Location, Location, Location

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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.

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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?

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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**

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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

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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

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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)
```

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$GPGGA

Global Positioning System Fix Data

eg1. $GPGGA,170834,4124.8963,N,08151.6838,W,1,05,1.5,280.2,M,-34.0,M,,,*75

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

Courtesy of Brian McClure, N8PQI.

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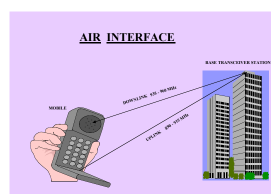
Global Positioning System Fix Data. Time, position and fix related data for a GPS receiver.

eg2. $GPGGA,hhmmss.ss,ddmm.mmm,a,dddmm.mmm,b,q,xx,p.p,a.b,M,c.d,M,x.x,nnnn

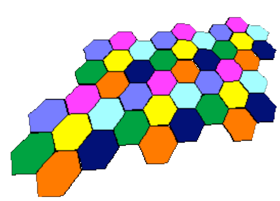
hhmmss.ss = UTC of position
ddmm.mmm = latitude of position
a = N or S, latitutde hemisphere
dddmm.mmm = longitude of position
b = E or W, longitude hemisphere
q = GPS Quality indicator (0=No fix, 1=Non-differential GPS fix, 2=Differential GPS fix, 6=Estimated fix)
xx = number of satellites in use
p.p = horizontal dilution of precision
a.b = Antenna altitude above mean-sea-level
M = units of antenna altitude, meters
c.d = Geoidal height
M = units of geoidal height, meters
x.x = Age of Differential GPS data (seconds since last valid RTCM transmission)
nnnn = Differential reference station ID, 0000 to 1023

Information gotten from:
http://home.pacific.net.au/~gnb/gps/nmea.html

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



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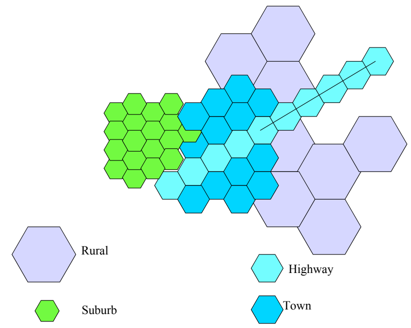
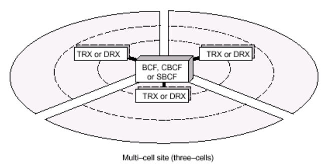
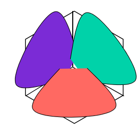
GSM Cellular Location

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



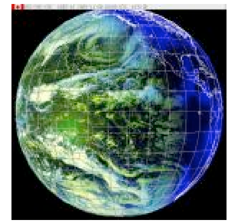


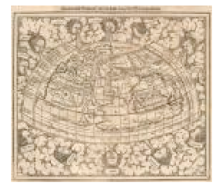


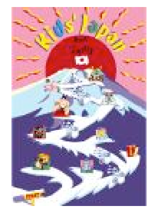
Enhanced Method

- **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

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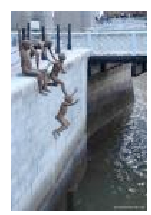
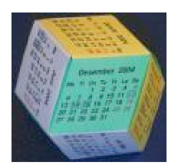
Other Data Formats



- **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



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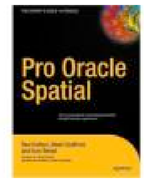
Spatial Databases



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

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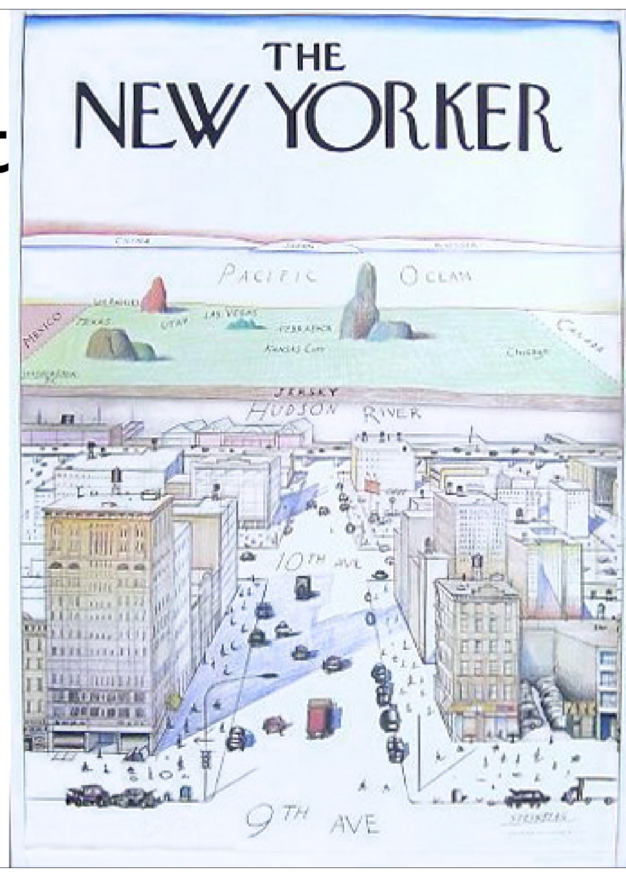
People don't speak GPS

- Different people have different views of the world.



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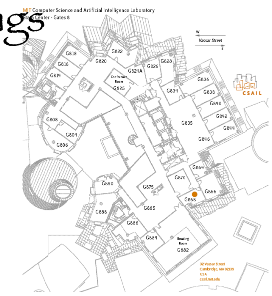
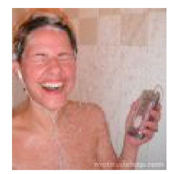
Places -- big and small

- **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

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

Table 1: Location-Based Services.

Service	Rated usefulness	Rated intrusiveness	Average # of daily use
Service A: Private ringing profiles	3.75	2.1	1.5
Service B: Public ringing profiles	2.6	2.2	0.4
Service C: Lunch service	2.2	3.7	0.3
Service D: Localization of predefined friends	3.75	3.25	1.3

1= not useful at all, 5 = very useful

1= not intrusive, 5 = very intrusive

Table 2: Average rating of the services.

Table 1. The three levels of services presented to participants.

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

Does Age Matter?

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

Table 2. General participant demographics.

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

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.