the note is removed.

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



Jogging the Distance

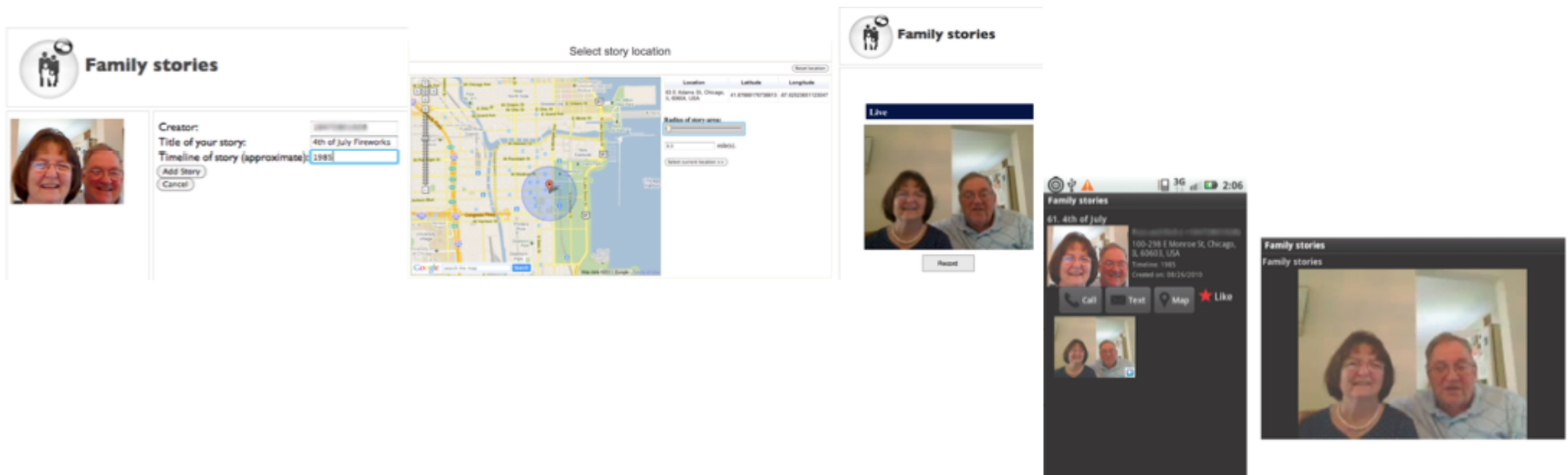
REXplorer (Ballagas 2007)

- 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



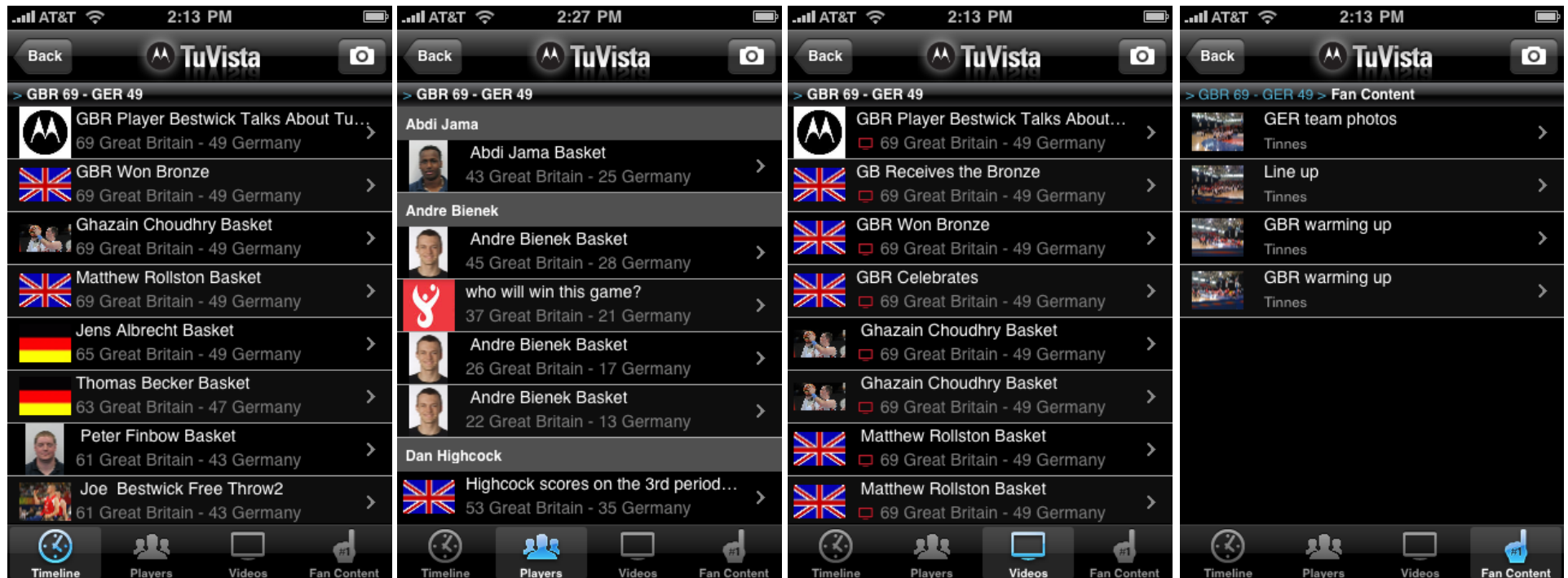
SFS Findings



- 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 (due 4/5)



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



- 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



- 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

Technology	Uplink Speed (mbps)	Downlink Speed (mbps)	Observed Speeds (mbps)
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

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

Common networking issues...

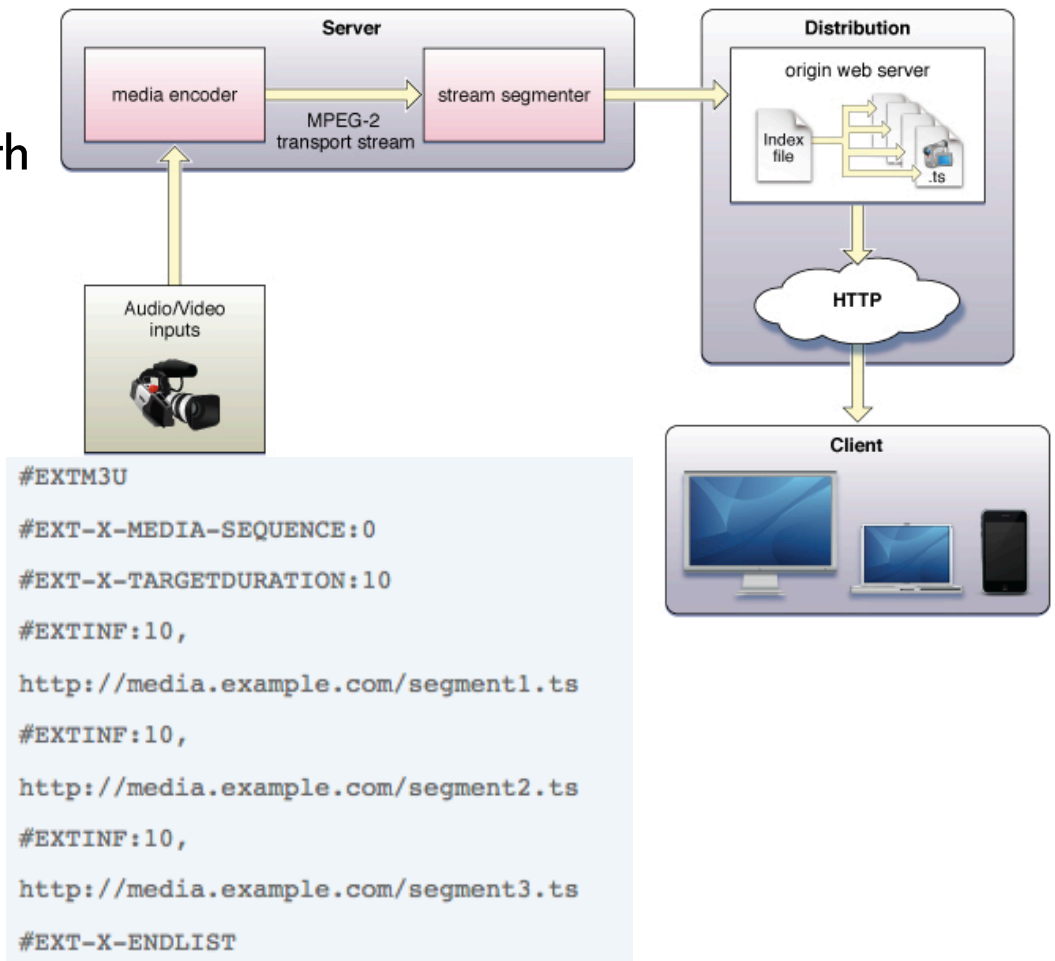


- “Persistent” connections do not persist
 - ▣ Phones sleep after 1-5 minutes
 - ▣ Changing networks can change IP address of device, drop all active connections

- 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



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 (due 4/5)

- Measure the download speed and latency of downloading a file on multiple networks in multiple conditions
- Write a simple program that downloads this file (<http://web.mit.edu/21w.789/www/papers/griswold2004.pdf>) and records the latency (time until first byte is received) and the throughput (bytes/sec) for each 10 second interval. The file is 650,924 bytes long.
- 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

Example Posters

Serendipitous Family Stories:

Using findings from a study on family communication to share family history

Frank Bentley and Sujoy Kumar Chowdhury - Motorola Mobility Applied Research



THE CONCEPT

This project aims to increase the sharing of family history about places and open up new opportunities to communicate with family members who live at a distance. Stories can be recorded on the web and artifacts can be placed in front of the camera to tell the story, much like telling a story in person. Family members receive notifications of nearby stories as they live their lives and travel near these locations. Lightweight communication is enabled back to the story creator from the mobile device.

THE INSPIRATION

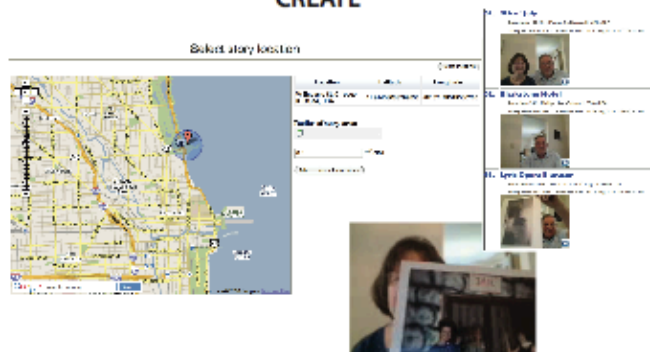
A study on communication between generations across distance demonstrated the importance of storytelling when family gets together. These stories of past history were less common over a distance. One participant in our study happened to be walking past a theater where her grandfather used to dance and commented on this to her mom creating a connection across three generations. We aim to create these types of experiences serendipitously as people go about their lives and highlight places with family importance in daily life.

UBICOMP "FAMILY" STORIES

For this conference, we are collecting stories from past conferences which can be shared with others using this system.

- * Please visit <http://stories.motlabs.com/s/> from a Windows computer (sorry, we are still having issues with Mac video capture) and leave a story of a past conference for others in the community to explore.
- * Add +18475551234 as a friend to share with others
- * Download the mobile phone software or try one of our phones to see the stories that others have shared. Clicking on "Set Location" in the options menu will let you virtually travel to locations of past conferences.

CREATE



1) Create a story in a location and share with family members.

2) Record video for the story. Show artifacts as if you were telling it in person.

VIEW



3) Family members come near the location of a story and are notified that there is a story nearby

4) Family members can unlock stories and watch the videos telling the story of that place. They can call you or "like" the story.

Example Posters

Social Groups and Music Capital - Applying Theory and Research in Design

Crysta J. Metcalf, Ph.D., Frank Bentley, Gunnar Harboe, Vivek Thakkar
User-Centered Solutions Lab, Motorola Labs

A study of music listening behavior provided findings on social music sharing that led to design implications currently being tested in the field.

Studying music use

Purpose: Explore effects of context on music use for new product ideation

Qualitative ethnographic-style research:

- 13 frequent music listeners
 - Diverse in age, ethnicity, gender and occupation
 - City and suburban dwellers
 - Multiple formats in music collections
- Semi-structured interviews
 - Descriptions of recent experiences alone and with others
 - Home tours with explanations of music organization and music use in different areas of the house

- Task-based interviews
 - Participants asked to select music from their home collections based on a number of different scenarios
 - True-to-life scenarios created based on information collected during phone interviews prior to the home visit
- Affinity analysis and model building
 - Cross-functional team-based analysis
 - Used for subsequent brainstorming

Findings:

Social sharing demonstrates unique music expertise

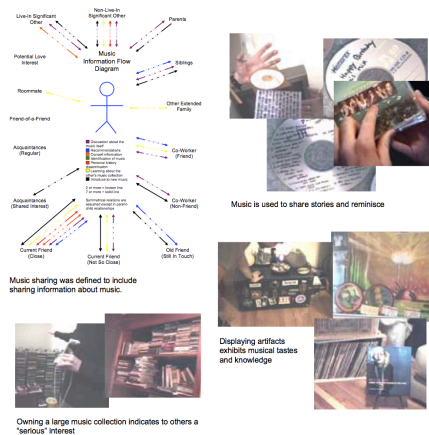
Music sharing includes sharing knowledge about music and artists, and playing music for others, as well as giving and lending songs or CDs.

People talk about and select music when with others in order to:

- Introduce others to new music
- Influence what others purchase and play
- Acquire respect for their expertise in music
- Tell stories and reminisce

Participants exchanged music and music knowledge primarily with people in their immediate social circle; very little importance was placed on introducing strangers or acquaintances to new music.

Participants in our study actively tried to demonstrate unique musical tastes that they hoped friends and family would adopt and respect.



Conclusions: Unique and respected music expertise accumulates capital

The more people share music that others enjoy and have not heard before, the more respect they receive from others in their social circle.

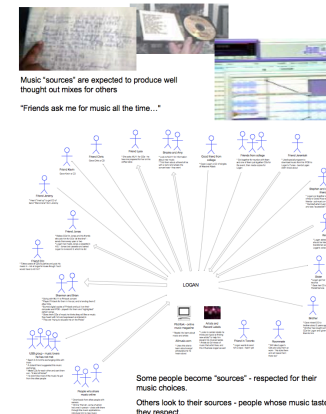
Social exchange theory helps us understand and predict the reciprocal give-and-take of music sharing.

- People respond to the consequences of past music-sharing choices.
- Knowing who values music sharing increases future sharing.
- People "value the act of reciprocity, per se, over and above the instrumental benefits of exchange," (Molm 2003).

Those who garner respect become music "sources" for their social circle.

"Sources" are looked to for:

- Unique music
- Music information
- Expertly mixed music
- Music selection at parties



Implications:

For product design

Develop applications that help people in already established social circles:

- Increase their music capital
- Utilize their "sources"
- Demonstrate their music knowledge and taste to others in their social circle
- Discover new music by seeing what their friends are playing
- Know if their friends are playing music they introduced them to
- Decide who values their musical choices
- Reminisce and share stories

Prototypes:

Leveraging our understanding

The first iteration of a mobile music presence application, embodying our understanding of music sharing was created and tested with a single group of friends.

The second iteration of the prototype is currently being tested in the field.

- Three groups of friends
- Two week period of use
- Quantitative as well as qualitative data being collected

Prototype Features	
1 st Iteration	<ul style="list-style-type: none"> • Designed for established social groups • Shows who is playing music • Provides artist, song and album being played • Updates automatically each time a new song is played
2 nd Iteration	<ul style="list-style-type: none"> • Provides all of the above functionality • Enables users to send "thumbs-up," "thumbs-down," and "shout-out" • Enables users to send SMS messages • Allows users to play clips of songs played by their "buddies"



Assignments (summary)



- Next Class (3/29)
 - Poster and Demo
- 4/5
 - Location Assignment (2 pages)
 - Networking Assignment (2 pages)