MOBILE LOCATION / NETWORKING
PERSUASION / URBAN COMPUTING

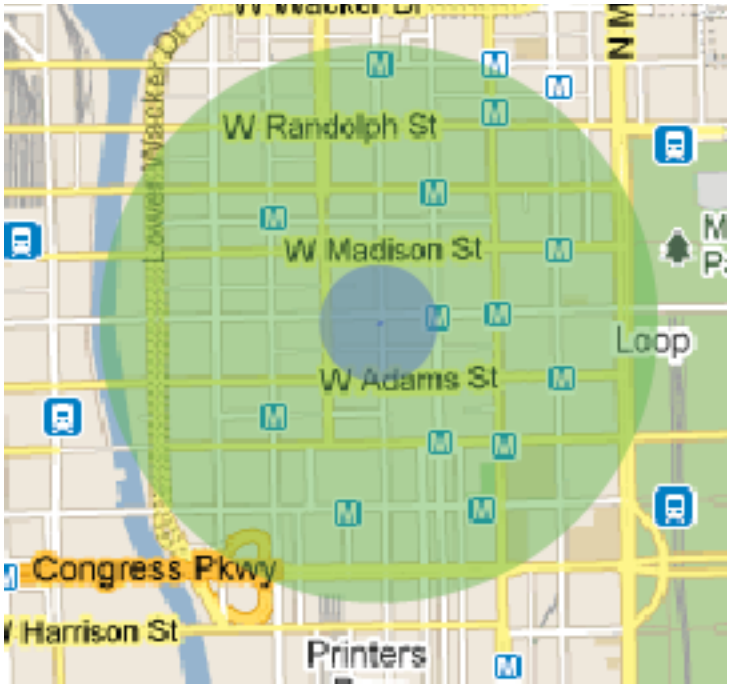
21w.789 Spring 2014

Mobile Location

- Location Tech
  - GPS
  - Cell ID
  - WiFi
- Mixed Methods (Skyhook)
- 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)



Map: maps.google.com

Cell ID

- Uses 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 to map these into lat, lon
- Cells also can be manually mapped to semantic locations (e.g. Campus, Home, Downtown Boston, etc.)

Cell Topology

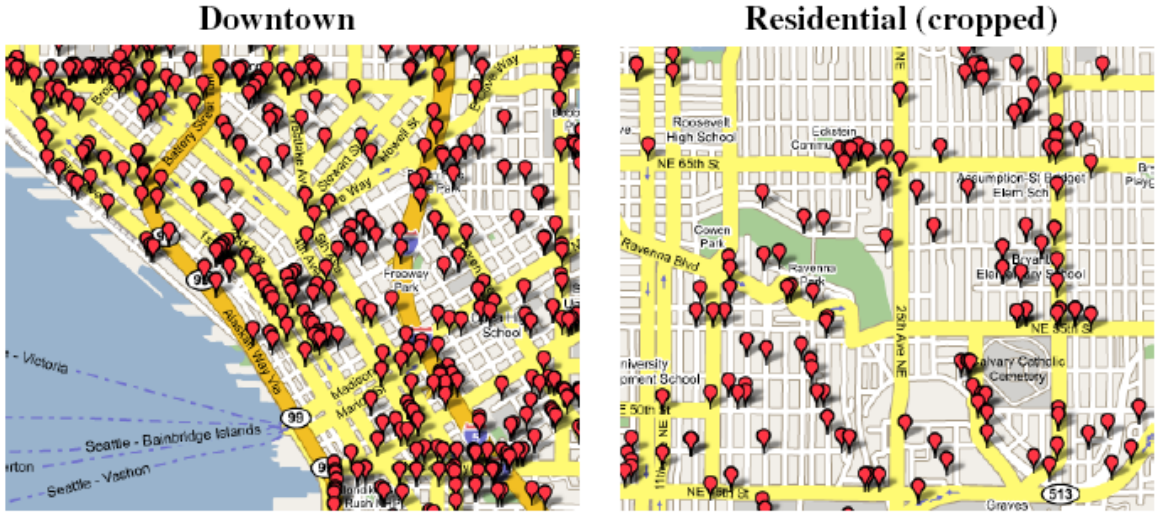


Fig. 3. Cell location map for the three network providers; each dot represents the estimated location of a cell. The left map shows Downtown with an average density of 66 cells/Km^2. The right map shows a cropped Residential region with an average cell density of 26 cells/Km^2.

Mike Y. Chen, Timothy Sohn, Dmitri Chmelev, Dirk Haehnel, Jeffrey Hightower, Jeff Hughes, Anthony LaMarca, Fred Potter, Ian Smith, and Alex Varshavsky. 2006. Practical metropolitan-scale positioning for GSM phones. In Proceedings of the 8th international conference on Ubiquitous Computing (UbiComp'06), 225-242. http://dx.doi.org/10.1007/11853565_14 Used with Permission.

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
  - Skyhook
  - Yahoo
  - Open Cell ID

- Now part of most mobile platforms…transparent to developer/user when you ask for a “network” location

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:
  - The provider database needs to have sampled fairly close 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
- Receivers often provide access to position data as a NMEA stream (National Marine Electronics Association)

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 (500m requests/day)

Tradeoffs…

Technology	Time	Power	Accuracy
Cell ID	~1-5 seconds	Low (already has cell tower information), just needs a network transaction (or cache hit) to look up	100-2000m
WiFi	~10 seconds (wifi scan and then network transaction for lookup)	Moderate (needs wifi scan and a network transaction)	~50-100m
GPS	Up to 1 minute for first fix	Extremely High (high power amplifier active)	< 10m

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

- Start the service:

```
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);
```

- Get updates:

```
@Override
public void onLocationChanged(Location location) {
    int lat = (int) (location.getLatitude());
    int lng = (int) (location.getLongitude());
    latituteField.setText(String.valueOf(lat));
    longitudeField.setText(String.valueOf(lng));
}
```

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

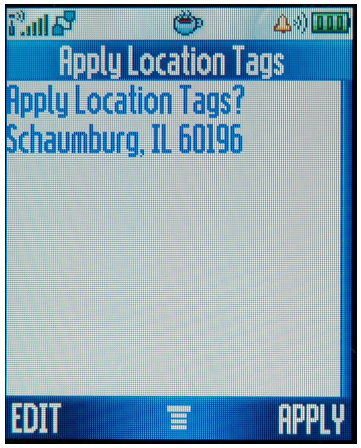
- All location queries handled by CLLocation Manager
  - Uses a variety of means to determine location (Cell ID, Wifi positioning, AGPS, GPS)
  - Returns asynchronously as location is refined
  - Gives accuracy with each response
- locationManager = [[[CLLocationManager alloc] init] autorelease];
  locationManager.delegate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

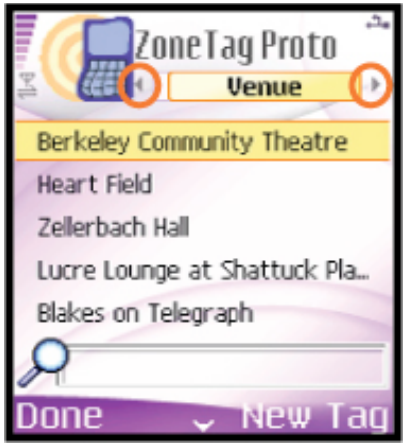
Applications

- 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





Morgan Ames and Mor Naaman. 2007. Why we tag: motivations for annotation in mobile and online media. In Proceedings of CHI '07. ACM, New York, NY, USA, 971-980. http://doi.acm.org/10.1145/1240624.1240772. Used with Permission.

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?

Frank R. Bentley and Crysta J. Metcalf. 2007. Sharing motion information with close family and friends. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '07). ACM, New York, NY, USA, 1361-1370. http://doi.acm.org/10.1145/1240624.1240831. Used With Permission.

Place Its (Sohn et al 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.)

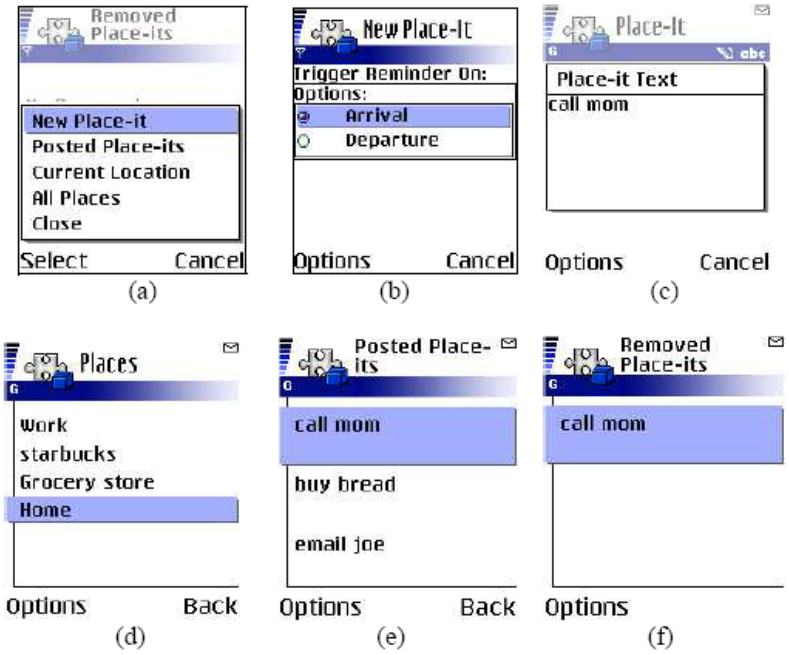
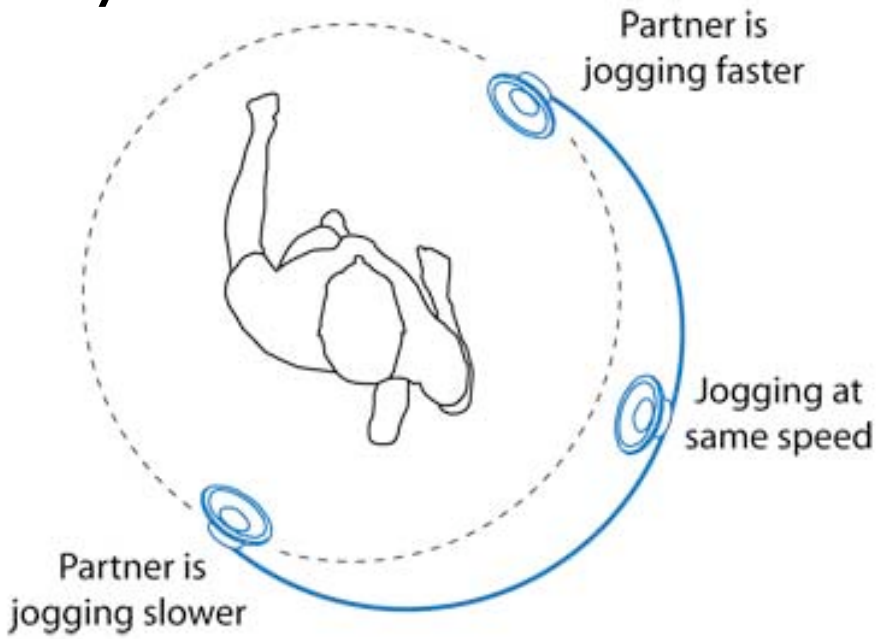


Figure 1. **(a)** Creating a new Place-It note; **(b)** Setting the note to be triggered upon arrival; **(c)** Typing the text of the note; **(d)** Posting the note to 'Home'; **(e)** Showing all posted Place-It notes; **(f)** The reminder is triggered when Jill arrives at the home and the note is removed.

Timothy Sohn, Kevin A. Li, Gunny Lee, Ian Smith, James Scott, and William G. Griswold. 2005. Place-Its: a study of location-based reminders on mobile phones. In Proceedings of UbiComp'05, 232-250. http://dx.doi.org/10.1007/11551201_14. Used with Permission.

Jogging the Distance (Mueller et al 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

Florian 'Floyd' Mueller, Shannon O'Brien, and Alex Thorogood. 2007. Jogging over a distance: supporting a "jogging together" experience although being apart. In CHI '07 Extended Abstracts on Human Factors in Computing Systems (CHI EA '07). ACM, New York, NY, USA, 2579-2584. 5 http://doi.acm.org/10.1145/1240866.1241045. Used with Permission.

REXplorer (Ballagas et al 2007)

- Tourist game in Regensberg, 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

Rafael A. Ballagas, Sven G. Kratz, Jan Borchers, Eugen Yu, Steffen P. Walz, Claudia O. Fuhr, Ludger Hovestadt, and Martin Tann. 2007. REXplorer: a mobile, pervasive spell-casting game for tourists. In CHI '07 Extended Abstracts on Human Factors in Computing Systems (CHI EA '07). ACM, New York, NY, USA, 1929-1934. http://doi.acm.org/10.1145/1240866.1240927. Used with Permission.

Serendipitous Stories (2010)

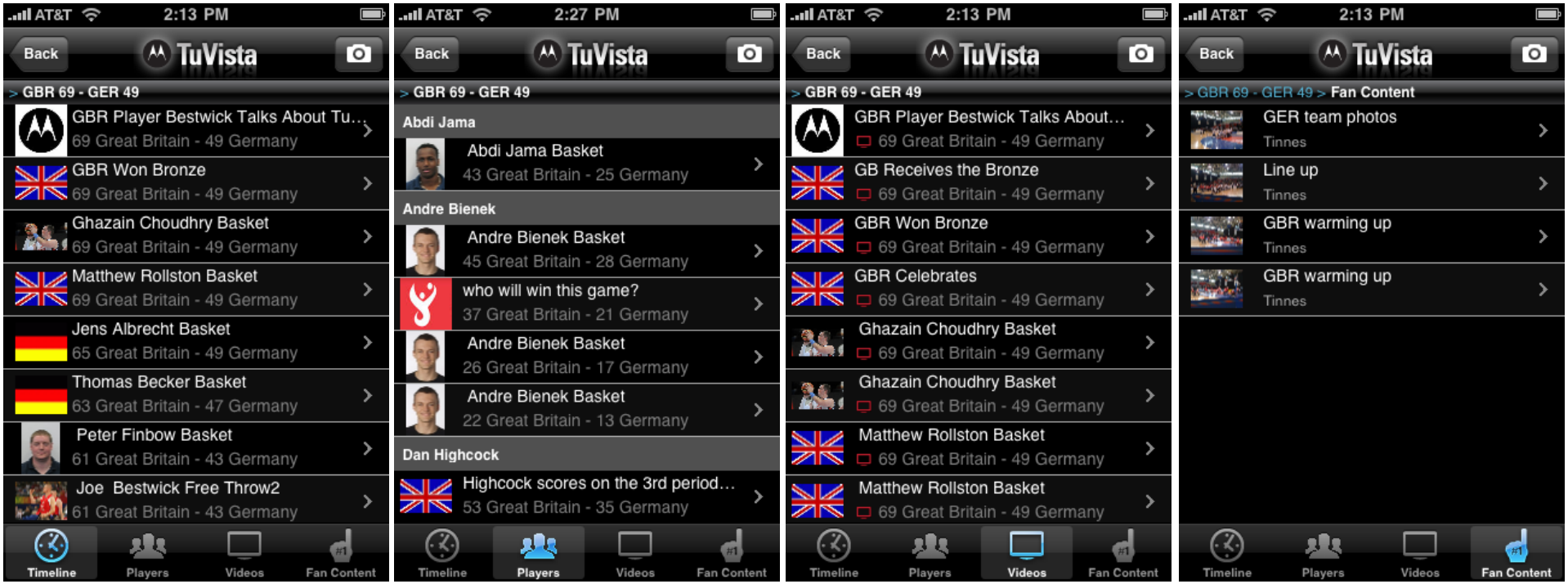
- Asynchronous location-based communication
- Record a video, save it in a place, share it with friends
- Friends serendipitously discover videos when they approach the location of a video (phone vibrates)
- Built in summer 2010, field study (n=20) in fall 2010

Frank R. Bentley, Santosh Basapur, and Sujoy Kumar Chowdhury. 2011. Promoting intergenerational communication through location-based asynchronous video communication. In Proceedings of the 13th international conference on Ubiquitous computing (UbiComp '11). ACM, New York, NY, USA, 31-40. http://doi.acm.org/10.1145/2030112.2030117. Used With Permission.

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
  - Deployed with the Denver Broncos

Frank R. Bentley and Michael Groble. 2009. TuVista: meeting the multimedia needs of mobile sports fans. In Proceedings of the 17th ACM international conference on Multimedia (MM '09). ACM, New York, NY, USA, 471-480. http://doi.acm.org/10.1145/1631272.1631337. Used With Permission.



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 4/1)

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 campus in each of these conditions and save the log files. This route must 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 either your log files or a Google Map showing your route, each point captured, and error radius at each point for this assignment.

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

Frank Bentley and Edward Barrett. 2012. Building Mobile Experiences. The MIT Press. Used with Permission.

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 (sometimes for minutes at a time)

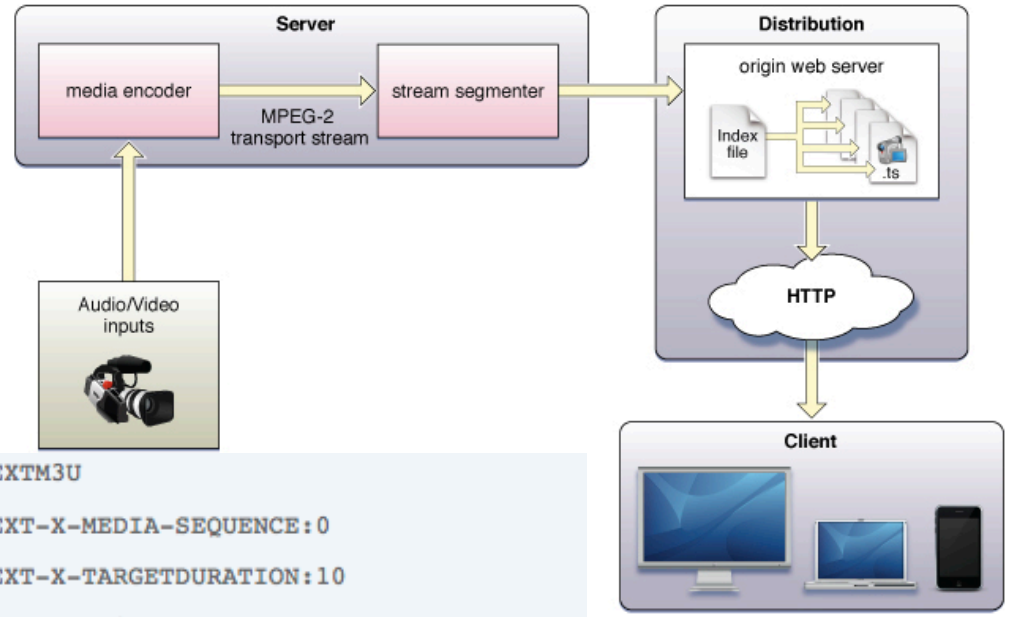
- Network freezes
  - Common to have connections hang for 20 seconds
    - Sometimes when switching to a new tower or from 2G-3G
    - Sometimes for totally unexplained reasons
  - Be patient and set long timeouts

Strategies for congestion

- 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:
    - TripIt
    - Gmail
    - Various transit apps

Strategies for congestion / video

- 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)

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 (CDM)
  - 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

Testing Network Code

- 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 4/1)

- 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 1 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 4G/3G in the settings in order to get 2/2.5G in the same location.
- Upload results to: http://goo.gl/WD1SC
- Write 2 pages on your results where you explain your methods, data observed, and any interesting findings. Submit this along with your log files.

Assignments (summary)

- Next Class (4/1)
  - Location Assignment (2 pages)
  - Networking Assignment (2 pages)

- Following class (4/8)
  - Poster and demo session (more details next class)
    - Must have working application on your phone by 4/8!

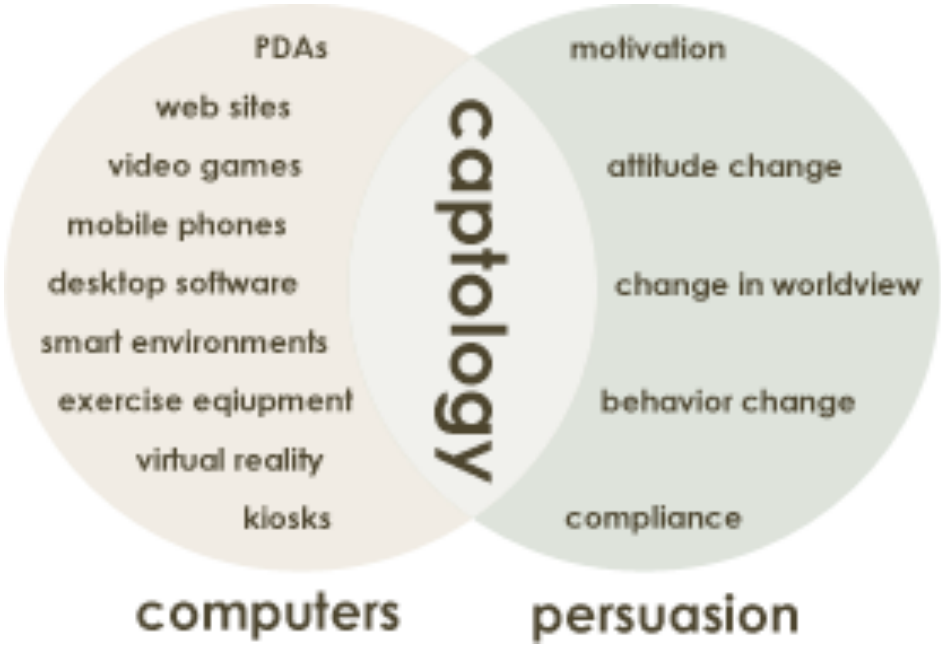
MOBILE PERSUASION
URBAN COMPUTING

Outline

- Persuasion
  - Captology
  - Background from Psychology
  - Trans-Theoretical Model of Behavior Change
  - Mobile Persuasive Applications
- Urban Computing
  - Familiar Stranger
  - Participatory Sensing
  - Community Feedback
  - Urban Games

Captology

- BJ Fogg (Stanford) 1996
  - Computers as Persuasive Technologies
  - World peace in 30 years…



https://pbs.twimg.com/profile_images/1149632593/captology.jpg

Mobile Persuasion

- "Mobile phones will soon become the most important platform for changing human behavior."

  - BJ Fogg

- Applications that help people make changes in their lives
  - Healthcare
  - Wellness
  - Communication

8 step process for design

- BJ Fogg's 8 simple steps for creating apps for behavior change:
  - Choose a simple behavior to target
  - Choose a receptive audience
  - Find what prevents the target behavior
  - Choose a familiar technology channel
  - Find relevant examples of persuasive technology
  - Imitate successful examples
  - Test and iterate quickly
  - Expand on success

Trans-Theoretical Model of Behavior Change

- Prochaska 1992
- Stages of Making a change in behavior:
  - Pre-contemplation - "people are not intending to take action in the foreseeable future, usually measured as the next 6 months"
  - Contemplation - "people are intending to change in the next 6 months"
  - Preparation - "people are intending to take action in the immediate future, usually measured as the next month"
  - Action - "people have made specific overt modifications in their life styles within the past 6 months"
  - Maintenance - "people are working to prevent relapse," a stage which is estimated to last "from 6 months to about 5 years"
  - Termination - "individuals have zero temptation and 100% self-efficacy... they are sure they will not return to their old unhealthy habit as a way of coping"

TTM

- Interventions should be stage-matched
- Earlier stages involve building awareness, desire
- Later stages involve goals and commitments

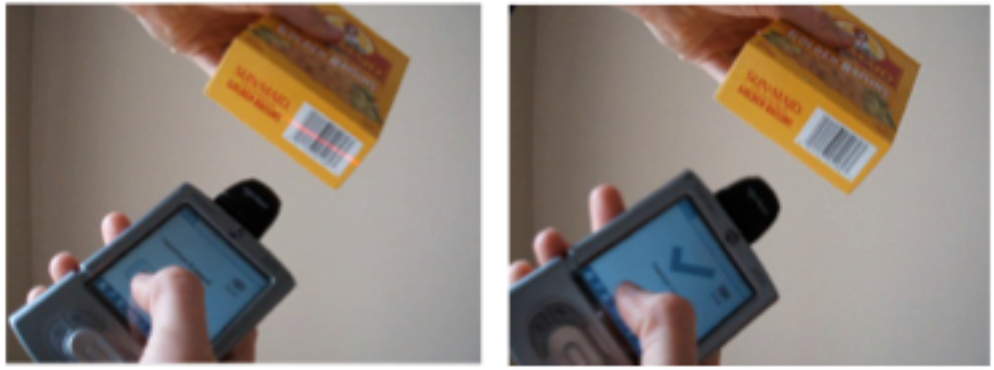
- Challenges:
  - Riemsma 2003 – Interventions that are stage-matched no better than common intervention for all
  - Clear boundaries between stages, not so clear in practice. More going back and forth than a real stage-matched intervention allows for.
- Still, a useful tool to think about where in a change-making process a person is.

Examples on the market

- Nike+
- Many mobile food choice apps
  - Calorie lookup apps
- Logging apps (workout, food, weight, etc.)
  - FitBit, WiThings, etc.
- Persuade to give up info (GMail, Foursquare, etc.)

Health Applications

- When do we eat?
  - Kay Connelly
  - Low-literacy, kidney disease patients
  - Build awareness of what and when they eat
  - Vital to maintaining health
  - Awareness led to better eating behaviors



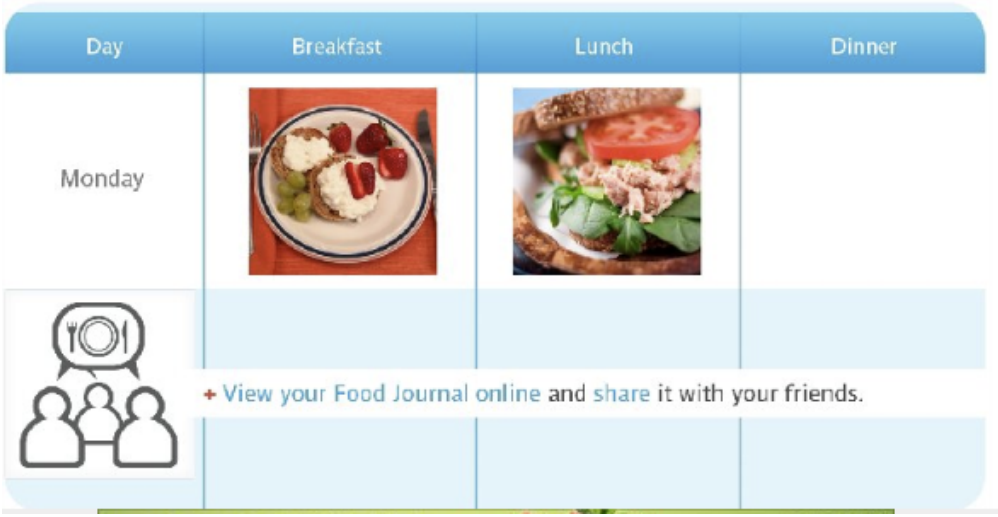
When Do We Eat? An Evaluation of Food Items Input into an Electronic Monitoring Application, Katie Siek, Kay H. Connelly, Yvonne Rogers, Paul Rohwer, Desiree Lambert and Janet L. Welch. In the Proceedings of the First International Conference on Pervasive Computing Technologies for Healthcare (Pervasive Health), November 2006. Innsbruck, Austria.

Mobile Health Applications

- Zeer
  - Mobile ingredients lists – know what you're eating
- uBox
  - Medication reminder/dosing
- uPhone
  - Mobile tool for rural health professionals
  - Track disease/keep digital records

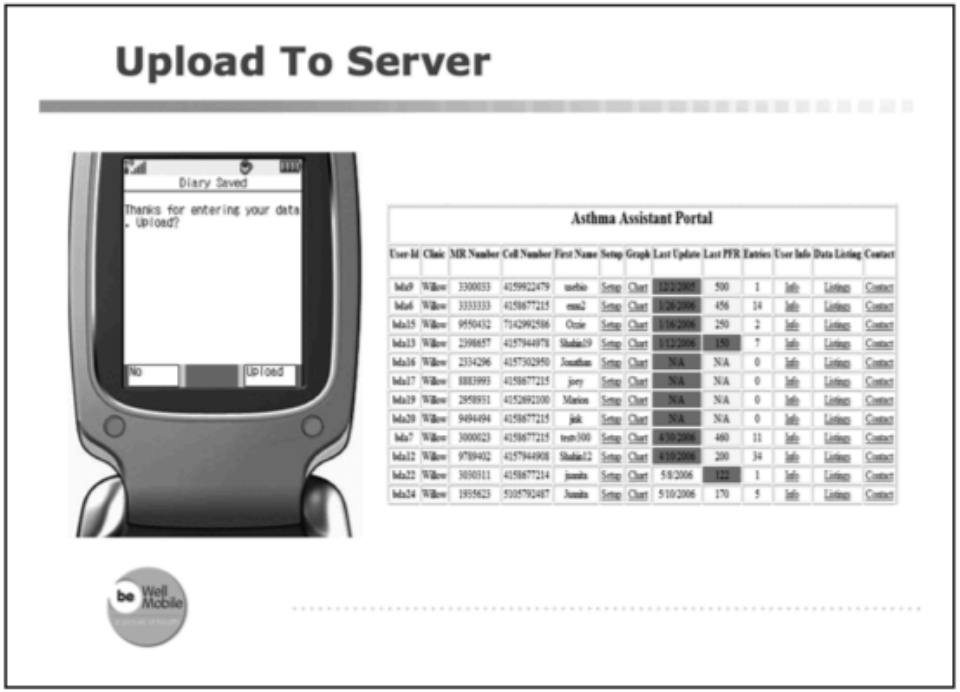
MyFoodPhone

- Food blog of everything you eat
- Pictures taken from mobile phone
- Forces you to reflect on food choice and quantity



BeWell - asthma

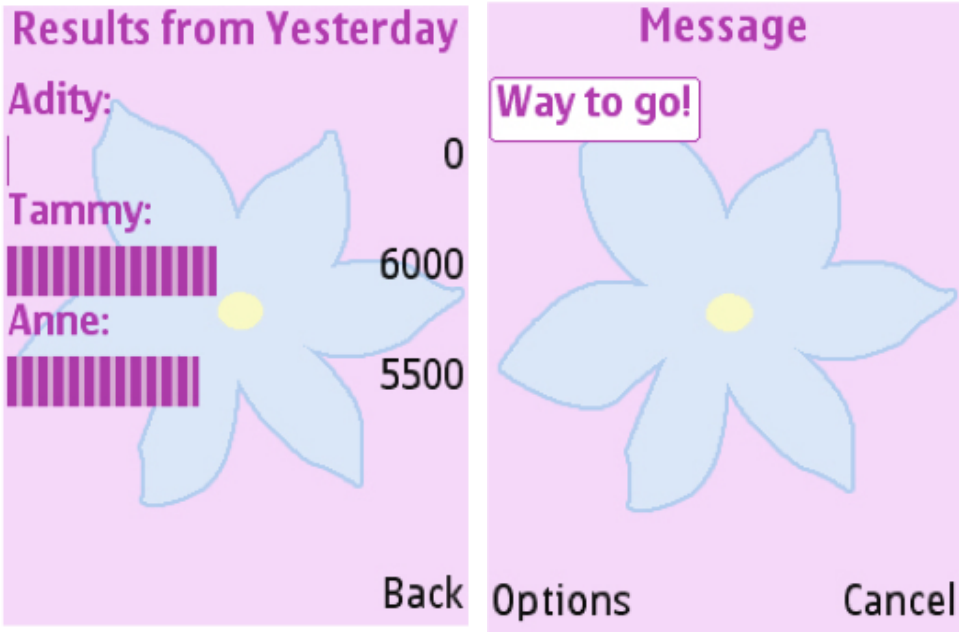
- Log episodes, upload to doctor
- Leads to better care
- Persuasion to keep more accurate logs for care



http://www.bewellmobile.com/MCO-050106.pdf

Wellness

- Chick Clique
  - Step count tracking
  - Share among group of girls
  - Motivation messages sent to others, see progress towards goals
  - Problems: Not everyone walks the same amount, discouraging when always losing to friends who walk a lot
  - Teens can be mean to each other



Tammy Toscos, Anne Faber, Shunying An, and Mona Praful Gandhi. 2006. Chick clique: persuasive technology to motivate teenage girls to exercise. In CHI '06 Extended Abstracts on Human Factors in Computing Systems (CHI EA '06). ACM, New York, NY, USA, 1873-1878. http://doi.acm.org/10.1145/1125451.1125805 Used With Permission.

Houston

- Sunny Consolvo et al (Intel, UW)

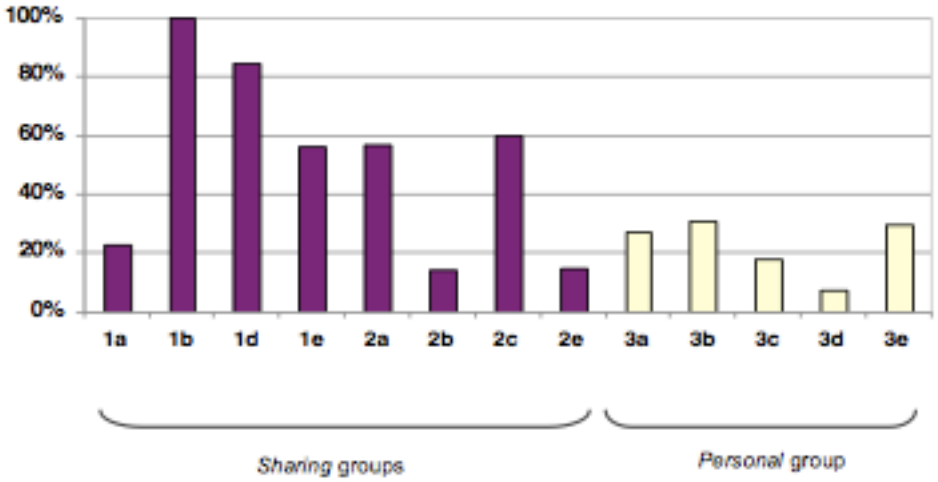


Figure 3. Percentage of days participants met their goals.

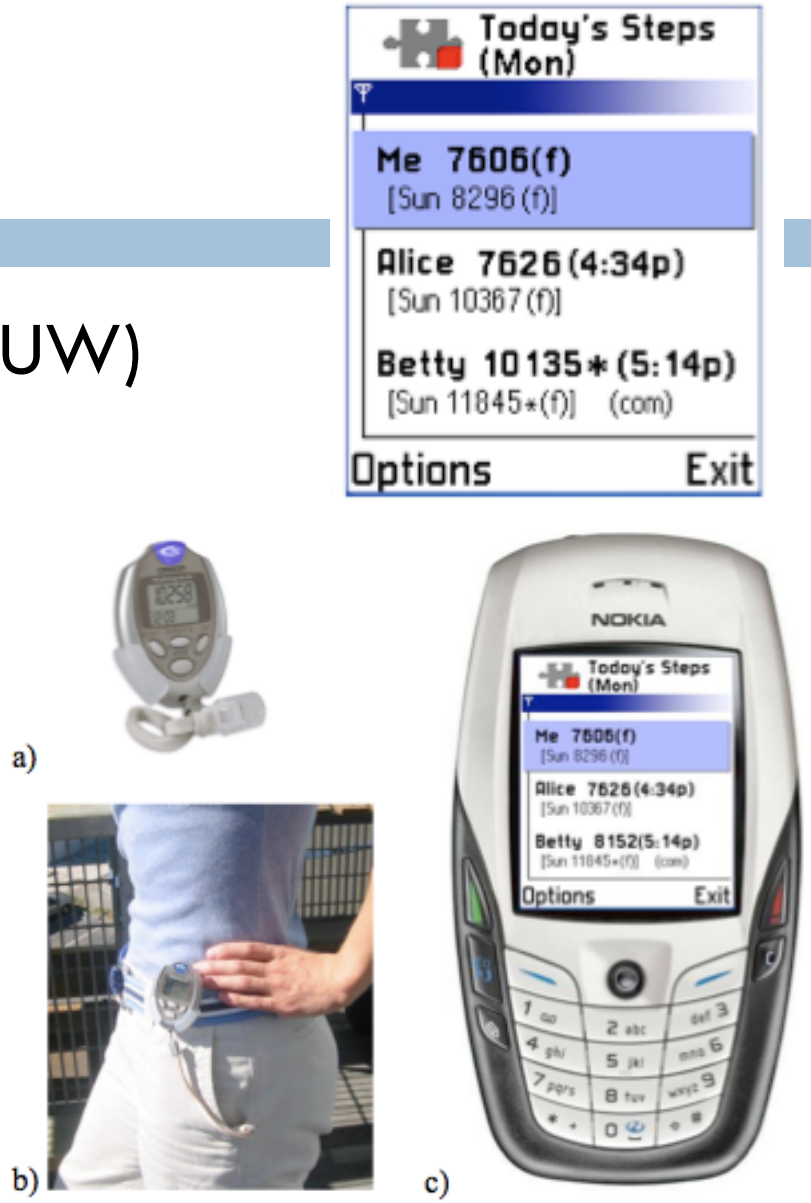


Figure 1. a) The Omron HJ-112 pedometer, b) the pedometer in use, and c) the Nokia 6600 mobile phone running Houston.

Sunny Consolvo, Katherine Everitt, Ian Smith, and James A. Landay. 2006. Design requirements for technologies that encourage physical activity. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '06), Rebecca Grinter, Thomas Rodden, Paul Aoki, Ed Cutrell, Robin Jeffries, and Gary Olson (Eds.). ACM, New York, NY, USA, 457-466. http://doi.acm.org/10.1145/1124772.1124840
Used with Permission.

Design Recommendations from Houston

- Give users proper credit for activities
- Provide personal awareness of activity level
- Support social influence
- Consider the practical constraints of users' lifestyles

UbiFit Garden

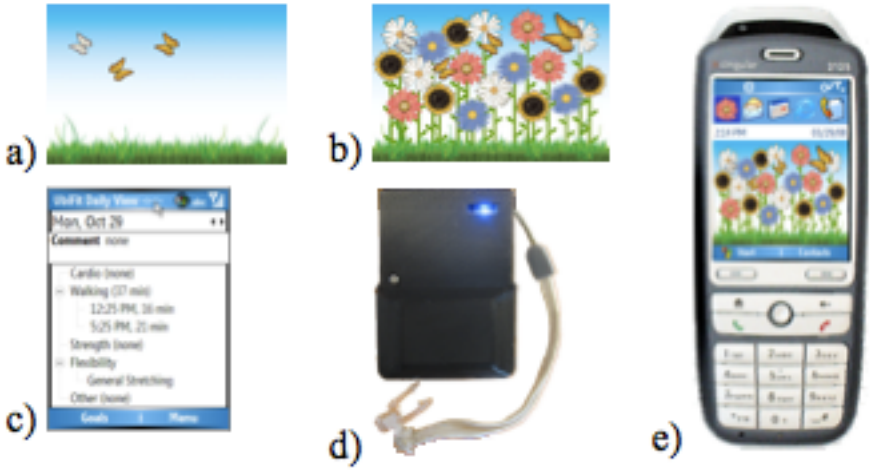
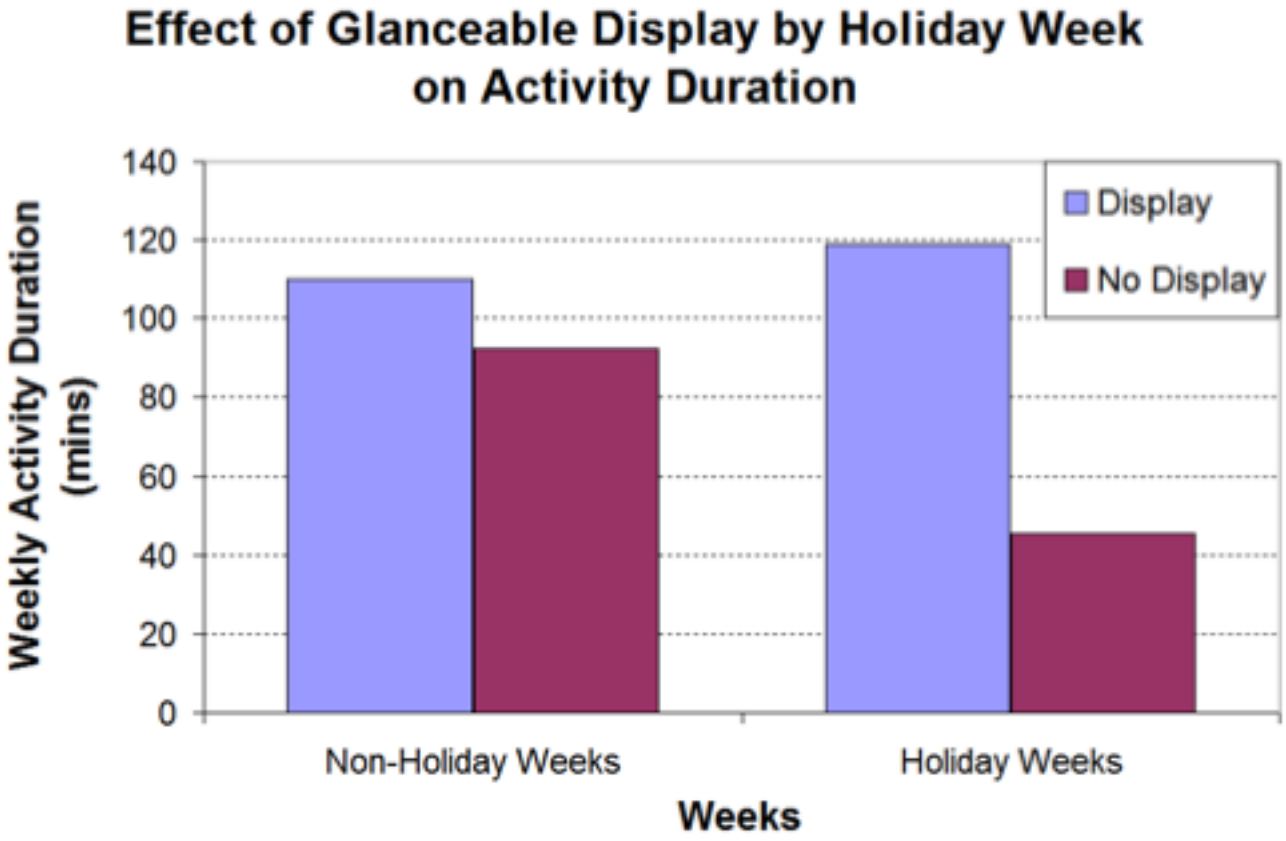


Figure 1. The UbiFit Garden system. a) The garden at the beginning of the week; b) an active week with variety; c) the interactive application; d) the MSP; and e) the garden on the background screen of a mobile phone.

Sunny Consolvo, David W. McDonald, Tammy Toscos, Mike Y. Chen, Jon Froehlich, Beverly Harrison, Predrag Klasnja, Anthony LaMarca, Louis LeGrand, Ryan Libby, Ian Smith, and James A. Landay. 2008. Activity sensing in the wild: a field trial of ubifit garden. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). ACM, New York, NY, USA, 1797-1806.
http://doi.acm.org/10.1145/1357054.1357335 Used with Permission.

Glanceable displays and persuasion



Sunny Consolvo, David W. McDonald, Tammy Toscos, Mike Y. Chen, Jon Froehlich, Beverly Harrison, Predrag Klasnja, Anthony LaMarca, Louis LeGrand, Ryan Libby, Ian Smith, and James A. Landay. 2008. Activity sensing in the wild: a field trial of ubifit garden. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). ACM, New York, NY, USA, 1797-1806. http://doi.acm.org/10.1145/1357054.1357335 Used with Permission.

UbiGreen

- Using same concept to encourage people to live greener lives

Figure 1 (left) The UbiGreen Transportation Display shows transit behavior as "wallpaper" on a phone's screen. Here the tree is nearly full of leaves, indicating that the user has completed several green trips for the week. (top) The MSP sensor worn near the waist and the phone's GSM cell tower data are used to semi-automatically infer transportation mode.

Jon Froehlich, Tawanna Dillahunt, Predrag Klasnja, Jennifer Mankoff, Sunny Consolvo, Beverly Harrison, and James A. Landay. 2009. UbiGreen: investigating a mobile tool for tracking and supporting green transportation habits. In Proc CHI '09. ACM, New York, NY, USA, 1043-1052. http://doi.acm.org/10.1145/1518701.1518861 Used with Permission.

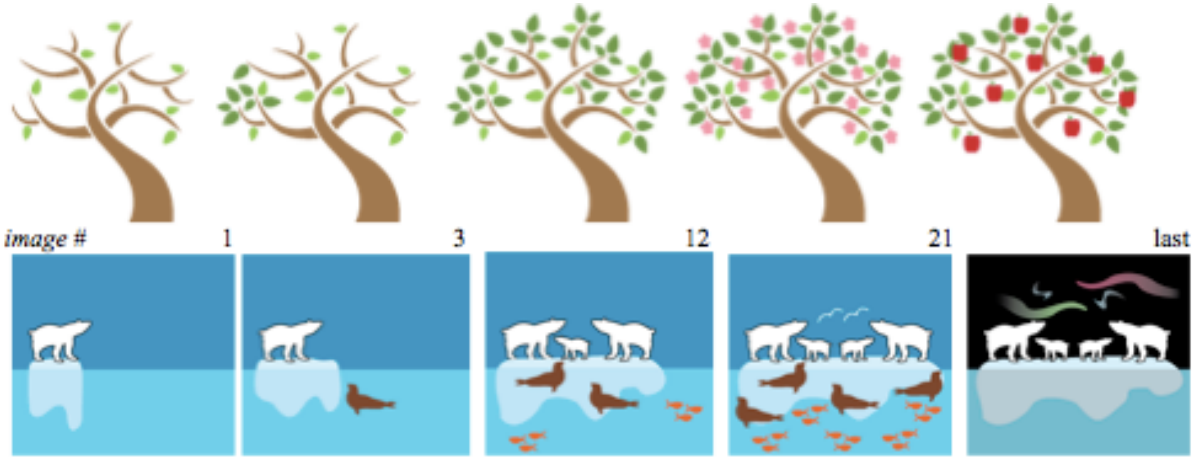
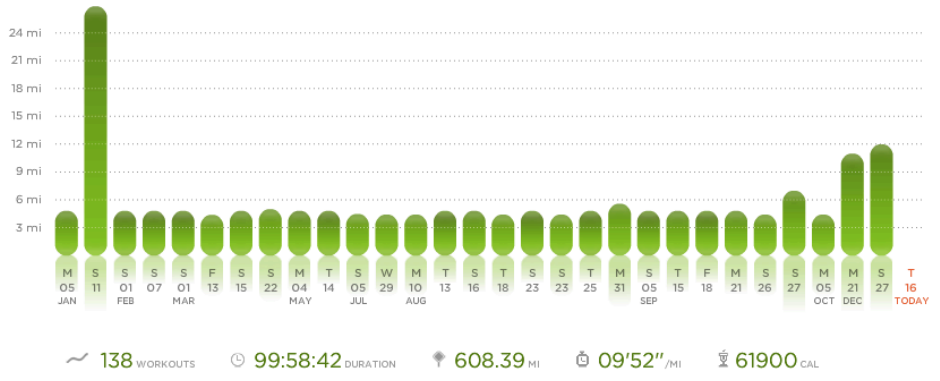


Figure 3: (top-left) A sample of images from the tree progression and **(bottom-left)** a sample of images from the polar bear progression. **(right)** Screenshots showing the graphics in context. In both examples, the user recently carpooled (as indicated by the car with the "2" in the windshield). Since carpooling saves money, the piggy bank is highlighted.

Nike+

- Tracking + Motivation (Immediate + long term)



Design Strategies for Behavior Change (Sunny Consolvo et al)

1. **Abstract & Reflective.** Use data abstraction, rather than raw or explicit data collected from the user and any technologies, to display information to encourage the user to reflect on his/her behaviors by showing the user what s/he has done and how those behaviors relate to his/her goal.
2. **Unobtrusive.** Present and collect data in an unobtrusive manner, and make it available when and where the user needs it, without unnecessarily interrupting his/her everyday life or calling attention to him/her.
3. **Public.** Present and collect the data, which is personal in nature, such that the user is comfortable in the event that others may intentionally or otherwise become aware of it. Because the data needs to be available whenever and wherever the user needs it, it is likely to be something that s/he wears/carries, resides in a shared/common space, or uses while in the presence of others. The technology should not make the user uncomfortable in those situations.

Design Strategies for Behavior Change

4. **Aesthetic.** If the display and any accompanying devices function as a personal object(s) that may be used over time, they need to be inquisitive and sustain interest. The physical and virtual aspects of the technology must be comfortable and attractive to support the user's personal style.
5. **Positive.** Use positive reinforcement to encourage change. Reward the user for performing the desired behavior and attaining his/her goal. When the desired behavior is not performed, the user should not receive a reward nor a punishment, but his/her interest should be sustained.
6. **Controllable.** When appropriate, permit the user to add to, edit, delete, and otherwise manipulate data so that it reflects the behaviors that s/he deems suitable. The user should be in control of who has access to what aspects of his/her data.

Design Strategies for Behavior Change

7. **Trending / Historical.** Provide reasonable and accessible information about the user's past behavior as it relates to his/her goals. Historical data should accommodate changes in lifestyle goals over time and provide for the portability of data across devices.
8. **Comprehensive.** Account for the range of behaviors that contribute to the user's desired lifestyle; do not artificially limit data collection and representation to the specific behaviors that the technology can sense or monitor.

Ethical Issues

- What data is being collected
- Persuasion = Manipulation?
- Voluntary disclosure (to whom?)

Persuasion in your systems?

- Could your apps persuade people to…
  - Spend more time with friends
  - Walk a little out of your way
  - Reflect on your past
  - Use public transit more often
  - Be more artistic and share with others
  - Become smarter

Urban Computing

Urban Computing

- Overview of Urban Computing
- Familiar Stranger Phenomenon
- Participatory Sensing
- Community Feedback
- Urban Games
- Physical Tagging

What is urban computing?

- Computation in urban settings
- Usually mobile or installed in environments
- Seeks to encourage residents to become engaged
- “Citizen Science” (Paulos et al)

Domains of Urban Computing

- Participatory Sensing
  - Traffic
  - Pollution
  - Etc.
- Community Feedback
  - Broken Sidewalks
  - Harassment (hollabacknyc.com)
- Urban Games

Why “urban” computing

- Cities provide:
  - Critical mass of people using a given technology
  - Many interactions with new people and places
  - Opportunity for people to contribute to society
    - Every phone is a data collection device

Familiar Strangers

- Stanley Milgram (1972)
  - Someone you recognize but do not interact with
  - Share trains, buses, etc.
  - See coming out of work/apartment building
  - People you recognize at the grocery store
  - Usually mutual (e.g. not celebrity)

Familiar Stranger Study

- Who do we know and why don't we talk to them?
- Train station in NJ
- Took photo of people waiting for the train
- Returned and asked those present who was familiar

Findings

89% of people recognized at least one person

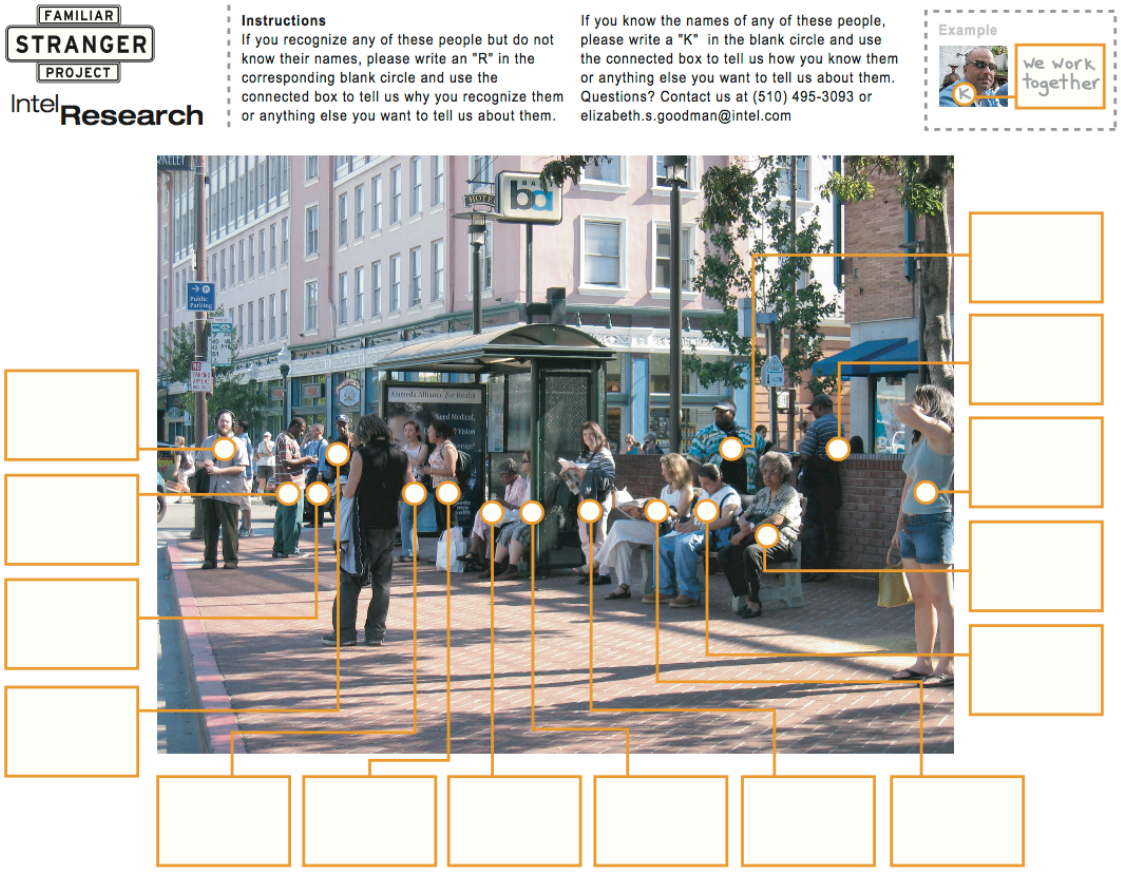
"We studied the familiar strangers. We spoke to them in station after station, and this is what they told us. As the years go by, familiar strangers become harder to talk to. The barrier hardens. And we know-if we were to meet one of these strangers far from the station, say, when we were abroad, we would stop, shake hands, and acknowledge for the first time that we know each other. But not here."

Why Familiar Strangers?

- People more likely to help familiar strangers than total strangers when in need
- Familiar strangers who meet in non-familiar settings more likely to introduce themselves, talk
- Increase feelings of community
- Increase feelings of safety

Intel + UC Berkeley

- Project to explore familiar strangers
- Replicated Milgram Study in Berkeley Plaza

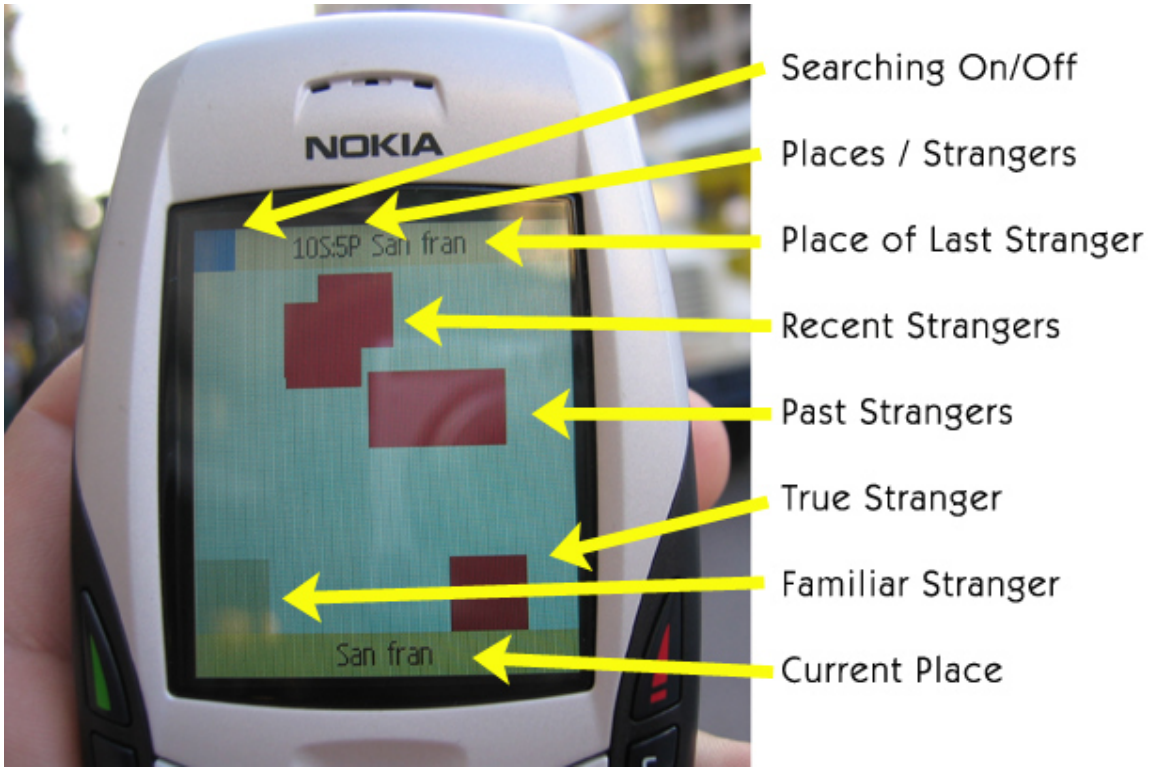


Findings from Berkeley Study

- Milgram – 89% of people recognized one person
- Intel – 77% (less set times, BART station, not commuter rail)
- Those interviewed valued information about familiar people most when they felt unsafe and when they had a choice of options.
- Would "respect" a venue more if people they knew came there
- "What if my device showed that I didn't know anyone? I would feel worried about my safety in a crowd."
- "It depends whether I'm looking for people, for connections. When I'm on my own business I'd be more discrete."

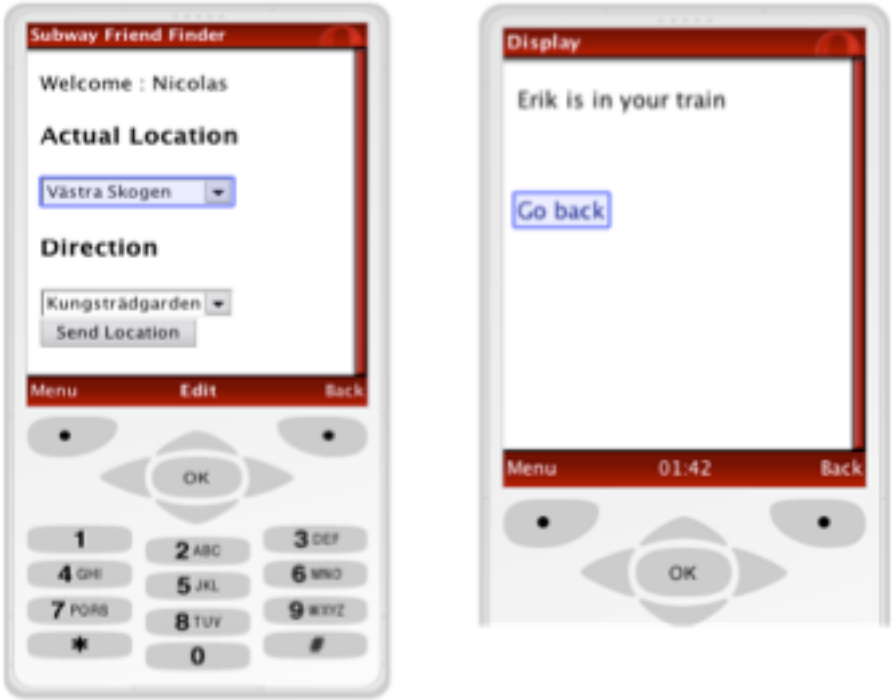
Jabberwocky

- Visual confirmation of when you are around people you regularly see
- Reassurance that you are around people who "know" you



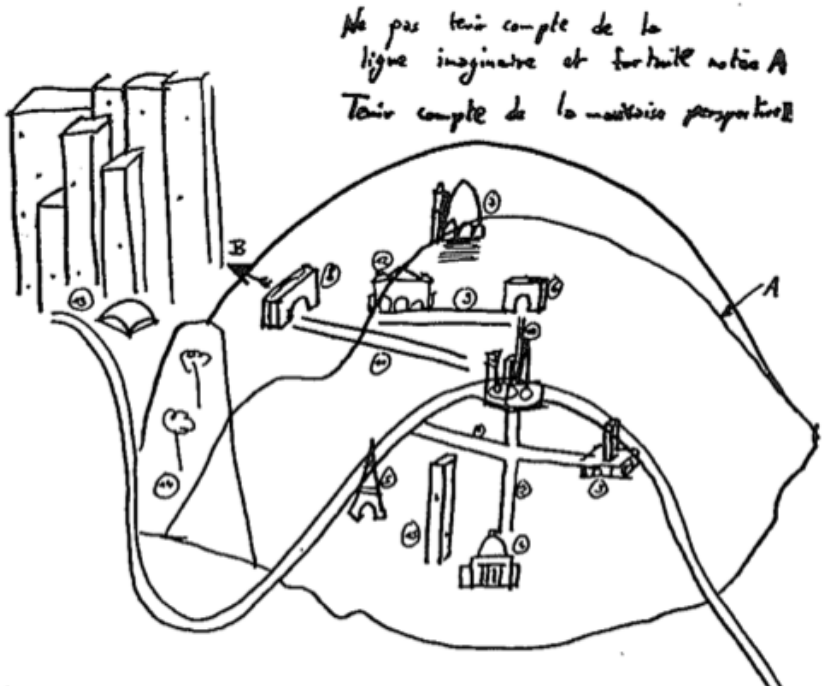
Other uses of Familiar Stranger…

- "See you on the Subway" Belloni et al (2009)



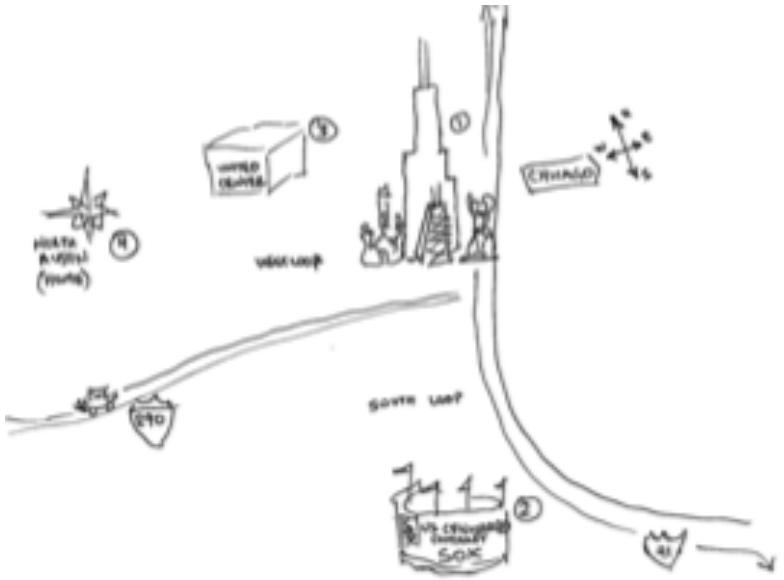
Mental Maps of Cities

- Milgram studies in the 1970s
- Draw maps of "their" Paris (and later other cities)
- Found differences between maps and reality (distances, areas around metro stations, bend of the river, etc.)



Milgram Revisit

- Motorola and Mobile Life (CHI 2012)
- Looking at differences between location technology / demographics and maps that are produced
- Few statistically significant differences
  - Foursquare users more likely to draw more neighborhoods
  - Transit users and walkers were more likely to use mobile maps
  - Residents of dangerous neighborhoods less likely to identify them as such
  - Participants only reported knowing 12% of the city “well”



Implications of Map Studies

- Opportunities exist to teach real structures of neighborhoods, how communities connect to form city
- Teaching differences in crime (issues of perpetuating status quo)
- Encouraging users to explore more of the city, getting beyond neighborhood

Participatory Sensing

- Systems that allow the public to systematically observe, study, reflect on, and share their unique world (participatorysensing.org)
- Turning citizens into scientists
  - Let billions of phones be the sensors to learn about the world and make it better
  - Hopefully carefully
  - Data needs to be easy to interpret/visualize

Feral Robots (U of London)

- Robots with environmental sensors on.
- Drove around park measuring air quality.
- Web interface to view results.

(i)

(ii)

(iii)

Snout (U of London)

- Extension to feral robots
- Display air quality on clothing in a street performance

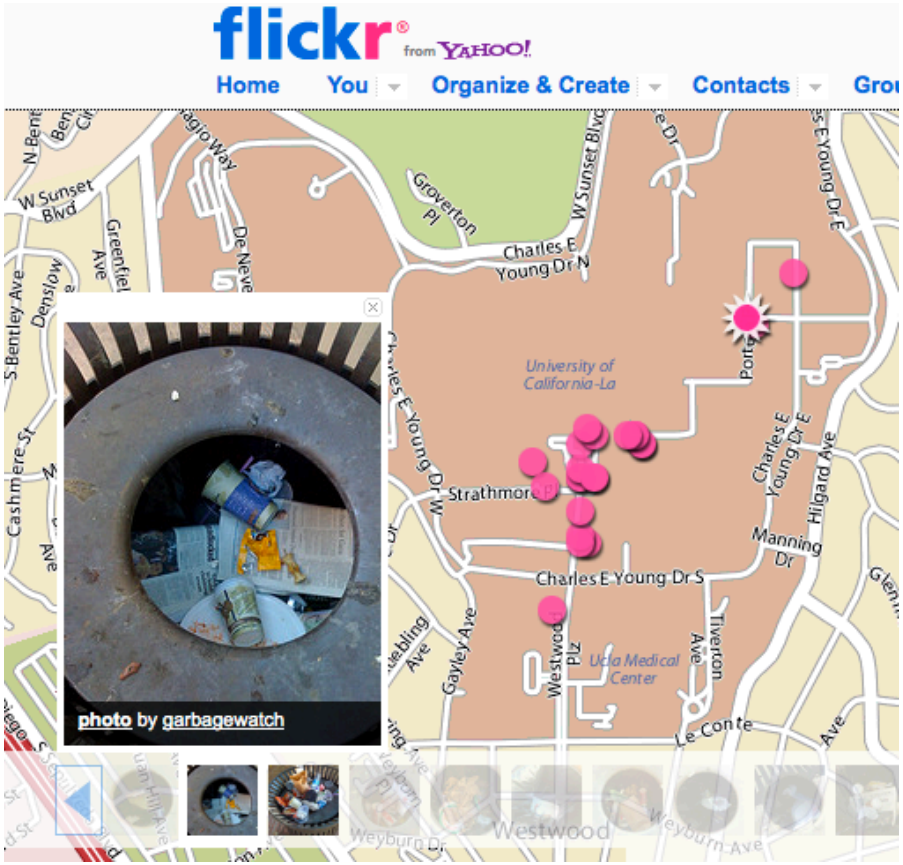
Fig. 2 Snapshots from the Snout performance.

Deborah Estrin (UCLA)

- Leads Center for Embedded Networked Sensing at UCLA
- Many participatory sensing applications over the years
- Created platforms for upload of mobile geotagged images for various community application

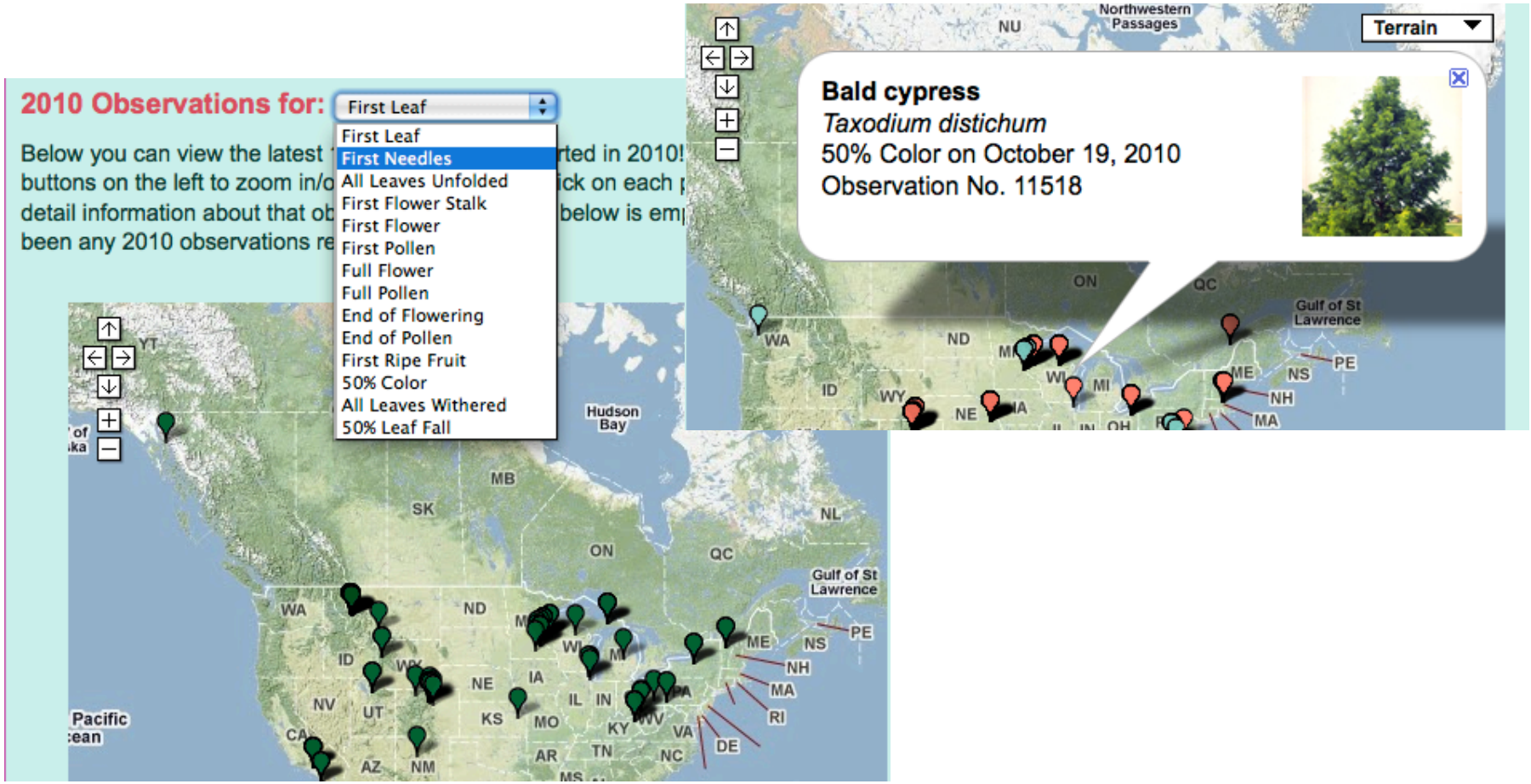
Garbage Watch (Estrin et al)

- Mobile upload of trash cans that are full
- Help to get them emptied
- Work with reduced staff cleaning cans
- Identify where recycling bins should be placed
- Most cleaning staff do not analyze garbage when emptying trash



Networked Naturalist (Estrin et al)

- Project Bud Burst (tracking flower bloomings)



What's Invasive (Estrin et al)

- Android app
- Log sightings of invasive plants of animals in your community

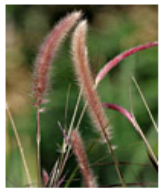
Use your **Android** mobile phone to help us locate invasive species!

To participate:
Step 1. Sign up.
Step 2. Download the app.
Step 3. Start collecting!

12 People Contributing **979** Invas

Top Invasive Plants!


Anise, Fennel


Fountain grass

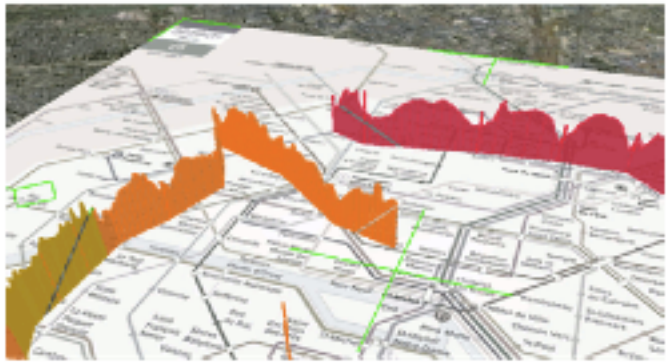

Giant Reed

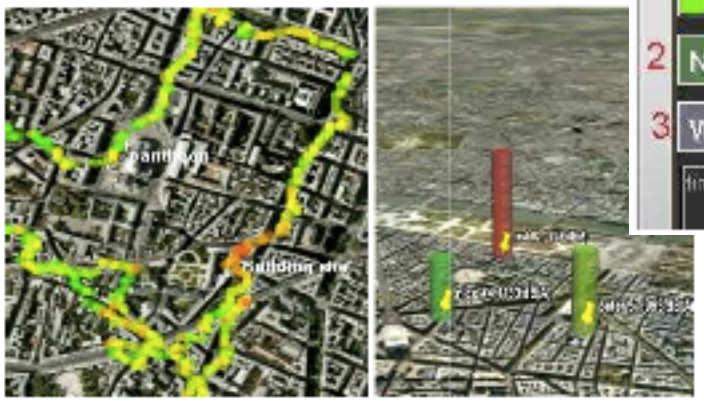

Terracina spurge - East


Terracina spurge - West

Noise Monitoring

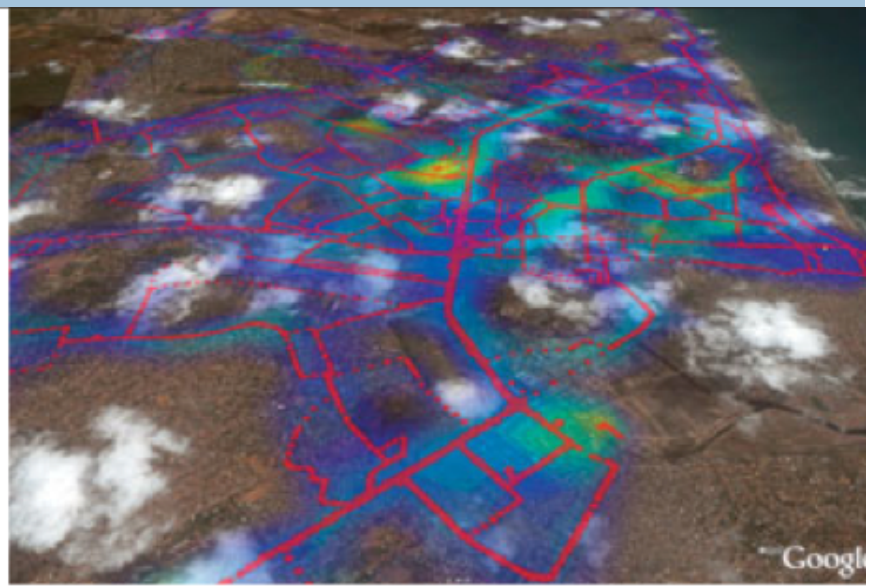
- Maisonneuve et al 2009 (Sony CS Lab)
- Phones record noise, location
- Reported to and aggregated on central server
- Visualizations of aggregate data





Pollution Sensing (Paulos et al)

- Accra Ghana – pollution sensing devices to cab drivers for two weeks
- Micro-climates, pockets of bad air
- Drivers exchanged information with each other, drove different routes, took cars in for emissions testing



A heat-map visualization of carbon monoxide readings across Accra, Ghana rendered atop Google Earth. Colors represent individual intensity reading of carbon monoxide during a single 24-hour period across the city. Red circles are locations where actual readings were taken.

Indoor Air Quality (Kim + Paulos 09)

- inAir system
- People became more aware of air quality
- Took steps to improve it:
  - Open window or turn on fan while cooking
- Issues understanding cause and effect

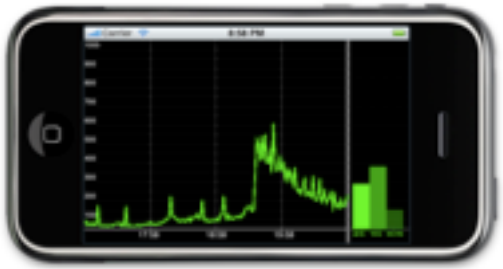
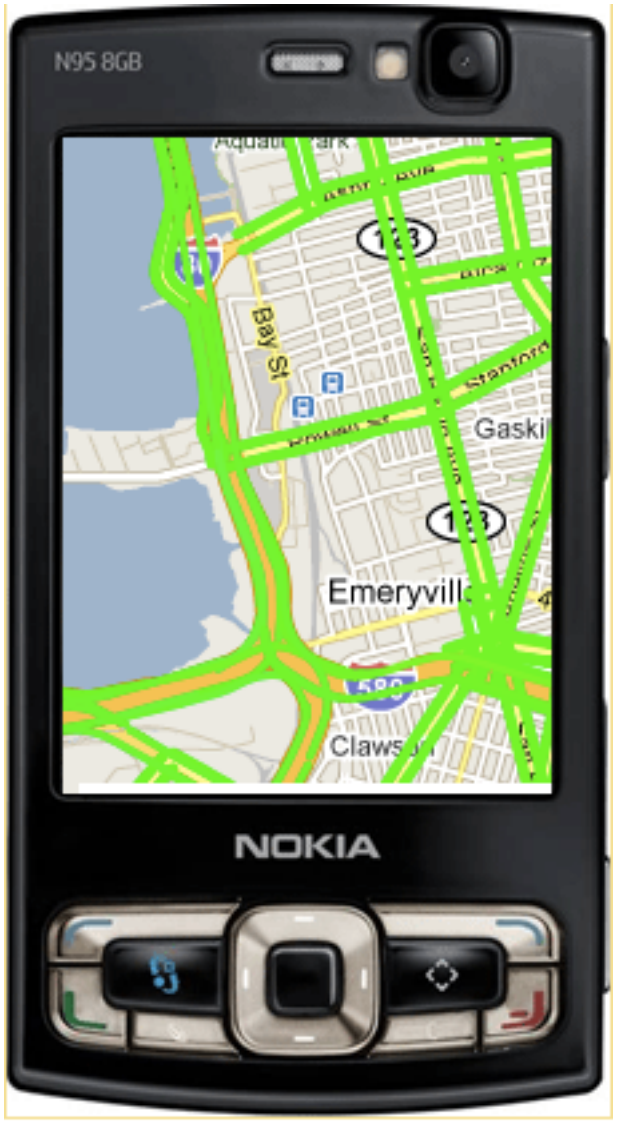


Figure 2. iPod Touch Screen

Figure 1. *inAir* located in a living room.

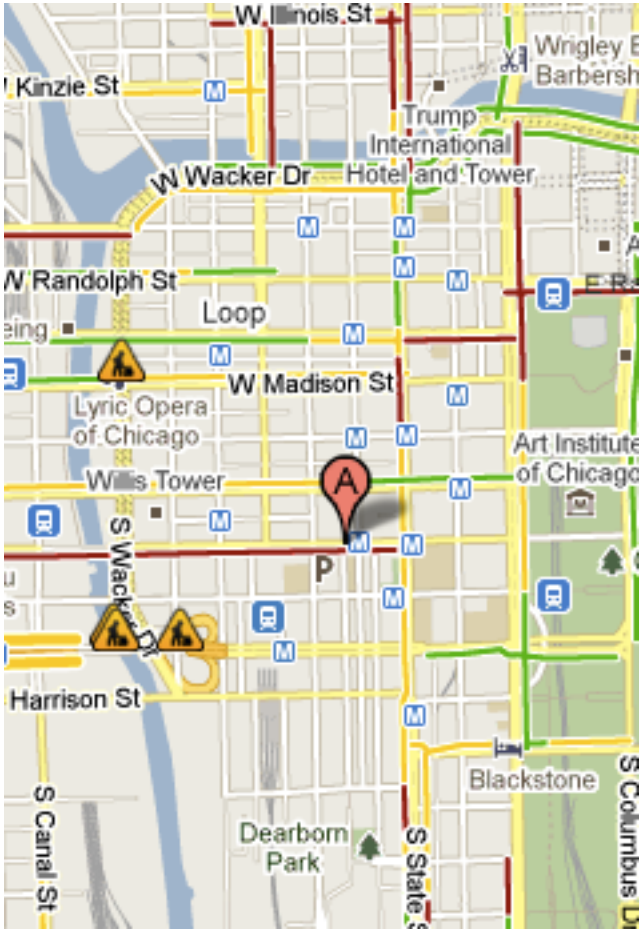
Traffic Monitoring

- Berkeley and Nokia (2008)
- Use GPS traces from mobile phones to infer traffic on Bay Area Roads
- EVERY taxi driver in SF
- Augmented with traffic loop sensors in roads, radar, etc.



Concept currently used by Google

- Areas with colors have had people using Google Maps with GPS on in the last few minutes
- Augmented with data from govt. sources



Pulse of the City (Froehlich et al)

- Barcelona bike stations

Figure 1. (a) A nearly full Bicing station; (b) A station kiosk; (c) A close-up of a locked bicycle; (d) A map of Barcelona showing the location of the 373 Bicing stations. The five highlighted stations are discussed below.

Measuring the Pulse of the City

- Patterns throughout the day…

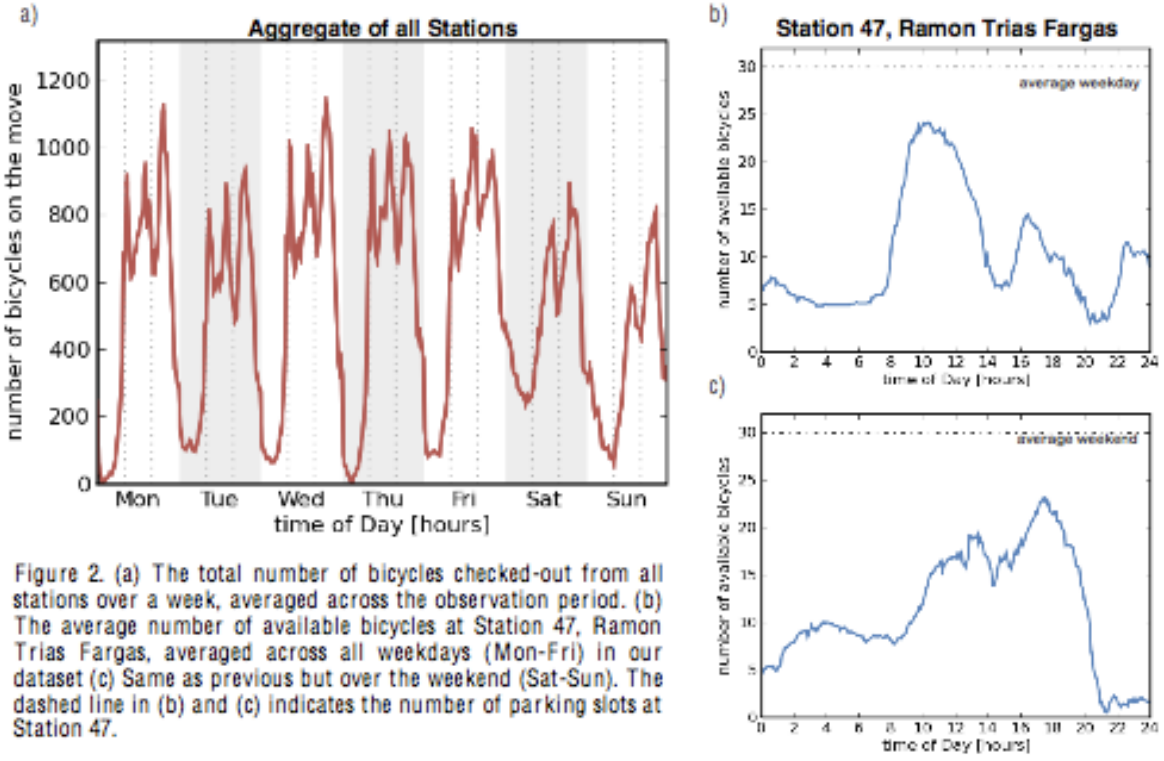


Figure 2. (a) The total number of bicycles checked-out from all stations over a week, averaged across the observation period. (b) The average number of available bicycles at Station 47, Ramon Trias Fargas, averaged across all weekdays (Mon-Fri) in our dataset (c) Same as previous but over the weekend (Sat-Sun). The dashed line in (b) and (c) indicates the number of parking slots at Station 47.

III. ANALYZING THE "PULSE OF THE CITY"

MIT – Inquiry with Imagery (1999)

- Seeing the city through different eyes … the past

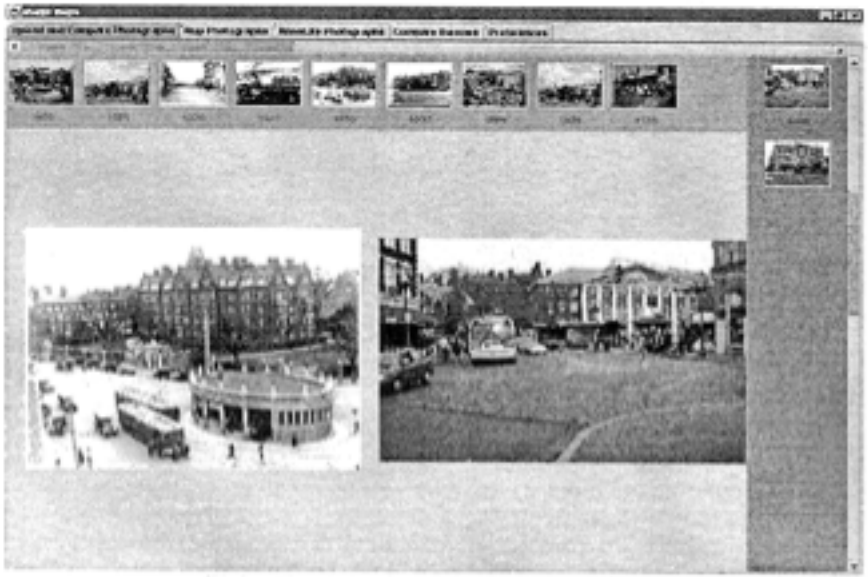
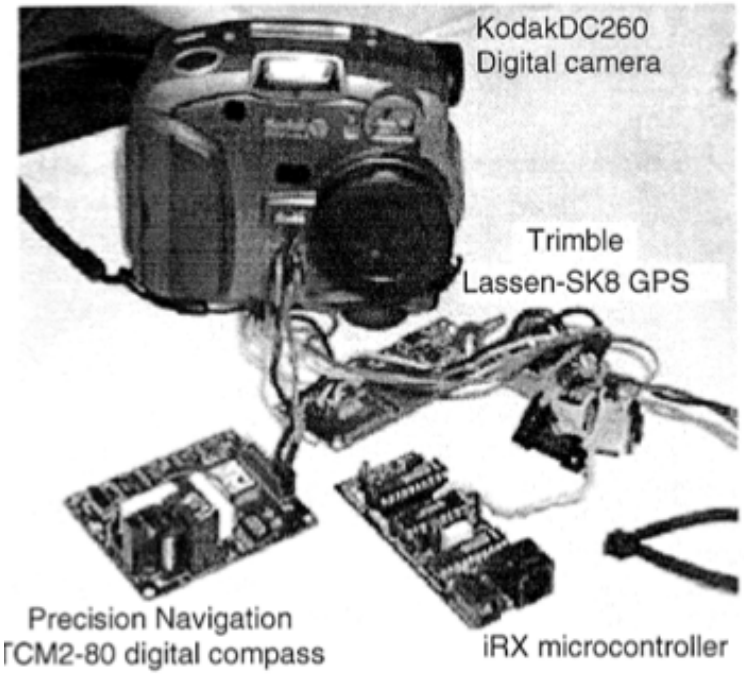


Figure 1: The current retrieval interface. Thumbnails on the right are images taken by students. Choosing one of these displays its larger image and an array of historical thumbnails across the top. The left image is the historical photo chosen from the retrieved collection.



Participatory Sensing - Issues

- How do you ensure data is valid?
  - Require multiple reports from different people
  - Assign trustworthiness to each participant based on past performance (trust data more over time when confirmed by others)
- Can everyday people (non-scientists) interpret data
  - Decision of moving to suburbs because of crime, but driving on the highway every day is more dangerous
- What if you get data but have no power to affect change? Miserable population?

Participatory Sensing - Issues

- How do you end your experiment?
  - People in the community might now rely on it
  - Keep datasets available?
  - Keep something simple running?
  - What if getting really popular, meeting demand?

Urban Games

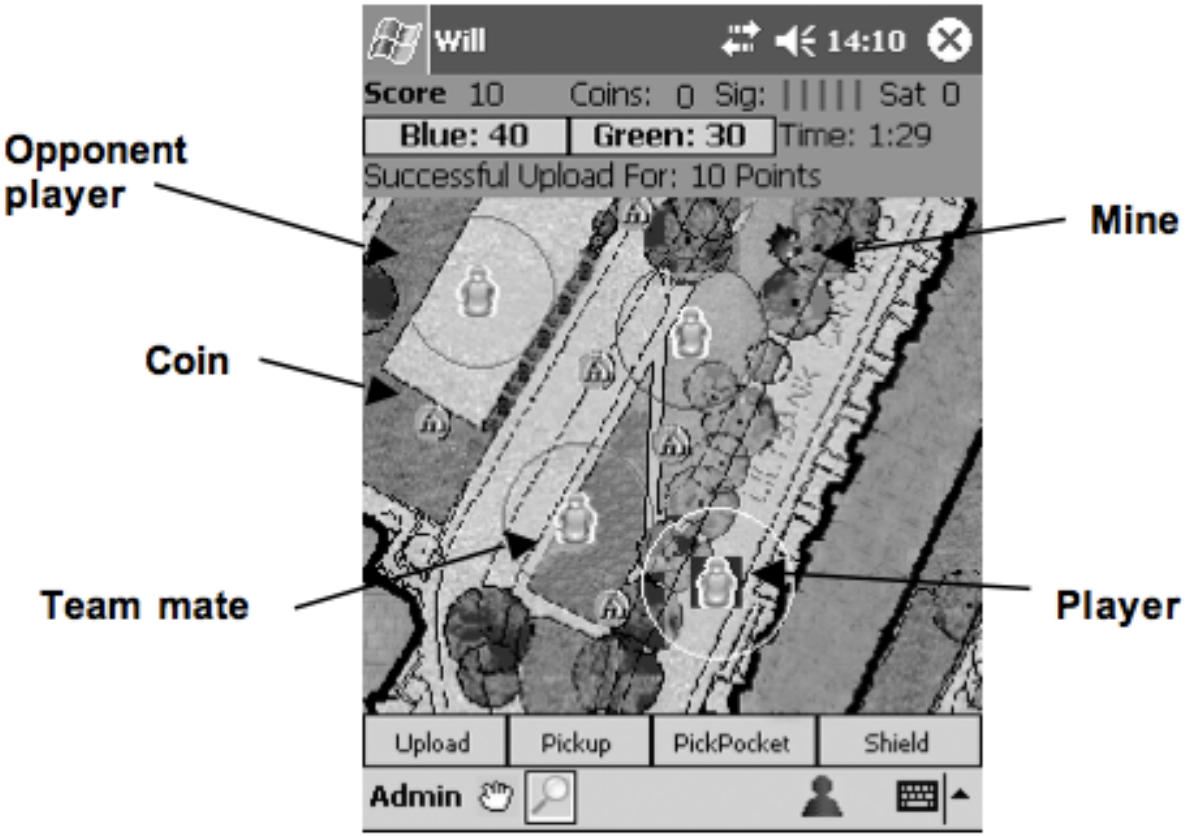
- Games that take place in the world
- Use mobile devices
- Take advantage of proximity to others or urban infrastructure
- Take place on “human scale”

Geocaching

- Year 2000 – selective availability turned off on GPS
- Now consumers could get accurate fix on a $100 device
- People would hide things in the world to be found by others. Coordinates posted online.
- 1.2 million caches around the world
- Video at: http://www.geocaching.com/

Picking Pockets on the Lawn (Glasgow)

- Takes place in a park setting
- Goal to collect (and steal) coins



Picking Pockets Side Effects

- Used GPS – could hide under a big tree to be "invisible" and thus not get your coins stolen
- Got people active in the city!

Disney's Kim Possible World Showcase

- Pick up phone from desk and pick a country for mission
- Phone guides you to country where you interact with environment in various ways
- Take pictures of objects to prove location
- Make gong ring, interact with objects

REXplorer

- Mobile game to discover history of a city
- Played in groups
- Phone interacts with city as you travel around
- Users given quests as the travel around

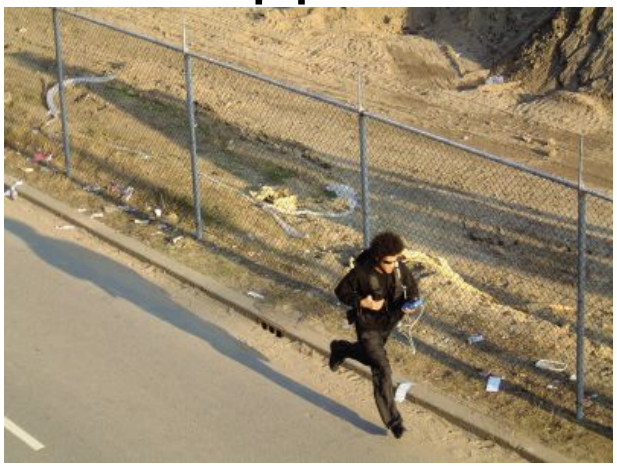
- Video: http://www.youtube.com/watch?v=Mf7m97tF3Ls

Meet Your Heartbeat Twin (XiLabs)

- Paris startup
- Participants wear heart rate monitors
- You are paired up with someone with same heartbeat in your city
- Need to keep heartbeats the same to stay matched and physically find each other

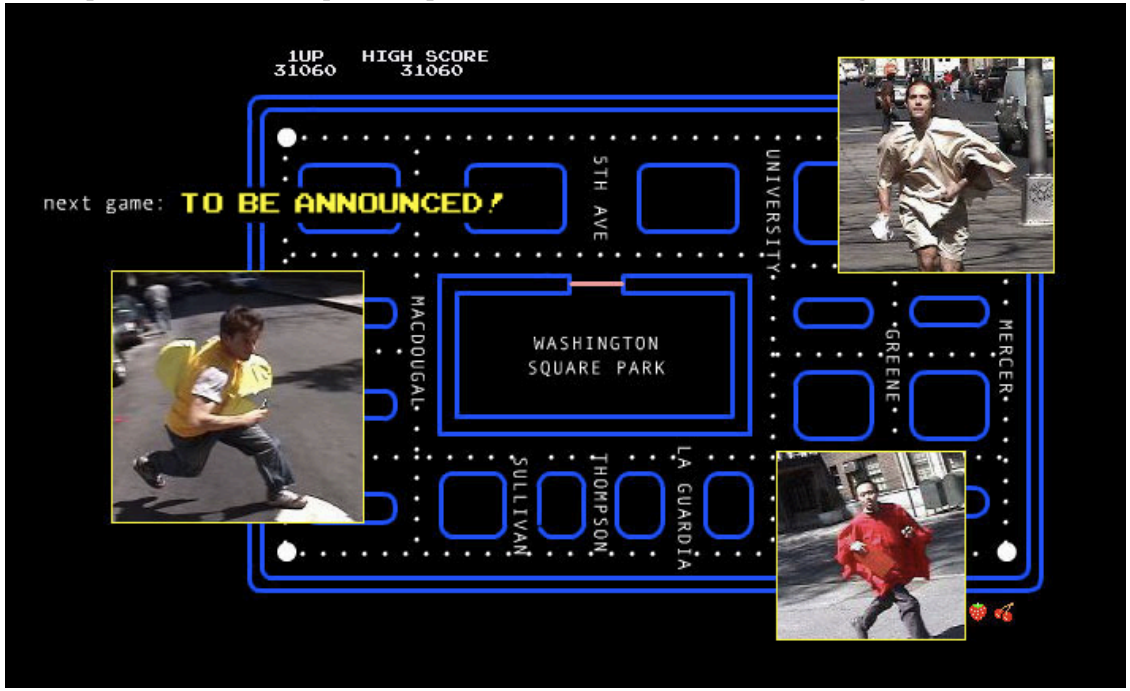
Can You See Me Now

- Blast Theory and Mixed Reality Lab (UK)
- Mobile + Online Game
- Being chased through the city by real and virtual people. Can hear their messages as you run.
- Creates real memories in particular parts of the city based on events that happened virtually



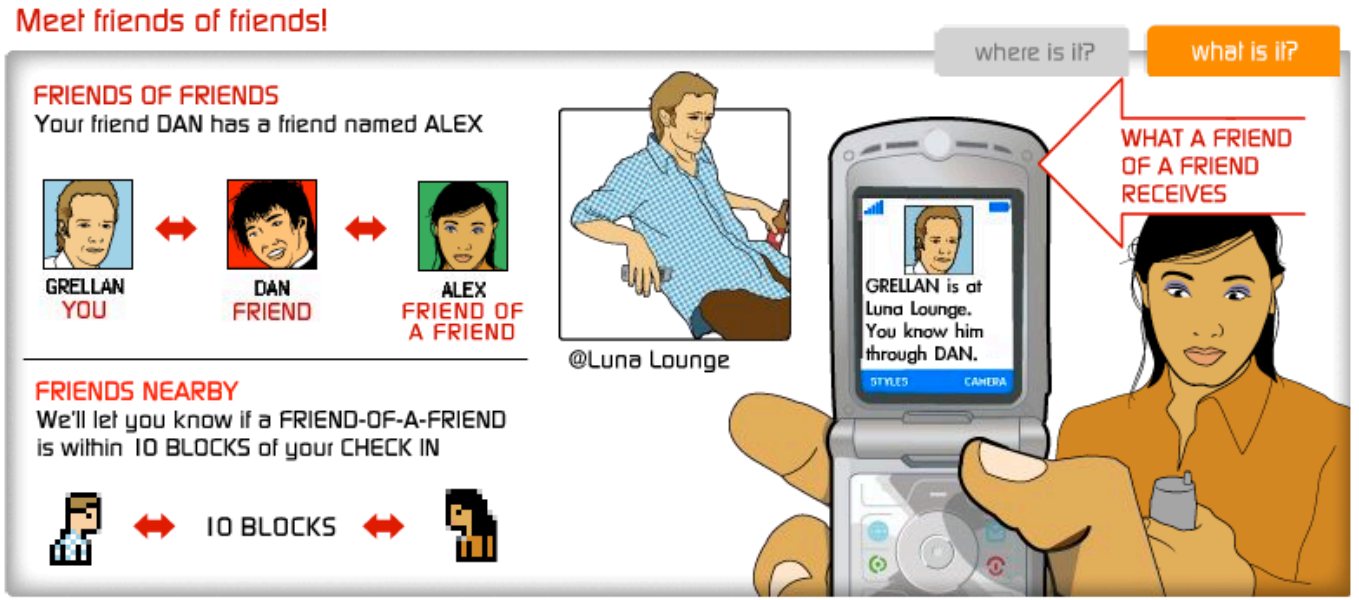
PacManhattan

- Game of physical pacman around Manhattan
- Run around, collect “dots” in augmented-reality system
- Chased by other players who are ghosts



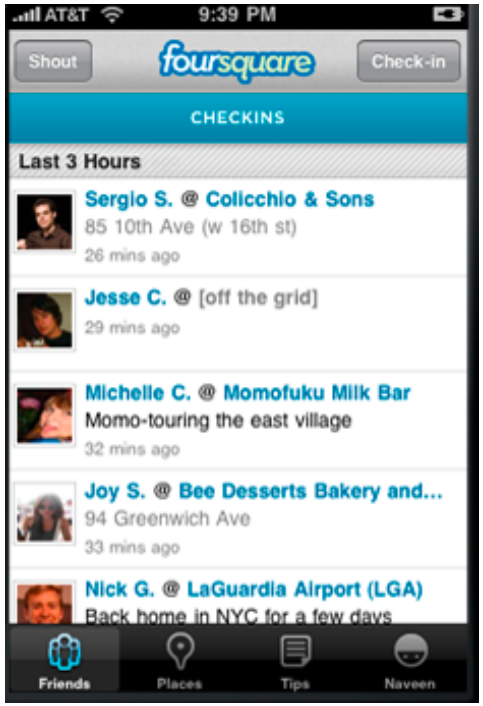
Dodgeball

- Precursor to Foursquare
- Bought by Google
- Check into places, have your friends see you there
- SMS/MMS based



Foursquare

- Urban: Going about city and checking into physical places
- Game: Earning points, competing with friends and strangers to be mayor



Physical Tagging

- Putting physical objects in the world that can be scanned by mobile phones
- Tags link to online content
- QR Codes:

QR Codes

- Started in 2004 in Japan
- Posted on movie posters, magazines
- Used for downloading apps to mobile phones
- Getting more information about bus stops, etc.

QR Code data capacity[1]	
Numeric only	Max. 7,089 characters
Alphanumeric	Max. 4,296 characters
Binary (8 bits)	Max. 2,953 bytes
Kanji/Kana	Max. 1,817 characters

Phi Square

- Physical tags for FourSquare
- Automatically check in if scanned from phone
- MIT Building 4:

- Video: http://phi2.mobilelifecentre.org/

Urban Computing

- Changing the way people engage with the city
- In your projects can users…
  - Provide data (e.g. train arrivals, popular places to eat lunch, etc.)
  - Interact with features of the city (music in particular locations, places to meet up with friends, etc.)
  - Engage with familiar strangers

In Sections

- Present your results from Usability Study
- Discuss design changes
- Discuss plan to have functional app by 4/8

- Don't forget Location/Networking assignment due next class (4/1)!