

Location, Location, Location

Lecture 7
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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.



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?



At first, cell phones is all about making sure that the phone can send and receive phone calls. A phone number is all that is needed to identify the phone. There is a huge infrastructure required to support all of this, from towers, to protocols, databases, and intelligent phones. This is mostly independent of the land-lines for telephone communication. There are gateways, but the two are mostly separate. For example, one cannot get an SMS message on a landline phone.

The is also a huge infrastructure. The mobility aspect, however, fits in smoothly. A base station looks mostly like an ethernet.

The middle ground would be only having one friend connect to base station and others connect via local communication (e.g. bluetooth). The middleground can be adapted to mobile phones and it is instructive to think about how this can be done. For example a group of friends can travel together. one phone is the master, but the master can rotate like the lead rider in a bicycle race. As the master takes over, it registers with an stationary

How can you be found?

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



There is a connection between the network knowing where is the phone and the phone knowing where it is. The connection might be tenuous but in thinking this way, the tradeoffs become clearer.

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



What are the ways of a device knowing where it is. GPS is a crazy invention. It works but I am fascinated by the type of person who thought of it. There is a similarity in placing satellites in the sky and cell towers on the ground. Remember paging? That is done via satellites and it is a broadcast mechanism. I believe it is an interesting way to get phones to wakeup and connect to the network.

It is instructive to appreciate the power of thinking big. The internet actually started out small -- just a couple of places interconnected and it then grew. But at the start it was still useful. Cell towers are not useful unless one starts with reasonable coverage of a reasonable number of cities. One tower is not very useful.

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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Now we can get back to the traditional lecture on GPS. The idea of putting up satellites so that every location on earth is covered is another example of thinking big. In my mind, it was even more fantastic than cell towers. One cannot do GPS with just two satellites and then add more. They all have to work (or at least most) and it is very expensive when one does not work.

So we can represent any location on earth by longitude, latitude and altitude. But for cars, bicycles, walkers, and other non-flying things, altitude is not that important (maybe for hikers). So really, only two pieces of info needed (and can lookup the altitude given position). In a city, where visibility of satellites is difficult, when one is traveling along the streets, ones position is even more constrained.

GPS info, in and of itself is not so useful. Need a map to do something useful with it. But that is an interesting question -- without a map, can gps info give you something interesting? Can give relative positions of a group.

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



The distinction between military and civilian needs is often obliterated by price. GPS units dropped dramatically when they became useful for consumers. When devices are built for the military, they are expensive. When they hit the consumer market, the price drops dramatically. That in turn, opens up whole new opportunities, as we shall see. Geo-tagging is just one example of low-cost GPS. We should all be happy that the ‘security’ features were turned off in 2000, by Clinton, and so now we can enjoy better precision. Even without that, it would only have taken a few years to get the precision, anyway, by augmenting the signal with ground stations.

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



The slides provided by the government are not complicated but they have nicer graphics.