UbiComp Location
L5

By: Dr. Abdussalam Nuri Baryun
ITMC421
Mobile Computing Dept.
University of Tripoli

Required by student

- As required with previous lecture:
  - Please read chapter of Location within the course textbook [1].
  - UbiComp applications needs location awareness because mobility services is important requirement for UbiComp systems.

Characterizing Location Technologies

- Location is a position in a physical space and it can be represented in absolute, relative, or symbolic form. The most common means of specifying a precise absolute location is using the points' degrees of latitude and longitude on the surface of the Earth, as defined by the geographic coordinate system.

Decimal coordinates

- The latitude and longitude are a decimal number, with the following characteristics:
  - latitude between 0° and 90°: Northern hemisphere,
  - latitude between 0° and -90°: Southern hemisphere,
  - longitude between 0° and 180°: East of the Greenwich meridian,
  - longitude between 0° and -180°: West of the Greenwich meridian,

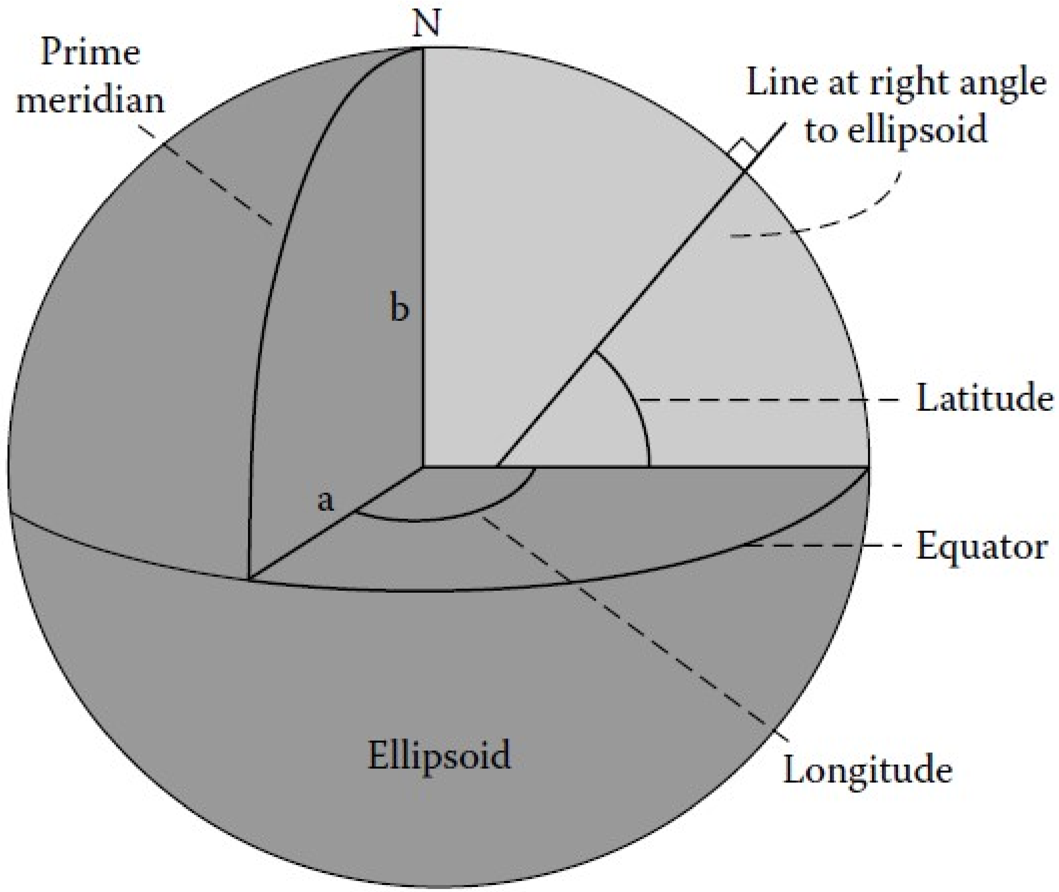


FIGURE 7.1 An example of a latitude and longitude angles to a point on Earth. (Accessed from http://home.online.no/~sigurdhu/artimages/Lat-Long.gif)

Three components coordinates

- Using: degrees, minutes and seconds. Each of these components is usually an integer, but the seconds can be a decimal number in case of need of a greater precision.
- One angle degree includes 60 angle minutes and one angule minute consists of 60 angle seconds of arc.
- Unlike decimal coordinates this coordinates can not be negative.

Location manager

developers

Constants	
`int`	**FORMAT_DEGREES** Constant used to specify formatting of a latitude or longitude in the form " [+-]DDD.DDDDD where D indicates degrees.
`int`	**FORMAT_MINUTES** Constant used to specify formatting of a latitude or longitude in the form " [+-]DDD:MM.MMMMM" where D indicates degrees and M indicates minutes of arc (1 minute = 1/60th of a degree).
`int`	**FORMAT_SECONDS** Constant used to specify formatting of a latitude or longitude in the form "DDD:MM:SS.SSSSS" where D indicates degrees, M indicates minutes of arc, and S indicates seconds of arc (1 minute = 1/60th of a degree, 1 second = 1/3600th of a degree).

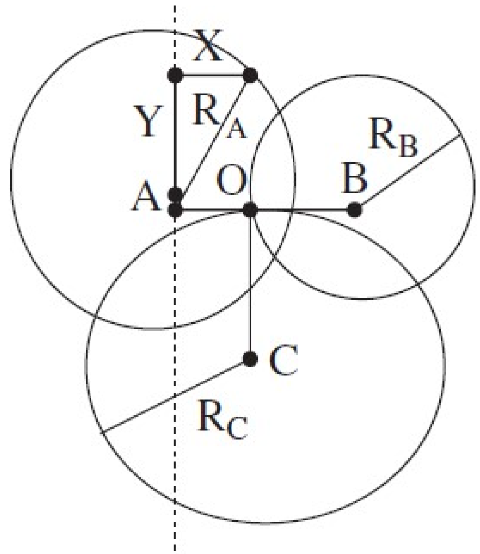
Approaches to Determining Location

- Proximity
- Trilateration
- Hyperbolic Lateration
- Triangulation
- Fingerprinting
- Dead Reckoning

Read these techniques from textbook p290.

- Using lateration to determine the location of point **O** with respect to three reference points A, B and C (left figure below). Using angulation to determine the location of point **O** with respect to two angles for the line of sight from two points A and B and knowing the distance between A and B.
- Trilateration uses absolute measurements of time of arrival from three or more sites.

Lateration and Angulation

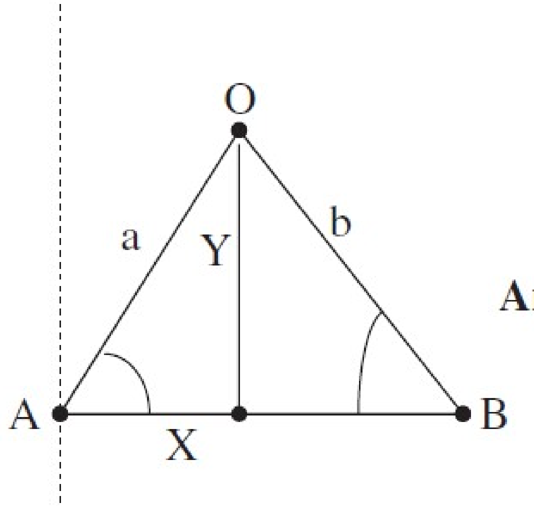


Lateration

3 Equations to determine location of point O w r.t. known locations A,B, and C on a 2D plane

$R_A{}^2 = X^2 + Y^2$
$R_B{}^2 = (X - (AO + OB))^2 + Y^2$
$R_C{}^2 = (X - AO)^2 + (Y - OC)^2$
Use substitution to get X and Y

$X = (R_A{}^2 - R_B{}^2 + (AO + OB)^2)/2\ (AO + OB)$
$Y = (R_A{}^2 - R_C{}^2 + AO^2 + OC^2)/2OC) - AOX/OC$



Angulation

If distance AB, angles at A and B are known then X and Y can be determined using basic trigonometry

$\text{Sin } A = Y/a$
$\text{Sin } B = Y/b$
$Y = a * \text{Sin } A = b * \text{Sin } B$
$\text{Cos } A = X/a$
$X = a * \text{Cos } A = AB - b * \text{Cos } B$

Indoor Location determined by RSSI

- Received Signal Strength Indication (RSSI)

Distance **(m)** = 10 ^ ((Measured Power – RSSI)/(10 * N))

Measured Power **(dBm)** is also known as the 1 Meter RSSI.

N (Constant depends on the Environmental factor. Range 2-4)

Estimate Direction with Location

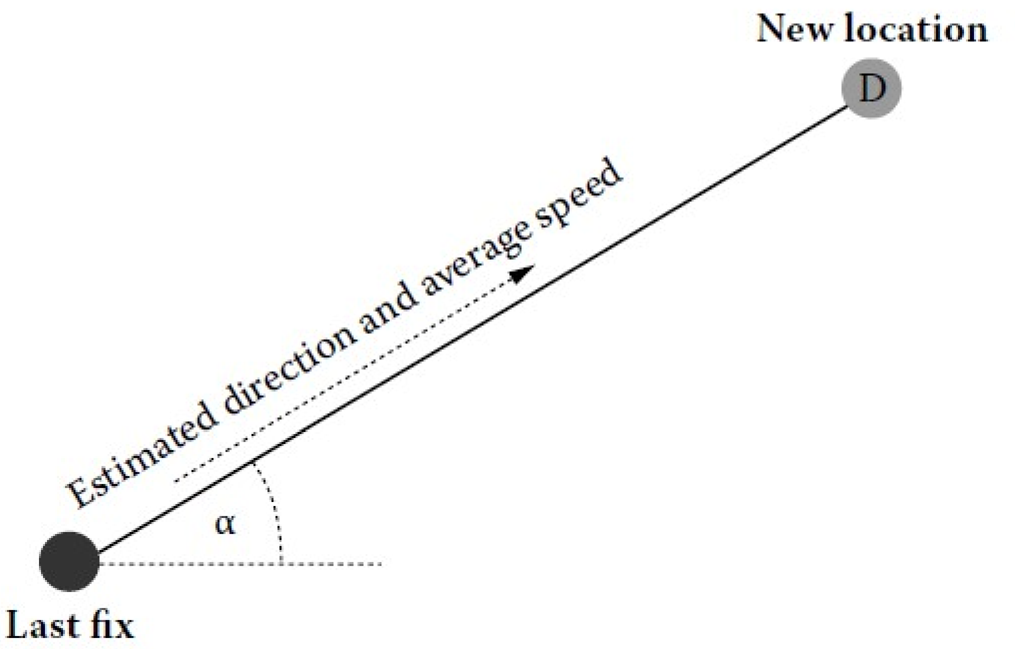
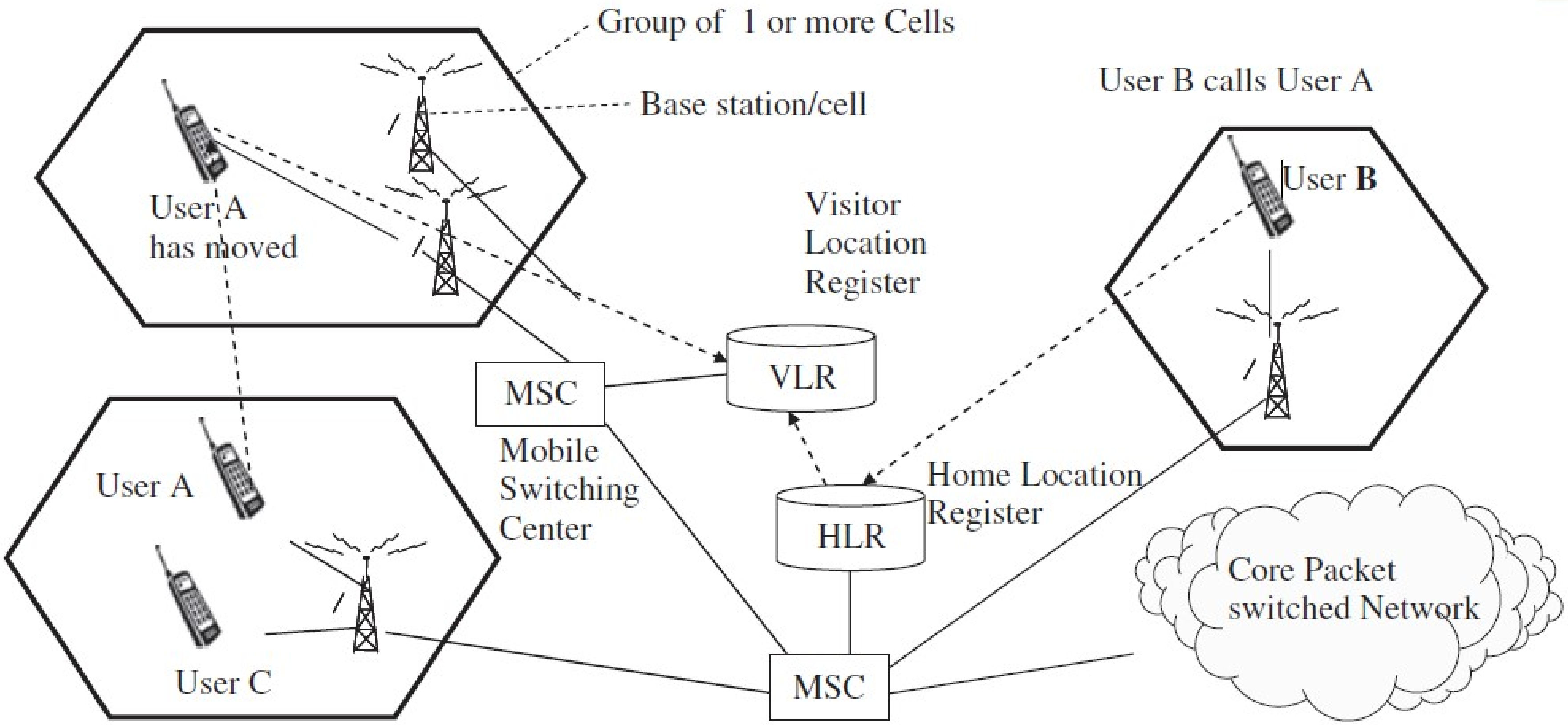


FIGURE 7.5 An example of dead reckoning in 2-D. The black dot represents the position of the last fix. The gray dot represents the estimated location of the device.

Location Determination in Cellular Mobile Network



Location determination in mobile networks

- Mobile phone users tend to be registered in a Home Location Register (HLR) database by a Mobile Switching Centre (MSC) that is maintained by a mobile network operator.
- A Visitor Location Register (VLR) database in a MSC is also maintained for a cluster of mobile phone cells within a location area

- When users pass between areas, a cell notifies its VLR that the user is entering or leaving its location area.
- When a call is made by user B to user A, the call first queries the VLR of user B to see if it knows the location of user A.
  - If it is not there, a call is made to the user A's HLR as each VLR that A visits will notify A's HLR. A's HLR will then notify B's VLR which VLR A is in.
- A type of query called paging can be used to locate the particular cell user A is in

Time Of Arrival

- TOA system is a satellite based Global Positioning System (GPS). TOA measures the time the signal is sent versus the time it is received. The distance d between the sender and receiver can be estimated if the signal propagation is known

  (distance d = time * signal propagation speed).
- This assumes accurate clock synchronization and that the sender knows the time of transmission, but this may not be practical.
- Time Difference Of Arrival (TDOA) measurement at two or more receivers or sent from two or more senders can be used to provide improved estimates of the difference in distances between the senders and receivers.

Spatial Aware System

- Spatial Aware Systems (SAS) are commonly referred to as Location Aware Systems (LAS).
- The term spatial aware is a more accurate term as this type of system is often not just aware of locations but needs to be aware of spatial features that can range from simple point location features, through to two dimensional polygon type areas.
- Also to more complex irregular three dimensional spaces that vary with time and their spatial relations.

Error Reporting

- Unfortunately, in practice, location systems often produce inaccurate estimates due to a variety of reasons.
  - *Incorrect reference point coordinates*
  - *Clock synchronization*
  - *Multipath*
  - *Geometry*

Three different improved position determination methods based upon:

- Enhanced observed time difference of arrival (TDOA) between the handset and multiple base stations.
- GPS (support in handsets, for outdoor use) and
- Hybrid techniques

Location Systems and Applications

- Global Positioning System
- Active Badge
- Active Bat
- Cricket
- UbiSense
- RADAR

- Some of these techniques assume a presence of one or more reference points, whose precise location is known in advance (example: GPS satellite, a WiFi access point (AP), or a cellular tower.)

References

[1] John Krumm, Ubiquotous Computing Fundamentals, 2010.