Context Aware Indoor & Outdoor Location Sensing

Hagop Araklian

Bonn, July 13th, 2007

The main parts of this talk:

1- Techniques used in location sensing

2- Properties of location sensing

3- location awareness systems

1- Techniques used in location sensing

1.1.1 Triangulation (Lateration / Angulation)

Lateration: measuring distance

- Direct: realizing physical movement, Robot hard estimating coordination.

- TOF: Velocity, Movement

fix object, difference between transmission & arrival time of emitted signal.

GPS, hard measuring time of space to the object; use local time

- Attenuation: signal becomes weaker, measure attenuation. SpotOn

1.1.2 Angulation: measuring two angles.

Cisco's VOR system

1.2 Proximity

- Detecting physical contact

  e.g. pressure, touch sensors

- Monitoring wireless cellular access points

  e.g. mobile device in range of one or more AP

- Observing automatic ID systems

  e.g. Credit cards, land line telephone records

1.3 Scene analysis

- Uses analyzing method to estimate object
- Observing particular point
- Different in the scene is the movement
- + getting result without angels or distances
- - The observer need to have access

1.4 RFID

- Includes chips and antenna

	Active RFID	Passive RFID
Communication Range	Long range (100m or more)	Short or very short range (3m or less)
Multi-Tag Collection	• Collects 1000s of tags over a 7 acre region from a single reader • Collects 20 tags moving at more than 100 mph	• Collect's hundreds of tags within 3 meters from a single reader • Collects 20 tags moving at 3 mph^2 or slower.
Sensor Capability	Ability to continuously monitor and record sensor input; data/time stamp for sensor events	Ability to read and transfer sensor values only when tag is powered by reader; no date/time stamp
Data Storage	Large read/write data storage (128KB) with sophisticated data search and access capabilities available	Small read/write data storage (e.g. 128 bytes)

Table taken from: Active and Passive RFID: Two Distinct, But Complementary, Technologies for Real Time Supply Chain Visibility

Continue RFID

	Active RFID	Passive RFID
Tag Power Source	Internal to tag	Energy transferred from the reader via RF
Tag Battery	Yes	No
Availability of Tag Power	Continuous	Only within field of reader
Required Signal Strength from Reader to Tag	Low	High (must power the tag)
Available Signal Strength from Tag to Reader	High	Low

Table taken from: Active and Passive RFID: Two Distinct, But Complementary, Technologies for Real Time Supply Chain Visibility

1.5 Infrared (IR)

- Connect wirelessly between tags
- Antenna detect by receivers close tag
- Higher RF, shorter range, more waves propagate in a straight line

+ good accuracy

- can’t emit through walls
- Lower availability (pocket)

1.6 WLAN 802.11b

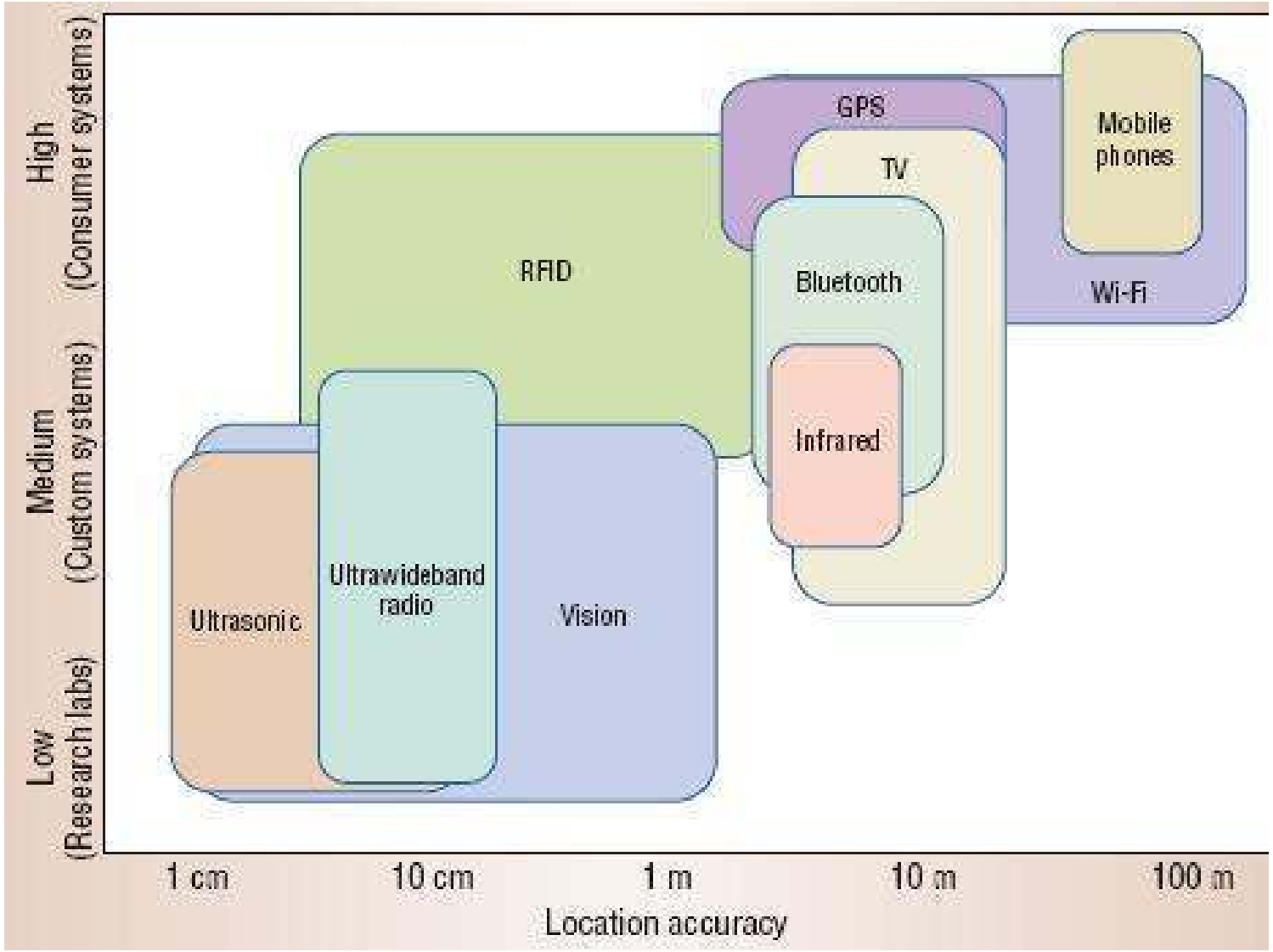
- Popular technology
- Easy, reliable using WLAN infrastructure
- Additionally using location server
- Bit rate 11Mbps, range 50-100m
- Accuracy 2m

- Power supplier after each short time period

1.7 Bluetooth

- New in the market of location sensors
- Bit rate 1Mbps
- Range short 10-15m

Details later on section 3



Graphic taken from Hazas, M., Scott, J., and Krumm, J. Location-aware computing

2- Properties of location sensing

2.1 Absolute & Relative:

- Uses coordinating system for locating
- 2 GPS receivers responds to the same position using Latitude, Longitude, Altitude

- Relative uses other object references
- Emergency call, two teams, two different positioning.

2.2 Accuracy & Precision requirements:

- Important concept of positioning
- Military & Civil applications

2.3 Scale:

- Evaluating the scale depends on the coverage area, number of objects, time.
- GPS serves huge number of receivers
- Some tags can't read more than one in the same area.

2.4 Cost & Limitation

- Time: install the process, administration needs
- Range of work

2.5 Recognition

- GUID, tag, label of an object
- External database (name, type, semantic info)
- GUID and contextual information e.g. museum retrieve of description in a specified language

3 Location awareness systems

- Indoor location systems:
  +Active Badge
  +Active Bat
  +Cricket
  +Radar
  +Bluetooth
- Outdoor location systems
  +GPS
  +GLONASS
  +Galileo

Active Badge

- Current version offers bidirectional communication, 48 bit address
- Badge transmits each ten seconds
- Control device collects information after each emitting from the sensors

- Telephone receptionist scenario, below 100% moving, not sighted 5 minutes last info, away means absence more than week.
- FIND, WITH, LOOK, HISTORY

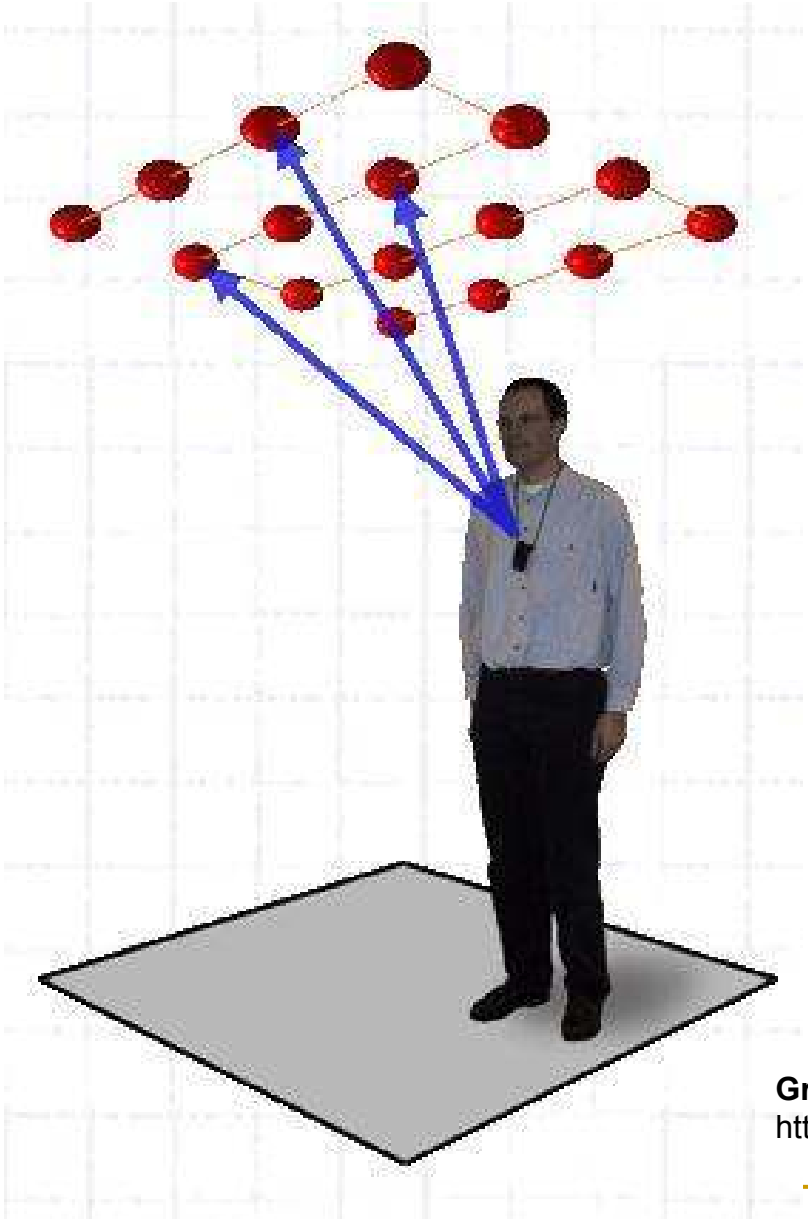
55*7mm package, weighted 40g

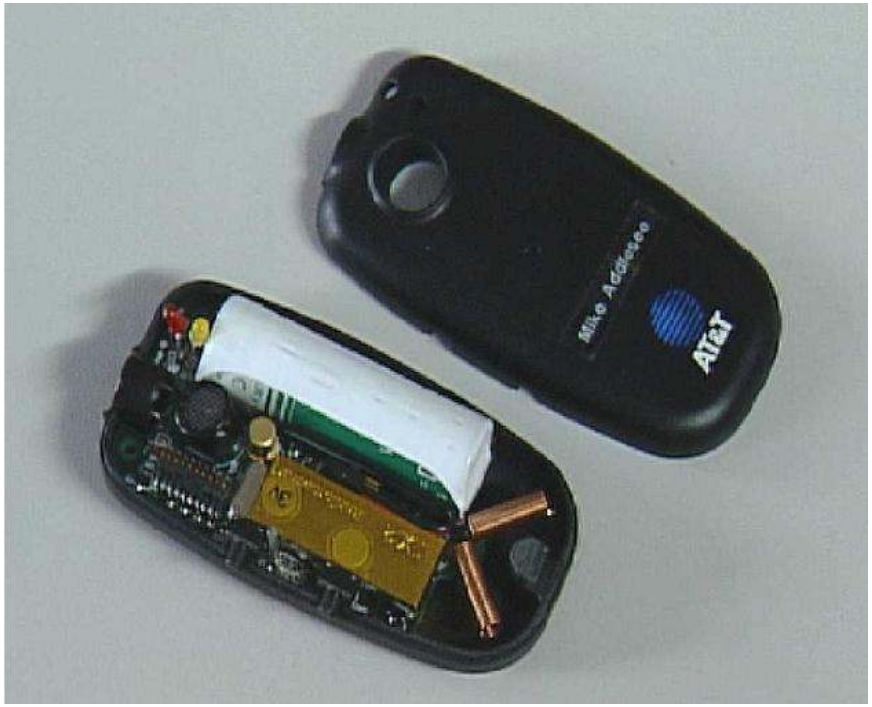
Graph taken from http://ei.cs.vt.edu/~wwwbtb/fall.96/Presentations/badges.gif

Active Bat

+ 3D Ultrasonic location system
+ Low power, wirelessly & inexpensive
+ Useful for limited range tracking

- Bat carried by users, receivers fixed on the ceiling, based on triangulation positioning
- Calculate the distance TOF, when the pulse is emitted, speed of sound is known





Active Bat has 95% accuracy of Triangulation within 3cm.

Graphs taken from
http://www.cl.cam.ac.uk/research/dtg/attarchive/bat/flatBatInside.jpg

Cricket

- Has both RF & Ultrasonic techniques
- Beacons listen and send signals, and find distance by measuring the time difference

  (ability of positioning without central server for query)

+ decentralizing decreases the cost of management.
+ increases the privacy of each user

Taken from http://cricket.csail.mit.edu/pictures/lab_view.jpg

Cricket V2:
Improved and simplified hardware component
Auto configuring (Beacon, Listener, or both)

Taken from http://cricket.csail.mit.edu

RADAR

- RF based system
- Uses signal strength from wireless equipment
- RF transceivers called the base station (connector between the wireless & wired networks)
- Generally laptops or computers with WLAN 802.11 ars used as base station
- Stable & continuously connected
- Location consist of multi floors
- Tracking might be hard, when the device is limited in power

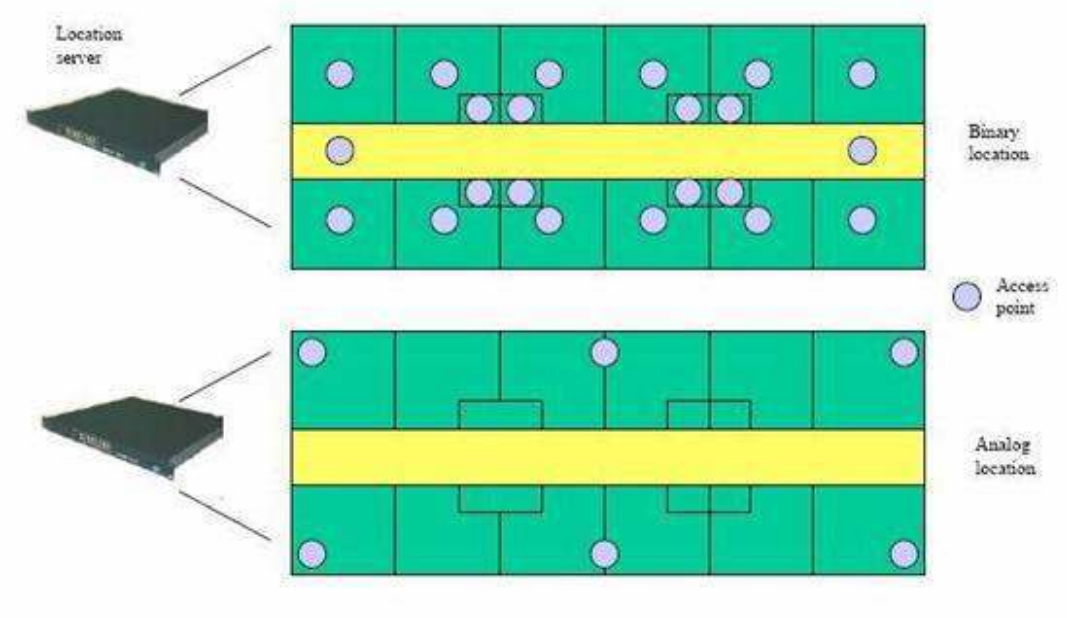
System	Bat	Active Badge	RADAR	*Cricket*
User privacy	No	No	Possible, with user computation	*Yes*
Decentralized	No	No	Centralized RF signal database	*Yes*
Heterogeneity of networks	Yes	Yes	No	*Yes*
Cost	High	High	No extra component cost, but only works with one network	*Low (U.S. $10) component cost*
Ease of deployment	Difficult; requires matrix of sensors	Difficult; requires matrix of sensors	RF mapping	*Easy*

Table taken from: Nissanka B. Priyantha, Anit Chakraborty, and Hari Balakrishnan. The Cricket Location Support System

Bluetooth

- Access point act as Master, connected with seven other devices called Slaves
- The group of 8 devices called piconet
- Divides the band into 79 channels & hops
- Can fit the radius up to 10m

+ low cost, low power query



Graph taken: http://www.cl.cam.ac.uk/research/dtg/attarchive/bat

*** Binary location: a room-oriented approach. An access point is installed in every room.**
***Analog location – an X-Y oriented approach, AP's are installed more sparsely (typically, 10-15 m apart).**

GPS

- United States Global Positioning System consists of 29 Satellites
- Every satellite has its own atomic clock for time measuring in an accurate way

Civil GPS receivers positioning

Accuracy of GPS system with SA activated	± 100 Meter
Typical accuracy with SA deactivated	± 15 Meter
Typical accuracy of differential GPS (DGPS)	± 3 - 5 Meter
Typical accuracy with WAAS/EGNOS	± 1 - 3 Meter

Table taken from: http://www.kowoma.de/en/gps/accuracy.htm

Selective availability (SA) deactivated on may 2, 2000

WAAS, wide area augmentation system has been opened since 99 in USA, and it's available as portable GPS since 2001

In Europe a similar technique used, it's called EGNOS (European Geostationary Navigation Overlay Service).

	Technique	Attributes	Accuracy (Precision)	Scale	Cost	Limitations
GPS	Radio time-of-flight lateration	Physical Absolute	1-5 m (95-99%)	24 satellites worldwide	Expensive infrastructure $100 receivers	Not indoors
Active Badges	Diffuse infrared cellular proximity	Symbolic Absolute Use exposes location	Room size	One base per room, badge per base per 10 sec	Administration costs, cheap tags and bases	Sunlight and fluorescent light interfere with infrared
Active Bats	Ultrasound time-of- flight lateration	Physical Absolute Use exposes location	9 cm (95%)	One base per 10 sq m, 25 computations per room per sec	Administration costs, cheap tags and sensors	Required ceiling sensor grid
Cricket	Proximity lateration	Symbolic Absolute/relative	4 x 4 ft regions (≈100%)	≈1 beacon per 16 sq ft	$10 beacons and receivers	No central management receiver computation
MSR RADAR	802.11 RF scene analysis and triangulation	Physical Absolute Use exposes location	3-4.3 m (50%)	Three bases per floor	802.11 network installation, ≈$100 wireless NICs	Wireless NICs required

Source: Adapted from Table 1 of Hightower and Borriello (2001)

GLONASS

- The former Soviet Union GLObal NAvigation Satellite System
- It's a radio based navigation system
- Now GLONASS use the third generation Uragan-K
- with a life time of 10-12 years
- will enter the Uragan-M next year.
- The availability of this satellite is 45% in Russia, 25% significant areas, and less than 30% for the whole earth
- But the problem is that among GLONASS 19 satellites only 12 are operating, the spacecraft life time of some are going to expire by the end of 2008. However this means GLONASS needs to launch 17 new satellites if the deadline kept 2009.

GALILEO

- The European Union positioning system. It would be operational on 2012, having 30 spacecrafts, with 12 years lifetime
- The number of countries wishing to participate actively in Galileo is growing. The European Commission is holding discussions with Ukraine, India, Brazil, South Korea, Mexico and Australia. Some countries like China, and Israel has also indicated its aim of investing soon in Galileo by joining the Galileo Joint Undertaking.
- problems needs to fix before the deadline. still the companies didn’t decide the way to go forward.
- Galileo will be free of charge, the security conditions are satisfactory

Conclusion

- Why do we need many systems ?
- Which system is better ?
- Systems improved everyday
- New techniques arrived
- Non-stop competition

Thank You !

Any questions …