Indoor & Outdoor location sensing

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This paper gives an overall description about indoor and outdoor location sensing. To get the complete idea and how those sensors work, first I present the types of techniques and methods which are used in both, indoor and outdoor localizations. Then, I take a look at the conditions and requirements for selecting a specific system in a given use case. Finally I make a comparison between the most important indoor location systems and take a look when and under what circumstances we may use each of them. For the outdoor location sensing there is an explanation of how to use GPS, which is still the only usable system, and how in the future the competition between GPS, Galileo and GLONASS will be run, and what are the main problems which they face.

1 Introduction

Location awareness is becoming the most important issue in many cases, such as when an urgent accident needs the nearest doctor in the hospital, or in the university the staff members want to check available members to a quick meeting, or even I when I need to know where am I now? And how could I find my way?

Those are some of essential and daily questions which need fast, reliable answers by keeping the privacy as a priority. For unlimited reasons localization is rapidly growing, the context awareness consist of six questions What, Who, Where, When, Why and How, and the location awareness tries to answer the two “where” and “who”. Location sensing is divided into indoor and outdoor awareness.

The indoor location technologies have a big competition by various companies, offering many types of indoor technologies. A central problem in location-aware computing is the determination of physical location. Researchers in academia and industry have created numerous location sensing systems that differ in respect to accuracy, coverage, frequency of location updates, and cost of installation and maintenance.

The indoor location systems are used in security issues, hospitals, airports, museums, universities, education centers …

Indoor location systems mainly contain a set of antennas with wireless tags. The antennas communicate wirelessly with tags, which are attached to humans, or to desired positions.

The techniques of communicating include RFID, IR, WLAN, and Bluetooth. To understand all those techniques, we need to know the basic concepts with the advantages and disadvantages of using each technique, and which system uses which technique.

The main uses of having global navigation satellites were for military issues, but beside that, nowadays there is a huge usability of navigators as outdoor sensors for civil issues too, and despite the new competition has already started among the Russian GLONASS, the European Galileo, and the USA's GPS, but outdoor location technologies rely on GPS technology especially in civil issues.

For outdoor location sensing, still GPS is the only worldwide operational system, and tries to stay number one. While others becoming operational, the GPS is up to date system, with each generation, they try to give more facilities and reliable.

This system uses either 2-D or 3-D triangulation for calculation the position and it's ready at any moment to do this by offering at least four satellites at each moment.

2 Methods and Techniques used in location sensing

2.1 Triangulation

This technique consists of two types: Lateration which use the distance measurement, and Angulations which use the Angel measurement.

2.1.1 Lateration

Lateration is measuring the distance between the object and some reference positions. This happens either by calculating in two dimensions distances measurements from three non-collinear points, or by calculating in three dimensions, distance measurements from four non-collinear points are required in this situation.

The lateration technique [1, 2, and 3] has three general measuring approaches:

2.1.1.1 Direct: This measurement uses the realizing of the physical movement, despite is simple in analyzing, but difficult to get it automatically, because of the hard estimating the coordination of the movement.

2.1.1.2 Time of Flight (TOF): This measurement uses the velocity and movement to measure the time between two points. As an example let say we have a car which is

moving with a known velocity, or other type of example is when we have a fix object and a signal from a point to the object, TOF here calculate the time of arriving the signal to the object.
We have to concern the round trip reaction of the signal in the measurement, in the car example to estimate an exact distance; we have to keep its time because the car is transmitting and receiving too.

Other real example is GPS receivers, while it's too hard to measure the time from the space to the object; it uses local time in transmitting where the GPS receivers estimates the TOF.

In section three we will have a look to the systems those use this technique Active Bat, Cricket (as indoor sensors) and GPS (outdoor sensor)

2.1.1.3 Attenuation: While the distance is between the source and destination, the signal becomes weaker; this causes attenuation to the signal.

This technique measures the attenuation of the signal when it arrive the destination.

As any technology like mobile, networking … the attenuation influenced by reaction, and refraction interferes. These reasons let attenuation not efficient as TOF in Lateration technique. This technique used by some systems those uses radio signal as SpotOn system [2].

2.1.2 Angulation

Angulation [3] measures two angles between the station and the receiver or the object where the signal has been emitted.

"An example is aircraft navigation VOR (VHF Omni-directional Ranging) have used AOA for quite some time." http://www.cisco.com/web/AT/assets/docs/tlatzer_Location_seclub_0606.pdf

2.2 Proximity

This technique uses three type of sensing proximity [1,2, and 3], and in general we can say that this technique determines the object is near to a known location, and it uses a physical phenomenon with limited range.

Here are the three types of this technique:

2. 2.1 Detecting physical contact

The most basic sort of proximity sensing, "includes pressure sensors, touch sensors, capacitive field detectors" [3]

2.2.2 Monitoring wireless cellular access points

Such as mobile wireless cellular like in Active Badge location system [1], using the Infrared cells in an indoor environment.

2.2.3 Observing Automatic ID systems

Such as credit card, computer login histories, land line telephone records …

2.3 Scene analysis

This technique [1, 2] uses the analyzing method to estimate the object, this done by observing a particular point to draw the details about the location of the objects in scene.
The difference in the scenes is the movement of the object. The advantage is getting the result using passive observation without corresponding to angels and distances,

“disadvantage of scene analysis is that the observer needs to have access to the features of the environment against which it will compare its observed scenes.” [3]

2.4 Wireless Technologies

These technologies are used by indoor location sensing systems.

2.4.1 RFID

RFID means Radio Frequency Identification [4], it’s a small device combines a chip and an antenna. To get the information which is included, we need to scan the chip.

How to use RFID: we need to install RFID tags in suitable positions, supply the location information to each tag, add RFID reader, and we need to have a required tag database.

2.4.1.1Passive RFID:

A passive RFID [4] tag uses four frequencies LF, HF, UHF, and Microwave with a short range of 1-2 meters; this is a disadvantage of using the passive RFID, and additionally being passive RFID tag readable after changing the place of the tag gives some negative points to this technique.

But on the other hand they are some positive point concerning the power, where tags works without carrying any batteries, and have lifetime of twenty years. And it’s inexpensive and small too.

2.4.1.2 Active RFID:

This technique [5] has some opposite properties by comparing to passive RFID, such as the range is longer, and has smaller antennas.

But it needs power supplier, where the lifetime is not long as much as the passive, and costs about 20$ (in 2006) [5]. (For more details check the comparison feature below between passive and active RFID).

	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 1: comparison between Active and passive RFID [29]

	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 2: shows the main distinction in functional capabilities between passive and active RFIDs [29]

2.4.2 Infrared (IR)

IR [1] used to connect wirelessly between tags by emitting light. Antennas detect by receivers close tags, and then it sends the information to location server. The higher the RF frequency, the shorter the range and the more waves tend to propagate in a straight-line pattern.

Despite IR is limited where it can't emit through walls, but it has good accuracy inside the block. This might count is as an advantage of this technique, but the disadvantage of a lower availability (light also remains with the pocket boundaries – and often can't be detected).

2.4.3 Ultra Wide Band (UWB)

A UWB [6] is expected to be the next generation most important technique; it works in wireless space sending pulses over the air. It is low power and high speed technique, this combination gives UWB more reliability in indoor positioning.

UWB is pulse based system; it uses pulses to send the signal across a wide bandwidth, sometimes a several GHZ, and the destination uses receiver to catch the right pulses and convert them as data.

2.4.4 WLAN

In general WLAN is one of the popular technologies, it is easy and reliable using the WLAN infrastructure for location awareness and additionally using the location server, still IEEE 802.11b is the standard used to positioning, with bit rate of 11Mbps, and a range 50-100 m, and has accuracy of about 2m [1].

Despite WLAN is widely spread technique but has the disadvantage, this technique needs to have power supplier after each short period of time.

2.4.5 Bluetooth (IEEE 802.15)

Bluetooth is a new technique in indoor location sensing markets.

"Compared to WLAN, the gross bitrate is lower (1 Mbps), and the range is shorter (typically 10-15 m, though it can be longer)." [1]

Now let's have a look in an illustrated view of differences in these techniques:

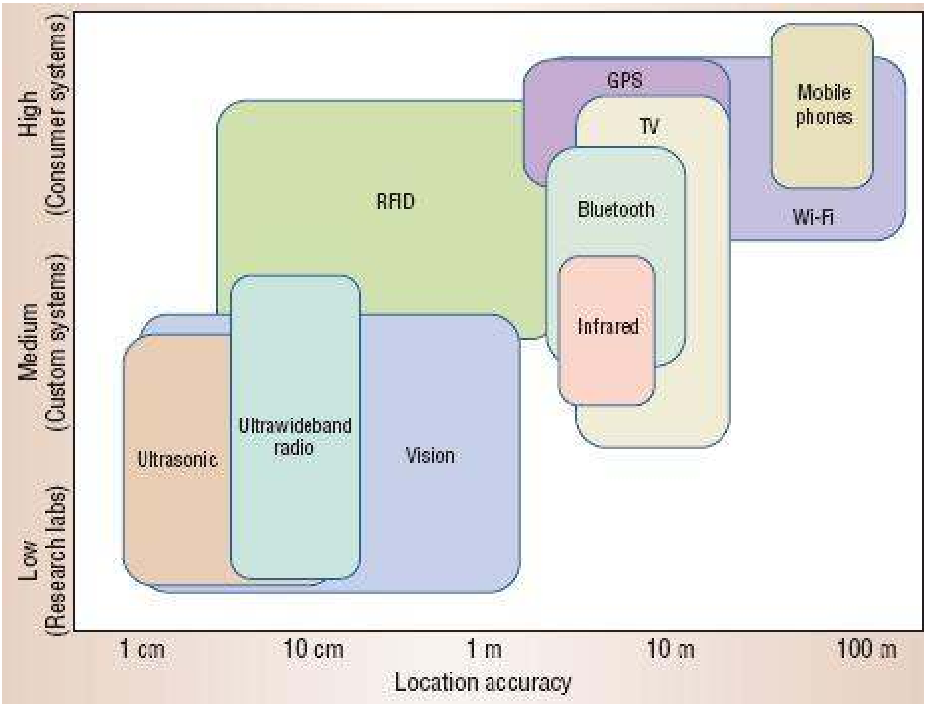

Figure 1: a diagram shows the range of accuracy of each usable technology, where the top boundary technologies shows the new and next generation of current technologies. [30]

3 Properties of location sensing

3.1 Physical & Symbolic Location

> "The distinction between physical position and symbolic location is more pronounced with some technologies than others. GPS is clearly a physical positioning technology. Point-of-sale logs, bar code scanners, and systems that monitor computer login activity are symbolic location technologies mostly based on proximity to known objects" [31]

Any location system can provide physical and symbolic information as in GPS receivers. But some systems like in Cricket can be used in either mode; it depends on the configuration of the system itself [8].

3.2 Absolute & Relative

For the Absolute location systems [7], uses coordinating system for locating. As in GPS receivers use longitude, latitude and altitude. In Relative system each object has its own references, to locate it uses other objects references and landmarks relative to it. like if there is an emergency call, and at the same time two teams starts to reach the position and each team has its own position, here the location and references are different for each team, and in this case you can't use the absolute system. This means that what information we have and how the system uses are the main different between the Absolute and Relative systems.

3.3 Accuracy & Precision requirements

Those are the most important concepts of the location [7], because in case of using it for military or civil applications, we need to have accurate result as much as possible. For the civil applications such as the GPS receivers, could do fewer mistakes with expensive receivers, about 1-3 meters to 10 meters.

3.4 Scale

Evaluating the scale of a location sensing system depends on the coverage area and the number of the objects the system can locate, the time is important issue too. For example GPS can serve unlimited number of receivers [7]; it uses 27 satellites for this purpose. But some tags can't read more than one in the same range.

3.5 Cost & Limitation

The cost evaluation depends on many important issues, one of the assess ways is the time [8], the time needed to install the process, time of the administration needs. Time plays an essential role, and mainly people concerns the times of preparation, and due to it, they fill up there schedule to start there business.

The space, what is the size of the hardware. For example civilian GPS receiver costs around $100 (in 2007) [8] and presents the incremental cost.

The Limitation of any system is the range where it's work properly. Such as the Active Bat system, it has a range where you can't use it out of the coverage area, or as outdoor sensor.

4 Location awareness systems

4.1 Indoor location systems

The indoor location is very efficient and everyday developed system.

It's the way where we can identify a desired position, and gives the ability to observe an object. This has done by attaching a tag to the object and fixed number of wireless antennas or receivers, where the connection between the transceiver and receiver is by the air wirelessly.

There are many kinds of indoor sensors, and those depend on the techniques which is usable (for more information about techniques look above in section 1). Each technique has its own advantages and disadvantage, and using one instead of the others rely on the customers, and what are the requirements. In this paper I will try to bring out the most important systems which are worldwide popular, there main properties, and I will start with the oldest systems which are very popular and still one of the important system, and there new generations takes the challenge of modern technologies.

4.1.1 Active Badge

This system is the oldest indoor location sensor developed by Olivetti research laboratory, Cambridge, UK (1989-1992).

"The badge transmitted a unique five-bit code every fifteen seconds. Successive versions have expanded the functionality and address-space size of the badge. The current version of the badge incorporates a small microprocessor, offering bi-directional communication, and a 48 bit address." [10]

The badge attached to the persons and transmits IR signal each ten seconds, for detection there is especial device called sensors fixed in suitable places within the buildings. Sensors are connected to the control device.

The control device which is the central receiver collects the information after each emitting from all sensors [9].

"These periodic signals are picked up by a network of sensors placed around the host building. A master station, also connected to the network, is given the task of polling the sensors for badge `sightings', processing the data, and then presenting it in a useful visual form. The badge was designed in a package roughly 55x55x7mm and weighed a comfortable 40g." [9]

Figure 2: some patterns of Active badge sensors
http://ei.cs.vt.edu/~wwwbtb/fall.96/Presentations/badges.gif

Scenario: when AT&T invented this system [10], they concerned the initial application of this system to be an aid for a telephone receptionist. So let's explain the scenario regarding the initial application. Firstly the sensors mounted in the offices, and common areas, except some places where people expect to be free.

The system provides a list of names with dynamically updating field containing the nearest telephone extension and a description of the location.

PC display shows the people inside the location, when it's below 100% means the person is moving, and if not sighted for 5 minutes, the field contains the last time and location of the person. If the person not sighted for more than one week, indicates as "AWAY" [9], and this is an advantage of this system where no overloading of information occurs. Below is the list of the most usable commands:

"FIND: provides the current location of the named Badge, current position, and where has been sighted in the last 5 minutes.
WITH: provides the name of the Badge and the name of neighboring Badges.
LOOK: allows information about the Badges that are near to the desired location.
HISTORY: provides a report about the history for the named Badge for a one hour long period" [9]

4.1.2 Active Bat

After inventing the Active Badge system, a disadvantage appeared regarding to 3D location and orientation information, these were the reason to develop a new system uses 3D ultrasonic location system, Low power, wireless and relatively inexpensive. The scenario is: this system is based on triangulation position finding be measurement of distances, the Bat is the small device carried by users, and the receivers are fixed on the ceiling. When the Bat emit a pulse of ultrasound, the measurement of the pulse starts with TOF, the speed of sound is known, so it just need a calculation of the distance from Bat to each receiver (uses three) [11].

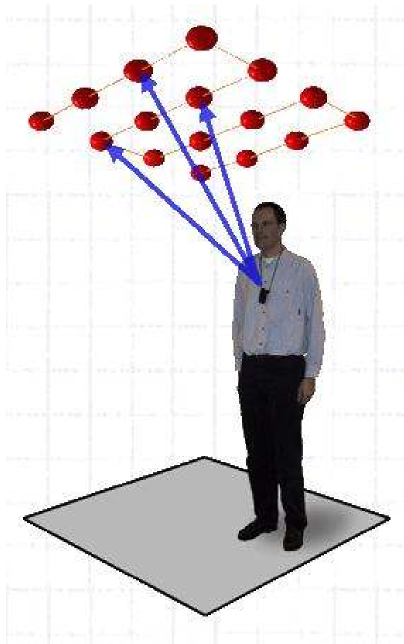

Figure 3: How triangulation works with Active Bat [11]

For calculating of the orientation, it happens by finding the relative position of two or more Bats attached to an object, and even more it's possible to determine the direction of the person by analysis of the patterns of receivers that detected ultrasonic signals from that transmitter, and the strength of signal they detected.

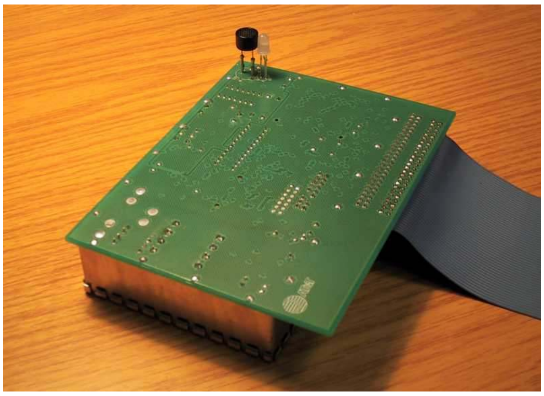

Figure 4: Receiver used to detect ultrasonic signals.

"Receivers are placed in a square grid, 1.2m apart, and are connected by a high-speed serial network in daisy-chain fashion. The serial network is terminated by a DSP calculation board, which collects results from the receivers and uses them to compute transmitter positions." [11]

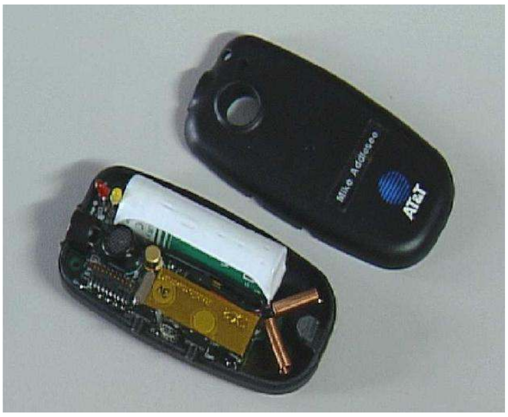

Figure 5: AT&T developed Active Bat sensor
http://www.cl.cam.ac.uk/research/dtg/attarchive/bat/flatBatInside.jpg

According to AT&T laboratories [11], the active bat system has 95% accuracy of triangulation within 3 cm.

Active Bat "is a very useful system for limited-range tracking. Provided that it is used with the user's consent, in locations such as a company office it can be invaluable in the absence of technologies such as cell phones." [20]

4.1.3 Cricket

Cricket uses both RF and Ultrasound techniques. Speed of ultrasound signal is smaller than RF. Beacons are small devices attached to the ceiling or some other locations within the required space, they are used to data by RF and ultrasound pulses [12].

Main concept of cricket is decentralizing:
The cricket gives the ability of positioning with non central server for query,

"A person can configure and install a beacon in a room that tells about the its identity which is some character string and like this every beacon integrates with the system. Listener is attached to every device for which user wants to get location information. Listener uses inference algorithm to determine space with help of beacon messages" [21]

The decentralizing of cricket decreases the cost of management and increases the privacy of each user. And this let cricket design unique not similar to the previous two systems active badge and bat.

Figure 6: Example of used beacons in an office
http://cricket.csail.mit.edu/pictures/lab_view.jpg

Figure 7: Cricket indoor location system
http://cricket.csail.mit.edu

Cricket Version 2:

This version is the improved and simplified hardware component Cricket; it gives the possibility of Auto-configuring, and can be configured to either be beacon or a listener, or both. The beacons use RFID and Ultrasonic to listen and send signals, and it finds the distance by measuring the time difference.

3.1.4 RADAR

RADAR is an RF-based system for locating users inside building; it developed at Microsoft Research implements for indoor location service [3]. It uses the signal strength information from wireless networking equipment. The system is capable of locating users to within a few meters of their actual location. The system uses a combination of empirically determined and theoretically computed signal strength information, as the propagation of RF inside buildings is hard to cope with.

Where the RF transceivers called the base station, the base station is the connector between the wireless and wired networks, it is stable and continuously connected, in general laptops or computers with WLAN 802.11 are used as base stations.

What are the advantages and disadvantages of RADAR?

Despite RADAR [13] had some disadvantages when the devices are limited in power and small, here tracking might be hard, and when the location consist of multi floors.

But on the other hand RADAR system provides some positive points as:

Uses WLAN infrastructure, have base stations, because the system requires only few BS. These points give a positive view to the RADAR system.

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 3: This table does a quick comparison among the main indoor sensor systems, and the result shows that cricket is batter than the other systems, concerning the privacy, cost, and deployment. [12]

4.1.5 GSM indoor localization

GSM [14] has many positive points concerning its special properties of being used with WLAN, and has reliability because it’s usable out of any indoor boundaries, additionally, GSM is worldwide popular with mobile phones.

What makes GSM indoor location possible is fingerprinting technique, this technique can read up to 29 GSM channels, and it’s good for detecting but at the same time weak in communication.

> “GSM is the most widespread cellular telephony standard in the world, with deployments in more than 100 countries by over 220 network operators . In North-America, GSM operates on the 850 MHz and 1900 MHz frequency bands. Each band is subdivided into 200 KHz wide physical channels using Frequency Division Multiple Access (FDMA). Each physical channel is then subdivided into 8 logical channels based on Time Division Multiple Access (TDMA). There are 299 non-interfering physical channels available in the 1900 MHz band, and 124 in the 850 MHz band, totaling 423 physical channels in North-America.” [14]

4.1.6 Bluetooth

Bluetooth [1] is one of the new incomers as indoor sensors, the access point act as "Master" and the master is connected with seven other devices called "Slave", normally the Master interconnect via a hub or LAN switch.

It divides the band into 79 channels and hops, one of the Bluetooth devices act as a "Master" and the master is connected with 7 other devices called "Slave".
This group of eight devices called piconet. Bluetooth is short range system; it can fit a radius up to ten meters. It's wireless device, with some advantages like low cost, and low power query.

They are two types of Bluetooth base band:
Asynchronous connectionless (ACL): provides reliability by retransmitting packets.
Synchronous connection-oriented (SCO)
The Master device supports seven ACL and three SCO links.

Bluetooth location could have one of the two approaches:

"Binary location: a room-oriented approach uses the PD method. An access point is installed in every room. For each tag, the system than finds the nearest AP, and respectively indicates its room location.

Analog location – an X-Y oriented approach, based on the RSSI method. APs are installed more sparsely (typically, 10-15 m apart). For each tag, the distance from each AP is measured, and the system triangulates the tag's position." [1]

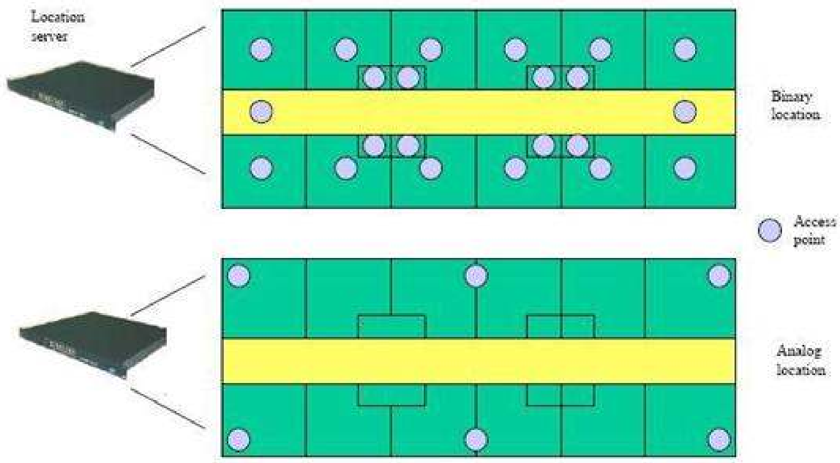

Figure 8: The two types of AP arrangement [11]

BIPS used for positioning via Bluetooth, its Proximity based technique, observes the users motion among the Bluetooth coverage. Once the user detected, its position saved in a database, this way the BIPS makes a database reporting the accuracy of the device to the system.

4.2 Outdoor Location Sensors

Determining outdoor location sensing using (Longitude, Latitude, and Altitude), as well as time by the Global Navigation Satellite Systems (GNSS).
The following systems use GNSS:

4.21. GPS

United States Global Positioning System consists of 29. The Global Positioning System (GPS) is currently the only fully functional (GNSS). The operation happens by measuring the distance between the GPS receiver and three or more GPS satellites [15].
The radio signal is used to get the distance and position to each satellite, the receiver computes its position using trilateration. GPS receivers can relay position data to a PC or other device using the NMEA 0183 protocol [15].

GPS Receiver as an example to understand how GPS Location sensor works:

GPS consists of 27 satellites; each of these 3000-to 4000 pound solar-powered satellites surrounding the globe at about 20000 Km, making two complete rotations everyday [15].

Every satellite has its own atomic clock for time measuring in an accurate way, when the satellite emits a signal, it indicates the time when the signal start emitting. On the ground the GPS receivers contains usual clock, when the signal arrives, the GPS receiver is able to recognize the satellite, and the time taken. This way it's possible to calculate the distance, and this occurs after getting four signals from different satellites (at least).and as a result the user will get the numbers regarding to longitude latitude, altitude, and some other information this depends on the GPS receiver[18].

They are some special cases where we might lose the communication, such as facing a long building, thick clouds, forest, storm …etc. those reasons make positioning takes much more time to reach the aim. Sometimes it might be satellite working issues, for example not finding enough satellites, where you can't have fix position for the desire point.

> " Periodically, particularly during periods of heightened concern about national security, the US military downgrade the quality of the signals that their satellites provide, and thus the position fix is far weaker, a situation known as "Selective Availability" (presumably this is because you can make an effective and very accurate guided missile relatively cheaply using a GPS)" [27].

Before selective availability (SA) deactivated on may 2, 2000 [34], the standard GPS receiver for civil uses had accuracy about 5-20m, depending on the number of available satellites.

To get more accuracy other techniques has been used, Differential GPS (DGPS) [34], this technique provides accuracy of 5m for civil GPS receivers, the get accuracy it needed another GPS receiver to correct the measurements. Other technique is WAAS, wide area augmentation system has been opened since 99 in USA, and it's available as portable GPS since 2001, it doesn't need any other GPS receiver as in DGPS situation. In Europe a similar technique used, it's called EGNOS (European Geostationary Navigation Overlay Service).

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 4: An overview of Typical Accuracies of civil GPS receivers [34]

4.2.2 GLONASS

The former Soviet Union **GLO**bal **Na**vigation **S**atellite **S**ystem is a radio based navigation system; the purpose of developing this system was to provide the real time position and speed determination. Now GLONASS use the third generation Uragan-K, with a life time of 10-12 years, and 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 [16].

Nowadays GLONASS facing more problems [33], the last meeting, Russian President declared that the system will start operating this year, and it will start with 18 satellites, and expected till 2009 to cover the whole world. 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.

After launching the spacecrafts need few Month to start operating, and still is not officially clear whether GLONASS could be global, still Russian airlines use GPS 92%, the Russian prime minister declared [33]: "We must realize that the GLONASS system will not be commissioned before 2010-2011, and that there would be no use for a smaller 18-satellite version." Moreover they expect that Uragan-KM will operate in 2025 with 27 satellites and will have more competition chances.

4.2.3 Galileo

The European Union positioning system. It would be operational on 2012, having 30 spacecrafts, with 12 years lifetime, as in GPS or GLONASS location sensing this system will use the atomic clock to measure the time very accurately. The satellites emit personalized signals indicating the precise time the signal leaves the satellite [17].

"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, through the Israel Export and International Cooperation Institute." [26]

Although many countries European and worldwide expecting a good start to Galileo, as it mention in the quoted paragraph above, but the news says, a serious problems needs to fix before the deadline. It occurred when Galileo companies have given deadline to move the project forward, and still the companies didn't decide the way to go forward. The German Transport Minister Wolfgang Tiefensee expecting critical days: "We're in a dead end street. The cardinal problem is that the companies still have not been able to agree on the way forward. We need to find an alternative solution." [32]

Comparing GPS with the future Galileo we may notice cost issues like GPS, Galileo will be free of charge to basic users, the security conditions are satisfactory; an appropriate security framework is specifically required.

In the table below there is a comparison between some indoor and outdoor systems which have already explained in this paper:

	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

Table 4: comparison among the most important indoor and outdoor systems
SOURCE: Adapted from Table 1 of Hightower and Borriello (2001)

5 CONCLUSIONS

The location awareness is everyday required technique, the competition between the companies and researches is huge to improve there systems and produce new versions of old systems to keep them up to date, and try to exist new systems which might spread and cover the marketing.

In indoor positioning new comers to this technology are devices which we already use them in our life, like Bluetooth case, where it's not invented to role as a sensor.

For the outdoor situation, the competition is going to reach the top between the old GPS system, which is still controlling the outdoor market, and the new operational becoming systems in the next few years, the Russian GLONASS which is declared officially at the end of this may, that is available for all civilians by free and without limitation, and the other big competitor is the European new Galileo satellite navigator.

6 References

[1] Dr. Zeev Weissman.White paper. Indoor Location

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