DES535
Ubiquitous Computing

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Google Classroom Code : pcwnf5t

Location Sensing

Module IV (Part I)

References:
https://homes.cs.washington.edu/~shwetak/classes/cse590p/notes/location_preview_draft.pdf
https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=3a7cb58dec6c39d31db6c36aec6091e3149baaf6
https://graphics.stanford.edu/courses/cs428-03-spring/Papers/readings/Location/gaetano_ieee_computer01.pdf

Location Sensing : Systems

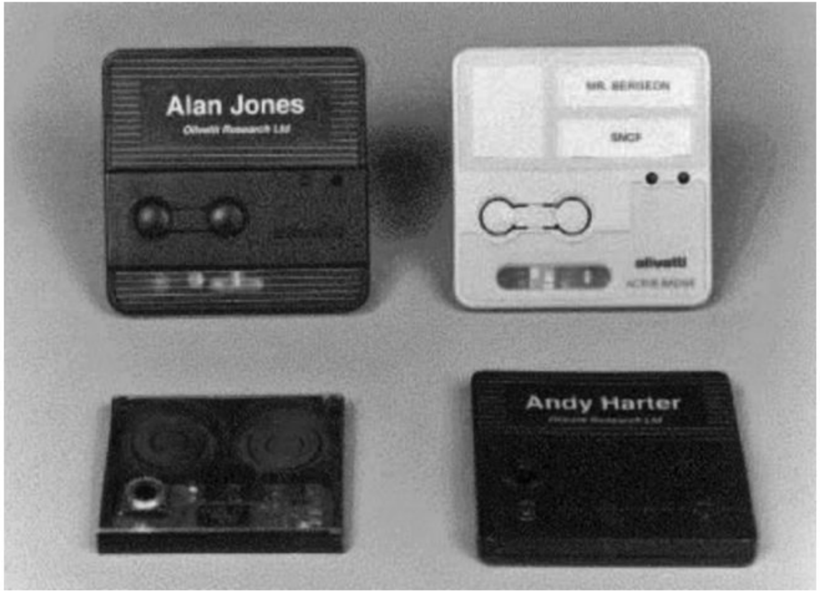
- **Global Positioning System (GPS)**
  - GPS consists of receivers that passively receive signals being transmitted from a subset of at least 24 geosynchronous satellites orbiting the earth (8 additional satellites are emergency satellites).
  - Each GPS satellite transmits data that contains its location and the current time.
  - Although the signals transmitted by the satellites are synchronized, they arrive at the receiver at different times due to the difference in distance between the satellites and the receiver. Thus, the distance to the GPS satellites can be determined by estimating the amount of time it takes for their signals to reach the receiver.
  - These GPS satellites transmit data over various radio frequencies, designated as L1, L2, etc. Civilian GPS uses the L1 frequency of 1575.42 MHz in the ultrahigh frequency band.

Location Sensing : Systems

- **Global Positioning System (GPS)**
  - This signal consists of three different pieces of information—a pseudorandom ID code, ephemeris data, and almanac data.
    - The pseudorandom code is a simple ID code that identifies which satellite is transmitting information.
    - The ephemeris data indicates to the GPS receiver where each GPS satellite should be located (orbital data) at a given time in the day.
    - Finally, the almanac data contains information about the status of the satellite (healthy or unhealthy), current date, and time.
  - To determine its location, the receiver applies hyperbolic lateration in 3-D using the estimated Time Difference Of Arrival values.
  - How many satellites are required to identify a device's location in earth?

Location Sensing : Systems

- **Active Badge**
  - The Active Badge (Want et al., 1992) was first introduced by the Olivetti Research Laboratory in Cambridge and was one of the first indoor location tracking systems developed.
  - The Active Badge is designed to be worn by visitors and employees of an organization to allow a central database to keep track of their location within the building.



Location Sensing : Systems

- **Active Badge**
  - The badge transmits a unique code via a pulse-width modulated IR signal to networked sensors/receivers deployed throughout a building.
  - The badge periodically beacons the unique code (approximately every 10–15 s), and the information regarding which sensors detected this signal is stored in a central database. The IR-based solution is designed to operate up to 6 m away from a sensor.
  - The IR signal is strong enough to be reflected off walls and ceiling, so that sensors can detect these signals in a small room without line-of-sight operation.
  - Since the IR signal does not travel through wall, the sensors are deployed throughout the space.
  - The Active Badge system uses a lookup table in the central server for determining the location of the badge, based on which sensors are detecting the badge.

Location Sensing : Systems

- **Active Bat**
    - Active Bat (Ward et al., 1997) is an ultrasonic-based location tracking systems consisting of ultrasound receivers dispersed in a space and location tags that emit ultrasonic pulses.
    - Active Bat tags emit short pulses of ultrasound and are detected by receivers mounted at known points on the ceiling, which measure the time-of-flight of each pulse. Using the speed of sound, the distance from the tag to each receiver is calculated.
    - In response to a request the controller sends via short-range radio, a Bat emits an ultrasonic pulse to a grid of ceiling-mounted receivers. At the same time the controller sends the radio frequency request packet, it also sends a synchronized reset signal to the ceiling sensors using a wired serial network.
    - Each ceiling sensor measures the time interval from reset to ultrasonic pulse arrival and computes its distance from the Bat.
    - The local controller then forwards the distance measurements to a central controller, which performs the lateration computation.
    - What are the disadvantages?

Location Sensing : Systems

- **Cricket**
  - Each Cricket tag is a small platform incorporating an RF transceiver, a microcontroller, and hardware receiving ultrasonic signals.
  - Cricket beacons are affixed to known locations and are typically attached to the ceilings or walls of a building.
  - Each beacon periodically transmits a wireless RF message while at the same time sending a short ultrasonic pulse that allows the receiver tag to measure the distance from the beacon using the time-of-flight of the ultrasonic signal.
  - The tag determines the time-of-flight of the acoustical signal and computes the position of the tags relative to the nearby beacons using trilateration.
  - Each tag then uses these distance measures and the beacon position information contained in the RF messages to compute their location relative to the space.

Graded Activity

- **Create an app with MIT App inventor that simulates the process of trilateration graphically. (5 marks)**
  - Create 4 fixed reference points (predefined).
  - Create a device point by touching a location on screen.
  - The distance of this point from all reference points should be shown by lines, along with distance measures.
  - The point of intersection of the circles must be shown.
- **Modify this app and make the device point move automatically based on the change in your device's latitude and longitude. (5 marks)**
  - Repeat the visualization automatically.